The Western Riverside County Agriculture Coalition

Agricultural Nutrient Management Plan (AgNMP) for the San Jacinto Watershed

April 30, 2013

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ACKNOWLEDGEMENTS

The Agricultural Nutrient Management Plan (AgNMP) is being submitted by the Western Riverside County Agriculture Coalition (WRCAC) as a deliverable for TMDL compliance for the Lake Elsinore and Canyon Lake nutrient TMDL. This report has been a “work-in-progress” for many years and part of an overall strategy for agricultural operators in the San Jacinto Watershed. With that being said, there are many components that have been completed by several sources that are used in this final product. WRCAC recognizes the significant contribution that all of these entities have made and acknowledge their efforts:

Assessment of Best Management Practices to Reduce Nutrient Loads in the San Jacinto River Watershed Final Report, University of California Riverside, Laosheng Wu and his entire staff of investigators and project coordinators, December 31, 2009. This project was funded through a 319 grant and managed by the Santa Ana RWQCB..

Agricultural Nutrient Management Program For Operations Within the Newport Bay/ San Diego Creek Watershed, a cooperative effort between the Orange County Farm Bureau (OCFB) and the University of California cooperative Extension (UCCE)

Voluntary Agricultural Operator TMDL Implementation Plan with BMP Implementation WRCAC, 2005-2006 Consolidated Grant and American Resource and Recovery Act (ARRA) Funding grant, June 30, 2010. This grant was funded through the SWRQB.

Management Practices to Reduce Nutrient Loads from Agricultural Operations in the San Jacinto Watershed, Tetra Tech Inc, February 29, 2008.

Integrated Regional Dairy Management Plan for the San Jacinto Watershed, San Jacinto Basin Resource Conservation District, 2005-2006 Consolidated grant effort, December 2009. This grant was funded through the SWRQB.

Certification of Salt Reduction in Dairy Waste, Deanne Meyers, University of California Davis, CDQAP-WDR General, April 2009.

Supplemental Environmental Project Report: Source Identification for Phosphorous, Nitrates and Salts in the San Jacinto Watershed and Identification of Technologies and Alternate Control Measures Report, WRCAC & Tetra Tech, May 16, 2006.This report was funded from a Santa Ana RWQCB Supplemental Environmental Project.

WRCAC would like to extend a special thank you to the MS4 permittees and everyone working on the Comprehensive Nutrient Reduction Plan (CNRP), especially Jason Uhley, Chief of Watershed Protection, Riverside County Flood Control District; and the CNRP consultants, CDM Smith. Without their cooperation such coordination would not have been possible. We would also like to thank Hope Smythe, Chief Inland Waters, and Santa Ana Regional Water Quality Control Board for her expertise and assistance in the development of this plan.

Bruce Scott

Chairman, Western Riverside County Agriculture Coalition

April 23, 2013

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LIST OF ACRONYMS

AgNMP	Agricultural Nutrient Management Plan
BMPs	Best Management Practices
CAFO	Concentrated Animal Feeding Operations
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CL	Canyon Lake
CNRP	Comprehensive Nutrient Reduction Plan
CWA	Clean Water Act
CWAD	Conditional Waiver for Agricultural Discharges
CWP	Center for Watershed Protection
EPA	Environmental Protection Agency
IRDMP	Integrated, Regional Dairy Management Plan
LA	Load Allocations
LE	Lake Elsinore
LE/CL	Lake Elsinore/Canyon Lake
LESJWA	Lake Elsinore & San Jacinto Watersheds Authority
mL	Milliliters
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NPS	Non-Point Source
PTP	Pollutant Trading Plan
RCFC&WCD	Riverside County Flood Control and Water Conservation District
RWQCB	Regional Water Quality Control Board
SAWPA	Santa Ana Watershed Project Authority
SEP	Supplemental Environmental Project
SCAG	Southern California Association of Governments
SJR	San Jacinto River
TMDL	Total Maximum Daily Load
USGS	United States Geological Study
WebNMP	Web Based BMP tool
WLA	Waste Load Allocations
WQMP	Water Quality Management Plan
WQO	Water Quality Objective
WQT	Water Quality Trading
WRCAC	Western Riverside County Agriculture Coalition

Section 1
Background and Purpose

The Santa Ana Regional Water Quality Control Board ("Regional Board") adopted a Nutrient Total Maximum Daily Load (TMDL) for Canyon Lake and Lake Elsinore which requires the agricultural operators to develop an a Agricultural Nutrient Management Plan (AgNMP). There is no current permit for agricultural operators. Confined Animal Feeding Operations (CAFOs) are under permit R-8-2007-0001.A new permit is expected to be in place around June 2013. Both dairy and agricultural operators have participated in the TMDL through the TMDL Task Force and are represented on said Task Force by the Western Riverside County Agriculture Coalition (WRCAC). WRCAC has developed the AgNMP as a long term plan designed to achieve compliance with wasteload allocations (WLAs) established in the Lake Elsinore and Canyon Lake Nutrient Total Maximum Daily Loads ("Nutrient TMDLs"). This document fulfills the agricultural operator task requirement in the TMDL. The following sections provide the regulatory background, purpose, and framework of the AgNMP.

1.1 Regulatory Background

The 1972 Federal Water Pollution Control Act and its amendments comprise what is commonly known as the Clean Water Act (CWA). The CWA provides the basis for the protection of all inland surface waters, estuaries, and coastal waters. The federal Environmental Protection Agency (EPA) is responsible for ensuring the implementation of the CWA and its governing regulations (primarily Title 40 of the Code of Federal Regulations) at the state level.

California's Porter-Cologne Water Quality Control Act of 1970 and its implementing regulations establish the Santa Ana Regional Board as the agency responsible for implementing CWA requirements in the Santa Ana River Watershed. These requirements include adoption of a Water Quality Control Plan ("Basin Plan") to protect inland freshwaters and estuaries. The Basin Plan identifies the beneficial uses for waterbodies in the Santa Ana River watershed, establishes the water quality objectives required to protect those uses, and provides an implementation plan to protect water quality in the region (RWQCB 1995, as amended).

The CWA requires the Regional Board to routinely monitor and assess water quality in the Santa Ana River watershed. If this assessment indicates that beneficial uses are not met in a particular waterbody, then the waterbody is found to be impaired and placed on the state's impaired waters list (or 303(d) list[1]). This list is subject to EPA approval; the most recent EPA-approved 303(d) list for California is the 2010 list[2].

Waterbodies on the 303(d) list require development of a Total Maximum Daily Load (TMDL). A TMDL establishes the maximum amount of a pollutant that a waterbody can receive (from both point and nonpoint sources) and still meet water quality objectives.

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[1] 303(d) is a reference to the CWA section that requires the development of an impaired waters list.

[2] On November 12, 2010, EPA approved California's 2008-2010 Section 303(d) list of impaired waters and disapproved the omission of several water bodies and associated pollutants that meet federal listing requirements. EPA identified additional water bodies and pollutants for inclusion on the State's 303(d) list. On October 11, 2011, EPA issued its final decision regarding the waters EPA added to the State's 303(d) list.

1.2 Lake Elsinore and Canyon Lake Nutrient TMDLs

Through its bi-annual water quality assessment process, the Regional Board determined that Lake Elsinore was not attaining its water quality standards due to excessive nitrogen and phosphorus. This finding led to the Regional Board placing Lake Elsinore on the 303(d) list in 1994 as a result of the impairment of the following uses: warm water aquatic habitat (WARM), and water contact and non-water contact recreation (REC1 and REC2).

Similarly, a Regional Board water quality assessment of Canyon Lake identified excessive nutrients causing impairment of the lake. Accordingly, Canyon Lake was listed on the 303(d) list in 1998. The following uses were identified as impaired by nutrients: municipal water supply (MUN), warm water aquatic habitat (WARM), and water contact and non-water contact recreation (REC1 and REC2).

Regional Board staff prepared the Lake Elsinore Nutrient TMDL Problem Statement and the Canyon Lake Nutrient TMDL Problem Statement in October 2000 and October 2001, respectively. These reports documented the impairment caused by excessive nutrients and provided preliminary recommendations for numeric targets to ensure beneficial uses of both lakes would be protected.

Following completion of the Lake Elsinore and Canyon Lake Problem Statements, a number of studies were conducted:

- UC Riverside conducted studies to quantify the internal nutrient loading from Lake Elsinore and Canyon Lake sediments, as well as the response of the lakes to these internal nutrient loadings.
- Regional Board staff and watershed stakeholders conducted in-lake monitoring to evaluate the current nutrient cycling processes and to determine the in-lake response to nutrient loads from the watershed and characterize spatial and temporal trends of nutrients, algal biomass, dissolved oxygen, and other water quality parameters.
- Regional Board staff and watershed stakeholders implemented a watershed-wide monitoring program that assessed nutrient loadings from various land uses in the watershed.
- Lake Elsinore San Jacinto Watershed Authority (LESJWA), a joint powers authority, implemented watershed modeling to simulate nutrient loads under different hydrologic conditions and assess the impact of various implementation plans on the water quality of each lake.
- LESJWA conducted a survey of lake users from April through September 2002 to link lake users' opinions of Lake Elsinore to water quality parameters monitored on the same day as surveys were conducted.

The Regional Board used the data developed from the above studies to develop the Nutrient TMDLs. This information was reported in the Regional Board's Staff Report, released for public review May 21, 2004. The purpose of the Staff Report was to provide the technical basis for the proposed TMDLs. Table 1-1 summarizes the nutrient numeric targets applicable to Lake Elsinore and Canyon Lake.

Public workshops were held on June 4 and September 17, 2004 to gather public comment on the proposed Nutrient TMDLs. Based on the comments received, the Regional Board prepared final Nutrient TMDLs that were adopted on December 20, 2004 (Order No. R8-2005-0037). The subsequent TMDL approval process included: State Water Resources Control Board (State Board) approval on May 19, 2005, Office of Administrative Law approval on July 26, 2005, and EPA approval on September 30, 2005.

Table 1-1 TMDL Compliance Requirements

Indicator	Lake Elsinore	Canyon Lake
Total Phosphorus Concentration (Final)	Annual average no greater than 0.1 mg/L to be attained no later than 2020	Annual average no greater than 0.1 mg/L to be attained no later than 2020
Total Nitrogen Concentration (Final)	Annual average no greater than 0.75 mg/L to be attained no later than 2020	Annual average no greater than 0.75 mg/L to be attained no later than 2020
Ammonia Nitrogen Concentration (Final)	Calculated concentrations to be attained no later than 2020 Acute: 1 hour average concentration of total ammonia nitrogen (mg/L) not to exceed, more than once every three years on the average, the Criterion Maximum Concentration (CMC) (acute criteria), where CMC = 0.411/(1+107.204-pH) + 58.4/(1+10pH-7.204) Chronic: 30-day average concentration of total ammonia nitrogen (mg/L) not to exceed, more than once every three years on the average, the Criterion Continuous Concentration (CCC) (chronic criteria), where CCC = (0.0577/(1+107.688-pH) + 2.487/(1+10pH-7.688)) * min (2.85, 1.45*100.028(25-T)	Calculated concentrations to be attained no later than 2020 Acute: 1 hour average concentration of total ammonia nitrogen (mg/L) not to exceed, more than once every three years on the average, the Criterion Maximum Concentration (CMC) (acute criteria), where CMC = 0.411/(1+107.204-pH) + 58.4/(1+10pH-7.204) Chronic: 30-day average concentration of total ammonia nitrogen (mg/L) not to exceed, more than once every three years on the average, the Criterion Continuous Concentration (CCC) (chronic criteria), where CCC = (0.0577/(1+107.688-pH) + 2.487/(1+10pH-7.688)) * min (2.85, 1.45*100.028(25-T)
Chlorophyll a concentration (Interim)	Summer average no greater than 40 µg/L; to be attained no later than 2015	Summer average no greater than 40 µg/L; to be attained no later than 2015
Chlorophyll a Concentration (Final)	Summer average no greater than 25 µg/L; to be attained no later than 2020	Summer average no greater than 25 µg/L; to be attained no later than 2020
Dissolved Oxygen Concentration (Interim)	Depth average no less than 5 mg/L; to be attained no later than 2015	Minimum of 5 mg/L above thermocline; to be attained no later than 2015
Dissolved Oxygen Concentration (Final)	No less than 5 mg/L 1 meter above lake bottom to be attained no later than 2015	Daily average in hypolimnion no less than 5 mg/L; to be attained no later than 2015

TMDL coordination efforts have been underway since August 2000, well before adoption of the Nutrient TMDLs. These activities were coordinated and administered through the LESJWA. Following TMDL adoption, the existing TMDL stakeholders formally organized into a funded TMDL Task Force ("Task Force") in 2006. This Task Force in coordination with LESJWA has been actively involved in the implementation of the TMDL requirements, which include 14 tasks.

Attachment A summarizes the status of the implementation of these tasks, in particular those that are relevant to the dairy and agricultural operators.

1.3 Western Riverside County Agriculture Coalition

The Western Riverside County Agricultural Coalition (WRCAC), a non-profit organization was formed in March of 2004 to assist agricultural and dairy operators with environmental issues in the San Jacinto Watershed. WRCAC became the designated voting member of the TMDL Task Force representing agricultural operators and dairy operators in 2006. Stakeholder allocations were distributed by the Lake Elsinore/Canyon Lake TMDL Task Force beginning in 2006. The dairy and agricultural community, a one-third watershed stakeholder in the baseline/initial allocation, did not have a collection process or mechanism in place to contribute in the TMDL stakeholder process.

Lake Elsinore **Photo Courtesy of Pat Boldt**

A TMDL voluntary implementation process for agricultural and dairy operators was developed and implemented. It was a complex, costly and extremely challenging exercise. Aerial mapping was the most reliable tool for the task of identifying agricultural operators and the correct agricultural land use within a defined period.

The agricultural specific deliverable for agriculture in the TMDL is an Agricultural Nutrient Management Plan (AgNMP).

1.4 Agricultural Nutrient Management Plan (AgNMP)

This section provides information on the requirements for AgNMP development and the applicability of the plan to agricultural discharges in the watershed that drains to Canyon Lake and Lake Elsinore. In addition, information is provided on the general framework of this plan and the process associated with its development.

The goal for agriculture is to reduce nutrient loads in surface runoff. Pursuant to the Porter-Cologne Water Quality Act (Chapter 5;article 6; section 13360), an agricultural nutrient management plan does not specify the design, location, type construction, or particular manner in which compliance with RWQCB TMDL allocation numbers are to be achieved by agricultural stakeholders within the watershed. The San Jacinto AgNMP will consist of a voluntary program that integrates guidelines for nutrient management, water management and erosion reduction in an attempt to address the watershed concerns of both nitrogen and phosphorous transportation from surface water runoff.

1.4.1 Purpose and Requirements

The current CAFO permit (R-8-2007-0001 issued in September of 2007) includes TMDL requirements. The new permit currently being negotiated has extensive TMDL requirements in the permit draft. Specific requirements of the Conditional Waiver for Agricultural Discharges (CWAD) program have not yet been defined; we expect that the need for the development of the AgNMP will be described in both of these future permits and programs similarly to those stated in the MS4 permit:

- Interim compliance (compliance determination prior to the final WLA compliance dates) determination with the WLAs in the TMDLs will be based on the Lake Elsinore and Canyon Lake (LE/CL) agricultural and dairy operator progress towards implementing the various TMDL Implementation Plan tasks as per the resultant studies and plans approved by the Regional Board. The LE/CL agricultural and dairy operators are developing an AgNMP designed to achieve compliance with the WLAs by the final compliance date for approval of the Regional Board. It is important to note that the agricultural community has embraced the requirements of the LE/CL TMDL and the implementation process without any actual permit being in place.

- The Regional Board recognizes that additional research is needed to determine the most appropriate control mechanism to attain water quality standards for nutrients in these two lakes. This Order provides the LE/CL stakeholders the flexibility to meet WLAs through a variety of techniques. Water quality standards in the lakes may be met through biological or other in-Lake control mechanisms, and the stakeholders' obligation to meet the WLAs is satisfied as the impairment for which the TMDLs were developed would not exist anymore. The dairy and agricultural operators are required to develop an AgNMP designed to achieve the WLAs by the compliance dates specified in the TMDL.

- To achieve compliance with TMDL WLAs as per the TMDL Implementation Plans, the LE/CL dairy and ag operators shall submit an AgNMP by April 30, 2013 describing, in detail, the specific actions that have been taken or will be taken to achieve compliance with the agricultural and dairy WLA by December 31, 2020. Unlike other stakeholders, ag operators may address the BMPs' as individuals although the plan is written for the benefit of the group. Different crops will require different BMPs. WRCAC will supply the fundamental guidance process and offer tools and assistance whenever possible. The AgNMP will include the following:

  - Evaluation of the effectiveness of BMPs (Best Management Practices) and other control actions implemented. This evaluation shall include the following:

    - The specific BMPs implemented to reduce the concentration of agricultural nutrient sources and the water quality improvements expected to result from these BMPs.

    - Identification of appropriate BMPs based upon type of agricultural practice.

  - Implementation of tools, such as the WRCAC weBMP database, that will aid in the identification and effectiveness of BMPs being implemented by individual agricultural operators.

- Proposed method for evaluating progress towards compliance with the nutrient WLA for agricultural Runoff. The progress evaluation shall include:

  - The scientific and technical documentation used to conclude that the AgNMP, once fully implemented, is expected to achieve compliance with the agricultural waste load allocation for nutrients by December 31, 2020.

  - A detailed schedule for implementing the AgNMP. Descriptions of any BMPs planned that WRCAC is aware of, and the time required to implement those BMPs, in the event that data from the watershed-wide water quality monitoring program indicate that water quality objectives for nutrients are still being exceeded after the AgNMP is fully implemented.

1.4.2 Applicability

The applicability of this AgNMP is limited to those agricultural and dairy operators that are members in good standing of WRCAC. Agricultural and dairy operators may choose to meet the TMDL requirements on their own. There are also-non-WRCAC stakeholders, such as tribal lands, Federal lands or state lands that may also be zoned as agricultural operators. Only those WRCAC members in good standing meet the applicability of this AgNMP TMDL deliverable.

1.4.3 Compliance with Agricultural Wasteload Allocation

The WRCAC agricultural and dairy operators have developed an AgNMP that is designed to achieve compliance with the agricultural WLAs by the compliance date of December 31, 2020. Compliance with the agricultural and dairy WLAs can be measured using one of the two following methods:

- Directly, using relevant monitoring data and approved modeling procedures to estimate actual nitrogen and phosphorus loads being discharged to the lakes, or,

- Indirectly, using water quality monitoring data and other biological metrics approved by the Regional Board, to show water quality standards are being consistently attained (as measured by the response targets identified in the Nutrient TMDLs).

Compliance with the agricultural and dairy WLAs may also be accomplished through the trading of pollutant allocations among sources to the extent that such allocation tradeoffs optimize point and non-point source control strategies to achieve the compliance in an efficient manner. WRCAC is developing a feasibility assessment looking at NPS to NPS water quality trading between dairy and agricultural operators through a 319 grant funded through the SWRCB. This process will allow trading between dairy and agricultural operators and in some situations agricultural operators to other agricultural operators. The feasibility assessment is expected to be complete in fall of 2013.

1.4.4 AgNMP Conceptual Framework

Compliance with the agricultural and dairy WLAs will require implementation of nutrient mitigation activities in both the watershed and the lakes. Accordingly, the AgNMP is built around a framework that includes both watershed-based BMPs and in-lake remediation activities. Coupled with this framework is a monitoring program to evaluate progress towards compliance with agricultural and dairy WLAs and an adaptive implementation program to provide opportunity to make adjustments to the AgNMP, where deemed necessary to achieve the needed WLAs.

- *Watershed-based BMPs* – The AgNMP identifies the process for identifying individual agricultural operator BMPs that will be implemented in the watersheds that drain to Lake Elsinore or Canyon Lake. These activities focus on targeting and mitigating nutrients at their source, prior to discharge during wet weather events. Activities may include individual agricultural operator BMPs or regional –based larger scale BMPs, such as composting facilities or gasification projects.

- *In-lake Remediation Projects* – A significant source of nutrients to Lake Elsinore and Canyon Lake are in-lake sediments. Practical remediation projects for reducing or managing these sources of nutrients have been identified and incorporated into the AgNMP. In some cases these projects are already ongoing; in others, new project activities will be initiated. The AgNMP identifies the agricultural and dairy operator commitments to the implementation of these types of projects as these projects develop.

- *Monitoring Program* – The original monitoring program (Lake Elsinore, Canyon Lake and San Jacinto watershed) established in 2006 was modified in 2010 to allow resources dedicated to monitoring activities to be used to support implementation of in-lake remediation projects. Under the AgNMP, monitoring will continue to be implemented at a reduced level through FY 2014-2015 to facilitate dedicating resources to necessary in-lake projects. In FY 2015-2016, monitoring will be increased to provide sufficient data to evaluate progress towards achieving the agricultural WLAs or lake water quality response targets. Section 2.2.3 describes the monitoring program that will be implemented as part of the AgNMP.

- *Special Studies* – The AgNMP describes several special studies that may be undertaken by the agricultural and dairy operators to support changes to the AgNMP and/or the TMDL. Execution of these studies is optional and at the sole discretion of the agricultural and dairy operators. If the agricultural and dairy operators decide to implement any of these studies, efforts will be coordinated with the Regional Board and the Task Force when applicable.

- *Adaptive Implementation* – Implementation of the AgNMP will be an iterative process that involves implementation of watershed BMPs and in-lake remediation projects followed by monitoring to assess compliance with agricultural WLAs or lake water quality response targets. As additional data becomes available, the AgNMP may need to be revised as part of an adaptive implementation process.

1.4.5 AgNMP Development Process

The AgNMP was developed by the agricultural and dairy operators subject to the TMDL requirements. Originally, the draft deadline of the AgNMP was December 31, 2010. A draft was submitted to the RWQCB for review. In early 2011, it was decided that the CNRP and AgNMP should contain many similar components such as pollutant trading, monitoring, and some project implementation. It was determined that the AgNMP would also have a new deliverable date of December 31, 2011 and that a coordinated effort, in many areas, between the CNRP and AgNMP would be beneficial. In parallel with and prior to AgNMP development, the agricultural and dairy operators have actively participated in TMDL related implementation activities (e.g., see Attachment A). Coordination activities since 2010 have included:

WRCAC Technical Advisory meetings

*A draft AgNMP was developed in 2010 and delivered to the RWQCB on 12/31/10. Meetings for the development of the AgNMP occurred throughout 2010.

Throughout 2011, WRCAC members were kept informed on the progress of the CNRP. A coordinated effort to write the AgNMP in the same fashion as the CNRP did not begin however until late November of 2011 when a suitable draft was available. RWQCB comments on the AgNMP were received and addressed. Significant implementation project compliance section data occurred late in 2012. Both the CNRP and the AgNMP required significant changes. The CNRP was submitted 1/31/13. Based upon the fact that the data needed to be similarly formatted and coordinated, the AgNMP compliance section was revised in March of 2013. The final submittal will be delivered to the RWQCB 4/30/13.

Activities (e.g., see Attachment A). Coordination activities since January 2010 have included:

LE/CL TMDL Task Force Meetings

- January 25, 2010
- February 22, 2010
- April 12, 2010
- June 28, 2010
- August 23, 2010
- February 22, 2011
- April 19, 2011
- May 31, 2011
- July 12, 2011
- January 23, 2012
- February 14, 2012
- March 27, 2012
- April 23rd, 2012
- May 21st, 2012
- June 18, 2012
- August 21, 2012
- September 19, 2012
- January 23, 2013
- February 19, 2013
- March 20, 2013

LE/CL TMDL Task Force Technical Advisory Committee Meetings

- August 4, 2010
- September 27, 2010
- October 25, 2010
- November 18,2010
- December 15, 2010
- March 22, 2011
- April 6, 2011
- May 18, 2011
- June 14, 2011
- August 15, 2011
- September 13, 2011
- October 19, 2011
- November 15, 2011
- December 12, 2012

WRCAC Technical Advisory Committee Meetings

WRCAC has monthly meetings to discuss issues relevant to the dairy and agricultural operators in the San Jacinto watershed. The TMDL is a regular calendar item on the agenda and is discussed as issues arise. This has occurred since 2004. WRCAC has spent an estimated 120 meetings on the TMDL issues and an estimated 200 hours of stakeholder outreach discussion regard the LE/CL TMDL

1.4.6 AgNMP Roadmap

The AgNMP is presented in two parts: (1) primary sections that provide an executive level summary of the components, schedule, strategy, and technical basis for the AgNMP; and (2) supporting attachments that provide additional information to support the primary sections. Following is a summary of the purpose and content of each primary part of the AgNMP:

- ***Section 2*** – Describes the AgNMP program elements, the AgNMP implementation schedule and the incorporation of an adaptive implementation strategy into the plan.
- ***Section 3*** – Provides the technical basis for the conclusion that full implementation of the AgNMP will achieve compliance with the agricultural and dairy WLAs and Las or lake water quality response targets applicable to each lake.

The above sections are supported by the following attachments:

- ***Attachment A, TMDL Implementation*** – Documents TMDL implementation activities completed to date by the Task Force and the dairy and agricultural operators.
- ***Attachment B, Watershed Characterization*** – Provides background information regarding the general characteristics of the watersheds draining to Canyon Lake and Lake Elsinore and existing water quality in each lake.
- ***Attachment C, Canyon Lake Nutrient TMDL In-Lake Strategies Evaluation –*** Provides additional information to support the selection of in-lake remediation projects for Canyon Lake.

- ***Attachment D, Existing Nutrient Source Control Programs -*** Documents existing activities that have been implemented by ag operators that reduce the runoff of nutrients to Canyon Lake and Lake Elsinore. Lists BMP options and data collected in University of California study.

- ***Attachment E, Implementation Schedule –*** Provides additional information regarding the implementation schedule summarized in Section 2.3.

- ***Attachment F, 2007 Aerial Information System Aerial Mapping Final Report, supporting document***

- ***Attachment G, Management Practices to Reduce Nutrient Loads from Agricultural Operations in the San Jacinto Watershed, supporting document***

- ***Attachment H, References***

Section 2
AgNMP Implementation Program

2.1 Introduction

The agricultural and dairy operators have been actively participating in the implementation of the Nutrient TMDLs through the activities of the Task Force since 2006. Substantial effort, e.g., data collection, in-lake and watershed modeling, program development and BMP implementation, have been completed to date. This compilation of work provides the foundation for this AgNMP, which establishes the additional actions that will be carried out by agricultural and dairy operators to achieve compliance with the agricultural WLAs and Las or lake water quality response targets.

The agricultural and dairy operators will achieve compliance with the agricultural WLAs or LAs or lake water quality response targets applicable to the Lake Elsinore and Canyon Lake through a combination of watershed-based BMPs and in-lake remediation projects. While some watershed-based BMP implementation activities are expected to be generally uniform across the area, others may vary by individual owner /operator and implementation dependent on each operator available resources and opportunities, and local sub-watershed needs. In addition to the watershed-based BMPs implemented by individual operators, the AgNMP identifies specific in-lake remediation projects and monitoring activities planned for implementation under the AgNMP. These AgNMP elements will be implemented individually but monitored through WRCAC activities.

The agricultural operators have participated voluntarily in the TMDL process to-date as there is no permit in place. BMPs that agricultural operators have individually implemented over the past decade have not been measured or acknowledged in any way. Therefore, the current load reduction needed we believe is easily obtained through changes in land use and the documentation of BMPs currently employed.

This AgNMP supersedes all other plans for the CL/LE Nutrient TMDL, including previous versions of the AgNMP and monitoring plans.

The following sections describe the key elements contained in this AgNMP and provide an implementation schedule to achieve compliance by December 31, 2020. Where necessary, AgNMP attachments provide supplemental information.

2.2 AgNMP Program Elements

AgNMP implementation consists of the following key implementation activities:

- Watershed-based BMPs to reduce nutrient loading in agricultural runoff, primarily wet weather flows.
- In-lake remediation projects to mitigate nutrient impacts from in-lake sediments. Separate remediation projects are included for Lake Elsinore and Canyon Lake.
- Monitoring activities to assess compliance with the TMDL.

- Optional special studies to develop data to support BMP implementation or provide the basis for revisions to the TMDL.

Each of these implementation activities is described in more detail below. In addition to these activities, the AgNMP program includes an adaptive implementation element to provide opportunity to make changes to the AgNMP or TMDL as more information is developed.

2.2.1 Integrated strategy: TMDL and CWAD

Currently, the Santa Ana RWQCB is in the process of developing a Conditional Waiver for Agricultural Discharges (CWAD) for the San Jacinto Watershed and eventually the entire Santa Ana Watershed. The purpose of this program is to control pollutants from discharges from agricultural operations to surface waters. Ag waivers are an efficient way to regulate a large number of dischargers with similar wastes and who use similar practices to manage their discharges, without issuing a permit to each discharger.

The goals of the CWAD program for the San Jacinto River watershed are to reduce the amount of nutrient pollutants discharged from agricultural operations to surface waters, to support the ongoing work to implement the TMDL, and to develop more information about the quality of runoff from agricultural operations that can be used to improve watershed management. It is WRCAC's goal to compliment the AgNMP process with the development of the CWAD. An integrated strategy benefits everyone as the objectives of the CWAD and TMDL program are intertwined.

The objectives of this Ag NMP are:

1. To communicate the requirements of the TMDL(s) and TMDL strategies developed by the Santa Ana Regional Water Quality Control Board to growers, operators, landowners and any agricultural stakeholder in the watershed.

2. To assist agricultural operators in the San Jacinto watershed in meeting their TMDL compliance commitments and reducing nutrient loads in the watershed.

3. To develop and provide the tools and recordkeeping process necessary to implement Best Management Practices in the watershed on a voluntary basis.

4. Improved identification of agricultural runoff discharges in the watershed during large storm events for agricultural parcels.

5. On-going education in the form of workshops, training and outreach for stakeholders on BMPs to reduce nutrient loading.

2.2.2 Watershed-based BMPs

WRCAC believes that a holistic approach to the watershed agricultural TMDL nutrient loading is the best approach. Individual agricultural operators cannot be held accountable for implementing the same types of BMPs with varying types of crops and loads, identification of nutrient loading will be addressed by WRCAC on a watershed scale. The implementation of BMPs will be proposed and implemented on an individualized per operator basis. WRCAC will assist in the process and develop tools in this process such as the WeBMP and aerial mapping.

In keeping with WRCAC's holistic watershed-wide approach to this complex issue, The AgNMP begins with a greater level of determination of existing nutrient loading for agricultural lands as well as existing BMPs by individual operators. All agricultural should not be treated the same in levels of nutrient loading responsibility as is currently the case. We believe that a tiered-pay schedule based upon amount of nutrients on parcels is a better and fairer approach. Agricultural operators that currently invest and apply BMPs have no current means to be rewarded. The system we propose is based upon the level of environmental stewardship implemented and creating the process for agricultural participation in this process.

The five (5) key steps identified to assess and improve agricultural BMP implementation of the AgNMP in the San Jacinto watershed are:

- Step 1: Determine Agricultural Nutrient Loading using various tools: such as agricultural surveys, Blue Water Satellite Technology, traditional monitoring, and aerial mapping.
- Step 2: Develop a tiered pay structure based upon amount of nutrients, BMPs implemented, proximity to waterbodies and other relevant factors. This process will need to be developed and will need to be phased in over an extended period of time.
- Step 3: Provide a database (WebNMP) for agricultural operators to input BMPs and data into a centralized database. This is being created as part of a 319 grant and will be operational by fall of 2013.
- Step 4: Provide stakeholder outreach and education for both TMDL and CWAD requirements .Education and outreach should include BMP "measures for success." Identification of those BMPs that have more merit in reducing nutrient loads than others. (*Perhaps tie into tiered process.)
- Step 5: Develop a cafeteria-style tiered approach based upon nutrient load level tiers for BMP implementation. The specifics would need to be developed over the next few years and in close coordination with the CWAD program.

The ultimate goal is to assess nutrient loading in the agricultural community in such a manner that BMP implementation is rewarded for those practicing good environmental stewardship. Those agricultural operators that have low nutrient loads will do low levels of BMP implementation. Likewise, those that use high levels of phosphorous will be expected to have a higher level of BMP commitment. Using a cafeteria-style tiered BMP selection process based upon nutrient loading imaging, ag operators can meet AgNMP requirements. WRCAC will dedicate significant time and energy in developing this process which allows individual agricultural operators to implement BMPs accordingly on their property.

Management measures and guidance practices have been identified for BMP use in the San Jacinto Watershed. These are the currently identified BMPs being utilized in the watershed, as well as those listed in Attachment D.

Buffer strip BMP at Scott Farms Photo courtesy of Nanette Scott

WRCAC believes that Blue Water Satellite technology may be useful in the Agricultural BMP process. Blue Water Satellite, Inc. (BWSI) has developed methods to detect concentrations of Total Phosphorus in surface water using Satellite imagery and patented algorithms which results in a data screening tool which makes it possible to evaluate data over entire surface water bodies in a single snapshot of time. This image data is processed to look at combinations of spectral bands where the target has a unique signature based on absorption and/or reflectance. The imagery is then processed to map the concentrations of these targets throughout the waterbody. Additionally, soil applications for determining levels of phosphorous are also currently being evaluated. It is this soil technology WRCAC is interested in reviewing and utilizing if deemed appropriate in the San Jacinto watershed.

2.2.3 AgNMP Management Measures and Guidance Practices

The Ag NMP Management Measures and Guidance Practices has been developed to include EPA and SWRCB guidelines regarding Best Management Practices (BMPs) for agriculture, as well as incorporating many of the 1998 revisions to the NRCS Agronomy Manual. The SARWQCB is currently looking at a Conditional Waiver for Agricultural Discharges (CWAD) in the San Jacinto Watershed. Typically in the State of California only runoff discharges from irrigated lands are being regulated, however in our watershed the CWAD program being developed includes irrigated and non-irrigated lands as well as other livestock operations and AFOs, such as poultry and horse ranches. WRCAC supports the irrigated lands component of the CWAD process in keeping with the rest of the State of California. Dairy is under a CAFO permit and is treated separately, although this plan will certainly address manure issues as part of the agricultural operator component.

Individual operators cannot be held accountable for implementing the same types of BMPs with varying types of crops and loads, identification of nutrient loading will be addressed by WRCAC on a watershed scale while implementation of BMPs will be proposed and implemented on an individualized basis.

The specifics of the program in this document have been laid out as Management Measures and Guidance Practices with regards to BMPs. Each Management Measure covers a central topic or focus, followed by Guidance Practices that present many of the specific actions a grower might employ to meet the stated focus. It should be understood that the Guidance Practices presented are not the only methods which will reduce nutrients in surface runoff. Reduction of runoff is a very complex interaction of practices, many of which may not be covered in this AgNMP document. WRCAC would encourage the use of any reasonable /acceptable BMP and would encourage use of new proven technologies.

The Guidance Practices have been designed so that there is reasonable assurance they can be voluntarily implemented and maintained by the grower. It should be noted that preliminary surveys of agricultural operations within the San Jacinto watershed have indicated that many growers already voluntarily incorporate many of the Guidance Practices into their normal crop production methods.

The University of California's Final Report, Assessment of Best Management Practices to Reduce Nutrient Loads in the San Jacinto Watershed, Attachment D-Best Management Practices for Agriculture in the San Jacinto Watershed, addresses Dairy Nutrient Management & Dry Land Crop BMPs, Citrus, Vegetable, and Turfgrass BMPs. These are typical BMPs that may be implemented by individual dairy and agricultural operators. They are not inclusive but are typical representations. The full report is listed in Attachment D.

2.2.4 In-Lake Remediation Activities

The AgNMP includes implementation of in-lake remediation activities that serve as regional treatment facilities for Canyon Lake and Lake Elsinore. The following sections describe the remediation activities planned for each lake; information regarding the expected water quality improvements to result from implementation of these activities is provided in Section 3.

Canyon Lake

Numerous studies have been conducted by the Task Force to evaluate potential in-lake nutrient management BMPs for Canyon Lake, including addition of chemicals; alum, Phoslock, and zeolite, and construction of aeration or hypolimnetic oxygenation. The most recent studies are summarized in Attachment C. They provide the basis for the selected in-lake BMPs. Table 2-1 provides a matrix showing how two selected in-lake BMPs for inclusion in the AgNMP perform in meeting either WLAs or LAs for agricultural and dairy sources or TMDL numeric targets for causal and response variables. The basis for these determinations is provided by modeling studies conducted in 2012 (Attachment C).

Table 2-1 Matrix Comparing Effectiveness of HOS and Alum In-Lake Nutrient Management BMPs for Compliance with the TMDL, per the MS4 Permit

Criteria	Constituent	HOS	Alum
WLA/LA	TP	■	■
	TN	■	□
TMDL Numeric Targets	TP (causal)	□	■
	TN (causal)	□	□
	Chlorophyll-a (response)	□	■
	Dissolved Oxygen (response)	■	◪

Key: Filled in square denotes an expectation that the target will be achieved, partially filled square denote an expectation of signifcant improvement, but not enough to achieve target as currently described in TMDL, and blank boxes indicate targets that are not effectively managed

To comply with the TMDL, the agricultural and dairy operators must either demonstrate that 1) WLAs and LAs for agricultural and dairy sources can be achieved with implementation of a project or 2) that the project will improve lake water quality to protect water quality standards, as measured by TMDL response targets for chlorophyll-a and DO. Incubation studies and subsequent models specific to Canyon Lake suggest that the HOS would suppress sediment nutrient flux to offset enough watershed loads to bring the WRCAC dairy and agricultural operators into compliance with the WLA and LA's. However, Anderson 2012b determined that exceedences of the chlorophyll-a response target would continue to occur if only HOS were to be implemented in the lake. In its March 31, 2012 comment letter, the Regional Board states that if allocations are met by all dischargers, but in-lake water quality response targets are not achieved, then the TMDL will be reconsidered and allocated loads may be further reduced. Thus, the stakeholders opted to prioritize in-lake BMPs based on their effectiveness in meeting the TMDL response targets for chlorophyll-a, and DO. Adding alum to Canyon Lake was estimated to be highly effective in achieving the interim and final chlorophyll-a response target; therefore to control algae in the lake, the stakeholders plan first conduct five alum applications over a two-year period. By binding phosphorus and reducing algae growth, the continued use of alum will reduce the cycling of nutrients and associated sediment oxygen demand in the lake bottom. Accordingly, the changes in biogeochemical processes will indirectly increase DO in the hypolimnion, and may be sufficient to achieve the interim and final DO response target.

The effectiveness of in-lake remediation using alum addition will be evaluated as part of the adaptive management process incorporated into this AgNMP (see Section 2.4). If it is found that a combination of watershed BMPs and alum additions are not sufficient to meet the final DO response target, then the stakeholders plan to implement additional in-lake solutions which can include aeration and/or HOS, if necessary. These additional in-lake BMPs would be constructed to provide the additional oxygen needed to meet the DO final response target. This is expected to be a much smaller scale than if the HOS was used for suppression of sediment nutrient flux.

Lake Elsinore

Work completed through the Task Force identified several recommended Phase 1 in-lake remediation activities, as well as potential supplemental BMPs, for deployment in Lake Elsinore (In-Lake Sediment Nutrient Reduction Plan for Lake Elsinore, October 22, 2007. The in-lake aeration/mixing system was installed in Lake Elsinore in two phases. The first phase, implemented by LESJWA in 2005, involved the construction of axial flow water pumps to improve lake circulation. A second phase, implemented in 2007, involved construction of an in-lake aeration project designed to pump air through a system of twelve perforated pipelines submerged along the bottom of lake. The intent of the aeration system is to improve circulation so that oxygen levels are better distributed throughout the water column. The bubble diffuser "lifts" oxygen-deficient bottom waters to the surface where it can be re-saturated through direct contact with the atmosphere.

The agricultural and dairy stakeholders in late 2012 decided to participate in the operation of the in-lake aeration system. At this time, based on lake modeling and compliance analyses, the stakeholders believe the aeration system will provide the necessary nutrient load reductions to comply with agricultural WLAs and LAs. In the event that additional BMPs are necessary, the In-Lake Sediment Nutrient Reduction Plan for Lake Elsinore (October 22, 2007) identified a number of other in-lake control strategies. Of these strategies, participation in fishery management activities or the application of metal salts, are the preferred next steps if additional BMPs are necessary.

Similar to Canyon Lake, the stakeholders are continuing to evaluate alternative compliance options should we determine that an alternative compliance approach is needed to achieve in-lake response targets for Lake Elsinore. If the stakeholders determine that an alternative compliance approach is necessary, the agricultural and dairy stakeholders may propose revisions to this AgNMP to incorporate the alternative compliance approach.

2.2.5 Monitoring Program

This requirement will be fulfilled through implementation of watershed and in-lake monitoring programs. Monitoring activities have been implemented in a phased manner since adoption of the TMDL. WRCAC will coordinate monitoring requirements of the agricultural and dairy operators for the TMDL with any CWAD agricultural specific requirements of agricultural operators. WRCAC anticipates that in-lake monitoring will continue through the TMDL Task Force or in some partnership with the MS4 permittees. The following sections provide a brief history of the monitoring program and expectations for continued monitoring under the AgNMP.

Phase 1 Monitoring

The agricultural and dairy operators, as participants in the Task Force, have conducted water quality monitoring on Lake Elsinore and Canyon Lake since 2006. The Task Force prepared the Lake Elsinore and Canyon Lake Nutrient TMDL Monitoring Plan ("Monitoring Plan") in February 2006. Monitoring began after the Regional Board approved the Monitoring Plan in March 2006. This plan included three components:

- Lake Elsinore – Provide data to evaluate compliance with interim and final nitrogen, phosphorus, chlorophyll *a*, and dissolved oxygen numeric targets.

- Canyon Lake - Provide data to evaluate compliance with interim and final nitrogen, phosphorus, chlorophyll *a*, and dissolved oxygen numeric targets.
- San Jacinto River watershed – Provide data to evaluate compliance with interim and/or final nitrogen and phosphorus TMDL WLAs and load allocations.

The original monitoring program included a multi-phase approach:

- *Phase 1 (Intensive Lake Elsinore and Canyon Lake Study)* - Phase 1 focused on collecting data to evaluate in-lake processes and develop a linkage analysis to relate external pollutant loading to the in-lake response, e.g., with regards to nutrient concentrations. Phase 1 was scheduled to occur over a two to three-year period.
- *Phase 2 (Intensive Watershed Study)* - Phase 2 is an intensive watershed study that provides data to support compliance analyses and provide data to understand external nutrient source contributions from the watershed.
- *Phase 3 (Compliance Monitoring)* – Upon completion of Phases 1 and 2, a compliance monitoring phase would begin. Phase 3 monitoring would consist of an agreed upon base level of in-lake and watershed compliance monitoring based on the findings from the previous phases.

Revision to Phase 1 Monitoring

In December 2010, the Task Force, in consultation with the Regional Board, revised the Phase 1 monitoring program for Lake Elsinore and Canyon Lake. The revised Phase 1 program decreases the number of sample locations in these waterbodies. The watershed monitoring program was not revised. Table 2-2 summarizes the currently approved Phase 1 monitoring program elements.

AgNMP Monitoring Program

Through fiscal year 2014-2015 the agricultural and dairy operators propose to continue the existing Phase I watershed monitoring program (see Table 2-2). The stakeholders also propose to eliminate existing in-lake monitoring programs through the same period to ensure that resources are dedicated to facilitating and constructing in-lake BMPs. The stakeholders will propose a revised comprehensive watershed and in-lake monitoring program by December 31, 2014 for implementation in fiscal year 2015-2016.

Table 2-2 Phase 1 Monitoring Summary

Monitoring Program	Sample Stations	Sampling Frequency	Field Parameters	Laboratory Parameters
Lake Elsinore	Station E2 (lake center)	16 events/year: Monthly (Oct to May); Bi-weekly (June to September)	Temperature, dissolved oxygen, conductivity, pH, turbidity, and redux potential	Chlorophyll *a*, hardness, total phosphorus, soluble reactive phosphorus, total organic phosphorus, nitrogen (total N, nitrite + nitrate, Ammonia N, total inorganic nitrogen, total organic nitrogen, iron, and total dissolved solids
Canyon Lake	Station C7 (deep lake)	16 events/year: Monthly (Oct to May); Bi-weekly (June to September)		
	Station C8 (mid-lake)			
	Station C10 (east bay)			
San Jacinto River Watershed	Site 3 - Salt Creek at Murrieta Rd	Three storm events per wet season	Temperature, turbidity, pH	Total organic nitrogen, nitrite nitrogen, nitrate N, ammonia, total phosphorus, soluble reactive phosphorus, total suspended solids, chemical oxygen demand, biological oxygen demand
	Site 4 –San Jacinto River at Goetz Road			
	Site 6 – San Jacinto River at Ramona Expressway			
	Site 30 – Canyon Lake Spillway			
	Site 1 – San Jacinto River, Cranston Guard Station			

2.2.6 Special Studies

As resources allow, the agricultural and dairy operators may implement a number of studies during AgNMP implementation to provide additional data to support TMDL implementation efforts. These studies are optional; Ag and dairy operators implementation of or participation in these studies (if initiated by other TMDL stakeholders) is solely at their discretion. Where implemented, the outcome from various analyses or studies would be used to support the adaptive implementation process (see Section 2.3). The purpose of such studies is to provide data to refine TMDL parameters, e.g., development of more accurate land use data, revisions to the TMDL watershed and lake models based on updated water quality and land use data, and technical data to support use of supplemental BMPs should the effectiveness of planned in-lake remediation strategies be lower than anticipated. The implementation and timing of such studies is solely at the discretion of the agricultural and dairy stakeholders; however, implementation would consider regular triennial reviews of the TMDL and TMDL compliance milestones.

2.3 Adaptive Implementation

The AgNMP may be updated as needed based on BMP effectiveness analyses completed as part of annual reporting activities. In addition the AgNMP will provide descriptions of any additional BMPs planned, and the time required to implement those BMPs, in the event that monitoring data indicate that water quality objectives for nutrient are still being exceeded after the AgNMP is fully implemented This AgNMP establishes a program to reduce agricultural sources of nutrients through the implementation of watershed-based BMPs and to reduce nutrients already entrained in Canyon Lake and Lake Elsinore through the application of in-lake remediation strategies for Canyon Lake. With regards to the in-lake remediation projects, the following has been stated previously:

> "It is unlikely that the stakeholders will implement the perfect solution on the first try. Rather, success will depend on an iterative process of developing mitigation projects,

> measuring results, updating the predictive models and refine the follow-on strategy. This process of "adaptive implementation" makes best use of scarce public resources and reduces the risk of unforeseen consequences by emphasizing incremental changes. Using the lake as a laboratory, successful projects can be repeated or expanded. Unsuccessful projects can be terminated and resources shifted to alternative approaches. Moreover, as additional data becomes available, the ability to accurately assess the lake's true potential, and the steps necessary to achieve that potential, will also improve." (*In-Lake Sediment Nutrient Reduction Plan for Lake Elsinore*, October 22, 2007, page 28).

This statement applies to any of the proposed watershed-based BMPs and in-lake remediation projects in either Canyon Lake or Lake Elsinore. For example, the Ag operators may determine prior to 2014 that Zeolite or other remediation tools will provide a more cost effective method to address agricultural nutrient loads and and/or attain in-lake response targets. A revision to the AgNMP may be suggested based on new information as it develops.

The compliance analysis (Section 3) quantifies the expected water quality benefits from implementation of this comprehensive nutrient management program. Based on this analysis, the AgNMP, when fully implemented, is expected to result in compliance with the TMDL WLAs applicable to the WRCAC member agricultural and dairy operators. This finding is based on the quantified compliance analysis results coupled with the margin of safety associated with the implementation of watershed-based BMPs that could not be quantified. All analyses are based on currently available data, including what is known regarding the effectiveness of the various BMPs included in the AgNMP.

Over time, through the monitoring program and information collected through the CWAD monitoring, additional data will be developed to evaluate the effectiveness of various AgNMP elements. These data may be supplemented by additional information developed through the optional special studies described above. WRCAC will prepare a trend analysis for the response targets and nutrient levels in Lake Elsinore and Canyon Lake by December 31, 2018. Based on the outcome of this analysis, the operators will make recommendations for additional BMPs and a schedule for deployment of those BMPs for incorporation into a revised AgNMP by September 30, 2019. Upon Regional Board approval, the agricultural and dairy operators will implement the revised AgNMP.

2.4 Implementation Schedule

The agricultural and dairy operators have provided a detailed schedule in the AgNMP that provides the following information:

- Identifies the discrete milestones, decision points and alternative analyses necessary to assess satisfactory progress toward complying with requirements for the CL/LE Nutrient TMDL by December 31, 2020.
- Indicates which agency or agencies are responsible for meeting each milestone.

- Establishes the specific metric(s) that demonstrate the effectiveness of the AgNMP and acceptable progress toward complying with requirements for the CL/LE Nutrient TMDL by December 31, 2020.

Table 2-3 shows the overall tasks and schedule for AgNMP implementation. Attachment E provides the detailed information required above for each AgNMP task.

Table 2-3 AgNMP Implementation Plan

AgNMP Activity	AgNMP Element	Milestones	Metrics	Lead	Complete by	Status
Watershed-based BMPs	AgNMP Implementation		Complete and submit AgNMP. Obtain approval by RWQCB and implement	WRCAC, ag stakeholders	Begin implementation within 6 months of Regional Board approval of AgNMP	
	Public Education & Outreach	Develop tiered BMP approach for agricultural operators	Develop tiered program for BMPs	WRCAC	31-Dec-14	
		Implement web based weBMP tool	Incorporate tiered program into weBMP	WRCAC	1-Jul-15	
		Develop load reduction rates for BMPs in webNMP(above)	Based upon reported BMPs in the SJ watershed ,develop rates for load reduction	WRCAC	30-Nov-15	
		Participation in CWAD development	Assist RWQCB in development of CWAD Program	WRCAC	ongoing	
		Develop and implement outreach program/began with 319 grant	319 grant development of outreach	WRCAC	31-Oct-143	
			Continued public outreach as needed(WRCAC newsletters, meetings, workshops)	WRCAC	ongoing	

Table 2-3 AgNMP Implementation Plan

AgNMP Activity	AgNMP Element	Milestones	Metrics	Lead	Complete by	Status
In-Lake Remediation Projects	Lake Elsinore	Support implementation of existing lake aeration system	Establish necessary agreements among aeration system participants	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-12	
	Canyon Lake	Conduct tests to evaluate potential for chronic aluminum toxicity with planned doses of alum	Toxicity test results to support CEQA initial study	Agricultural and dairy operators in collaboration with stakeholders	March 15, 2013	
		Complete CEQA process	CEQA initial study and approval of alum addition plan	Agricultural and dairy operators in collaboration with stakeholders	July 31, 2013	
		Implement process to obtain all permits and approvals	Secure permits and approvals to add alum from barge at surface	Agricultural and dairy operators in collaboration with stakeholders	September 30, 2013	
		Implement planned alum additions	Completion of planned alum additions to surface of Main Body and East Bay using barge	Agricultural and dairy operators in collaboration with stakeholders	September, 2013, February, 2014, September 2014, February, 2015, September, 2015	
		TMDL reopener for DO response target	Revision of response target that takes into account controllability considerations	Agricultural and dairy operators in collaboration with stakeholders	June 30, 2016	
		Support implementation of long-term in-lake nutrient management BMPs	If needed, establish additional watershed or in-lake BMPs to meet final response targets (e.g. regular alum additions, aeration, HOS, etc.)	Agricultural and dairy operators in collaboration with stakeholders	December 31, 2020	
Monitoring Program	In-Lake Monitoring	Implement reduced monitoring program	Completion of annual monitoring as required by current approved monitoring program	Agricultural and dairy operators in collaboration with stakeholders	30-Jun-15	

Table 2-3 AgNMP Implementation Plan

AgNMP Activity	AgNMP Element	Milestones	Metrics	Lead	Complete by	Status
		Prepare revised comprehensive monitoring program	Submit revised comprehensive monitoring program to the Regional Board for approval	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-14	
		Implement Regional Board-approved revised comprehensive monitoring program	Completion of annual monitoring as required by revised program	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-20	
	Watershed-based Monitoring	Continue implementation of Phase I watershed monitoring program	Completion of annual monitoring as required by current approved monitoring program	Agricultural and dairy operators in collaboration with stakeholders	30-Jun-15	
		Prepare revised comprehensive monitoring program	Submit revised comprehensive monitoring program to the Regional Board for approval	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-14	
		Implement Regional Board-approved revised comprehensive monitoring program	Completion of annual monitoring as required by revised program	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-20	
	Annual Reports	Complete annual reports to assess effectiveness of AgNMP	Submittal of annual reports to Regional Board by August 15	Agricultural and dairy operators in collaboration with stakeholders	November 30, annually	
	Interim Compliance Assessment	Demonstrate compliance with interim TMDL requirements	Submittal of assessment of compliance with interim TMDL requirements	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-15	
	Final Compliance Assessment	Demonstrate compliance with WLAs	Submittal of assessment of expected compliance with final TMDL requirements including any recommended supplemental actions.	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-19	

CDM Smith

Table 2-3 AgNMP Implementation Plan

AgNMP Activity	AgNMP Element	Milestones	Metrics	Lead	Complete by	Status
Special Studies (Optional)	Use of Chemical Additives	Evaluate potential to use chemical additives, e.g., alum, Zeolite or Phoslock, as an in-lake remediation strategy alternative	Complete studies, as appropriate, to evaluate potential for use of chemical additives	Agricultural and dairy operators in collaboration with stakeholders	30-Jun-13	
	Land Use Updates	Update watershed agricultural land use based on 2010 data; WRCAC estimates updates every 3 years	Submit land use revision to the Regional Board	Agricultural & dairy operators	31-Dec-20	WRCAC has completed 2007, 2010 and plans on updates using 2013, 2016 and 2019 data
Adaptive Implementation	TMDL Model Update	Revise/update TMDL models for Canyon Lake/ Lake Elsinore based on new data (e.g., land use, water quality)	Submit TMDL models to the Regional Board	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-18	
	Task Force	Participate in Task Force process	Regular attendance at Task Force & Technical Advisory meetings	Agricultural and dairy operators in collaboration with stakeholders	Ongoing	
	AgNMP Revisions	Review progress towards achieving TMDL requirements based on compliance assessments; modify AgNMP as needed	Prepare compliance assessment; if needed, submit revised AgNMP to the Regional Board	Agricultural and dairy operators in collaboration with stakeholders	30-Nov-15	

Table 2-3 AgNMP Implementation Plan

AgNMP Activity	AgNMP Element	Milestones	Metrics	Lead	Complete by	Status
		Review progress towards achieving final TMDL requirements based on compliance assessments; modify AgNMP as needed	Prepare compliance assessment; if needed, submit revised AgNMP to the Regional Board	Agricultural and dairy operators in collaboration with stakeholders	30-Nov-19	
	TMDL Revision	Based on degree of Regional Board support, prepare materials to support revision to the TMDL as part of the Triennial Review process, if revision is appropriate	Submit recommendations and supporting material for revisions to the TMDL to the Regional Board	Agricultural and dairy operators in collaboration with stakeholders	Prior to potential triennial review dates in 2015 and 2019	

Section 3
Compliance Analysis

3.1 Introduction

The TMDL sets LAs for agricultural and WLAs for CAFO sources of nutrients that will result in reductions needed to achieve numeric targets for response variables in Lake Elsinore and Canyon Lake. In the nutrient TMDL, sources with LAs and WLAs include urban, septic, reclaimed water, agriculture, and CAFO sources. This compliance analysis only addresses agricultural LAs and CAFO WLAs for WRCAC compliant properties, and presumes other TMDL Stakeholders (including non-compliant or exempt agricultural / CAFO sources) reduce loads as required to achieve numeric targets in the lakes.

In the Canyon Lake watershed, there are both WRCAC and other agricultural / CAFO properties that have a collective responsibility to reduce loads to the LAs and WLAs for TP and TN. The allocations, converted to a unit based loading rate in Table 3-1, are used to evaluate compliance with the Canyon Lake TMDL for WRCAC sources. Compliance analysis using unit based loading rates (per acre for agriculture and per cow for CAFO) allows for the evaluation of compliance in future years, when significant changes to the land use within the San Jacinto River watershed are expected. General plans for the watershed cities and the County of Riverside show diminishing agriculture and CAFO land uses to allow for urban growth.

Table 3-1 Load and Wasteload Allocations for Agriculture and CAFO Nutrient Sources in Canyon Lake Watershed

Nutrient	Nutrient	Allocation (kg/yr)	Unit	Allocation (kg/ac/yr)
Agriculture	TP	1,183	per acre[1]	0.021
	TN	7,583	per acre[1]	0.136
CAFO	TP	132	per cow[2]	0.002
	TN	1,908	per cow[2]	0.026

1) *TMDL developed based on land use estimate of ~56,000 acres of agricultural land in Canyon Lake watershed*
2) *TMDL developed when cow population in the Canyon Lake watershed was ~72,000*
Note: Lake Elsinore nutrient TMDL includes a load allocation for overflows from Canyon Lake to Lake Elsinore, which is partially from agriculture and CAFO sources within the Canyon Lake watershed.

Since there are no WRCAC properties within the local Lake Elsinore watershed, the only required reductions associated with the Lake Elsinore nutrient TMDL is from the pass through load from Canyon Lake to Lake Elsinore. The Lake Elsinore nutrient TMDL includes a LA of 2,770 kg TP and 20,774 kg TN for load coming from Canyon Lake. The portion of this LA that comes from WRCAC agriculture and CAFO sources provides the basis for determining load reduction requirements for Lake Elsinore.

3.1.1 Compliance Analysis Approach

The following sections provide detailed description of the methodology employed to demonstrate compliance with the LAs and WLAs for agriculture and CAFO sources. The analysis involved several key questions, including:

- What is the average load of nutrients from agriculture and CAFO sources in the Canyon Lake watershed?

  Development of the TMDL involved application of lake and watershed models to characterize nutrient sources for setting LAs and WLAs. In addition, the TMDL watershed model was updated in 2010 to incorporate a more recent land use distribution. Projected attrition of agriculture and CAFO land use in the Canyon Lake watershed will continue to reduce the load from these sources.

  Section 3.2.1 describes the results from these models and projected attrition of agriculture and CAFO land uses.

- To what extent do reductions in watershed loads (referred to as "washoff") translate to reductions in loads delivered to Canyon Lake?

  Section 3.3.2 describes the estimation of loading factors to account for loss of nutrients between washoff areas and inputs to Canyon Lake.

- What is the nutrient load reduction necessary to reduce estimates of existing and projected loads to the LA and WLA for agriculture and CAFO sources for WRCAC members?

  See Section 3.2.2.

- How much nutrient load reduction has occurred or is expected to occur from watershed BMPs implemented by WRCAC agriculture and CAFO properties in the watershed?

  See Section 3.3.1.

- For Lake Elsinore, what in-lake nutrient control strategy is recommended to address remaining load reduction requirements after accounting for watershed load reduction?

  Section 3.4.1 summarizes in-lake nutrient control recommendations and demonstrates how the selected strategy will provide the necessary load reduction to achieve compliance with the Lake Elsinore WLAs and LAs.

- For Canyon Lake, what in-lake management action(s) is recommended to manage lake water quality so that numeric targets for response variables chlorophyll-a and DO can be achieved?

  Section 3.4.2 summarizes proposed in-lake management actions. Modeling results demonstrate that the selected strategy will provide the necessary reductions in annual average chlorophyll-a, and increase in daily average DO to achieve the TMDL numeric targets.

- What is the certainty that the AgNMP, once implemented, will result in compliance with TMDLs for Lake Elsinore and Canyon Lake?

  Section 3.5 characterizes several important sources of uncertainty, including the role of spatial and temporal variability in nutrient loading as a result of hydrology and modeling assumptions for land use change, watershed and lake BMP effectiveness, and lake water quality response to both reduced watershed loads and in lake management actions.

The analysis contained herein is based on the TMDL staff report, 2003 TMDL watershed model, 2010 watershed model and other studies and analyses conducted by various individuals, task forces and agencies. These documents and studies represent the best available data regarding the lakes, their impairments, and potential remediation strategies. However, they are limited by the quality and amount of data that was available at the time of publication. This compliance analysis relies on this older information but also incorporates new data where available. However, this analysis is still an approximation based on best available data.

3.2 Watershed Load Assessment

3.2.1 Nutrient Loads from WRCAC Agriculture and CAFO Sources

The linkage analysis used to develop the Nutrient TMDLs and the subsequent 2010 watershed model update evaluated the role of land cover in the contribution of washed-off nutrients to receiving waterbodies, such as Salt Creek, San Jacinto River, Perris Valley Channel, and other major tributaries to the lakes. The method used to simulate loads from the watershed involved a continuous simulation of pollutant buildup during dry periods and pollutant washoff as a function of hydrologic response to historical (1990-2009) rainfall records. The Loading Simulation Program C++ (LSPC) tool was used to simulate hydrology and pollutant buildup and washoff using exponential functions. Variables used to simulate hydrology and pollutant buildup and washoff for different land cover types were adjusted within expected ranges to generate results that approximate observed data at six U.S. Geological Survey streamflow gauges and six water quality monitoring sites (Tetra Tech, 2010). The TMDL was developed based on a frequency-weighted average loading simulated from three hydrologic year types; Wet at 16 percent weight (Water Year [WY] 1997-1998); Dry at 43 percent weight (WY 1999-2000), and Moderate at 41 percent weight (WY 1993-1994).

Nutrients washed off from source areas are transported to Canyon Lake by a variety of drainage courses. Reduction of nutrient loads within conveyance systems, referred to as natural decay, is generally the result of settling of suspended solids and runoff infiltration within channels and upstream lakes, most notably Mystic Lake. The LSPC model accounted for this decay in the runoff routing simulation. Based on these results decay factors (ratios of lake loading to watershed washoff) were computed for the Canyon Lake watershed, downstream (Figure 3-1, Zones 2-6) and upstream of Mystic Lake (Figure 3-1, Zones 7-9) (Table 3-2).

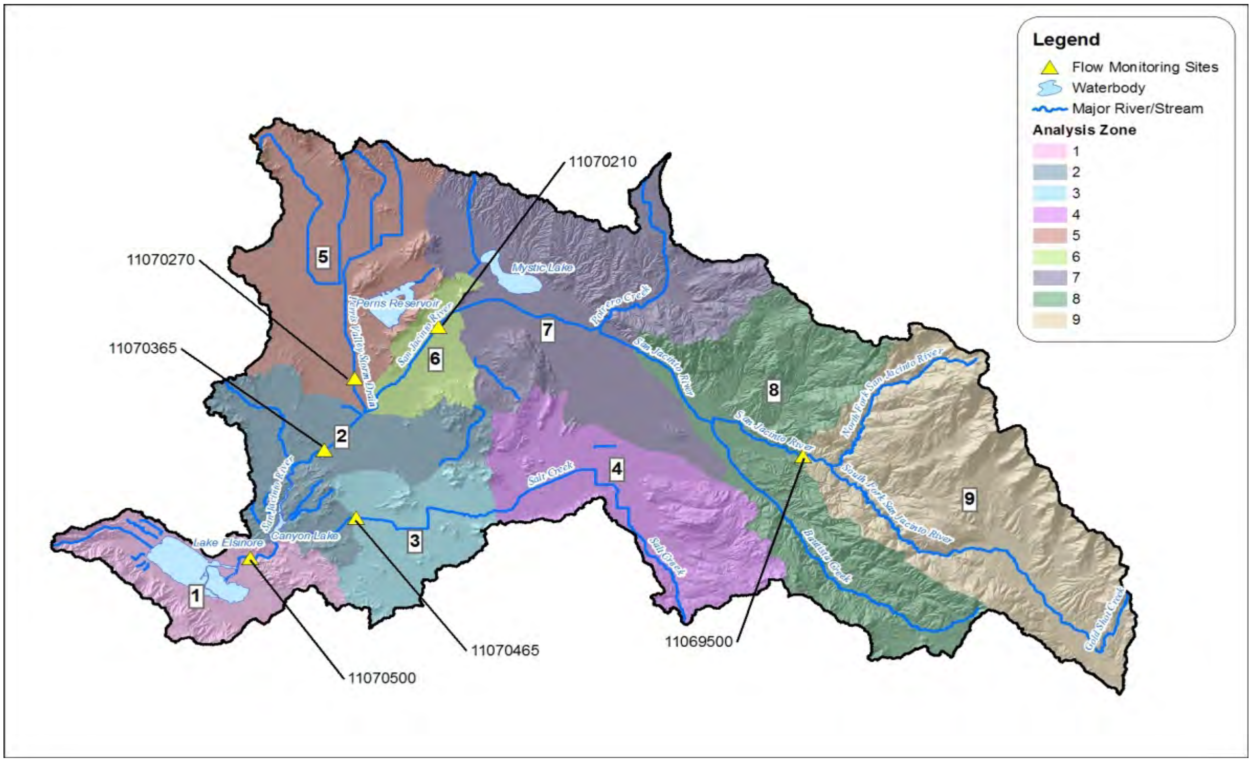

Figure 3-1
San Jacinto River Watershed Analysis

Table 3-2 Estimation of Decay Factors for Agriculture Land Uses for Portion of Watershed Nutrient Washoff that is Expected to Reach Canyon Lake

Watershed Analysis Zone	Watershed Washoff		Loads to Lake (kg/yr)		Loading Factor	
	TP (kg/yr)	TN (kg/yr)	TP (kg/yr)	TN (kg/yr)	TP	TN
Canyon Lake below Mystic Lake (Zones 2-6)	3,122	5,040	1,956	3,289	63%	65%
Above Mystic Lake (Zones 7-9)	2,356	3,552	<1	<1	< 0.01%	< 0.01%

The computed loading factors show that roughly two thirds of nutrient washoff reaches Canyon Lake from the portion of the drainage area that is downstream of Mystic Lake, while any loading to Canyon Lake from upstream of Mystic Lake is extremely rare, as has been shown with flow gauge data and simulation models. The loading factors must be included in any estimate of reduced loading to Canyon Lake as a result of watershed BMPs, thus washoff reduction in the watershed does not achieve an equivalent benefit in load reduction to the lakes. For example, watershed BMPs in drainages above Mystic Lake would have to reduce washoff by 10,000 kg to achieve a 1 kg reduction in loads to Canyon Lake. Therefore, this compliance analysis does not evaluate washoff reduction from agriculture and CAFO sources above Mystic Lake.

The 2010 watershed model update estimated watershed washoff from all agriculture and CAFO sources in the Canyon Lake below Mystic Lake watershed. The proportion of washoff from WRCAC member drainage areas to the total washoff from agriculture and CAFO land uses was used to approximate the portion of the simulated load into Canyon Lake that could be attributable to WRCAC members (Table 3-3). Table 3-3 shows WRCAC agricultural members comprise approximately 30 percent of the simulated nutrient washoff from the Canyon Lake watershed below Mystic Lake (i.e. watershed zones 2-6). For CAFO sources, WRCAC members represent approximately 5 percent of simulated washoff. These very different ratios for WRCAC members between agriculture and CAFO sources is the reason for developing separate compliance estimates for each, as documented in the following sections.

Table 3-3 LSPC Simulated Nutrient Washoff from WRCAC Compliant and Other Agriculture and CAFO Sources in the Canyon Lake Watershed below Mystic Lake

Land Use	TP Washoff (kg/yr)	TN Washoff (kg/yr)
WRCAC Ag Members	889	1,572
Other Agriculture	2,233	3,468
WRCAC Washoff (% of total)	28%	31%
WRCAC Dairy Members	70	183
Other Dairy / Livestock	1,618	3,452
WRCAC Washoff (% of total)	4%	5%

3.2.2 Gap Analysis for WRCAC CAFO Sources

For CAFOs in Zones 2-6, there are only three existing WRCAC member CAFO operators, all of which have implemented an Engineered Waste Management Plan (EWMP) to comply with the CAFO Permit. The Permit requires retention of the 25-year storm event on-site and therefore no loading of nutrients from these areas will occur, except during extreme storm events, when loads are likely to pass through both Canyon Lake and Lake Elsinore. The CAFO Permit includes ongoing inspection of these properties to ensure compliance with the Permit and hence the TMDL. Thus, there is no additional watershed load reduction required from CAFO sources in the Canyon Lake watershed.

3.2.3 Gap Analysis for WRCAC Agriculture Sources

The load reduction to Canyon Lake, necessary to demonstrate compliance with the LAs for agriculture sources, is equal to the difference between existing loads and the allowable load. For the AgNMP, allowable load is expressed as a per acre loading rate based on land use acreage at the time of TMDL development. Allowable loads in subsequent years are determined as the product of the allocated load per acre, and the number of acres of agriculture land use.

Applying the ratios of WRCAC to total washoff (from Table 3-3) to watershed loads into Canyon Lake from all agriculture sources, provides an estimate of existing loads from

WRCAC members, and the focus of the targeted load for TMDL compliance in this AgNMP (Table 3-4). Table 3-4 also shows the total load from agriculture sources, prior to formation of WRCAC (see column for 2003 conditions), based on original modeling to develop the TMDL, and future projections of load, which are proportional to diminishing land use acreage. Projections of the rate of decline of agriculture for WRCAC and non-WRCAC members is only an approximation, and should be continually re-evaluated through land use map and watershed model updates.

Table 3-4 Estimation of load reduction requirements for WRCAC member agriculture sources in the Canyon Lake Watershed below Mystic Lake

Land Use	Nutrient	Loading (kg/yr)	2003[1]	2007[2]	2015[2]	2020[2]
Agriculture	TP	Existing / Estimated Load	4,413	578	484	383
		Allowable Load [3]	1,183	229	192	152
		Required Reduction / (Credit)	3,230	348	292	231
	TN	Existing / Estimated Load	11,057	971	241	47
		Allowable Load [3]	7,583	1,471	1,233	974
		Required Reduction / (Credit)	3,474	(499)	(993)	(927)

1) *Based on TMDL LA for all agriculture sources*
2) *Loads shown represent WRCAC members only*
3) *Allowable load is equal to the TMDL unit based LAs and WLAs and current and projected WRCAC member agriculture acres and cow population for CAFOs*

For the AgNMP, the rate of attrition for agriculture land uses was developed to match projected land use change included in the urban Comprehensive Nutrient Reduction Plan (CNRP). The CNRP used buildout general plan land use projections for each watershed city and the County of Riverside and a Caltrans growth rate forecast3 to develop the land use projections for years between 2010 and buildout, assumed to occur in 2035 (Figure 3-2). For this analysis, the rate of urban development in Riverside County was assumed to be comparable to the rate of agriculture land use attrition in the San Jacinto River watershed.

