



The Western Riverside County Agriculture Coalition

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

December 31, 2011

DRAFT

I. 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.

Equestrian-Related Water Quality Best Management Practices, a cooperative effort among private and public entities in Orange and San Diego counties, California, June 2004.

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 of Riverside County Flood Control District.

Bruce Scott
Chairman, Western Riverside County Agriculture Coalition
December 31, 2011

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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 |
| 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 Agricultural Nutrient Management Plan (AgNMP). There is no current permit for agricultural operators. Confined Animal Feeding Operations (CAFOs) are under permit. 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 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) list¹). This list is subject to EPA approval; the most recent EPA-approved 303(d) list for California is the 2010 list².

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.

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 Elsinoire | 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) | <p>Calculated concentrations to be attained no later than 2020</p> <p>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</p> $CMC = 0.411 / (1 + 10^{7.204 - pH}) + 58.4 / (1 + 10^{pH - 7.204})$ <p>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</p> $CCC = (0.0577 / (1 + 10^{7.688 - pH}) + 2.487 / (1 + 10^{pH - 7.688})) * \min(2.85, 1.45 * 10^{0.028(25 - T)})$ | <p>Calculated concentrations to be attained no later than 2020</p> <p>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</p> $CMC = 0.411 / (1 + 10^{7.204 - pH}) + 58.4 / (1 + 10^{pH - 7.204})$ <p>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</p> $CCC = (0.0577 / (1 + 10^{7.688 - pH}) + 2.487 / (1 + 10^{pH - 7.688})) * \min(2.85, 1.45 * 10^{0.028(25 - T)})$ |
| 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.

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 off-site.

1.4.1 Purpose and Requirements

The current CAFO permit (issued in September of 2007) includes TMDL requirements and we expect additional TMDL language to be included in the new permit in 2012. 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 should be noted that the agricultural community has embraced the requirements of the LE/CL TMDL and the implementation process without any actual permit being in place.
- To achieve compliance with TMDL WLAs as per the TMDL Implementation Plans, the LE/CL dairy and ag operators shall submit an AgNMP by December 31, 2011 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. 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. Detailed descriptions of any BMPs planned, 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. The Task Force is developing a Pollutant Trading Plan (PTP) separately from this AgNMP to provide a basis for pollutant trading. Additionally, 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.

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.
- *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 this reduced level of monitoring will continue through 2014 . Following 2014, monitoring will be increased to provide sufficient data to evaluate progress towards achieving the agricultural WLAs and to meet CWAD monitoring requirements. WRCAC will work to minimize overlap of sampling activities and develop a monitoring program that meets both the TMDL and CWAD program requirements. 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 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.
- *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. 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 occur. 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 January 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 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.

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

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

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- November 15, 2011

1.4.6 AgNMP Roadmap

The AgNMP is presented into 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 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.
 - **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.
 - **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, Equestrian-related Water Quality Best Management Practices, supporting document**
 - **Attachment I, Poultry Production Best Management Practices (BMPs)**
 - **Attachment J, References**
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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. The agricultural and dairy operators will achieve compliance with the agricultural WLAs 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 operators 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 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 TMDL WLAs.
- 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 over time.

2.2.1 Integrated strategy: TMDL & 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. Because individual operators can not 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 the implementation of BMPs will be proposed and implemented on an individualized basis. WRCAC proposes to use a new technology called Blue Water Satellite Imaging Technology for assisting in this identification process.

In keeping with WRCAC's holistic watershed-wide approach to this complex issue, The Ag NMP 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: Agricultural surveys, Blue Water Satellite Technology, monitoring, 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.
- 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. Example: low level tier one may be zero BMPs required; Tier 3 may need to implement 2 BMPs of their choice and a Tier 5 may need to implement 5 BMPs of their choice or 3 BMPs with approval. The specifics would need to be developed over the next few years.



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 the currently identified BMPs being utilized in the watershed, as well as, those listed in [Appendix XXX](#).

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. Additional information regarding the Blue Water Satellite imaging technology can be reviewed in [Appendix A](#).

Ag NMP 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 discussed includes irrigated and non-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 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 watershed have indicated that many growers already voluntarily incorporate many of the Guidance Practices into their normal crop production methods.

The next 4 sections are taken directly from the University of California's Final Report, *Assessment of Best Management Practices to Reduce Nutrient Loads in the San Jacinto Watershed*.

Section 8-Dairy Nutrient Management & Dry Land Crop BMPs

Section 9-Citrus BMPs

Section 10-Vegetable BMPs

Section 11-Turfgrasses BMPs

An aerial mapping agricultural land use map is provided to assist the reader in determining types of agriculture in the San Jacinto watershed.