Figure 3-2 shows the projected rate of growth over time from 2010 until the projected buildout date of 2035. This growth rate was used to compute dynamic land use based loading between 2010 and 2020 for TP and TN in Canyon Lake below Mystic Lake (Figures 3-3 and 3-4).

[3] http://www.dot.ca.gov/hq/tpp/offices/eab/socio_economic_files/2011/Riverside.pdf

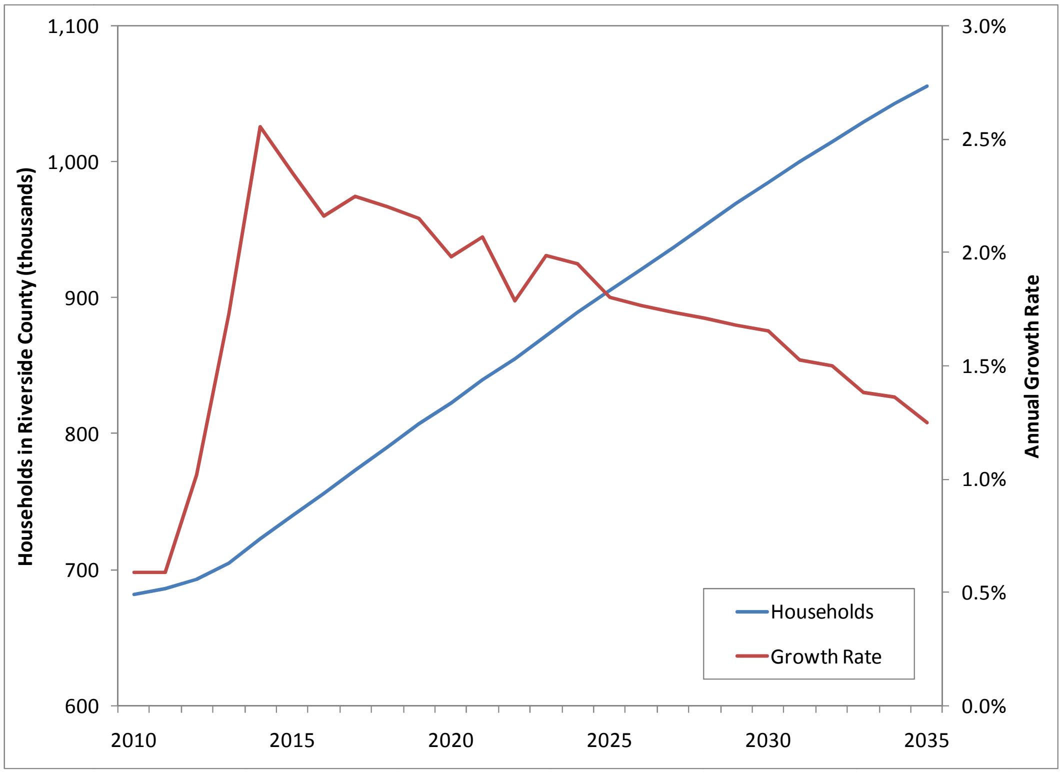

Figure 3-2
Projected Growth Rate for Urban Development in Riverside County (from Caltrans, 2011)

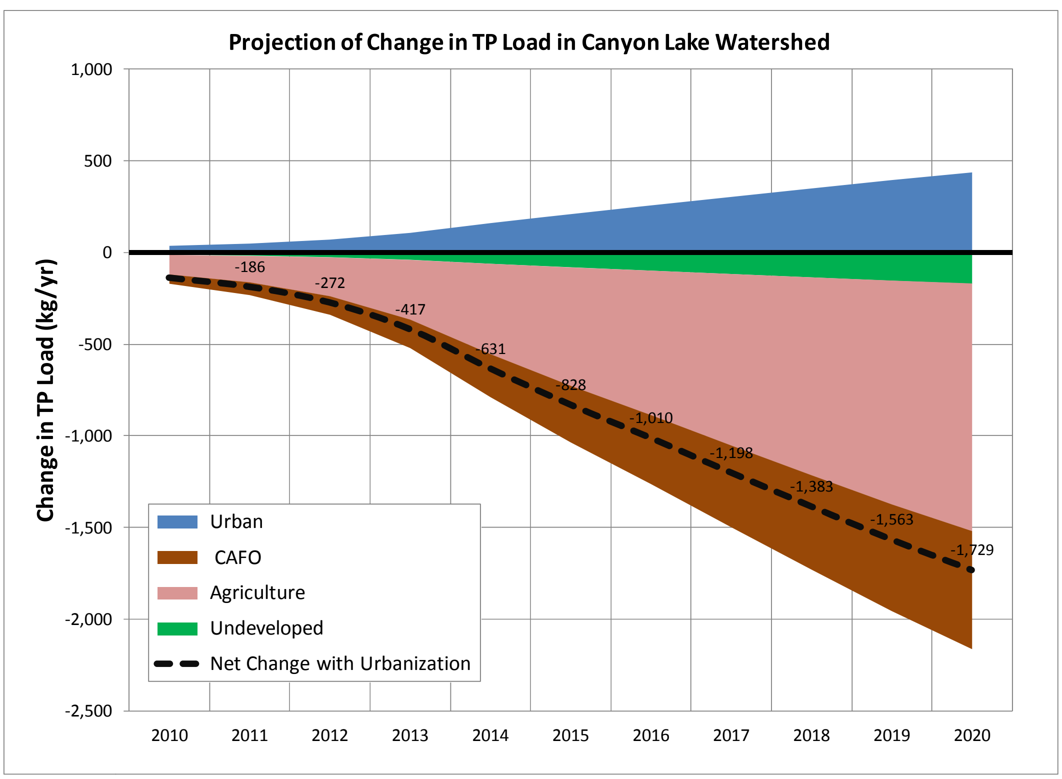

Figure 3-3
Projected TP Load from Urban, Agriculture, CAFO, and Undeveloped Lands in Canyon Lake Watershed

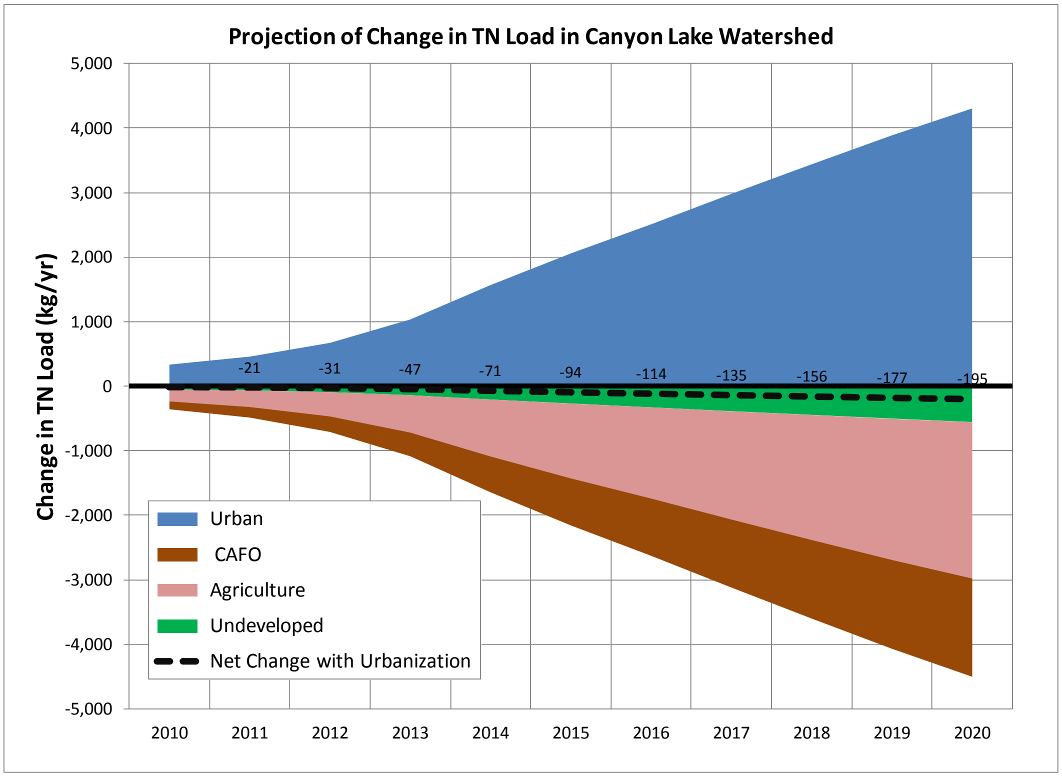

Figure 3-4
Projected TN Load from Urban, Agriculture, CAFO, and Undeveloped Lands in Canyon Lake Watershed

The total agriculture TN loading rate in kg/acre, as estimated in the 2010 watershed model, is less than the agricultural per acre LA, thus there is a nitrogen credit. This credit could be used to offset required reductions from other sources though pollutant trading. Conversely, agriculture sources do show a required reduction in TP loads to achieve compliance with the TMDL; however, load reduction requirements are reduced over time as attrition of lands occurs with urban growth (Figure 3-5).

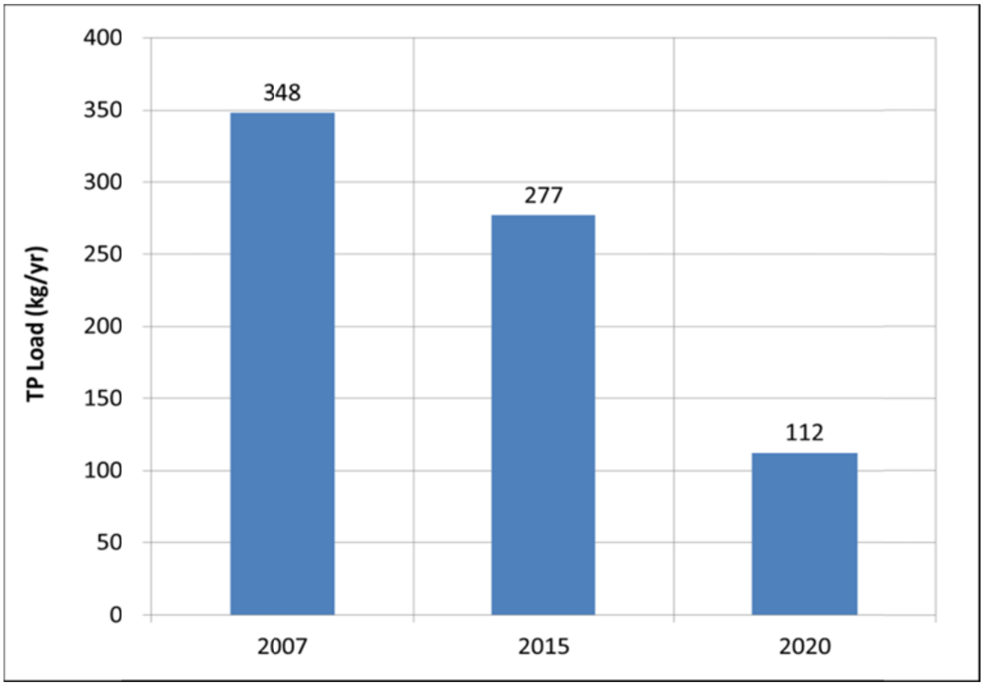

Figure 3-5
TP Load Reduction Needed from WRCAC Members in the Canyon Lake below Mystic Lake Watershed (no TN reduction is required)

3.3 Load Reduction from Watershed BMPs

Since its formation in 2004, WRCAC has worked to conduct studies, educate farmers on watershed issues, and develop BMP implementation strategies for controlling runoff from agriculture properties. For many of WRCAC's past efforts, the nutrient washoff reduction benefit cannot be quantified due to uncertainty in effectiveness (see Section 2.2.1). Watershed BMPs planned for implementation in the San Jacinto River watershed that provide a quantifiable reduction of nutrient washoff include:

- Conditional Waiver for Agricultural Discharges (CWAD)
- Individual agricultural operator BMPs
- Manure management practices

3.3.1 Conditional Waiver for Agricultural Discharges (CWAD)

The CWAD Program will require the implementation of structural and non-structural BMPs. To determine the most effective BMP options available to different types of agricultural lands, UCR received a 319 Grant to identify BMPs in the San Jacinto Watershed. A field study with samples collected downstream of experiment plots, with varying BMP applications for several storm events in the 2007-08 and 2008-09 wet seasons, was completed. Results of the study showed that BMP effectiveness is dependent upon the type of agricultural land use, and that BMPs used to stabilize soils within agricultural fields are most effective at reducing nutrient washoff. Reductions as a percent of control plots are presented in Figure 3-6. While it is not yet known which BMPs an individual WRCAC member will choose for complying with the CWAD, these results can be used to approximate the percent reduction in nutrients that will be achieved assuming average reductions of effective (found to reduce loading relative to control) treatments, as shown in Table 3-5. WRCAC will develop a tiered system for BMP deployment for agricultural operators that should be available by late 2015. This will also include a database tool for inputting BMPs and better understanding load reductions achieved by each agricultural operator.

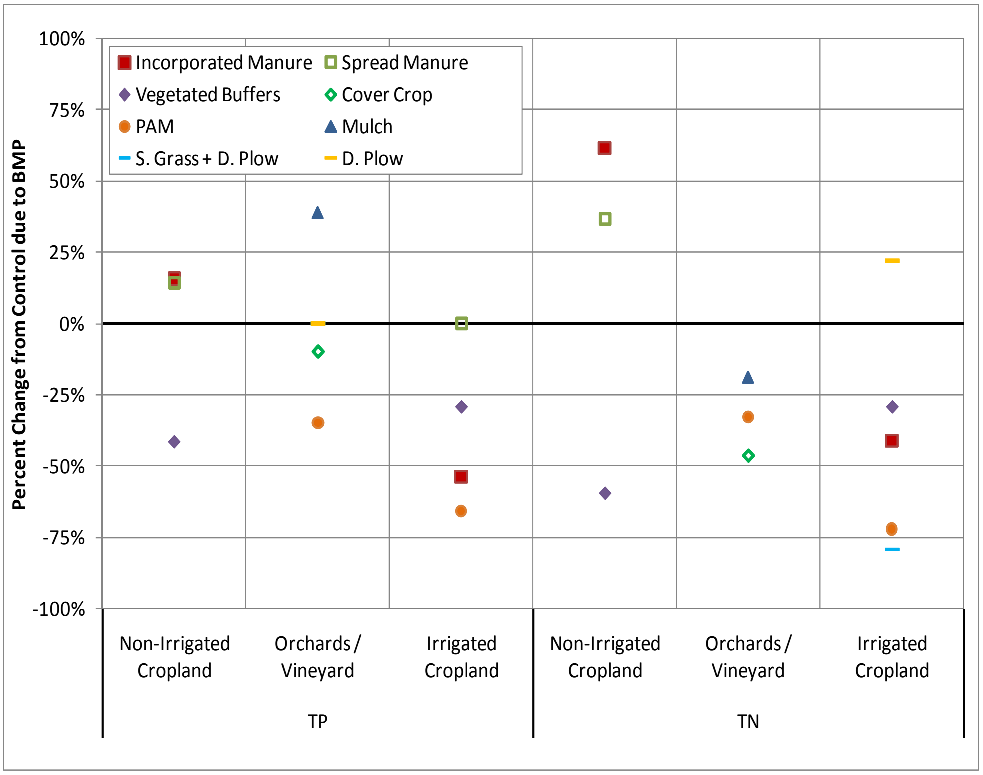

Figure 3-6
Effectiveness of Agricultural BMPs for TP and TN Loading Rate Reduction (data from UCR, 2011)

Table 3-5 TP and TN Washoff Reduction from Existing BMPs and Projected Implementation of BMPs

Land Use	2010 Model TP Washoff (kg/yr)	2010 Model TN Washoff (kg/yr)	TP Washoff Reduction (kg/yr)			TN Washoff Reduction (kg/yr)		
			2010[1]	2015[2]	2020[3]	2010[1]	2015[2]	2020[3]
Irrigated Cropland [4]	594		-70	-113	-125	-92	-148	-164
Non-irrigated Cropland [5]	280	932	-29	-52	-67	-65	-116	-151
Orchards / Vineyards [6]	7	440	-1	-1	-2	-1	-2	-2
On-site retention (various agricultural types)	889	1,572	-36	-45	-47	-63	-79	-83
Total Washoff Reduction (kg/yr)			-135	-211	-241	-221	-346	-401

1) Based on estimate of existing BMP implementation downstream of 25 percent of WRCAC agriculture area. The 2010 watershed model update did not account for BMPs implemented by agricultural operators

2) Based on an assumption that 50 percent of WRCAC agriculture area could comply with the CWAD requirements by 2015 (including currently compliant lands)

3) Based on an assumption that 75 percent of WRCAC agriculture area could comply with the CWAD requirements by 2020 (including currently compliant lands)

4) Effective BMPs include vegetated buffers and PAM application. For treated areas, AgNMP assumes 47 percent TP and 40 percent TN removal efficiency

5) Effective BMPs include vegetated buffers. For treated areas, AgNMP assumes 41 percent TP and 59 percent TN removal efficiency. Reduction is function of reduced washoff in future as a result of attrition

6) Effective BMPs include cover crop and PAM application. For treated areas, AgNMP assumes 37 percent TP and 33 percent TN removal efficiency. Reduction is function of reduced washoff in future as a result of attrition

Many farms are already implementing stormwater runoff controls, based on results of the WRCAC Agricultural Operator Survey (see Attachment D). This survey shows that roughly 25 percent of WRCAC agriculture acreage is currently implementing one or more runoff controls that would meet the criteria under consideration for inclusion in the CWAD Program. Washoff reduction benefits from new BMPs constructed to comply with the CWAD will take some time to be realized; therefore a conservative implementation achievement factor of 50 percent is assumed for BMPs implemented prior to 2015; and 75 percent prior to 2020.

Use of berms and levees to retain runoff on-site is another approach that some farms have used to address stormwater management (agricultural operator survey shows roughly 5 percent of the WRCAC member drainage acreage). In the future, it is anticipated that a total 10 percent of WRCAC drainage areas may be retained on-site by these types of BMPs to comply with CWAD requirements, thus washoff reductions for retention BMPs are also included in the AgNMP compliance analysis (Table 3-5). Agricultural operators are currently not under any permit requirements.

3.3.2 Manure Management

For dairy operators, the use of manure as a fertilizer will be diminished significantly in the future years. The Santa Ana Regional Water Quality Control Board (RWQCB) issued order number R-8-2007-0001 which will prohibit the disposal of manure to land on those ground water management zones lacking assimilative capacity for TDS and or nitrate-nitrogen unless a salt offset program is in place that is acceptable to the Executive Officer of the RWQCB, Santa Ana Region. Reduction in the use of manure by is expected as a result of the following planned BMPs:

- Hauling of manure out of the San Jacinto watershed and implementation of a ban to prevent importation of manure.
- Pilot study for converting manure through gasification into biodiesel fuel. If successful, the pilot project may be expanded to a regional facility.
- Improved manure tracking through a manure manifest tracking system is recommended and additional special studies.

Accordingly, the AgNMP compliance analysis computes a reduction in washoff that is expected from elimination of most manure spreading activities in the watershed. The agriculture operator survey found that about 10 percent of respondents currently utilize manure to fertilize fields, which equates to approximately 600 acres of agricultural land in the Canyon Lake watershed below Mystic Lake.

The San Jacinto Integrated Dairy Management Plan included manure application rates of 7.7 tons/acre and 33.3 tons/acre. Other studies have estimated manure application rates for fields in various geographies ranging from of 20 to 45 tons/acre (Gilley and Risse, 2000). Taking an average manure application rate of 20 tons per acre, and nutrient concentrations in wet manure of 1,000 mg TP/kg and 6,000 mg TN/kg, provides an estimate of the loading of nutrients to the watershed by spreading of manure. Farmers use spreading practices to attempt to retain manure and beneficial nutrients within agricultural fields; however some manure is lost in surface runoff. Choi (2006) estimated that 3 percent of nutrients in spread manure were lost in surface runoff. Applying this factor to the estimate of applied manure by WRCAC member agricultural operators in the Canyon Lake watershed below Mystic Lake, equates to a washoff rate of 0.5 kg TP per acre and 3.3 kg TN per acre. This washoff rate is used to approximate the reduction in nutrient washoff that may be achieved by reducing the acreage of agricultural land with manure spreading (Table 3-6).

Table 3-6 TP and TN Washoff Reduction from Projected Elimination of Manure Spreading in the Canyon Lake below Mystic Lake Watershed

Year	TP in Spread Manure (kg/yr)[1]	TN in Spread Manure (kg/yr)[1]	TP Washoff Reduction (kg/yr)[2]	TN Washoff Reduction (kg/yr)[2]
2010	10,884	65,304	0	0
2015	5,442	32,652	-163	-980
2020	2,721	16,326	-245	-1,469

1) Nutrients in spread manure are estimated as a function of manure application rate of 20 tons/acre, wet concentrations of TP and TN in manure of 1,000 mg/kg and 6,000 mg/kg, respectively. Assumed ~10 percent of irrigated agriculture land in 2010 still uses manure spreading (~600 acres) per survey responses

2) Washoff reduction based on estimate of 3 percent of spread manure lost to surface runoff and assumed reduction of current levels of manure spreading of 50 percent by 2015 and 75 percent by 2020.

3.3.3 Watershed BMP Summary

Table 3-7 provides a summary of the estimated reduction of TP and TN washoff from agriculture drainage areas in the Canyon Lake below Mystic Lake watershed. Washoff reductions include accrued benefits from existing BMPs implemented since the adoption of the TMDL as well as projections of future manure management and structural BMPs implemented to comply with the CWAD. It should be noted that there is currently no system to track implementation of BMPs by WRCAC individual member agricultural properties at the present time. WRCAC members have been implementing BMPs on agricultural lands for many years; therefore, it is likely that the actual watershed load reductions are significantly higher than shown in Table 3-7. WRCAC is developing a process for documenting and acknowledging BMP implementation by individual properties, which will be complete and available by 2020.

Table 3-7 Summary of Expected Watershed Nutrient Washoff Reduction from Implementation of BMPs in the Canyon Lake below Mystic Lake Watershed

Year	Agriculture BMPs for CWAD (kg/yr)		Reduction of Manure Spreading (kg/yr)		Total Watershed Washoff Reduction (kg/yr)	
	TP	TN	TP	TN	TP	TN
2010	-135	-221	0	0	-135	-221
2015	-211	-346	-163	-980	-374	-1,326
2020	-241	-401	-245	-1,469	-486	-1,870

Reductions of watershed nutrient washoff (using the appropriate loading factors in Table 3-3) translate to reductions in nutrient load to Canyon Lake and Lake Elsinore. Table 3-8 shows the remaining load reduction requirement after accounting for watershed washoff reductions. The WRCAC member agriculture operators will meet these load reductions through implementation of in-lake remediation projects.

Table 3-8 Calculation of Load Reduction Requirements to be Achieved with In-Lake Remediation Projects by WRCAC Member Agriculture Operators

Year	Total Load Reduction Requirement (kg/yr) [1]		Watershed Load Reduction / (Debit) [2] kg/yr)		In-Lake BMP Load Reduction Requirement (kg/yr)	
	TP	TN	TP	TN	TP	TN
2010	348	-499	-84	-144	264	-643
2015	292	-993	-236	-862	56	-1,855
2020	231	-927	-306	-1,216	-75	-2,143

1) Negative values indicate no reduction requirement, and presence of a credit relative to the WRCAC agriculture load allocation

2) Washoff reduction benefits reduced by a loading factor of 63 percent for TP and 65 percent for TN to account for losses in nutrients from watershed washoff to loads into Canyon Lake

3.4 Load Reduction from In-Lake Remediation Projects

Reducing agricultural loads down to the LA via watershed-based BMPs alone would be nearly impossible and extremely costly. Watershed-based BMPs would need to be designed to treat extreme storm events; whereas they are typically designed to treat smaller storm events (e.g.

1 inch or less of rainfall). Alternatively, for lake nutrient TMDLs, water quality objectives can be achieved through the implementation of in-lake remediation projects in Lake Elsinore and Canyon Lake. Reduction of internal nutrient loads can offset reductions required that cannot be achieved with existing and planned watershed BMPs. Additionally, in-lake BMPs can be designed to achieve numeric targets for response variables in the TMDL, which include chlorophyll-a and DO. The following sections describe existing in-lake remediation activities ongoing in Lake Elsinore that provide sufficient nutrient reduction to offset the remaining load reduction needed to achieve WLAs and LAs. Also included is a new in-lake remediation project planned for Canyon Lake that will demonstrate compliance with the TMDL by achieving numeric targets for response variables chlorophyll-a and DO.

3.4.1 Lake Elsinore

Three in-lake remediation projects (or BMPs) are being implemented currently in Lake Elsinore: operation of an aeration/mixing system, fishery management, and lake stabilization through the addition of reclaimed water. Various parties subject to the TMDL have implemented each of these projects through the Task Force. WRCAC member agriculture and CAFO operators have determined that support of the aeration/mixing system is sufficient to achieve in-lake nutrient load reduction needed to offset baseline sediment nutrient reduction requirements in Lake Elsinore. Additional load reductions are not required to offset WRCAC agriculture and CAFO sources for TP and TN, as shown in Table 3-8 above.

An average annual estimate of internal TP loading from sediments of 33,160 kg/yr for Lake Elsinore was found to exceed the TMDL allocation of 28,634 kg/yr, leaving no assimilative capacity for external loading (Regional Board, 2004). However, since the Lake Elsinore aeration/mixing system was planned for implementation at the time of TMDL adoption, a 35 percent TP reduction was assumed to restore assimilative capacity and allow for development of LAs and WLAs for external sources. This assumed reduction in TP requires that all sources with WLAs or LAs in the San Jacinto River watershed continue to operate the aeration system to achieve the presumed 35 percent TP reduction, referred to as the baseline sediment nutrient reduction requirement. For the WRCAC member agriculture and CAFO operators, the baseline sediment nutrient reduction requirement is 1,435 kg/yr, 12 percent of the total presumed load reduction of 11,606 kg/yr (35 percent of 33,160 kg/yr internal TP load). Most of this requirement is for agricultural operators, 1,418 kg TP/yr, but WRCAC member CAFOs will participate to offset their responsibility of 17 kg TP/yr until the watershed model and TMDL is updated and any revision to the requirement is determined. Table 3-9 provides the basis for determining the WRCAC member agriculture and CAFO portion of the baseline sediment nutrient reduction requirement.

Table 3-9 Baseline Sediment Nutrient Reduction Requirement for WRCAC Agriculture and CAFO

Nutrient Source	Watershed	Relative to Total Lake Elsinore WLA[1]	Baseline Sediment Nutrient Reduction Requirement (kg/yr)
Agriculture	Local Lake Elsinore	0.9%	101
	Canyon Lake [2]	12.3%	1,429
CAFO	Local Lake Elsinore	0.0%	0
	Canyon Lake [2]	1.4%	159
Total		14.6%	1,689

1) For the local Lake Elsinore watershed, there are no WRCAC agriculture or CAFO members in operation.
*2) Transfer LA from Canyon Lake watershed of 2770 kg/yr is 41% of total allocation of 6,744kg/yr for reclaimed water, urban, septic, agriculture, and transfer from Canyon Lake. The agriculture and CAFO portion of the transfer from Canyon Lake to Lake Elsinore was assumed to be equal to the LA and WLA distribution in the Canyon Lake TMDL; agriculture LA of 1,183 kg/yr is 65% of the total allocation and CAFO WLA of 132 kg/yr is 7% of the total allocation. Accounting for the portion of agriculture and CAFO that are WRCAC members (45% of agriculture and 5% of CAFOs), the portion of baseline sediment nutrient reduction requirement assigned to WRCAC agriculture and CAFO nutrient sources in Canyon Lake watershed is 12% (0.41 * 0.45*0.65) and 0.1% (0.41 * 0.05 * 0.07), respectively.*

WRCAC is currently working with other stakeholders to develop an agreement for sharing the cost of operating the Lake Elsinore aeration/mixing system. The draft agreement involves an initial 20 percent cost share for WRCAC member agriculture and CAFOs. This portion of the 11,606 kg/yr assumed for total system TP offset capacity is 2,321 kg/yr, which exceeds the requirement of 1,689 kg/yr shown in Table 3-9 above. The excess offset capacity would be sufficient to provide additional TP reductions needed in the short term, as shown in Table 3-8. For 2010, it is estimated that the WRCAC members need an additional 264 kg/yr of TP offset, and this value declines over time as agricultural land uses are converted to urban land uses.

3.4.2 Canyon Lake

WRCAC agriculture sources will have a small unmet load reduction requirement to meet the TMDL, which declines from ~300 kg/yr in 2010 to zero in 2020 as a result of attrition and implementation of aggressive watershed BMP programs. In the interim period, WRCAC agriculture members will partner with the MS4 Permittees to implement the addition of aluminum sulfate (alum) to Canyon Lake to achieve interim numeric targets. The following sections describe how the use of alum additions will achieve compliance with the response targets for chlorophyll-a and DO.

A one dimensional lake water quality model, DYRESM-CAEDYM, was developed by the Task Force for use in evaluating nutrient management strategies for Canyon Lake and Lake Elsinore. The analysis of in-lake nutrient management alternatives to achieve response targets does account for estimated load reductions from watershed BMPs included in this WRCAC AgNMP by reducing daily inflow loads to DYRESM-CAEDYM. Since watershed load reductions are estimated on an annual basis, an assumption was made that percent load reductions are roughly equivalent for different seasons and storm event sizes, allowing for daily inflow loads reductions at the same percentage as annual reductions. Table 3-10 shows total external load reduction with additional watershed load reductions projected (2010-2020 average) from implementation of the CNRP for urban and septic sources in the CL/LE nutrient

TMDL and from expectation of continued improvement to vehicle emissions as a result of more stringent federal and state air quality standards (State Implementation Plan, South Coast Air Quality Management District).

The Task Force has completed detailed evaluations of aeration, oxygenation, and chemical addition (Anderson, 2007; Anderson, 2012b; Anderson, 2012c). Based on these evaluations, the Task Force has determined that chemical addition, using aluminum sulfate (alum), is the most effective in-lake nutrient control strategy to achieve interim numeric targets for the response variables, chlorophyll-a and DO. Appendix C provides the basis for this determination.

Table 3-10 Projected External Nutrient Load Reduction to Canyon Lake from all Jurisdictions with Allocated Loads

Nutrient Reduction Source	TP Load Reduction (kg/yr)	TN Load Reduction (kg /yr)
AgNMP Projects	287	1,180
Land use change (2003 to 2010)	818	2828
Stormwater program implementation	182	955
Future urbanization w/ LID (2010 to 2020)	649	-217
Atmospheric Deposition [1]	0	384
Estimated Load Reduction	1,936	5,130
External Load to Lake from 2010 Model Update	8,932	32,209
% of TMDL External Load	22%	16%

1) Reduced emissions of NOx from new air quality standards are expected to reduce atmospheric NOx concentrations in southern California by 60 percent (State Implementation Plan, South Coast Air Quality Management District). Based on recent TMDL implementation planning in the Chesapeake Bay, it was assumed this reduced NOx concentration could translate into 20 percent less TN load from direct atmospheric deposition over Canyon Lake. This reduction does not account for reduced deposition and subsequent washoff from watersheds.

3.4.2.1 Chlorophyll-a Response Target

When alum is added to a waterbody, an aluminum hydroxide precipitate known as floc is formed. The floc binds with phosphorus in the water column to form an aluminum phosphate compound which will settle to the bottom of the lake or reservoir. Once precipitated to the bottom of the reservoir, the floc will also act as a phosphorus barrier. It binds any phosphorus released from the sediments during normal nutrient cycling processes that occur primarily under anoxic conditions such as those found in much of the hypolimnion at Canyon Lake. The aluminum phosphate compounds are insoluble in water under most conditions and will render all bound phosphorus unavailable for nutrient uptake by aquatic organisms. It is through the reduction of bioavailable phosphorus that alum additions reduce the growth of algae in Canyon Lake, as measured by chlorophyll-a concentration in water samples.

Algae need both nitrogen and phosphorus for growth. The limiting nutrient is the one that is completely used for algal growth while some of the other still remains in its bioavailable form.

Thus, only reductions of the limiting nutrient would be expected to generate reductions in algal growth. A Redfield ratio of TN to TP of greater than 7 suggests the waterbody is phosphorus limited, while a ratio less than 7 suggests the waterbody is nitrogen limited. Historical water quality data for Canyon Lake shows that the system is weakly nitrogen limited. However, alum additions are only effective for addressing phosphorus. Thus, Canyon Lake alum additions must reduce phosphorus sufficiently to create a condition of phosphorus limitation before generating any positive results toward compliance with the chlorophyll-a response target.

Seasonality

Generally, algal blooms in Canyon Lake occur at similar times of year (Figure 3-7) and are primarily a function of nutrient loading trends. For this reason, the AgNMP and CNRP were developed to reduce seasonal chlorophyll-a concentrations, despite the numeric target being an annual average basis. This approach provides an additional MOS for compliance. In addition, this approach is more likely to gain support from the public as it addresses the impairment as it occurs.

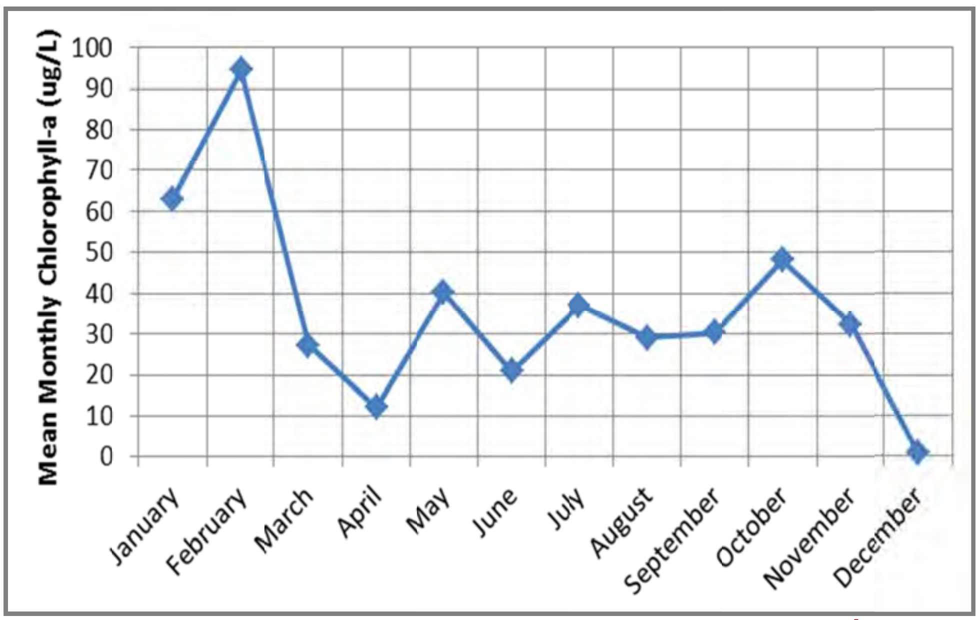

Figure 3-7
Mean Monthly Chlorophyll-a in Main Body of Canyon Lake

The first algal bloom occurs around February and is caused by the presence of nutrient rich external loads in dissolved or suspended particulate form that remain in Canyon Lake at the end of the wet season, coincident with increasing daylight hours and water temperatures. The second algal bloom occurs around October and is caused by turnover of the lake, which brings nutrient enriched water from the hypolimnion to the photic zone where it serves as a food source for algae. This source of nutrients comes from internal loads released from bottom sediments into the hypolimnion during the period of thermal stratification (roughly March through October). The presence of anoxic conditions in the hypolimnion increases the rate of nutrient flux from bottom sediments and subsequent loading of nutrients to photic zone at turnover. To address both periods of enhanced algal growth, alum applications to Canyon Lake are proposed twice per year, once around February 15th and again around September 15th.

Analysis for Main Body

The DYRESM-CAEDYM model was used to estimate the reduction of bioavailable phosphorus that would be needed to limit algae growth, and maintain average annual chlorophyll-a concentration at less than 25 ug/L in all hydrologic years. Adsorption isotherms were then used to estimate the required dose of alum needed to reduce phosphorus from current levels to the target concentration. Results showed that a dose of 10 mg/L of alum (~1 mg/L as Al) would effectively reduce 10-year averages of chlorophyll-a from ~35 ug/L to less than ~5 ug/L by reducing TP from ~0.31 mg/L to ~0.15 mg/L (Anderson, 2012e). The model predicted a significant reduction in chlorophyll-a despite average TP concentrations being above the TMDL numeric target of 0.1 mg/L. The reason for this is that the reduction accounts for most of the bioavailable pool of phosphorus (i.e. dissolved orthophosphate form). At a relatively low dose of 10 mg/L, alum forms a less than typical floc size or "microfloc", which has a longer residence time as it settles through the water column. The longer residence time allows for chemical processes needed to bind dissolved forms of phosphorus relative to heavier doses (50-100 mg/L) that largely only provide physical entrainment of particulates as a larger floc settles through the water column (Moore et al., 2009).

Analysis for East Bay

The one dimensional DYRESM-CAEDYM model simulates a lake wide average vertical profile of water quality, therefore areas of relatively greater concern for chlorophyll-a are averaged with areas of typically better water quality. Of particular interest to the agricultural operators is the East Bay of Canyon Lake. The East Bay is shallower than the Main Body, receives runoff from a different watershed, has higher nutrient concentrations, more dense and persistent algal blooms, and experiences minimal lateral mixing with the Main Body of the lake. A separate analysis using CDM Smith's Simplified Lake Analysis Model (SLAM) was completed for this zone of Canyon Lake to assess whether alum can be effective for reducing chlorophyll-a. Once calibrated using historical nutrient and chlorophyll-a data (2007 – 2010), SLAM was used to test the effect of reduced water column TP on chlorophyll-a. See Attachment C for details on the SLAM application to Canyon Lake. SLAM results suggest that TP would need to be reduced to ~0.05 mg/L to reduce seasonal chlorophyll-a concentrations to below the numeric target of 25 ug/L (Figure 3-8).

Elsinore Valley Municipal Water District (EVMWD) conducted jar tests to determine the reduction of TP that could be achieved at varying doses of alum (see Attachment C). Jar test results from the two East Bay monitoring locations (CL09 and CL10) showed that a dose of 20-40 mg/L alum would result in a TP of ~0.05 mg/L, therefore a dose of 30 mg/L alum (~3 mg/L as Al) was selected for East Bay alum applications.

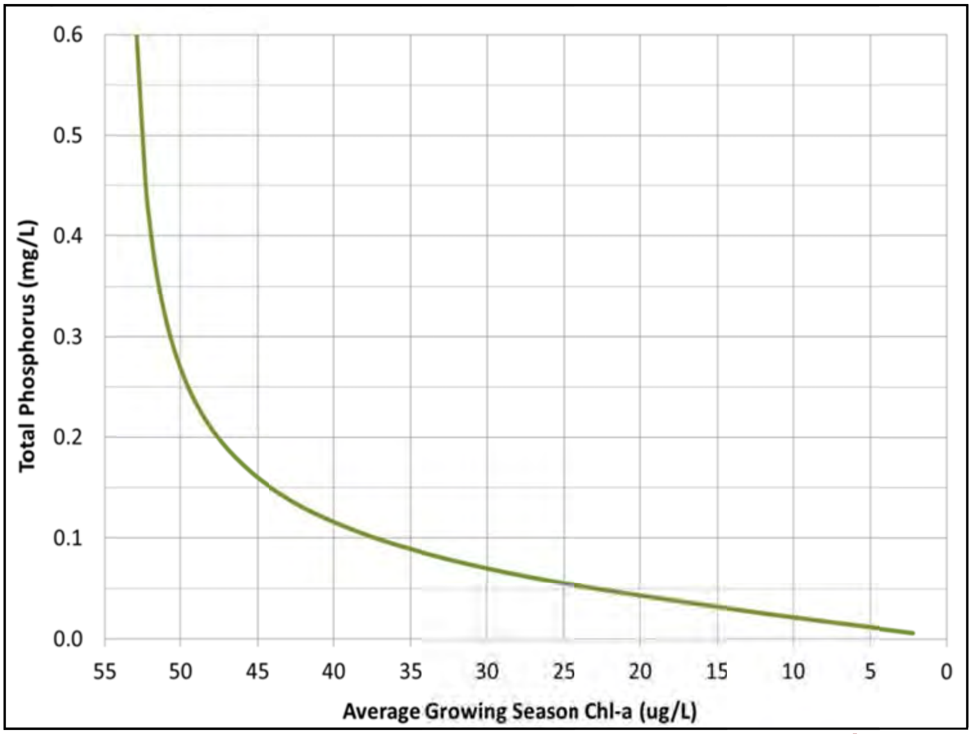

Figure 3-8
SLAM Results Showing Chlorophyll-a for Varying Reductions in Total Phosphorus during Growing Seasons

3.4.2.2 Dissolved Oxygen Response Target

Per the TMDL, the numeric target for DO is not limited to conditions that exist "as a result of controllable water quality factors", a condition which is contained in the Basin Plan WQO for DO. The TMDL Staff Report recognizes uncertainty and comes to the resolution that "as the relationship between nutrient input and dissolved oxygen levels in the lakes is better understood, the TMDL targets for dissolved oxygen can be revised appropriately to ensure protection of aquatic life beneficial uses". To evaluate controllability, the Task Force developed a DYRESM-CAEDYM model scenario to assess DO conditions above and below the thermocline if the watershed were completely undeveloped (Anderson 2012d). The cumulative frequency plots in Figure 3-9 show the full range of daily results. For the hypolimnion, exceedances of the DO WQO of at least 5 mg/L occur roughly 50 percent of the time in the predevelopment scenario, therefore such exceedences may be considered uncontrollable.

For the epilimnion (model output average for top 3 meters of water column), the model predicted no exceedences of the DO WQO in the predevelopment or in the watershed BMP + alum condition. However, DO monitoring data shows that exceedences of the DO target do occur in the epilimnion, but are limited to the period when the lake is turning over. Turnover occurs around October and involves destratification, which allows for low DO water from bottom of the lake to mix with surface waters. This problem is also expected to occur under pre-development conditions; however, the degree to which the current rate of non-compliance may differ from pre-development conditions has not yet been modeled. Thus, it can be concluded that Canyon Lake is currently meeting interim numeric targets except for a temporary period when the lake is turning over.

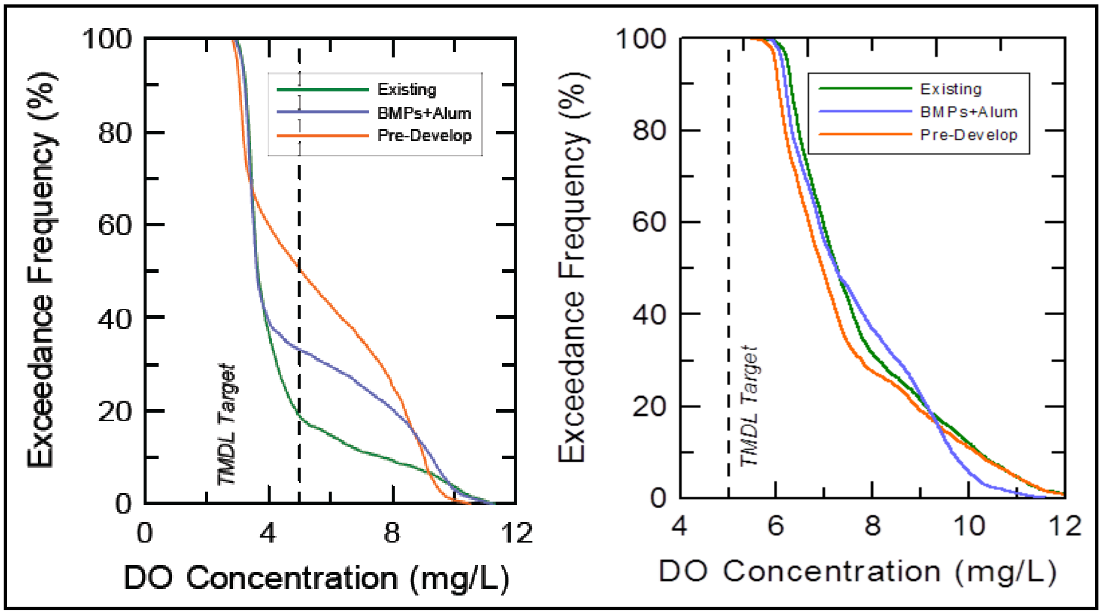

Figure 3-9
Cumulative Frequency of Daily Average DO in hypolimnion (left) and epilimnion (right) for DYRESM-CAEDYM Simulations of Existing, Pre-development, and with Watershed BMP Implementation Scenarios

The combination of watershed BMPs and alum additions will not directly increase dissolved oxygen within Canyon Lake; however, over time, the indirect benefit of reduced algal growth and die-off/settling will reduce sediment oxygen demand, and therefore reduce anoxic conditions at sediment-water interface. In turn, more anoxic conditions at the sediment-water interface will reduce the flux of nutrient from bottom sediments to the water column, which would provide additional reductions in algal growth and die-off/settling. Figure 3-7 shows that implementation of watershed BMPs and alum additions over a 10-year period would be expected to provide significant progress toward returning exceedence frequency of WQOs to pre-development levels. However, the ultimate load reduction will be realized over an even longer timeframe, and could take multiple decades to accrue given that the half-life of settled nutrients in Canyon Lake is estimated to be approximately 10 years (Anderson, 2012a). Attachment C includes a slideshow presentation, given by Michael Anderson on February 14, 2012, describing kinetic modeling completed to assess the length of time settled nutrients are rendered no longer bioavailable, or inert, in Canyon Lake bottom sediments.

3.4.2.3 Ammonia Toxicity Response Target

Limited instances of acute and chronic ammonia toxicity occur in the Main Body and East Bay for samples taken from the hypolimnion or depth integrated over the entire water column. These ammonia levels of concern are the result of anoxic conditions at the sediment-water interface, which facilitates ammonification of organic nitrogen in lake-bottom sediments. Over time, reduced algal growth and die-off/settling due to alum additions will reduce sediment oxygen demand, and therefore reduce anoxic conditions at sediment-water interface. In turn, more oxic conditions at the sediment-water interface will reduce the frequency of ammonia toxicity in the water column. If ammonia toxicity continues to occur after the initial alum additions, then a supplemental BMP will be considered that would more directly address ammonia in the lake bottom or from external sources.

3.4.2.4 Canyon Lake In-Lake BMP Implementation

Table 3-11 shows the plan for alum additions to Canyon Lake for both the wet and dry season applications. These applications are based on the evaluation of an effective dose for the Main Body and East Bay as well as an assessment of seasonality in algal growth to determine the appropriate times of year to conduct the alum additions. The estimate of treated TP with the proposed alum applications is roughly six times the current TP load from WRCAC member agriculture sources to Canyon Lake based on the 2010 update to the watershed model used for the TMDL linkage analysis (Tetra Tech, 2010). Thus, the proposed alum addition plan would provide more than enough TP removal to offset the load reduction needed to meet the LA for WRCAC member agriculture sources, as well as providing excess credits for other potential project proponents.

Table 3-11 Alum Addition Plan for Canyon Lake (2013-2015)

Zone	Application Date	Description	Alum Dosage (mg/L)	Alum Application (kg dry alum)	Treated TP (kg)
Main Body	February	Water column stripping following wet season storms prior to spring algal bloom	10	70,000	685
	September	Water column stripping prior to turnover/fall algal bloom and suppression of internal sediment nutrient flux	20	140,000	1,309
East Bay	February	Water column stripping following wet season storms prior to date of historic algal bloom occurrence	30	50,000	808
	September	Water column stripping prior to turnover in deeper sections and fall algal bloom	30	50,000	808
			Annual Total	310,000	3,609

With the addition of alum, there is potential for acute or chronic aluminum toxicity to aquatic life in surface waters (e.g. zooplankton) that receives the initial dose of alum. Studies of aluminum toxicity from similar source waters show that this is not a likely condition, especially considering the low dose proposed for Canyon Lake in ambient waters with a pH greater than 7.0 (EPA Region 9, 2007). Jar tests performed at each of the Canyon Lake compliance monitoring stations provided an approximation of the dissolved aluminum that may be present in the water column immediately following the alum application. With dissolved aluminum concentrations ranging from 200-600 ug/L, acute or chronic toxicity is not expected (Colorado Department of Public Health, 2012; EPA Region 9, 2007). However, in February 2013, the TMDL Task Force conducted toxicity tests using ambient water from different parts of Canyon Lake and found no acute or chronic toxicity for the proposed range of doses. This finding was used in the supporting environmental documentation to develop a case for a mitigated negative declaration in the CEQA analysis required for project implementation.

Beginning in September 2013, assuming CEQA compliance is complete, alum application will be performed according to the schedule shown in Table 3-11. After the fifth alum application in September of 2015, TMDL Task Force will evaluate water quality data in the lake, and determine whether response targets are achieved or if modification to the alum application plan or potential supplemental BMPs may be needed to achieve response targets in Canyon Lake for chlorophyll-a and DO.

In 2016, the TMDL will be reopened to revise the final numeric target for DO to incorporate controllability by means of an allowable exceedence frequency representative of a pre-development condition in the watershed. The 2012 DYRESM-CAEDYM simulations of a lake water quality for a pre-development level of watershed nutrient loads will be used to represent an uncontrollable frequency of exceeding the final DO target of at least 5 mg/L in the hypoliminion. A cumulative frequency plot of average daily DO data from the two year period of alum applications (Sep 2013 through Sep 2015) will be compared to the pre-development cumulative frequency to determine whether sufficient improvement to DO was achieved with the alum applications.

3.5 Uncertainty

The AgNMP is expected to achieve compliance with long-term average annual LAs and WLAs for agriculture and CAFO sources. Also, in assessing the WRCAC portion of agriculture and CAFO land use, only the acreage from the AIS mapping project were included. Hence, a higher load reduction responsibility was assumed by WRCAC by excluding from the total of agriculture and CAFO, those areas modeled as agriculture or CAFO, based only on SCAG land use data.

We believe these points of conservatism in the AgNMP compliance analysis offset the other sources of uncertainty in the determination that the AgNMP, once implemented will achieve the LAs and WLAs for agriculture and CAFO sources. Specifically, estimates of reduction in nutrient washoff from WRCAC agriculture and CAFO lands involved many assumptions on cropland BMP effectiveness, manure application and retention processes, urban growth rates, and future WRCAC membership. WRCAC is developing special studies of land management practices and effects on nutrient loading to improve understating of these areas of uncertainty. Also, through nutrient offsets, in-lake BMPs are responsible for all of the Lake Elsinore and part of the Canyon Lake load reduction needed by WRCAC agriculture and CAFO members, yet nutrient load reduction estimated from implementation of alum addition in Canyon Lake and fishery management in Lake Elsinore are based on limited data, empirical modeling, and incubation studies.

The following sections characterize some of these sources of uncertainty that could cause the AgNMP to be more or less effective than expected.

3.5.1 Use of 2010 Watershed Model Update

Load reduction requirements for this AgNMP compliance analysis were based on existing load estimates from the 2010 watershed model update. Since the adoption of the TMDL, urban land use has increased while agricultural land use has declined and this trend is expected to continue as the watershed approaches a buildout condition. Accordingly, the 2010 watershed model update generally showed an increased nutrient load from urban sources and a decreased nutrient load from agricultural sources. Urban septic loads also decreased based on the more accurate accounting of septics resulting from the 2007 SSMP. CAFO loads increased with the model update, despite extensive data showing the opposite trend in CAFOs and cow population in the watershed. The TMDL did not account for future changes in land use distribution in the watershed. For example, as agricultural and CAFO land use acreage decreases, and if the LA were to remain the same, then the allowable per acre loading would increase. The opposite conditions occur when looking at urban acreage increasing resulting in a reduced allowable per acre loading rate using the mass based WLA. To assess the impact of these changes on the feasibility of meeting the TMDL, WLAs were converted to allowable per acre loading rates using land use acreage used to develop the TMDL and the 2010 watershed model update. Additionally, actual animal head counts (RWQCB annual dairy reports) should be used regarding dairy allocations not acreage.

3.5.2 Controllability of TMDL Allocations and Response Targets

The DYRESM-CAEDYM simulation projected the implementation of the CNRP and AgNMP, annual average chlorophyll-a, for the entire lake would be 5 ug/L with wetter years reaching 10 ug/L. Therefore, the model projects that the AgNMP will achieve compliance with the final chlorophyll-a response target of an annual average of 25 ug/L; irrespective of hydrologic fluctuation. This model estimates a lake-wide average chlorophyll-a, which is the same metric used to determine compliance with the response target per the TMDL. Even if the lake-wide average chlorophyll-a meets the response target, specific areas of Canyon Lake during critical seasons may still experience more algal growth than others, such as East Bay. For this reason, a heavier dose of alum is planned for shallower areas to drop TP below 0.1 mg/L, furthering limiting the available phosphorus needed for algae to grow, based on East Bay specific simulations using SLAM.

These models rely on a relationship between the dose of alum addition and resultant phosphorus reduction, which was based on one set of jar tests from each of the four compliance monitoring station, collected in dry season of 2012 (see Attachment C). These jar tests may not be representative of potential ambient water quality when alum additions are implemented in 2013-2015, and thus the expected benefits may not be realized. For example, if pH is higher than it was in the jar test samples, then a portion of the applied alum would be spent acidifying the water before forming an effective aluminum hydroxide floc that is able to bind with phosphorus. The stakeholders will continually evaluate water quality data to assess whether the alum applications are performing as expected or if the plan should be modified.

Uncertainty is greatest when it comes to the ability for alum to achieve the final DO response target for the hypolimnion, even after accounting for controllability. The DYRESM-CAEDYM results showed a reduction in exceedance frequency from 80 to 65 percent of the time, attributable to the indirect benefits of reduced nutrient cycling and associated sediment oxygen demands. Anderson 2012a suggests that such benefits may continue to accrue over several decades, but there is much uncertainty as to the ultimate potential for DO conditions in the hypolimnion. Consequently, the stakeholders have developed adaptive management into the CNRP and AgNMP. In 2016, the stakeholders will evaluate the effectiveness of alum applications for DO in the hypolimnion and determine whether a supplemental in-lake project for DO, such as aeration or oxygenation, would be needed.

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Appendix Documents-Available Upon Request

A. Blue Water Satellite Imaging Technology

B. Integrated, Regional Dairy Management Plan (IRDMP)

C. SEP Report-Identification of Technologies and Alternate Control Measures

D. Voluntary Agricultural Operator TMDL Implementation Plan with BMPs in the San Jacinto Watershed

E. AIS Aerial Mapping Final Report

F. Tetra Tech Report–Management Practices to Reduce Nutrient Loads from Agricultural Operations in the San Jacinto Watershed

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ATTACHMENT A
TMDL Implementation

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Attachment A
TMDL Implementation

A.1 Introduction

TMDL coordination efforts have been underway since August 2000, well before adoption of the Lake Elsinore and Canyon Lake Nutrient TMDLs (“Nutrient TMDLs”). These activities were coordinated and administered through the Lake Elsinore San Jacinto Watersheds Authority (LESJWA), a joint powers authority. The Santa Ana Regional Water Quality Control Board (Regional Board) adopted the Nutrient TMDLs on December 20, 2004; the Nutrient TMDLs became effective on September 30, 2005, after EPA approval. The existing TMDL stakeholders formally organized into a funded TMDL Task Force in 2006. This Task Force in coordination with LESJWA has been actively involved in the implementation of the TMDL requirements. The following sections describe the organizational structure and responsibilities of LESJWA and the Task Force and status of TMDL implementation activities as applicable to the agricultural and dairy operators.

A.2 Lake Elsinore San Jacinto Watersheds Authority

LESJWA is made up of representatives from the Santa Ana Watershed Project Authority, Elsinore Valley Municipal Water District, City of Lake Elsinore, City of Canyon Lake and County of Riverside. LESJWA was formed in April of 2000 after California voters passed Proposition 13, a bond measure to fund water projects throughout the State. Proposition 13 earmarked $15 million for LESJWA to implement projects to address the impairments in Lake Elsinore and Canyon Lake. LESJWA is charged with improving water quality and protecting wildlife habitats, primarily in Lake Elsinore, but also in Canyon Lake and the surrounding watershed. Several LESJWA projects are central to the stakeholder TMDL compliance strategies, including:

- Lake Elsinore Aeration System
- Lake Elsinore Wetland Enhancement
- Lake Elsinore Carp Removal
- Lake Elsinore Axial Flow Pumps
- Lake Elsinore Island Wells
- Lake Elsinore Dredging Project

LESJWA has conducted several studies to evaluate lake conditions, alternative management measures and potential funding mechanisms.

These efforts provide the basis for ongoing compliance work of the TMDL Task Force. In addition, the TMDL Task Force continues to rely on the LESJWA Technical Advisory Committee for technical guidance.

A.3 Lake Elsinore and Canyon Lake TMDL Task Force

In December 2004, all responsible parties named in the TMDL began the process of creating a formal cost-sharing body, or Task Force, to collaboratively implement various requirements defined in the implementation plan for the nutrient TMDLs. A Task Force Agreement was signed March 5, 2007. The purpose of the Task Force is to conduct studies necessary to collect data to analyze the appropriateness of the TMDL, identify in-lake and regional watershed solutions, pursue grants, coordinate activities among all of the various stakeholders, and recommend appropriate revision to the Basin Plan language regarding Lake Elsinore and Canyon Lake based on data collection and analysis. The Task Force includes the following participants:

- County of Riverside
- Riverside County Flood Control & Water Conservation District
- City of Beaumont
- City of Canyon Lake
- City of Hemet
- City of Lake Elsinore
- City of Menifee
- City of Moreno Valley
- City of Murrieta
- City of Riverside
- City of San Jacinto
- City of Wildomar
- Elsinore Valley Municipal Water District
- Eastern Municipal Water District
- California Transportation Department
- California Department of Fish & Game
  - March Air Reserve Joint Powers Authority
  - US Air Force (March Air Reserve Base)
  - Western Riverside County Agriculture Coalition on behalf of Agricultural & Dairy Operators in the San Jacinto River watershed

SAWPA serves as the administrator for the Task Force. In this role, SAWPA provides all Task Force meeting organization/facilitation, secretarial, clerical and administrative services, management of Task Force funds, annual reports of Task Force assets and expenditures and hiring of Task Force authorized consultants. SAWPA maintains a website with all information developed to date through the Task Force: www.sawpa.org/roundtable-LECLTF.html.

A.4 TMDL Tasks Applicable to Agricultural and Dairy Operators

The Nutrient TMDLs include 14 tasks in the TMDL implementation Plan (Resolution No. R8-2004-0037). Not all tasks are applicable to the agricultural and dairy operators. Table A-1 briefly describes each TMDL task, its relevance to the agricultural and dairy operators, and general status. Further discussion on the status and work performed for each task for which the agricultural and dairy operators have responsibilities is detailed in the subsections that follow.

A.4.1 Task 2.3 – General WDR for Concentrated Animal Feeding Operations (CAFOs)

All dairies and related facilities are currently under a General Waste Discharge Requirement for Concentrated Animal Feeding Operations within the Santa Ana Region under Order No. R-8-2007-0001. The new draft permit Order No. R8-2013-0001/NPDES No. CAGo18001 is currently in comment period and two RWQCB workshops have been held. Nutrient TMDLs for Canyon Lake and Lake Elsinore are addressed in the current and the new permit and in Attachment D.

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Table A-1. TMDL Implementation Plan Tasks Applicable to Agricultural and Dairy Operators

Task No.	Task Name	Task Description	Compliance Date (per	Relevance to Riverside County MS4 Permit and Status
Task 1	Establish new Waste Discharge Requirements (WDR)	Issue new WDR to Elsinore Valley Municipal Water District for supplemental discharges to Canyon Lake	March 31, 2006	Not applicable to agricultural and dairy operators; per Regional Board status is ongoing
Task 2	2.1 – WDR for Riverside County MS4 Permittees	Revise existing MS4 permit (Order R8-2002-0011) as needed to incorporate TMDL requirements	March 31, 2006	Not applicable to agricultural and dairy operators; per Regional Board status is ongoing
	2.2 – Watershed-wide WDRs for Discharges of Storm Water Runoff associated with new developments in the San Jacinto Watershed	Rescind Order 01-34 when revised Water Quality Management Plan (WQMP) approved under Order R8-2002-0011	March 31, 2006	Not applicable to agricultural and dairy operators; per Regional Board status is ongoing
	2.3 – General WDR for Concentrated Animal Feeding Operations (CAFOs)	Revise existing General WDR (Order 99-11) as needed to incorporate TMDL requirements	March 31, 2006	The CAFO permit is currently being issued and is in the comment period. It will be Order No. R-8-2013-0001 8-2013-0001
	2.4 – Waste Discharge and Producer/User Reclamation Requirements for the EVMWD, Regional Water Reclamation Facility	Revise Order No. 00-1 to take into consideration Lake Elsinore Recycled Water Pilot Project findings	March 31, 2006	Not applicable to agricultural and dairy operators; per Regional Board status is complete/ongoing-as needed

Table A-1. TMDL Implementation Plan Tasks Applicable to Agricultural and Dairy Operators

Task No.	Task Name	Task Description	Compliance Date (per TMDL)	Relevance to Riverside County MS4 Permit and Status
	2.5 – WDR for Eastern Municipal Water District (EMWD), Regional Water Reclamation System	If needed, revise order No. 99-5 to address EMWD discharge of recycled water to Lake Elsinore and to take into consideration Lake Elsinore Recycled Water Pilot Project findings	March 31, 2006	Not applicable to agricultural and dairy operators; per Regional Board status is ongoing
	2.6 – WDR for US Air Force, March Air Reserve Base	Revise Order R8-2004-0033 to incorporate TMDL requirements	March 31, 2006	Not applicable to agricultural and dairy operators; per Regional Board status is ongoing
Task 3	Identify Agricultural Operators	Regional Board will develop a list of all known agricultural operators in the San Jacinto watershed responsible for TMDL implementation	October 31, 2005	Complete
Task 4	4.1 – Watershed-wide Nutrient Monitoring Plan(s)	TMDL responsible parties to submit collectively or individually a watershed-wide nutrient water quality monitoring program for Regional Board approval; submit modified program as needed	Initial plan due December 31, 2005; Revised plan due December 31, 2006 Annual report due by August 15 each year	Monitoring Program approved by Regional Board in March 2006 (Order R8-2006-0031); Amended monitoring program approved in March 2011 (Order R8-2011-0023; Annual reports submitted through August 25, 2011

Table A-1. TMDL Implementation Plan Tasks Applicable to Agricultural and Dairy Operators

Task No.	Task Name	Task Description	Compliance Date (per TMDL)	Relevance to Riverside County MS4 Permit and Status
	4.2 – Lake Elsinore Nutrient Monitoring Plan(s)	TMDL responsible parties to submit collectively or individually a Lake Elsinore in-lake nutrient water quality monitoring program for Regional Board approval; submit modified program as needed		
	4.3 – Canyon Lake Nutrient Monitoring Plan(s)	TMDL responsible parties to submit collectively or individually a Canyon Lake in-lake nutrient water quality monitoring program for Regional Board approval; submit modified program as needed		
Task 5	Agricultural Discharges – Nutrient Management Plan (AgNMP)	Agricultural operators collectively or individually shall submit an NMP that addresses a range of agricultural-related activities	Plan/Schedule due September 30, 2007	A draft AgNMP was submitted 12/31/11. The RWQCB extended the deadline requesting coordination with the CNRP. The CNRP was submitted1/31/13. AgNMP delivered 4/30/13
Task 6	On-site Disposal System (Septic Systems) Management Plan	County of Riverside and Cities of Perris, Moreno Valley, and Murrieta shall submit collectively or individually a Septic System Management Plan	Dependent on State Board approval of relevant regulations	Not applicable to agricultural and dairy operators; per Regional Board status is ongoing

Table A-1. TMDL Implementation Plan Tasks Applicable to Agricultural and Dairy Operators (Continued)

Task No.	Task Name	Task Description	Compliance Date (per TMDL)	Relevance to Riverside County MS4 Permit and Status
Task 7	7.1 – Revision of Drainage Area Management Plan (DAMP)	Revise DAMP to include TMDL requirements	August 1, 2006, ff.	Not applicable to agricultural and dairy operators; per Regional Board status is ongoing
	7.2 – Revision of the Water Quality Management Plan (WQMP)	Review WQMP to include TMDL requirements	August 1, 2006,ff.	Not applicable to agricultural and dairy operators; per Regional Board status is ongoing
	7.3 – Update of the Caltrans Stormwater Management Plan (SWMP) and Regional Workplan	Revise SWMP annually as required; submit a Regional Workplan that includes plans and schedules for meeting TMDL requirements	August 1, 2006	Not applicable to agricultural and dairy operators; per Regional Board status is ongoing
	7.4 – Update of US Air Force, March Air Reserve Base SWPPP	Revise facility SWPPP as needed to incorporate TMDL requirements	Dependent on nutrient monitoring program results	Not applicable to agricultural and dairy operators; per Regional Board status is ongoing
Task 8	Forest Area – Review/Revision of Forest Service Management Plans	Submit for approval a plan with a schedule for the identification and implementation of Management Practices to reduce nutrients from Cleveland and San Bernardino National Forests	Plan/schedule due September 30, 2007	Not applicable to agricultural & dairy operators; considered complete – draft submitted to the Regional Board on September 27, 2007 that stated the existing Forest Plans are sufficient to meet TMDL requirements. Regional Board found the proposed plan and schedule for BMP implementation satisfies TMDL requirements

Table A-1. TMDL Implementation Plan Tasks Applicable to Agricultural and Dairy Operators (Continued)

Task No.	Task Name	Task Description	Compliance Date (per TMDL)	Relevance to Riverside County MS4 Permit and Status
Task 9	Lake Elsinore In-Lake Sediment Nutrient Reduction Plan	TMDL responsible parties (including agricultural & dairy) to submit collectively or individually a proposed plan and schedule for in-lake sediment nutrient reduction that includes a monitoring program	Plan/schedule due March 31, 2007	Complete; implementation ongoing
Task 10	Canyon Lake In-Lake Sediment Treatment Evaluation	TMDL responsible parties (including agricultural & dairy) to submit collectively or individually a proposed plan and schedule for in-lake sediment nutrient reduction that includes a monitoring program	Plan/schedule due March 31, 2007	Complete
Task 11	Watershed and Canyon Lake and Lake Elsinore In-Lake Model Updates	TMDL responsible parties (including agricultural & dairy) to submit collectively or individually a proposed plan and schedule to update the existing Lake Elsinore/San Jacinto River Nutrient Watershed Model and the Canyon Lake and Lake Elsinore in-lake models	Plan/schedule due March 31, 2007	Modeling efforts completed December 23, 2010 per June 30, 2011 RCFC&WCD letter to the Regional Board

Table A-1. TMDL Implementation Plan Tasks Applicable to Agricultural and Dairy Operators (Continued)

Task No.	Task Name	Task Description	Compliance Date (per TMDL)	Relevance to Riverside County MS4 Permit and Status
Task 12	Pollutant Trading Plan or functional equivalent	TMDL responsible parties (including agricultural and dairy) to submit collectively or individually a proposed plan, schedule and funding strategy for project implementation, an approach for tracking pollutant credits and a schedule for reporting status of implementation	Plan/schedule due September 30, 2007	Initial plan/schedule for developing Pollutant Trading Plan has been submitted and approved; implementation on-going. WRCAC completing 319 grant for a Pollutant Trading Feasibility Assessment with weBMP database tool. The grant looks at trading between agricultural stakeholders.
Task 13	Review and Revise Nutrient Water Quality Objectives (WQOs)	For Canyon Lake and Lake Elsinore, the Regional Board will (a) review and revise as necessary the total inorganic nitrogen WQOs; and (b) evaluate the appropriateness of establishing total phosphorus and un-ionized ammonia WQOs	December 31, 2009	Regional Board action pending collection of additional data
Task 14	Review of TMDL/WLA/LA	Regional Board will re-evaluate basis for the TMDLs and implementation at least once every three years, and revise TMDL as needed	Once every 3 years	To date, TMDL has not been revised; the next triennial review is scheduled for 2015

A.4.2 Task 4 - Nutrient Water Quality Monitoring Program

Task 4 of the TMDL implementation plan requires the responsible jurisdictions to submit to the Regional Board for approval a proposed watershed-wide compliance monitoring program (Task 4.1) and in-lake compliance monitoring plans for Lake Elsinore (Task 4.2) and Canyon Lake (Task 4.3). The required Monitoring Program should include:

- A watershed-wide monitoring program to determine compliance with interim and/or final nitrogen and phosphorus allocations, and compliance with the nitrogen and phosphorus TMDL, including the waste load allocations (WLAs) and load allocations (LAs).
- A Lake Elsinore in-lake nutrient monitoring program to determine compliance with interim and final nitrogen, phosphorus, chlorophyll-a, and dissolved oxygen numeric targets. In addition, this program will evaluate and determine the relationship between ammonia toxicity and the total nitrogen allocation to ensure that the total nitrogen allocation will prevent ammonia toxicity in Lake Elsinore.
- A Canyon Lake nutrient monitoring program to determine compliance with interim and final nitrogen, phosphorus, chlorophyll-a, and dissolved oxygen numeric targets. In addition, the monitoring program will evaluate and determine the relationship between ammonia toxicity and the total nitrogen allocation to ensure that the total nitrogen allocation will prevent ammonia toxicity in Canyon Lake.

The Lake Elsinore & Canyon Lake Nutrient TMDL Monitoring Program was approved by the Regional Board March 3, 2006 (Order No. R8-2006-0031). The Task Force submitted a Quality Assurance Project Plan (QAPP), which was also approved by the Regional Board. All required activities have been carried out and Annual Reports prepared and submitted to the Regional Board by August 15th of each year.

The Lake Elsinore and San Jacinto Watershed Authority (LESJWA) on behalf of the Task Force submitted a revised in-lake monitoring program for Lake Elsinore and Canyon Lakes to the Regional Board on December 23, 2010. This proposal also provided a rationale for the deferral of a watershed-wide monitoring program pending development of the AgNMP and CNRP. The Regional Board approved the revised in-lake monitoring program and the request for deferral of the watershed-wide monitoring program to the CNRP (Order No. R8-2011-0023, March 4, 2011).

In a letter dated June 7, 2011 the Task Force requested that monitoring be reduced further to allow resources to be re-focused on project implementation in Canyon Lake. However, monitoring efforts would be restored in time to assess compliance with the 2015-16 interim targets. The Regional Board indicated by letter (September 2, 2011) that it may be supportive of further reductions in the monitoring program as long as the reductions are justified and that there are firm and certain commitments by the Task Force to move forward with specific in-lake and/or watershed projects. The Regional Board also stated that reductions in in-lake monitoring may be appropriate given the existing volume of lake data; however, reducing watershed monitoring is a concern given the need to assess compliance with the TMDL, WLAs and LAs. Regardless, the Regional Board agreed to work with the Task Force on the development of a revised monitoring program.

Subsequently, new data by Dr. Anderson indicated that the HOS system alone would not meet the requirements. Additional options were evaluated and a project has been initiated to address adding alum applications to Canyon Lake. The TMDL Task Force received a grant to assist with this project.

A.4.3 Task 5 – Agricultural Nutrient Management Plan (AgNMP)

Task 5 of the TMDL requires development of an Agricultural Nutrient Management Plan (AgNMP) Agricultural operator may develop the agricultural nutrient management plan as individuals or as members of the Western Riverside County Agricultural Coalition (WRCAC). Only those agricultural operators that are paid members in good standing and have paid the appropriate TMDL allocation fees are in compliance. This document includes only the WRCAC member agricultural operators.

Non-members such as Federal, tribal and State entities that have chosen not to participate must meet individual requirements with the RWQCB. Scientific and technical documentation is provided in the AgNMP. Once the AgNMP id fully implemented it is expected to achieve compliance with the agricultural WLA for TN and TP by December 31, 2020.

A.4.4 Task 9 - Lake Elsinore In-Lake Sediment Nutrient Reduction Plan

The In-Lake Sediment Nutrient Reduction Plan, dated October 31, 2007, relies on existing projects that have been or are being implemented to improve the water quality in Lake Elsinore. These Phase 1 remediation projects include (a) stabilizing Lake Elsinore depth with recycled water; (2) reducing the carp population in Lake Elsinore through a fishery management program; and (3) installing and operating an aeration/mixing system in Lake Elsinore. The Regional Board approved this plan (Order No. R8-2007-0083) on November 30, 2007).

The October 31, 2007 plan included a preliminary list of other mitigation strategies (Phase 2 Alternatives) for potential implementation in the event that the three remediation strategies described above are not sufficient to achieve the in-lake numeric targets for Lake Elsinore. However, in a letter dated June 30, 2011 the Task Force indicated that the Phase 1 projects are performing as expected, and if continued, are likely to achieve the nutrient reductions required to comply with the WLAs and LAs in Lake Elsinore. In its response (September 2, 2011), the Regional stated that while it appears that the Phase 1 projects may be sufficient to reduce phosphorus levels in Lake Elsinore, that nitrogen and chlorophyll-a may not be controlled by the Phase 1 projects and further consideration of Phase 2 projects may be necessary.

A.4.5 Task 10 - Canyon Lake In-Lake Sediment Treatment Evaluation

Task 10 of the TMDL required completion of an in-lake sediment treatment evaluation plan for Canyon Lake. The Task Force submitted this plan to the Regional Board on June 25, 2007. The plan included an evaluation of alum treatment, aeration and hypolimnetic oxygenation system (HOS) as alternatives for in-lake sediment treatment in Canyon Lake, and a proposed plan for additional modeling and preparation of an implementation schedule. Regional Board Order No. R8-2007-0083 approved the plan and schedule for additional implementation activities.

In LESJWA's December 31, 2010 letter to the Regional Board, the Canyon Lake stakeholders indicated that it was considering two alternatives for nutrient control in Canyon Lake: (1) HOS; and (2) application of Phoslock. However, of these two alternatives, the letter indicated that the stakeholders believed that it would only be necessary to implement the HOS in order to achieve the response targets specified in the TMDL. In a May 17, 2011 meeting with the Regional Board, the Task Force discussed the proposed alternatives further in the context of implementation strategies: (a) Strategy A - use of alum, Phoslock or zeolite; and (b) Strategy B -implementation of HOS. The Task Force preferred Strategy B.

The Task Force completed a study titled *Canyon Lake Hypolimnetic Oxygenation System Preliminary Design Phase I Report i*n April 2011. The report evaluated multiple scenarios and identified a recommended design scenario. To facilitate continued planning for implementation of the HOS, LESJWA submitted a letter to the Regional Board on June 7, 2011 requesting a formal response from Regional Board regarding the proposed strategies. In a letter dated September 2, 2011, the Regional Board indicated its support, as long as watershed improvements and nutrient reduction actions are also undertaken.

In January of 2012, the Task Force sought Dr. Michael Anderson to conduct additional studies to determine the potential impact of the HOS on in-lake TMDL response targets for chlorophyll-a and DO and to evaluate chemical addition alternatives. The studies were intended to provide additional confirmation on the selection of a HOS by assessing whether it can be a whole-lake solution, or to revise the proposed in-lake nutrient management strategy to use chemical addition or regulatory approaches to achieve the response targets. Dr. Anderson 2012b determined that exceedences of the chlorophyll-a response target would continue to occur if only the HOS were to be implemented in the lake. In a March 31, 2012 CNRP comment letter, the Regional Board states that if allocations are met by all dischargers, but in lake water quality response targets are not achieved, then the TMDL will be reconsidered and allocated loads may be further reduced.

Thus, the stakeholders opted to prioritize in-lake BMPs based on their effectiveness in meeting the TMDL response targets for chlorophyll-a and DO. Adding alum to Canyon Lake was estimated to be highly effective in achieving the interim and final chlorophyll-a response target. Therefore to control algae in the lake, the stakeholders plan is to first conduct 5 alum applications over a 2-year period beginning in September 2013. A grant has been awarded to assist all stakeholders in this task.

A.4.6 Task 11 - Watershed and Canyon Lake and Lake Elsinore In-Lake Model Updates

The Lake Elsinore and Canyon Lake TMDLs are based on watershed and in-lake water quality models (Lake Elsinore and Canyon Lake Nutrient Source Assessment –Final Report, January 2003). Task 11 requires an update of these models to consider additional data and information gathered from TMDL monitoring programs. The Task Force submitted a plan and schedule for updating these models to the Regional Board by letter dated October 31, 2007. The Regional Board subsequently issued its approval (Order No. R8-2007-0083, November 30, 2007).

The Task Force submitted the updated model *(San Jacinto Watershed Model update (2010) –Final, October 7, 2010)* and a spreadsheet tool for calculating the nutrient loads contributed by each TMDL responsible party to the Regional Board on December 23, 2010. Additional modeling needs were identified in the 2010 update. However, in its December 23, 2010 letter to the Regional Board, the Task Force stated rather than updating the model, resources would be more wisely spent on implementing in-lake projects to achieve the numeric response targets. This recommendation was reiterated in a June 30, 2011 letter to the Regional Board. The June 30, 2011 letter also indicated that the Task Force considers Task 11 to be complete.

The Regional Board's September 2, 2011 letter stated that in principle staff agreed that at this time resources should be expended on implementation activities rather than modeling. However, for the Regional Board to consider Task 11 complete, the following conditions should be met:

Funds earmarked or considered necessary for model update work are used to implement new remediation projects; these new projects do not include the Phase 1 projects already implemented in Lake Elsinore, though enhancements to those projects may be considered;

- The Task Force should explicitly acknowledge that it is its responsibility to conduct updates to the watershed model should (a) the spreadsheet tool proves insufficient to develop the AgNMP & CNRP; and/or (b) the Regional Board independently determines that updates to the model are necessary;
- The Task Force submits a proposed plan for update and use of the in-lake models; and
- If monitoring does not demonstrate TMDL compliance by December 31, 2015, then implementation efforts, including possible model updates, will need to be increased.

A.4.7 Task 12 - Pollutant Trading Plan (PTP)

Task 12 of the TMDL requires that a PTP be developed. On October 31, 2007 the Task Force submitted a plan and schedule outlining the steps for developing a pollutant trading plan. The Regional Board issued its approval in Order No. R8-2007-0083 (November 30, 2007). The Task Force plans to submit a PTP or its functional equivalent for Regional Board consideration, on an as needed basis, to support implementation of individual in-lake nutrient management projects. The agricultural and dairy operators participate in the Task Force PTP.

Additionally, WRCAC received a 319 grant that will be completed in fall of 2013. The project is a Feasibility Assessment for Pollutant Trading for Agricultural Operators in the San Jacinto Watershed and the Development of a Best Management Practices (BMPs) Database Tool (Agreement 10-446-558). Included in the grant, is an agricultural operator survey, pollutant suitability analysis, economic suitability analysis and development of a weBMP database tool for collecting BMP information from agricultural operators.

Attachment B
Watershed Characterization

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Attachment B
Watershed Characterization

B.1 Introduction

Lake Elsinore and Canyon Lake lie within the San Jacinto Watershed, an area encompassing approximately 780 square miles in the San Jacinto River Basin. The San Jacinto watershed is located approximately 60 miles southeast of Los Angeles, and 22 miles southwest of the City of Riverside, the San Jacinto Watershed lies primarily in Riverside County with a small portion located within Orange County.

Historically, land use development in the San Jacinto watershed has been associated with agricultural activities. Agricultural and dairy operators are both identified as TMDL stakeholders in the LE/CL nutrient TMDL.

B.2 Land Use

Upon adoption of the TMDL, it was clear that current and accurate data for the agricultural community was necessary. WRCAC has used a specialized land use consultant, Aerial Information Systems, AIS since 2005. WRCAC has completed aerial mapping studies for 2005, 2007 and 2010. The baseline TMDL data was collected using EMWD and SCAG data. (Figure B-1).

The TMDL load allocations were based upon land use that was predominantly generated by EMWD and SCAG data. Figure B-1 shows the 1999 EMWD land use data. The updated 2007 aerial mapping for the agriculture in the San Jacinto Watershed is shown in Figure B-2.

WRCAC compiled aerial mapping data on the San Jacinto watershed for agricultural activities due to the attrition of agriculture from the initial loading data. Mapping was completed by Aerial Information Systems (AIS) in 2005, 2007, and 2010. Additionally, it should be noted that future aerial mapping updates are expected around 2013, 2016, and 2019. Table B-1, B-2, B-3, B-4 and B-5 summarize the current aerial mapping available. All mapped land use classes shows raw totals of agricultural land use categories as well as some that eventually fall out of the characterization as flood control or water bodies and non-agricultural entities.

Table B-2 shows a comparison of three cycles of mapping and the reduction of all agricultural acreage. Table B-3 further characterizes true, WRCAC member or potential WRCAC agriculture. This table excludes Federal, State and Tribal entities.

Table B-4 and B-5 demonstrates ownership by sub-watershed zones with Table B-5 excluding once again the federal, State and Tribal entities. Both tables show owners of greater than 20 acre parcels as is the specified definition for TMDL agricultural responsible parties.

The 2005 Southern California Association of Governments (SCAG) and the 2009 Western Riverside County Agriculture Coalition (WRCAC) land use data were used to characterize land use within the watershed. Where appropriate, land use data were consolidated into broader categories to help accurately support nutrient loading analyses (Table B-6). Tetra Tech (2010) provides additional information regarding land classification in the watershed.

Historically, land use development in the San Jacinto watershed has been associated with agricultural activities. However, over the past ten years land use has shifted markedly from agricultural-related to urban. This shift has influenced to a large degree the expected nutrient loading from various portions of the watershed. The county has been adding an estimated 16,000 people per year because of natural increases since 1999.A continued shift from agriculture to urban land is expected to continue in future years.

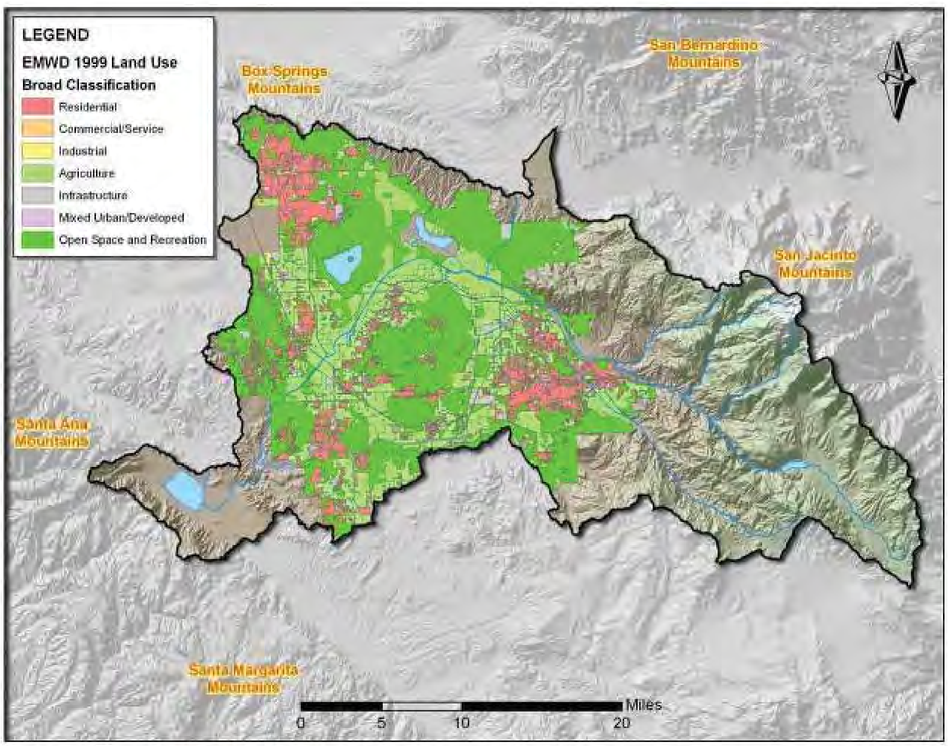


Figure B-1
EMWD Land Use in the San Jacinto River Watershed, 1998

Using 2007 data, a land use mapping effort (AIS Final report, 2009) produced a more detailed, land use classification for agricultural land in the San Jacinto River watershed (Figure B-2).

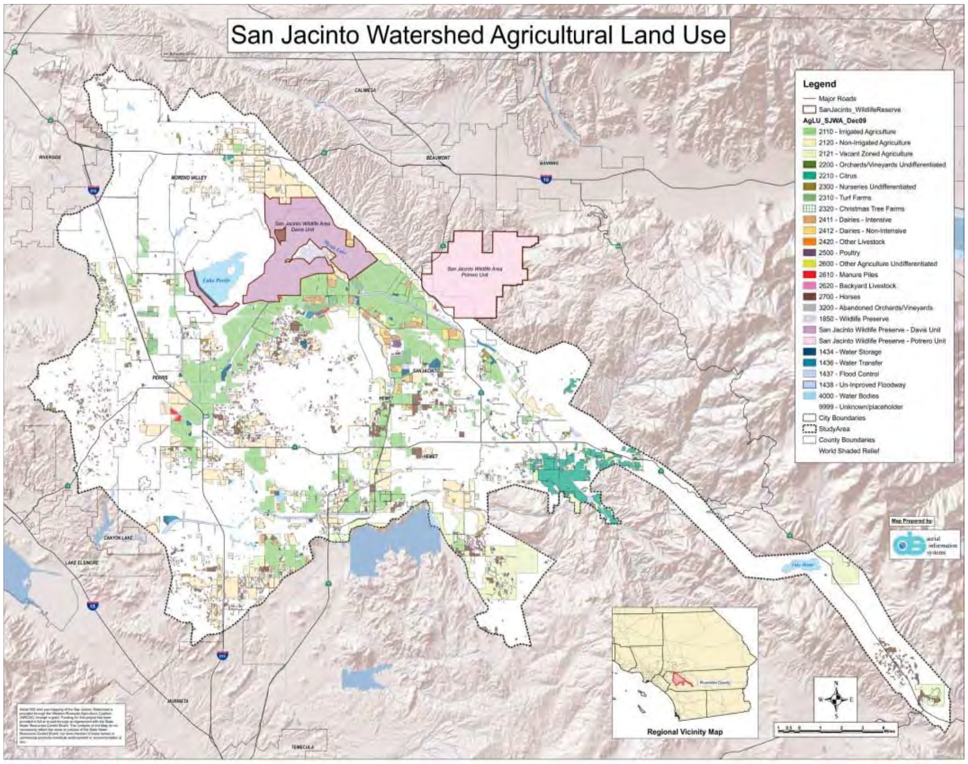


Figure B-2
WRCAC 2007 Land Use for Agriculture in the San Jacinto River Watershed

WRCAC 2010

Table 2

All Mapped Land Use Classes
Area Comparison

Ag Land Use Code	Ag Land Use Description	2005 Total Area (ac.)	2007 Total Area (ac.)	2010 Total Area (ac.)
1434	Water Storage	1,023.8	1,007.7	988.1
1436	Water Transfer	328.0	332.4	310.5
1437	Flood Control	2,374.9	2,414.6	3,002.2
1438	Unimproved Flood Way (not used in 2005 and 2007)			93.6
1850	Wildlife Areas other than SJWA (active disturbed areas and duck ponds)	531.8	552.6	714.3
1851	San Jacinto Wildlife Area - Davis Unit	10,080.9	10,080.8	10,080.8
1852	San Jacinto Wildlife Area - Potrero Unit	9,122.6	9,122.6	9,122.6
2110	Irrigated Agriculture	25,058.8	20,775.8	18,938.5
2120	Non-Irrigated Agriculture	22,545.2	15,521.7	14,537.5
2121	Vacant - Zoned Agriculture	11,436.6	11,603.4	12,131.5
2200	Orchards/Vineyards, Undifferentiated	284.7	170.3	231.7
2210	Citrus	3,273.5	3,157.5	3,255.1
2300	Nurseries, Undifferentiated	879.2	929.5	884.1
2310	Turf Farms	1,044.0	1,130.5	1,141.6
2320	Christmas Tree Farm	13.3	13.4	18.5
2411	Dairies - Intensive	1,168.0	1,004.5	982.5
2412	Dairies - Non-Intensive	1,215.4	1,076.2	1,249.7
2413	Abandoned Dairies	91.8		57.3
2420	Other Livestock	218.0	191.1	151.6
2500	Poultry	358.7	329.1	267.6
2600	Other Agriculture, Undifferentiated	493.2	349.7	413.6
2610	Compost/Manure Piles	52.7	147.1	183.5
2620	Backyard Livestock	1,453.3	1,548.0	1,542.4
2700	Horses	2,820.6	2,784.1	2,744.0
3200	Abandoned Orchard/Vineyard	148.4	15.3	15.8
4000	Water	3,295.2	2,717.1	2,822.7
9999	Unknown/Placeholder	633.1	2,180.1	1,007.7
	Totals	**99,945.7**	**89,155.2**	**86,888.9**

Note: The study area was modified to match the Watershed boundary.

3/27/2012

All agricultural land use comparison table

Note: The study area was modified to match the Watershed boundary

Table B-2 All Agricultural land use in the San Jacinto River watershed- comparison table

Ag Land Use Code	Ag Land Use Description	2005 Total Area (ac.)	2007 Total Area (ac.)	2010 Total Area (ac.)
2110	Irrigated Agriculture	25,058.8	20,775.8	18,938.5
2120	Non-Irrigated Agriculture	22,545.2	15,521.7	14,537.5
2121	Vacant -Zoned Agriculture	11,436.6	11,603.4	12,131.5
2200	Orchards/Vineyards, Undifferentiated	284.7	170.3	231.7
2210	Citrus	3,273.5	3,157.5	3,255.1
2300	Nurseries, Undifferentiated	879.2	929.5	884.1
2310	Turf Farms	1,044.0	1,130.5	1,141.6
2320	Christmas Tree Farm	13.3	13.4	18.5
2411	Dairies -Intensive	1,168.0	1,004.5	982.5
2412	Dairies -Non-Intensive	1,215.4	1,076.2	1,249.7
2413	Abandoned Dairies	91.8		57.3
2420	Other Livestock	218.0	191.1	151.6
2500	Poultry	358.7	329.1	267.6
2600	Other Agriculture, Undifferentiated	493.2	349.7	413.6
2610	Compost/Manure Piles	52.7	147.1	183.5
2620	Backyard Livestock	1,453.3	1,548.0	1,542.4
2700	Horses	2,820.6	2,784.1	2,744.0
	Totals	**72,407.0**	**60,732.0**	**58,730.6**

WRCAC 2010

Table 3

Agriculture Land Uses for Operators with Greater than 20 acres (excluding Federal, State and Tribal owners)

Agriculture Land use Code	Agriculture Land Use Description	Total Agriculture Area (ac.)	Total Agriculture Area (ac.) minus 2121, 2411, 2412, and 2413
2110	Irrigated Agriculture	17,607.8	17,607.8
2120	Non-Irrigated Agriculture	12,110.6	12,110.6
2121	Vacant - Zoned Agriculture	8,949.3	
2200	Orchards/Vineyards, Undifferentiated	101.3	101.3
2210	Citrus	2,900.2	2,900.2
2300	Nurseries, Undifferentiated	329.4	329.4
2310	Turf Farms	1,123.7	1,123.7
2320	Christmas Tree Farms	7.6	7.6
2411	Dairies - Intensive	976.4	
2412	Dairies - Non-Intensive	1,227.8	
2413	Dairies - Abandoned	57.3	
2420	Other Livestock	34.3	34.3
2500	Poultry	233.5	233.5
2600	Other Agriculture, Undifferentiated	327.2	327.2
2610	Compost/Manure Piles	182.1	182.1
2620	Backyard Livestock	28.4	28.4
2700	Horses	1,148.1	1,148.1
Totals		**47,344.9**	**36,134.0**

3/27/2012

CDM Smith

WRCAC 2010

Table 4

All Agriculture Owners by Sub-Watershed Zones

Sub-Watershed Zone #	Number of Unique Owners*	Total Number of AG Operators**	# of AG Operators with > 20 Acres (including Vacant Zoned Ag and Dairies)	# of AG Operators with > 20 Acres, Excluding Dairies	# of AG Operators with > 20 Acres, Excluding Vacant Zoned Ag & Dairies
1	2	1	0	0	0
2	1271	1,040	37	37	37
3	634	490	64	62	54
4	835	680	102	102	48
5	1069	777	62	62	51
6	612	528	36	36	35
7	789	574	118	105	90
8	138	100	35	35	24
9	169	154	14	14	4
	5519	4,344	468	453	343

* The number of unique Owners in the database is 5,196. The total number shown is greater due to Owners having property in multiple Sub-Watershed zones.

** AG Operator is defined as a property owner having any of the Agricultural Land Use codes (2110 thru 2700) present on their lands at the time of interpretation.

3/27/2012

WRCAC 2010

Table 5

Number of Agriculture Owners by Sub Watershed Zones excluding Federal, State, and Tribal owners

Sub-Watershed Zone #	Number of Unique Owners*	Total Number of AG Operators**	# of AG Operators with > 20 Acres (including Vacant Zoned Ag and Dairies)	# of AG Operators with > 20 Acres, Excluding Dairies	# of AG Operators with > 20 Acres, Excluding Vacant Zoned Ag & Dairies
1	2	1	0	0	0
2	1268	1,039	36	36	36
3	633	488	63	61	53
4	835	678	100	100	47
5	1061	774	61	61	50
6	607	526	35	35	34
7	784	572	116	103	89
8	130	93	32	32	22
9	166	150	13	13	4
	5486	4,321	456	441	335

* The number of unique Non Federal, State or Tribal Owners in the database is 5,173. The total number shown is greater due to Owners having property in multiple Sub-Watershed zones.

** AG Operator is defined as a property owner having any of the Agricultural Land Use codes (2110 thru 2700) present on their lands at the time of interpretation.

3/27/2012

Table B-6 Land Use Acreage Among San Jacinto River Basin Jurisdictions (source: 2010 Watershed Model Report, 2007 WRCAC data)

Jurisdiction	Urban	Low-Density Residential	Med-Density Residential	High-Density Resident	Cropland	Irrigated Cropland	Non-Irrigated Cropland	Dairy/ Livestock	Orchards/ Vineyards	Pasture/Hay	Open Space	Forested	Water	Grand Total
Cities/County														
Banning	58	4	144	17			0				50	78		351
Beaumont	738	39	504	35			444	0	18		29	9,954		11,759
Canyon Lake	75	66	1,230	17			6	9			142	955	470	2,969
Hemet	2,666	560	4,371	632	36	1,299	2,117	511	21		674	4,114	304	17,306
Lake Elsinore	1,649	339	2,166	145	3	0	69		18		273	7,198	3,096	14,954
Menifee	3,304	3,512	4,825	294	199	1,232	5,971	746	210		1,640	6,419	640	28,994
Moreno Valley	3,341	2,245	8,520	340	56	1,862	4,388	200	261		953	8,297	398	30,861
Murrieta	152	16	203	14	1		54	10			7	47	11	516
Perris	2,925	1,055	2,056	154	49	3,269	2,710	50	144	327	2,151	4,917	470	20,277
Riverside	39		459								13			511
San Jacinto	1,617	489	1,951	169	83	4,266	757	1,737	99	339	466	3,647	513	16,132
Wildomar	480	1,346	532		2	32	84	7	32		31	2,539		5,083
Riverside County	3,406	12,891	3,640	328	580	14,926	7,488	4,360	3,898	459	4,811	104,903	4,235	165,925
Other Jurisdictions														
Air Force DOD	2,685		426				0				2,590	117	56	5,875
Indian Reservations BIA	77	222				35	325	3	102		42	6,239	83	7,130
U.S. National Forest	418	4,152	327		46	10	3	633	252		861	123,327	475	130,502

Table B-6 Land Use Acreage Among San Jacinto River Basin Jurisdictions (source: 2010 Watershed Model Report, 2007 WRCAC data) (continued)

Jurisdiction	Urban	Low-Density Residential	Med-Density Residential	High-Density Resident	Cropland	Irrigated Cropland	Non-Irrigated Cropland	Dairy/ Livestock	Orchards/ Vineyards	Pasture/Hay	Open Space	Forested	Water	Grand Total
Public Domain Land BLM	26	62	66		5	36	18	2	44		590	17,868		18,716
Wilderness Lands	2	16						0			24	12,459		12,501
Grand Total	23,537	27,043	31,243	2,142	1,077	27,254	25,145	8,343	5,100	1,130	14,226	313,357	10,751	490,346
Land Use Percentage	4.8	5.5	6.4	0.4	0.2	5.6	5.1	1.7	1.0	0.2	2.9	63.9	2.2	

B.3 Climate

Area climate is characterized as semi-arid with dry warm to hot summers and mild winters. Average annual precipitation in Lake Elsinore/Canyon Lake area is approximately 11 inches occurring primarily as rain during winter and spring seasons (Table B-7). Precipitation in the upper watershed averages 18.7 inches annually. RCFC&WCD monitors precipitation at six rain gauges within the San Jacinto River Basin. Table B-8 lists the monitoring stations and average annual precipitation. Figure B-3 illustrates the location of these gauges

Table B-7 Average Monthly Temperatures and Precipitation

Month	Average Monthly Precipitation (in)	Average Monthly High Temperature (°F)	Average Monthly Low Temperature (°F)	Average Monthly Temperature (°F)
January	2.8	66	38	52
February	2.96	68	40	54
March	2.29	71	43	57
April	0.56	77	46	62
May	0.22	83	51	67
June	0.02	91	56	74
July	0.1	98	61	80
August	0.12	98	62	80
September	0.3	93	58	76
October	0.36	84	51	67
November	0.78	73	42	58
December	1.58	67	37	52
Annual	12.09	81	49	65

Source: Monthly Average for Lake Elsinore, CA - weather.com
http://www.weather.com/weather/wxclimatology/monthly/USCA0580

Table B-8 Precipitation Monitoring Stations in San Jacinto Watershed

Station code	Agency	Station Name	Period of Record Collected	Annual Rainfall (inches)
67	RCFC&WCD	Elsinore	7/1/1990 – 7/31/2009	10.6
212	RCFC&WCD	Sun City	7/1/1990 – 7/31/2009	11.2
155	RCFC&WCD	Pigeon Pass	7/1/1990 – 7/31/2009	12.8
124	RCFC&WCD	Moreno East	7/1/1990 – 7/31/2009	12.1
248	RCFC&WCD	Winchester	7/1/1990 – 7/31/2009	10.8
89	RCFC&WCD	Hurkey Creek Park	7/1/1990 – 7/31/2009	18.7

Source: Tetra Tech Inc., San Jacinto Watershed Model Update, October, 2010

B.4 Hydrology

This section presents the hydrologic characteristics for the watershed draining to Canyon Lake and Lake Elsinore. The north fork and south fork San Jacinto River are located in the upper portions of the watershed where they converge and collectively become the San Jacinto River upstream of Mystic Lake. Overflow from Mystic Lake is conveyed by the San Jacinto River to Canyon Lake. Canyon Lake is formed by Canyon Lake Dam; water releases from Canyon Lake ultimately drain to the downstream Lake Elsinore.

All streams in the San Jacinto River watershed are ephemeral. Under normal dry periods, the mainstream of the San Jacinto River is dry, contributing no flow to Canyon Lake, and upstream pollutants do not reach the lakes. External sources contribute nutrients to the lakes via storm flows only during the wet season (October, through April). Further information regarding the hydrologic scenario evaluation is discussed in the Lake Elsinore and Canyon Lake TMDL.

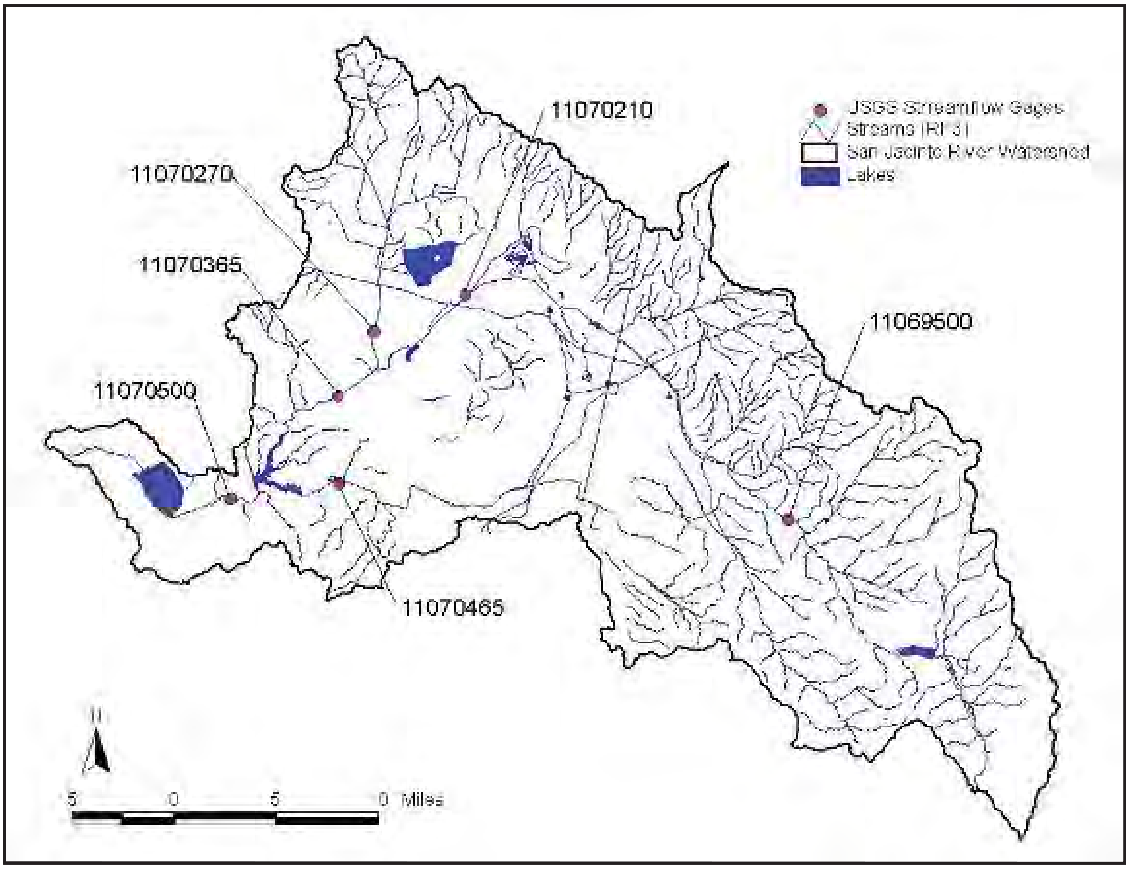
Due to the ephemeral nature of the San Jacinto River system, the location of the various land use sources within the watershed is a major factor affecting the ultimate delivery of nutrients to Canyon Lake and Lake Elsinore. A natural sump, formed by the confluence of two faults, known as Mystic Lake, serves as a hydrologic barrier between the upper and lower San Jacinto Watershed. Mystic Lake is located north of Ramona Expressway and east of the City of Moreno Valley in the San Jacinto Wildlife Preserve. This sump is gradually subsiding providing more runoff storage capacity over time.

During dry hydrologic seasons, Lake Elsinore and Canyon Lake only receive runoff from the subwatersheds directly tributary to them. For example, Lake Elsinore would only receive runoff from the local watershed downstream of Canyon Lake. Similarly, Canyon Lake would only receive runoff from the watershed areas downstream of Mystic Lake. Under moderate hydrologic years, Canyon Lake would be expected to spill, resulting in urban development and agricultural land practices in the central portion of the San Jacinto River watershed below Mystic Lake (including Perris Valley and the Salt Creek sub-watershed) additionally impacting water quality of Lake Elsinore. Lastly, during wet hydrologic years, heavy rain and/or extended periods of rainfall may exceed the storage capacity of Mystic Lake, causing surface flow from open space areas in the headwaters, stormwater runoff from portions of the cities of Hemet and San Jacinto draining to Zones 7-9, and agricultural runoff upstream of Mystic Lake, to reach Canyon Lake. Further, if the rainfall is significant, Canyon Lake may overflow into Lake Elsinore.

Major tributaries to the San Jacinto River include the Perris Valley storm drain and Salt Creek. Perris Valley storm drain conveys flows from the northern portion of the watershed to the San Jacinto River, between Mystic Lake and Canyon Lake. Salt Creek drains to Canyon Lake from the southeast. The U.S. Geological Survey (USGS) operates several flow gauges in the watershed (Table B-9, Figure B-3,), which provide the hydrologic data that were used in the development of the TMDL. The following subsections provide more detailed information regarding the hydrology of the watershed.

Table B-9 USGS Flow Gauge Stations in the San Jacinto Watershed

Station Number	Station Name	Historical Record
11070500	San Jacinto River near Elsinore, CA	1/1/1916–present
11070365	San Jacinto River near Sun City, CA	8/25/2000–present
11070270	Perris Valley Storm Drain at Nuevo Rd. near Perris, CA	10/1/1969–9/30/1997; 10/1/1998–present
11070210	San Jacinto River at Ramona Expressway near Lakeview, CA	8/23/2000–9/30/2010
11069500	San Jacinto River near San Jacinto, CA	10/1/1920–9/30/1991; 10/1/1996–present
11070465	Salt Creek at Murrieta Rd. near Sun City, CA	10/1/1983–9/30/1985; 10/1/2000–present



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Representative Hydrologic Flow Scenarios

Hydrologic flow scenarios were developed in the Lake Elsinore and Canyon Lake Nutrient Total Maximum Daily Loads (TMDL) (California Regional Water Quality Control Board, 2004) to classify hydrologic conditions within the San Jacinto Watershed. Three scenarios (wet, moderate, and dry) were developed in the Lake Elsinore and Canyon Lake TMDL to evaluate the variability of nutrient loading to the lake due to the various hydrologic conditions that occur in the San Jacinto watershed. Representative years from 1991 – 2000 were initially chosen to represent various hydrologic conditions, and are described in Table B-10. Under wet conditions, the main stem of the San Jacinto River flows into and fills Mystic Lake, which then spills to Canyon Lake. Canyon Lake also spills to Lake Elsinore, and depending on the existing elevation, Lake Elsinore could fill and spill to Temescal Wash. The moderate condition is when the main stem of the San Jacinto River doesn't flow all the way to Canyon Lake, with flows from Salt Creek and the Perris Valley Storm Drain making up the water to Canyon Lake. However, Canyon Lake may have moderate spills to Lake Elsinore. Under dry conditions, the flow from the San Jacinto River watershed never reaches Lake Elsinore, with external nutrient loads to the lake coming from the runoff from the local watershed surrounding the lake.

Table B-10. Three hydrologic conditions defined in the TMDL

Scenario	Hydrologic Condition	Representative Water Year	Description
I	Wet	1998	Both Canyon Lake and Mystic Lake overflow; flow at the USGS gauging station 11070500 was 17,000 acre-feet
II	Moderate	1994	No Mystic Lake overflow; Canyon Lake overflowed, flow at the USGS gauging station 11070500 was 2,485 acre-feet
III	Dry	2000	No overflows from Mystic Lake or Canyon Lake, flow at the USGS gauging station 11070500 was 371 acre-feet

The relative flow frequency of each of the scenarios was determined using the annual total flow data (for each water year) at the USGS gauging station #1170500. Table B-11 lists the relative flow frequency of the wet, moderate and dry seasons.

Table B-11. Relative flow frequency at the USGS gauging station #1170500 during 1917 – 2011 period

Hydrologic Scenario (Category)	Years in Each Category	Relative Frequency (%) [1]
Wet	15	16%
Moderate	43	45%
Dry	37	39%

1) Frequency weighting in TMDL is based on 1917-2003 period of record and therefore results are slightly different than shown above

B.4.1 Watershed Analysis Zones

As part of the development the TMDL model, the San Jacinto River Basin was divided into nine watershed analysis zones (Figure B-4). The delineation of these zones was based upon hydrologic features such as significant water retention features or major tributaries:

- Zones 7, 8, and 9, which drain to Mystic Lake, represent the most upstream portion of the watershed;
- Zone 6 represents the area downstream of Mystic Lake that drains directly to the San Jacinto River;
- Zone 5 drains to the Perris Valley Storm Drain which confluences with the San Jacinto River between Mystic Lake and Canyon Lake;
- Zones 3 and 4 drain to Salt Creek, which drains to Canyon Lake;
- Zone 2 drains the area downstream of the Perris Valley Storm Drain drainage area and drains to Canyon Lake; and
- Zone 1 represents that area that drains directly to Lake Elsinore.

B.4.2 Major Waterbodies

Lake Elsinore

Lake Elsinore is located in the southwest portion of the San Jacinto River Basin at the terminus of the San Jacinto River watershed. Lake Elsinore is a natural lake, which has been in existence for thousands of years. Prior to development in the area, the lake naturally experienced significant variations in lake level from being a dry lake bed to filling temporarily following extreme rain events. Today, the lake receives surface flows from local tributaries (Zone 1), which make up less than 10 percent of the overall San Jacinto River watershed and water releases from Canyon Lake. During rare overflow events, at approximately 1,255 feet water surface elevation, Lake Elsinore overflows into Temescal Creek and ultimately to the Santa Ana River.

Canyon Lake

Canyon Lake Reservoir was created in 1928 with the construction of the Railroad Canyon Dam. Over 90 percent of the San Jacinto watershed drains to Canyon Lake. Flows typically enter the reservoir from both the upper San Jacinto River watershed (Zones 5 and 6) and the Salt Creek watershed (Zones 3 and 4). Flows may also reach Canyon Lake from Zones 7-9 during rare periods when Mystic Lake overflows. The elevation of Canyon Lake Dam spillway is approximately 1,382 feet; when the lake level reaches this point flows continue downstream to Lake Elsinore. USGS flow gauge 11070500, located on the San Jacinto River downstream of Canyon Lake, has been in operation since 1916. During its operational period, it is estimated that flows from Canyon Lake have occurred 38 of the 94 years or a frequency of 40 percent.

Mystic Lake

Flows entering the San Jacinto River from upstream portions of the watershed (Zones 7-9) drain into Mystic Lake. Mystic Lake is typically a dry lake and serves as a water sink because flows entering the lake are generally lost from the system due to soil infiltration and evaporation.

Mystic Lake is formed by the confluence of two faults and is located north of Ramona Expressway and east of the City of Moreno Valley in the San Jacinto Wildlife Preserve. This sump is gradually subsiding providing more runoff storage capacity over time. During high or long duration flow events, the storage capacity of Mystic Lake may be exceeded and overflow back to the San Jacinto River and downstream to Canyon Lake. Overflow at Mystic Lake occurs when the water surface elevation is approximately 1,425 feet. USGS flow gauge 11070210 is located on the San Jacinto River roughly 3.5 miles downstream of Mystic Lake. This gauge was in operation between 8/23/2000–9/30/2010 and records local runoff as well as overflows from Mystic Lake. Flow was recorded at Ramona Expressway in 2005, however field investigations determined the flow was from the local watershed area and not Mystic Lake. Given the low flow rates during the other years, it is assumed that since 2000, Mystic Lake has not overflowed.

Lake Hemet

Lake Hemet was created when Hemet Dam was constructed in 1895. The dam is owned and operated by the Lake Hemet Municipal Water District (LHMWD) and is a water source for the cities of Hemet and San Jacinto, and the San Jacinto Mountain community of Garner Valley. The lake is approximately 4,340 ft above sea level and located in the San Jacinto Mountains. The lake volume is roughly 8,100 acre-ft and the outlet flows to the south fork of the San Jacinto River. Flow data at USGS flow gage 11069500, located downstream of Lake Hemet, indicates that this area generally sustains baseflow after a rain event throughout the year. This is in contrast to flow data recorded at other gauges in the San Jacinto River Basin.

San Jacinto River

The headwaters of the San Jacinto River begin in the San Bernardino National Forest where the north and south forks converge east of Valle Vista. The San Jacinto River drains the upper portions of the San Jacinto River Basin to Mystic Lake. The river continues downstream of Mystic Lake to Canyon Lake and again downstream of the Canyon Lake Dam to Lake Elsinore where it terminates. The San Jacinto River Basin is a complex hydraulic system which includes hydraulic sinks, little or no sustained baseflow in most areas especially during dry periods, deep groundwater losses, and reduction in groundwater levels due to excessive groundwater pumping and limited recharge. Generally, the San Jacinto River is not sustained by groundwater flows during dry years and remains waterless. With limited surface water recharge from groundwater, water that infiltrates into the ground is considered to be lost from the system.

Perris Valley Storm Drain

The northwest area of the San Jacinto River watershed is drained by Perris Valley Storm Drain. The drain has its confluences with the San Jacinto River upstream of Canyon Lake. USGS gauge 11070270 is located on the Perris Valley Storm Drain near Perris, California. Flows recorded at this gauge display high peak flow rates of short durations, a pattern commonly seen with stormwater runoff from developed areas with little or no associated groundwater flow.

Salt Creek

Salt Creek is an intermittent creek that drains southern portions of the San Jacinto River watershed. The drainage enters Canyon Lake from the southeast. USGS gauge 11070465 measures flow in Salt Creek near Sun City and displays a lower unit-area flow than other gauges in the watershed. However, the USGS rates the data recorded at this station as poor quality.

The dominant hydrologic features in the watershed are illustrated in Figure B-4.

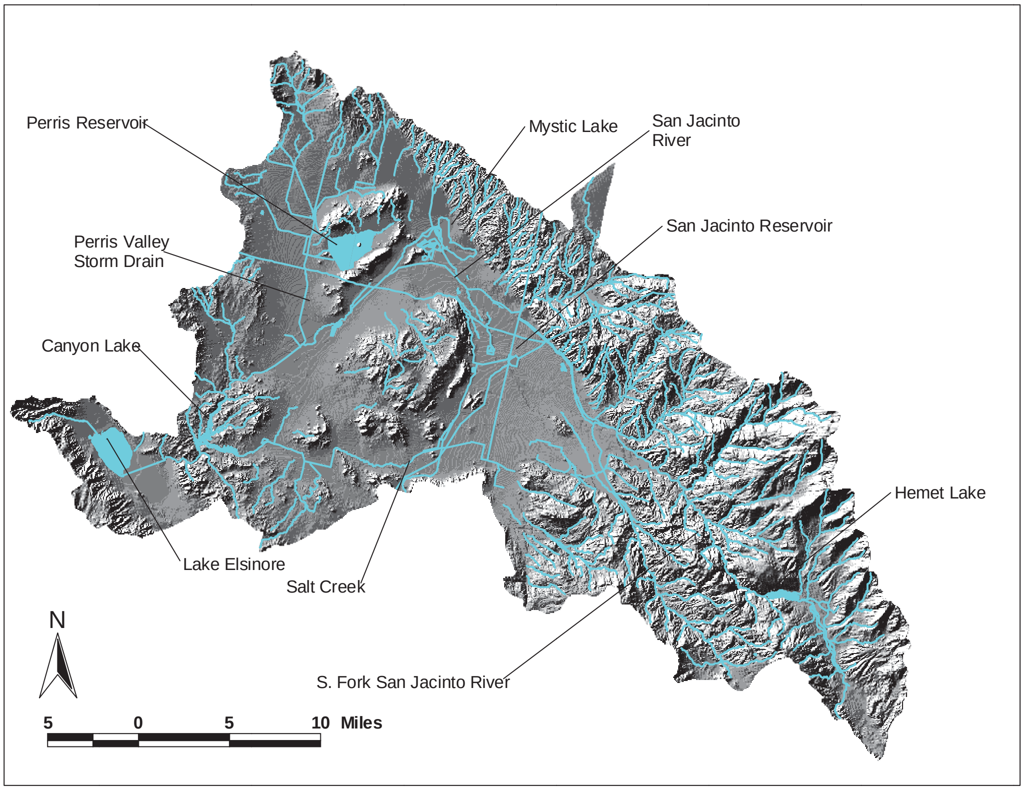


Figure B-4
Dominant hydrologic features in the watershed

B.4.3 Flow

Wet weather runoff is the primary influence on flow rates observed in the San Jacinto watershed. Figure B-5 presents a flow duration curve for daily mean discharges at the USGS gauges (See Table B-11). The figure shows the cumulative-frequency curves, which represent the likelihood that a particular flow discharge is equaled or exceeded at the site. Figure B-5 indicates that the upstream portion of the San Jacinto River has a more stable flow rate, which suggests that this area receives groundwater inflow and snowmelt runoff that tends to infiltrate prior to reaching the Ramona Expressway gauge.

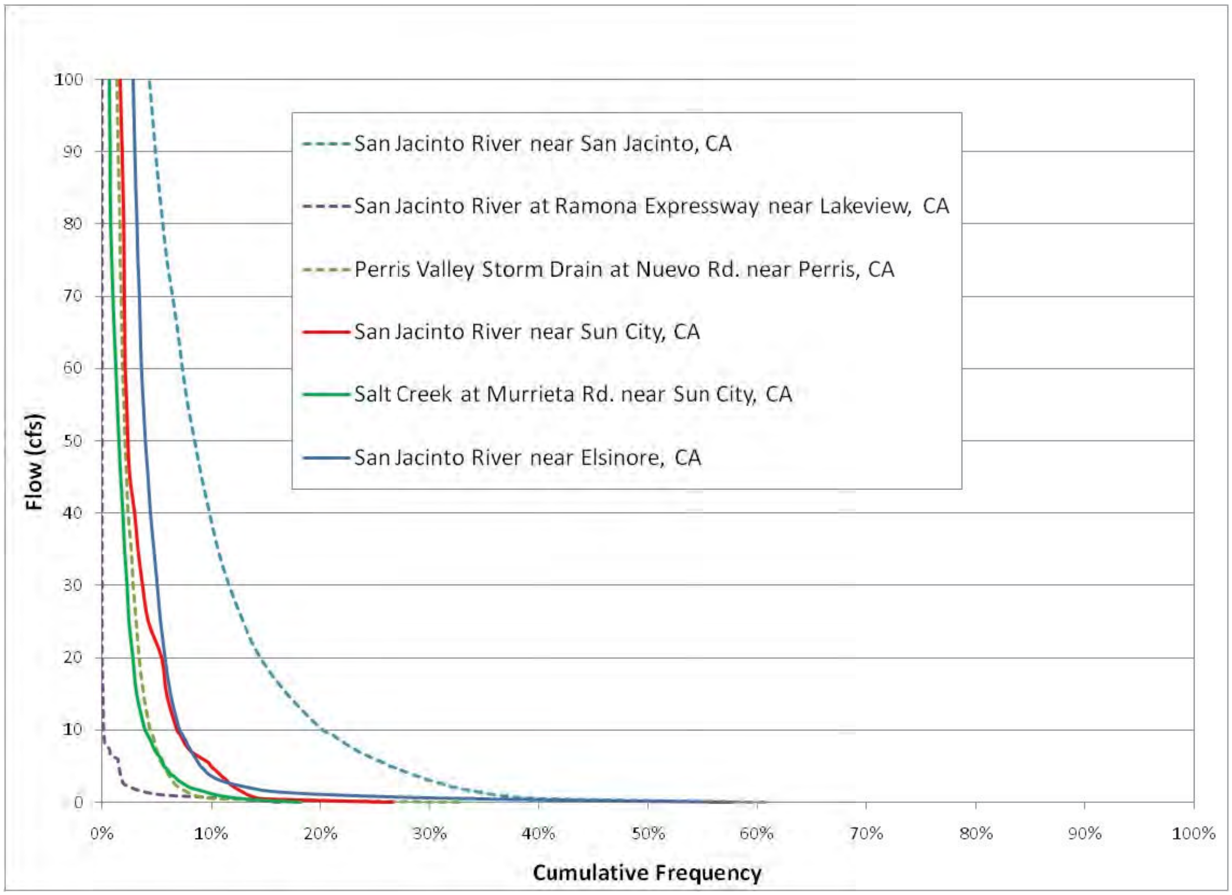


Figure B-5
Flow Duration Curves for Daily Mean Discharges at USGS Gauges in the San Jacinto River Watershed

B.4.4 Soils

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) categorizes soils into four distinct hydrologic soil groups, based on infiltration and transmission rates after prolonged wetting (Table B-12). Generally, soils in group A are well-drained and have a high infiltration while soils in group D have a slow infiltration rate. Soil data for the San Jacinto River Basin was obtained from STATSGO2 (USDA 2006) and summarized by hydrologic soil groups (Figure B-6). Areas draining to the north and south fork San Jacinto River are dominated by soil group C. Forest land is the most common land use in these areas. Areas draining to Salt Creek are also mainly represented by soil group C but differ from the north and south fork San Jacinto River drainage areas mainly because the unit-area flow for this area is lower. Potential causes for this difference may be poor quality of flow records, flows captured by the Paloma Valley Reservoir, or occasional diversions for irrigation and domestic use. The majority of the area draining to Perris Valley Storm Drain is classified as soil group B meaning the soil has moderate infiltration rates and a moderate rate of water transmission. This is a mixed land use area of the watershed and representative hydrographs show large stormwater runoff peaks with little or no associated groundwater flow. Local watersheds draining into Canyon Lake are classified as soil group D representing areas of low permeability.

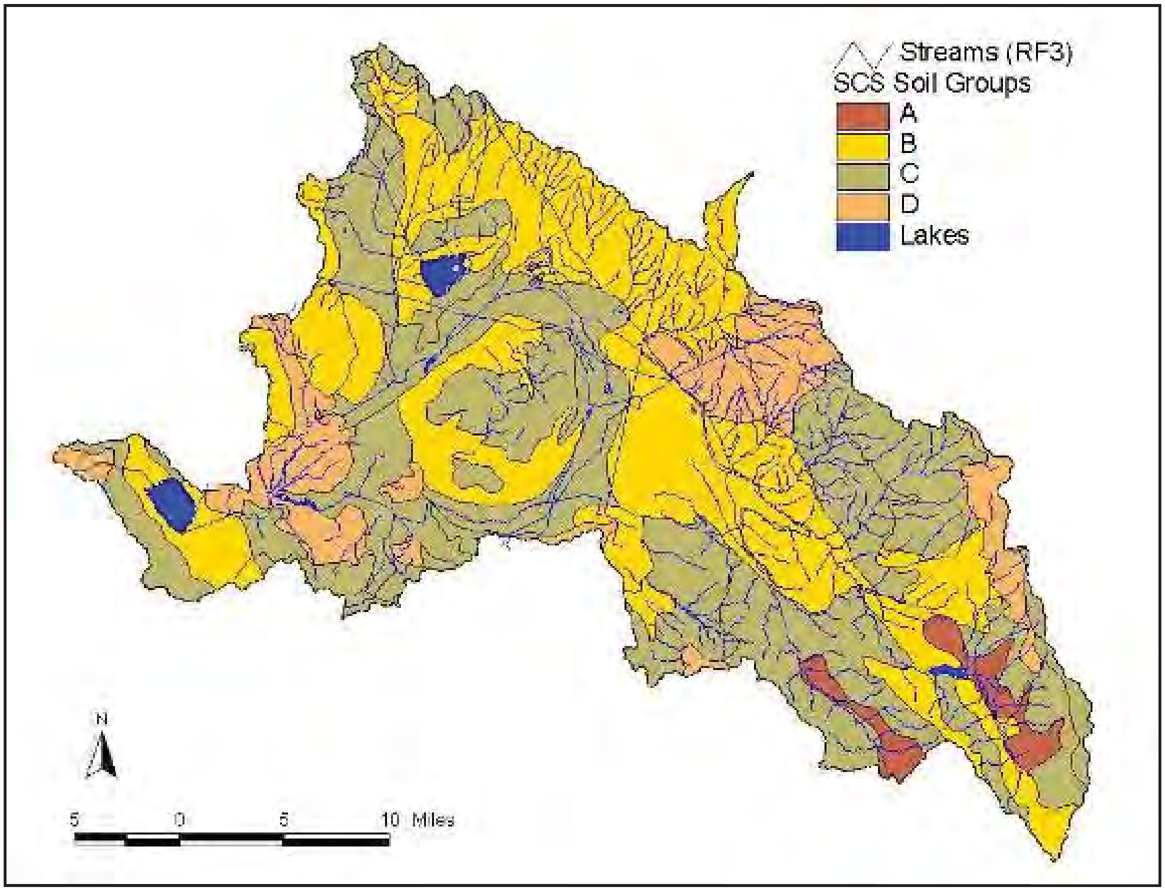


Figure B-6
Hydrological soil group map of the San Jacinto watershed

Table B-12. Hydrologic Soil Group Descriptions (USDA 2006)

Hydrologic Soils Group	Description
A	Soils with high infiltration rates. Usually deep, well drained sands or gravels. Little runoff.
B	Soils with moderate infiltration rates. Usually moderately deep, moderately well drained soils.
C	Soils with slow infiltration rates. Soils with finer textures and slow water movement.
D	Soils with very slow infiltration rates. Soils with high clay content and poor drainage. High amounts of runoff.
Not Applicable	Limited soil, exposed bedrock, or water body.

B.4.5 Water Quality

The following sections characterize water quality in Lake Elsinore, Canyon Lake, and runoff from the San Jacinto watershed. This analysis focuses on the primary indicators of nutrient impacts to water quality: total phosphorus, total nitrogen, dissolved oxygen, and chlorophyll a. This section is a summary of detailed information, which can be obtained Lake Elsinore & Canyon Lake Nutrient TMDL Annual Water Quality Reports, (http://www.sawpa.org/AnnualWQReports.htm).

Lake Elsinore

Elsinore Valley Municipal Water District's (EVMWD) initiated its NPDES compliance monitoring program for Lake Elsinore in April 2006. Initially, monitoring for nutrients occurred at three water quality sampling stations. Figure B-7 shows the sampling stations where surface, bottom, and integrated samples were collected. EMVWD collects samples monthly from October through May and biweekly from June through September.

Table B-13 summarizes monitoring results for the period July 1, 2006 through June 30, 2011 for the LEE2 sample location. Results are compared to basin plan objectives and TMDL targets.

Figure B-7 shows lake surface integrated, and lake bottom dissolved oxygen concentrations observed at station LEE2. Summer month's exhibit stratified dissolved oxygen, with the lake bottom samples declining to 0 mg/L. The winter months exhibit greater uniformity in dissolved oxygen concentrations, due to turnover and mixing of the epilimnion and hypolimnion.

Figure B-8 shows depth integrated total nitrogen and phosphorus results locations, averaged from all three sites. Nitrogen and phosphorus concentrations were generally uniform and did not exhibit seasonal fluctuations or significant changes as a result of depth. A spike in phosphorus concentrations was observed on April 11, 2011.

Figure B-9 shows depth integrated chlorophyll a, averaged from all three sites. There has been a gradual increase in chlorophyll a after October 2009, although further study is required to determine if this is a significant trend. Table B-14 provides the average chlorophyll a concentrations consolidated by season; concentrations decrease during the spring sample period compared to the other seasons, possibly due to an increase in precipitation which may dilute the algae.

Table B-13 Summary - Lake Elsinore Water Quality Data

Parameter	TMDL Compliance Date	Basin Plan Objectives or TMDL Targets	2006 - 2011 Results				
			No. of Sampling Events	Range of Daily Averages	Annual Mean	Annual Median	Standard Deviation
Dissolved Oxygen (mg/L) (Station LEE2, depth profile)	2015	Not less than 5 mg/L as a depth average	91	0.3 - 11.65	6.35	6.20	2.02
	2020	Not less than 5 mg/L 1 meter above lake bottom	91	0.00 - 11.50	4.24	3.65	2.56
pH (3 stations, depth profile)	---	6-5 - 8.5	101	6.72 - 9.76	8.92	8.95	0.35
Ammonia N (NH4-N) (mg/L) (3 stations, integrated samples)	2020	Data Results	100	ND - 0.77	0.14	0.09	0.15
		Acute Criteria Compliance	No observed exceedances of the acute criterion at the range of pH conditions measured.				
		Chronic Criteria Compliance	Exceedance of the chronic criteria observed 7.2% of the time (80 out of 1040 ammonia readings).on the following dates: 8/29/06, 12/19/06, 1/10/07, 10/12/07, 11/28/07, 1/16/08, 5/16/08, 6/27/08, 9/18/08, 7/29/09, 8/19/09 , 8/26/09, 9/11/09, 9/25/09, 10/21/09, 12/4/09, 6/9/10, 7/23/2010, 8/18/2010, 9/30/2010, 10/12/2010, and 6/29/2011.				
Total Nitrogen (TN) (mg/L) (3 stations, integrated samples)	2020	Annual average 0.75 mg/L	90	0.50 - 8.56	3.57	3.29	1.42
Total Phosphorus (TP) (mg/L) (3 stations, integrated samples)	2020	Annual average 0.1 mg/L	81	0.09 - 0.89	0.23	0.20	0.12
Chlorophyll *a* (µg/L) (3 stations, surface samples 0-2 m, April to September)	2015	Summer average no greater than 40 µg/L	95	15.2 - 247.5	93.27	88.37	55.08
Chlorophyll *a* (µg/L) (3 stations, integrated samples, April to September)	2020	Summer average no greater than 25 µg/L	96	16.1 - 271.3	89.41	90.19	52.51
Secchi Depth (cm) (3 stations)	---	---	100	28 - 102	57.56	52.19	19.64
Total Dissolved Solids (mg/L) (3 stations, integrated samples)	---	2000 mg/L	101	1082 - 1967	1449	1437	205

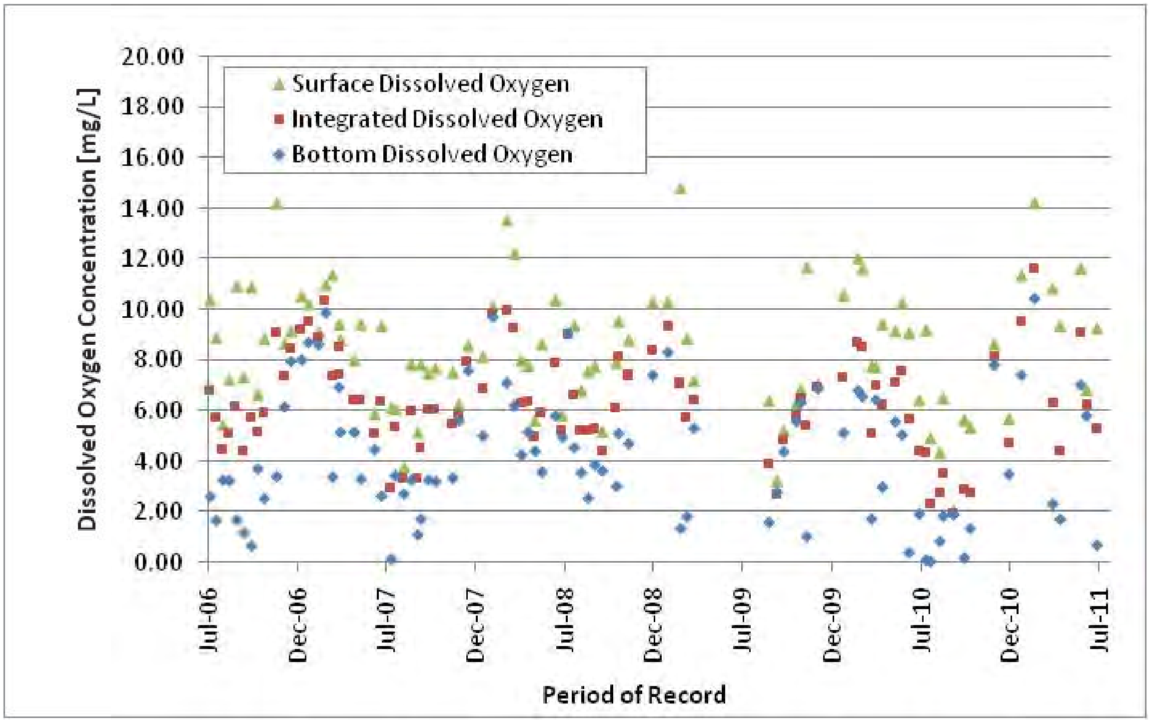


Figure B-7
Lake Elsinore Dissolved Oxygen Concentrations Observed at Station LEE2

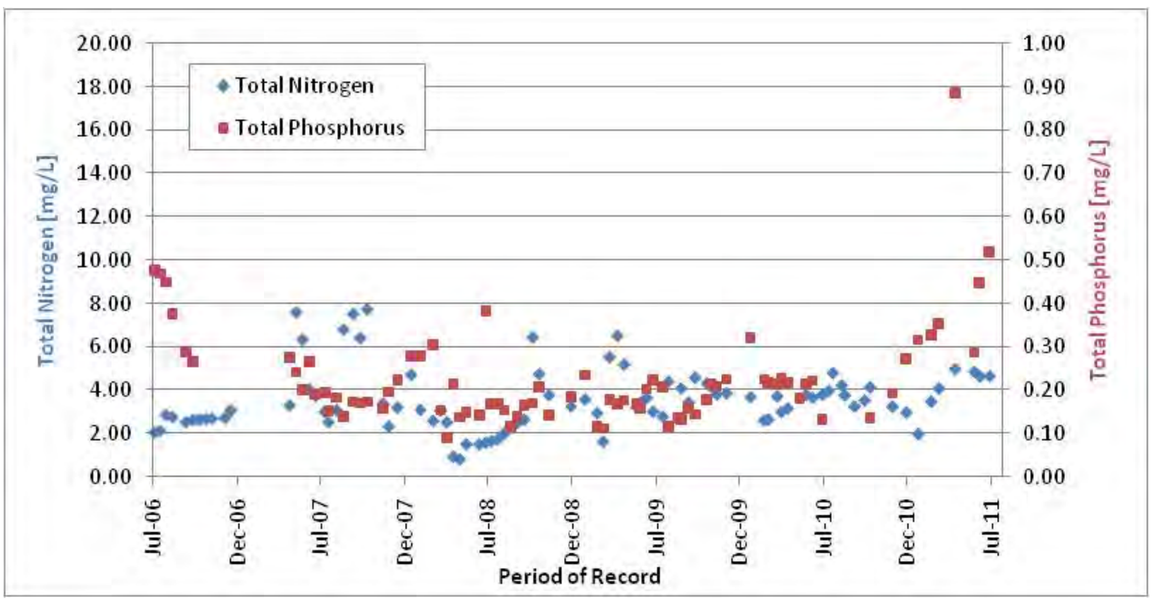


Figure B-8
Lake Elsinore Total Nitrogen and Total Phosphorus Concentrations

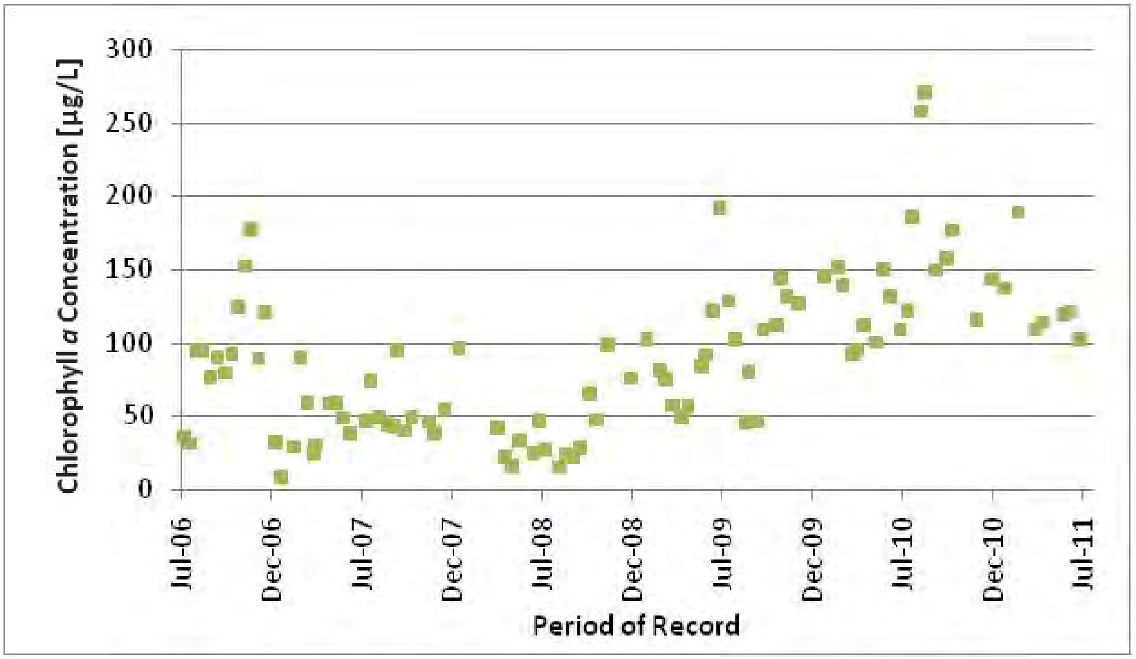


Figure B-9
Lake Elsinore Chlorophyll a Concentrations

Table B-14 Lake Elsinore average chlorophyll *a* concentrations consolidated by season

Season	Concentration [µg/L]
Winter	98.9
Spring	74.1
Summer	93.4
Fall	94.1

The Redfield ratio has been used to determine the limiting nutrient for algal growth in the lake. The nutrient that is below the ratio likely limits the growth of phytoplankton (Schindler et al. 2008). For this analysis, a 7:1 ratio for nitrogen to phosphorus (N:P) was used. Figure B-10 shows the N:P ratios observed in Lake Elsinore. For most of the period of record, the observed N:P ratio is greater than 7:1, indicating that phosphorus is the limiting nutrient.

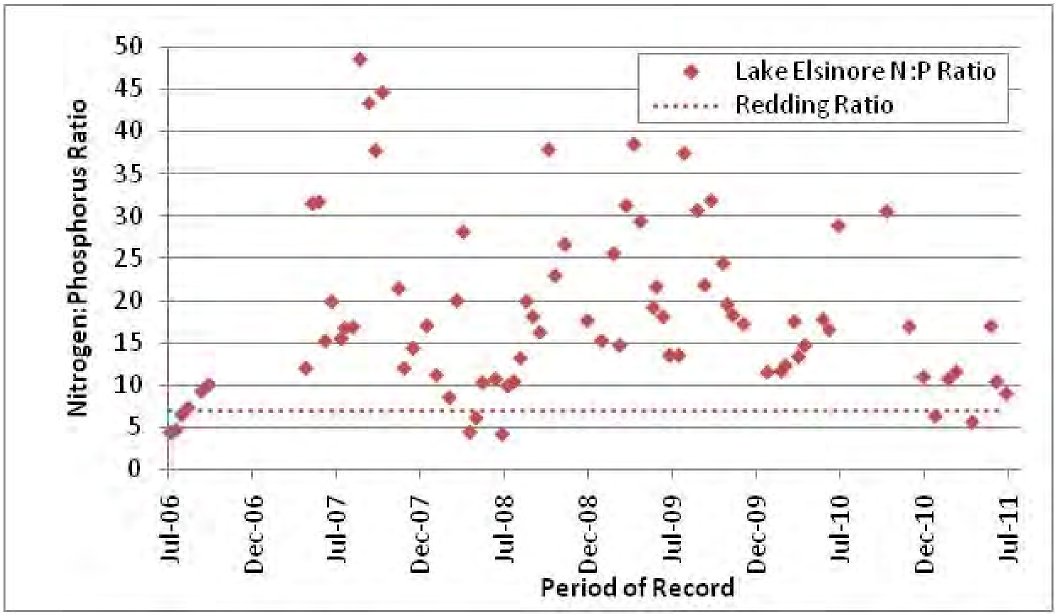


Figure B-10
Observed Lake Elsinore Nitrogen to Phosphorus Ratios

Canyon Lake

EVMWD's NPDES compliance monitoring program for Canyon Lake, which began June 2007, consists of four sampling locations (Figure B-11). Samples from Station CL07 and CL08 are located within the Main Basin and Stations CL09 and CL10 are located in the East Basin.