VIII. Dairy Nutrient Management &

Dry-land Crops Grown in San Jacinto Watershed

Section 8. BMP Manual / Nutrient Management Plan

8.1 Dairy Nutrient Management

Milk is California's number one agricultural commodity. California's dairy farms produce milk of unsurpassed nutritional quality used to make award-winning cheese, ice cream, yogurt, butter and many other products for both local and international markets.

Best Management Practices (BMPs) have been determined to be an effective and practical means of reducing point and non-point source water pollutants to levels compatible with environmental quality goals. The primary purpose for implementation of BMPs is to conserve and protect soil, water and air resources.

8.1.1 Background

Dairies in the San Jacinto Hemet area have cropland adjacent to their operation for disposing dairy waste. Waste is used at agronomic rates and in a responsible manner. Problems arise with dairy waste from other areas of the state that is often applied to non-cropland far in excess of agronomic rates. A system has been proposed where manure applied to both crop and non-cropland would be recorded and reported. This system provides many advantages to the current system.

8.1.2 Dairy Manure Management

The following best management practices will help mitigate surface and ground water pollution from dairy manure:

8.1.2.1 California Dairy Quality Assurance Program:

All dairy producers should be encouraged to obtain a California Dairy Quality Assurance Program (CDQAP) certificate. CDQAP helps the state's dairy producers understand and meet federal, state, regional, and local requirements for manure management and water quality protection. It offers a voluntary certification program that assists producers to comply with water quality regulation.

To become certified, dairy producers must complete six hours of University of California Cooperative Extension courses that cover water regulations, facility evaluation, manure management, and storm water pollution prevention plans. After the class work, each dairy producer evaluates their specific farm conditions and develops a plan for environmental

compliance specific to his or her dairy, covering issues from proper drainage and plumbing to proper manure storage and emergency plans. Dairies completing the short-course series and farm management plan are eligible for independent third-party compliance evaluations to meet all local, state and federal environmental laws. An independent third-party evaluator checks the plan, and evaluates the operation to ensure that it is in compliance with federal, state and local environmental laws. If adjustments are needed, the producer can schedule repairs and a second evaluation. Dairies completing the evaluation become certified.

8.1.2.2 Manage corrals so they do not become sources of pollution:

Dairies with little cropland are often based on a dry-lot system of cow management. Dry-lots can accumulate large amounts of manure and can present a risk to ground and surface water if not managed properly. Recommended best management practices to prevent standing water and infiltration of water into the corrals include the following:

- Scraping and removing manure from corrals two or three times per year, including immediately before the rainy season.
- Grooming corrals by grading and adding soil before the rainy season to ensure adequate corral slope and facilitate drainage.

8.1.2.3 Develop off farm markets for solid manure:

Not owning adequate cropland for the use of all the manure nutrients generated on the dairy can increase the risk of ground and surface water contamination in the nutrients remain on the farm. Dairy producers can mitigate this risk by establishing reliable business relationships that allow the producer to use the manure on nearby crop land. Such agreements should include a written contract specifying how much manure can be applied to the land.

The dairy producers in this area have suggested a modification to the manifest system to help protect ground and surface water quality. Under that system a notice of intent (NOIs) is submitted by manure producers, haulers, and landowners seeking manure. All parties are required to “register” to participate in the system. This is similar to the current County NOI Ordinance process and is the point of entry for parties to participate in the manifest system. The following process is envisioned:

- Dairy producers will provide basic information about the business, including contact name and address, facility location, and manure product amount and condition.
- Manure haulers will provide basic information about the business, including contact name, address, business license number, number of trucks, etc.
- The owner of the property receiving manure submits information about the property, including contact information, ownership, available acreage, crop history (past and current), soil information, groundwater management zone, and other relevant information. If the land is occupied by a farm tenant, the landowner can authorize the farm tenant to submit notice of intent information on his or her behalf. This agreement must be documented as part of the NOI process.

The manifest staff will review all NOIs for accuracy and completion. Site visits will be scheduled with landowners planning to apply manure to gather additional site details. Staff will determine crop history, manure application history, planned land use, and neighboring land use to identify possible conflicts. Soil samples will be collected and analyzed. The site will be assessed to determine drainage and runoff impacts and identify appropriate setbacks. Records will be augmented with a GPS-based field map and digital photos. GIS information will be used to determine the watershed and groundwater management basin(s) that may be affected by manure application.

Where data gaps or inconsistencies exist in the NOI information, staff may request clarification from applicants to complete the review and approval process.

Staff will evaluate all available information and will either (1) approve the application outright, (2) approve the application with conditions, such as setbacks, land application limitations, or required BMPs, or (3) reject the application.

At a later stage, additional considerations may be added to the review process, including a more detailed assessment of impacts, analysis of mitigation options for a particular site, or analysis of the cost-benefit of alternatives to land application at a particular site.