- Station CL07 – Located at the deepest part of the lake near the dam. The site is generally strongly stratified during the summer.
- Station CL08 – Located mid-lake in the main body of Canyon Lake.
- Station CL09 and CL10 – Two relatively shallow sample locations within the East Basin of the lake that receive local nuisance runoff and discharges from Salt Creek during wet weather events.

Unless stated otherwise, in subsequent tables and figures the Main Basin sampling results are averaged samples from Stations CL07 and CL08, and East Basin sampling results are averaged samples from Stations CL09 and CL10. Samples are collected monthly from October through May, and biweekly from June through September. Table B-15 summarizes Canyon Lake monitoring results for the period July 1, 2007 through June 30, 2011.

Table B-15 Summary – Canyon Lake Water Quality Data

Parameter	TMDL Compliance Date	Basin Plan Objectives or TMDL Targets	Main Basin 2007- 2011 Results					East Basin 2006 - 2011 Results				
			No. of Sampling Events	Range of Daily Averages	Annual Mean	Annual Median	Standard Deviation	No. of Sampling Events	Range of Daily Averages	Annual Mean	Annual Median	Standard Deviation
Dissolved Oxygen (mg/L) (Station 07 for Main Basin; Stations 09 and 10 for East Basin)	2015	Not less than 5 mg/L above the thermocline	61	0.94 - 13.75	7.01	7.27	2.85	60.00	0.33 - 11.17	6.24	6.01	1.56
	2020	Not less than 5 mg/L daily average in hypolimnion	61	0 - 5.7	0.89	0.21	1.53					
pH (Station 07 for Main Basin; Stations 09 and 10 for East Basin)	---	6-5 - 8.5	68	7.43 - 8.94	8.02	7.98	0.34	68	7.30 - 9.70	8.31	8.22	0.47
Ammonia N (NH4-N) (mg/L) (Station 07 for Main Basin; Stations 09 and 10 for East Basin)	2020	Data Results	70	0.011 - 1.800	0.49	0.44	0.31	70	ND - 1.290	0.40	0.37	0.28
		Acute Criteria Compliance	Exceedances of the acute criterion on: 5/30/08; observed 0.16% of the time (1 out of 644 samples)					Exceedances of the acute criterion on: 5/30/08; observed 0.18% of the time (1 out of 551 samples)				
		Chronic Criteria Compliance	Exceedances of the chronic criterion: 6/18/08, 7/2/08, 7/1/09, 7/24/09, 5/10/10, 6/28/10, 6/12/10, 7/30/10, 8/9/10, 8/30/10, 9/17/10, 10/26/10; Exceedances observed 2.95% of the time (19 out of 644 samples)					Exceedances of the chronic criterion: 5/30/08, 6/6/08, 6/18/08, 7/2/08, 7/24/09, 11/30/09, 6/11/10, 6/28/10; Exceedances observed 4.54% of the time (25 out of 551 samples)				
Total Nitrogen (TN) (mg/L)	2020	Annual average 0.75 mg/L	68	0.33 - 4.37	2.06	2.00	0.93	69	0.35 - 5.49	2.04	1.92	0.92
Total Phosphoru s (TP) (mg/L)	2020	Annual average 0.1 mg/L	70	0.33 - 1.74	0.68	0.64	0.25	70	0.09 - 2.27	0.61	0.53	0.36
Chlorophyll *a* (µg/L) (surface samples 0-2 m)	2015	Summer average no greater than 40 µg/L	40	1.5 - 138.3	34.33[1]	29.30	27.49	45	2.5 - 266.1	61.00	38.85	71.62

Table B-15 Summary – Canyon Lake Water Quality Data (continued)

Parameter	TMDL Compliance Date	Basin Plan Objectives or TMDL Targets	Main Basin 2007- 2011 Results					East Basin 2006 - 2011 Results				
			No. of Sampling Events	Range of Daily Averages	Annual Mean	Annual Median	Standard Deviation	No. of Sampling Events	Range of Daily Averages	Annual Mean	Annual Median	Standard Deviation
Chlorophyll *a* (µg/L) (integrated samples)	2020	Summer average no greater than 25 µg/L	60	1.0 - 171.8	37.56[1]	33.49	28.77	60	2.5 - 266.1	56.19	50.92	46.22
Secchi Depth (cm)	---	---	68	18 - 301	119.32	113.25	44.67	69	21 - 231	90.50	86.36	34.26
Total Dissolved Solids (mg/L) (integrated samples)	---	700 mg/L	69	152 - 901	616.63	684.00	215.96	68	336 - 1206	703.82	658.11	223.28

[1] Data presented as annual mean

Figure B-11 shows observed dissolved oxygen concentrations at Station CL07 (closest to the lake spillway). Highly stratified conditions exist throughout most of the year, with the lake bottom concentrations at 0 mg/L for most months. The winter months exhibit greater uniformity in dissolved oxygen concentrations, due to turnover and mixing of the epilimnion and hypolimnion.

Figure B-12 shows observed dissolved oxygen concentrations at Station CL08 (most representative of Main Basin). Dissolved oxygen concentrations are similar to the values found in CL07, with peaks and troughs occurring on the same sample dates as CL07. Highly stratified conditions exist throughout most of the year, with the lake bottom concentrations at 0 mg/L for most months. The winter months exhibit greater uniformity in dissolved oxygen concentrations, due to turnover and mixing of the epilimnion and hypolimnion.

Figure B-13 characterizes observed dissolved oxygen concentrations at Stations CL09 and CL10. Due to the low water depth and inflow from Salt Creek, stratification does not occur in this portion of the lake. Dissolved oxygen concentrations in the East Basin have remained relatively constant throughout the period of record.

Figures B-14 and B-15 show depth integrated total nitrogen and phosphorus observations within the Main Basin and East Basin, respectively. Similar observations occurred at both sample locations. Nitrogen and phosphorus concentrations were generally uniform and did not exhibit seasonal fluctuations or significant changes by depth. Peaks and troughs in nutrient concentrations occurred generally during the same periods. However, the spike in phosphorus concentrations, observed on April 11, 2011 and continuing to the end of the sampling season, was not observed for nitrogen.

Figure B-16 illustrates depth integrated chlorophyll a concentrations for the Main Basin and East Basin sample locations. Peaks and troughs of chlorophyll a concentrations occurred at the same time at both sites; however, concentrations in the East Basin have been typically higher than the Main Basin. Table B-16 summarizes the average seasonal chlorophyll a concentrations at both sample locations. The lowest concentrations have been observed in the spring.

Figure B-17 characterizes the average N:P ratio for both lake basins. For the majority of the period of record, the N:P ratio of N:P is less than 7:1, indicating that nitrogen is the limiting nutrient.

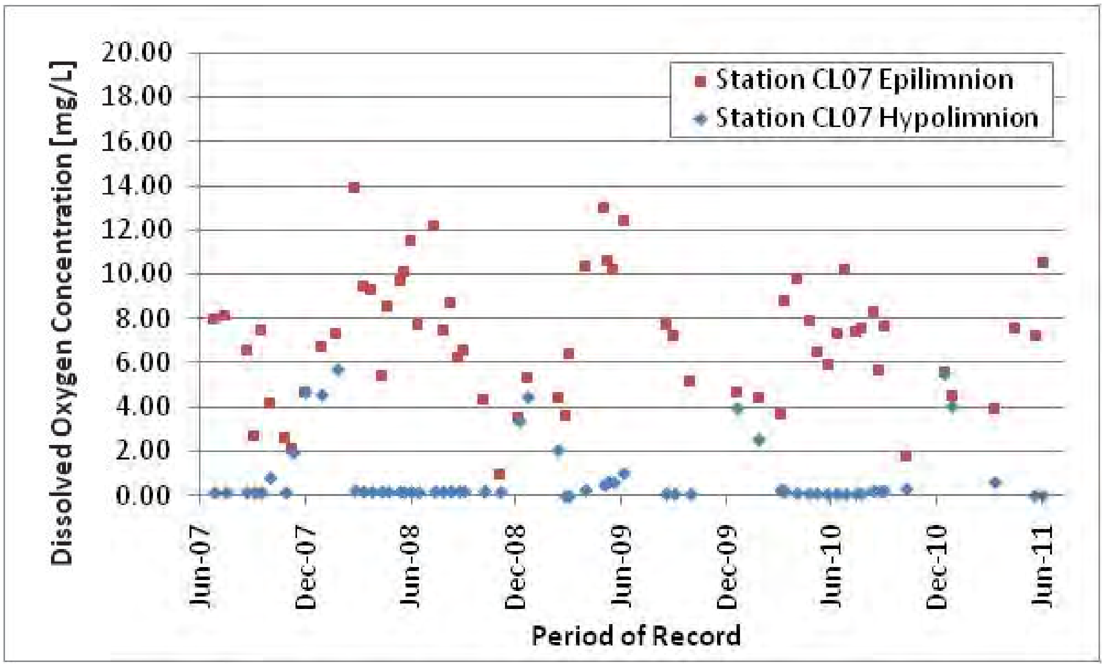


Figure B-11
Canyon Lake Dissolved Oxygen Concentrations at Station CL07

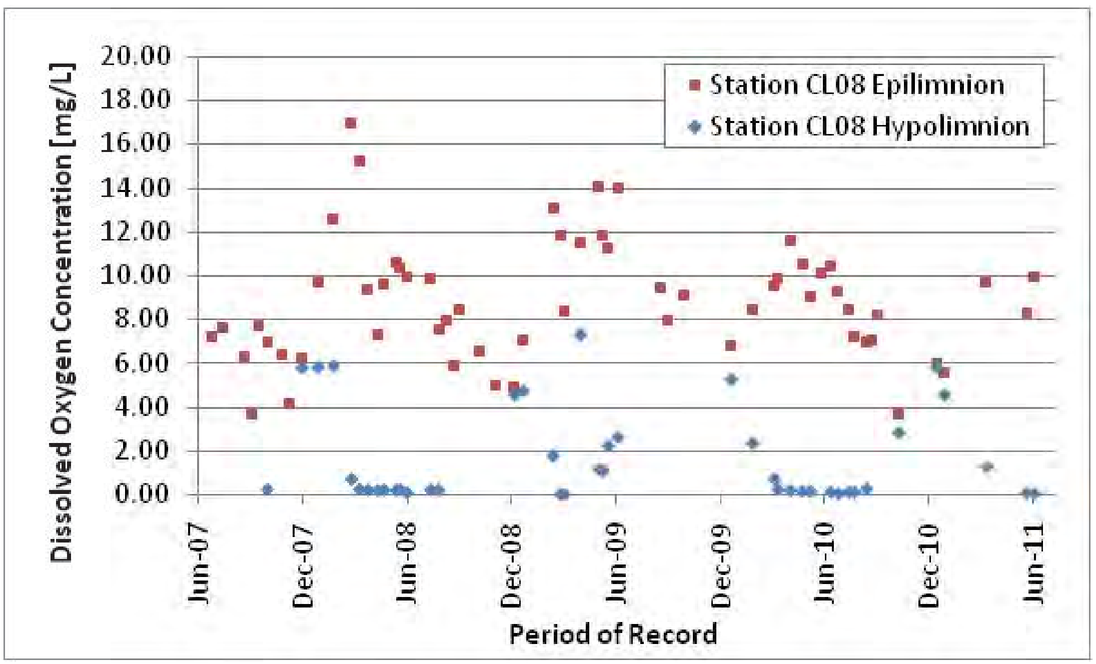


Figure B-12
Canyon Lake Dissolved Oxygen Concentrations at Station CL08

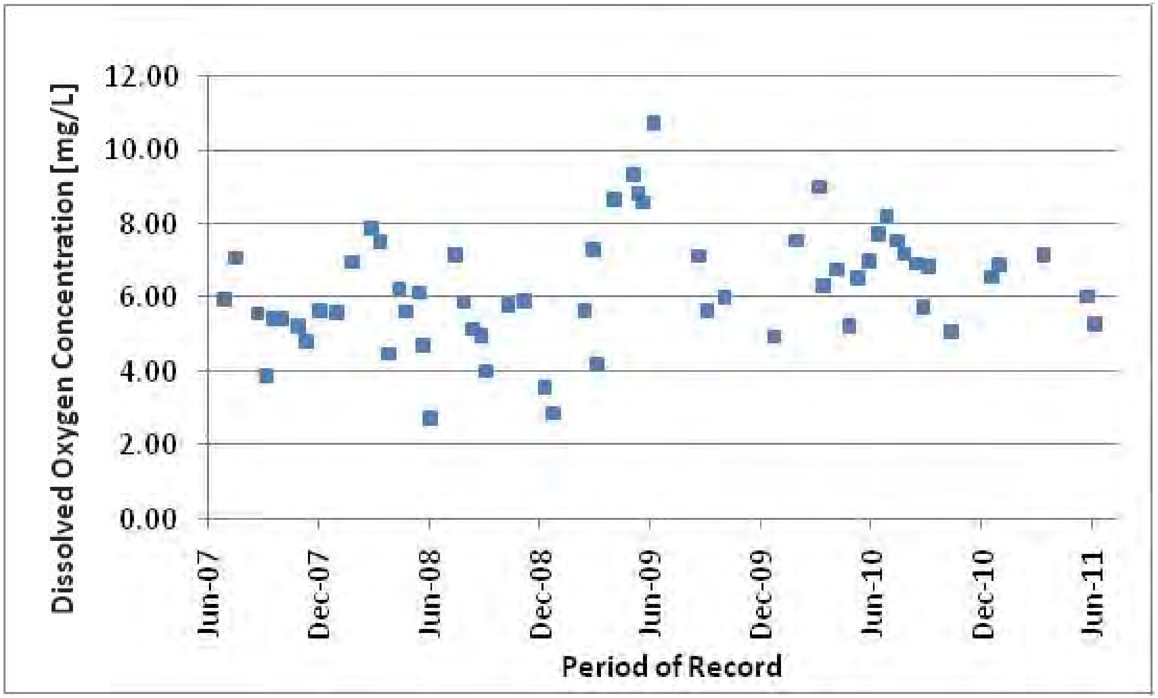


Figure B-13
Canyon Lake Dissolved Oxygen Concentrations at East Basin Sample Locations (CL09 and CL10)

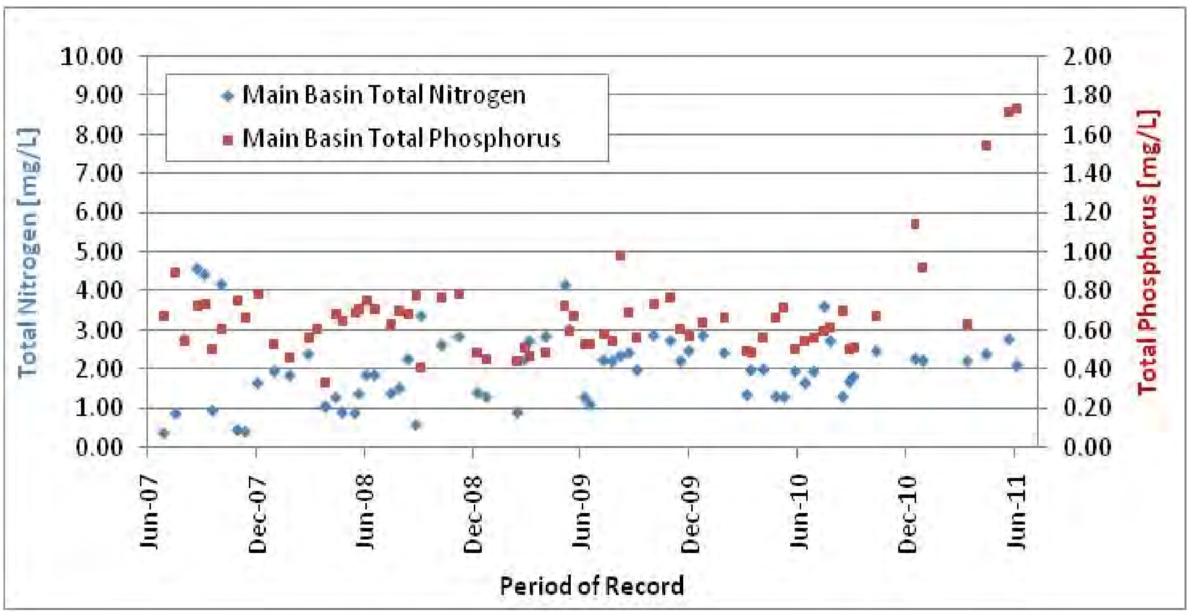


Figure B-14
Canyon Lake Total Nitrogen and Total Phosphorus Concentrations in the Main Basin

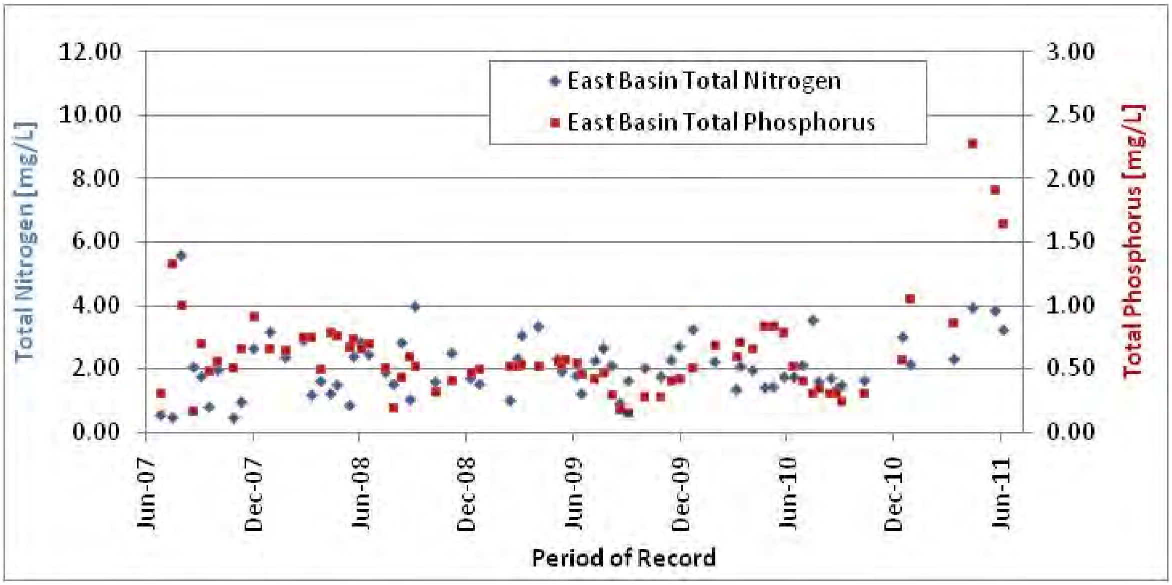


Figure B-15
Canyon Lake Total Nitrogen and Total Phosphorus Concentrations in the East Basin

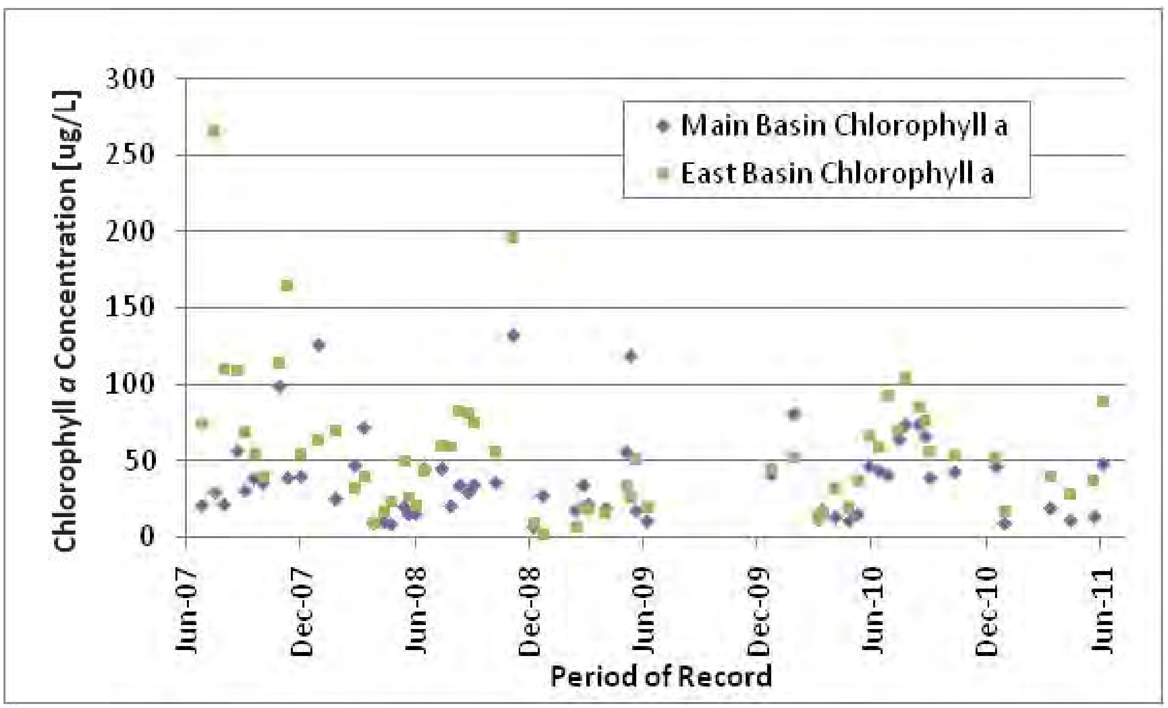


Figure B-16
Canyon Lake Chlorophyll *a* Concentrations

Table B-16 Canyon Lake average Chlorophyll *a* Concentrations (µg/L) by Season

Season	Main Basin	East Basin
Winter	41.4	36.7
Spring	27.9	25.4
Summer	35.1	74.0
Fall	51.6	87.8

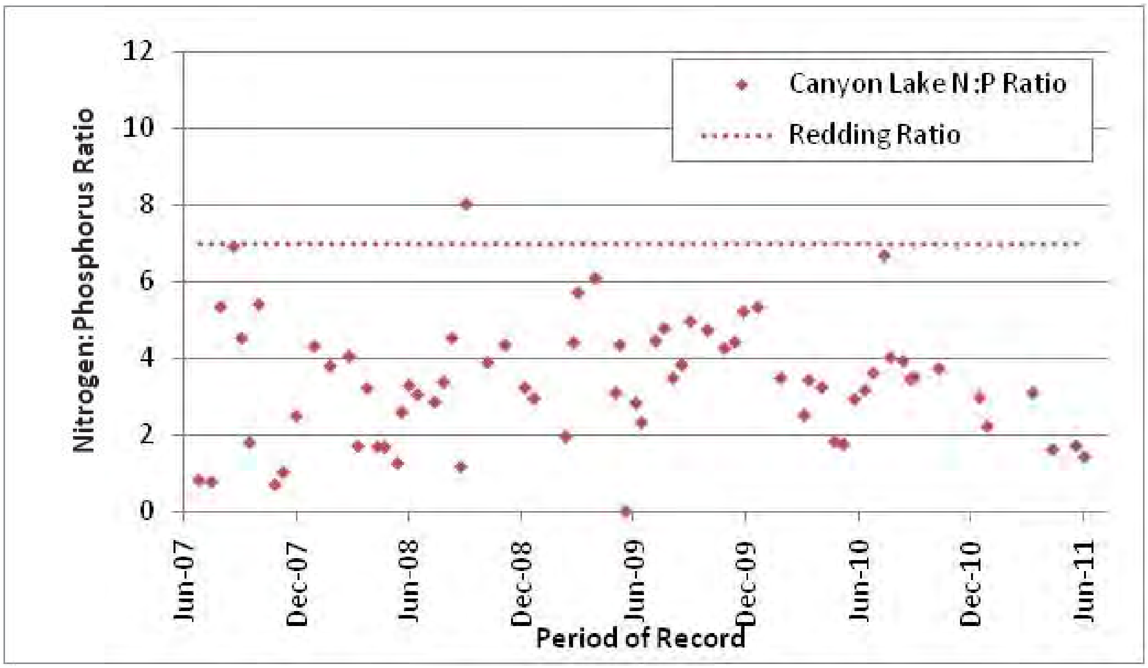


Figure B-17
Observed Canyon Lake Nitrogen to Phosphorus Ratios

San Jacinto Watershed

As part of the Phase I San Jacinto River Watershed Monitoring Program, water quality samples were collected from four sample locations during wet weather events (Figure B-18):

- Salt Creek at Murrieta Rd – Area tributary to this sample location includes the southern portion of the San Jacinto watershed, with land uses consisting of irrigated croplands and residential.
- Goetz Road – Tributary area includes the northern half of the San Jacinto watershed; land use includes urban, irrigated croplands, residential, and open space. This monitoring location has the largest tributary area, but much of the water is captured by nearby Mystic Lake.

- Canyon Lake Spillway – Only during high storm events is water released from Canyon Lake to Lake Elsinore. Samples are gathered from this site only when water is released.

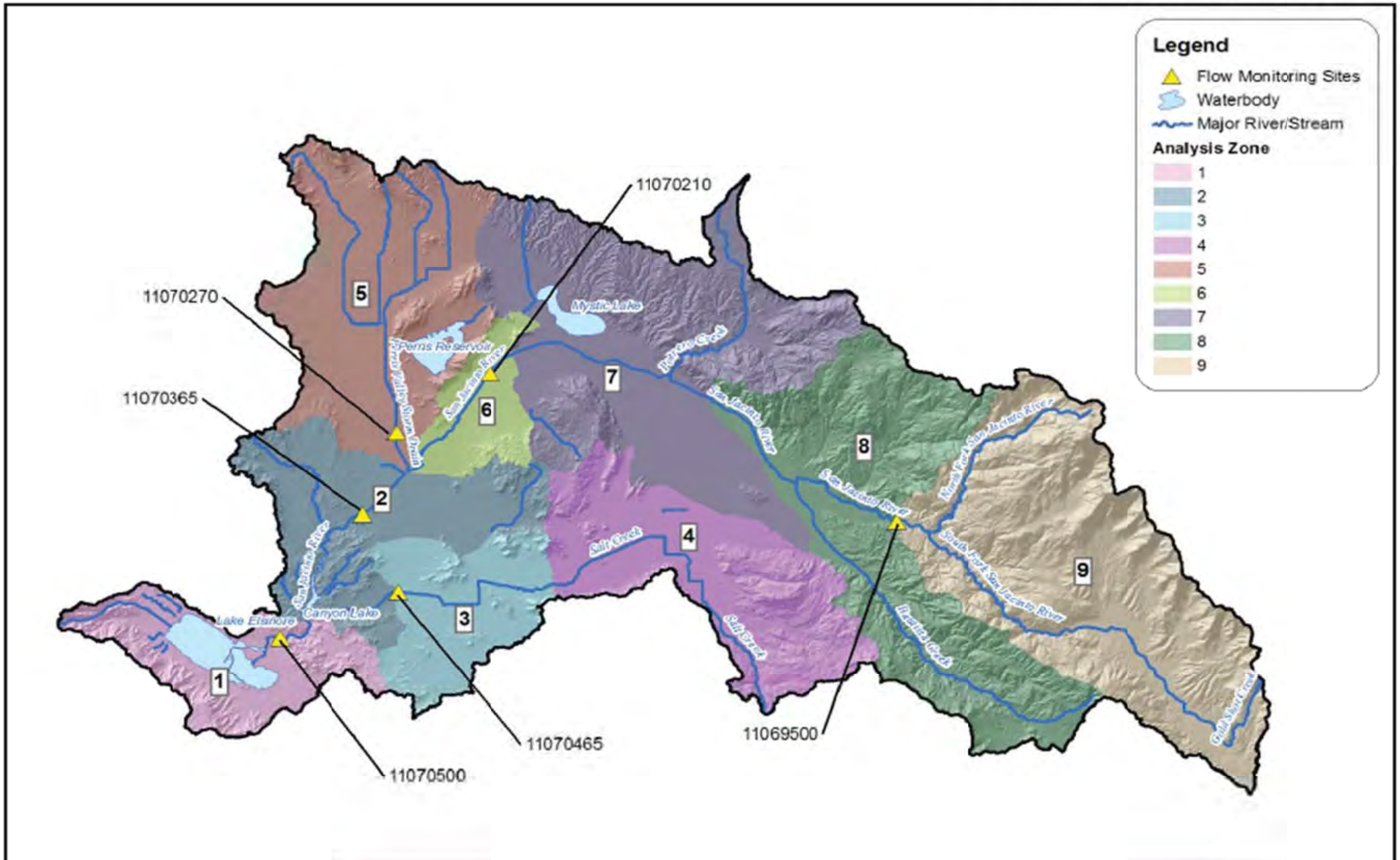
- Cranston Guard Station – This station is located at the eastern portion of the watershed. This station experiences the highest annual flows compared to the other stations. Sampling at this station is conducted by the United States Forest Service, and is dependent on whether adequate funding is allocated through Congress. Land use upstream of this site is forested area.

- A fifth station, San Jacinto River at Ramona Expressway, would be sampled if Mystic Lake overflows; however, since the implementation of this monitoring program no such overflows have occurred.

Samples are collected throughout observed storms at different points of the hydrograph to obtain a range of concentrations across the storm event. Sampling methodology is described in detail in the Lake Elsinore & Canyon Lake Nutrient TMDL Annual Water Quality Monitoring Reports. Figures B-19 and B-20 illustrate the observed water quality concentrations for total phosphorus and total nitrogen, respectively; Table B-17 summarizes the water quality data. Sample results indicate that nutrient concentrations tend to be higher during the beginning of the storm (first flush) and then decrease during later portions of the storm event. San Jacinto River at Goetz Road and Salt Creek at Murrieta Road have the highest concentrations of total nitrogen based on observed median concentrations, while the Goetz Road site has the highest total phosphorus. The average N:P ratio was calculated for each watershed water quality sample site; all ratios were less than 7.1, indicating that nitrogen is the limiting nutrient in wet weather runoff.

Table B-17. Summary of Nutrient Water Quality Data for San Jacinto Watershed (mg/L)

Waterbody	Nutrient	N	Average Concentration	Median Concentration	Standard Deviation	Average N:P Ratio
Salt Creek at Murrieta Road	Total Phosphorus	108	0.75	0.66	0.47	4.2
	Total Nitrogen	108	2.47	2.32	0.91	
San Jacinto River at Goetz Road	Total Phosphorus	90	1.44	0.95	1.84	2.7
	Total Nitrogen	90	2.73	2.26	1.70	
Canyon Lake Spillway	Total Phosphorus	59	0.57	0.50	0.21	3.2
	Total Nitrogen	59	1.78	1.76	0.55	
Cranston Guard Station	Total Phosphorus	29	0.65	0.49	0.44	2.4
	Total Nitrogen	29	1.22	1.10	0.57	



Agricultural Nutrient Management Plan for WRCAC in Canyon Lake and Lake Elsinore Watershed	Dec. 1, 2011	0 2 4 8 Miles		Figure B-18	CDM Smith
	Watershed Analysis Zones and Flow Monitoring Stations				

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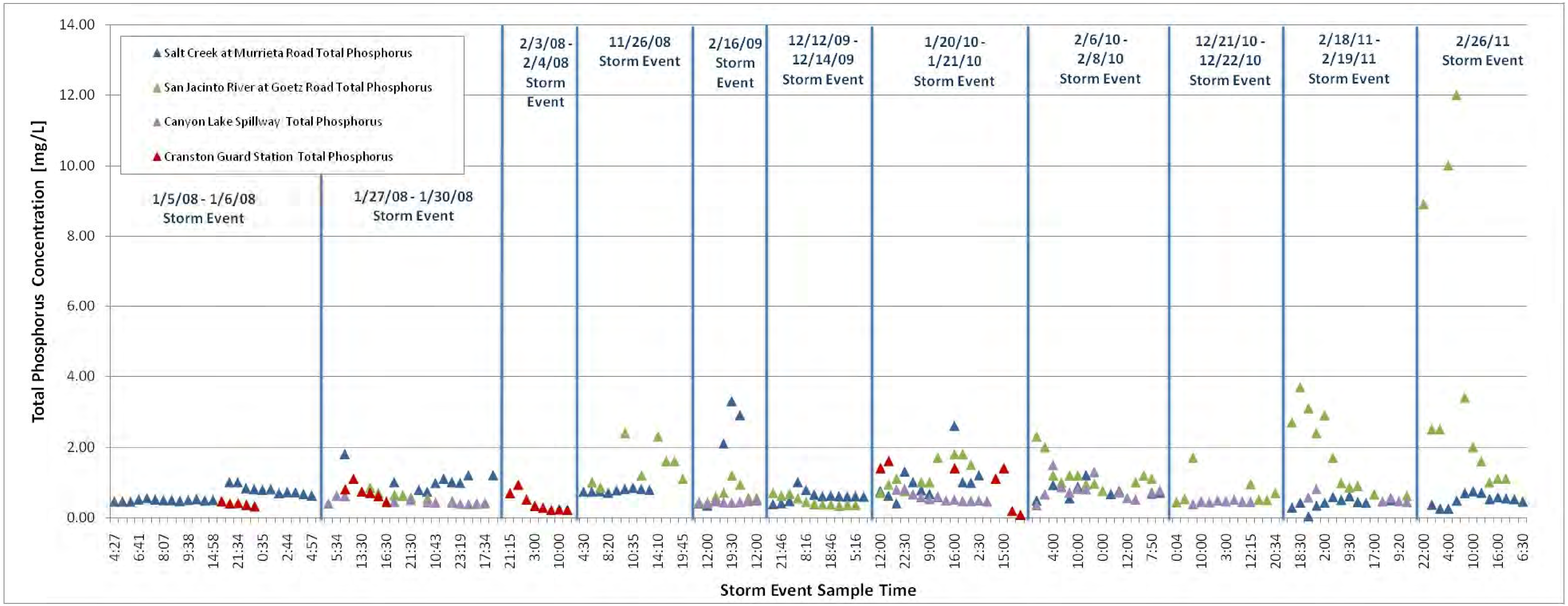

Figure B-19
Wet-Weather Sampling Total Phosphorus Concentrations

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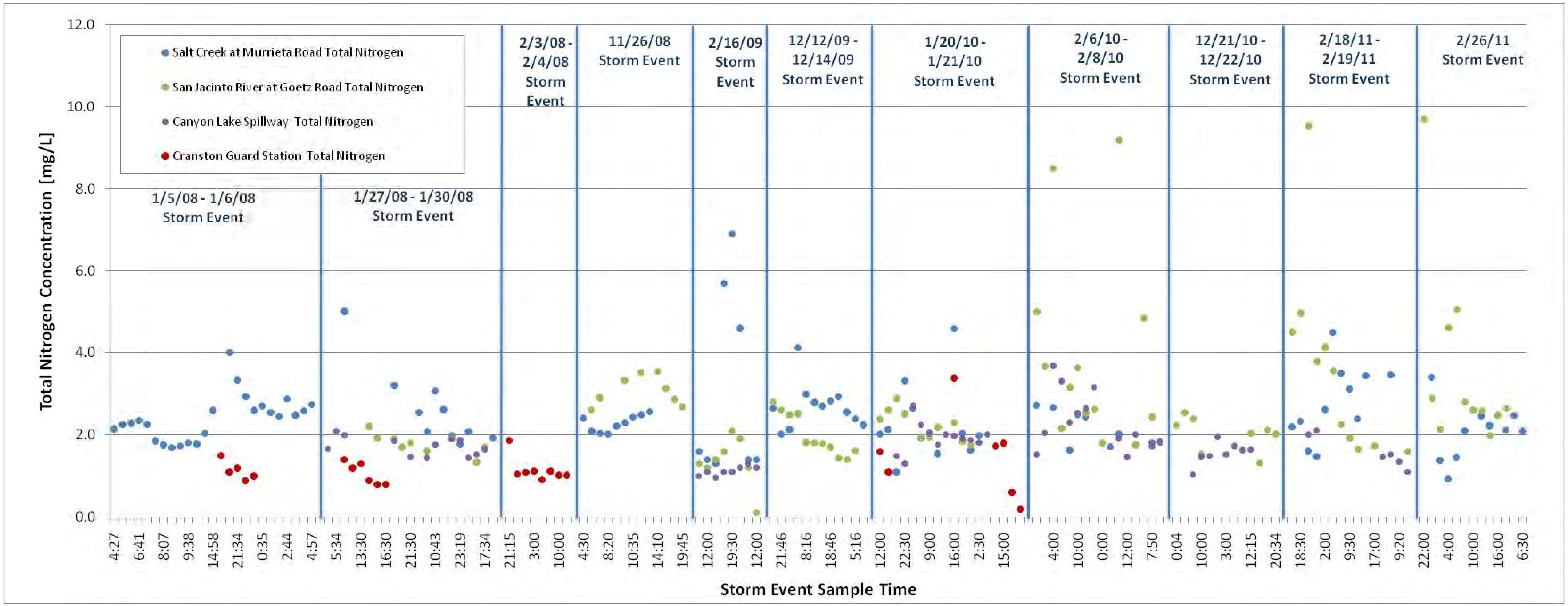

Figure B-20
Wet-Weather Sampling Total Nitrogen Concentrations

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Attachment C
Canyon Lake Nutrient TMDL In-Lake Strategies Evaluation

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Attachment C
Canyon Lake Nutrient TMDL In-Lake Strategies Evaluation

C-1 Executive Summary

In order to achieve compliance with the Lake Elsinore and Canyon Lake nutrient TMDLs, the responsible parties, which include WRCAC member agricultural and dairy operators, considered: (1) implementing watershed-based activities and projects that reduce the discharge of nutrients into the lake; (2) implementing projects in the lakes that reduce in-lake loads and concentrations projects; or (3) some combination of watershed and in-lake BMPs. The December 31, 2011 draft of the CNRP contained an evaluation of different strategies for in-lake reduction of nutrient levels in Canyon Lake, and determined that HOS would be the most effective means of complying with the nutrient TMDL. The basis for this determination were studies showing that suppression of nutrient flux from lake bottom sediments by creating an oxic condition at the sediment water interface would more than offset the load reduction needed to reduce existing urban and septic loads to the allowable WLA/LAs, after accounting for estimated watershed loads reduction.

In January of 2012, the Task Force sought Michael Anderson to conduct additional studies to evaluate chemical addition alternatives and to determine the potential impact of HOS on in-lake TMDL response targets for chlorophyll-a and DO. The studies were intended to provide additional confirmation on the selection of a HOS by assessing whether it can be a whole-lake solution (addressing needs for all sources with an allocated load), or to revise the proposed in lake nutrient management strategy to use chemical addition or regulatory approaches to achieve the response targets. Section C.2 of this attachment provides the results of these studies. The key findings from each study that led to a revision to the Canyon Lake in-lake nutrient management strategy are summarized below:

- Task 1: Estimate Rate at Which Phosphorus is Rendered No Longer Bioavailable in Sediments. This task showed that settled nutrients in lake-bottom sediments continue to release nutrients to the water column for several decades. Thus a reduction in external loads from CNRP implementation may not result in a significant change to internal nutrient cycling prior to 2020.

- Task 2: Evaluation of Long-Term Reduction of Phosphorus Loads from Internal Recycling as a Result of Hypolimnetic Oxygenation in Canyon Lake: This study showed that HOS will not provide sufficient nutrient reduction in years with above average rainfall to achieve response target for chlorophyll-a. In its March 31, 2012 comment letter, the Regional Board states that if the WLAs and LAs are effectively offset with in lake BMPs, but response targets are still not achieved, then the TMDL would be reopened to reduce WLAs and LAs. Thus, HOS alone is not sufficient to achieve compliance with the TMDL.

- Task 3: Evaluation of Alum Phoslock, and Modified Zeolite to Sequester Nutrients in Inflow and Improve Water Quality in Canyon Lake. This study evaluated the potential water quality benefit that could be achieved with chemical additional alternatives. The DYRESM-CAEDYM results showed that a reduction in dissolved orthophosphate at the lake inflows from ~0.35 mg/L to 0.20 mg/L would shift the lake to P-limitation and reduce average annual chlorophyll-a to below the final numeric target of 25 ug/L. The study also evaluated potential doses and associated costs for alum, Phoslock, or zeolite.

- Task 4: Predevelopment Condition Assessments for Canyon Lake (Task 4a) and Lake Elsinore (Task 4b). To estimate the controllability of water quality in Canyon Lake and Lake Elsinore, the DYRESM-CAEDYM model was run for a scenario with external loads reflective of a completely undeveloped watershed. This scenario showed chlorophyll-a consistently below the water quality objectives. For DO, exceedences of the water quality objectives were estimated to occur as much as 50 percent of the time in Canyon Lake. Thus, a completely undeveloped watershed would not comply with the DO numeric target, as stated in the TMDL. The WRCAC agricultural and dairy operators will work with the MS4 Permittees to modify the TMDL numeric target at the next reopener of the TMDL, to allow for exceedences of the DO water quality objective within the hypolimnion as would be expected if the watershed were completely undeveloped.

- Task 5a: Simulations Using Refined Model Parameter Set Under Steady State Conditions for Lake Elsinore. This analysis updated previous evaluations of management alternatives. The analysis quantifies the improvement to lake TP and chlorophyll-a that may be achieved with reclaimed water addition, carp fishery management, and aeration. Results suggest that, at a minimum, all three management strategies will be needed to comply with the TMDL

- Task 5b: Evaluate Effects of Management Alternatives for Canyon Lake on External Nutrient Loading to Lake Elsinore. This study updated the DYRESM-CAEDYM model to create a linkage between Canyon Lake and Lake Elsinore, for testing whether improved lake water quality in Canyon Lake would reduce pass-through loads to Lake Elsinore. Results showed limited pass-through load reductions as a result of in-lake BMPs in Canyon Lake.

- Task 6: Predicted Water Quality in Canyon Lake with In-Lake Alum Treatments and Watershed BMPs. This task involved simulation of the water quality response to proposed watershed BMPs and in-lake alum additions included in the AgNMP and CNRP. Results showed that the final numeric target for chlorophyll-a is expected to be achieved with the proposed project (Scenario 12 in the TM). For DO, the results show that the interim (epilimnion) DO target is expected to be achieved and significant progress toward the final (hypolimnion) target. These results are the primary basis for the Canyon Lake compliance demonstration presented in Section 3 of the AgNMP

When alum is added to a waterbody, an aluminum hydroxide precipitate known as floc is formed. The floc binds with phosphorus in the water column to form an aluminum phosphate compound which will settle to the bottom of the lake or reservoir.

EVMWD conducted jar tests to determine the reduction of TP that could be achieved at varying doses of alum. Samples collected at all four TMDL monitoring stations were collected and varying amounts of alum were added to each. Jar test results are summarized in Section C.3 of this Attachment.

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ATTACHMENT D
EXISTING NUTRIENT CONTROL PROGRAMS

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Acronyms

ARS	Agricultural Research Service
BARCT	Best Available Retrofit Control Technology
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
CCC	California Coastal Commission
CMS	Conservation Management System
CNMP	Comprehensive Nutrient Management Plan
DPR	Department of Pesticide Regulation
EQIP	Environmental Quality Incentives Program
FOTG	Field Office Technical Guide
GWPA	Ground Water Protection Area
IPM	Integrated Pest Management
LCAF	Large Confined Animal Facility
NEPA	National Environmental Policy Act
NMP	Nutrient Management Plan
NOx	Nitrate and Nitrite Nitrogen
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PAM	Polyacrylamide
PM10	Particulate Matter less than 10 micrometers in diameter
PM2.5	Particulate Matter less than 2.5 micrometers in diameter
PROSIP	Program Strategy and Implementation Plan
RUSLE	Revised Universal Soil Loss Equation
RWQCB	Regional Water Quality Control Board
SJRWC	San Jacinto River Watershed Council

TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOC	Volatile Organic Compounds

D.1 Introduction

California agriculture is the most highly regulated in the nation and probably the world. Producers must comply with many different types of government regulations ranging from environmental quality to food safety. These regulations were adopted to protect our health, the environment, and farm workers. But the regulations are often duplicative, conflicting, uncoordinated, inflexible or needlessly burdensome. While the agricultural community continually expands environmental stewardship through beneficial management practices there is also increased costs, and regulations from production inputs. On top of these hard costs are both the financial and time costs of complying with environmental laws and regulations which could often be reduced through more widespread adoption of feasible stewardship practices and coordination with multiple requirements. The AgNMP program will coordinate various ag programs, reduce redundancy that might otherwise occur and identify opportunities for reducing nutrient loads in the San Jacinto watershed. The Western Riverside County Agriculture Coalition (WRCAC) was formed in 2004 by dairy operators determined to be good environmental stewards on issues like the Total Maximum Daily Load (TMDL) for nutrients, a renewed dairy permit and the need to engage agricultural operators in this process. Agricultural operators became engaged in the TMDL process without a mandatory permit. The challenge was to identify actual agricultural ownership and types of land use for the watershed. Attachment B summarizes agricultural land use mapping activities. WRCAC is confident in the land use data collected over the past nine years as it accurately describes agricultural activity in the San Jacinto watershed. However, specific agricultural owner BMPs have not in any way been attributed in past model load reductions. There are many reasons for this omission but the obvious one is that there are hundreds of owners that each implements different BMPs. There is no single mechanism to record agricultural BMPs. A citrus grower may use mulch and micro-emitters to reduce water costs and surface runoff, while an irrigated farmer may place buffer strips along waterways next to his crops. The following sections discuss current practices and activities that will be completed in the AgNMP.

D.2 AgNMP Activities

AgNMP activities include: development of an agricultural survey and weBMP database tool, planned development and implementation of the process for individual agricultural operator reporting of BMPs and related activities to better assess load reductions, a pilot scale gasification project with regional potential on a larger scale, use of existing guidance practices, and continued participation in in-lake projects such as aeration for Lake Elsinore and alum application in Canyon Lake. The agricultural activities specific to the agricultural community are mentioned in this attachment.

D.2.1 Agricultural Survey and weBMP Database Tool

WRCAC received a 319 grant for “Implementation of Nutrient Total Maximum Daily Loads (TMDL) in the San Jacinto Watershed through a Feasibility Assessment for Pollutant Trading for Agricultural Operators and the Development of a Best Management Practices(BMPs) Database Tool “-Agreement 10-446-558. Significant progress has been made in identifying agricultural operators and aerial mapping for land use had been completed using 2007 data. Baseline TMDL data was then collected for 2005 and 2010 data was completed in 2012. However, specific BMPs, crops and land use practices remain unidentified. This first step in addressing this deficiency is important to the future CWAD program and the TMDL implementation process for agricultural operators in meeting 2020 compliance targets.

D.2.1.1 Agricultural Operator Survey

Task 3.0 of the grant developed an agricultural operator survey form to identify current land use practices and BMPs being implemented. This baseline survey was conducted on a 100 percent voluntary basis. The survey was developed with simplicity in mind. The two page survey addressed the most common questions for agricultural land use practices. A copy of the survey is attached, see Table D-1.

The foundation for the mailing lists for the survey were the compliant (those stakeholders with more than 20 acres and actively farmed within the past 5 years) and the exempt (those stakeholders excluded based on no agricultural activity within the past 5 years) as observed through the 2007 aerial mapping data. These lists were updated based upon August 2011 available existing information. On the initial lists for 2007, Federal, State and tribal lands were included. Recently, it was determined that WRCAC would not likely collect on these agencies and they were returned to the RWQCBs responsibility and were subsequently removed from the mailing list. It should also be noted that there were considerable returned envelopes having never reached their destination address. With the survey being done in August of 2011 and the mailing agricultural operator identification process utilizing 2007 data, it is understandable in the current economic climate that considerable change in ownership has occurred over a 4 year time period and undeliverable surveys were relatively high and expected.

Survey Results:

	Mailed	Returned/Undeliverable		Completed	
Compliant	181	14	7.7%	51	28.2%
Exempt	135	11	10.4%	26	19.3%
TOTAL	316	25	7.9%	77	24.4%

Identification of BMPs and land use practices in the San Jacinto watershed for agricultural operators is an important component for the future CWAD program and the implementation process for the TMDL. An agricultural operator BMP/ land use survey was distributed to 316 stakeholders. The response rate was 24.4 percent on a 100 percent voluntary survey. More significantly of the 181 compliant stakeholders, those stakeholders actively farming, there was a 28.2 percent return or 51 completed surveys.

Significant results were obtained in this survey. Perhaps one of the more important results was the percentage of leased land. Fifty-one (51 percent) of the agricultural surveys with active farm land indicated that the land being farmed was leased. Twenty-three and a half (23.5 percent) did not respond to this question. We expect that leased land in the watershed is realistically between the 60-75 percent range. This is significant for several reasons:

- Land owners are typically not as aware of the land practices on their land. Several land owners had to discuss the survey with the leases and in a high percentage documented that they were unaware of BMPs or land use practices on their property.
- Developers are a significant portion of the leased land owners and many indicated that the land would be developed as the economic climate improves.
- Education and responsibility of land use practices should be addressed in upcoming seminars and outreach venues.

Land use type was generally distributed as expected. One-Third (36 percent) irrigated, 38 percent non-irrigated, 6 percent citrus, 10 percent poultry, 6 percent horses/cattle/goats, and 4 percent other. Please note that 6 percent of the land use was characterized as irrigated and non-irrigated and the parcel acreage was not broken done in the survey. The 6 percent was divided equally for the summary calculation.

A total acreage of 15,198 acres was accounted for in the survey and although only 28 percent, the largest agricultural operators all participated in the survey and the remaining acreage we believe to be smaller parcels. Of the 15,198 acres, grain crops accounted for 6,363 acres, citrus was 2,298 acres, potatoes 5,663 acres and the balance in other crops.

Only 6 of 51 respondents used manure. Two of these users are large agricultural operators that accounted for an estimated 2,300 acres. One of these parcels is associated with a dairy and they use what they produce. There was one smaller dairy operator that also uses what they produce. Both have approved NMPs in place.

Only 3.92 percent or two operators import manure. We have seen a constant and continued reduction of imported manure into the San Jacinto Watershed over the past 8 years.

The use of chemical fertilizer was 47 percent. One would expect the use of fertilizer with irrigated crops and citrus. The type of fertilizer used was dependent upon crop type.

Those agricultural operators utilizing recycled water made up 15.69 percent of the survey sample or eight respondents out of the 51 actively farming. The recycled water source is Eastern Municipal Water District (EMWD).

Just under 30 percent of the active farming survey respondents rotate crops or 15 of the 51. Crop rotation was dependent upon the type of crop.

Pesticides/Herbicide use was 31 of the 51 respondents or 60.78 percent. Brands and frequency varied.

The majority of respondents did not file NOI's or 71 percent. Eleven or 21.6 percent either had filed NOI's or knew when to file an NOI. Again these were the larger irrigated crop users. Several indicated that they didn't know what an NOI was?

Of particular interest for our project, 68.62 percent said that they currently use BMPs. Thirty-two (32 percent) either did not know if they used BMPs or didn't respond to the question. This was a much higher percentage than we anticipated. We also noted that several people who said they did not use BMPs currently actually do. The understanding of what a BMP is should be addressed in future education and stakeholder outreach seminars. Landowners who leased had less knowledge of BMP practices than those who owned the land. BMPs implemented both increased and decreased costs almost equally.

When asked if they would be receptive to new BMPs, 47 percent said yes while 14 percent said no. An additional 39 percent either had no response or didn't know.

BMPs listed as most frequently used in the San Jacinto watershed were: sprinklers/micro-emitters, berms, wheel lines buffer zones, mulch and erosion control.

The amount of money invested in BMPs varied from 0 to $100,000. The majority did not know costs or there was no response.

When asked how much money they would invest in new BMPs 12 percent said none, 55 percent did not respond, 27 percent didn't know and only one respondent said yes.

The information collected from this survey will provide the baseline land use agricultural parcel data that will be used to assist in the determination of pollutant trading BMPs from non-point sources to non-point sources in the watershed. The web-based BMP tool which was developed in 2012 will use this data to populate the database along with the most current aerial mapping data.

D.2.1.2 Survey Conclusions:

The agricultural survey provided good land use data for the San Jacinto Watershed with a 24.4 percent rate of return in a 100 percent voluntary survey. The agricultural survey data accounted for 68.2 percent of the compliant acreage as compared to the 2007 compliant agricultural land use data. Additional surveys have been received since evaluating the data and WRCAC expects the final participation percentage to be around 35 percent or an estimated one-third of the agricultural operators polled. Educational and stakeholder outreach will be important areas of emphasis for the AgNMP and CWAD as well. With a large percentage of leased land and owners not understanding what is occurring on their property, developing BMPs and striving for load reductions may be more challenging than expected. The owners will need to take a more active role on their property's land use.

There is also a need to educate agricultural operators on what BMPs are and how they benefit agricultural operators in load reductions. It appears that a large number of BMPs are implemented but not accounted for by the agricultural operators.

Agricultural operators are not likely to spend any significant amount of money on new BMPs on their property in the current economic climate. Agricultural land use will likely diminish as the economy improves and urban development regains its momentum.

Table D-1 Agricultural Survey Form

Name: ______________________________

Business name: ______________________________

Address: ______________________________

City/State/Zip: ______________________________

Phone: ______________________________

E-mail address: ______________________________

If we have questions, do you prefer to be reached by: ☐ Phone or ☐ E-mail?

Has your property been vacant of any agricultural activity over the past 5 years?
☐ Yes ☐ No

Please list parcels: ______________________________

Do you lease this land for agricultural purposes? ☐ Yes ☐ No

If yes, Name of lessee: ______________________________

Lessee contact info: ______________________________

Land Use Type: (Please check all appropriate boxes)

☐ Irrigated Agriculture Please list crops: ______________________________

☐ Non-Irrigated Agriculture Please list crops: ______________________________

☐ Turf

☐ Citrus Please list type grown: ______________________________

☐ Nurseries Please list: ______________________________

☐ Poultry/ Horses Please list #'s: ______________________________

☐ Other Please identify: ______________________________

Agriculture Acreage:

Please list total acreage for each parcel used. If you have some irrigated and some non-irrigated please state by % how much of each. Use a separate sheet if necessary for multiple parcels.

*Do not include dairy cows or any land associated with dairy operations.

APN/Parcel #	Acres	Crops

Farming Practices:

Do you apply manure? ☐ Yes ☐ No – list parcels: ____________________

Do you import manure? ☐ Yes ☐ No – list parcels: ____________________

Do you apply a chemical fertilizer? ☐ Yes ☐ No

If yes, list parcels and type of fertilizer: ____________________

If yes, how often do you apply fertilizer? ____________________

Do you use recycled water? ☐ Yes ☐ No

Do you rotate crops? ☐ Yes ☐ No

If yes, how often do you rotate crops? ____________________

Do you apply pesticides/herbicides? ☐ Yes ☐ No

If yes, list parcels and brands and frequency:

____

Do you file a Notice of Intent (NOI)? ☐ Yes ☐ No

If yes, please list parcels: ______________________________

Do you currently use Best Management Practices (BMPs) on your land?
☐ Yes ☐ No

If yes, please answer the following questions. Examples include drip irrigation, mulching, buffer zones, etc. There are hundreds of possible BMPs. There is no incorrect answer. Any practice you use that reduces nutrient runoff from your land is an acceptable BMP. Please list them for each parcel where BMPs are used.(Use a separate sheet if necessary)

Parcel #	**BMPs used**

Have these BMPs ☐ increased or ☐ reduced your costs? Please explain:

____

____

If new BMPs were suggested that would reduce nutrient loss and save you money, would you be likely to implement new BMPs? ☐ Yes ☐ No

How much have you invested on existing BMPs on your property?

____

How much would you be willing to pay for new BMPs on your property?

____

Do you have any other comments? ______________________________

____

____

In keeping with WRCAC's holistic watershed-wide approach to this complex issue, The AgNMP begins with a greater level of determination of existing nutrient loading for agricultural lands as well as existing BMPs by individual operators. All agricultural should not be treated the same regarding levels of nutrient loading responsibility as is currently the case. We believe that a tiered-pay schedule based upon amount of nutrients on parcels is a better and fairer approach. Agricultural operators that currently invest and apply BMPs have no current means to be rewarded. The system we propose is based upon the level of environmental stewardship implemented and creating the process for agricultural participation in this process.

The Five (5) key steps identified to assess and improve agricultural BMP implementation of the AgNMP in the San Jacinto watershed are:

- Step 1: Determine Agricultural Nutrient Loading using various tools such as but not limited to agricultural surveys, Blue Water Satellite Technology, traditional monitoring, and aerial mapping.
- Step 2: Develop and implement a tiered pay structure based upon amount of nutrients, BMPs implemented, proximity to waterbodies and other relevant factors. This process will be developed in 2014 and phased in over an extended period of time.
- Step 3: Provide a database (WebNMP) for agricultural operators to input BMPs and data into a centralized database. This is being created as part of a 319 grant and is operational. Once a CWAD list of agricultural operators is identified, it is WRCAC's intent to pilot test our process and weBMP tool on this group of stakeholders.
- Step 4: Provide stakeholder outreach and education for both TMDL and CWAD requirements .Education and outreach should include BMP "measures for success." Identification of those BMPs that have more merit in reducing nutrient loads than others. (*Perhaps tie into tiered process.)
- Step 5: Develop a cafeteria-style tiered approach based upon nutrient load level tiers for BMP implementation. The specifics would need to be developed over the next few years and in close coordination with the CWAD program.

Buffer strip BMP at Scott Farms   Photo courtesy of Nanette Scott

The ultimate goal is to assess nutrient loading in the agricultural community in such a manner that BMP implementation is rewarded for those practicing good environmental stewardship. Those agricultural operators that have low nutrient loads will do low levels of BMP implementation. Likewise, those that use high levels of phosphorous will be expected to have a higher level of BMP commitment. Using a cafeteria-style tiered BMP selection process based upon nutrient loading imaging, ag operators can meet AgNMP requirements. WRCAC will dedicate significant time and energy in developing this process which allows individual agricultural operators to implement BMPs accordingly on their property.

Management measures and guidance practices have been identified for BMP use in the San Jacinto Watershed. These are currently identified BMPs being utilized in the watershed, as well as those listed.

WRCAC believes that Blue Water Satellite technology may be useful in the Agricultural BMP process. Blue Water Satellite, Inc. (BWSI) has developed methods to detect concentrations of Total Phosphorus in surface water using Satellite imagery and patented algorithms which results in a data screening tool which makes it possible to evaluate data over entire surface water bodies in a single snapshot of time. This image data is processed to look at combinations of spectral bands where the target has a unique signature based on absorption and/or reflectance. The imagery is then processed to map the concentrations of these targets throughout the waterbody. Additionally, soil applications for determining levels of phosphorous are also currently being evaluated. It is this soil technology WRCAC is interested in reviewing and utilizing if deemed appropriate in the San Jacinto watershed.

D.2.1.3 AgNMP Management Measures and Guidance Practices

The Ag NMP Management Measures and Guidance Practices has been developed to include EPA and SWRCB guidelines regarding Best Management Practices (BMPs) for agriculture, as well as incorporating many of the 1998 revisions to the NRCS Agronomy Manual. The SARWQCB is currently looking at a Conditional Waiver for Agricultural Discharges (CWAD) in the San Jacinto Watershed. Typically in the State of California only runoff discharges from irrigated lands are being regulated. However, in our watershed the CWAD program being developed will likely include irrigated lands as well as other livestock operations and AFOs, such as poultry and horse ranches. Dairy is under a CAFO permit and is treated separately, although this plan will certainly address manure issues as part of the agricultural operator component.

Individual operators cannot be held accountable for implementing the same types of BMPs with varying types of crops and loads, identification of nutrient loading will be addressed by WRCAC on a watershed scale while implementation of BMPs will be proposed and implemented on an individualized basis.

The specifics of the program in this document have been laid out as Management Measures and Guidance Practices with regards to BMPs. Each Management Measure covers a central topic or focus, followed by Guidance Practices that present many of the specific actions a grower might employ to meet the stated focus. It should be understood that the Guidance Practices presented are not the only methods which will reduce nutrients in surface runoff. Reduction of runoff is a very complex interaction of practices, many of which may not be covered in this AgNMP document. WRCAC would encourage the use of any reasonable /acceptable BMP and would encourage use of new proven technologies.

The Guidance Practices have been designed so that there is reasonable assurance they can be voluntarily implemented and maintained by the grower. It should be noted that preliminary surveys of agricultural operations within the San Jacinto watershed have indicated that many growers already voluntarily incorporate many of the Guidance Practices into their normal crop production methods. WRCAC will continue to encourage and develop outreach to stakeholders in various ways.

D.2.2 San Jacinto Watershed Agricultural BMPs

D.2.2.1 Management Practices to Reduce Nutrient Loads from Agricultural Operations in the San Jacinto Watershed

Section D. 2.2.1 "Management Practices to Reduce Nutrient Loads from Agricultural Operations in the San Jacinto Watershed" is a comprehensive look at acceptable guidance practices and BMPs for the San Jacinto watershed. This information is conveyed nearly in its entirety for this section of the AgNMP. TetraTech, Inc. was the consultant to WRCAC on a Voluntary Implementation of the Nutrient TMDL in the San Jacinto Watershed grant which was granted through the SWRCB. We wish to acknowledge and thank Jennifer Ferrando and Tetra Tech staff involved on this project.

D.2.2.1.1 Executive Summary

Approved nutrient Total Maximum Daily Loads, (TMDLs), for Lake Elsinore and Canyon Lake, calls for significant reductions in nitrogen, and phosphorus loads, from agricultural land in the San Jacinto watershed. Although current land use and agricultural operation data for the watershed are imprecise, wet weather runoff from cropland is believed to contribute a significant portion of the total nutrient load from the watershed. Numerous management practices (often called "best management practices", or BMPs) are available to help reduce nutrient loads from agricultural land in the watershed. BMPs typically act on one or more of four control principles:

- Minimizing pollutant availability (source reduction)
- Preventing pollutant detachment by water or wind
- Reducing the transport of pollutants either by reducing the amount of water transported, and thus the amount of the pollutant transported, or by increasing deposition of the pollutant
- Preventing delivery of pollutants to receiving waters

Numerous candidate practices related to reducing agricultural nutrient loads in the San Jacinto watershed are identified. A comprehensive catalog of practices appropriate for the watershed is contained in the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Field Office Technical Guide (FOTG) for Riverside County, California, available on the Internet1. BMPs applicable to specific crop types produced in the San Jacinto watershed (e.g., citrus, potatoes, grapes, and orchard crops) are included in this report as well.

At present it is impossible to recommend a single set of specific BMPs for all agricultural land in the San Jacinto watershed. The variety of agricultural activities, the need for site-specific planning and management, and uncertainty about the distribution of crops grown in the watershed preclude a one-size-fits-all prescription. Rather, we recommend general management principles that agricultural enterprises in the San Jacinto watershed should apply. Within each area, a grower can implement specific BMPs to meet these principles, tailored to the specific crop(s) and operation involved.

Nutrient Management

Crop nutrients should be supplied in quantities that reflect the amounts needed to produce a reasonable crop yield; the amounts already present in the soil; and the amounts contributed by all nutrient sources, including commercial fertilizers, animal manure, irrigation water, and other sources. Nutrients should be applied using rates, timing, and methods designed to minimize losses to surface water and ground water. Effective nutrient management reduces the amounts of nutrients available on agricultural land to be washed into surface or ground

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[1] Go to http://efotg.nrcs.usda.gov/. On the map on the right side of the page under Access eFOTG, click on California. On the map in the popup window, click on Southern California, then on Riverside County.

water, while providing for adequate crop growth. The specific elements of nutrient management vary by crop type, but they typically include these activities:

Nutrient and soil assessment

- Field maps
- Soil hazards and limitations, e.g., slopes, erosion potential
- Soil sampling and analysis
- Analysis of irrigation water for nutrient contribution
- Analysis of animal manure and other organic additions

Application of nutrients to croplands

- Application of amendments and organic materials to provide nutrients and improve soil quality
- Methods of fertilizer delivery and placement to reduce the potential for surface runoff, dust, ground water leaching, and volatilization of materials.
- Selection of materials considering all formulations of plant-available nutrients relative to the growth stage requirements of the plant.
- Calibration of equipment to deliver a known amount of material uniformly
- Storage and handling of materials away from surface waters and in an area where spills can be cleaned up easily.

Timing of nutrient applications to coincide as closely as possible with the crop growth stage requirements and short-term weather conditions.

Record keeping providing information used to evaluate management effectiveness and help refine ongoing nutrient management.

Irrigation Water Management

The amount of irrigation water applied should be managed to minimize surface runoff and unwanted ground water leaching beyond the root zone, while satisfying the moisture requirements of the crop. When making irrigation decisions, producers should consider environmental interactions and soil hazards relative to erosion potential and infiltration rates. Irrigation applications should be designed to maximize uniformity and efficiency in the delivery of water. Soil moisture should be assessed before all irrigations. Effective irrigation water management avoids providing excess water to move nutrients from cropland to surface and ground water, while satisfying the moisture requirements of the crops. The specific elements and techniques of irrigation water management vary by crop and irrigation system type, but they typically include these activities:

- *Crop water needs and soil moisture assessment*, considering the period between irrigation applications, weather conditions, and the amount necessary to replace the amount depleted between irrigations, plus the amount necessary to satisfy the leaching requirement for the crop

- *Irrigation system design* to efficiently apply irrigation water in the amounts and locations needed
- *Tracking irrigation applications* to aid in refining irrigation application timing and rates, in reconciling usage, and in calculating irrigation efficiency
- *Tail water management* to capture and treat excess water to prevent off-site discharge of nutrients and sediments, especially from furrow irrigation

Erosion Control

Tillage, planting, cultivation, and crop harvest should be conducted to minimize soil erosion by wind and water. Effective erosion control minimizes off-site movement of soil particles and associated nutrients to surface waters and helps to preserve soil productivity. Specific practices vary by crop type and field conditions, but erosion control practices usually address the following:

Detachment of soil particles by wind or water

- Residue and tillage management
- Cover crops
- Wind barriers

Movement of soil particles by wind or water

- Diversions and waterways
- Contour planting
- Terraces and water/sediment control basins
- Windbreaks and shelterbelts

Delivery of soil particles to waterways

- Sediment basins
- Filter strips
- Riparian buffers

Crop-specific Practices

Specific crops might require specific practices adapted to their production and management to accomplish nutrient management, irrigation management, and erosion control. Individual practices to suit the needs of specific crops produced in the San Jacinto watershed are described in this report. Growers should consult with their producer organizations, NRCS, and other resources to identify specific practices appropriate to their crops and operations.

One way to channel the collection of necessary agricultural information in the San Jacinto watershed is through the use of models or screening tools at the farm level. Systematic examination of representative or model farms to identify areas of risk for nutrient runoff losses would guide the selection and targeting of BMPs and support estimates of potential watershed nutrient load reductions. The information required by available screening tools varies, but it typically includes the following:

Soil test phosphorus results
Soil erosion estimates
Nutrient application rates
Irrigation management
Yield goals
Nutrient credits, e.g., from legumes or irrigation water
Site characteristics, e.g., soils, topography, drainage
Manure characteristics and applications
Calibration of application equipment
Record keeping

D.2.2.1.2 The Nature of Agricultural Management Practices

The management practices described in this document control the delivery of nonpoint source pollutants to receiving water resources by

- Minimizing pollutant **availability** (source reduction)
- Preventing pollutant **detachment** by water or wind
- Reducing the **transport** of pollutants either by reducing water transported, and thus the amount of the pollutant transported, or by causing deposition of the pollutant
- Preventing **delivery** of pollutants to receiving waters

The extent to which an individual management practice addresses the four methods of controlling the delivery of nonpoint source pollutants varies. For example, nutrient management addresses primarily source reduction, whereas conservation tillage can reduce both pollutant detachment and transport.

Management practices are usually designed to control a particular pollutant type from specific land uses. For example, conservation tillage is used to control erosion from irrigated or nonirrigated cropland. It is important to consider, however, that management practices might also provide secondary benefits by controlling other pollutants, depending on how the pollutants are generated or transported. For example, practices that reduce erosion and sediment delivery often reduce phosphorus losses because phosphorus is strongly adsorbed to silt and clay particles. Thus, conservation tillage not only reduces erosion but also can reduce transport of particulate phosphorus.

It is very important to recognize that some management practices might provide environmental benefits beyond those linked to water quality. For example, riparian buffers that reduce phosphorus and sediment delivery to waterbodies also provide habitat for many species of birds and plants. Reduced tillage decreases particulate phosphorus losses in surface runoff and can also reduce particulate matter in the air.

Sometimes, however, a practice used to control one pollutant can increase the generation, transport, or delivery of another pollutant. Conservation tillage, because it creates increased soil porosity, can increase nitrate leaching through the soil, particularly when the amount and timing of nitrogen application are not part of the management plan. Open composting can cause violations of air quality standards if ammonia-nitrogen is volatilized. Practices that detain surface runoff, such as grassed terraces and sediment basins, promote infiltration and might thereby increase pollutant delivery to ground water. It is important to carefully select management practices that meet nutrient load reduction goals while at the same time contributing to the solution of–or at the very least not exacerbating–salinity, air quality, and other problems in the watershed.

Management Practice Systems

Water quality problems cannot usually be solved with one management practice alone because single practices do not typically provide the full range and extent of control needed at a site. Multiple practices are combined to build *management practice systems* that address the treatment needs associated with pollutant generation and delivery from one or more sources. Management practice systems are typically more effective than individual practices in controlling a pollutant because they can be used at two or more points in the pollutant delivery process.

For example, in the San Jacinto watershed it is necessary to reduce nitrogen and phosphorus loads. A system of management practices can be designed to reduce nitrogen and phosphorus availability, soil detachment (for the particulate portion), runoff, and delivery to receiving waterbodies. Such a system could include nutrient management to reduce availability, conservation tillage to reduce soil detachment and runoff, irrigation management to reduce transport, and grassed buffers to capture remaining nutrients before they can be delivered to receiving waters. Nutrient management can minimize the availability of nitrogen and phosphorus for transport from cropland in surface runoff or infiltration by matching the fertilizer application rate with crop needs (based on soil testing, analysis of nutrient sources, and realistic yield expectations). Proper timing of nutrient application can also reduce nutrient availability by minimizing the period during which applied nitrogen and phosphorus are available but not being used by a growing crop. Filter strips can be used to decrease nitrogen delivery by increasing infiltration and by taking up available nitrogen. Nitrogen not controlled by nutrient management, conservation tillage, and filter strips can be intercepted and remediated through denitrification in riparian buffers.

Site-Specific Design of Management Practice Systems

There is no single, *ideal* management practice system for controlling a particular pollutant in all situations. Rather, the system should be designed on the basis of the type of pollutant; the source(s) of the pollutant; the cause of the pollution at the source; the agricultural, climatic, and environmental conditions; the pollution reduction goals; the economic situation of the farm operator; the experience of the system designers; and the willingness and ability of the producer to implement and maintain the practices. The relative importance of these and other factors will vary depending on other considerations; such as whether the implementation is voluntary (e.g., government cost-sharing program) or mandatory (e.g., discharge permits). All of these factors are considered through rigorous planning processes like those used by the NRCS. The central purpose of conservation planning by NRCS is to develop a Resource

Management System, which is a combination of conservation practices and resource management activities for the treatment of all identified resource concerns for soil, water, air, plants, animals, and humans that meets or exceeds the quality criteria in the FOTG for resource sustainability (USDA, 2007).

Why Practices Must Fit Together for Systems to Perform Effectively

Each practice in a management practice system must be selected, designed, implemented, and maintained in accordance with certain standards and with site-specific considerations to ensure that the practices function together to achieve the overall management goals. If, for example, nutrient management, conservation tillage, filter strips, and buffers are used to address a nitrogen problem, planting and nutrient applications need to be conducted in a manner consistent with conservation tillage goals and practices (e.g., injecting fertilizer rather than broadcasting and incorporating it). In addition, runoff from the fields must be conveyed evenly to the filter strips, which in turn must be capable of delivering the runoff to buffers in accordance with design standards and specifications. When liquid animal waste is applied with irrigation water to provide for both crop nutrient and water needs, it is important to adjust management to simultaneously meet but not exceed the requirements for both resources—a complex task in many cases.

Other Forces Influencing Practice Selection

Because selection of practices for an individual farm operation can have ramifications that go well beyond a single purpose, it is necessary to consider all factors and forces that contribute to the choices farm operators make as they determine how best to achieve their business goals within the context of satisfying broader environmental and social obligations. Within the narrow focus of achieving nutrient load reductions to satisfy TMDL requirements, it is logical to recommend nutrient management, animal waste management, erosion and sediment control, irrigation water management, and riparian buffers as the key set of management practices. However, the specific mix of practices and the application of each practice to an individual farm also depend on the current practices implemented on the farm, current met or unmet obligations regarding other environmental objectives (e.g., air quality, ground water salinity, endangered species protection), the feasibility of implementing practices on the farm given crop selection and other farm attributes, the willingness of the owner/operator to implement and maintain the practices, product marketing, and the cost of the practices. In the San Jacinto watershed other environmental considerations and legal requirements must be addressed when considering the best set of practices to meet surface water quality objectives, including air quality, ground water quality, water supply, and salinity issues. Table D-2 summarizes the major air quality and water quality requirements and expectations of agricultural operations that are separate from, but possibly complementary to, or in conflict with the TMDL nutrient load reduction requirements.

The collective impact of these requirements on the correct mix of practices needed to address the nitrogen and phosphorus load reductions required of any individual agricultural operation depends on the extent to which the requirements apply to the operation and the response by the operation.

Table D-2 Summary of non-TMDL practice requirements for agricultural operations

Rule or Initiative	Target Pollutants	Exemptions	Activities Covered	Performance Expectations and BMPs
Rule 223: Emission Reduction Permits for Large Confined Animal Facilities (LCAFs) [1] (Air)	All air pollutants that contribute to non-attainment of any ambient air quality standard and are within the District's regulatory authority	Does not apply to agricultural vegetative crop operations.	Any confined animal facility that maintains on any one day: • 1,000 or more milk-producing dairy cows; or • 3,500 or more beef cattle; or • 7,500 or more calves, heifers, or other cattle; or • 100,000 or more turkeys; or • 650,000 or more chickens other than laying hens; or • 650,000 or more laying hens; or • 3,000 or more swine; or • 15,000 or more sheep, lambs, or goats; or • 2,500 or more horses; or • 650,000 or more ducks; or • 30,000 or more rabbits or other animals.	• Submit a permit application that includes all equipment, all sources of air pollution, total animal capacity of the facility, and an emissions mitigation plan that demonstrates that the facility will use best available retrofit control technology (BARCT) to reduce emissions of covered pollutants. • Implement a specified number of mitigation measures for various categories of operation (feed and silage, milk parlor, freestall barns, corrals, handling of solid manure or separated solids, handling of liquid manure, land application of manure, poultry house) as provided in the rule. Measures for only dairy and poultry are specified.

Rule 403: Fugitive Dust[2] (Air)	Airborne particulate matter	• Dairies
		• Agricultural vegetative crop operations that voluntarily implement practices in Rule 403 Agricultural Handbook and perform self-monitoring
			• Agricultural vegetative crop operations larger than 10 acres
			• Non-dairy CAFOs (3,360 or more fowl or 50 or more animals) with disturbed surface area larger than 1 acre
				• May not emit fugitive dust that remains visible beyond property line (exception for winds exceeding 25 mph if specific measures are taken)
				• May not increase PM_{10} by 50 micrograms per cubic meter
				  o exception for winds exceeding 25 mph if specific measures are taken
				  o exception if additional specific measures are taken and records kept
				• Track-out from vehicles and equipment to paved road must be removed.
				• Non-dairy CAFOs must also implement practices for manure handling (poultry only), feedstock handling, disturbed surfaces, unpaved roads, and equipment parking areas.

Table D-2 Summary of non-TMDL practice requirements for agricultural operations (continued)

Rule or Initiative	Target Pollutants	Exemptions	Activities Covered	Performance Expectations and BMPs
Rule 1127: Emission Reductions from Livestock Waste[3] (Air)	NH_3, VOC, PM_{10}	• Manure spread on non-dairy farms • If moisture content of manure is maintained above 50% and tested at least weekly, required corral clearings are reduced by one. • Removal of all feed lane manure to a digester 6 days per week eliminates other manure clearing and stockpile removal requirements	• Dairies and related operations with 50 or more head, and the manure produced. • Manure procession operations (composting, anaerobic digesters)	• Practices associated with timing and method for manure removal, excess water in corrals, feed lane paving, and stockpile removal. Manure removed from dairy and handled within the District goes only to an approved manure processing operation and agricultural land within the District that is approved for manure spreading. • Manure may be processed only by a permitted anaerobic digester, a registered composting operation, or a registered alternative manure composting operation.
Rule 1133: Composting Emissions Database[4] (Air)	N/A	Agricultural composting conducted using feedstock generated on-site	All new and existing composting operations	Registration and annual updates reporting the type and amount of materials received, amount of products produced, facility design throughput (tons/year) and actual throughput, feedstock description, process description, published tipping fee schedule, and number of air quality- and odor-related enforcement actions issued in writing against the facility.
Rule 1133.2: Emission Reductions from Co-Composting Operations[5] (Air)	NH_3, VOC	• Agricultural composting conducted using feedstock generated on-site • Approved alternative manure composting operations in compliance with Rule 1127 • Smaller co-composting operations • Smaller municipal co-composting operations achieving 80% removal of NH3 and VOC	Co-composting operations (biosolids and/or manure mixed with bulking agents)	• Enclosed vessels required. • Inward airflow required. • No measurable increase in either NH3 or VOC outside enclosure. • Exhaust vented through emissions control system that removes at least 80% NH3 and VOC. • New facilities may submit alternative technology that achieves at least 80% reductions in NH3 and VOC. • Existing facilities may submit alternative technology that achieves at least 70% reductions in NH_3 and VOC.

Table D-2 Summary of non-TMDL practice requirements for agricultural operations (continued)

Rule or Initiative	Target Pollutants	Exemptions	Activities Covered	Performance Expectations and BMPs
Santa Ana Basin Plan[6] (Water)	Nitrate(NO_3) and high salinity, indicated by total dissolved solids (TDS)	Irrigation water is not directly regulated.	Amended in 2004 to incorporate an updated TDS and Nitrogen Management Plan	The plan seems to call for no management actions by agriculture. Agriculture is seen as an important source of water (water rights) to the basin. . Although historical agricultural activity has caused much of the salinity problem in the watershed, the Basin Plan tends to work around agriculture, with desalters and other practices and strategies carrying the bulk of the load in reducing salinity. Preservation of agriculture is important to maintaining water inflow to the watershed, so the plan has no requirements for agricultural operations.
Nonpoint Source Program Strategy and Implementa-tion Plan (PROSIP) (SWRCB and CCC, 2000) (Water)	All pollutants. BMPs directed to erosion, animal operations, nutrient & pesticide management, irrigation, and grazing	Primary emphasis is voluntary implementation through education, technical, and financial assistance. Backup enforcement authorities vary in coverage and include Porter-Cologne Water Quality Control Act, Fish and Game Code, Food and Agriculture Code, Health and Safety Code, California Water Code, California Code of Regulations, and FIFRA (CCC, 2000)	All agricultural activities associated with nonpoint source pollution	See discussion under “Candidate Practices for Reducing Nutrient Loads in San Jacinto Watershed.”
Ordinance No. 427.3, an Ordinance of the County of Riverside Amending Ordinance No. 427 Regulating the Land Application of Manure[7]	Animal waste, nutrients, pathogens, organic matter	Sites meeting certain specifications are exempt from general prohibition of disposal, land application, or storage of manure within the unincorporated portions of a designated area within the county.	Transport, disposal, land application, and storage of manure within unincorporated portions of the county	Exemption from prohibitions requires: • CAFOs, tree/vine farming, operating farms registered with Agriculture Commissioner • Minimum of 5 ac tillable soil • Quality manure at rate approved by Commissioner • Time frame for planting after application approved by Commissioner Standards for manure use at approved sites: • Manure not applied within 100 ft of any well • Manure spread evenly at approved rate • Manure incorporated promptly by discing or appropriate tillage • Manure not applied in windy or wet conditions

Table D-2 Summary of non-TMDL practice requirements for agricultural operations (continued)

Rule or Initiative	Target Pollutants	Exemptions	Activities Covered	Performance Expectations and BMPs
Ordinance No. 484.2, an Ordinance of the County of Riverside Amending Ordinance No. 484 for the Control of Blowing Sand[8]	Sand, airborne particulate matter	Applies only to designated Agricultural Dust Control Areas, defined as those areas subject to seasonal winds and having soil conditions as to require special measures to minimize soil erosion from wind	Disturbance of land surface by excavating, leveling, cultivating, plowing, removing natural or planted vegetation, or by depositing or spreading a substantial quantity of similar soil, or any other act likely to cause or contribute to wind erosion of said land	"No person owning, leasing, or controlling land in an Agricultural Dust Control Area shall disturb the surface or subsurface of any portion or portions thereof containing 3 acres or more, by excavating, leveling, plowing, cultivating, or discing or by removing crops or residues… without first having obtained a valid permit therefore or without complying with the terms or conditions of such permit."

[1]*South Coast Air Quality Management District, http://www.aqmd.gov/rules/reg/reg02/r223.pdf (Diamond Bar, CA, 2006), retrieved October 2007.*
[2]*South Coast Air Quality Management District, http://www.aqmd.gov/rules/reg/reg04/r403.pdf (Diamond Bar, CA, 2005), retrieved October 2007.*
[3]*South Coast Air Quality Management District, http://www.aqmd.gov/rules/reg/reg11/r1127.pdf (Diamond Bar, CA, 2004), retrieved October 2007.*
[4]*South Coast Air Quality Management District, http://www.aqmd.gov/rules/reg/reg11/r1133.pdf (Diamond Bar, CA, 2003), retrieved October 2007.*
[5] *South Coast Air Quality Management District, http://www.aqmd.gov/rules/reg/reg11/r1133-2.pdf (Diamond Bar, CA, 2003) retrieved October 2007.*
[6]*Santa Ana Regional Water Quality Control Board, Water Quality Control Plan – Santa Ana River Basin (8), http://www.swrcb.ca.gov/rwqcb8/html/basin_plan.html (Riverside, CA, 1995), retrieved October 2007.*
[7]*Clerk of the Board, Riverside County, http://www.clerkoftheboard.co.riverside.ca.us/ords/400/427.3.pdf (Riverside County, 2000), retrieved November 2007.*
[8]*Clerk of the Board, Riverside County, http://www.clerkoftheboard.co.riverside.ca.us/ords/400/484.2.pdf (Riverside County, 2000), retrieved November 2007.*

Air Quality. Specifically, the types of practices that could be implemented on agricultural crop production operations in response to the air quality requirements in Table 3 include the following:

Active Operations: Cessation of tillage when winds exceed 25 mph ***and*** one of the following:

- Soil moisture monitoring for dust control
- Irrigation or bedding of fields as soon as possible after land leveling
- Conservation tillage
- Mulching: uniformly distributing plant residue, manure, or other material on soil surface before disturbing soil
- Avoidance of land disturbance in designated Agricultural Dust Control Areas

Inactive Operations—Three of the following:

- Compliance with local jurisdiction ordinance regarding windblown dust
- Cover crop with at least 60 percent ground cover
- Crop residue management with at least 60 percent ground cover
- Surface roughening
- Conservation tillage
- Cross-wind strip cropping
- Field windbreaks
- Ridge roughness
- Wind barriers

Farm Yard Area—One of the following:

- Vegetation
- Dust suppressants
- Surface area modification (material less susceptible to wind blowing)
- Disturbed surface area reduction

Track-Out—One of the following:

- Track-out area improvements (e.g., paving or chemical stabilization)
- Track-out prevention

- End of row equipment turnaround areas (keep tractors off roads)

Unpaved Roads—One of the following:

- Speed control to 15 mph
- Access restriction
- Unpaved road treatments (e.g., mulch, water, chemical dust suppressants)
- Surface modification (e.g., cover with asphalt, concrete, or gravel)

Storage Pile—One of the following:

- Wind sheltering (3-sided barrier)
- Watering to prevent dust
- Chemical stabilization
- Covering with tarps or other temporary cover

It is notable that nutrient management is not addressed by any of the air quality requirements. The management of animal waste hauled to and applied on crop operations is not addressed by the air quality requirements in Table 3, nor are riparian buffers or field buffers required. Irrigation water management is addressed but only for the purpose of dust control. Erosion and sediment control, however, is addressed, albeit piecemeal, by virtue of including conservation tillage, windbreaks, cover crops, strip cropping, and the like.

The practices required by existing air quality authorities form a potentially solid baseline to address the detachment, transport, and delivery of particulate nutrients because of the emphasis on erosion and sediment control, but the quality of this baseline depends heavily on the practice choices made by the crop producers. For example, a combination of conservation tillage, cover crops, and cross-wind strip cropping could yield nutrient loads very different from those achieved through a combination of field windbreaks, wind barriers, and ridge roughness, particularly if the cover crops scavenged nutrients. While not affecting crop production operations directly, the provisions for handling and disposing of manure from dairy operations could be helpful within the broad context of watershed-based nutrient management because they help create an infrastructure for routing and managing the nutrient content of manure even though that is not the current focus of those requirements.

Water Quality. In California’s 2000 *Nonpoint Source Program Strategy and Implementation Plan* (PROSIP) (SWRCB and CCC, 2000), the State Water Resources Control Board and California Coastal Commission, along with other state agencies, identified seven management measures to address agricultural nonpoint sources of pollution that affect state waters. The state committed to implementing these and other management measures for other nonpoint sources by 2013 through the nine RWQCBs and the CCC. The agricultural management measures include practices and plans installed under various nonpoint source programs in California, including systems of practices commonly used and recommended by USDA as components of Resource Management Systems, Water Quality Management Plans, and

Agricultural Waste Management Systems. The management measures contain performance expectations that can generally be achieved with a range of practices, providing an important context within which to consider specific agricultural BMPs to be implemented in the San Jacinto watershed. Although implementation of BMPs under PROSIP is expected to occur primarily in a voluntary fashion supported by educational outreach, technical assistance, and financial assistance and incentives, backup authorities are identified for use in cases where voluntary implementation has not occurred by 2013 or as needed to address priority water quality problems (CCC, 2000). The agricultural management measures are described in detail below under "Candidate Practices for Reducing Nutrient Loads in San Jacinto Watershed."

Nutrient management is promoted in a variety of ways in the San Jacinto watershed. For example, the San Jacinto Basin Resource Conservation District identifies nutrient management as one of its areas of program interest and includes in its long-range plan efforts to encourage nutrient management in support of water quality projects (SJBRCD, 2002). The NRCS is supporting with Environmental Quality Incentives Program (EQIP) funds a statewide animal water quality initiative that focuses on nutrient management at animal feedlot operations (USDA-NRCS, 2007). General EQIP funds are also used to support nutrient management for tree and vine crops.

Ground Water Protection Areas. The California Department of Pesticide Regulation (DPR) has identified sensitive areas to prevent contamination in the first place and to avoid further contamination of areas already contaminated. The DPR found that specific combinations of soil types and depth to ground water are common to areas where pesticides have been found in ground water because of routine agricultural uses. DPR then designated all sections of lands in California with similar features as Ground Water Protection Areas, or GWPAs—geographically defined areas that are vulnerable to pesticide contamination by leaching or runoff. GWPAs include all existing Pesticide Management Zones, plus other areas based on specified soil types and a depth to ground water of 70 feet or less. Users of pesticides regulated under section 6800(a) of the California Code of Regulations are regulated in GWPAs.

Leaching GWPAs are defined as sections of land where pesticide residues move downward from the application site on the soil surface through the soil matrix with percolating water to ground water. Leaching GWPAs are in areas with coarse-textured soils that have rapid infiltration rates. Pesticides containing active ingredients that are regulated to protect ground water may be applied by a permitted applicator if any one of the following mitigation measures is met:

No Irrigation. No irrigation water is applied for 6 months.

No Contact with Irrigation Water. Pesticides are applied to the planting bed or the berm so there is no contact with the irrigation water that percolates to ground water.

Irrigation Management. The irrigations are managed so that for each irrigation applied for 6 months after the pesticide is applied, the amount of water applied divided by the net irrigation requirement is 1.33 or less.

Other management practices approved by DPR that may be more suitable to specific cultural practices or farming techniques are used.

Runoff GWPAs are defined as sections of land where pesticide residues are carried in runoff water from application sites to more direct routes of ground water recharge, such as dry or drainage wells, poorly sealed production wells, or ditches or retention areas excavated below confining soil layers, or to areas where leaching can occur. Soils in runoff GWPAs have low infiltration rates caused by a hardpan layer or fine-textured soils. Pesticides containing active ingredients that are regulated to protect ground water may be applied by a permitted property operator when any one of the following mitigation measures is chosen:

Band Treatment. The pesticide is applied as a band treatment, not to exceed 33 percent of the distance between the rows, except in citrus, where the band may extend out to the drip line of the tree.

Soil Disturbance. The soil is disturbed within 7 days before the pesticide is applied.

Incorporating the Pesticide. The pesticide is incorporated on at least 90 percent of the area treated within 48 hours after the pesticide is applied, by mechanical means or sprinkler or by low-flow irrigation (1/4 to 1 inch), including chemigation if allowed by the label.

Timing of Application. The pesticide is applied between April 1 and July 31.

Control of Runoff Within a Field. All runoff (from irrigation or precipitation) is retained on-site for 6 months after application, provided the holding area has a percolation rate of less than 0.2 inch per hour. The holding area may have a percolation rate of 0.2 inch per hour or greater if the runoff water is completely recirculated every 24 hours.

Control of Runoff Outside a Field. All runoff (from irrigation or precipitation) is stored off-site for 6 months after application, provided the holding area has a percolation rate of less that 0.2 inch per hour.

Control of Runoff Outside a Field. For 6 months following application, runoff is managed so that it runs off onto an adjacent fallow field at least 300 feet long that is not irrigated for 6 months after application, with full consideration of any plant back restrictions.

Control of Runoff from Canal Banks and Rights-of-Way. For 6 months following application, runoff water from the tops and outer sides of canal banks and from rights-of-way moves off-site as overland flow onto adjacent land, at least equal in area to the treated area, where it infiltrates into the soil with no chance of flow into structures such as dry wells, ditches, or excavated retention areas with percolation rates greater than 0.2 inch per hour.

Other management practices approved by DPR that may be more suitable to specific cultural practices or farming techniques are used.

Information on GWPAs in the San Jacinto watershed is available at http://www.cdpr.ca.gov/docs/emon/grndwtr/gwpa_maps/c33gwpa_final.pdf or from the Riverside County Agricultural Commissioner's Office, http://www.rivcoag.org/opencms/index.html.

D.2.2.1.3 Candidate Practices for Reducing Nutrient Loads in San Jacinto Watershed

Numerous practices are available to help reduce nutrient loads from agricultural land in the San Jacinto watershed. As noted earlier, the State Water Resources Control Board and California Coastal Commission, along with other state agencies, have identified seven management measures to address agricultural nonpoint source pollution that affects state waters. Candidate practices to implement management measures related to nutrient loads are identified in this section. To the extent possible, the candidate practices were selected from those practices deemed appropriate for the San Jacinto watershed. For example, a primary source was the NRCS, which publishes standards and specifications for practices in its FOTG. The version of the NRCS FOTG adapted for Riverside County is available on the Internet at http://efotg.nrcs.usda.gov/. An additional source of information on management practices to control nonpoint source pollution is the U.S. Environmental Protection Agency's *National Management Measures to Control Nonpoint Source Pollution from Agriculture* (USEPA, 2003). This EPA guidance document contains detailed information on management measures to address nonpoint source water quality issues associated with nutrient management, erosion, pest management, animal feeding operations, grazing, and irrigated cropland, as well as information on the effectiveness and costs of such measures. The document can be accessed at http://www.epa.gov/owow/nps/agmm/index.html.

The NRCS practices listed are broadly applicable to many types of agricultural activities. However, because of the distinctive practices used to grow some crops, more specific BMPs might be required. For some specific crop types produced in the San Jacinto watershed—citrus, potatoes, grapes, and orchard crops—practices recommended from other regions have been included where local or regional recommendations were not available. It is likely that many of these practices can be adapted for use in the San Jacinto watershed.

PROSIP, introduced above under "Other Forces Influencing Practice Selection," calls for implementing the following agricultural management measures (CCC, 2000):

1A. Erosion and Sediment Control

Apply the erosion component of a Conservation Management System (CMS), as defined in the NRCS FOTG, to minimize the delivery of sediment from agricultural lands to surface waters, *or* design and install a combination of management and physical practices to settle the settleable solids and associated pollutants in runoff delivered from the contributing area for storms of up to a 25-year, 24-hour frequency.

1B. Facility Wastewater and Runoff from Confined Animal Facilities

Management Measure Component (1): Contain both facility wastewater and the contaminated runoff from confined animal facilities at all times up to and including storms exceeding a 25-year, 24-hour frequency event [storage facilities should be of adequate capacity to allow for proper wastewater utilization and should be constructed so they prevent seepage to ground water].

Management Measure component (2): Manage stored runoff and accumulated solids from the facility through an appropriate waste utilization system that is consistent with Management Measure 1C.

1C. Nutrient Management

Develop, implement, and periodically update a nutrient management plan to (1) apply nutrients at rates necessary to achieve realistic crop yields, (2) improve the timing of nutrient application, and (3) use agronomic crop production technology to increase nutrient use efficiency. When the source of the nutrients is other than commercial fertilizer, determine the nutrient value and the rate of availability of the nutrients. Determine and credit the nitrogen contribution of any legume crop. Soil and plant tissue testing should be used routinely. Nutrient management plans contain the following core components:

Management Measure Component (1): Farm and field maps showing acreage, crops, soils, and waterbodies.

Management Measure Component (2): Realistic yield expectations for the crop(s) to be grown based primarily on the producer’s actual yield history, State Land Grant University yield expectations for the soil series, or NRCS Soils-5 information for the soil series.

Management Measure Component (3): A summary of the nutrient resources available to the producer, which at a minimum include (a) soil test results for pH, phosphorus, nitrogen and potassium; (b) nutrient analysis of manure, sludge, mortality compost (birds, pigs, etc.), or effluent (if applicable); (c) nitrogen contribution to the soil from legumes grown in the rotation (if applicable); and (d) other significant nutrient sources (e.g., irrigation water).

Management Measure Component (4): An evaluation of field limitations based on environmental hazards or concerns such as (a) sinkholes, shallow soils over fractured bedrock, and soils with high leaching potential; (b) lands near surface water; (c) highly erodible soils; and (d) shallow aquifers.

Management Measure Component (5): Use of the limiting nutrient concept to establish the mix of nutrient sources and requirements for the crop based on a realistic yield expectation.

Management Measure Component (6): Identification of timing and application methods for nutrients to (a) provide nutrients at rates necessary to achieve realistic crop yields; (b) reduce losses to the environment; and (c) avoid applications as much as possible to frozen soil and during periods of leaching or runoff.

Management Measure Component (7): Provisions for the proper calibration and operation of nutrient application equipment.

Management Measure Component (8): When manure from confined animal facilities is to be used as a soil amendment and/or is disposed of on land, take steps to ensure that subsequent irrigation of that land does not leach excess nutrients to surface or ground waters.

1D. Pesticide Management

To reduce contamination of surface water and ground water from pesticides, use the following core components:

Management Measure Component (1): Evaluate the pest problems, previous pest control measures, and cropping history.

Management Measure Component (2): Evaluate the soil and physical characteristics of the site, including mixing, loading, and storage areas, for potential leaching or runoff of pesticides. If leaching or runoff is found to occur, steps should be taken to prevent further contamination.

Management Measure Component (3): Use integrated pest management (IPM) strategies that (a) apply pesticides only when an economic benefit to the producer will be achieved (i.e., applications based on economic thresholds) and (b) apply pesticides efficiently and at times when runoff losses are unlikely.

Management Measure Component (4): When pesticide applications are necessary and a choice of registered materials exists, consider the persistence, toxicity, runoff potential, and leaching potential of products in making a decision.

Management Measure Component (5): Periodically calibrate pesticide spray equipment.

Management Measure Component (6): Use anti-backflow devices on hoses used for filling tank mixtures.

1E. Grazing Management

Protect range, pasture, and other grazing lands using the following core components:

Management Measure Component (1): Implement one or more of the following to protect sensitive areas (such as streambanks, wetlands, estuaries, ponds, lake shores, and riparian zones): (a) exclude livestock, (b) provide stream crossings or hardened watering access for drinking, (c) provide alternative drinking water locations away from surface waters, (d) locate salt and additional shade, if needed, away from sensitive areas, or (e) use improved grazing management (e.g., herding) to reduce the physical disturbance and reduce direct loading of animal waste and sediment caused by livestock.

Management Measure Component (2): Achieving either of the following on all range, pasture, and other grazing lands not addressed under (1) above: (a) implement the range and pasture components of a CMS as defined in the NRCS FOTG by applying the progressive planning approach of the NRCS to reduce erosion, or (b) maintain range, pasture, and other grazing lands in accordance with activity plans established by either the Bureau of Land Management of the U.S. Department of the Interior or the Forest Service of USDA or with the California Rangeland Water Quality Management Plan.

1F. Irrigation Water Management

To reduce nonpoint source pollution of surface and ground waters caused by irrigation, use the following core components:

Management Measure Component (1): Operate the irrigation system so that the timing and amount of irrigation water applied match crop water needs. This will require, at a minimum, (a) the accurate measurement of soil-water depletion volume and the volume of irrigation water applied and (b) uniform application of water.[2]

Management Measure Component (2): When chemigation is used, include backflow preventers for wells; minimize the harmful amounts of chemigation waters that discharge from the edge of the field, and control deep percolation. In cases where chemigation is performed with furrow irrigation systems, a tailwater management system might be needed.[3]

1G. Education/Outreach

Implement educational programs to provide greater understanding of watersheds, and to raise awareness and increase the use of applicable agricultural management measures and practices where needed to control and prevent adverse impacts on surface water and ground water. Public education, outreach, and training programs should involve applicable user groups and the community.

The goal of education and outreach efforts is to implement pollution prevention and education programs to reduce nonpoint source pollutants generated from the following activities where applicable:

- Activities that cause erosion and loss of sediment on agricultural land and land that is converted from other land uses to agricultural land
- Activities that cause discharge from confined animal facilities to surface waters
- Activities that cause excess delivery of nutrients and/or leaching of nutrients
- Activities that cause contamination of surface water and ground water from pesticides
- Grazing activities that cause physical disturbance of sensitive areas and the discharge of sediment, animal waste, nutrients, and chemicals to surface and ground waters
- Irrigation activities that cause nonpoint source pollution of surface waters

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[2] The following limitations and special conditions apply:
(1) In some locations, irrigation return flows are subject to other water rights or are required to maintain stream flows. In these special cases, on-site reuse could be precluded and would not be considered part of the management measure for such locations.
(2) By increasing the water use efficiency, the discharge volume from the system will usually be reduced. While the total pollutant discharge load may be reduced somewhat, there is the potential for an increase in the concentration of pollutants in the discharge. In these special cases, where other management measures (nutrients and pesticides) do not reduce concentrations in the discharge, increasing water use efficiency would not be considered part of the management measure.
(3) In some irrigation districts, the time interval between the order for the delivery of irrigation water to the farm might limit the irrigator's ability to achieve the maximum on-farm application efficiencies that are otherwise possible.
(4) In some locations, leaching is necessary to control salt in the soil profile. Leaching for salt control should be limited to the leaching requirement for the root zone.
(5) Where leakage from delivery systems or return flows supports wetlands or wildlife refuges, it might be preferable to modify the system to achieve a high level of efficiency and then divert the "saved water" to the wetland or wildlife refuge. This approach will improve the quality of water delivered to wetlands or wildlife refuges by preventing the introduction of pollutants from irrigated lands to such diverted water.
(6) In some locations, sprinkler irrigation is used for frost or freeze protection, or for crop cooling. In these special cases, applications should be limited to the amount necessary for crop protection and applied water should remain on-site.

Of these management measures, erosion and sediment control, nutrient management, irrigation water management, and education/outreach are the most directly relevant to the reduction of nutrient loads from agricultural land in the San Jacinto watershed. To the extent that grazing activities occur in the watershed, grazing management measures could also be applicable.

Practices identified as candidates for implementation on agricultural land in the San Jacinto watershed are listed in Tables 3 through 6, along with the definition, purpose, and applicability of each practice. The definitions given for these practices are quite general; consult the full practice standard (available through the NRCS FOTG) for details. Note that although some practices are widely applicable to many crops (e.g., nutrient management and buffers), not all practices are applicable to all sites or agricultural enterprises. Candidate practices for specific crop types are listed in Tables 7 through 11.

As noted previously, management practices might have different effects on different pollutants in different media. Sometimes these effects are additive; for example, a practice installed to control erosion can also reduce delivery of pollutants into ground water. In other cases, the effects of practices might conflict; a practice intended to control one pollutant in surface runoff might promote delivery of that pollutant into ground water. The NRCS uses a semi-quantitative evaluation system to identify and catalog the array of practice effects. The system assists in planning for implementation of practices to achieve a specific goal. The estimated effects of the candidate practices for the San Jacinto watershed on selected resource concerns—soil erosion, soil condition, water quantity, ground water quality, surface water quality, and air quality—are summarized in Table 11. For complete information on these and other practices for other resource concerns, consult the complete *Conservation Practice Physical Effects* database for California, available at http://efotg.nrcs.usda.gov/references/public/CA/RMSPlanningTool8-27-07Calif.xls.

Over the past four decades, considerable research has been conducted to quantify the effectiveness of BMPs and conservation practices on water quality at the field and watershed levels. Many studies are cited in the scientific literature and in government reports. Much of this work is highly site-specific and difficult to apply directly to the San Jacinto watershed; however, some general ranges are shown in Table 12.

Note that there is often a wide range in reported pollutant reductions attributed to BMPs. This variation is the result of a number of factors. Performance of a practice tested under controlled conditions in a plot study might be close to the ideal compared to the performance of the same practice when implemented on a farm field in the real world. Treatment effectiveness varies by pollutant characteristics. For example, removal of highly adsorbed pesticides by a vegetated buffer would tend to be higher than removal of poorly adsorbed pesticides in the same buffer. The same practice might also perform differently on different soils, in different climates, and in different management systems. The final effect of a practice also depends on the starting point. Nutrient management, for example, might result in large nitrogen or phosphorus reductions in a situation where fertilizer and animal waste are being significantly overapplied but might yield only small improvements when a producer is already close to the ideal.

Cost is a factor in selecting practices to control nonpoint source pollutants. The NRCS has published cost estimates for many of its conservation practices, including annual operation and maintenance as well as initial installation costs. However, the costs of practice installation, operation, and maintenance vary widely among agricultural operations. The NRCS's cost figures are shown in Table 13 for the candidate practices for the San Jacinto watershed. It should be noted that the cost figures are only general guidelines. The cost of large structural practices like sediment basins and tailwater recovery systems is highly dependent on size. Local costs in Riverside County might be different from the state averages shown in Table 13. In addition, the costs that NRCS uses for conservation planning are often considered on the high end of the scale. Examples of other practice cost figures are summarized in Table 14 to allow comparison.

Finally, it should be noted that practices to address nonpoint source nutrients beyond those in the NRCS FOTG might be available. The USDA Agricultural Research Service (ARS) Salinity Laboratory in Riverside (http://www.ars.usda.gov/main/site_main.htm?modecode=53 10 20 00) is one local source for technical information applicable to nutrient load reduction. Research being conducted by ARS scientists into water flow and chemical fate and transport in irrigated agricultural soils might provide new practices or improvements to existing practices that can be applied in the San Jacinto watershed. For example, a research project under way in the San Jacinto watershed— *Spatio-Temporal Assessment of Nutrient Management Plan (NMP) Performance for Field-Scale Lagoon Water Application*—is assessing the performance and long-term sustainability of nutrient management for a field-scale dairy lagoon water application. A second project on the same dairy—*Transport and Fate of Nitrate and Pathogens at a Dairy Lagoon Water Application Site: An Assessment of CNMP Performance*—is tracking the fate of different nitrogen species and bacteria in soil and ground water following implementation of a Comprehensive Nutrient Management Plan (CNMP) at the site using dairy lagoon water and well water on winter wheat-rye. Results of these investigations will be directly applicable to the selection and implementation of nutrient management practices in the San Jacinto watershed.

The NRCS practices identified above focus exclusively on those recommended for Southern California; it is possible that other practices from other areas with similar climate, soils, and agriculture can be adapted to work in the San Jacinto watershed. Finally, the ingenuity of agricultural producers in the watershed should not be overlooked. Some informal, common-sense management activities, such as avoiding tillage or nutrient applications during rainy seasons or during individual storms or using producer-developed spreadsheets to manage fertigation might make important contributions. Clearly, novel or unproven practices might need to be evaluated rigorously to document their pollution control effectiveness before their application can be reliably counted on in nutrient load reduction programs.

Table D-3 Conservation practices directed primarily toward pollutant source reduction (USDA-NRCS, 2007a)

NRCS Code	Practice Name	Definition	Purpose	Conditions where practice applies
370	Atmospheric Resource Quality Management	A combination of treatments to manage resources that maintain or improve atmospheric quality.	• Minimize or reduce emissions of o Particulate matter (PM_{10} and $PM_{2.5}$) o Odors o Greenhouse gases o Ozone (NO_x and VOC) o Chemical drift • Maintain or increase visibility	Applies to all land uses that contribute primary airborne particulates (dust, smoke, and chemicals), gaseous emissions causing secondary airborne particulates (ammonia, nitrates [fertilizers]), organic products, odor, greenhouse gases, ozone precursors, objectionable odors, and other gases that have a negative impact on air quality. Applies to cropland as well as roads and staging areas.
590	Nutrient Management	Managing the amount, source, placement, form, and timing of the application of nutrients and soil amendments.	• Properly utilize manure or organic by-products as a plant nutrient source • Minimize agricultural nonpoint source pollution of surface and ground water resources • Maintain or improve the physical, chemical, and biological condition of soil	Applies to all lands where plant nutrients and soil amendments are applied.
595	Pest Management	Using environmentally sensitive prevention, avoidance, monitoring, and suppression strategies to manage weeds, insects, diseases, animals, and other organisms (including invasive and non-invasive species) that directly or indirectly cause damage or annoyance.	• Enhance quantity and quality of commodities • Minimize negative impacts of pest control on soil, water, air, plant, and animal resources and/or humans	Applies wherever pests will be managed.
610	Salinity and Sodic Soil Management	Management of land, water, and plants to control and minimize accumulations of salts and/or sodium on the soil surface and in the crop rooting zone.	• Reduce and control harmful salt concentrations in the root zone • Reduce problems of crusting, permeability, or soil structure in sodium-affected soils • Promote desired plant growth and to utilize excess water in the root zone in nonirrigated saline seep areas and their recharge areas	Applies to all land uses where the concentration or toxicity of salt limits the growth of desirable plants or where excess sodium causes crusting and permeability problems.

Table D-3 Conservation practices directed primarily toward pollutant source reduction (USDA-NRCS, 2007a) (continued)

NRCS Code	Practice Name	Definition	Purpose	Conditions where practice applies
633	Waste Utilization	Using agricultural wastes such as manure and wastewater or other organic residues.	• Protect water quality • Protect air quality • Provide fertility for crop, forage, fiber production, and forest products • Improve or maintain soil structure • Provide feedstock for livestock • Provide a source of energy	Applies where agricultural wastes (including animal manure and contaminated water from livestock and poultry operations), solids and wastewater from municipal treatment plants, and agricultural processing residues are generated and/or used.
702	Agrichemical Handling Facility	A permanent structure used in the mixing, loading, unloading, and rinsing operations involved in the handling of on-farm chemicals, such as pesticides and fertilizers.	Provide for capture, collection, recovery, and storage of agrichemical spills and rinsate in order to minimize the potential for pollution	Applies (1) where current methods of mixing agrichemicals and rinsing of equipment are polluting or have the potential for polluting resources and (2) where nutrient and/or pest management plans that include the reuse or disposal of materials resulting from operation of the handling facility have been developed.
--	Manure/Soil Treatment	Using alum, water treatment residuals, or other products to reduce the available phosphorus content of animal waste or soil.	• Reduce the quantity of water-soluble phosphorus in applied manure or in soil available to be transported off-site • Improve the nitrogen-to-phosphorus ratio of animal waste to facilitate use in a nutrient management plan	Applies (1) where animal waste application supplies phosphorus in excess of crop/soil need and (2) where levels of soil phosphorus are excessive.

Table D-4 Conservation Practices Directed Primarily toward Preventing Pollutant Detachment (USDA-NRCS, 2007a)

NRCS Code	Practice Name	Definition	Purpose	Conditions where practice applies
327	Conservation Cover	Establishing and maintaining permanent vegetative cover to protect soil and water resources.	• Reduce soil erosion and sedimentation • Improve water quality • Enhance wildlife habitat	Applies on land to be retired from agricultural production requiring permanent protective cover, and on other lands that need permanent protective cover. Does not apply to plantings for forage production or to critical area plantings.
328	Conservation Crop Rotation	Growing crops in a recurring sequence on the same field.	This practice may be applied as part of a conservation management system to support one or more of the following: • Reduce sheet and rill erosion • Reduce irrigation induced erosion • Reduce soil erosion from wind • Maintain or improve soil organic matter content • Manage the balance of plant nutrients • Improve water use efficiency • Manage saline seeps • Manage plant pests (weeds, insects, and diseases) • Provide food for domestic livestock • Provide food and cover for wildlife	Applies to all cropland and other land where crops are grown.
340	Cover Crops	Establishing crops, including grasses, legumes, and forbs, for seasonal cover and other conservation purposes.	• Reduce erosion from wind and water • Increase soil organic matter content • Capture and recycle or redistribute nutrients in the soil profile • Promote biological nitrogen fixation • Increase biodiversity • Suppress weeds • Provide supplemental forage • Manage soil moisture • Reduce particulate emissions into the atmosphere • Minimize and reduce soil compaction	Applies on all lands that require vegetative cover for natural resource protection or improvement.

Table D-4 Conservation Practices Directed Primarily toward Preventing Pollutant Detachment (USDA-NRCS, 2007a) (continued)

NRCS Code	Practice Name	Definition	Purpose	Conditions where practice applies
342	Critical Area Planting	Establishing permanent vegetation on sites that have or are expected to have high erosion rates, and on sites that have physical, chemical, or biological conditions that prevent the establishment of vegetation with normal practices.	• Stabilize areas with existing or expected high rates of soil erosion by water • Stabilize areas with existing or expected high rates of soil erosion by wind • Restore degraded sites that cannot be stabilized through normal methods	Applies on areas with existing or expected high rates of erosion or degraded sites that usually cannot be stabilized by ordinary conservation treatment and/or management and, if left untreated, could be severely damaged by erosion or sedimentation or could cause significant off-site damage.
345 346 329A 344	Residue and Tillage Management	Managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round while limiting the soil-disturbing activities used to grow crops. **Mulch till** (345): the entire field surface is tilled prior to planting. **Ridge till** (346): crops are grown on preformed ridges alternated with furrows protected by crop residue. **No till/strip till** (329A): crops are planted in narrow slots or tilled strips in previously untilled soil and residue. **Seasonal residue management** (344): residues are managed on the soil surface during a specified period of the year, while planting annual crops on a clean-tilled seedbed, or when growing biennial or perennial seed crops.	• Reduce sheet and rill erosion • Reduce wind erosion • Reduce soil particulate emissions • Maintain or improve soil condition • Increase plant-available moisture • Provide food and escape cover for wildlife	Applies to all cropland and other land where crops are planted. Selection of a specific residue/tillage management system depends on crops grown, soil and climate conditions, and producer management preferences.
450	Polyacrylamide (PAM) Erosion Control	Erosion control through application of water-soluble anionic PAM	The practice is applied as part of a conservation management system to minimize or control furrow irrigation-induced soil erosion.	Applies on furrow irrigation lands susceptible to irrigation-induced erosion.

Table D-4 Conservation Practices Directed Primarily toward Preventing Pollutant Detachment (USDA-NRCS, 2007a) (continued)

589A	Cross-Wind Ridges	Ridges formed by tillage, planting, or other operations and aligned across the prevailing wind erosion direction.	Reduce soil erosion from wind.	Applies to cropland. Best adapted on soils that are stable enough to sustain effective ridges and cloddiness, such as clayey, silty, and sandy loam soils. Not well adapted on unstable soils like sands, loamy sands, and certain organic soils.
603	Herbaceous Wind Barrier	Herbaceous vegetation established in rows or narrow strips in the field across the prevailing wind direction.	• Reduce soil erosion and/or particulate generation from wind • Protect growing crops from damage by wind-borne soil particles • Provide food and cover for wildlife	Applies to cropland or other land where crops are grown.

Table D-5 Conservation practices directed primarily toward affecting pollutant transport (USDA-NRCS, 2007a)

NRCS Code	Practice Name	Definition	Purpose	Conditions where practice applies
330	Contour Farming	Tillage, planting, and other farming operations performed on or near the contour of the field slope.	• Reduce sheet and rill erosion • Reduce transport of sediment and other water-borne contaminants	Applies on sloping land where crops are grown. Most effective on slopes between 2 and 10 percent. Not well suited to rolling topography that has a high degree of slope irregularity because of the difficulty of meeting row grade criteria.
332	Contour Buffer Strips	Narrow strips of permanent, herbaceous vegetative cover established across the slope and alternated down the slope with parallel, wider cropped strips.	• To reduce sheet and rill erosion. • To reduce transport of sediment and other water-borne contaminants downslope, on-site or off-site. • To enhance wildlife habitat	Applies to cropland. Most suitable on uniform slopes ranging from 4 to 8 percent. Not suited to fields with extremely long slopes unless the field slope length is shortened by installing other practices (e.g., terraces).
362	Diversion	A channel constructed across the slope generally with a supporting ridge on the lower side.	This practice may be applied as part of a resource management system to support one or more of the following purposes: • Break up concentrations of water on long slopes, on undulating land surfaces, and on land that is generally considered too flat or irregular for terracing • Collect or direct water for water-spreading or water-harvesting systems • Increase or decrease the drainage area above ponds • Protect terrace systems by diverting water from the top terrace where topography, land use, or land ownership prevents terracing the land above • Intercept surface and shallow subsurface flow • Reduce runoff damages from upland runoff • Divert water away from active gullies or critically eroding areas • Supplement water management on conservation cropping or stripcropping systems	Applies to all cropland and other land uses where surface runoff water control and/or management is needed. Also applies where soils and topography are such that the diversion can be constructed and a suitable outlet is available or can be provided.
380	Windbreak/ Shelterbelt Establishment	Linear plantings of single or multiple rows of trees or shrubs or sets of linear plantings.	• Reduce wind erosion • Protect growing plants • Provide shelter for structures and livestock • Provide noise and visual screens • Improve irrigation efficiency • Increase carbon storage	Applies to any areas where linear plantings of woody plants are suited.

Table D-5 Conservation practices directed primarily toward affecting pollutant transport (USDA-NRCS, 2007a) (continued)

NRCS Code	Practice Name	Definition	Purpose	Conditions where practice applies
412	Grassed Waterway	A natural or constructed channel that is shaped or graded to required dimensions and established with suitable vegetation.	This practice may be applied as part of a conservation management system to • Convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding • Reduce gully erosion • Protect/improve water quality	Applies to areas where added water conveyance capacity and vegetative protection are needed to control erosion resulting from concentrated runoff and where such control can be achieved by using this practice alone or combined with other conservation practice
422	Hedgerow Planting	Establishment of dense vegetation in a linear design to achieve a natural resource conservation purpose.	Provide at least one of the following conservation functions: • Food, cover and corridors for terrestrial wildlife • Intercept airborne particulate matter • Reduce chemical drift and odor movement • Increase carbon storage in biomass and soils • Function as barrier to noise and dust	Applies wherever it will accomplish at least one of the stated purposes
449	Irrigation Water Management	The process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned, efficient manner.	• Manage soil moisture to promote desired crop response • Optimize use of available water supplies • Minimize irrigation-induced soil erosion • Decrease nonpoint source pollution of surface and ground water resources • Manage salts in the crop root zone • Manage air, soil, or plant micro-climate • Provide proper and safe chemigation or fertigation • Improve air quality by managing soil moisture to reduce particulate matter movement	Applies to all irrigated lands. An irrigation system adapted for site conditions (soil, slope, crop grown, climate, water quantity and quality, air quality, etc.) must be available and capable of efficiently applying water to meet the intended purpose(s).

Table D-5 Conservation practices directed primarily toward affecting pollutant transport (USDA-NRCS, 2007a) (continued)

NRCS Code	Practice Name	Definition	Purpose	Conditions where practice applies
various	Irrigation System	Elements of irrigation systems may include reservoirs, furrows, channels, channel lining, pipelines, nozzles, microirrigation equipment, and appurtenances installed in an irrigation system.	Specific irrigation system elements may be applied as part of a conservation management system to achieve one or more of the following: • Efficient and uniform application of irrigation water to maintain adequate soil water for the desired level of plant growth and production without causing excessive water loss, erosion, or water quality impairment • Climate control and/or modification • Application of chemicals, nutrients, and/or wastewater • Leaching for control or reclamation of saline or sodic soils • Reduction in particulate matter emissions to improve air quality	Irrigation system elements are planned and located to serve as an integral part of an irrigation water distribution system designed to facilitate the conservation of water on a farm or group of farms. Selection of specific system or facilities depends on site conditions, crops grown, and producer preferences.
570	Runoff Management System	A system for controlling excess runoff caused by construction operations at development sites, changes in land use, or other land disturbances.	Used to regulate and manage the rates and amounts of runoff and sediment from development sites during and after construction operations or to retrofit existing sites to minimize or lessen undesirable effects like flooding, erosion, and sedimentation.	Applies if there is a need to control runoff, erosion, and sedimentation to compensate for increased peak discharges and erosion resulting from construction operations at development sites or from other changes in land use that affect the runoff characteristics of the site. The discharges may be caused by such factors as increased runoff, reduced time of concentration, and reduced natural storage.
598C	Cross-Wind Trap Strips	Herbaceous cover resistant to wind erosion established in one or more strips across the prevailing wind erosion direction.	• Reduce soil erosion from wind • Induce deposition and reduce transport of wind-borne sediment and sediment-borne contaminants downwind • Protect growing crops from damage by wind-borne soil particles • Provide food and cover for wildlife	Applies to cropland or other land susceptible to wind erosion

Table D-5 Conservation practices directed primarily toward affecting pollutant transport (USDA-NRCS, 2007a) (continued)

NRCS Code	Practice Name	Definition	Purpose	Conditions where practice applies
600	Terraces	An earthen embankment or a combination ridge and channel, constructed across the field slope.	This practice may be applied as part of a resource management system to support one or both of the following: • Reduce soil erosion • Retain runoff for moisture conservation	Applies where 1. Soil erosion by water is a problem 2. There is a need to conserve water 3. The soils and topography are such that terraces can be constructed and farmed with reasonable effort 4. A suitable outlet can be provided 5. Excess runoff is a problem
601	Vegetative Barrier	Permanent strips of stiff, dense vegetation along the general contour of slopes or across concentrated flow areas.	• Reduce sheet and rill erosion. • Reduce ephemeral gully erosion. • Manage water flow. • Stabilize steep slopes. • Trap sediment.	Applies to all eroding areas, including but not limited to cropland, pastureland, rangeland, forestland, farmsteads, mined land, and construction sites. Applies only when used in conjunction with other conservation practices as part of a conservation management system.
638	Water and Sediment Control Basin	An earth embankment or a combination ridge and channel generally constructed across the slope and minor watercourses to form a sediment trap and water detention basin.	A water and sediment control basin may be established to • Improve ability to farm sloping land • Reduce watercourse and gully erosion; • Trap sediment • Reduce and manage onsite and downstream runoff • Improve downstream water quality	Applies to sites where 1. The topography is generally irregular 2. Watercourse or gully erosion is a problem 3. Sheet and rill erosion is controlled by other conservation practices 4. Runoff and sediment damage land and improvements 5. Soil and site conditions are suitable 6. Adequate outlets can be provided. Water and sediment control basins will not be used in place of terraces.

Table D-6 Conservation practices directed primarily toward affecting pollutant delivery (USDA-NRCS, 2007a)

NRCS Code	Practice Name	Definition	Purpose	Conditions where practice applies
350	Sediment Basin	A basin constructed to collect and store debris or sediment.	• Preserve the capacity of reservoirs, wetlands, Conservation Practice Standard 638 (water and ditches, canals, diversion, waterways, and sediment control basin) • Prevent undesirable deposition on bottom possible after construction ends to control erosion lands and developed areas and prevent excess sediment from leaving the site • Trap sediment originating from construction • Reduce or abate pollution by providing basins for deposition and storage of silt, sand, gravel, stone, agricultural waste solids, and other detritus	Applies where physical conditions or land ownership preclude treatment of a sediment source by the installation of erosion-control measures to keep soil and other material in place or where a sediment basin offers the most practical solution to the problem.
393	Filter Strip	A strip or area of herbaceous vegetation situated between cropland, grazing land, or disturbed land (including forestland) and environmentally sensitive areas.	• Reduce sediment, particulate organics, and sediment adsorbed contaminant loadings in runoff. • Reduce dissolved contaminant loadings in runoff. • Serve as Zone 3 of a Riparian Forest Buffer, Practice Standard 391. • Reduce sediment, particulate organics, and sediment adsorbed contaminant loadings in surface irrigation tailwater. • Restore, create or enhance herbaceous habitat for wildlife and beneficial insects. • Maintain or enhance watershed functions and values.	Applies as part of a resource management system (1) in areas situated below cropland, grazing land, or disturbed land (including forest land); (2) where sediment, particulate matter, and/or dissolved contaminants might leave these areas and are entering environmentally sensitive areas; and (3) in areas where permanent vegetative establishment is needed to enhance wildlife and beneficial insects, or to maintain or enhance watershed function.

Table D-6 Conservation practices directed primarily toward affecting pollutant delivery (USDA-NRCS, 2007a) (continued)

NRCS Code	Practice Name	Definition	Purpose	Conditions where practice applies
386	Field Border	A strip of permanent vegetation established at the edge or around the perimeter of a field.	• Reduce erosion from wind and water • Provide soil and water quality protection • Manage harmful insect populations • Provide wildlife food and cover • Increase carbon storage in biomass and soils. • Improve air quality	Applies at the edges of cropland fields and to connect other buffer practices within the field. May also apply to recreation land or other land uses where agronomic crops are grown.
391	Riparian Forest Buffer	An area of predominantly trees and/or shrubs located adjacent to and up-gradient from watercourses or waterbodies.	• Reduce excess amounts of sediment, organic material, nutrients, pesticides, and other pollutants in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow • Create shade to lower water temperatures to improve habitat for fish and other aquatic organisms • Create wildlife habitat and establish wildlife corridors • Provide a source of detritus and large, woody debris for fish and other aquatic organisms and riparian habitat and corridors for wildlife	Applies on areas adjacent to permanent or intermittent streams, lakes, ponds, or wetlands and areas with ground water recharge that are capable of supporting woody vegetation.
447	Irrigation Tailwater Recovery	A planned irrigation system in which all facilities such as sumps, pits, tanks, and pumps used for the collection, storage, and transportation of irrigation tailwater for reuse have been installed.	This practice may be applied as part of a conservation management system to support one or both of the following: • Conserve irrigation water supplies • Improve off-site water quality.	Suitable for use on lands and facilities that are served by a properly designed and installed irrigation system where recoverable irrigation runoff flows can be anticipated under current or expected management practices.

Table D-7 Potential management measures for citrus production (Boman et al., 2004; Ventura County Resource Conservation District, 2006; Wu, 2008)

Management Measure	General Description
Irrigation/Drainage Management	
Water Table Management	Water table control can be managed more efficiently by having sufficient hydraulic capacity in the ditch/canal system, using water control structures on culverts, performing laser land leveling where appropriate, constructing and maintaining a properly designed drainage system, and actively monitoring the water table.
Scheduling Irrigation and Drainage	Drainage and irrigation schedules should focus on optimal crop production and promotion of deep rooting by maintaining a constant water table that minimizes water quantity and quality impacts.
Salinity Management	All irrigation sources should be analyzed and monitored frequently. As individual irrigation sources are characterized, the use of high-salinity sources should be reduced and low-salinity and/or alternative irrigation sources maximized. Practices that reduce salt buildup in the soils offer increased fruit yield, more effective nutrient uptake, and reduced potential water quality impacts on receiving surface waterbodies.
Moderate Discharge Rate	Adjust the rate of discharge proportionate to the rate of lateral movement of water through soils. Slowing the discharge rate lessens the turbulence, reduces sediment movement, reduces erosion, and moderates the impacts on the receiving waterbody.
Water Furrow Maintenance	Maintain a consistent bottom slope on water furrows between beds to achieve uniform drainage. Avoid rutting and sloughing of water furrow areas. Where possible, maintain vegetation management programs that minimize soil movement in the event of heavy rains by keeping a grass or vegetation cover on the soil surface between tree rows.
Drainage Management Plan	Implement and maintain a written drainage management plan that provides specific responses to various types and levels of rainfall. The goal of the plan should be a reduction in volume of off-site discharge while maintaining a healthy rooting environment for citrus trees, thereby maximizing fruit production. The plan should include target water table levels and pump or drainage structure operating procedures that will be used for typical and extreme rainfall events. Consideration should be given to the use of existing canals and ditches for temporary water storage.
Drainage Rate and Volume	Drainage rates and the volume of water released or discharged following intense rainfall events should provide an adequately drained root zone while minimizing off-site impacts.
Discharge Structures	Structures and/or pumps that regulate off-site water discharge should be adequately designed, constructed, and maintained so that target water table levels within the grove can be achieved.
Detention, Tailwater Recovery, and Surface Water Use	Where possible, on-site detention should be considered to reduce both the rate and volume of off-site discharges following heavy rains.
Erosion Control/Sediment Management	
Riser-board Water Control Structures	Place and maintain culverts with riser-board control structures at locations where runoff is discharged off-site.
Sediment Settling Basins	Create and maintain localized settling basins (sumps) to trap sediments at lateral and collector ditch connections, and at locations upstream of where water discharges from the grove.
Ditch Construction	Construct ditches and canals with side-slopes consistent with soil types.
Stabilize Bare Soils	Stabilize bare soils and canal or ditch banks by encouraging coverage by noninvasive vegetation.
Ditch Bank Contours	Contour ditch bank top edges or berms to divert water away from the drainage ditch.

Table D-7 Potential management measures for citrus production (Boman et al., 2004; Ventura County Resource Conservation District, 2006; Wu, 2008) (continued)

Management Measure	General Description
Erosion Control/Sediment Management	
Ditch Bank Vegetation Maintenance	Control broadleaf weeds by using herbicides or conducting maintenance mowing of slopes and ditch banks to increase grass cover and decrease the proliferation of shade-producing shrubs and weeds, thus reducing erosion from wind and rainfall.
Protect Ditch Banks	Protect canal and ditch banks from erosion in areas subject to high water velocities
Vegetative Stabilization	Plant noninvasive vegetation and/or maintain desirable vegetation within all water furrows to prevent/minimize erosion and trap sediments that might result from stormwater runoff or irrigation drainage.
Aquatic Plant Management	When removing vegetation from ditch bottoms, avoid disrupting side slopes.
Ditch Maintenance, Cleaning, and Dredging	Develop and implement a systematic management plan for removing sediments from canals and farm ditches on a regular basis: • Spoil material should be removed and deposited on a self-contained, upland spoil site and not placed in a delineated floodplain. • Do not remove any more material than is necessary to restore the original design specifications or configurations. • No significant impacts on previously undisturbed natural areas should occur. • Erosion and sedimentation control devices (e.g., turbidity screens) should be used to prevent bank erosion and scouring and to prevent turbidity from discharging into adjacent waters during maintenance dredging.
Grove Development/Renovation	Upon completion of the soil bedding process within citrus groves, all bare soil areas (except tree rows) should be planted with grass or other vegetation species to minimize soil movement from rain and/or wind.
Water Furrow Drain Pipes	Use PVC drain pipe or flexible pipe to connect all water furrows or field ditches to lateral ditches. Extend the pipe on the downstream side away from the ditch bank to prevent bank scouring.
Construction and Temporary Erosion Control Measures	Special measures and/or temporary erosion control measures should be used during construction and renovation of groves, when culverts and control structures are replaced or repaired, and when there is a major disruption of established vegetation, such as during irrigation system installation or when buried water lines are repaired, e.g., straw bale dike, temporary sediment trap, seeding/mulching, fabric drop inlet, silt fence, outlet stabilization structure.
Mulching between Tree Rows	Place any loose material over the soil to control weeds, conserve soil moisture, and shield soil particles from the erosive forces of raindrops and runoff. Usually the material is coarse organic matter, such as leaves or bark, but it can also be chipped clippings from tree pruning or trimming.
PAM	Apply PAM to irrigation water and soil to stabilize soil structure, reduce soil erosion, and increase water infiltration.
Nutrient Management	
Education	Proper training of the field operators responsible for handling, loading, and operating fertilizer spreading equipment and for correctly maintaining field equipment can help achieve desired placement of fertilizers, avoid waste, and prevent contamination of open waters.
Nutrient Management	Develop a nutrient management plan based on soil, water, plant, and organic material sample analyses and expected crop yields considering nutrient budget; realistic yield goals; form, timing, placement, and method of fertilizer application; proper calibration and use of equipment;

Table D-7 Potential management measures for citrus production (Boman et al., 2004; Ventura County Resource Conservation District, 2006; Wu, 2008) (continued)

Management Measure	General Description
Nutrient Management	
Utilization of Waste Resources	Use of animal waste and other waste products on land in an environmentally acceptable manner can be helpful in maintaining or improving soil, air, plant, and water resources.
Utilize Tissue and Soil Analysis	Fertilizer applications based on leaf tissue and soil tests will help avoid over-fertilization and subsequent losses of nutrients in runoff water.
Use Appropriate Application Equipment	Operate machinery as designed so as to achieve precise and desired placement of nutrient materials at specified rates consistent with the form and source of nutrient materials.
Equipment Calibration and Maintenance	Proper calibration and maintenance of fertilizer application equipment is essential to avoid misapplication of nutrients.
Apply Materials to Target Sites	Place nutrients within the root zone of individual trees or drip-line bands along hedgerows of trees. Avoid placement in areas prone to off-site transport of nutrients, especially water furrows
Avoid High-Risk Applications	Do not apply materials in "high-risk" situations, such as before forecasted rainfall. Avoid applications of nutrients during intense rainfall, on bare soils with extreme erosion potential, or when water tables are near the soil surface.
Fertilizer Storage	Use caution when storing fertilizer to prevent contamination of nearby ground water and surface water.
Spilled Fertilizers	Immediately remove any fertilizer materials spilled on ground surfaces and apply at recommended rates to crops.
Use Caution When Loading Near Ditches, Canals, and Wells	Minimize the potential for spilled materials to pollute surface waters. When possible, locate mixing and loading activities away from ground water wells, ditches, canals, and other areas where runoff might carry spilled fertilizer into surface waterbodies. If such areas cannot be avoided, protect wells by properly casing and capping them and use berms to keep spills out of surface waters. Recover and apply spilled materials to intended zone of application.
Alternate Loading Operation Sites	Use multiple fertilizer loading and transfer sites to prevent concentration of nutrients in a single area.
Use Backflow Prevention Devices	Use backflow prevention devices on irrigation and spray tank filling systems to prevent nutrients from entering surface water and ground water.
Split Applications	Dividing the annual fertilizer requirement into two or more applications can minimize leaching of nutrients during the summer rainy season and help maintain the supply of nutrients over the entire growing season. Frequent fertigations can be an efficient method of application for nitrogen and potassium, while minimizing the potential for leaching of nutrients during excessive rainfall events.
Foliar Applications	Use foliar application of nitrogen to supply a portion of the annual nitrogen input, thus reducing the amount applied to the soil.
Irrigation Management	Limit irrigation to wetting only the root zone of the tree where possible; efficient irrigation to replenish only the water deficit within the rooting depth may improve nutrient uptake efficiency, while minimizing leaching losses.
Well Protection	Prevent ground water contamination by properly storing fuels, fertilizer, and agrichemicals. Avoid mixing/loading operations near wells, and backplug improperly constructed and/or deteriorated wells.
Use Appropriate Sources and Formulations	Reduce the potential for nutrient leaching and off-site movement by choosing appropriate sources and formulations of fertilizer based on nutritional needs, season (rainy vs. dry), and anticipated weather conditions to achieve the greatest efficiency and reduce the potential for off-site transport. Use controlled-release and slow-release formulations when feasible.

Table D-7 Potential management measures for citrus production (Boman et al., 2004; Ventura County Resource Conservation District, 2006; Wu, 2008) (continued)

Management Measure	General Description
Nutrient Management	
Salinity	Fertilizer sources should be monitored closely in groves with high salinity levels. Fertilizers with high salt index levels can compound existing salinity problems.
Conservation Buffers and Setbacks	Strategically incorporating vegetative buffers (naturally occurring ones or planted forbs and grasses) into the citrus grove design can help to protect water quality by providing biological filtration, increasing residence time and/or residual nutrient uptake.

Table D-8 Potential management measures for potato production (Hutchinson et al., 2002; Mikkelsen, 2006; Potato Growers of Alberta, 2002; Potato Growers of Idaho, 2007)

Management measure	General Description
Nutrient Management	
Nutrient Budgeting	Applying nutrients based on a nutrient budget that considers ***all*** sources of nutrients, including legume credits, organic matter, animal manure, crop residues, and irrigation water.
Split Applications of Nitrogen	Applying some of the total nitrogen requirement before planting and applying the remainder during the season with sidedress applications or through the irrigation system when plant needs are high and leaching/runoff potential low.
Soil Testing	Routine testing and analysis of soil in accordance with accepted procedures to ensure optimal application of nutrients according to crop need and available supply.
Plant Tissue Testing	Using petiole analysis during the growing season to determine the nitrogen status of the crop and respond in a timely manner with appropriate nutrients.
Erosion Control	
Tillage Management	Use of tillage techniques that minimize soil erosion and maintain soil organic matter while preparing the soil in a way that promotes potato plant growth. The use of minimal tillage whenever possible, especially before seeding and after harvest.
Residue Management	Maintenance of soil residue cover through proper rotations and straw management, such as the use of direct-cutting cereal crops, with no straw removal.
Cross-wind Trap Strips	Growing “trap” strip crops like corn within potato fields, leaving an anchored, vertical row of vegetation to slow wind and trap eroding soil.
Windbreaks	Linear plantings of single or multiple rows of trees or shrubs or sets of linear plantings to reduce wind erosion and protect growing crops.
Cover Crops	Crops, including grasses, legumes, and forbs, for seasonal cover between potato crops.
Soil Management	
Conservation Crop Rotation	Crop rotations that include low-nitrogen-requiring crops such as cabbage and cover crops.
Organic Matter Management	Maintenance of soil organic matter through accepted soil conservation tillage practices that minimize soil erosion from wind and water and through the use of manure and compost where available and economical.

Table 8 Potential management measures for potato production (Hutchinson et al., 2002; Mikkelsen, 2006; Potato Growers of Alberta, 2002; Potato Growers of Idaho, 2007) (continued)

Irrigation Management	
Irrigation Water Management	Application of irrigation water to meet crop needs and according to soil moisture reserves and consumptive use.
Irrigation Scheduling	Adjusting irrigation schedules according to transpiration and rainfall rates for the area; use of field scheduling tools such as evapotranspiration soil moisture monitoring and field verification to reduce risk of leaching pesticides and fertilizer below the root zone, while still meeting the water demands of the crop.
Irrigation Efficiency	Improvement of irrigation system application efficiency; minimization of water losses in the on-farm irrigation water distribution system.

Table D-9 Potential management measures for grape production (Coalition for Urban/Rural Environmental Stewardship, 2006; Peacock et al., 1998)

Management Measure	General Description
Nutrient Management	
Nutrient Application Decisions	Apply only the amount of fertilizer needed to meet yield and quality goals, based on petiole or leaf analysis, vine vigor, soil testing, and soil water nitrate analysis.
Application Rates	Do not apply nitrogen at rates that exceed vine requirements. Nitrogen inputs from irrigation water, crop residues, and mineralization of soil organic matter must be considered when determining nitrogen fertilizer requirements.
Split Applications of Nitrogen	Apply nitrogen during the growing season, preferably after budbreak through fruit set, or postharvest to coincide with periods of rapid nitrogen uptake; avoid applications when vines are dormant.
Nutrient Application	Apply nutrients through a drip irrigation system when possible; ensure that irrigation water does not move off-site.
Application Practices	Follow good housekeeping procedures for fertilizer applications: • Clean up fertilizer spills promptly. • Shut off applicators during turns. • Maintain proper calibration of application equipment. • Clean tanks and equipment properly and apply rinse water evenly in vineyard using good agronomic practice. • Use back-flow prevention valves on the source water supply when injecting fertilizer into irrigation lines.
Vegetative Practices	
Cover Crops	Plant close-growing vegetation in the vineyard row to reduce or prevent runoff, trap sediment, and absorb nutrients.
Vegetative Buffers	Surround a field with strips of permanent vegetation that slow water runoff and increase infiltration so that sediment and attached nutrients are trapped and prevented from moving off-site.
Vegetative filter strips	Maintain strips of land in permanent vegetation between the vineyard and a waterbody. Filter strips slow runoff flow, allowing particulate material to settle out.
Constructed wetlands	Construct wetlands at tile line outlets or as part of buffer systems to provide conditions for deposition of particulate material, uptake of nutrients, and denitrification of excess nitrates.
Irrigation Management	
Irrigation efficiency	Efficiently manage irrigation water to minimize leaching and promote denitrification. Irrigations must be accurately scheduled and applied, and irrigation systems must be properly designed, operated, and maintained. Drip irrigation, when managed properly, can achieve high irrigation efficiency primarily by minimizing water flow below the root zone but also from reduced surface evaporation and runoff.

Table D-10 Potential management measures for orchards (Coalition for Urban/Rural Environmental Stewardship, undated; RWQCB, Central Valley Region, 2002)

Management Measure	General Description
Vegetative Practices	
Orchard Floor Vegetation	Grow seeded or resident vegetation on orchard floors that is later mowed or disked. Orchard floor vegetation anchors soil during winter rains preventing soil, nutrient, and pesticide runoff; improves water infiltration, soil aeration, and soil texture; and improves soil fertility.
Cover and Green Manure Crop	Disk plants to incorporate organic material and improve soil fertility and tilth; mow cover crops to reduce dust during harvest operations and improve water infiltration rates.
Vegetative Buffers	Maintain areas or strips of land surrounding an orchard in permanent vegetation. Vegetative buffers are effective in trapping eroded sediment, reducing runoff of pesticides that are adsorbed to soil particles.
Vegetative Filter Strips	Use areas of grass or other permanent vegetation to reduce sediment, organics, nutrients, pesticides, and other contaminants in runoff to maintain or improve water quality.
Vegetative Barriers	Establish narrow, permanent strips of stiff-stemmed, erect, dense, perennial vegetation in parallel rows and perpendicular to the dominant slope of the field. Vegetative barriers are effective in dispersing concentrated flow, thereby increasing sediment trapping and water infiltration.
Grassed Waterways	Plant natural or constructed channels in permanent vegetation in an area where runoff concentrates. Grassed waterways help to slow the flow of water to a nonerosive level and carry surface water at a nonerosive velocity to a stable outlet and are effective in trapping sediment and dissolved chemicals when designed to spread concentrated water flow evenly across a vegetative filter adjacent to waterways.
Constructed Wetlands	Construct wetlands at tile outlets or as part of riparian buffer systems for degrading pesticides and denitrifying nitrates.
Hedgerows	Establish fences of shrubs or trees in, across, or around a field. If runoff flows across the hedgerow in sheet flow, sediment can be trapped, reducing the amount of sediment and sediment-borne nutrients and pesticides that enter surface waters. Deep roots of many of the native species used in hedgerows can hold the soil and increase water permeability, reducing water runoff and off-site movement of sediment.
Soil Improvement	
Aeration	Use specialized tillage equipment to break crusts and aerate orchard soils to increase water penetration and retention, thus reducing runoff; improves the soil profile with minimal disruption to the orchard floor.
Ripped Resident Vegetation	In orchards with permanent or semipermanent sod, rip vegetation at various lengths and/or depths; ripping significantly increases soil water due to increased infiltration and porosity.
Managing Runoff Water	
Water and Sediment Control Basins	Construct earthen embankments or a combination ridge and channel across the slope and minor watercourses to form a sediment trap and water detention basin. Basins trap sediment and pesticides adsorbed to soil particles, reduce and manage on-site and downstream runoff, and divert the flow of dissolved substances like nutrients and pesticides.
Avoid Compaction/Wheel Rutting	Minimize creation of wheel ruts with equipment when the orchard floor is saturated. Wheel ruts formed by equipment passing through wet fields can create channels for water to run off from orchards.