8.1.2.4 Minimize liquid waste volume requiring off-farm disposal:

Manure water produced during normal dairy operations is generally disposed of on-site. Practices have been developed to reduce the risk that these nutrients can present. These recommended best management measures include:

- Water conservation: Water should be conserved and reused whenever possible. For example, water used to cool the milk should be collected and reused to wash the cows.
- Triple cropping on the small areas of available cropland: Growing a continuous rotation of warm and cool season grasses allows multiple applications of manure nutrients during the year. Triple cropping requires a high level of crop management.
- Manure water containment: No water that has come into contact with manure leaves the property as run off. It is collected and held in large ponds until it can be applied to the wastewater management land.
- Timely removal of buildup of manure solids in ponds to maximize lagoon storage capacity. Even with settling basins and screens, fine solids will accumulate in storage lagoons. This material must be checked and removed by dredging or excavation.

8.1.2.5 Assess dairy farm nutrient balance and manure recordkeeping system:

Modern dairy management systems are information intensive and require relatively sophisticated data collection and analysis systems. These recordkeeping and analysis procedures must be expanded to cover the manure generation and recycling components of the dairy. Dairy producers should conduct a whole farm nutrient assessment in which nutrient inputs in the form of feed etc are compared to nutrient exports in milk and any transfer of manure off-farm. This assessment should include the following items:

- Calculations of average daily volume of manure and wastewater generated (liquids and solids), including storm water runoff contacting areas that may contain animal waste that would: a) be generated during a 25-year, 24-hour storm event, and b) be likely to accumulate in the wettest winter that may occur in a 25-year period. (Information on the 25-year, 24-hour storm event and the wettest winter in a 25-year period in your facility's vicinity should be available from the National Weather Service or from local flood control agencies.)
- A description of confined areas that are scraped or flushed (including corrals and areas covered by roofs), the scraping/flushing frequency, and the average daily volumes of solid and liquid wastes generated in each area.
- Calculation of existing and required storage capacity. An evaluation of collection system including the use of any sumps, pumps, scraping pits, settling ponds, solids separators, wastewater recycling facilities, waste ponds or other waste containment areas or facilities. Capacity shall be defined in terms of both volume and animal capacity. Indicate whether pumps are activated manually or automatically.
- An agronomic analysis and nutrient budget shall be developed for each pasture/crop where solid or liquid wastes are applied. Discharges to land of solid or liquid waste shall be at rates that are reasonable for crop, soil, climate, special local situations, management system and type of manure. The total nutrient loading shall not exceed the amount needed to meet crop demand or 20 tons per acre whichever is less.
- The frequencies that waste containment areas or structures are cleaned out and the responsible party for work.
- A description and analysis, including application rates, of all wastewater disposal methods (i.e., spray irrigation, wastewater recycling, etc.)
- A description and analysis, including application rates, of all solid waste disposal methods (i.e., composting, land spreading, etc.).
- A description of management measures utilized to prevent off-site waste migration from disposal areas. Discharges to land of solid and liquid waste shall be conducted in such areas that prevent the discharge of waste to surface waters or flood-prone areas and shall be managed to minimize percolation to ground water.
- If any wastes are disposed off-site, indicate the volume disposed, disposal frequency, the disposal site, and the name of the contractor hauling the wastes.

8.2 Dry-Land Agriculture Nutrient Management

The main water quality goal when applying manure to dry-land crops is to limit the movement of nutrients and pathogens from manure into surface water to protect aquatic organisms, habitat, and recreational waters. The specific measures taken by a producer to protect water quality will vary with topography, climate and surrounding land use and availability.

8.2.1 Apply nutrients to crops at agronomic cropping rates:

A principle cause of over-application of manure to crops is the variability in the nutrient value of manure. Knowledge of manure nutrient content allows producers to reduce use of commercial fertilizers without risking crop yields. The following BMP will help in this process:

- Since manure nutrient content is highly variable and “book values’ are unreliable, producers should frequently sample and analyze manure for nutrient content.
- Obtain nutrient analysis (NPK) of biosolids
- Apply based on percent P concentration because applying based on percent N concentration will result in over applying P
- Prevent contaminated runoff by not applying manure during precipitation or when precipitation is imminent
- Apply based on percent dry matter of biosolids
- Recorded keeping must be in place to ensure and document that wherever manure is used, it is applied at appropriate rates and times and in a manner that does not pollute water or create a nuisance.
- Soil and plant analysis should be used as a tool to back up manure nutrient application decisions and to evaluate the manure application program at the end of each season.
- On land where soil erosion is not a major concern, surface and ground water is often protected by incorporating the manure into the ground.
- It was necessary to water our buffer strips to keep them growing and hardy. Since this is dry-land agriculture, a source of water to provide this insurance will in most cases not be available.
- Apply manure on fields that are not highly erodible.
- Apply manure early in the morning until early afternoon.
- Apply manure on days with low humidity and little or no wind.
- Splitting applications of N between preplanting and early spring is a BMP that often results in greater N use efficiency and reduced economic, environmental, and agronomic risks.
- Prevent contaminated runoff by not applying manure to land which is saturated or contains ponded water
- Prevent contaminated runoff by not applying manure near a creek, river or fields adjacent to them.
- Determine the necessary application rate and properly calibrate your equipment.
- Practice Conservation Tillage or No-Till in the cropping system.