Table D-10 Potential management measures for orchards (Coalition for Urban/Rural Environmental Stewardship, undated; RWQCB, Central Valley Region, 2002) (continued)

Drainage System Management	Filter runoff water through vegetation allowed to grow in drainage ditches. Drainage management can help to mitigate off-site movement of nutrients suspended or dissolved in storm runoff.
Berms	Construct raised berms at the low ends of fields to trap sediment and adsorbed nutrients. Berms hold back water, increasing runoff retention and allowing infiltration.
Irrigation Management	
Improved Water Application	Change water volume being applied to increase irrigation efficiency, e.g., reduce volume of water applied to refill the crop root zone; change the amount, rate, or timing of water being applied to the crop to improve efficiency with no loss of crop production; increase distribution uniformity of applied water; reduce erosion caused by irrigation.
Improved Control, Regulation, and Measurement of water	Install measuring devices, division boxes, checks, turnouts, and valves and gates for greater control over water application.
Irrigation Erosion Control/Irrigation Water Additives	Use additives like PAM, gypsum, and humic acid, which can reduce nutrients and pesticides in the tailwater by increasing infiltration during irrigation events, reducing erosion, and promoting the aggregation of dispersed soil colloids.
Tailwater Recovery Systems	Collect, store, and transport irrigation tailwater for reuse in an irrigation distribution system. Tailwater recovery systems are suitable for use on sloping lands with surface irrigation systems or for use in areas where there is recoverable irrigation runoff flow or where such flows can be expected under the management practices used.

Table D-11 Potential management measures for sod production (OMAFRA, 2002)

Management Measure	General Description
Managing Nutrients	
Phosphorus Application	Apply phosphorus only once based on soil testing, immediately before seeding, when it can be incorporated and will increase seedling vigor.
Nitrogen Application	Apply nitrogen in light but frequent applications, based on the color, density, and vigor of the turf. The amount should be adjusted depending on desired growth.
Managing Soil Loss	
Soil Preparation	Prepare a level soil surface with tillage and land leveling; if soil is moist, roll immediately before harvesting to flatten irregularities. These two practices promote uniform cutting, which avoids wasting sod and removing excess soil.
Erosion Control	Use light surface cultivation followed by seeding of a winter cereal crop like rye immediately after harvest. Keep soil surface covered to avoid erosion.

Effects Quantification for Tables 12a and 12b:

-5	Significant Increase in the Problem
-4	Moderate to Significant Increase in the Problem
-3	Moderate Increase in the Problem
-2	Slight to Moderate Increase in the Problem
-1	Slight Increase in the Problem
0	No Effect, Situational, Insignificant, Facilitating
1	Slight Decrease in the Problem
2	Slight to Moderate Decrease in the Problem
3	Moderate Decrease in the Problem
4	Moderate to Significant Decrease in the Problem
5	Significant Decrease in the Problem

Table D-12a Effects of candidate practices on selected resource concerns: Air quality, erosion, soil condition, and water quantity (USDA-NRCS, 2006)

NRCS Code	Practice	Air Quality			Erosion			Soil Condition				Water Quantity	
		PM 10	PM 2.5	Grnhs Gas	Sheet & Rill	Wind	Irrigation induced	Salts	N (fert. or an. waste)	P (fert. or an waste)	Pesticides	Excessive Seepage	Excessive Runoff
327	Conservation Cover	2	2	1	3	3	2	2	2	2	0	2	2
328	Conservation Crop Rotation	2	2	1	4	4	3	2	4	4	3	1	2
329 A	No Till/Strip Till	4	4	3	4	4	3	1	0	0	0	-1	2
330	Contour Farming	0	0	1	4	0	3	0	0	0	-1	-2	1
332	Contour Buffer Strips	1	1	1	4	0	3	0	0	0	-1	-2	1
340	Cover Crops	3	2	2	4	5	4	1	2	2	2	1	2
342	Critical Area Planting	2	2	1	5	5	4	1	0	0	1	0	0
344	Seasonal Residue Management	2	2	2	4	4	3	1	0	0	0	-1	1
345	Mulch Till	4	4	2	4	4	3	1	0	0	0	-1	1
346	Ridge Till	4	4	2	4	4	3	1	0	0	1	-1	2
350	Sediment Basin	0	0	0	0	0	0	0	0	0	0	-2	2
362	Diversion	0	0	0	1	0	0	0	0	0	0	-1	3
370	Atmospheric Resource Quality Management	3	3	3	3	3	0	0	4	4	0	0	0
380	Windbreak/Shelterbelt	3	3	2	3	5	1	1	2	2	1	2	-1
386	Field Border	1	1	1	4	4	4	1	2	2	2	-2	2
393	Filter Strip	1	1	1	4	0	4	1	2	2	2	0	0
412	Grassed Waterway	0	0	1	4	0	5	0	-1	-1	-1	0	3
422	Hedgerow Planting	2	2	1	1	2	1	0	0	0	0	0	0
447	Irrigation Tailwater Recovery	0	0	0	0	0	0	-1	0	0	-1	-1	3
449	Irrigation Water Management	3	3	0	0	3	3	3	0	0	0	0	0
	For specific irrigation practice components, consult NRCS table												
450	PAM Erosion Control	3	3	0	3	3	3	1	0	0	0	0	0
570	Runoff Management System	0	0	0	2	0	0	0	0	0	0	0	2
590	Nutrient Management	2	3	1	0	0	-1	2	2	2	0	0	0
595	Pest Management	2	2	2	1	0	3	0	0	0	3	0	0
589 A	Cross-Wind Ridges	2	2	0	0	4	0	0	0	0	0	0	0
589 C	Cross-Wind Trap Strips	2	2	0	0	4	0	0	0	0	0	0	0
600	Terrace	0	0	0	5	1	1	0	0	0	0	-2	4
601	Vegetative Barrier	1	1	0	4	1	4	-1	-1	-1	0	0	-2
603	Herbaceous Wind Barrier	3	2	1	0	4	0	0	0	0	0	0	0
610	Salinity/Sodic Soil Management	1	1	0	0	0	0	3	0	0	0	0	0
633	Waste Utilization	0	2	2	2	1	2	0	0	0	1	0	0
638	Water and Sediment Control Basin	0	0	0	0	0	3	0	0	0	0	-2	2
702	Agrichemical Handling Facility	0	0	0	0	0	0	0	0	0	2	0	0
--	Manure/Soil Treatment	0	0	3	0	0	0	0	4	4	0	0	0

Table D-12b Effects of candidate practices on selected resource concerns: Ground water and surface water quality (USDA-NRCS, 2006)

NRCS Code	Practice	Water Quality										
		Ground Water					Surface Water					
		Pesticides	Salinity	Nutrients	Metals	Pathogens	SS/ turbidity	Pesticides	Salinity	Nutrients	Metals	Pathogens
327	Conservation Cover	3	1	2	1	2	3	3	1	2	2	1
328	Conservation Crop Rotation	2	2	2	1	2	2	2	1	2	1	1
329A	No Till/Strip Till	1	0	0	1	0	3	4	1	1	1	1
330	Contour Farming	0	0	0	0	0	3	1	1	3	2	1
332	Contour Buffer Strips	0	-1	-1	0	-1	3	2	1	3	3	1
340	Cover Crops	2	1	2	1	2	2	2	0	2	2	1
342	Critical Area Planting	0	0	1	1	1	4	0	0	2	2	1
344	Seasonal Residue Management	0	0	0	1	0	1	1	1	1	1	1
345	Mulch Till	1	0	0	1	0	1	4	1	2	1	1
346	Ridge Till	1	0	0	1	0	2	4	1	1	1	1
350	Sediment Basin	-1	-1	-1	-1	-1	4	2	2	5	2	2
362	Diversion	1	0	0	0	0	2	1	0	0	1	1
370	Atmospheric Resource Quality Management	0	0	0	0	0	1	3	0	1	0	0
380	Windbreak/Shelterbelt	0	0	5	0	0	2	2	0	1	1	0
386	Field Border	2	1	2	1	0	2	2	0	2	1	1
393	Filter Strip	1	1	3	1	1	5	3	1	5	4	1
412	Grassed Waterway	0	0	0	0	0	2	2	2	2	1	2
422	Hedgerow Planting	0	0	0	0	0	0	1	0	2	0	0
447	Irrigation Tailwater Recovery	2	-1	0	0	0	1	2	1	2	4	1
449	Irrigation Water Management	3	3	3	2	2	3	3	2	3	3	3
	For specific irrigation practice components, consult NRCS table											
450	PAM Erosion Control	0	0	0	0	0	4	4	0	4	1	0
570	Runoff Management System	0	0	0	0	0	2	0	0	0	0	0
590	Nutrient Management	1	1	5	2	1	1	1	1	5	3	1
595	Pest Management	5	0	0	0	0	2	5	0	0	0	0
589A	Cross-Wind Ridges	0	0	0	0	0	1	2	1	2	0	0
589C	Cross-Wind Trap Strips	0	0	0	0	0	1	2	1	2	0	0
600	Terrace	-2	-2	-2	-1	-1	3	3	2	2	2	2
601	Vegetative Barrier	-1	-1	-1	-1	0	2	2	1	2	2	2
603	Herbaceous Wind Barrier	0	0	0	0	0	1	1	1	1	1	0
610	Salinity/Sodic Soil Management	0	0	0	0	0	0	0	0	0	0	0
633	Waste Utilization	2	2	2	0	2	0	0	2	2	0	0
638	Water and Sediment Control Basin	-1	-1	-1	-1	-1	4	2	1	2	2	2
702	Agrichemical Handling Facility	2	0	2	1	0	0	0	0	0	0	0
--	Manure/Soil Treatment	0	4	4	0	0	0	0	0	4	0	0

Table D-13 General pollutant reduction effectiveness of selected management measures from the literature (USEPA, 2003; USDA-NRCS, 2000)

Management Measure	General pollutant reduction effectiveness (%)				
	Phosphorus	Nitrogen	Sediment	Pesticides	Bacteria
Nutrient Management	35	15			
Reduced Tillage	45	55	75		
Terrace Systems	70	20	85		
Filter Strips	75–85	70	0–70	22–63	55
Ridge Till				30	
No Till				21–92	
Buffers				11–100	
Animal Waste Systems	90	80	60		85
Constructed Wetland	42	42	53		
Livestock Exclusion	15	12	34		29–46
Irrigation Sediment Basins			75–95		
Straw in Furrows			40–80		

Table D-14 Estimated cost of selected NRCS conservation practices: California, 2007 (USDA-NRCS, 2007)

NRCS Code	Conservation Practice Name	Unit	Installation Cost	Life (Years)	Installation Cost /Yr	O&M Factor	O&M Cost/Yr	Total Annual Cost
327	Conservation Cover	Ac	$1,000.00	10	$131.87	0.03	$30.00	$161.87
328	Conservation Crop Rotation	Ac	$15.00	1	$15.00	0.00	$0.00	$15.00
329	Residue Management, No Till/Strip Till/Direct Seed	Ac	$50.00	1	$50.00	0.00	$0.00	$50.00
330	Contour Farming	Ac	$5.00	1	$5.00	0.00	$0.00	$5.00
332	Contour Buffer Strips	Ac	$90.00	10	$11.87	0.03	$2.70	$14.57
340	Cover Crop	Ac	$300.00	1	$300.00	0.00	$0.00	$300.00
342	Critical Area Planting	Ac	$1,000.00	10	$131.87	0.05	$50.00	$181.87
344	Residue Management, Seasonal	Ac	$30.00	1	$30.00	0.00	$0.00	$30.00
345	Residue Management, Mulch Till	Ac	$30.00	1	$30.00	0.00	$0.00	$30.00
346	Residue and Tillage Management, Ridge Till	Ac	(no information)					
350	Sediment Basin	No	$10,000.00	20	$828.14	0.03	$300.00	$1,128.14
362	Diversion	Ft	$20.00	10	$2.64	0.02	$0.40	$3.04
370	Atmospheric Resource Quality Management	Ac	$10.00	1	$10.00	0.00	$0.00	$10.00
380	Windbreak/Shelterbelt Establishment	Ft	$6.00	15	$0.59	0.01	$0.06	$0.65
386	Field Border	Ft	$4.00	10	$0.53	0.01	$0.04	$0.57
393	Filter Strip	Ac	$500.00	10	$65.94	0.02	$10.00	$75.94
412	Grassed Waterway	Ac	$500.00	10	$65.94	0.02	$10.00	$75.94
422	Hedgerow Planting	Ft	$2.00	15	$0.20	0.05	$0.10	$0.30
447	Irrigation System, Tailwater Recovery	No	$10,000.00	20	$828.14	0.03	$300.00	$1,128.14
449	Irrigation Water Management	Ac	$35.00	1	$35.00	0.00	$0.00	$35.00

Table D-14 Estimated cost of selected NRCS conservation practices: California, 2007 (USDA-NRCS, 2007) (continued)

NRCS Code	Conservation Practice Name	Unit	Installation Cost	Life (Years)	Installation Cost /Yr	O&M Factor	O&M Cost/Yr	Total Annual Cost
450	Anionic PAM Erosion Control	Ac	$50.00	1	$50.00	0.00	$0.00	$50.00
570	Runoff Management System	No.	$10,000.00	15	$988.00	0.02	$200.00	$1,188.00
589	Cross Wind Trap Strips/Ridges	Ac	$12.00	5	$2.80	0.01	$0.12	$2.92
590	Nutrient Management	Ac	$60.00	1	$60.00	0.00	$0.00	$60.00
595	Pest Management	Ac	$125.00	1	$125.00	0.00	$0.00	$125.00
600	Terrace	Ft	$5.00	10	$0.66	0.03	$0.15	$0.81
601	Vegetative Barrier	Ft.	$0.75	10	$0.10	0.02	$0.02	$0.11
603	Herbaceous Wind Barriers	Ft	$0.01	5	$0.00	0.05	$0.00	$0.00
610	Salinity and Sodic Soil Management	Ac	$200.00	1	$200.00	0.00	$0.00	$200.00
633	Waste Utilization	Ac	$15.00	1	$15.00	0.00	$0.00	$15.00
638	Water and Sediment Control Basin	No	$10,000.00	10	$1,318.73	0.03	$300.00	$1,618.73
Specific irrigation practice components								
202	Irrigation System, Low-Energy Precision Application	Ac	$1,500.00	10	$197.81	0.05	$75.00	$272.81
320	Irrigation Canal or Lateral	Ft	$15.00	10	$1.98	0.20	$3.00	$4.98
388	Irrigation Field Ditch	Ft	$6.00	10	$0.79	0.20	$1.20	$1.99
428	Irrigation Ditch and Canal Lining	Ft	$6.00	20	$0.50	0.02	$0.12	$0.62
428	Irrigation Water Conveyance, Ditch and Canal Lining	Ft	$20.00	20	$1.66	0.02	$0.40	$2.06
430	Irrigation Water Conveyance, Pipeline	Ft	$40.00	25	$2.95	0.02	$0.80	$3.75
436	Irrigation Storage Reservoir	No	$25,000.00	15	$2,469.99	0.01	$250.00	$2,719.99
441	Irrigation System, Microirrigation	Ac	$1,200.00	10	$158.25	0.05	$60.00	$218.25
442	Irrigation System, Sprinkler	Ac	$2,500.00	15	$247.00	0.02	$50.00	$297.00
443	Irrigation System, Surface and Subsurface	Ac	$3,000.00	15	$296.40	0.03	$90.00	$386.40
464	Irrigation Land Leveling	Ac	$350.00	15	$34.58	0.03	$10.50	$45.08
468	Lined Waterway or Outlet	Ft	$60.00	15	$5.93	0.02	$1.20	$7.13
552	Irrigation Regulating Reservoir	No	$25,000.00	15	$2,469.99	0.01	$250.00	$2,719.99
428A	Irr. Water Conveyance, Ditch/Canal Lining, Concrete	Ft	$20.00	20	$1.66	0.02	$0.40	$2.06
428B	Irr. Water Conveyance, Ditch/Canal Lining, Flexible Membrane	Ft	$15.00	20	$1.24	0.02	$0.30	$1.54
428C	Irr. Water Conveyance, Ditch/Canal Lining, Galvanized Steel	Ft	$20.00	20	$1.66	0.02	$0.40	$2.06
430AA	Irr. Water Conveyance, Pipeline, Aluminum Tubing	Ft	$16.00	25	$1.18	0.04	$0.64	$1.82
430CC	Irr. Water Conveyance, Pipeline, Nonreinforced Concrete	Ft	$25.00	25	$1.84	0.02	$0.50	$2.34
430DD	Irri.Water Conveyance, Pipeline, High-Pressure, Plastic	Ft	$12.00	25	$0.88	0.02	$0.24	$1.12

Table D-14 Estimated cost of selected NRCS conservation practices: California, 2007 (USDA-NRCS, 2007) (continued)

NRCS Code	Conservation Practice Name	Unit	Installation Cost	Life (Years)	Installation Cost /Yr	O&M Factor	O&M Cost/Yr	Total Annual Cost
430EE	Irr. Water Conveyance, Pipeline, Low-Pressure, Plastic	Ft	$15.00	25	$1.10	0.02	$0.30	$1.40
430FF	Irr. Water Conveyance, Pipeline, Steel	Ft	$25.00	25	$1.84	0.02	$0.50	$2.34
430HH	Irr. Water Conveyance, Pipeline, Rigid Gated Pipeline	Ft	$20.00	10	$2.64	0.04	$0.80	$3.44
776	Irr. Water Conveyance, Pipeline, On Ground Aluminum	Ft	$5.00	25	$0.37	0.04	$0.20	$0.57
794I	Irr. Water Conveyance, Pipeline, HDPE	Ft	$15.00	25	$1.10	0.02	$0.30	$1.40

Table D-15 Other cost estimates

Practice	Unit	Cost (2006 $) [1]	Source
PAM application via irrigation	$/acre	$10–$18	Kay-Shoemaker et al. 2000
Irrigation Water Systems[2] for water conservation	$/acre served	$97	USDA-FSA 1996
Irrigation Water Systems[2] for water quality	$/acre served	$89	USDA-FSA 1996
Irrigation Water Systems[2] for erosion control	$/acre served	$109	USDA-FSA 1996
Sediment Retention Water Control Structures[3]	$/acre served/year	$138	USEPA 2003
Nutrient Management	$/acre	$6–$37	NAICC 1998

[1]Cost adjusted to 2006 dollars using Consumer Price Index conversion factors (Sahr, 2007).

[2] Components of practice are critical area planting, canal or lateral, structure for water control, field ditch, sediment basin, grassed waterway or outlet, land leveling, water conveyance ditch and canal lining, water conveyance pipeline, trickle (drip) system, sprinkler system, surface and subsurface system, tailwater recovery, land smoothing, pit or regulation reservoir, subsurface drainage for salinity, and toxic salt reduction.

[3] Median costs (1990 dollars) obtained from the Chesapeake Bay Program Office BMP tracking database and Chesapeake Bay Agreement Jurisdictions' unit data cost. Annualized BMP total cost including O&M, planning, and technical assistance costs. Ten-year life assumed.

D.2.2.1.4 Selecting and Implementing Agricultural Management Practices to Achieve Water Quality Goals in the San Jacinto Watershed

The achievement of water quality goals depends on both the individual and collective actions of all persons who affect the problems in the watershed or the solutions to those problems. Management programs to reduce pollutant loads from the San Jacinto watershed should include specific practices tailored to the needs and opportunities of each agricultural operation, as well as a plan for applying appropriate practices throughout the watershed. In the first case, individual producers make decisions that address pollution control and economic sustainability using technical assistance and a comprehensive farm planning approach. At the watershed scale, managing nutrient loads requires balancing multiple actions, including targeting practices to the most important sources (both spatially and by magnitude) and applying practices that serve multiple users, such as management of manure distribution from within and without the watershed.

Individual Agricultural Operators

Management practices selected for individual agricultural operations must achieve on-farm goals for both managing pollutant export and ensuring economic sustainability, while also contributing as needed to the overall nutrient load reductions required in the watershed. Other environmental requirements and constraints must be considered as well.

BMPs must be adapted to the particular objectives and circumstances of an individual agricultural operation; at the same time, they must adhere to certain standards and specifications. Therefore, developing a plan to select and implement specific practices is most often a one-on-one cooperative effort that involves technical assistance (e.g., from NRCS district staff, extension staff) and choices to be made by the producer. This planning effort usually works best when the entire farm operation is considered at the same time, rather than trying to “fix” a single problem. The following steps, adapted from NRCS planning procedures, are usually useful in this process:

Identify problems and opportunities

Determine objectives for both load reduction and farm operation

Inventory available resources, including

- Land units, locations, crops produced, current management practices
- Information on human considerations, such as labor availability
- Identification of other ecological concerns, such as threatened and endangered species
- Identification of cultural resources such as archaeological or historic sites
- Identification of infrastructure physical features such as roads, houses, fences, power lines, and other utilities

Analyze resource data

- Benchmark condition of the farm resources
- Environmental evaluation data
- Cultural resources identification and evaluation data
- Other program and legal evaluations data
- Identification of resource problems, such as existing on- or off-site pollution problems
- Identification of the causes or conditions that resulted in the resource problems
- Identification of conditions with the potential to cause future resource problems

Planner and producer agree on accepted definition of problems, opportunities, and concerns

Planner and producer agree on statement of objectives

Formulate alternatives, including full description and list of applicable permits and certification requirements

Evaluate alternatives

- A set of practical alternatives that meet design standards and specification and are compatible with the producer's objectives
- An evaluation of the beneficial effects and potentially harmful impacts for each alternative

Make decisions

- Assemble plan document, including potential program or implementation opportunities, and operation and maintenance
- Schedule of conservation system(s) and practice(s) implementation
- Documentation of environmental compliance (all National Environmental Policy Act [NEPA], cultural resources, and other applicable environmental laws and regulations)

The process of selecting specific practices among identified alternatives is often a complex mix of balancing multiple considerations, e.g., practice effectiveness, practicality on the farm, and compliance with other resource requirements. The decision tree in Figure D-1 illustrates the process that should be followed in selecting management practices at each agricultural operation in the San Jacinto watershed. Note that there should be a provision for evaluating the performance of innovative BMPs that lack proven effectiveness in the region.

The objectives of such a technical evaluation would be (1) to quantify the effects of the BMP on pollutant concentrations and loads under real operational conditions and (2) to collect information on the installation and operation of the practice that would affect its practicality and cost-effectiveness for other applications. The effectiveness of a single BMP can best be evaluated using an input/output monitoring design, in which paired samples of inflow to and outflow from the practice are collected. The specific variables selected for evaluation should include the constituents responsible for waterbody impairment and those expected to be changed by the action of the BMP; associated explanatory variables such as flow (necessary to calculate load), precipitation, or temperature should also be measured as needed. In addition to water quality data, additional data on the use of the BMP, its function, and any operation and maintenance issues should also be collected. Water quality data can be evaluated using basic statistics like a *t*-test, and results can be expressed in terms of pollutant removal efficiency or mass balance. The more typical or representative the initial situation is and the BMP, the greater the likelihood that the results of a single-BMP evaluation will be broadly applicable within the watershed. It is very important to carefully document the situation on the land before the BMP is applied to support informed judgment regarding the likely performance of the BMP in other applications.

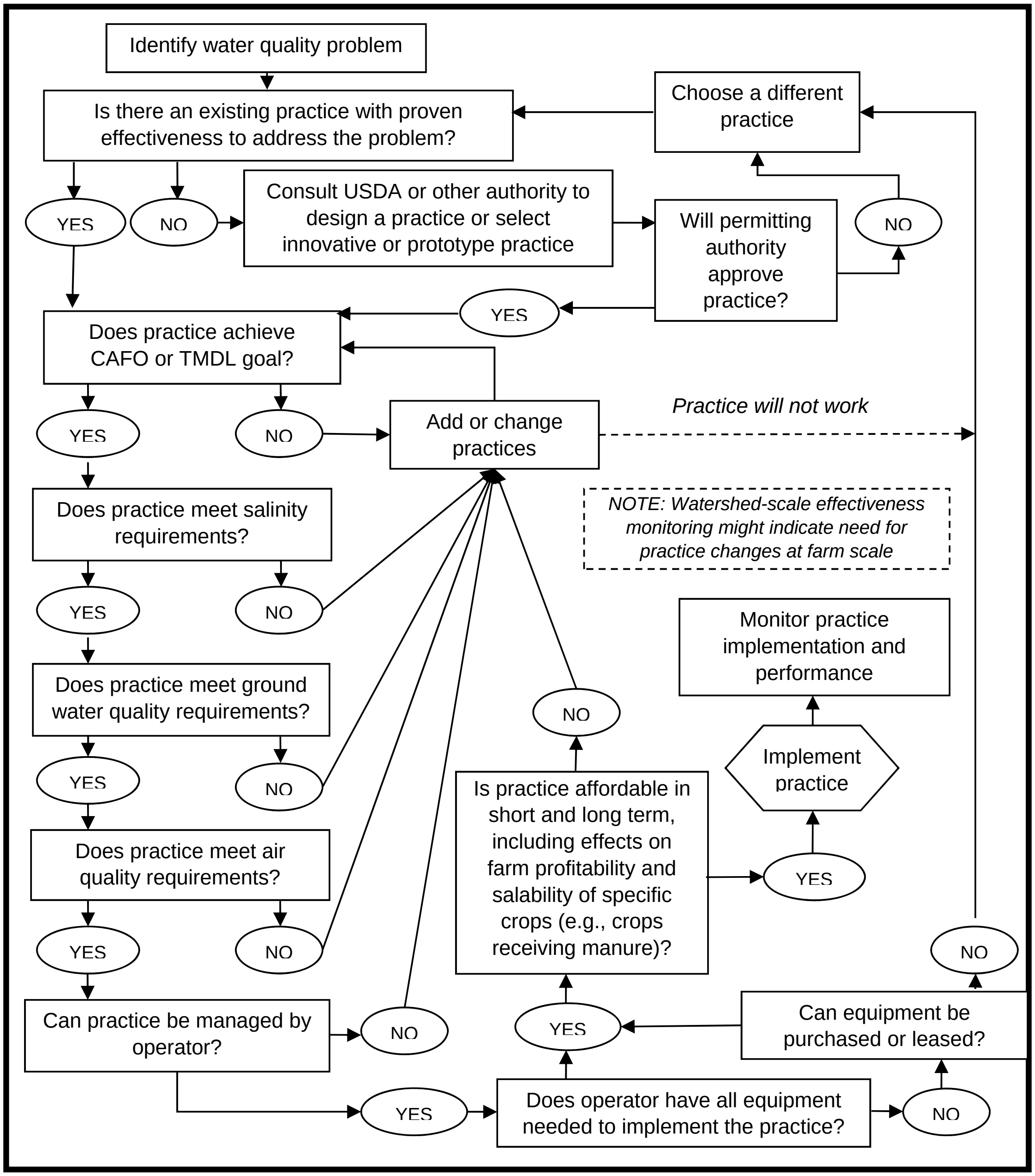

Figure D-1
Practice Selection, Implementation, and Tracking Process for Single Operations in San Jacinto Watershed

For example, consider an effort to evaluate the performance of a specially vegetated ditch in removing suspended sediment and attached phosphorus in runoff collected from an orchard. The evaluation could start with a conventional ditch with the downstream half-vegetated. Samples collected from the ditch just before the newly vegetated section would represent the input to the BMP section, and samples of the same plug of water as it reaches the outlet of the ditch would represent the result of the treatment. The monitoring program would include flow measurement during storm events, along with analysis of samples collected over the event for suspended sediment and total phosphorus. Results could be expressed as the quantity or percent reduction in sediment or phosphorus load based on comparison of input against output. Other data important to collect in such a project would include precipitation (to place monitored storm events in the context of average or extreme conditions) and observations or measurements of vegetation or sediment in the ditch (to assess maintenance issues and the long-term prospects of the BMP).

Note that monitoring to determine BMP effectiveness is a complex and often challenging task. Such an activity could be a grant-funded project, contracted to a qualified and experienced contractor. Good sources of guidance on the design and operation of monitoring programs include the following:

USDA. 1996. *National Handbook of Water Quality Monitoring,* part 600 national water quality handbook. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, DC. ftp://ftp.wcc.nrcs.usda.gov/downloads/wqam/wqm1.pdf.

USEPA. 1997. *Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls*. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA 841-B-96-004 (available from the National Service Center for Environmental Publications at (800) 490-9198).

Watershed Scale

The selection of practices begins with a thorough, accurate assessment of the water quality problems in the watershed. USEPA's guidance to states regarding the use of Clean Water Act section 319 Nonpoint Source Program funds lays out basic elements of a watershed plan to solve identified water quality problems at the watershed scale (USEPA, 2003a). This guidance essentially states that successful watershed-based plans involving nonpoint sources of pollution must generally include at least the nine elements listed below.

1. An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in the watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (2) immediately below.

2. An estimate of the load reductions expected for the management practices described under (3) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management practices over time).

3. A description of the management practices that will need to be implemented to achieve the load reductions estimated under (2) above (as well as to achieve other watershed goals identified in the watershed-based plan), and an identification (using a map or a description) of the critical areas in which those practices will be needed to implement the plan.

4. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement the plan.

5. An information/education component that will be used to enhance public understanding of the project and encourage early and continued participation of the public in selecting, designing, and implementing the management practices that will be implemented.

6. A schedule for implementing the management practices identified in the plan that is reasonably expeditious.

7. A description of interim, measurable milestones for determining whether management practices or other control actions are being implemented.

8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards and, if not, the criteria for determining whether the watershed-based plan needs to be revised or, if a nonpoint source TMDL has been established, whether the nonpoint source TMDL needs to be revised.

9. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (8) immediately above.

Where the watershed-based plan is designed to implement a TMDL, these elements will help provide reasonable assurance that the nonpoint source load allocations identified in the nonpoint source TMDL or anticipated in National Pollutant Discharge Elimination System (NPDES) permits for the watershed will be achieved.

It is not possible to estimate precisely the load reductions that will result from implementing practices on a single farm, let alone the cumulative load reduction from multiple practices across a watershed. The reasons for the latter difficulty are complex. Not all land in a watershed—even land in the same land use/land cover—generates pollutant loads equally. The same practice implemented in two different settings might yield different load reductions because of variation in initial condition or specific operation. Load reductions from individual operations high up in the watershed might require considerable time to be expressed at the watershed outlet. This could be particularly relevant to the San Jacinto watershed, where the transport of nonpoint source pollutants below Mystic Lake is intermittent.

Nevertheless, it is very important to make a reasonable effort to identify the significant sources; identify the management practices that will most effectively address those sources; and broadly estimate the expected load reductions that will result. Scattershot implementation of management practices is usually an inefficient, if not ineffective, approach to achieving water quality goals. It is highly recommended that practices be targeted first to those locations in the watershed where the greatest pollutant load reductions can be achieved, while also considering logistics issues, cost, and acceptability to producers.

As a starting point, using immediately available information, the nutrient source analysis

Although evaluating the effects of practices at the watershed scale is conceptually similar to the evaluation of individual BMPs described earlier, the former is considerably more complex and challenging. Numerous additional factors must be considered: year-to-year weather variations, gradual implementation of a variety of practices across a large land area, variability in operation and maintenance among multiple producers, lag time in the expression of water quality response far downstream of practice installation, and many more. Whereas it is typical to evaluate the effectiveness of a single BMP using an input/output monitoring design, it might be desirable to evaluate the cumulative effectiveness of multiple BMPs at the watershed scale by tracking designated beneficial use support status in the watershed, conducting paired-watershed studies, performing trend analysis or measuring pollutant loads against TMDL targets at a single downstream station, using an above/below monitoring design, or applying a combination of approaches that could even include some input/output monitoring for BMPs of special significance.

As for monitoring of single BMPs, the specific variables selected for evaluation should include those constituents responsible for waterbody impairment and those expected to be changed by the action of the BMPs, as well as associated explanatory variables like flow (necessary to calculate load), precipitation, and temperature. It is similarly important to collect additional data on the use of the BMPs applied in the watershed, their function, and any operation and maintenance issues. The level of detail needed and the necessary sampling frequency, however, will vary depending on the specific evaluation approach selected. Water quality data for any monitoring station, for example, are often reduced to annual values (e.g., annual mean, annual load) for statistical analysis, but there are also situations where quarterly values are more meaningful (e.g., seasonal patterns). Land use and land treatment data, , would be summarized as aerial mapping is updated. The design of a watershed-level monitoring program to evaluate the effects of implemented practices is critical because of the need to be able to attribute observed changes in water quality to the practices rather than to differences in weather or other factors unrelated to the BMPs.

D.2.2.1.5 Recommended BMPs for Agriculture in the San Jacinto Watershed

Many tools to reduce nutrient loads in surface runoff from agriculture in the San Jacinto watershed are available. However, at present it is impossible to recommend a single set of specific BMPs for all agricultural land in the watershed. The variety of agricultural activities, the need for site-specific planning and management, and the uncertainty about the distribution of crops grown in the watershed preclude a one-size-fits-all prescription.

This section recommends general management principles that should be applied by agricultural enterprises in the San Jacinto watershed. Within each area, specific BMPs can be implemented by a grower to meet these principles, depending on the specific crop(s) and operation involved. This report has presented many such BMPs. It should be emphasized that the BMPs discussed are not necessarily the only methods that can reduce nutrient loads in surface runoff. Control of nonpoint source nutrient runoff involves a complex interaction between natural processes and management actions. Some potential control measures, such as innovative practices currently under development or novel, site-specific practices, might not be covered.

Nutrient Management

Crop nutrients should be supplied in quantities that take into consideration the amounts needed to produce a reasonable crop yield, the amounts already present in the soil, and the amounts contributed by all nutrient sources, including commercial fertilizers, animal manure, irrigation water, and other sources. Nutrients should be applied using rates, timing, and methods designed to minimize losses to surface and ground waters. Many provisions of nutrient management are included in the NRCS Practice 590 standard. The specific elements of nutrient management vary by crop type, but they typically include these activities:

Nutrient and soil assessment

- Field maps
- Soil hazards and limitations, e.g., slopes, erosion potential
- Soil sampling and analysis
- Analysis of irrigation water for nutrient contribution
- Analysis of animal manure and other organic additions

Application of nutrients to croplands

- Application of amendments and organic materials to provide nutrients and improve soil quality
- Methods of fertilizer delivery and placement to reduce the potential for surface runoff, dust, ground water leaching, and volatilization of materials
- Selection of materials considering all formulations of plant-available nutrients relative to the growth stage requirements of the plant
- Calibration of equipment to deliver a known amount of material uniformly
- Storage and handling of materials away from surface waters and in an area where spills can be easily cleaned up

Timing of nutrient applications to coincide as closely as possible with the crop growth stage requirements and short-term weather conditions

Record keeping to provide information used to evaluate management effectiveness and help refine ongoing nutrient management.

Effective nutrient management reduces the amounts of nutrients available on agricultural land to be washed into surface or ground water, while providing for adequate crop growth.

Irrigation Water Management

The quantity of irrigation water applied should be managed to minimize surface runoff and unwanted ground water leaching beyond the root zone, while satisfying the moisture requirements of the crop. Irrigation applications should consider environmental interactions and soil hazards relative to erosion potential and infiltration rates. Irrigation applications should strive for uniformity and efficiency in design and delivery of water. Soil moisture should be assessed before all irrigations. Numerous specific irrigation water management practices are defined in NRCS standards, including the Practice 449 standard. The specific elements and techniques of irrigation water management vary by crop and irrigation system type, but they typically include these activities:

Crop water needs and soil moisture assessment, considering the period between irrigation applications, weather conditions, and the amount necessary to replace the amount depleted between irrigations, plus the amount necessary to satisfy the leaching requirement for the crop

Irrigation system design to efficiently apply irrigation water in quantity and locations needed

Tracking irrigation applications to aid in refining irrigation application timing and rates, reconciling usage, and in calculating irrigation efficiency

Tailwater management to capture and treat excess water to prevent off-site discharge of nutrients and sediments, especially from furrow irrigation

Effective irrigation water management will avoid providing excess water to move nutrients from cropland to surface water and ground water, while satisfying the moisture requirements of the crops.

Erosion Control

Tillage, planting, cultivation, and crop harvest should be conducted to minimize soil erosion by wind and water. NRCS specifies numerous wind and water erosion control practices. Specific practices vary by crop type and field conditions, but the practices generally address the following:

Detachment of soil particles by wind or water

- Residue and tillage management
- Cover crops
- Wind barriers

Movement of soil particles by wind or water

- Diversions and waterways
- Contour planting
- Terraces and water/sediment control basins
- Windbreaks and shelterbelts

Delivery of soil particles to waterways

- Sediment basins
- Filter strips
- Riparian buffers

Effective erosion control will minimize off-site movement of soil particles and associated nutrients to surface waters and help preserve soil productivity.

Crop-specific Practices

Specific crops might require specific practices adapted to their production and management to accomplish nutrient management, irrigation management, and erosion control. Individual practices to suit the needs of specific crops produced in the San Jacinto watershed are described in Tables 7 through 11 of this attachment. Growers should consult with their producer organizations, NRCS, and other resources to identify specific practices appropriate to their crops and operations.

Education/Outreach

Regional organizations, watershed groups, and government agencies should implement educational programs to raise awareness and promote the use of applicable agricultural management practices where needed to reduce nutrient inputs to surface water and ground water in the San Jacinto watershed. Public education, outreach, and training programs should involve appropriate user groups and the community. In cases where a major piece of equipment is needed to implement a new management practice, local agencies and agricultural organizations should consider purchasing that equipment for rental/sharing with producers in the San Jacinto watershed.

D.2.2.1.6 Information Needs

Recommendations for BMPs to reduce nutrient losses from agricultural land in the San Jacinto watershed need to be more specific on several levels. First, greater understanding of the agricultural nutrient sources in the watershed—by geographic area and by crop type—is needed to identify the specific practices needed and to set priorities for their implementation both by geographic area and by crop. Second, the current state of management on watershed farms must be assessed to understand the starting point, identify treatment needs, and estimate the potential results of nutrient reduction efforts.

To fine-tune general recommendations for agricultural BMPs, additional information is needed. In general, this information includes the following:

The extent and geographic distribution of agricultural land, by crop type and rotations, in the San Jacinto watershed

The current state of management on agricultural land in the watershed, including information on current practices related to nutrient applications of fertilizers and animal manure, tillage, erosion control, and irrigation management

The willingness of producers in the watershed to adopt new management practices

The availability of funding and technical assistance to implement new management practices

One way to guide the collection of necessary agricultural information in the San Jacinto watershed is through the use of models or screening tools at the farm level. With sufficient general information about watershed agriculture, it would be possible to construct several representative model farms of appropriate type, size, and management, e.g., citrus, grapes, tree crops, or vegetables. Systematic examination of these model farms to identify areas of risk for nutrient runoff losses would guide the selection and targeting of BMPs.

For example, *Farm*A*Syst* (UWEX, 2007) is a screening tool used across the nation to assess risks from fertilizer and livestock waste use, storage and handling of petroleum products, and management of hazardous wastes on the farm. Application of *Farm*A*Syst* requires information on a wide array of farm management activities:

Frequency of soil tests
Nutrient application rates
Yield goals
Nutrient credits, e.g., from legumes or irrigation water
Site characteristics
Manure characteristics and applications
Irrigation scheduling
Calibration of application equipment
Record keeping

Another widely used farm-level screening tool is the Phosphorus Index (USDA NRCS, 1994), a numerical assessment of landforms and management practices within a farm to determine the potential risk of phosphorus movement to waterbodies. The ranking of the Phosphorus Index identifies sites where the risk of phosphorus movement might be relatively higher than that of other sites. Application of the Phosphorus Index requires information about the sources of phosphorus and the existence of transport pathways to move the phosphorus:

Soil test phosphorus
Commercial fertilizer phosphorus application rate, method, and timing
Organic fertilizer phosphorus application rate, method, and timing
Soil erosion (calculated from the Revised Universal Soil Loss Equation [RUSLE])
Irrigation-induced erosion
Ephemeral gully erosion
Irrigation tailwater
Soil runoff class
Subsurface drainage

These screening tools are not necessarily the only or the best ones to apply to the San Jacinto watershed; regionally or locally adapted tools should be researched and applied as available.

Once model farms are developed and data obtained, evaluations using the appropriate screening tools with and without BMPs would help in exploring opportunities to implement specific practices, the types of water quality changes expected, and the cost-effectiveness of alternative practices.

D.2.2.2 Assessment of Best Management Practices to Reduce Nutrient Loads in the San Jacinto River Watershed

The University of California's Final Report, Assessment of Best Management Practices to Reduce Nutrient Loads in the San Jacinto Watershed, Best Management Practices for Agriculture in the San Jacinto Watershed, addresses Dairy Nutrient Management & Dry Land Crop BMPs, Citrus, Vegetable, and Turfgrass BMPs. These are typical BMPs that may be implemented by individual dairy and agricultural operators. They are not inclusive but are typical representations. While the UCR final report also addresses the guidance practices discussed in the Tetra Tech report and typical for implementation in the San Jacinto watershed, this section of their report addresses the specific BMPs tested in the watershed by University of California riverside staff. The report in its entirety is available upon request.

This project was funded by Federal Clean Water Act Section 319(h) Grant monies, through the Santa Ana River Regional Water Quality Control Board (SARWRCB). We wish to thank the lead investigator Laosheng Wu, Nyles Peterson, Mike Henry, David Birkle, Darren Haver and the various UCR staff that participated on this project. Other supporting staff included: Dr. Cindy Li of the SARWQCB, Pat Boldt with WRCAC and the SJRWC.

D.2.2.2.1 Best Management Practices Tested

D.2.2.2.1.1 Citrus Orchard BMPs

Management practices which were investigated within citrus orchards included (1) the application of PAM to the surface soil, (2) the growth of a cover crop, (3) fertigation plus mulch, and (4) conventional fertigation (control) (Table D-16).

Table D-16 Experimental treatments for the three field sites

Field	Treatments			
Citrus	Fertigation (Control)	Fertigation + Cover crop	Fertigation + Mulch	Fertigation + PAM
Potato	Chemical fertilizer	Chemical fertilizer + Cover crop	Chemical fertilizer + PAM	Chemical fertilizer + Deep plowing
Dryland	Chemical fertilizer (Control)	Manure (spread)	Manure (disking)	Chemical fertilizer + Buffer strip

Field Site Description and Layout

This study was conducted in a mature (20 to 30 years old) citrus grove located near Valle Vista, the main citrus growing region in the San Jacinto watershed. Here about 2500 acres of citrus are grown, which represents about 20 percent of Riverside County's production.

The treatments listed in Table D-16 were studied using established rows. The experiment in this site consists of 4 treatments with 3 replications (a total of 12 plots). A plot is 600 ft by 20 ft, and represented the full length and width of each row in the orchard. The plot layout is depicted in Fig. D-2. The first sample (first flush) of runoff from each plot was collected with a passive sample station. Then, runoff of the replicated treatments from the three blocks was diverted to a 4 inch drain pipe line that carried the runoff (composite sample) to a monitoring station, which consisted of a sump-pump, a digital flow meter and a data-logger. Water samples at the monitoring stations were collected by passive siphon collectors that were controlled by timers. Detailed photos show the sample collection stations.

Soil series at the study site is mapped as Hanford coarse sandy loam (USDA-SCS, 1971). (A description of this soil series is provided in the appendix). These soils are well-drained. Slope at the site is about 2 to 4 percent. Common for the citrus orchards in this region is the use of micro-sprinklers for fertigation. Fertigation treatment followed the common practices in the region (Citrus Production Manual ed. By L. Ferguson, Personal Communication). Fertilizers are applied at a rate of about 250 pounds N per acre per year. In addition, two foliar sprays of zinc sulfate and manganese sulfate (two 5 pound applications per acre per year) are usually sprayed during the summer and fall flush.

Treatments were put in place in December early in the rainy season. For the mulch treatment, leaves and trimmings were collected from nearby rows (outside of the research plots) and placed on the mulch treatment rows. Wheat was planted as the winter cover crop. It took a few weeks for the cover crop to establish and become effective as a treatment. PAM, was applied at a rate of 10 lbs per acre, it was applied on the same day that wheat was planted for the cover crop. The grower used his micro sprinkling system and fertigation on the same schedule as the remainder of the orchard and we did not interfere with this portion of his operation.

Time Table: The experiment at this site started in January 2007 to allow sampling of some of the rainstorms for the wet season of 2006-2007. The original plan was to monitor up to three rainstorms during the wet season of 2007-2008 but this was dependent on the actual weather conditions. Due to very dry weather the first two seasons the SARWRCB allowed us to continue to monitor runoff for the 2008-2009 rainy season. There was never any evidence of measurable irrigation runoff from these plots; thus this project only collects storm runoff; no irrigation runoff was monitored in this project.

Results: Detailed graphs and tables of our results are provided elsewhere in Section 2.4.1.

D.2.2.2.1.2 Vegetable Crop BMPs

For the vegetable plots the original plan was to investigate management practices within vegetable crop (potato) fields including (1) application of PAM to the soil surface or irrigation water, (2) growth of a cover crop, (3) deep plowing to alleviate compaction layer, and (4) control (Table D-16).

Field Site Description and Layout

This study was to be conducted in a potato field located near San Jacinto, within one of the main potato growing regions in the watershed. There are approximately 7,000 acres under potato production in the inland valleys of southern California, including Riverside, San Bernardino, and San Diego counties.

We were told that the field being considered was to be planted in the early spring for summer harvest, and with a summer planting (late July to early August) for fall and winter harvest. We started laying out our plots in the fall of 2006 and deep plowing was done in late November. The grower planted wheat in December. We assumed this was a cover crop and that it would be plowed under for spring planting. Spring of 2007 came and went and no potatoes were planted. The first potatoes were not planted until August 2007.

The spring crop is primarily White Rose, Kennebec, Orgold Russet, or some other processing varieties, plus some seed potatoes. The fall crop is almost exclusively the White Rose variety. All varieties are planted at the rate of 40 sacks to the acre so they obtain a 3" spacing between plants. The market no longer wants big potatoes, so these varieties are harvested young. Red potatoes take about 75-90 days to go from planting to harvest; white potatoes, 80-100 days, and Red Chieftans, 120 days.

Soil at the study site is mapped as Ramona sandy loam (USDA-SCS, 1971). (A description of this soil series is provided in the appendix.) Slope at the site is 0 to 2 percent. This soil is generally well drained with slow run-off. However, significant near surface soil compaction from the use of heavy farm equipment is common when growing potatoes and can increase the run-off potential. Fertilizer additions are tailored to the varieties being grown. Generally, 70 lbs of N is added preplant. However, if soil tests indicate that no additions of fertilizer are needed, they are not applied preplant. Manure is not currently being used at this site, since the grower has observed that it encourages scab disease and clogs wash ponds during tuber processing.

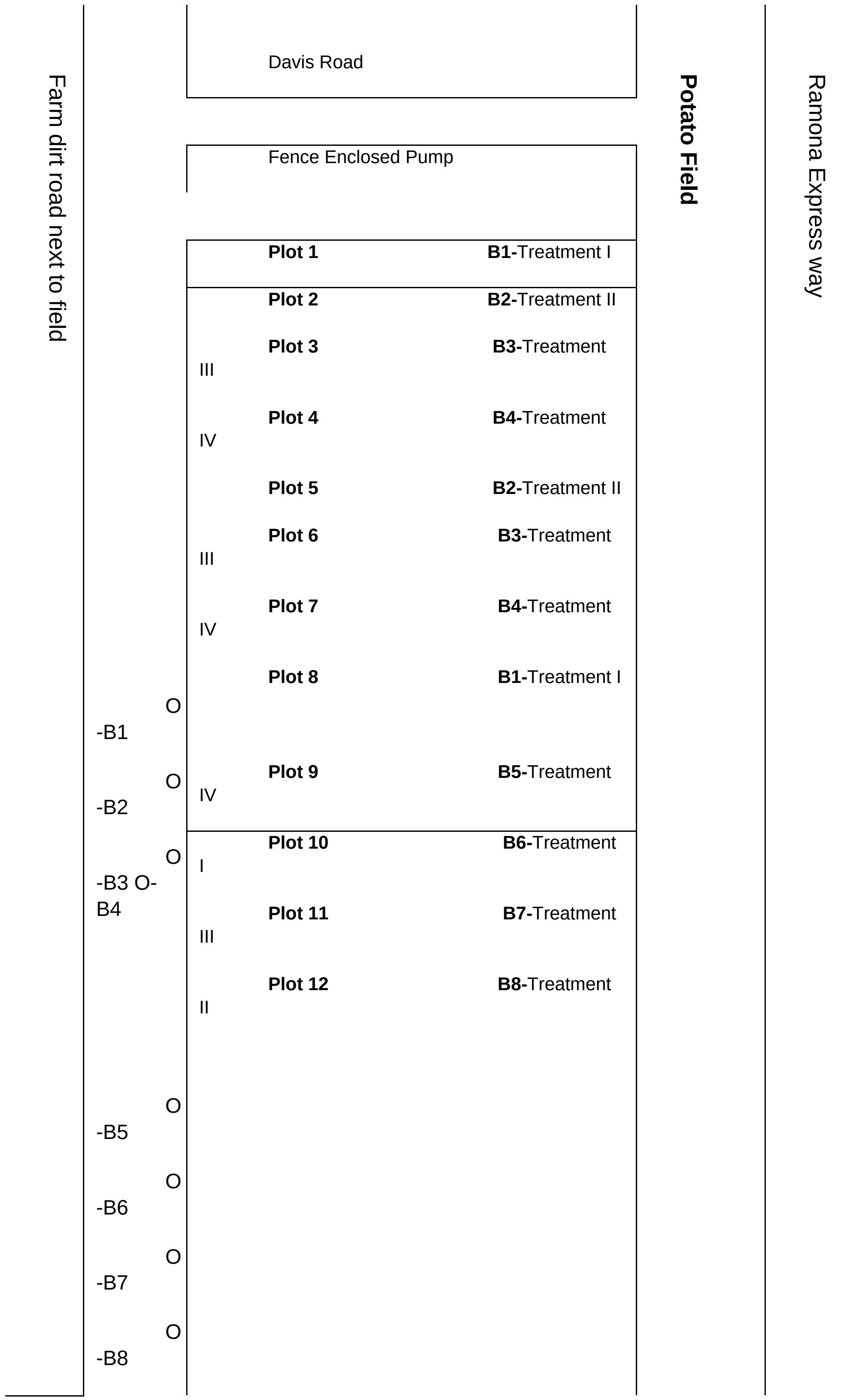

Figure D-2
Field Plot Layout in the Potato Field

The field is tilled during which plant debris from the previous harvest is incorporated. The plant debris is chopped or shred as fine as economically feasible prior to incorporation. Since undecomposed organic debris can cause serious nutritional and quality problems, ample time is allowed such that decomposition is reasonably complete prior to planting the potato seed.

The experiment at this site consists of 4 treatments with 3 replications (a total of 12 plots, see Figure D-2). Randomized block design was used to minimize the effect of the differences in soil and topographical differences on treatments. The first sample of runoff from each plot was collected with a passive sample station. Then runoff of the same treatment from the three blocks (replications) was diverted into a 4 in. pipe line that carried the runoff to a monitoring station consisting of a sump-pump, a digital flow meter and a datalogger. Composite water samples at the monitoring stations were taken by the passive siphon collectors that are controlled by timers. The experimental design is similar to the citrus field, but the plot layout was not the same because of the specific field conditions.

Specific Treatments: The grower used cover crops as follows: In the summer, Sudan-grass which was present on our plots in the fall of 2006, and in the winter, wheat (or possibly barley or oat). Irrigation water was applied by sprinkler. We learned that the grower had a very inefficient leaky system, which led to runoff water flooding our collection system and ruining some of our data.

We applied granular PAM spread on the surface before the first August irrigation event. Fertilization followed the typical fertilizer recommendations for this region (approximately 70 lb N).

Time Table: The potato grower messed up our workplan time table by not planting in the spring as expected. We set up our plots in June and July (very hot) after the wheat cover crop was harvested. All of our sample collection was from irrigation runoff, except for eight plot samples, which were hand collected from a storm event on November 30, 2007. We did not carefully monitor any storms in the 2006-2007 or 2007–2008 wet seasons because the grower was uncooperative. We were able to monitor or partially monitor enough irrigation events to fulfill our requirement to monitor two irrigation events.

Results: Results from the irrigation events for potatoes are provided later in Section 2.4.2 of this report.

D.2.2.2.1.3 Pumpkin Plots Summer and Fall of 2008

Due to the problem with the uncooperative potato grower we requested and received permission to shift our plots to the dry-land wheat plots. An irrigation system was installed and pumpkins were planted in the summer of 2008. Management practices which were investigated within dryland winter wheat fields included (1) chemical fertilizer with a buffer strip to reduce sediment and nutrients within run-off, (2) the practice of incorporating manure into the fields soon after its spread, (3) the practice of PAM application, and (4) common chemical fertilizer (control).

Field Site Description and Layout: This study was conducted as a plot study on a 10-acre winter wheat field near Winchester/Murrieta/Menifee area, a major wheat growing region in the San Jacinto watershed. The grower made special arrangements to provide irrigation water to the plots specifically for our study. We installed the irrigation system. Soil at the study site is mapped as Cajalco fine sandy loam (USDA-SCS, 1971). This soil is well-drained, with a slope at the site of 7 to 8 percent.

The experimental design used a randomized block design (3 blocks) and 4 treatments (a total of 12 plots). Each plot was 24 ft by 120 ft. The first sample of runoff from each plot was collected with a passive sample station. Then runoff from the same treatment of the three replications was diverted to a 4 in. pipe line that carried the runoff to a monitoring station that consisting of a sump-pump, a digital flow meter and a datalogger. Water samples at the monitoring station will be taken by the passive siphon collectors that are controlled by a timer. The experimental layout is depicted in Figure D-3, except that the plot numbers may not follow the same order due to randomization.

Specific Treatments: Manure application rate was about 12 tons per acre and incorporated. A 10-ft buffer zone was established within the Vegetative Buffer Strip treatment plots. PAM was applied at a rate of 10 pounds per acre by mixing the weighed PAM with corn meal and was applied dry with a fertilizer spreader. Chemical fertilizer application rate for the control, vegetative buffer and PAM plots was applied at a rate of 60 lb N/Ac.

Dry Land Winter Wheat 2008 - 2009 Treatment Map

Treat. III	Treat. II	Treat. IV	Treat. I	Treat. III	Treat. I	Treat. II	Treat. IV	Treat. I	Treat. III	Treat. II	Treat. IV
1,600 lbs/plot manure/ spread	1,600 lbs/plot manure/ incorporated			1,600 lbs/plot manure/ spread		1,600 lbs/plot manure/ incorporated			1,600 lbs/plot manure/ spread	1,600 lbs/plot manure/ incorporated	
Plot # 12	Plot # 11	Plot # 10	Plot # 9	Plot # 8	Plot # 7	Plot # 6	Plot # 5	Plot # 4	Plot # 3	Plot # 2	Plot # 1
		Veg. Buffer Strip					Veg. Buffer Strip				Veg. Buffer Strip

- E
- N < > S **Plots are 24 feet X 120 feet**
- W
- **Treatment I** – **Control** (chemical fertilizer) Plots - 4, 7, 9
- **Treatment II** – **Manure, incorporated** (via rota-tiller) Plots - 2, 6, 11
- **Treatment III** – **Manure, spread** Plots - 3, 8, 12
- **Treatment IV** – **Chemical fertilizer + Vegetated buffer strips** (10 ft X 24 ft buffer strips) Plots - 1, 5, 10

Figure D-3
Dryland Wheat and Pumpkin Field Plot Layout

It should be noted that in order to induce runoff, we were forced to apply irrigation water at much greater rates than the requirements of the crop. If the grower were using standard methods of irrigation, it is unlikely that runoff would have occurred on most plots and the runoff from the control plots would have been substantially more.

D.2.2.2.1.4 Dry-Land Wheat BMPs

Management practices which were investigated within dryland winter wheat fields included (1) chemical fertilizer with a buffer strip to reduce sediment and nutrients within run-off, (2) the practice of incorporating manure into the fields soon after its spread, (3) the practice of manure surface spread, and (4) common chemical fertilizer (control).

Field Site Description and Layout

This study was conducted as a plot study on a 10-acre winter wheat field near Winchester/Murrieta/Menifee area, a major wheat growing region in the San Jacinto watershed. Dryland wheat yields in southern California are highly variable and depend on the timing and amount of winter precipitation. For all three wet seasons of our study 2006-2007, 2007-2008 and 2008-2009 the quantity and timing of the rainfall provided very poor conditions for growing dryland wheat. Profits can be substantial in good years, but financial losses are common in dry years. Because yields are often only marginal, farmers operate as efficiently as they can, minimizing costs when possible. Soil at the study site is mapped as Cajalco fine sandy loam (USDA-SCS, 1971). (A description of this soil series is provided in the appendix.) This soil is well-drained, with a slope at the site of 7 to 8 percent. Winter wheat grown in southern California relies entirely on incoming precipitation for its water, with no irrigation available. However, the field used for this study offered the advantages of being fenced in to protect against possible vandalism of sampling equipment, and of having a source of water nearby that was used to establish a vegetated buffer strip in a timely fashion for the start of these field tests.

Both inorganic and/or organic fertilizers are used by area growers during winter wheat cultivation. The behavior of organic fertilizers is more difficult to predict in dryland systems than for irrigated crops. This is because moisture is a key component for converting or “mineralizing” nutrients, particularly nitrogen and phosphorus, from fixed to plant-available forms. The conversion process occurs as soil microbes decompose the material. Because these microbes must have water in order to develop, fertilizer mineralization would be expected to slow significantly in dry seasons and years. The extent of this effect is difficult to predict, however, since a number of other factors, such as temperature and the history of the applied material also strongly affect mineralization (Barbarick and Ippolito 2000).

Since dryland farmers derive much of their income during years when rains are optimal, fertilizers are applied assuming that yields will be optimal. Fertilizers are typically applied to supply adequate nitrogen for the optimal yield. Because manures are phosphorus-rich, these applications can lead to a gradual enrichment of soil phosphorus (Gollehon et al. 2001) which can be exported to surface waters during heavy precipitation events. A minority of the phosphorus is dissolved and rinses off of the field, but most is in solid form and is lost with surface sediments that erode from the field (Baker 2000). Pollution control strategies for controlling surface water pollution from dryland are therefore similar to strategies used to control soil erosion.

As seen in the above drawing, the experimental design uses a randomized block design (3 blocks) and 4 treatments (a total of 12 plots). Each plot is 24 ft by 120 ft. The first sample of runoff from each plot was collected with a passive sample station. Then runoff from the same treatment of the three replications was diverted to a 4 in. pipe line that carried the runoff to a monitoring station that consisting of a sump-pump, a digital flow meter and a datalogger. Water samples at the monitoring station were taken by the passive siphon collectors that are controlled by a timer. The experimental layout is depicted in Figure D-4.

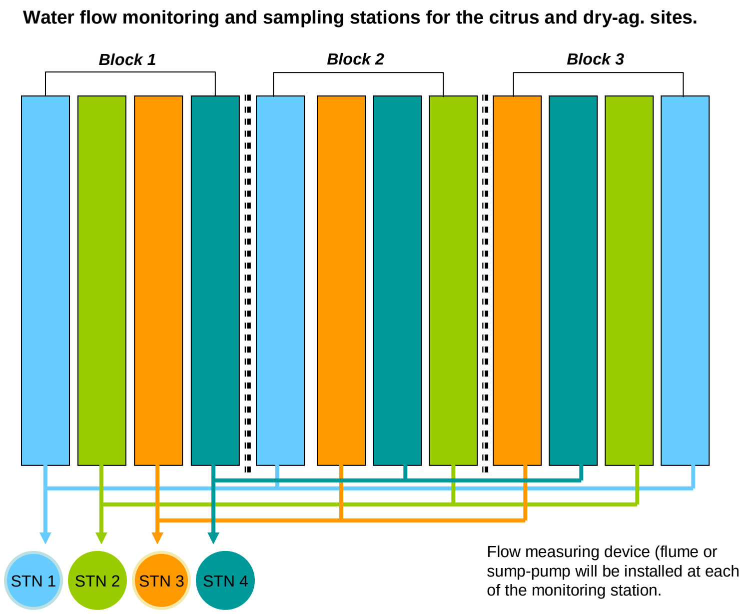

Figure D-4
Diagram for Water Flow and Water Sampling in the Citrus Site and Dryland Site

Specific Treatments: Manure application rate is about 12 tons per acre. A 10-ft buffer zone will be established within the *Buffer Strip* treatment plots. Chemical fertilizer application rate for the control is 60 lb N/Ac.

Time Table: Experiment at this site started in January 2007 so that were able to catch at least some of the rainstorms for the wet season of 2006-2007. It was continued until 2008-09 wet seasons. Since no irrigation was applied at this site, no monitoring took place during the dry seasons.

Results: Results from the dry-land wheat are presented in Section 2.4.4 of this report.

D.2.2.2.1.5 Turf BMPs

This part of the project did not involve field experiment, but a compilation of existing turf BMPs. Research findings on turf grass BMPs from UCR and UCCE were reviewed and compiled to generate outreach education materials. The BMPs used in this project primarily work by keeping or applying a cover to the soil surface. Thus, turf naturally is a BMP because it protects the soil surface and slows the movement of sheet water flows into water courses. Turf problems come from the over application of nutrients or from careless applications that allow these nutrients to reach impervious surfaces and thus runoff. Workshops/training classes were conducted to extend the BMPs to the growers in the watershed.

D.2.2.2.2 Monitoring Results

D.2.2.2.2.1 Citrus Results

Experimentally the citrus plots were very useful and they were in an established grapefruit orchard in full commercial operation by the grower. They were the plots for which we obtained data for all three winter seasons. Shown below is a photo of the orchard in its natural condition without BMP treatments. It can be seen that there is considerable natural mulch present and some moss growing between the rows.

Citrus plot treated with mulch

During the first two seasons there were a total of nine rain storms for which we collected data. The total nutrient runoff for these storms is shown individually on graphic form below (Figures D-5 to D-11.

One observation that is very clear from the data is that total nutrient runoff from the citrus plots during the period we examined is very minimal. The total averaged approximately one gram for each nutrient for two seasons. That is one gram for three treatment plots which calculates to only 0.003 pounds per acre. In the simplest terms there is only three pounds of either nitrogen or phosphorous runoff for each 1000 acres of citrus regardless of the treatment used. The citrus farms are doing a very effective job of nutrient runoff control under the conditions of low to moderate rainfall that occurred during our study period.

With that said, all three treatments, mulch, PAM, and cover crop were effective in reducing the nitrate and total phosphorous. The treatments were not effective in controlling the loss of ammonium nitrogen from the plots. Mulch was very effective for all but the largest storms in controlling runoff. It was in place before the cover crop had a chance to sprout and grow, and before the PAM became activated during the first rainstorm. For this reason, December storms showed that the only effective treatment was mulch.

However, over time the mulch material breaks down and the nitrogen and phosphorous contained in the mulch material is converted to inorganic forms that can runoff and contribute to the problem. Thus, late season runoff from the mulch may even have higher values than the control. During the winter growing season, after the cover crop has germinated and is growing it takes up excessive nutrients from the soil and may serve as the best treatment during the late season.

Perhaps as a future treatment, the grower could try a combination of mulch and a cover crop to take advantage of the best characteristics of both treatments and provide a very good BMP for both early season and late season.

The first data we obtained is from February 12, 2007. The quantities of total nutrient runoff for the storm are very small as shown in the graph below, with the highest (nitrate on the PAM plots) approaching 0.005 grams (5 milligrams). There was no runoff from the mulch plots during this storm, indicating that it was the best treatment.

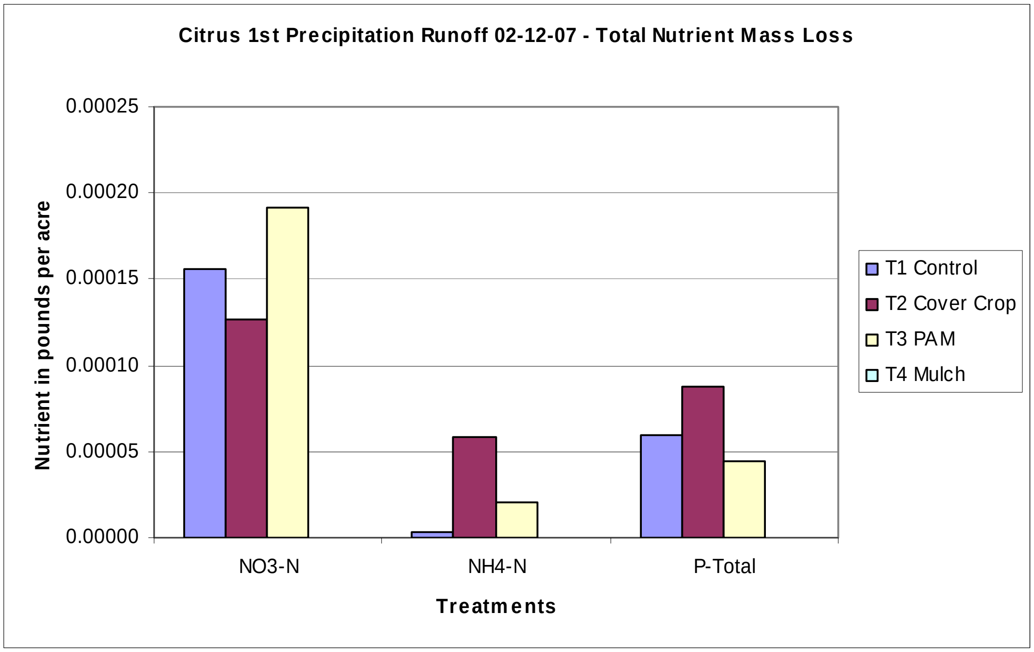

Figure D-5
Treatment Effect on Amount of Nutrients (Nitrate, Ammonium, and Total-P) in Runoff Water at the Citrus Site on February 12, 2007

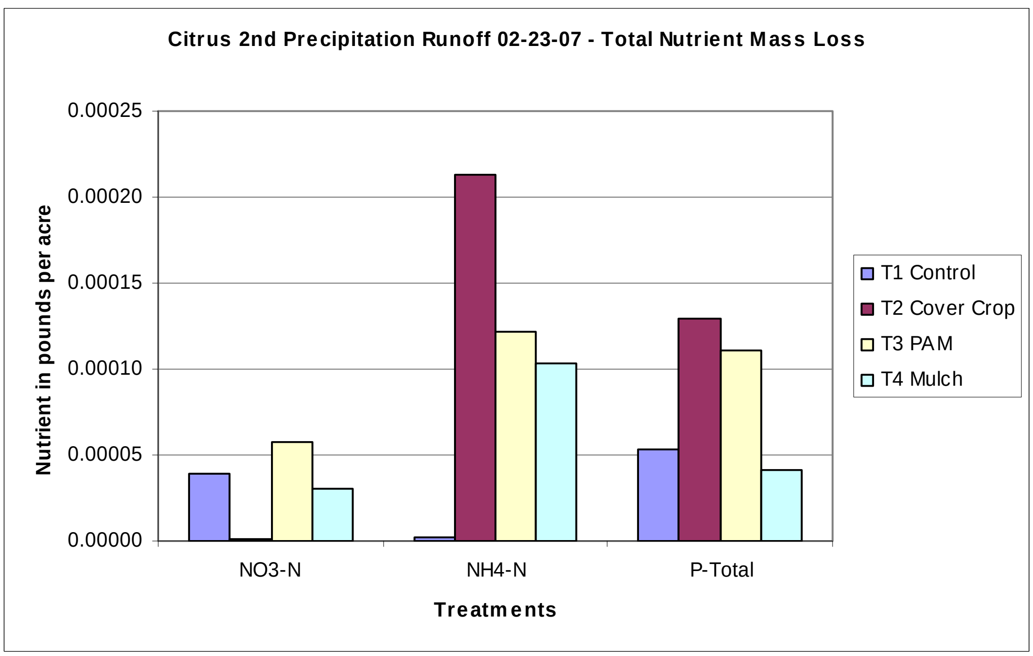

Figure D-6
Treatment Effect on Amount of Nutrients in Runoff Water at the Citrus Site on February 23, 2007

The second storm with runoff occurred on February 23, 2007. We obtained runoff from all treatments and had considerably more nutrient runoff from the plots in comparison to the earlier storm. Strangely the ammonia runoff from the treatments was higher for all treatments than the control, but the treatments were shown to be effective in reducing nitrate, phosphate and total phosphorous. As with the earlier storm event mulch was the most effective treatment for reduction of nutrients.

The third storm event for which we obtained data was on February 27, 2007. The total nutrient runoff was in the vicinity of 0.12 grams; this time for nitrate and phosphate from the control plots. As shown in the graph below the mulch was once again the best treatment, but the cover crop was also very effective in reducing runoff.

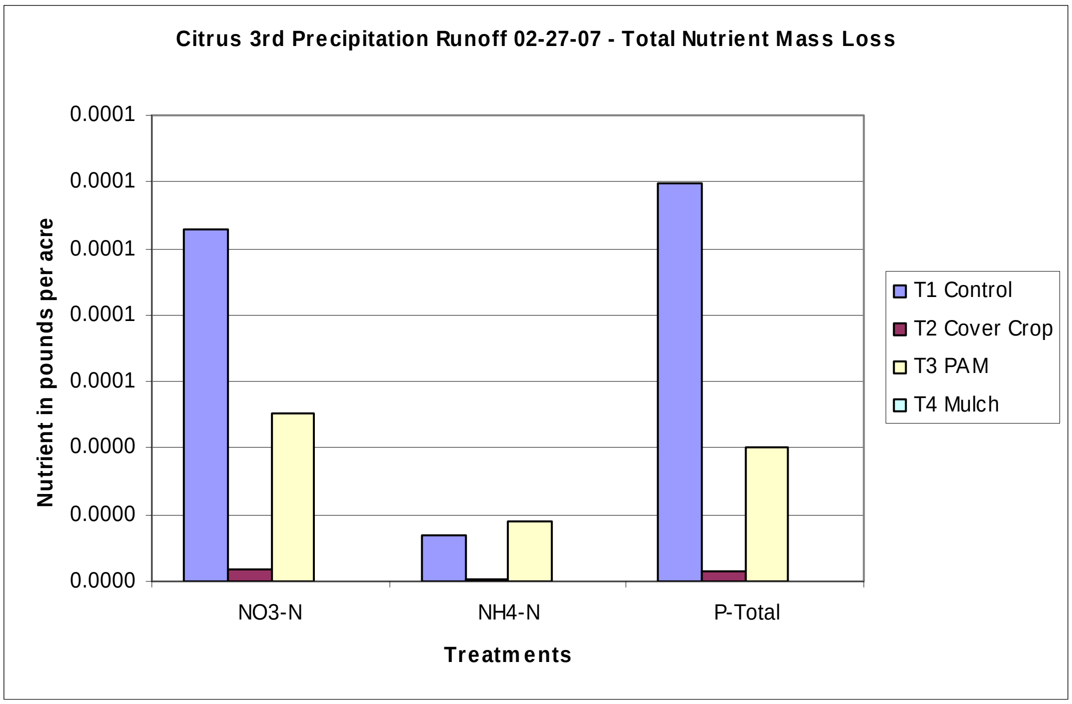

Figure D-7
Treatment effect on Amount of Nutrients in Runoff Water at the Citrus Site on February 27, 2007

The fourth storm event for which we obtained data was on April 16, 2007. The total nutrient runoff was in the vicinity of 0.05 grams; this time for ammonia from the PAM plots. As shown in the graph below the mulch was once again the best treatment, but the cover crop was also very effective in reducing runoff.

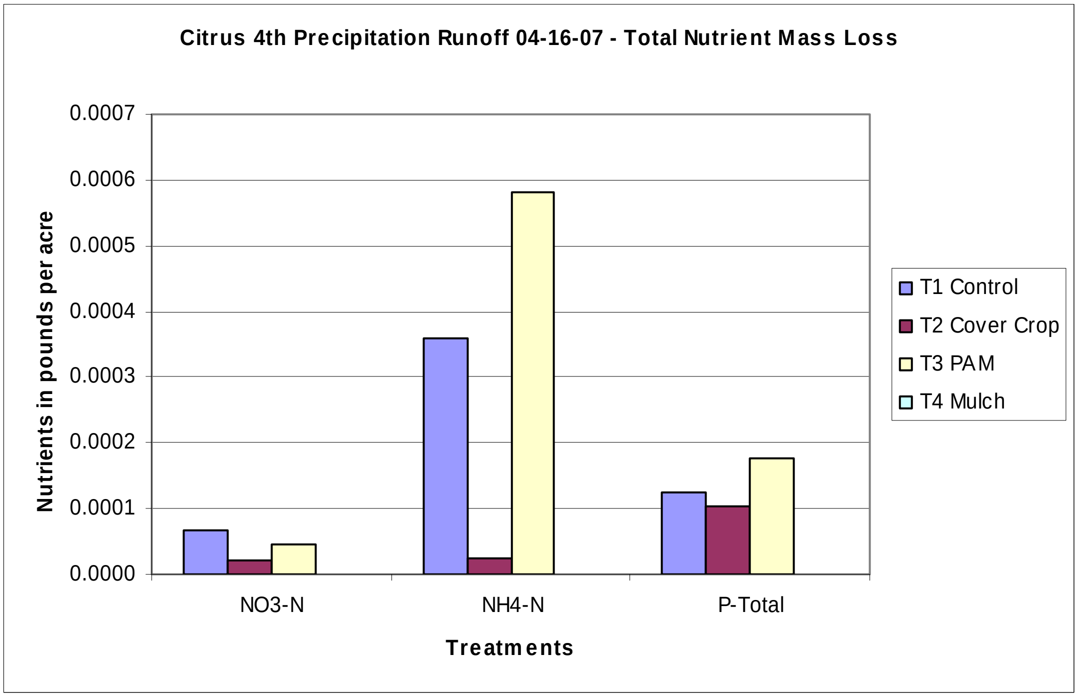

Figure D-8
Treatment effect on amount of nutrients in runoff water at the citrus site on April 16, 2007

The fifth storm event for which we obtained data was on April 20, 2007. The total nutrient runoff was over 0.50 grams; this time for phosphate from the control plots. As shown in the graph below the mulch and PAM were the best treatments but the cover crop treatments were also very effective in reducing runoff when compared with the control.

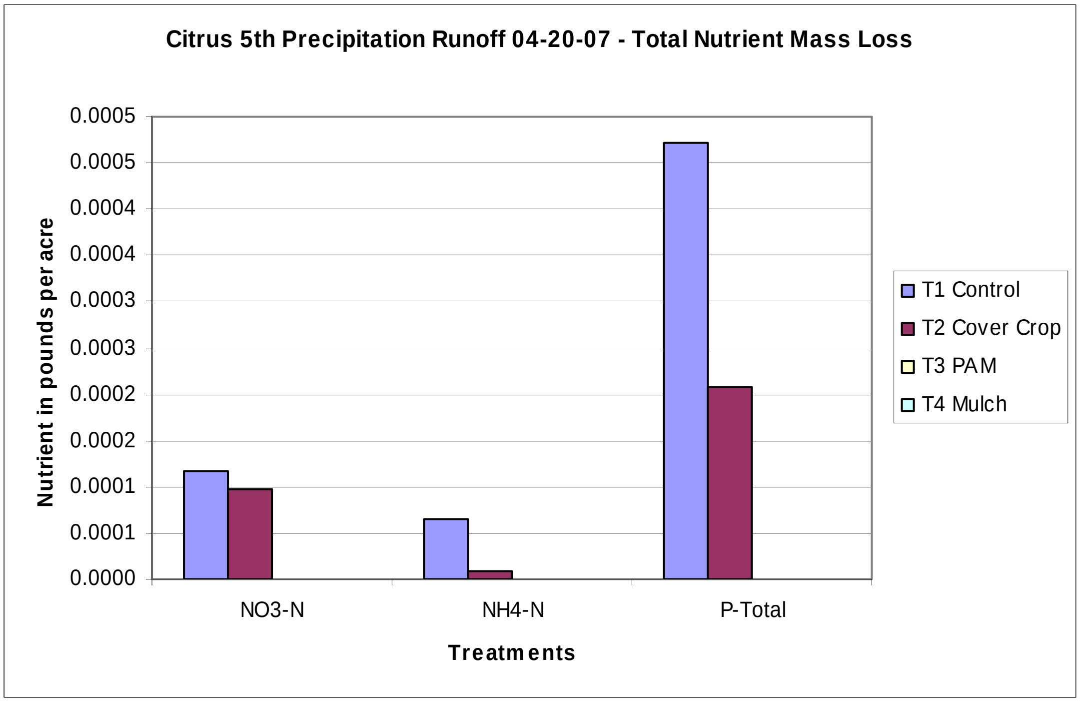

Figure D-9
Treatment effect on amount of nutrients in runoff water at the citrus site on April 20, 2007

The first storm of the 2007 – 2008 rainy seasons showed the same trends that we observed during the spring storms of the previous season; very small amounts nutrient runoff from the plots. One surprise was that ammonium concentrations tended to be the highest in the mulch treatments. This could be from the conversion of organic nitrogen into ammonium once the mulch was wetted by the first storm. There is a natural mulch in every plot due to the accumulation of leaf matter and stem trimmings from the normal operation of the orchard.

This second storm of the season was the only other storm for which data was collected during this second rainy season. Once again mulch tended to be high in ammonium runoff, but all other treatments were superior to the control in reducing runoff.

The third runoff from February 3, 2008. All treatments showed greater nutrient runoff than control and the quantities of runoff are a little bit higher than all earlier results as can be seen from the following storm data.

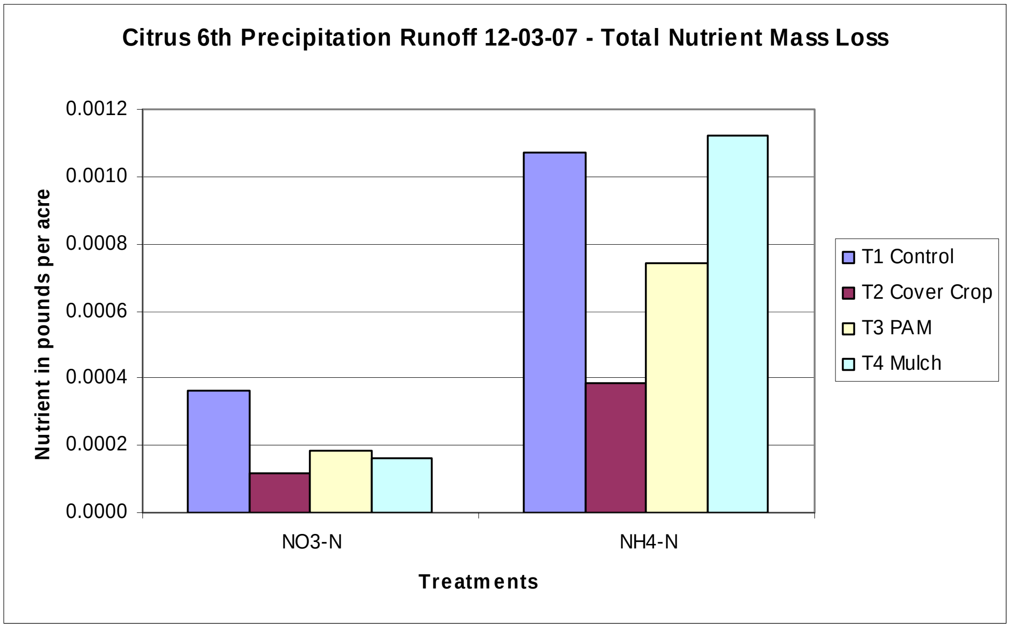

Figure D-10
Treatment effect on amount of nutrients in runoff water at the citrus site on December 3, 2007. No P was detected in this storm runoff

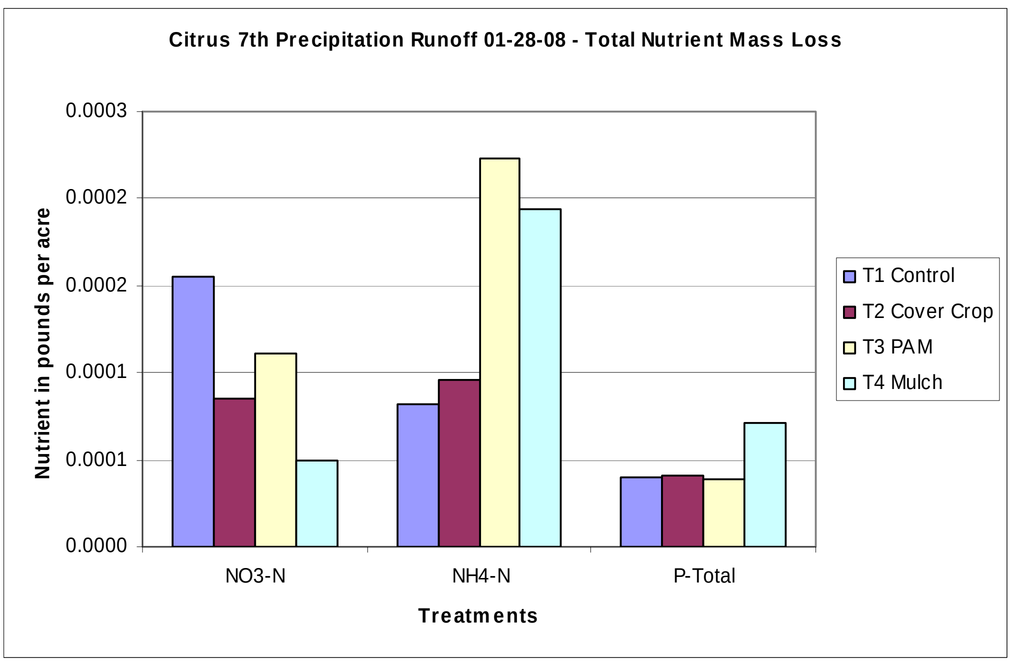

Figure D-11
Treatment Effect on Amount of Nutrients in Runoff Water at the Citrus Site on January 28, 2008

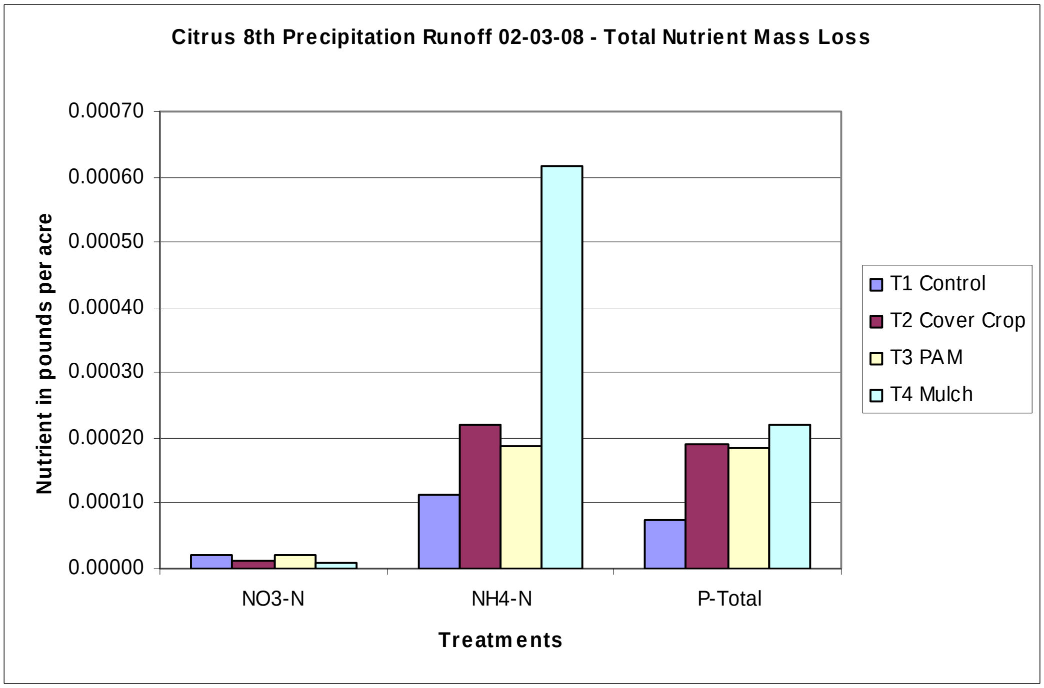

Figure D-12a
Treatment Effect on Amount of Nutrients in Runoff Water at the Citrus Site on February 3, 2008

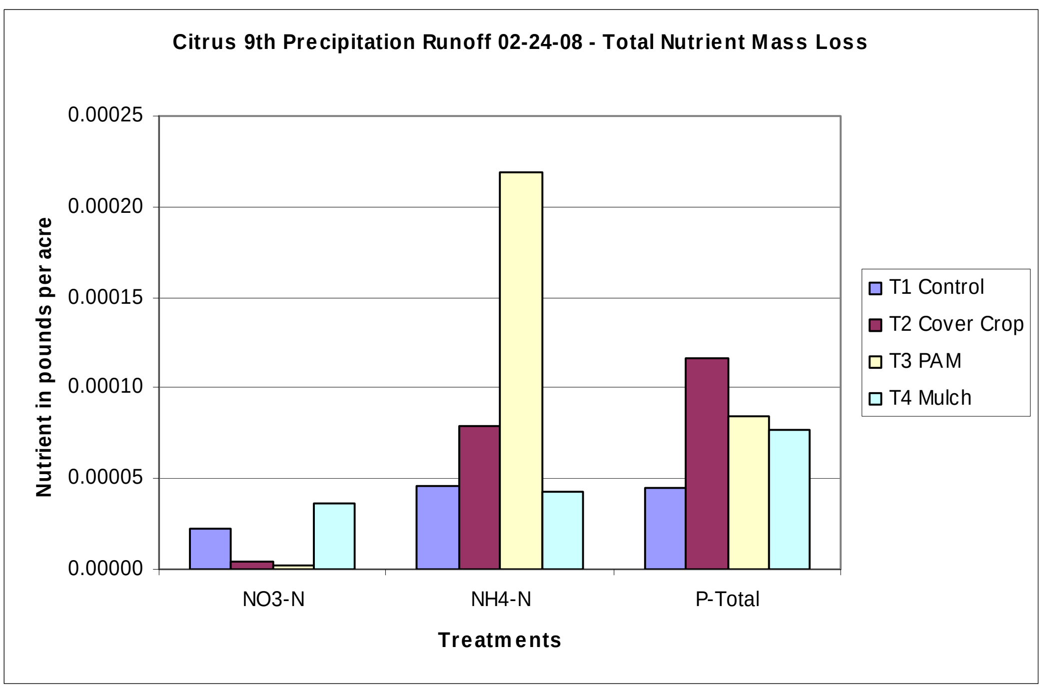

Figure D-12b
Treatment Effect on Amount of Nutrients in Runoff Water at the Citrus Site on February 24, 2008

Table D-17 Nutrient Runoff for Citrus By Treatment

Treatments	NO_3-N	NH_4-N	P-Total
Control	0.00105 ± 0.00011	0.00177 ± 0.00035	0.00121 ± 0.00015
Cover Crop	0.00046 ± 0.00006	0.00131 ± 0.00018	0.00097 ± 0.00009
PAM	0.00069 ± 0.00007	0.00212 ±0.00026	0.00077 ± 0.00007
Mulch	0.00040 ± 0.00008	0.00277 ± 0.00055	0.00054 ± 0.00008

Table D-18 Runoff volume, concentrations of nitrate, ammonium, total-P, and nutrient loss for each storm of the Control treatment in Citrus, 2007-08

	First Flush and Sump Pump Collection Results				Calculated Pounds per Acre		
Storm event date	Volume (l)	NO_3-N mg/l	NH_4-N mg/l	Total-P mg/l	NO_3-N mass (lbs/Ac)	NH_4-N mass (lbs/Ac)	Total-P mass (lbs/Ac)
2-12-07	7.50*	3.89	0.07	1.50	0.00016	0.000003	0.00006
	0**	0	0	0			
2-23-07	7.50	0.99	0.07	1.33	0.00004	0.000003	0.00005
	0	0	0	0			
2-27-07	7.50	1.30	0.16	1.27	0.0001	0.00001	0.0001
	0	0	0	0			
4-16-07	7.50	1.40	8.87	2.50	0.00007	0.00036	0.00013
	0	0	0	0			
4-20-07	7.50	0.64	0.60	1.05	0.00013	0.00007	0.00049
	131.72	0.43	0.21	1.90			
12-03-07	7.50	9.07	26.82	0	0.00036	0.00107	0.00000
	0	0	0	0			
1-28-08	7.50	0.67	0.41	1.00	0.0002	0.0001	0.0002
	189.25	0.38	0.20	0.60			
2-03-08	7.50	0.50	2.83	1.87	0.00002	0.00011	0.00007
	0	0	0	0			
2-24-08	7.50	0.55	1.16	1.13	0.00002	0.00005	0.00005
	0	0	0	0			

** From first flush sample.*
*** From pump at the monitoring station. The calculated pounds per acre combined both first flush and pump readings.*

Table D-17 summarized (sums and standard deviations) the total nutrients runoff from the citrus field under different treatment. The average runoff NO_3 and total-P were the highest in the Control treatment than other BMPs, but the runoff amount was very insignificant from each of the treatment, including the Control. NH_4 was slightly higher from PAM and Mulch treatment than the Control, but their difference was not significant.

Table D-18 showed that the total runoff volume (L) from the 600 by 20 ft (approximately 0.27 ac) plots and the concentrations of nitrate, ammonium, and total-P in runoff water. The runoff volume was very low in the entire season of 2007-08, which explains the low total loss of N and P from the field (low N and P loads to surface water).

The following figures (Figures D-13 to D-15) show the nutrients runoff in the citrus field for the second rainy season. The data very much reflect the same trend as the first rainy season. Table D-19 shows the summaries of the nutrient runoff from the four storms in the 2007-08 rainy seasons for which samples were collected. The data clearly shows that all three of the BMP treatments are effective in reducing the total nitrate loss from the plots. But again, the total amount of runoff from the citrus field (lb/Ac) was very small. Overall the BMPs are effective in reducing nutrient runoff from the citrus plots.

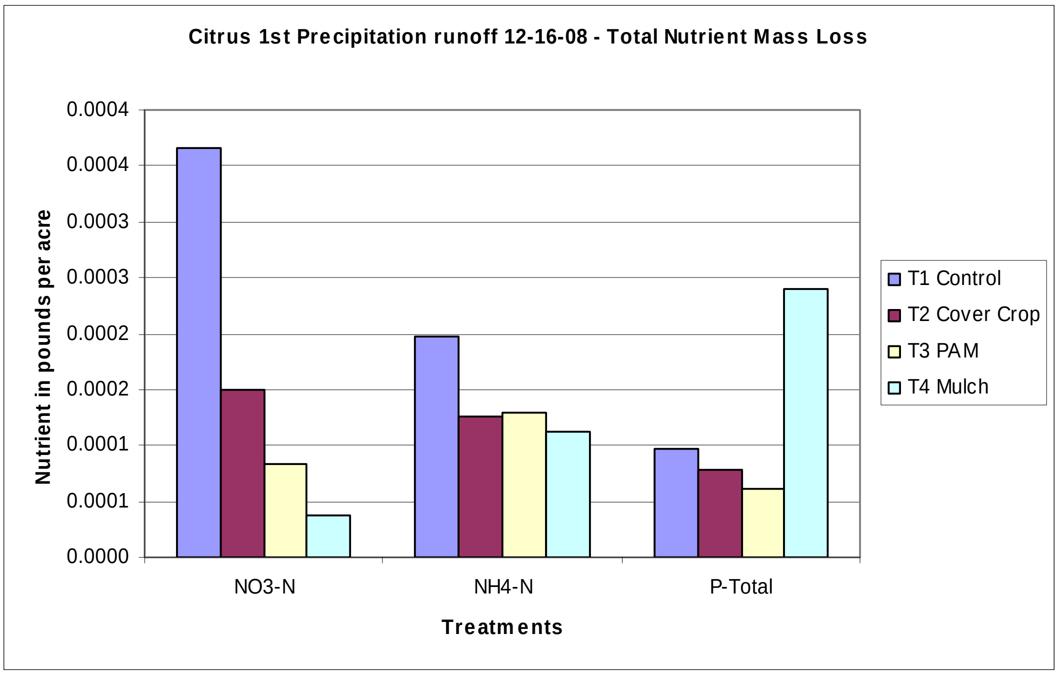

Figure D-13
Treatment Effect on Amount of Nutrients in Runoff Water at the Citrus Site on December 16, 2008

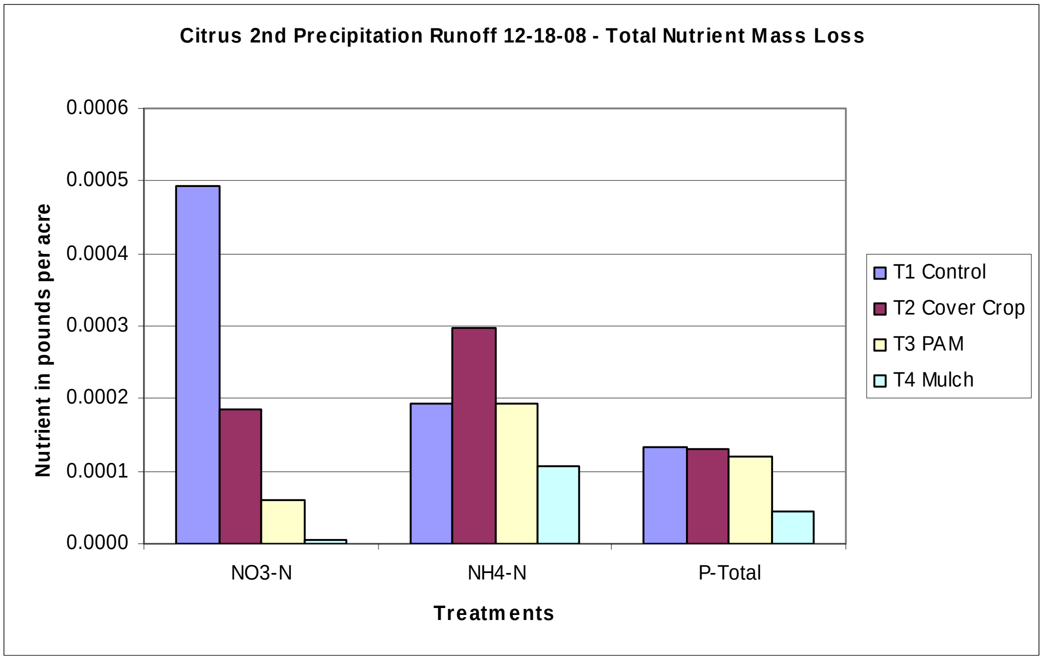

Figure D-14
Treatment Effect on Amount of Nutrients in Runoff Water at the Citrus Site on December 18, 2008

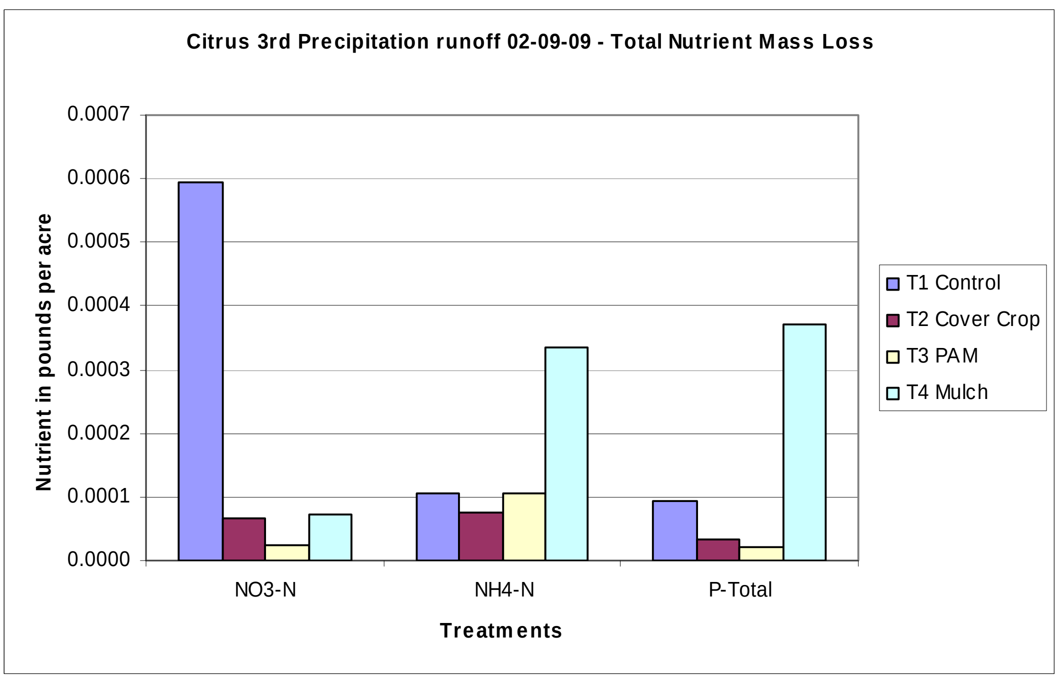

Figure D-15
Treatment Effect on Amount of Nutrients in Runoff Water at the Citrus Site on February 9, 2009

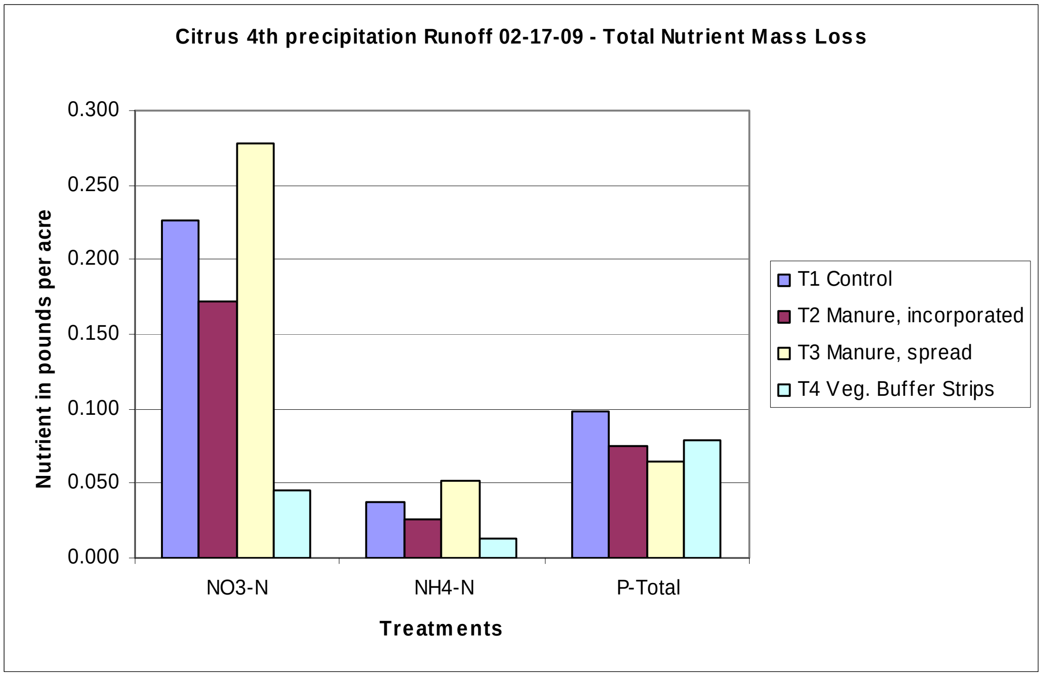

Figure D-15a
Treatment Effect on Amount of Nutrients in Runoff Water at the Citrus Site on February 17, 2009

Table D-19 Seasonal Total Runoff (Sum ± STD) in pounds per acre (lbs/ Ac) of NO_3-N, NH_4-N and P-Total in Citrus crop 2008-09 (n = 4)

Treatments	NO_3-N	NH_4-N	P-Total
Control	0.0015 ± 0.00024	0.0005 ± 0.00009	0.0003 ± 0.00005
Cover Crop	0.0004 ± 0.00007	0.0005 ± 0.00012	0.0003 ± 0.00005
PAM	0.0002 ± 0.00004	0.0005 ± 0.00007	0.0002 ± 0.00005
Mulch	0.0002 ± 0.00006	0.0008 ± 0.00018	0.0007 ± 0.00017

Table D-20 Runoff volume, concentrations of Nitrate, Ammonium, total-P, and nutrient loss for each storm of the Control treatment in Citrus, 2008-09

	First Flush and Sump Pump Collection Results				Calculated Pounds per Acre		
Storm event date	Volume (l)	NO_3-N mg/l	NH_4-N Mg/l	Total-P mg/l	NO_3-N mass (lbs/Ac)	NH_4-N mass (lbs/Ac)	Total-P mass (lbs/Ac)
12-16-08	7.50*	1.98	1.98	0.93	0.00039	0.00020	0.00010
	28.77**	6.12	2.32	1.18			
12-18-08	7.50	0.37	0.60	0.54	0.0005	0.0002	0.0001
	50.34	5.36	1.90	1.25			
2-09-09	7.50	0.63	1.16	0.51	0.00059	0.00011	0.00009
	40.50	7.91	0.82	1.03			
2-17-09	1.00	0.60	0.58	0.64	0.00005	0.000005	0.00001
	4.54	5.90	0.23	1.22			

** First Flush Sample Results.*
*** Sump Pump Sample results. The calculated pounds per acre combined both first flush and pump readings.*

Similarly, Table D-19 showed the total nutrient loss from the citrus field in 2008-09 seasons, and Table D-20 was runoff volume (L) and concentrations of the runoff water, as well as nutrient loss for each storm for the Control treatment. The results are similar to the 2007-08 season: the low total loss of N and P from the field (low N and P loads to surface water) was attributed to low runoff volume.

D.2.2.2.2.2. Vegetable Experimental Results

D.2.2.2.2.2.3 Potatoes (Summer and Fall of 2007)

First, on this section it is important to point out that the data gathered was from potato plots being irrigated with recycled water which would normally contain higher nutrient content than rainfall. The second thing to remember is that these samples were collected from irrigation water leaving the plots, but this water was not allowed to leave the farmland. The grower is fined $3000 per event when his irrigation drainage water leaves the property and gets into a stream or watercourse.

Shown below is the map of the potato site showing the treatments. You will note that we were not able to keep all the plots in one uniform location. There is some distance between plots 1 -8 and plots 9 -12. Each plot was ultimately 8 potato rows with one or two rows between plots.

Treatment I – No Sudan Grass + No Deep Plow (Control)	Plots - 1,8,10
Treatment II – Sudan Grass + Deep Plow	Plots - 2,5,12
Treatment III – No Sudan Grass + Deep Plow	Plots – 3,6,11
Treatment IV – PAM	Plots – 4,7,9

The picture below shows the installation of pipe across the waste water collection ditch the grower used to prevent his water from flowing off his land and into the water courses of the San Jacinto watershed. These pipes lead to collection points in front of each plot where passive samples were collected and the runoff was then diverted in an underground system we installed to a point where the timed samples from multiple plots could be collected. A frequent problem was that the grower would from time to time pull out our collection pipes to cultivate his field or to remake the diversion ditch.

Installing Runoff Collecting System at the Potato Field

The four graphs shown below vary greatly. Figure D-16 shows the first runoff from the potato field. There was a 0.3 lb/Ac nitrate and 0.2 lb/Ac ammonium runoff from the treatment of Cover-crop + Deep-plow. While during the second runoff, no crop cover with deep-plow treatment has the highest nitrate and ammonium loss, with Control being the second largest loss.

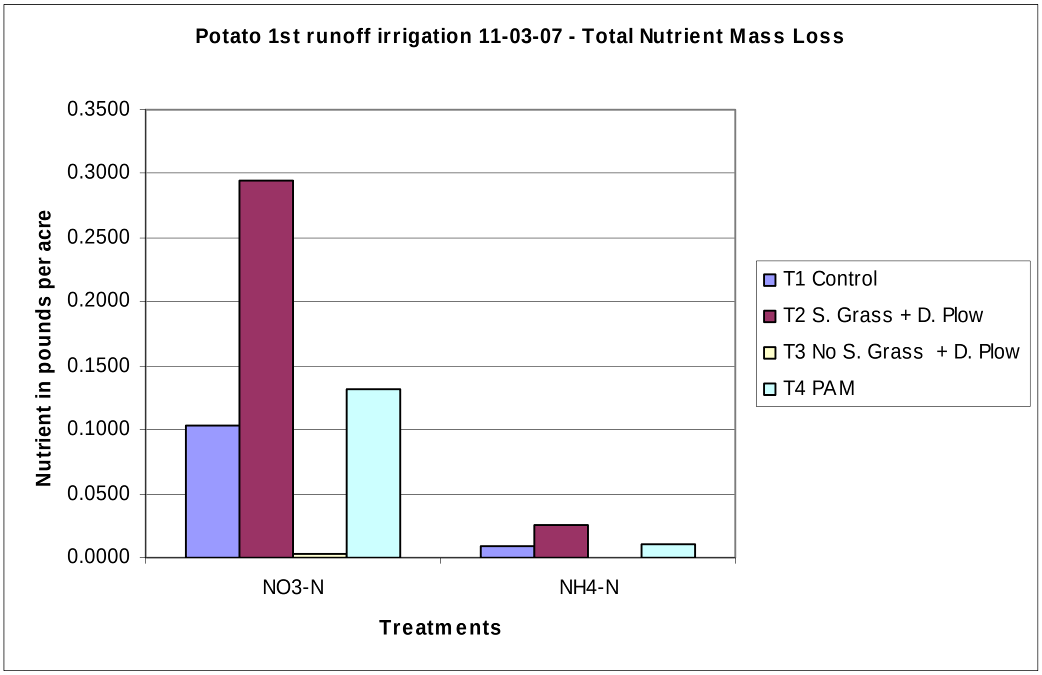

Figure D-16
Treatment effect on amount of nutrients in runoff water at the potato site on November 3, 2007

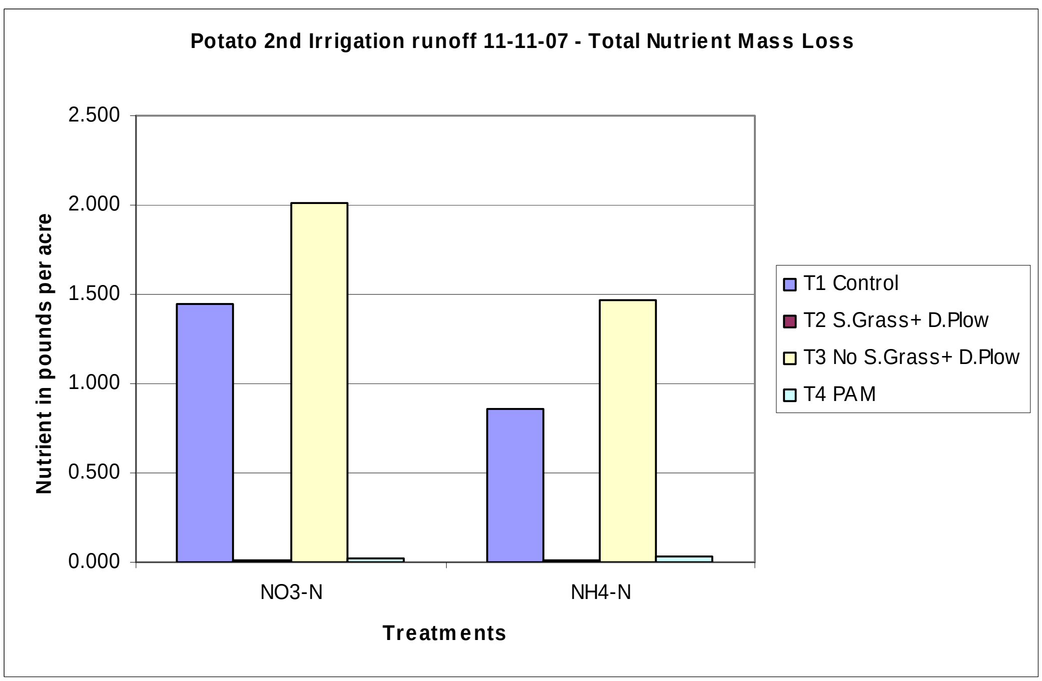

Figure D-17
Treatment effect on amount of nutrients in runoff water at the potato site on November 11, 2007

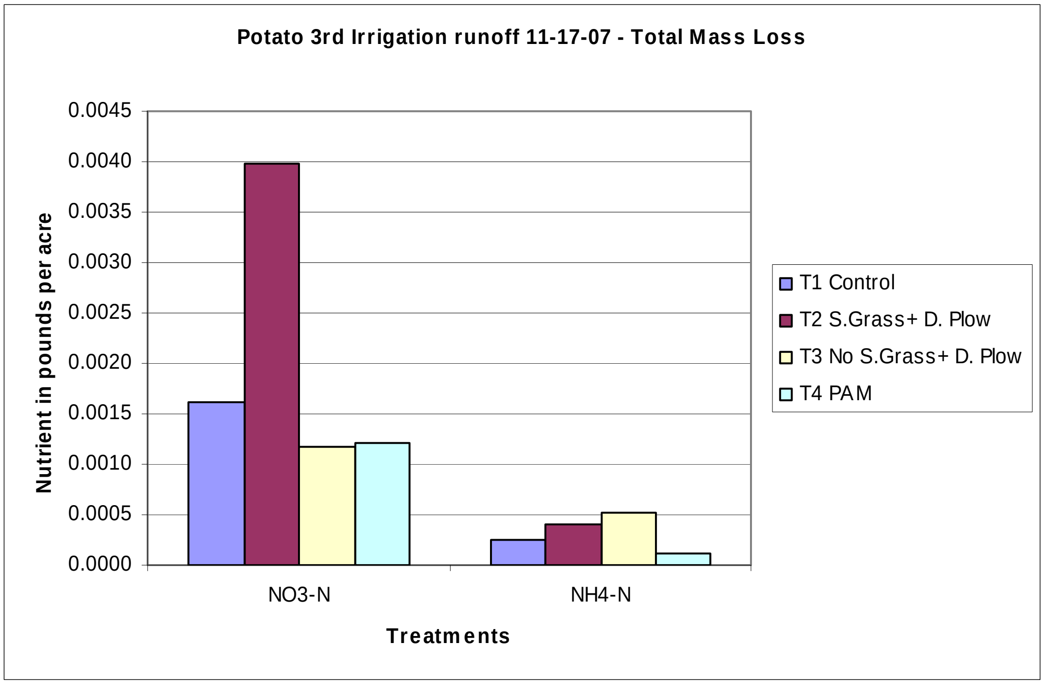

Figure D-18
Treatment effect on amount of nutrients in runoff water at the potato site on November 17, 2007. No P was detected (Table 4-5)

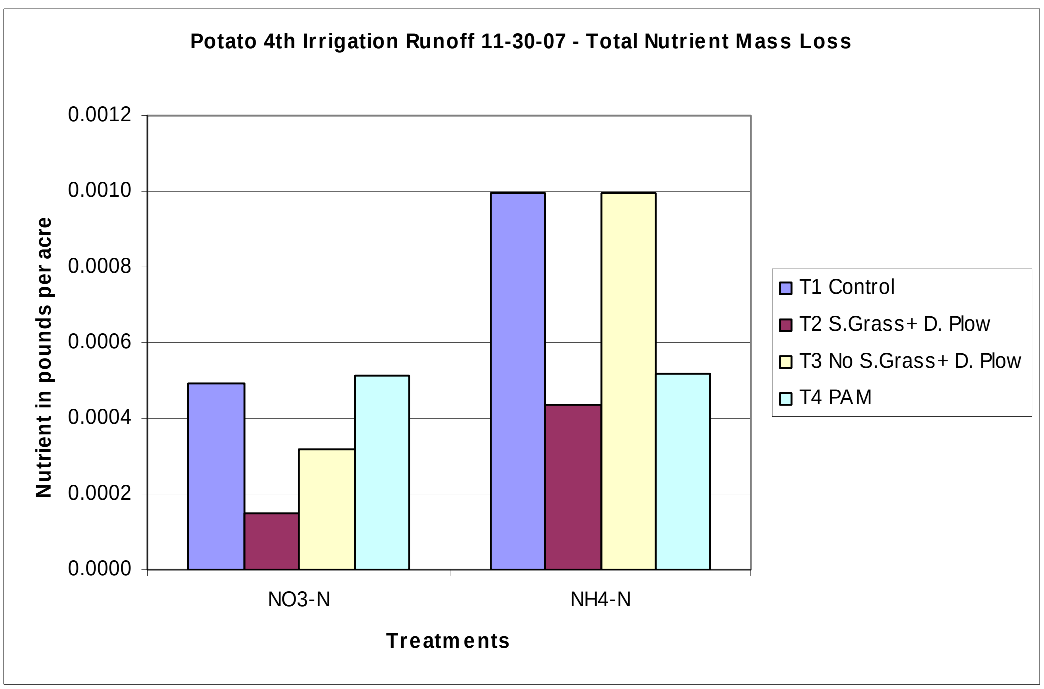

Figure D-19
Treatment effect on amount of nutrients in runoff water at the potato site on November 30, 2007. No P was detected (Table 4-5)

When all the runoff events are combined, the Control has the second highest runoff of nitrate and ammonium, while No-cover crop with deep-plow has the highest loss of both nitrate and ammonium. The PAM treatment, on the other hand, has the least amount of nitrate and ammonium runoff (Table D-21). It was observed that the samples from the PAM plots had much less sediment runoff than from all the other plots, but this did not seem to carry through into reduced nutrients.

Table D-22 showed the runoff volume (L) and concentrations of the runoff water, as well as nutrient loss for each storm for the Control treatment. The relatively large amount of nutrient runoff is mainly from the Nov. 3 and Nov. 11, 2007 storms, which had both high volume and nutrient concentrations.

Table D-21. Seasonal total runoff (Sum ± STD) in pounds per acre (lbs/ Ac) of NO_3-N, NH_4-N and P-Total in Potato crop 2007 (n = 4)

Treatments	NO_3-N	NH_4-N	P-Total
Control	0.494 ± 0.177	0.246 ± 0.116	0.0 ± 0.0
S. Grass+ D. Plow	0.118 ± 0.044	0.036 ± 0.011	0.0 ± 0.0
D. Plow	0.516 ± 0.252	0.386 ± 0.191	0.0 ± 0.0
PAM	0.069 ± 0.021	0.030 ± 0.012	0.0 ± 0.0

Table D-22 Runoff volume, concentrations of nitrate, ammonium, total-P, and nutrient loss for each storm of the Control treatment in Potato Crop, 2007

	First Flush and Sump Pump Collection Results				Calculated Pounds per Acre		
Storm event date	Volume (l)	NO_3-N mg/l	NH_4-N mg/l	Total-P mg/l	NO_3-N mass (lbs/Ac)	NH_4-N mass (lbs/Ac)	Total-P mass (lbs/Ac)
11-03-07	7.50*	26.70	5.95	0	0.1149	0.0094	0.0000
	0**	0	0	0			
	7.50	32.70	1.92	0			
	194.17	31.49	2.46	0			
11- 11-07	7.50	31.97	51.89	0	0.3762	0.2349	0.0000
	1330.43	33.37	19.41	0			
	7.50	31.31	51.30	0			
	7.50	28.91	1.36	0			
11-17-07	7.50	2.55	0.25	0	0.0025	0.0003	0.0000
	7.50	15.90	3.17	0			
	7.50	2.96	0.26	0			
	0	0	0	0			
11-30-07	7.50	0.44	2.26	0	0.00034	0.00134	0.0000
	7.50	1.60	1.86	0			
	7.50	0.44	2.27	0			
	0	0	0	0			

** First Flush Sample Results.*
*** Sump Pump Sample results. The calculated pounds per acre combined both first flush and pump readings.*

D.2.2.2.2.4 Pumpkins (Summer and Fall of 2008)

Since we had difficulty in controlling the experimental design at the potato plots the previous season we converted the dry-agriculture (wheat) plots to irrigated vegetable plots for the summer season. We found that it was necessary to excessively irrigate the crop in order to generate runoff and obtain samples.

The graph below shows our vegetated buffer strips as the worst treatment, but this was early in the season and the buffer strips had been taken out and replanted when the plots were being prepared for the pumpkins, so it would be more effective later in the season.

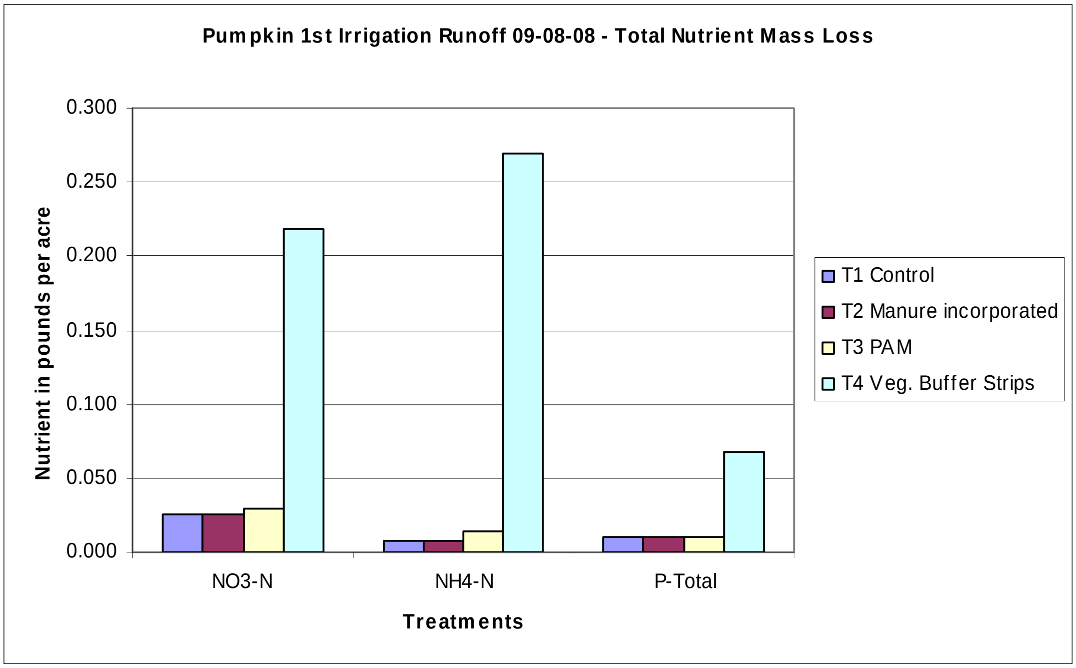

Figure D-20
Treatment Effect on Amount of Nutrients in Runoff Water at the Pumpkin Site on September 8, 2008

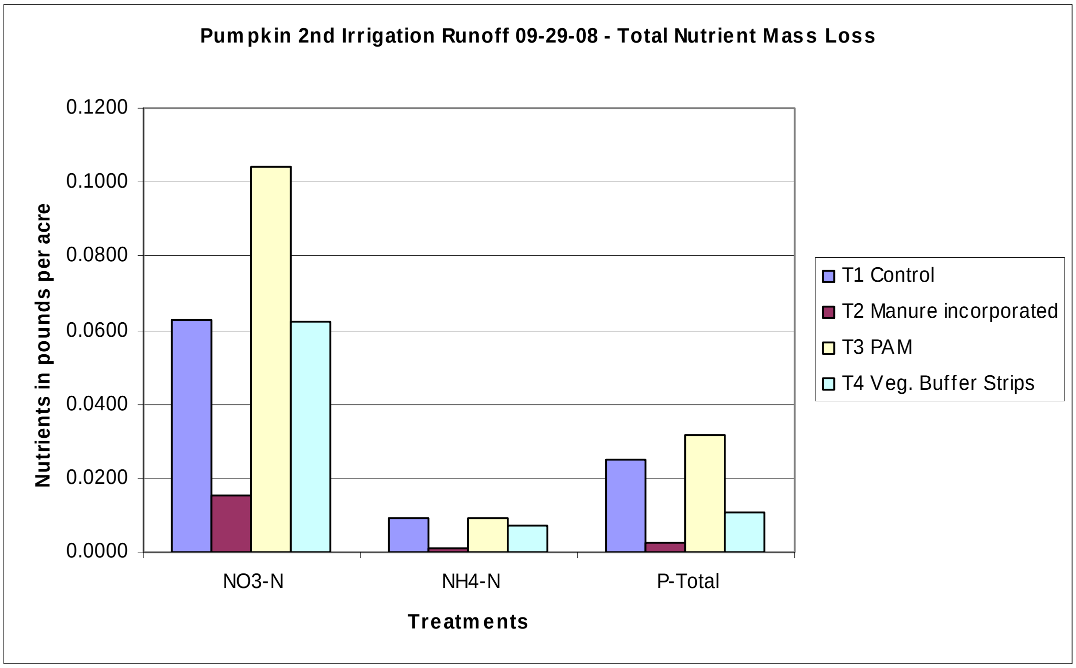

Figure D-21
Treatment Effect on Amount of Nutrients in Runoff Water at the Pumpkin Site on September 29, 2008

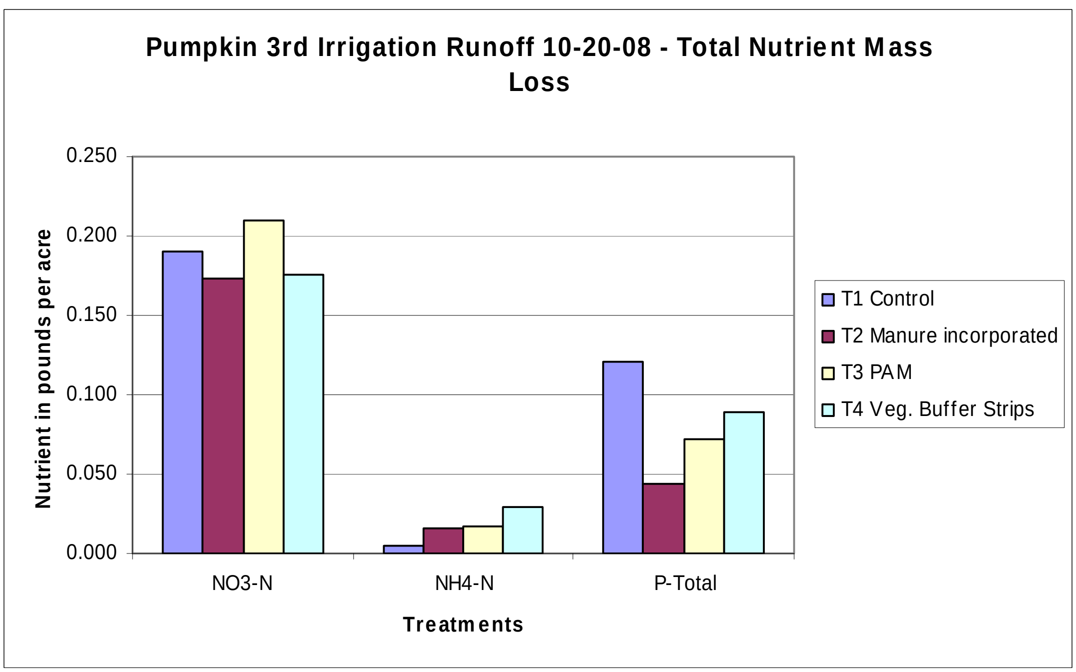

Figure D-22
Treatment Effect on Amount of Nutrients in Runoff Water at the Pumpkin Site on October 20, 2008

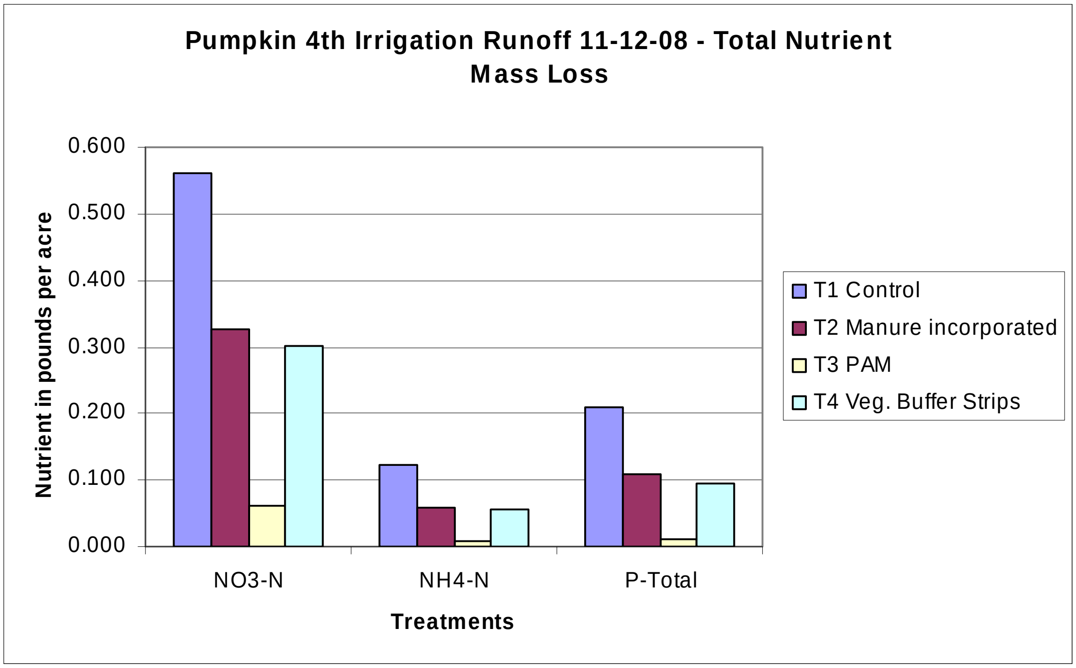

Figure D-23
Treatment Effect on Amount of Nutrients in Runoff Water at the Pumpkin Site on November 12, 2008

Looking at the four graphs (Figs. D-20 to D-23) showing the total nutrient mass running off from the plots we found a significant variance in the vertical scale. The greatest quantities are in the fourth graph, so it is dominant in the summary.

Table D-23 Seasonal total runoff (Sum ± STD) in pounds per acre (lbs/ Ac) of NO_3-N, NH_4-N and P-Total in Pumpkin crop 2008 (n = 4)

Treatments	NO_3-N	NH_4-N	P-Total
Control	0.223 ± 0.059	0.047 ± 0.014	0.093 ± 0.023
Manure incorporated	0.138 ± 0.037	0.021 ± 0.006	0.043 ± 0.012
PAM	0.103 ± 0.019	0.012 ± 0.001	0.032 ± 0.007
Vegetated Buffer Strips	0.192 ± 0.025	0.092 ± 0.031	0.066 ± 0.010

Table D-24 Runoff volume, concentrations of nitrate, ammonium, total-P, and nutrient loss for each storm of the Control treatment in Pumpkin Crop 2008

	First Flush and Sump Pump Collection Results				Calculated Pounds per Acre		
Storm event date	Volume (l)	NO_3-N mg/l	NH_4-N mg/l	Total-P mg/l	NO_3-N mass (lbs/Ac)	NH_4-N mass (lbs/Ac)	Total-P mass (lbs/Ac)
9-08-08	7.50*	7.19	3.42	31.50	0.0175	0.0122	0.0040
	236.18**	5.99	4.32	1.40			
9-29-08	7.50	2.82	0.36	0.72	0.0162	0.0024	0.0064
	809.61	1.72	0.25	0.70			
10-20-08	7.50	4.03	0.75	1.25	0.0482	0.0014	0.0305
	3133.22	1.35	0.03	0.87			
11-12-08	7.50	5.48	1.02	1.05	0.1411	0.0312	0.0523
	4548.43	2.76	0.61	1.03			

** First Flush Sample Results.*
*** Sump Pump Sample results. The calculated pounds per acre combined both first flush and pump readings.*

The data (Table D-23) show that all three treatments reduced the quantity of nitrate leaving the field compared to the control. PAM is obviously the best treatment reducing the nitrate to approximately one-half that of the control with 0.4 lbs/Ac for the season. As to the quantity of runoff the control has just under 0.9 lbs./Ac for the season.

The fact that the vegetated buffer strip was freshly planted early in the season probably ruined some chance of demonstrating that it was an effective method of reducing nutrients. As the season progressed, it became more effective. Also, chemical fertilizer was applied in this treatment. The highest ammonium runoff from the Vegetated Buffer Strips-Chemical Fertilizer application is an indication that chemical fertilizers are more vulnerable to runoff.

The results for the ammonium runoff have a similar pattern except for the vegetative buffer strips. We are explaining this as a problem caused by rabbits. The only green grass for several hundred feet around was found on the vegetated buffer strips and they were harvested down to bare ground by the rabbits in early September. On that date ammonium runoff was eight times higher than the control. On all other dates ammonium runoff from the plots was less than the quantity from the control plots; throwing out that one result would place the graph approximately equal to the results for the manure incorporated. Note that the ammonium N quantities of runoff are substantially less than the nitrate quantities.

From the data in Table D-23, the results for the total phosphorous quantities also indicate that all the treatments are better than the control and that PAM application is the best treatment for reducing nutrient runoff. Overall, PAM is an effective method of reducing nutrient runoff for vegetables in the San Jacinto watershed, and thus can be used as a BMP.

The runoff volume, concentrations of nitrate, ammonium, total-P, and nutrient loss for each storm of the Control treatment in Pumpkin Crop 2008 were shown in Table D-24 The data demonstrated the relative contribution of runoff volume and nutrient concentration to the total loss of nutrient from the plots.

The yield of the pumpkins was not significantly different among the treatments. The photo below shows the pumpkin plots and irrigation system as they were in peak growth near the end of September. See Appendix for detailed Pumpkin Information.

Pumpkin field

D.2.2.2.2.5 Dryland Wheat Results

Experimentally the wheat plots were probably the best for this particular study. They were uniformly sized and shaped with clearly defined borders on every plot. There were only slight differences in slope. The grower was very cooperative and provided all the treatments, the tillage and planting and even provided irrigation for the buffer strips when it became apparent that natural rainfall would not suffice for the establishment of seeded areas.

D.2.2.2.2.6 Results for the first Winter Season (2006-2007)

For the first winter season (2006-2007) we did not obtain any samples from the wheat plots due to the lack of rainfall after the treatments were in place. There was one storm that caused most of the wheat seeds to germinate, but by the time the seedlings were approximately 2-3 inches in height, the soil was so dry that the plants were dying. During this season, few of the growers in the area were able to harvest a crop without irrigation. The Riverside Press-Enterprise reported that rainfall for this period was 10 - 75 percent of normal in Riverside and San Bernardino Counties.

The very best storm of the 2007 - 2008 rainy seasons came in early December. The plots were very dry, but the treatments were all in place from the previous season, (it had been so dry that not even weeds were growing). Our staff went out after the rainstorm and made observations. The Press-Enterprise reported that rainfall for this period was 10 - 50 percent of normal in Riverside and San Bernardino Counties.

The grower was not able to plant the crop on a timely basis, but we had our collection system in place for the subsequent storms in December. The natural rainfall came early in the season and the growers in the area were looking at a pretty good crop in early February, but by mid-March the wheat crop had dried out and very little grain was harvested in the area. Ultimately the crop on our plots turned out to be mostly weeds, but we were able to collect samples. These are the results.

D.2.2.2.2.7 Results for the second Winter Season (2007-2008)

For the 2008 rainy season, the Riverside Press-Enterprise reported that rainfall for this period was 50 - 90 percent of normal in Riverside and San Bernardino Counties, but on July 10, 2009, the newspaper reported that "Riverside County agricultural officials are seeking a state of emergency drought declaration for the area because 20,000 acres of grain crops worth $5,000,000 have been lost this year. This is followed by 2007, the driest year on record when $4.1 million in crops were lost."

The first data we obtained from the wheat plots on November 30, 2007 looked very favorable as to the quantities of total nutrient runoff. Up until this time the nutrient runoff had been zero because there were no rain events large enough to generate runoff. When this early season storm occurred there were no new treatments in place and certainly no wheat. From this storm the soil was apparently so dry that most of the rain soaked into the dry soil. The predominant nutrient running off as shown below was ammonium, but as you can see the quantities were very small *(Tables D-26 & D-27).* The vegetated buffer strip, even though it was nothing but dried sod, did appear to have some effect in reducing the nutrient runoff.

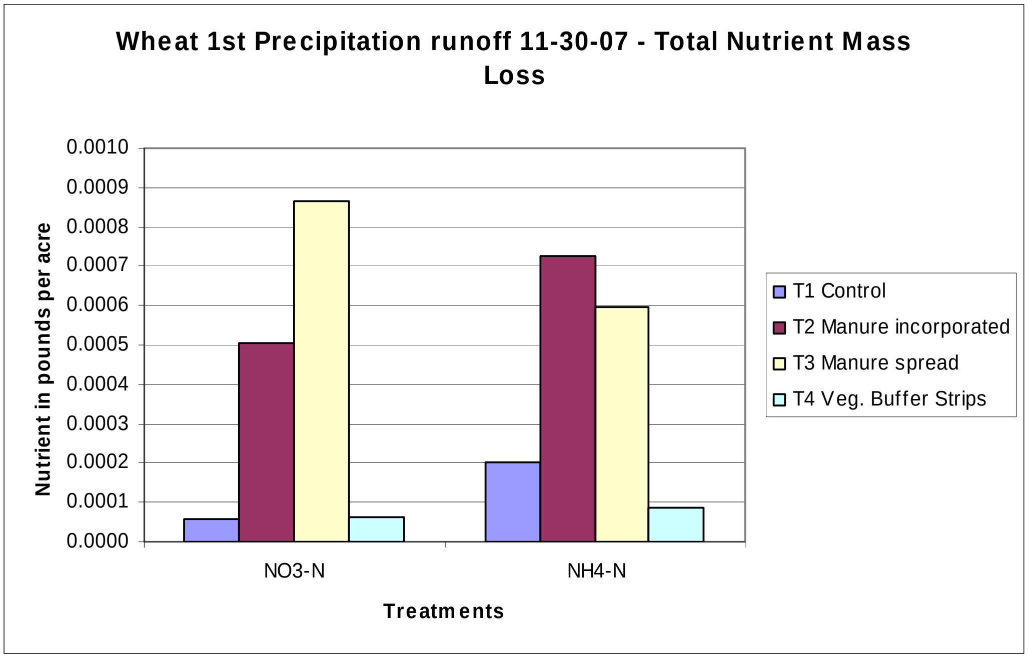

Figure D-24
Treatment Effect on Amount of Nutrients in Runoff Water at the Wheat Site on November 30, 2007

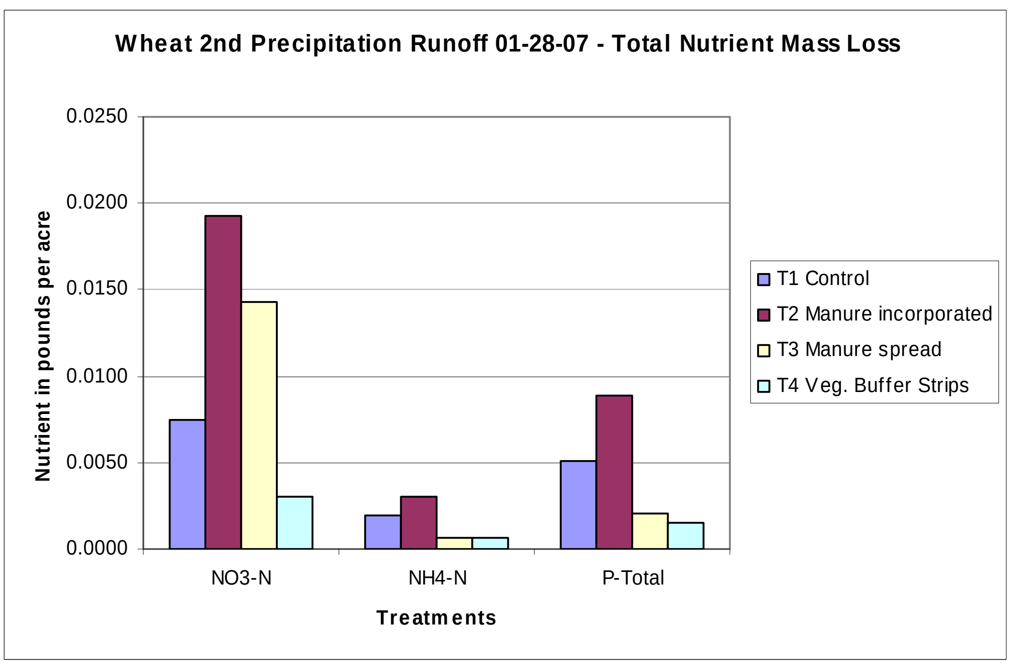

Figure D-25
Treatment effect on amount of nutrients in runoff water at the wheat site on January 28, 2007

The only other storm which provided runoff data and samples for nutrient analysis came in the few days before January 28, 2008. From this event we again see that the vegetated buffer strip does provide the best protection in controlling the runoff of nutrients. We also noted that from these results the manure on the surface seemed to serve as a mulch and control the quantity of water running off and thereby also reduced the nutrient loss from the plots.

It is interesting to analyze the storm event that occurred in the above period. Our field data show that on 1/23/2008 we had 0.43 inches of rainfall and no runoff. This was followed a day later (1/24/2008) with 0.27 inches of rainfall, but still no runoff. On 1/25/2008 there was only 0.02 inches of rainfall, but two of our four stations now recorded small quantities of runoff. It is evident that when the soil is dry and loose, it takes a considerable size of rainfall before runoff is generated.

Then, on 1/27/2008 we had the largest recorded storm of the season, 1.37 inches of rainfall, followed by 0.57 inches the next day (1/28/2008). For the period there was a total of 2.66 inches of rainfall which calculates to approximately 4980 gallons of water per plot or in round figures 15,000 gallons per treatment. Our runoff amounts were as follows in the table below (Table D-25):

Table D-25 Runoff Volumes Collected from the Dry-Wheat Field in the 2007-08 Seasons

Date	Control	Manure Inc.	Manure Spread	Veg. Buffer Strips
Runoff amounts	Gallons	Gallons	Gallons	Gallons
1/23/2008	0	0	0	0
1/24/2008	0	0	0	0
1/25/2008	5.3	10.8	0	0
1/26/2008	0	0	0	0
1/27/2008	7.3	512.3	4.4	65.2
1/28/2008	178.4	398.2	44.7	30.2
Totals	191.0	921.3	49.1	95.4
% of Rainfall	1.3%	6.1%	0.3%	0.6%

It can be concluded from the above data that: First, manure spread had the least amount of rainfall runoff of any of the treatments; from that it is assumed that manure on the surface acted as a mulch allowing the rainfall to soak into the soil rather than runoff. However, the concentration of the nutrients in the runoff from this treatment was higher than for other treatments. Secondly, the vegetative buffer strips were effective in reducing runoff to about half of the control and is the most effective treatment shown here for reducing the nutrient load in the runoff. The greater quantity of runoff from the manure incorporated plots also helps to explain why there is greater nutrient loss from these plots. Lastly, even the highest nitrate runoff from the manure incorporated plots is only 0.02 pounds per acre running off. This is the highest amount of any nutrient shown in the graphs above and in the runoff summary table (Table D-26).

The most important conclusion to be drawn is shown by the last row in the table. Only a small percentage of a significant rainfall event generated runoff from the agricultural land and that runoff does not begin until nearly an inch of rainfall has occurred, since the total runoff volume was very insignificant (Table D-27).

Table D-26 Seasonal total runoff (Sum ± STD) in pounds per acre (lbs/ Ac) of NO_3-N, NH_4-N and P-Total in Wheat crop 2007-2008 n =2

Treatments	NO_3-N	NH_4-N	P-Total
T1 Control	0.00215 ± 0.00144	0.00077 ± 0.00026	0.00149 ± 0.00105
T2 Manure, incorporated	0.00623 ± 0.00369	0.00166 ± 0.00015	0.00251 ± 0.00178
T3 Manure, spread	0.00527 ± 0.00250	0.00088 ±0.00022	0.00099 ±0.00070
T4 Vegetated Buffer Strips	0.00104 ± 0.00065	0.00030 ±0.00009	0.00047 ± 0.00033

Table D-27 Runoff volume, concentrations of nitrate, ammonium, total-P, and nutrient loss for each storm of the Control treatment in Wheat Crop, 2007-08

	First Flush and Sump Pump Collection Results				Calculated Pounds per Acre		
Storm event date	Volume (l)	NO_3-N mg/l	NH_4-N mg/l	Total-P mg/l	NO_3-N mass (lbs/Ac)	NH_4-N mass (lbs/Ac)	Total-P mass (lbs/Ac)
11-30-07	7.50*	0.22	0.80	0	0.00006	0.00020	0.0000
	0**	0	0	0			
01-28-08	7.50	1.17	0.44	1.20	0.00209	0.00057	0.00149
	178.4	0.91	0.23	0.60			

** First Flush Sample Results.*
*** Sump Pump Sample results. The calculated pounds per acre combined both first flush and pump readings.*

D.2.2.2.2.8 Results for the Third Winter Season (2008-2009)

The picture below shows the area near the wheat plots during the first storm of the season on December 16, 2008. It shows our wheat plots on the right side of the photo which are protected by a berm. It shows the runoff coming down from the hills to the west of the wheat field and the water standing on the west side of the berm. It was important as part of the experimental design to protect the plots from the water outside the plot area.

At the time of this photo, the plots had been prepared and the treatments been applied, but the wheat had not been planted. The storms on December 16 -18, wet the soil so that the wheat was unable to be planted until early January. Thus, the experimental runoff results for the storms of this period are for a bare soil with the manure treatments freshly applied. The vegetated buffer strips were in place, so the only BMP that could be completely evaluated was this treatment. The results will show that the buffer strip was an effective BMP.

The quantity of nutrient runoff from this information is huge compared to the two earlier rainfall events. As stated above wheat had not been planted, so we have bare soil on the plots and freshly applied manure, so it is understandable that the nutrient loss from the unprotected land would be high.

Wheat plots during the first storm of the season on December 16, 2008

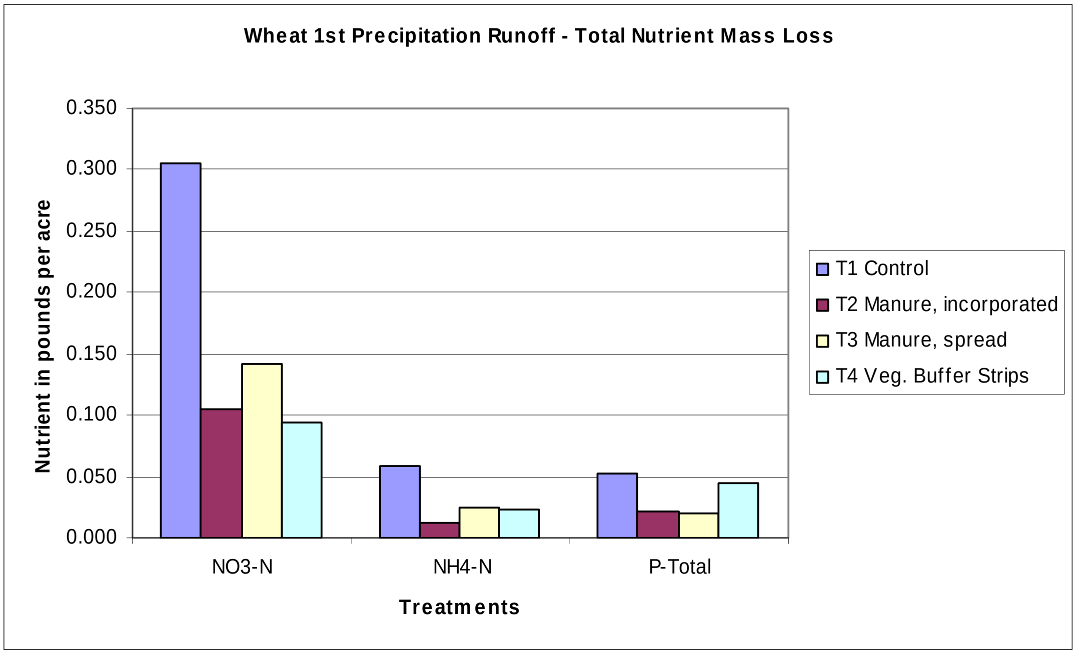

Figure D-26
Treatment Effect on Amount of Nutrients in Runoff Water at the Wheat Site on December 16, 2008

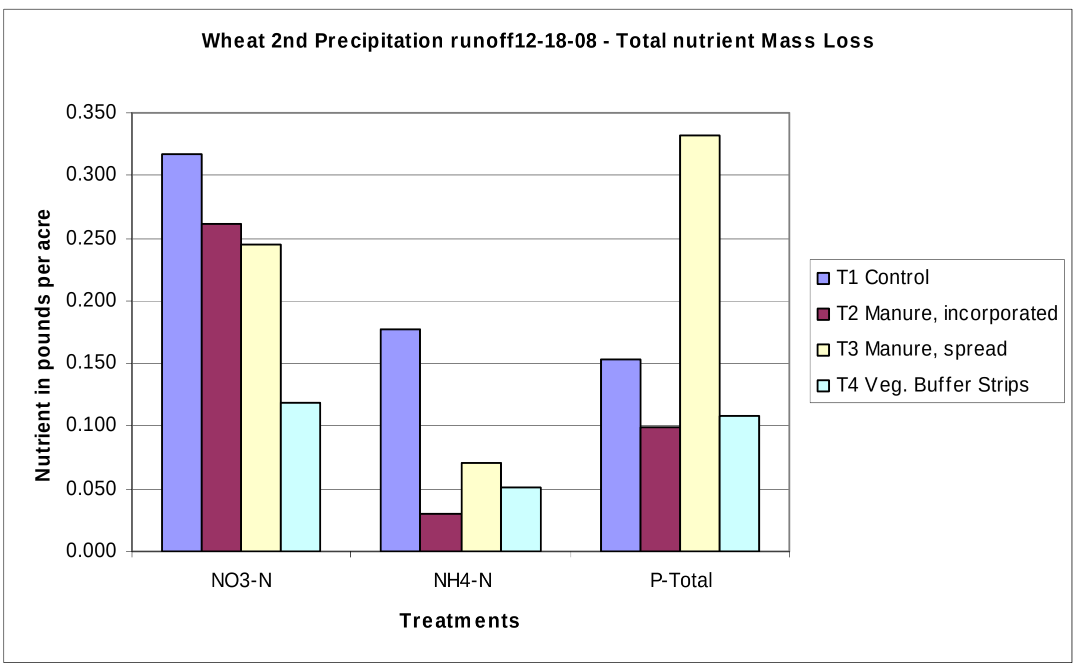

Figure D-26a
Treatment Effect on Amount of Nutrients in Runoff Water at the Wheat Site on December 18, 2008

The results from the total nutrient mass loss from the data on December 18, 2007 is about what one might expect from an early season storm with fresh manure applied to the soil. The wheat crop was not evident at this time so the soil on the plots was bare. The manure treatments had higher nitrate loss than the control and the manure on the surface also had higher phosphorous runoff than the control. Samples were also collected two days earlier which had even higher quantities of nutrient runoff. The vegetated buffer treatment had a substantial reduction in nitrate, but smaller reductions in ammonium or phosphate as compared to the control.

We irrigated the wheat in January to make certain there was a crop in the field. The irrigation quantities were chosen to be lower than amounts which would create runoff. However, in many places the stand was poor and we had weeds instead of wheat. After the December storm we had no rain events which were large enough to provide us with samples until this event on February 7, 2009. The graph below clearly shows the effectiveness of our treatments in reducing nitrate and ammonium runoff concentrations, with reductions of nearly thirty percent. Phosphorous runoff totals were all slightly higher than the control for the other three treatments.

Note that when comparing the quantities of nutrient runoff that the totals regardless of treatment are much smaller than when the soil was bare and the manure freshly applied as shown with the December storms. The wheat crop itself is effective in reducing runoff and the nutrients associated with that runoff.

For the fourth wheat rain event of the season the nutrient runoff totals are smaller than the earlier events. Manure on the surface is still providing greater nitrate and phosphate run off than the control. The vegetated buffer strip is effective in reducing the nutrients compared to the other treatments.

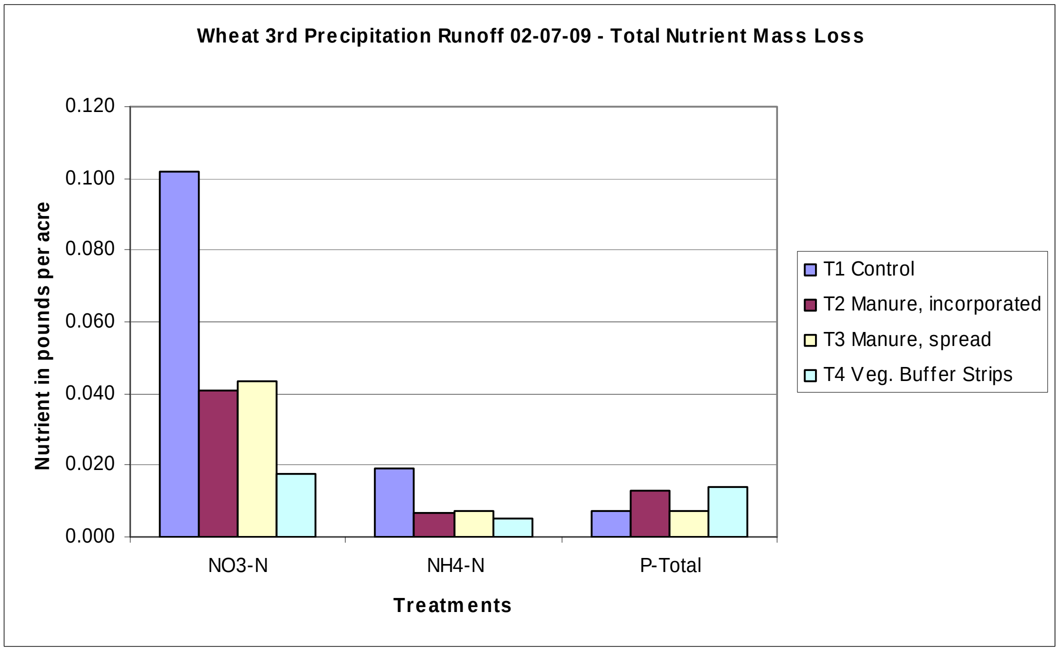

Figure D-27
Treatment effect on amount of nutrients in runoff water at the wheat site on February 7, 2009

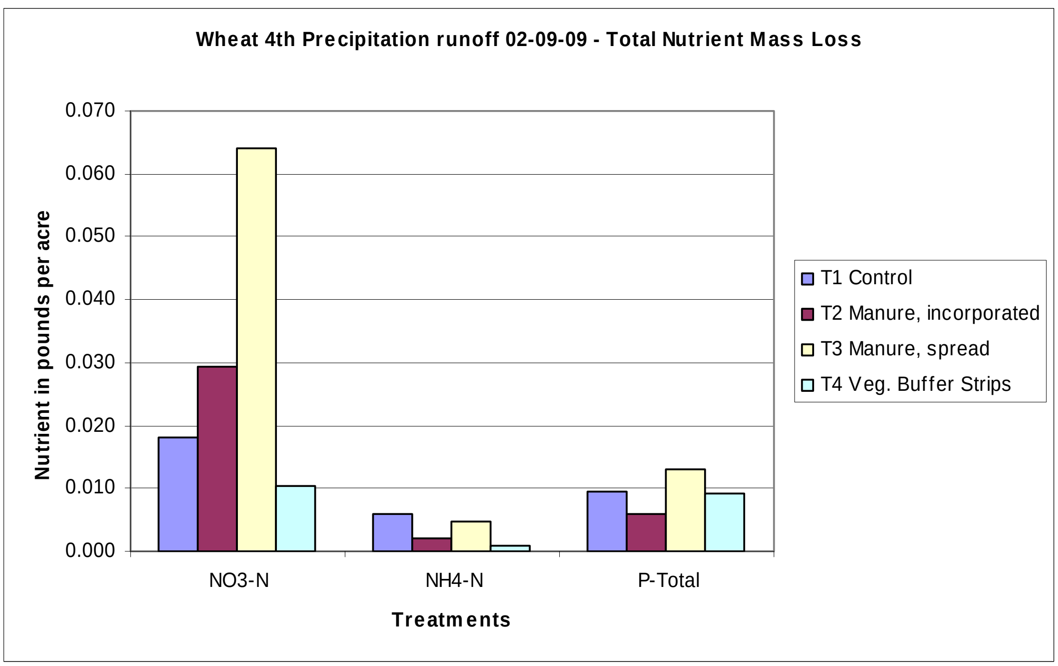

Figure D-28
Treatment Effect on Amount of Nutrients in Runoff Water at the Wheat Site on February 9, 2009

For this storm event the quantities of nutrient loss from runoff are considerably less than from all the earlier storms, but there is little evidence that the treatments have any effect in reducing quantities. Note that even with these small quantities of nutrient runoff they are considerably higher than any of the data from the citrus runoff. Still, we are showing less than 0.1 pound of nitrate per acre for even the highest shown in the manure incorporated plots.

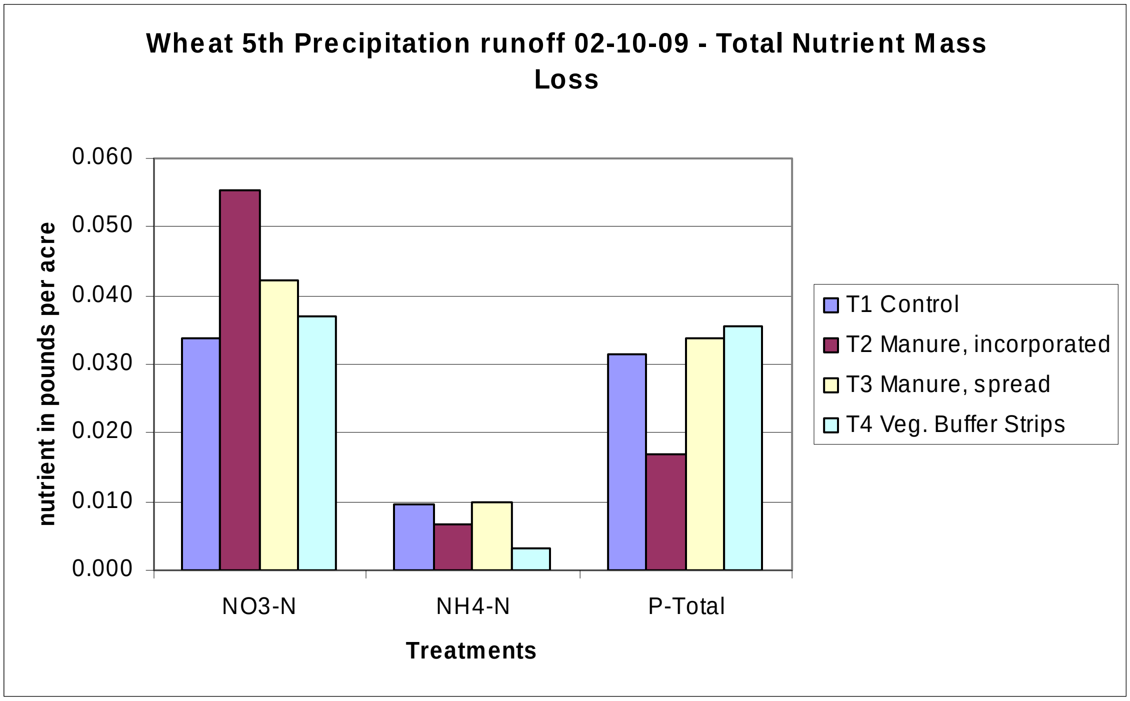

Figure D-29
Treatment effect on amount of nutrients in runoff water at the wheat site on February 10, 2009

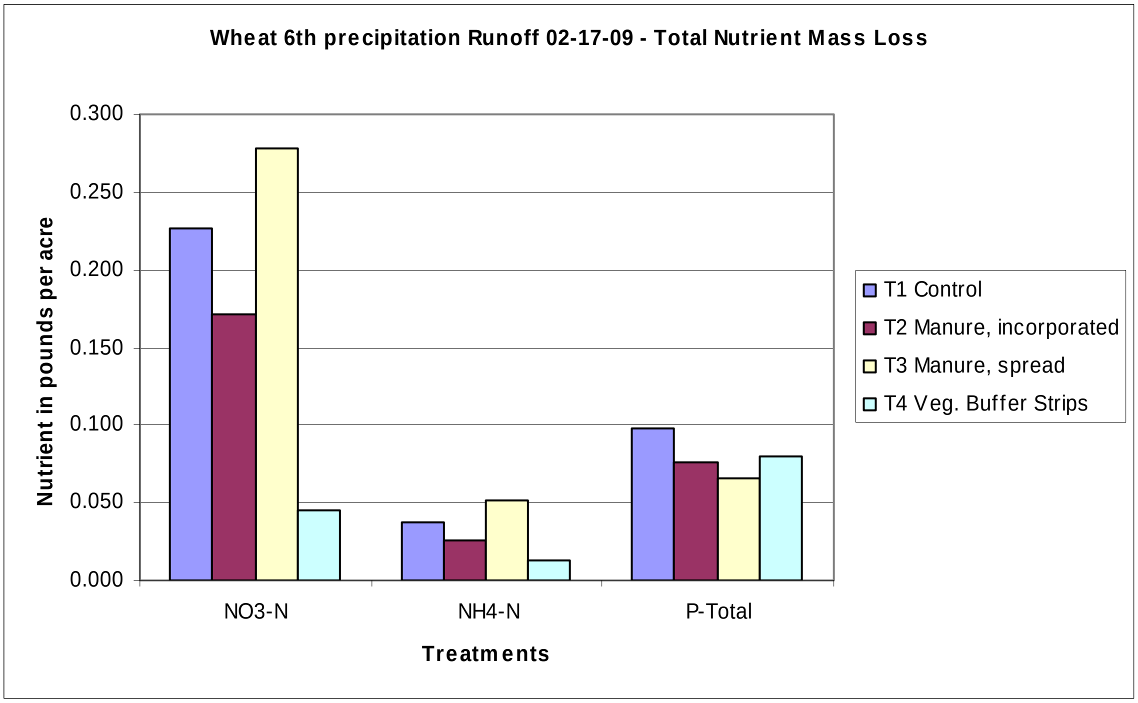

Figure D-30
Treatment effect on amount of nutrients in runoff water at the wheat site on February 17, 2009

It is not clear why the nutrient runoff amounts were higher here than they were a week earlier.

In summary for the 2008-2009 seasons, the vegetative buffer strips were the most effective BMP treatment for the wheat. During this winter season the manure on the surface did not seem to be effective as a mulch which had been an indication of the earlier seasons. Visually, there seemed to be less manure on the surface than we had seen during the first season.

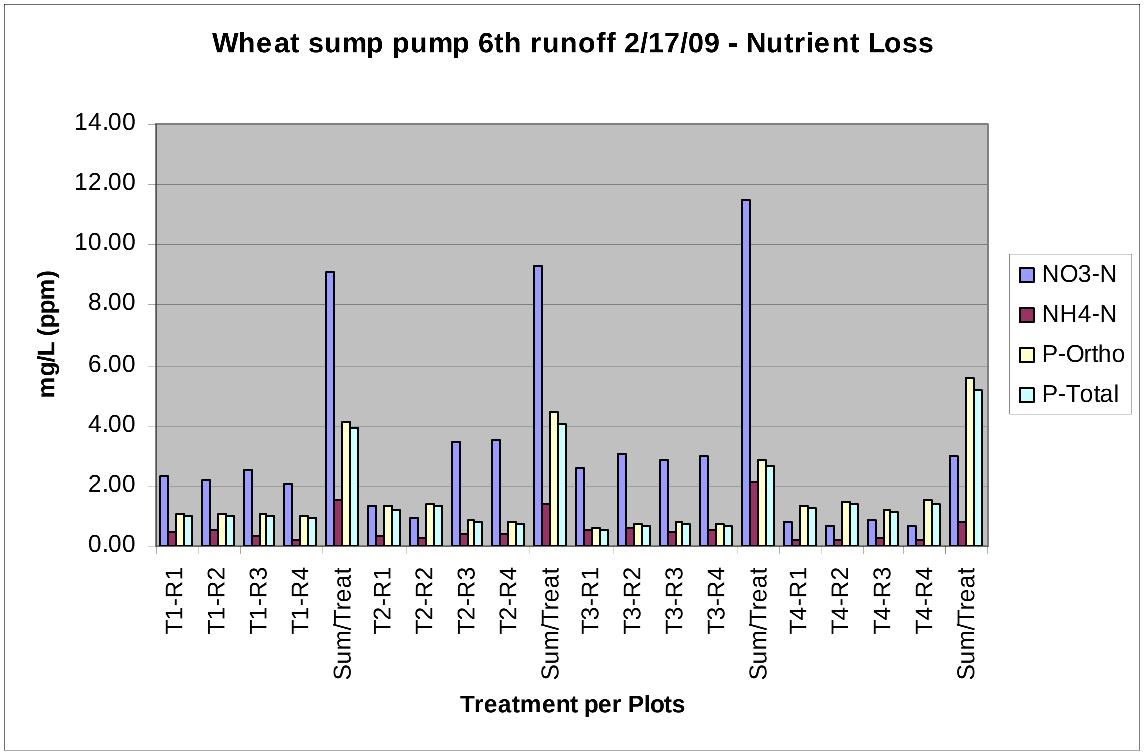

Figure D-31
Nutrient concentrations from the sump pumps sampled at different times after a storm even started on February 17, 2009. T1, T2, T3, and T4 are Treatments 1, 2, 3 and 4; R1, R2, R3, and R4 are the time sequence for runoff sampled at time 1(t=0), time 2 (t=30 min), time 3 (t=1 hr), and time 4 (t=3 hr)

This is a complicated graph (Fig. D-31), but it is important that at least one be shown and explained. The T (1-4) indicates the treatments as shown earlier. The R symbol is used for the timed samples taken from the central collection point for each treatment. The four summaries with the highest peaks are the total of the four concentrations from the same treatment of the timed samples. These values divided by 4 are the average concentrations for their corresponding treatment.

Looking at R1 through R4 for the control one can see that there is no significant trend either up or down for any of the nutrients. This is also true for the T3 and T4 treatments, but the T2 manure incorporated treatment does seem to have a significant increase in the nitrate runoff for R3 and R4 as compared to the earlier samples R1 and R2.

Table D-28 Seasonal total runoff (Sum ± STD) in pounds per acre (lbs/ Ac) of NO_3-N, NH_4-N and P-Total in Wheat crop 2008-09 (n = 6)

Treatments	NO_3-N	NH_4-N	P-Total
Control	0.1981 ± 0.0358	0.0687 ± 0.0163	0.0646 ± 0.0138
Manure, incorporated	0.1260 ± 0.0231	0.0150 ± 0.0026	0.0406 ± 0.0087
Manure, spread	0.1381 ± 0.0225	0.0300 ± 0.0063	0.1049 ± 0.0304
Vegetated Buffer Strips	0.0720 ± 0.0123	0.0218 ± 0.0048	0.0554 ± 0.0097

Table D-28 summarized the nutrient runoff from the wheat field for the 2008-09 rainy seasons. Again, the Control treatment has the highest seasonal total nitrate and ammonium runoff, and the manure spread on surface has the highest total-P runoff. Vegetative buffer strip is a good practice to reduce nutrient runoff for the dry wheat. It was observed that relatively large storms contributed to the high total loss of nutrients from the plots

Table D-29 Runoff volume, Concentrations of Nitrate, Ammonium, total-P, and nutrient loss for each storm of the Control treatment in Wheat Crop, 2008-09

	First Flush and Sump Pump Collection Results				Calculated Pounds per Acre		
Storm event date	Volume (l)	NO_3-N mg/l	NH_4-N mg/l	Total-P mg/l	NO_3-N mass (lbs/Ac)	NH_4-N mass (lbs/Ac)	Total-P mass (lbs/Ac)
12-16-08	7.50*	9.52	2.16	1.41	0.0782	0.0149	0.0134
	562.27*	12.12	2.30	2.08			
12-18-08	7.50	1.76	1.86	1.40	0.0796	0.0448	0.0385
	2319.46	3.07	1.72	1.48			
2-07-09	7.50	7.93	1.42	1.21	0.0270	0.0051	0.0020
	206.28	10.89	2.06	0.74			
2-09-09	7.50	1.13	0.26	1.28	0.0047	0.00011	0.0026
	184.33	2.17	0.71	1.11			
2-10-09	7.50	0.86	0.27	1.20	0.0086	0.0024	0.0084
	551.93	1.36	0.38	1.27			
2-17-09	7.50	4.03	0.27	1.09	0.0006	0.0001	0.0001
	2234.54	2.27	0.38	0.98			

* From first flush sample.
** From pump at the monitoring station. The calculated pounds per acre combined both first flush and pump readings.

D.2.2.2.3 Survey on Manure and Fertilizer Application

A survey on Manure and Fertilizer Application in the San Jacinto River Watershed was sent to a group of representative growers. We mailed out 36 surveys, and received 16 responses. The following are the major findings from the Survey:

1. The size of the agricultural operations ranges from 10.5 to 1600 ac. Based on the received surveys, 81 percent of the growers own their land; 94 percent of the growers irrigated their fields. Among them, 81 percent growers said that their size of operation will remain the same, 16 percent will reduce, and only 6 percent (one response) said that s/he will increase.

2. Among the responders, only 19 percent of the growers use manure in their production (cow manure: 2; horse manure: 1). Manure was applied by surface spread or disk plowing. One grower said that manure application reduced his/her fertilizer application by 75 percent.

3. The range of manure application rate is from 1 to 1.5 tons per ac per year.

4. 69 percent of the growers use chemical fertilizers; most of them use urea and N-P-K formula. Among the 11 users, 7 of them injected fertilizers through irrigation water; 1 applied as base fertilizer; and another by side dressing. Fertilizer application frequency ranges from 1 to 3 times per year. The highest use rate is 100 lb N per ac per year.

5. 88 percent of the surveys consider water quality in the watershed is important. 38 percent of them take measures to reduce runoff, 25 percent of them observed no runoff because of micro irrigation practices. Only one responder (6 percent) did not take action on runoff reduction.

D.3 Comments and Recommendations

Reviewing all of our research, we are not seeing a problem caused by runoff from the growers' fields. It has been dry, but even when it has rained we are not seeing substantial runoff from our plots. The growers are taking a lot of blame for the nutrients getting into Lake Elsinore and Canyon Lake and are credited with the "historical legacy" of nutrients that have already accumulated in the water bodies.

The desired outcomes have largely been met. We have conducted a field study on citrus and dryland wheat that lasted through three Southern California wet seasons and found effective BMPs for reducing nutrients in runoff. We have conducted field studies on summer irrigation of potatoes and vegetables and found effective BMPs for reducing nutrients in runoff. Turf BMPs have been identified and education outreach meetings were held for golf course managers and residents in Western Riverside County. Specifically,

1. All selected agricultural BMPs were found to be effective in reducing nutrient N and P carried by storm/irrigation generated runoff.

2. We carried out outreach education to educate residents and golf course professionals about turf-related BMPs and their value by meetings.

3. Growers and stakeholder groups have been informed about agricultural BMPs and their value.

4. Load reductions were quantified from adoption of these BMPs in citrus, dryland wheat and vegetables, and it was proved that certain BMPs are effective in reduce nutrient loads to surface waters, although we cannot be certain at this point that we have increased use of turf-related BMPs in the watershed.

The main long term goal with which this project is associated is to control the nutrients in Lake Elsinore and Canyon Lake and to bring them into compliance with EPA water quality goals. Since the 1930's, it has been common knowledge that soil surfaces need to be protected from wind and water erosion or the soil particles themselves will runoff into lakes, streams and other water courses. Nutrients attached to the soil particles and/or dissolved in the runoff water also runoff into the water bodies causing eutrophication. Most of the BMPs evaluated here are methods used to protect the soil surface and thus prevent soil particles from leaving the field in question. The exceptions to this may be PAM and deep-plowing, which work primarily by enabling more water to move down into the soil profile thus reducing runoff.

It should also be noted that our surveys and research indicate those growers that had previously adopted methods of reducing runoff into the streams of the San Jacinto Watershed.

CITRUS

At the citrus plots with the micro-irrigation system we have never observed runoff from the plots during irrigation events we have witnessed. The only time we saw excessive water was when the temperature fell below freezing and extra water was sprayed on the young plants to keep them from freezing (an ice shield). Most of this water froze and ran off slowly or infiltrated into the sandy soil as the ice melted in the warmer days following the freeze.

The citrus grower has his own runoff collecting system and we have not determined where it discharges and what BMPs he might be using at the discharge point. We do know that it does run during heavier rainfall events and we know that some water is discharged through the roadways during heavier rainfall.

Outside the area of our plots we have observed, in the rows themselves, the trimmings from the trees form natural mulch, and we see moss growing in some areas. This is a natural process that he uses that reduces runoff.

WHEAT (DRY-AG)

During heavy storms, there seems to be more runoff coming onto the Boris property from the surrounding hillsides than is generated from the farmland itself. There has been some erosion processes on the western end of our plots from this excessive runoff, but no erosion has been observed in the plots themselves and we have not been able to measure a substantial runoff.

VEGETABLES

In the 2007 Potato plots we observed that the grower created a system to collect the irrigation runoff water and keep it contained on the farm property. We learned that he would be fined by the Eastern Municipal Water District if he allowed the water to runoff his property, since the irrigation water is recycled water. Even though he was using a primitive sprinkler irrigation system that leaked badly and created some problems for our collection system, the sprinklers were managed to prevent runoff from the property. Good irrigation management can effectively reduce the surface runoff during an irrigation event.

In the 2008 pumpkin plots we had to excessively irrigate (above the requirement for the crop) in order to create runoff which we could collect for quantification and analysis. A grower limiting his water use to that required to economically grow the pumpkin crop would not have created any runoff from these particular plots.

Summary

Our results showed that agriculture did not contribute significant amount of N and P to the lakes in the San Jacinto River Watershed, at least for the particular weather conditions from 2006 to 2009. Nevertheless, adoption of agricultural best management practices that were proven to be effective in reducing water pollution should be encouraged and adopted, since pollution control in a watershed requires the effort of all stakeholders and potential contributors.

D.3.1 Scott Brothers Dairy Farm Pilot Gasification Project

Scott Brothers Dairy has embarked on a new and innovative technology that addresses multiple concerns and issues in the San Jacinto watershed agricultural community. As an entity that has a dairy and associated forage cropland associated with the dairy, Scott Brothers Dairy and Farm is the perfect candidate for this pilot scale project. This project is garnering a significant amount of excitement as we move forward. Federal, State, local, public and private entities are watching this technology closely. Reducing nutrient loads, eliminating waste streams, reducing salts, producing renewable diesel energy all by converting dairy waste.

Successful completion of this project could provide the foundation for significant dairy waste-to-fuel production capacity. At commercial scale, the technology could produce 6.8 million gallons of renewable diesel per year and the diversion of manure from the estimated 35,000 cows used in a commercial scale model would result in reductions of 85,150 tons/year CO2E of methane and 72,066 tons/year of nitrous oxide.

Based upon the results of this pilot scale, WRCAC will address a regional approach and examine the feasibility issues. This technology has the capability of addressing biosolid and green waste issues as well.

The pilot project has received its SCAQMD permits as well necessary building permits as of May 13, 2013. Construction of the project is underway with an estimated operational start date of 07/15/13

WRCAC has reviewed new and innovative technologies from around the world for the past 10 years. WRCAC reviews all promising technologies and processes and proceeds based upon ready-to-proceed conditions and the best project fit to meet regulatory compliance requirements.

WRCAC members are encouraged to participate in pilots or new technologies to assist the region and the dairy and agricultural operators. The Integrated Regional Dairy Management

Plan (IRDMP) included a vibratory shear enhancement process (VSEP) technology that was being used in Japan and with swine in Canada and the east coast. This technology was applied to a dairy facility in the Menifee area. Although impressive in results, cost benefit analysis was questionable and addressed only portions of dairy issues in the watershed.

Project Description: Agricultural Waste Solutions, Inc. (AWS) and its host siting partner, Scott Brothers Dairy Farms LP (Scott), will assemble and operate a pilot facility on the Scott dairy in Moreno Valley, California, to produce renewable diesel from Scott dairy manure waste. The facility will utilize four skid-mounted, AWS modules: a Solids Recovery Module that separates suspended solids from liquid dairy waste; a Water Treatment Module that converts the centrate (liquid discharge) from the Solids Recovery Module into reclaimed and clean water; a Gas Production Module that gasifies the manure solids to produce a high quality syngas; and, a Liquid Fuel Module that uses a Fischer-Tropsch liquefaction process to convert the syngas to renewable diesel fuel. The facility is sized to process manure from 125 dairy cows (the Scott dairy total is an estimated 2550 head) or about 250 pounds of manure per hour, 2.5 tons per day. AWS will own and operate the facility and it will operate the system on a continuous basis (16 hours/day, six days a week with scheduled maintenance). The project is budgeted for $1,741,157; the grant sought is $658,220 and the project partners are contributing $410,027 cash and $672,910 in in-kind services.

Scott is a member of the Western Riverside County Agriculture Coalition (WRCAC), a 501(3)(c) non-profit coalition (twenty six dairy members who, collectively, have a total of 56,000 dairy cows) that released in December 2009 the "*San Jacinto Watershed Integrated Regional Dairy Management Plan*" in order for dairy members to meet critical issues in the San Jacinto Watershed, including groundwater, surface water, air quality and salts issues, as well as meet regulatory requirements while maintaining the long-term sustainability of the dairy industry in the community. The principal objective of this AWS-Scott dairy pilot facility, SJBiodiesel #1, is to produce renewable diesel from dairy manure waste at a volume and cost that demonstrates that a commercial-size facility for WRCAC member dairies is economically sustainable and, when integrated into the best dairy management practices set out in the Integrated Regional Dairy Management Plan, will make a substantial contribution to meeting the issues in the San Jacinto Watershed and the social and environmental goals of the San Jacinto Watershed Integrated Regional Dairy Management Plan. The renewable diesel that is produced by the project will be used directly in Scott dairy off-road equipment.

The proposed project enhances and furthers state and federal efforts to achieve and maintain federal and state ambient air quality standards because (1) the AWS system modules operate within the permitting standards required by the AQMD and have twice previously been issued operating permits to gasify animal waste by South Coast Air Quality Management District; and, (2) the AWS system modules will reduce total greenhouse gas emissions (i) by gasifying manure waste prior to methane (CH_4) and nitrous oxide (NO2) emissions emanating from anaerobic decay of manure during traditional lagoon and land application; and, (ii) from replacing petroleum based diesel with cleaner renewable diesel from manure that is projected to result in reductions of as much as 49 percent hydrocarbon (HC), 33 percent carbon monoxide (CO), 27 percent nitrogen oxides (NOx), 21 percent particulate matter (PM) and 17 percent carbon dioxide (CO2). The project is not mandated by any local, regional, state, or federal law, rule, or regulation nor is the project intended to help AWS to meet any performance requirement mandated by local, regional, state, or federal law, rule, or regulation.

This AWS-Scott dairy pilot facility, SJ Biodiesel #1 facility has the following specific goals:

- Verifying the quantity of renewable diesel output—projected to be 4 gallons of renewable diesel/hour from every 250 pounds/hour of manure solids input (125 dairy cows);
- Verifying the renewable diesel quality and performance characteristics—projected to meet ASTM D 975 standard, ready for direct use in Scott off-road dairy equipment;
- Verifying that AWS's innovative Solid Recovery Module will separate and remove for gasification 98 percent of the total suspended solids over 5 microns in size from a flushed dairy waste stream and remove over 90 percent of the phosphorous (P), Chemical Oxygen Demand (COD), zinc and copper; over 65 percent of the total nitrogen (TKN); and, over 40 percent of the potassium (K) and salts from the dairy waste water;
- Verifying the volume of reduced TDS salt per year—projected to be a diversion of up to 16.46875 tons of TDS salt per year;
- Verifying that air emissions from the AWS system are well within AQMD standards and will meet air emission targets of: PM: 0 lbs/MM btu/hr; NOx: 20 PPM at 3 percent oxygen; SOx: 0; CO: 0 PPM at 3 percent oxygen; and VOC: 0;
- Verifying the greenhouse gas emission reductions from the diversion of dairy manure from 125 dairy cows—projected to be 304 tons/year CO2E of methane (CH4) and 257 CO2E of nitrous oxide (N2O);
- Verifying the calculation of potential greenhouse gas emissions of the proposed project in grams of CO2-equivalent per megajoule, total metric tons per annum, and total metric tons over the design life of the project, as well as an estimate for a future commercial facility;
- Verifying greenhouse gas emission reductions from the proposed use of 28,000 Fischer-Tropsch-produced gallons per year of renewable diesel in place of petroleum based diesel—projected to be a reduction of 49 percent HC, 33 percent CO, 27 percent NOx, 21 percent PM and 17 percent CO2.

Scott Brothers Dairy Farm LP (Scott) is a family owned business comprised of a working dairy facility and farm in San Jacinto, California, and their processing creamery in Chino, California. The Scott dairy has 1070 milking cows, 140 dry cows, 870 heifers, and 470 calves, for a total estimated herd size of 2550 cows. Scott dairy regularly ranks in the top 10 of their respective production tier for the California Dairy Herd Improvement Association (industry specific production rankings). They have a rich history in the Southern California dairy community, starting in 1913 when Ira J. Scott (the great grandfather to the current operators) moved his family from Iowa to Southern California. It was Ira's two sons who established the first "Scott Brothers Dairy" – and the tradition began. The current generation of "Scott Brothers" – Bruce and Brad, along with their father Stan—operate an environmentally certified facility under the voluntary California Dairy Quality Assurance Program. Their diverse interests in not only production agriculture, traditional crop farming, and food processing, coupled with the looming air and water quality regulatory requirements, makes them known as technical innovators in the local dairy community. They have successfully installed a solar panel grid to offset 25-35 percent of their facility electrical bill and provide needed carbon offset credits for their business and are looking forward to a second phased implementation in the future.

Bruce Scott is a 4th generation Southern California dairy farmer, and partner/owner with his brother Brad and father Stan in Scott Brothers Dairy Farm LP. Bruce primarily manages the day to day farming aspect of the dairy, cultivating approximately 750 acres of crops used to feed the dairy herd. Because of the wide range of environmental regulatory requirements the modern dairy farmer faces, Bruce has developed a strong interest in incorporating innovative technologies to manage the environmental impact the dairy farm can present. Scott dairy utilizes a solar grid to offset their electrical power needs; they have converted their water pumping mechanisms to high efficiency electrical pumps under state grant funding, and utilize hybrid methods to manage the waste water/manure handling in compliance with current regulatory mandates. Bruce actively participates in the local watershed regulatory community, helping to advocate for his fellow dairymen and farmers. Bruce is the chairman of the Western Riverside County Agriculture Coalition, a former director of the Riverside County Farm Bureau and currently sits on various water/environmental policy boards including the Hemet/San Jacinto Groundwater Management Plan, San Jacinto River Watershed Council San Jacinto Basin Resource Conservation District, South Coast Air Quality Management District, Regional Water Quality Control Board, Eastern Municipal Water District, and Riverside County Solid Waste Management Advisory Task Force. In addition, Bruce has been a key collaborator with the USDA-ARS Salinity Lab, and has donated his time resources and facility to facilitate the research projects for “Spatio-Temporal Assessment of Nutrient Management Plan (NMP) Performance for Field-Scale Lagoon Water Application” and “Transport and Fate of Nitrate and Pathogens For Dairy Lagoon Water.”

Brad Scott is a 4th generation Southern California dairy farmer, and partner/owner with his brother Bruce and father Stan in Scott dairy. Brad is the “Chief Herdsman” of Scott dairy, and also keenly interested in the incorporation of technology innovations to the modern dairy farming model. Brad’s management practices for the herd regularly ranks the herd in the top 10 of their respective production tier for the California Dairy Herd Improvement Association (industry specific production rankings.) Brad actively participates in local, regional and national industry related associations as a resource and advisor, as the past president of the Riverside County Farm Bureau, board member of the Milk Producers Council, Southern Counties Dairy Herd Improvement Association, California Beef Council, California Dairy Herd Improvement Association, and as a member of the Industry Priority/Innovation Center Committee of the National Dairy Board/Dairy Management Inc. Brad attended California Polytechnic University and majored in Dairy Science.

Coordination between AWS and Scott and the Western Riverside County Agriculture Coalition (WRCAC), a 501(3)(c) non-profit coalition (about twenty five dairy members who, collectively, have a total of 56,000 dairy cows) has been underway since February 2010. Scott and WRCAC consultant, Pat Boldt, and AWS have reviewed together the AWS facility in Chino and the operations and facilities of the Scott dairy and ranch in Moreno Valley, along with visits to other dairies in the San Jacinto area. AWS principals have addressed a regularly scheduled WRCAC meeting to explain the AWS system to WRCAC members. AWS has been briefed on the WRCAC-prepared "*San Jacinto Watershed Integrated Regional Dairy Management Plan*" that sets out the critical issues in the San Jacinto watershed, including groundwater, surface water, air quality and salts issues. Meetings and discussions have taken place to discuss how AWS systems can integrate with the Dairy Management Plan and help Scott and other WRCAC members meet the regulatory requirements. The pilot project is the first step to maintaining the long-term sustainability of the dairy industry in the community with the ultimate project being a commercial scale regional unit.

The principals of both Scott and AWS are experienced in administering and meeting contract obligations, including grant award contracts, and have developed and used in the past reporting systems to monitor grant projects to ensure the quality and integrity of test results and the reporting of the results to meet project requirements for producing a final report. McCorkle, Abruscato and the Scotts have successfully administered and complied with other grant requirements; AWS has meet FPPC requirements and Scott and WRCAC consultant, Pat Boldt, have met state, NRCS, EQIP and USDA grant requirements. Prior to initiating this SJ Biofuels #1 project, close coordination will take place between each group's principals and Pat Boldt to develop a mutually agreed upon process to monitor, audit and ensure compliance will all project deliverables and contract award requirements.

AWS and Scott will be administering together a total budgeted project cost of $1,741,157; the grant sought is $658,220 and the project partners are contributing $410,027 cash and $672,910 in in-kind services.

The San Jacinto Watershed where the Scott dairy is located faces critical issues including groundwater basin overdraft, poor quality groundwater that limits opportunities for recycled water use, and nutrient runoff contributing to nutrient overloading in Canyon Lake and Lake Elsinore. To help solve groundwater, surface water, air quality and salts problems in the watershed, Scott and the Western Riverside County Agriculture Coalition (WRCAC), a 501(3)(c) non-profit coalition (twenty six dairy members who, collectively, have a total of 56,000 dairy cows) prepared and released in December 2009 the "*San Jacinto Watershed Integrated Regional Dairy Management Plan*" in order to provide an integrated regional plan to meet these critical issues. One of the principal objectives of this AWS-Scott dairy SJ Biofuels #1 pilot facility is to demonstrate that diverting manure from traditional lagoon/land application to a feedstock for renewable diesel will make a substantial, positive, contribution toward meeting the Dairy Management Plan goals when an AWS system is integrated into the overall Dairy Management Plan. These goals include helping to solve the groundwater, surface water, air quality and salts problems of the San Jacinto Watershed by preventing significant quantities of nutrient runoff from entering the Watershed. For example, it is projected that diverting the dairy waste from 125 Scott dairy cows will eliminate 16.46875 tons of TDS salt per year. Accomplishing the objectives of the Dairy Management Plan will significantly contribute to the sustainability of the WRCAC member dairies and preservation of the environmental quality of the San Jacinto Watershed natural resources.

The Dairy Management Plan reported on several demonstration projects that were conducted to evaluate dairy Best Management Practices that could contribute to addressing nutrient and salt issues for the Watershed. The Dairy Management Plan was led by WRCAC and included representatives from Eastern Municipal Water District, Nuevo Water District, the San Jacinto Basin Resource Conservation District, the University of California Riverside Cooperative Extension, the USDA-ARS Salinity Lab and the USDA Natural Resources Conservation Service. Three Best Management Practices demonstration projects were demonstrated on San Jacinto dairies, including effectiveness monitoring: 'Spatio-Temporal Assessment of Nutrient Management Plan Performance for Field-Scale Lagoon Water Application' with the USDA-ARS Salinity Lab; Vibratory Shear Enhanced Processing (VSEP®) with New Logic Research, Inc. to separate and concentrate suspended solids in order to recover clean water for reuse on the dairy, including livestock drinking water; and, A Forage Crop Irrigation Demonstration Project to test and demonstrate modern monitoring technologies for irrigation and water use management for forage crop production. The Scott dairy utilizes best management practices for water saving technologies having converted their water pumping mechanisms to high efficiency electrical pumps under state grant funding.

This SJ Biofuels #1 project will recover reclaimed and re-useable water for both the project needs (replacement reclaimed water for re-circulating water for cooling) and for daily Scott dairy operations by removing 98 percent of the total suspended solids over 5 microns in size and over 90 percent of the phosphorous (P), Chemical Oxygen Demand (COD), zinc and copper; over 65 percent of the nitrogen (TKN); and, over 40 percent of the potassium (K) and salts from the dairy waste water from the manure produced by 125 dairy cows. The removal of these pollutants from dairy waste water will significantly reduce point source wastewater discharge and complement the Best Management Practices undertaken by Scott and WRCAC, particularly the salinity testing done with USDA and the VSEP technology. This recovered water could, with further commercially available treatment methodologies (not an objective of this project), like the VSEP technology already tested, be restored to drinking water quality standards. A project goal that directly relates to contributing to the goals of the San Jacinto Watershed Integrated Regional Dairy Management Plan is verifying the amount of reduced TDS salt per year, projected to be a diversion of up to 16.46875 tons of TDS salt per year from processing 250 pounds of dairy cow manure per hour.

Market Transformation: The SJ Biofuels #1 project will demonstrate the sustainability of commercial projects to convert dairy waste to liquid fuels, principally renewable diesel, a replacement for petroleum diesel, the type of fuel most commonly used in agricultural operations. The results from this project will enable and promote the commercial deployment of the technology in order to meet two important public policy goals, both for California and the nation: (i) reducing dependence on petroleum fuels by generating significant, commercial, renewable fuels from local market wastes; and (ii) meeting California's and the nation's goals to reduce greenhouse gas emissions, a reduction that will come both from the diversion of animal wastes to gasification and from the use of a cleaner burning, non-toxic, renewable fuel.

Viable and Alternative Fuels Market: The project goals are to verify the quantity of renewable diesel output per unit of input—projected to be 4 gallons of renewable diesel/hour from every 250 pounds/hour of manure solids input (125 dairy cows) and verify the renewable diesel quality and performance characteristics of the liquid fuel—which has been tested and met the ASTM D 975 standard, ready for direct use in Scott dairy vehicles and equipment as a direct, cleaner, substitute for diesel fuel. If the goals are met, and commercial projects initiated, then converting the dairy waste from the WRCAC member farms in San Jacinto—35,000 dairy cows—would produce about 6.8 million gallons of renewable liquid fuels annually. California has approximately 1.7 million dairy cows that produce a renewable manure waste feedstock of over 25 million dry tons annually or a *potential* renewable liquid fuel volume of about 330 million gallons annually.

Producing renewable liquid fuels from animal waste will diversity the state's source of transportation fuels and provide local jobs at livable wage standards in the rural areas of our economy while helping agriculture remain economically competitive and sustainable. Developing alternative, renewable fuels is consistent with California's legislation, executive orders and public policy (e.g., AB 32 and EXECUTIVE ORDER S-06-06).

Consistency with Climate Change Policies: This SJ Biofuels #1 project will demonstrate that the use of renewable diesel reduces greenhouse gas emissions (both tailpipe emissions and emissions on a total lifecycle basis, including emissions created in the production of renewable diesel), as well as other emissions such as particulate matter, carbon monoxide and unburned hydrocarbons. Recent research papers regarding experimental results concerning the effects of Fischer-Tropsch (F-T) diesel fuel on the emission characteristics of a single-cylinder direct injection diesel engine under different conditions, has reported lower HC, CO, NO_x and smoke emissions than conventional diesel fuel. F-T renewable diesel produced from syngas (CO and H_2) (the type of biogas to be produced in the SJ Biofuels #1 project) through F-T synthetic processes is characterized by a high cetane number, a very low sulfur content and a very low aromatic level. Other reported studies conducted on unmodified diesel engines have shown that the exhaust emissions are reduced significantly with the use of F-T diesel fuel, reporting that the CO, HC, NO_x and smoke emissions were reduced simultaneously when compared with those of conventional diesel fuel operation and NO_x and smoke emissions were reduced by 16.7 percent and 40.3 percent, respectively, with F-T diesel fuel. Other reports show reductions of 49 percent in HC, 33 percent in CO, 27 percent in NO_x and 21 percent in PM compared with standard federal No.2 diesel fuel.

SJ Biofuels #1 will produce F-T renewable diesel for direct substitute for diesel fuel on the Scott ranch. A project goal will be to verify both the direct substitutability of the F-T renewable diesel and the actual reduction of NOx, PM, CO, HC and smoke emissions, and greenhouse gas emissions, from the proposed use of 19,200 F-T- produced gallons per year of renewable diesel in place of petroleum based diesel. In addition, the project will seek sustainability certificates from national or international certifying organizations both for the renewable diesel and the feedstock.

In addition to reduced greenhouse gas emissions from the use of renewable diesel, this project also points a way forward to directly confront climate change by slashing greenhouse gas emissions from livestock operations (e.g., EPA-USDA's AgSTAR program) in order to move the state's and the nation's economy into the clean economy of the future. Greenhouse gas emissions from livestock operations can be dramatically slashed by the destruction of manure at the source and prior to the release of methane (CH4), nitrous oxide (N2O) and ammonia (NH3). Methane has 21 times and nitrous oxide 310 times the Global Warming Potential (GWP) as carbon dioxide (CO2) when converted to equivalents as CO2E.

Accumulated manure on the ground and in lagoons emits several air contaminants, including ammonia (NH3), methane (CH4), and nitrous oxide (N2O). The greenhouse gases methane and nitrous oxide contribute to climate change. The ammonia is understood to be a precursor to PM10 (fine particulate matter less than 10 microns in diameter). Each local community has an air quality control board or regulatory agency responsible for ambient air quality standards and PM10 emissions (for example, the area around the Chino, California Valley is part of the South Coast Air Quality Management District (SCAQMD). These regulatory boards have set goals for regulating emissions, and have prescribed measures for attaining State and federal air quality standards, e.g., the removal of manure from animal feeding operations (AFO's), like dairies— SCAQMD's rule 1127. For example, the Chino area has, in the past, exceeded State and federal ambient air quality standards for PM10 emissions, making it a "non-attainment zone". AWS system gasification of animal wastes will reduce PM10 emissions, directly contributing to the goals of the AQMD. The AWS Gas Production Module is the only gasifier that has been issued operating permits by AQMD to gasify animal wastes in the South Coast region. The AWS module was invented and is manufactured in Los Angeles County.

Untreated manure emits methane (CH4) and nitrous oxide (N2O). It is estimated that as much 304 tons/year CO2E of methane and 257 tons/year CO2E of nitrous oxide may be captured by operation of a .125 ton per hour (2.5 tons per day) AWS system that serves 125 cows annually. Greenhouse Gas reduction benefits include reductions of methane (CH4) and nitrous oxide (N2O) from the manure diverted to the AWS system. These emissions are translated to Carbon Dioxide Equivalents (CO2E) as shown in the calculations below:

Conclusions: The relative consistency of the project performance of the SJ Biofuels #1 project would confirm that using on-farm AWS Solid Recovery Modules with appropriately sized commercial Gas Production Modules (whether on-farm for larger operations or off-farm for smaller farms and clusters) is a good model to follow to deploy AWS gasification manure-to-renewable fuels systems to an area of concentrated animal feeding operations, such as the WRCAC dairy members in San Jacinto, dairies in the Chino basin, beef feedlots in the Central Valley, and other species clusters, like swine and poultry.

For individual farms and clusters of animal feeding operations, the deployment of the new, innovative AWS system technology systems, is challenged by the following factors:

- Farmers are challenged in the U.S. by low market prices, thus they do not produce a consistent enough income on their existing investment to justify investing new capital in new systems;
- Lack of consistent commitment on the part of animal feeding operations to install technology that is not in their core competency;
- Availability of third party capital for a new, previously untried, innovative system for agricultural operations;
- Individual farms, especially family farms at the scale of under 1,000 head, are becoming less and less economically viable, and many are shutting down rather than being passed on in the family.

The successful results of this SJ Biofuels #1 project will greatly overcome these factors by demonstrating the steps for integrating a centralized renewable fuels production into the daily life of a farm or dairy and the economic returns that can be earned from the *efficient* conversion of the energy value in agriculture wastes to renewable fuels. The deployment of commercial projects would be especially beneficial in any high-concentration cluster of animal feeding operations, such as the San Jacinto and Chino areas. The close proximity of farms has resulted in air and water quality issues, but an AWS system can greatly mitigate those issues, and proximity minimizes transportation distances from various farms to a commercial, centralized unit and the subsequent distribution of renewable fuels.

Deployment of this technology can readily be accomplished in time to make a significant contribution toward meeting both state and nationwide goals for renewable transportation fuels by 2020 and 2050. Nationally, annual agricultural waste is about 12x human waste and about 5x the amount of municipal waste, or about dry 823 million tons. Animal and process wastes could produce annually 24 billion gallons of renewable diesel and agricultural crop residues could produce annually 33 billion gallons of cellulosic ethanol. Together, agricultural wastes could produce about 1.5x the national renewable fuel requirement for 2022. California's agricultural industry, the number one industry in the state, has significant animal feeding operations—dairies, beef feedlots, poultry, swine. The widespread commercial application of the AWS system technology—technology invented and manufactured in California—would make California a leader in the production of renewable liquid fuels using just animal waste. Animal waste as the feedstock and the *efficient* conversion of its energy value to renewable fuels makes commercial scale facilities economically sustainable.

D.3.2 Public Education and Stakeholder Outreach

Public education and outreach activities that target nutrients will be implemented through WRCAC sponsored activities. A coordinated effort to discuss nutrients and the TMDL, BMPs for agricultural operators and requirements of the CWAD program, activities of agricultures' participation in the Task Force and new issues will be an important task of the AgNMP. The implementation of the AgNMP will only be successful with public education and stakeholder outreach in the agricultural community. WRCAC is committed and will promote workshops and seminars as part of a continuing education program. We intend to use experts such as the University of California Extension faculty, the Santa Ana Regional Water Quality Control Board, the Riverside County Ag Commissioners Office and other Outreach experts to target specific issues as identified in the UCR BMP Assessment study in the San Jacinto watershed. This will be a challenging task as each owner operator will ultimately be responsible for what they do or don't implement. WRCAC will continue to regularly evaluate these activities and update activities as needed.

Development of outreach courses, duration, stakeholder specific needs will be addressed in the development of the tiered approach program. We expect continuing education to be a component of the CWAD program with specific requirements.

It is not possible to directly quantify reductions in nutrient loads in agricultural runoff to specific public education and outreach activities. Accordingly, the water quality benefits that occur as a result of these activities are considered qualitatively as part of the margin of safety associated with implementation of the AgNMP.

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ATTACHMENT E
AGNMP IMPLEMENTATION PLAN

TABLE OF CONTENTS

TABLES

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E.1 Introduction

The dairy and agricultural operators are providing a detailed schedule including the following:

- Discrete milestones, decision points and alternative analyses necessary to assess satisfactory progress toward meeting the dairy and agricultural WLAs for nutrients by December 31, 2020.
- Specific metric(s) that demonstrate the effectiveness of the AgNMP and acceptable progress toward meeting the agricultural WLAs for nutrient by December 31, 2020

Section 2.4 provided an illustration of the key AgNMP elements in a timeline. In this attachment, Table E-1 provides the detailed information required above for each AgNMP task, specifically:

- *AgNMP Activity* – Programmatic area to be implemented;
- *Milestones* – Discrete actions associated with the completion of each AgNMP activity;
- *Metrics* – Specific outcomes to demonstrate completion of each milestone;
- *Lead Agency* – Assignment of the activity ; and
- *Completion Date* – Completion dates for the AgNMP activities.

E.2 AgNMP Activities

The following sections provide a brief summary of the activities that will be completed under each key AgNMP element.

E.2.1 Watershed-based BMPs

BMPs will be evaluated by the dairy and agricultural operators to determine if modifications or enhancements can be made that will improve the effective use of nutrients and/or reduce nutrient load.

Dairy BMPs may be addressed in the dairy Engineered Waste Management plans (EWMPs) and/or in the Nutrient Management Plans (NMPs) where applicable. WRCAC, as a coalition, will address issues for stakeholder outreach and grant development of projects to assist in meeting the load reductions. However, individual dairy operators will also provide load reductions thru special studies such as the pilot gasification study on one of the San Jacinto watershed dairies. WRCAC will collect and coordinate BMP data to assess load reduction progress.

Agricultural operators currently do not have any mechanism for obtaining load reduction or a credit system for individual BMP implementation other than attrition of land use towards BMP development. WRCAC is creating a tiered approach to collect, coordinate and document BMP implementation that is completed by individual agricultural operators.

We believe that the majority of agricultural operators, based upon survey data, employ BMPs however no system within the watershed recognizes their efforts. Therefore, additional load reductions from agricultural operators BMPs need to be measured.

The implementation schedule includes milestones for the evaluation of these BMPs and, if appropriate, completion of program modifications.

Public education and outreach activities that target nutrients will be implemented through WRCAC activities for both agricultural and dairy operators implemented. WRCAC will continue to regularly evaluate these activities and update activities as needed.

E.2.2 In-lake Remediation Projects

Lake Elsinore

The Lake Elsinore aeration system, incorporated into the AgNMP, is already being implemented. After new information regarding the aeration system was presented in early 2013, the agricultural and dairy operators requested to be included in the negotiation process and inclusion in the aeration system program. During AgNMP implementation the agricultural and dairy operators will support the continued operation of this system as needed to comply with their WLAs. However, as noted in Section 2.2.2., the agricultural and dairy operators will continue to evaluate alternative compliance approaches including use of chemical additives such as Zeolite or Phoslock. If it is determined that an alternative approach is more cost effective for achieving compliance with the agricultural and dairy WLAs, the stakeholders will recommend revision to the AgNMP.

Canyon Lake

The Taskforce has completed detailed evaluations of aeration, oxygenation, and chemical addition (Anderson, 2008; CDM, 2011; Anderson, 2012b; Anderson, 2012c). Based on these evaluations, the Taskforce has determined that chemical addition, using aluminum sulfate (alum), is the most effective in-lake nutrient control strategy to achieve interim numeric targets for the response variables, chlorophyll-a and DO. Appendix C provides the basis for this determination. Beginning in September 2013, assuming CEQA compliance is complete, alum application will be performed according to the schedule shown in Table 3-19. After the fifth alum application in September of 2015, the agricultural and dairy operators will evaluate water quality data in the lake, and determine whether response targets are achieved or if modification to the alum application plan or potential supplemental BMPs may be needed to achieve response targets for chlorophyll-a and DO (see Table E-1 in Attachment E for detailed implementation schedule).

In 2016, the TMDL will be reopened to revise the final numeric target for DO to incorporate controllability by means of an allowable exceedence frequency representative of a pre-development condition in the watershed. The 2012 DYRESM-CAEDYM simulations of lake water quality expected for a pre-development level of watershed nutrient loads will be used as the basis for determining the uncontrollable frequency of exceeding a final DO target of at least 5 mg/L in the hypolimnion. A cumulative frequency plot of average daily DO data from the two year period of alum applications (Sep 2013 through Sep 2015) will be compared to the pre-development cumulative frequency to determine whether sufficient improvement to DO was achieved with the alum applications. If not, the agricultural and dairy operators will consider a supplemental in-lake project for DO, such as aeration or oxygenation.

E.2.3 Monitoring Program

Watershed-based monitoring will continue at current levels through fiscal year 2014-2015. The dairy and agricultural operators propose to eliminate existing in-lake monitoring programs through the same period to ensure that resources are dedicated to implementation of projects contained in the AgNMP. By December 31, 2014, the dairy and agricultural stakeholders will propose a revised comprehensive watershed and in-lake monitoring program for implementation beginning in fiscal year 2015-2016. The level of effort associated with this revised program will be sufficient to provide data to assess compliance with the 2015 interim and 2020 final TMDL compliance requirements. These compliance assessments will provide the basis for determining whether the AgNMP requires revision to ensure compliance with TMDL requirements. Annual monitoring reports will be submitted to the Regional Board by November 30th of each year.

E.2.4 Special Studies (optional)

The AgNMP identifies several special studies that may be completed during implementation. Their primary purpose is to develop new data or information that could provide the basis for revisions to the Nutrient TMDLs or AgNMP. The three studies listed in Table E-1 (land use updates, TMDL model update and use of chemical additives, e.g., Zeolite or Phoslock application) may be implemented by the dairy and agricultural operators, but only if it is determined that the expenditure of resources on these efforts would yield appropriate outcomes. For that reason, Table E-1 notes that these tasks are optional and only lists general milestones and metrics. If the studies were to be implemented, the efforts would be coordinated with other stakeholders to the extent necessary. Currently, given the TMDL triennial review schedule, which provides periodic opportunity to revise the TMDL, these studies would be completed in a timely manner to inform the triennial review process.

E.2.5 Adaptive Implementation

This AgNMP element covers activities associate with continued participation in the Task Force, the development of a PTP, and the need, where appropriate, for revisions to the AgNMP or Nutrient TMDLs. The development of the PTP is currently occurring under the direction of the Task Force. The dairy and agricultural operators will collaborate on the development of this plan, its approval by the Regional Board, and implementation through continued participation in the Task Force. Additionally, the agricultural operators were granted a 319 grant for a Trading Feasibility Assessment. This grant will be completed in fall of 2013. The recommendations of this grant will identify whether NPS to NPS agricultural and dairy activities can be traded within the watershed.

The need for modification of the AgNMP will be determined by the findings of any special studies (if implemented) and the results of ongoing monitoring efforts which provide the basis for assessments of compliance with TMDL requirements. This assessment will include completion of a trend analysis for the response targets and nutrient levels in Lake Elsinore and Canyon Lake by November 30, 2018. Adaptive implementation also includes a provision for providing support to the TMDL revision process. Recommendations for revisions to the TMDL would be made by all stakeholders. Any recommendations made would be based on the findings of special studies or the data obtained from the monitoring program. The schedule for TMDL revisions is based on the TMDL review schedule that anticipates opportunity for TMDL revisions every three years.

Table E-1. AgNMP Implementation Plan						
AgNMP Activity	**AgNMP Element**	**Milestones**	**Metrics**	**Lead**	**Complete by**	**Status**
	AgNMP Implementation		Complete and submit AgNMP. Obtain approval by RWQCB and implement	WRCAC, ag stakeholders	Begin implementation within 6 months of Regional Board approval of AgNMP	
		Develop tiered BMP approach for agricultural operators	Develop tiered program for BMPs	WRCAC	31-Dec-14	
		Implement web based weBMP tool	Incorporate tiered program into weBMP	WRCAC	1-Jul-15	
		Develop load reduction rates for BMPs in webNMP (above)	Based upon reported BMPs in the SJ watershed ,develop rates for load reduction	WRCAC	30-Nov-15	
		Participation in CWAD development	Assist RWQCB in development of CWAD Program	WRCAC	ongoing	
	Public Education & Outreach	develop and implement outreach program/began with 319 grant	319 grant development of outreach	WRCAC	31-Oct-13	
			Continued public outreach as needed(WRCAC newsletters, meetings, workshops)	WRCAC	ongoing	
In-Lake Remediation Projects	Lake Elsinore	Support implementation of existing lake aeration system	Establish necessary agreements among aeration system participants	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-12	
	Canyon Lake	Conduct tests to evaluate potential for chronic aluminum toxicity with planned	Toxicity test results to support CEQA initial study	Agricultural and dairy operators in collaboration with stakeholders	15-March-13	

CDM Smith

Table E-1. AgNMP Implementation Plan

AgNMP Activity	AgNMP Element	Milestones	Metrics	Lead	Complete by	Status
		doses of alum				
		Complete CEQA process	CEQA initial study and approval of alum addition plan	Agricultural and dairy operators in collaboration with stakeholders	31-July-13	
		Implement process to obtain all permits and approvals	Secure permits and approvals to add alum from barge at surface	Agricultural and dairy operators in collaboration with stakeholders	30-September-13	
		Implement planned alum additions	Completion of planned alum additions to surface of Main Body and East Bay using barge	Agricultural and dairy operators in collaboration with stakeholders	September, 2013, February, 2014, September 2014, February, 2015, September, 2015	
		TMDL reopener for DO response target	Revision of response target that takes into account controllability considerations	Agricultural and dairy operators in collaboration with stakeholders	30-June-16	
		Support implementation of long-term in-lake nutrient management BMPs	If needed, establish additional watershed or in-lake BMPs to meet final response targets (e.g. regular alum additions, aeration, HOS, etc.)	Agricultural and dairy operators in collaboration with stakeholders	31-December-2020	
Monitoring Program	In-Lake Monitoring	Implement reduced monitoring program	Completion of annual monitoring as required by current approved monitoring program	Agricultural and dairy operators in collaboration with stakeholders	30-Jun-15	

Table E-1. AgNMP Implementation Plan

AgNMP Activity	AgNMP Element	Milestones	Metrics	Lead	Complete by	Status
		Prepare revised comprehensive monitoring program	Submit revised comprehensive monitoring program to the Regional Board for approval	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-14	
		Implement Regional Board-approved revised comprehensive monitoring program	Completion of annual monitoring as required by revised program	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-20	
	Watershed-based Monitoring	Continue implementation of Phase I watershed monitoring program	Completion of annual monitoring as required by current approved monitoring program	Agricultural and dairy operators in collaboration with stakeholders	30-Jun-15	
		Prepare revised comprehensive monitoring program	Submit revised comprehensive monitoring program to the Regional Board for approval	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-14	
		Implement Regional Board-approved revised comprehensive monitoring program	Completion of annual monitoring as required by revised program	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-20	
	Annual Reports	Complete annual reports to assess effectiveness of AgNMP	Submittal of annual reports to Regional Board by August 15	Agricultural and dairy operators in collaboration with stakeholders	November 30, annually	
	Interim Compliance Assessment	Demonstrate compliance with interim TMDL requirements	Submittal of assessment of compliance with interim TMDL requirements	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-15	

Table E-1. AgNMP Implementation Plan						
AgNMP Activity	**AgNMP Element**	**Milestones**	**Metrics**	**Lead**	**Complete by**	**Status**
	Final Compliance Assessment	Demonstrate compliance with WLAs	Submittal of assessment of expected compliance with final TMDL requirements including any recommended supplemental actions.	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-19	
Special Studies	Use of Chemical Additives	Evaluate potential to use chemical additives, e.g., alum, Zeolite or Phoslock, as an in-lake remediation strategy alternative	Complete studies, as appropriate, to evaluate potential for use of chemical additives	Agricultural and dairy operators in collaboration with stakeholders	30-Jun-13	
(Optional)	Land Use Updates	Update watershed agricultural land use based on 2010 data; WRCAC estimates updates every 3 years	Submit land use revision to the Regional Board	Agricultural & dairy operators	31-Dec-20	WRCAC has completed 2007, 2010 and plans on updates using 2013, 2016 and 2019 data
	TMDL Model Update	Revise/update TMDL models for Canyon Lake/ Lake Elsinore based on new data (e.g., land use, water quality)	Submit TMDL models to the Regional Board	Agricultural and dairy operators in collaboration with stakeholders	31-Dec-18	
Adaptive Impleme ntation	Task Force	Participate in Task Force process	Regular attendance at Task Force & Technical Advisory meetings	Agricultural and dairy operators in collaboration with stakeholders	Ongoing	

Table E-1. AgNMP Implementation Plan

AgNMP Activity	AgNMP Element	Milestones	Metrics	Lead	Complete by	Status
	AgNMP Revisions	Review progress towards achieving TMDL requirements based on compliance assessments; modify AgNMP as needed	Prepare compliance assessment; if needed, submit revised AgNMP to the Regional Board	Agricultural and dairy operators in collaboration with stakeholders	30-Nov-15	
		Review progress towards achieving final TMDL requirements based on compliance assessments; modify AgNMP as needed	Prepare compliance assessment; if needed, submit revised AgNMP to the Regional Board	Agricultural and dairy operators in collaboration with stakeholders	30-Nov-19	
	TMDL Revision	Based on degree of Regional Board support, prepare materials to support revision to the TMDL as part of the Triennial Review process, if revision is appropriate	Submit recommendations and supporting material for revisions to the TMDL to the Regional Board	Agricultural and dairy operators in collaboration with stakeholders	Prior to potential triennial review dates in 2015 and 2019	

ATTACHMENT F
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