8.2.2 BMP information from the project

- Our field research showed that manure spread had the least amount of rainfall runoff of any of the treatments, but the concentration of the nutrients in the runoff from this treatment was higher than for other treatments.
- 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.

8.2.3 Additional BMPs and Information:

University of Nebraska Extension – Lincoln: <http://www.extension.org/faq/27558>

Illinois: <http://www.epa.state.il.us/p2/fact-sheets/dairy-production-bmp.pdf>

Colorado State: <http://www.cdphe.state.co.us/ap/rmnp/agbmps.pdf>

J. Environ. Quality paper: <http://jeq.scijournals.org/cgi/content/full/35/4/1088>

Louisiana Department of Environmental Quality:
<http://www.lsuagcenter.com/NR/rdonlyres/oE64A9BF-BA23-449E-8636-8D897111357/3112/pub2823dairy6.pdf>

Ohio State Univ. Ext.: <http://ohioline.osu.edu/agf-fact/0207.html>

IX. Best Management Practices

Citrus Production in the San Jacinto Watershed

9.0 Nutrient Management for Citrus Production in the San Jacinto Watershed

9.1 Introduction

Citrus production in the San Jacinto watershed is mainly situated in the western foothills of the San Jacinto Mountains in Valle Vista. Approximately 2500 acres of citrus are grown in this area, representing 20% of Riverside County's citrus acreage. Due to the close proximity of this acreage to the San Jacinto River, citrus growers should be aware of the potential pollution of surface water and groundwater as a result of certain management practices, specifically management of nutrients. Nutrient loading of the San Jacinto River, during significant storm events, could further impact Canyon Lake and Lake Elsinore at the bottom of the watershed. Currently, both of these lakes frequently exceed nitrogen and phosphorus concentrations.

When nutrients exceed the required limits for the concentrations, the Santa Ana Regional Water Quality Control Board has developed a nutrient Total Maximum Daily Loads (TMDLs) for both lakes. Implementation of a TMDL requires all sources of the pollution to be identified and assigned a maximum allowable amount that source may discharge daily, seasonally, or annually. Agricultural in the watershed, including citrus production, are a potential source of nutrients to Canyon Lake and Lake Elsinore and therefore growers are required to implement Best Management Practices (BMPs) to mitigate nutrient pollution from their orchards. In order to address nutrient losses, a grower must complete an assessment of their orchards by identifying locations where surface runoff is discharged from both irrigation and storm events. Once these locations are identified, then the grower can select the appropriate mitigation measure based on its effectiveness at reducing nutrient losses and its cost to implement and maintain.

This chapter was created by the University of California Cooperative Extension and the University of California Riverside to assist citrus growers in selecting and implementing management measures effective at reducing nutrient losses both in surface water and groundwater. Although the effectiveness of many BMPs have been tested on various agricultural cropping systems, unique field conditions and production practices may impact just how well these BMPs actually reduce nutrient losses. In order to address the uniqueness of citrus production, soils, topography and climate in the San Jacinto watershed, UC Riverside, in cooperation with a citrus grower in Valle Vista, has tested the effectiveness of several BMPs, including the use of cover crops, mulch, and soil flocculants to control erosion. The results of these tests are included wherever possible to help assist growers with the selection of BMPs.

9.2 Orchard Water Quality Assessment

In order to conduct a thorough water quality assessment of an orchard or your overall property it is useful to utilize an existing map or one created specifically to note important features contributing to or possibly contributing to nutrient losses. Depending on the needs and resources of the grower, the map may be created by a professional utilizing GPS, aerial photographs and other advanced surveying technology or could be created easily using aerial maps from Google Earth®. Figure 1 is an example of a citrus orchard map created with Google Earth®.

Figure 9-1. Example of an orchard map created using Google Earth®.



The map should include the following features:

- Natural and man-made water features on and adjacent to the orchard such as rivers, streams, holding ponds, and wetlands.
- Discharge points where runoff leaves the orchard noting differences in flow patterns due to irrigation and storm events.
- Location of key structures such as wells, fertilizer storage facilities, sand filtration, and fertilizer injector and storage tanks.
- Location of roads and other non-vegetated areas of the orchard.
- Identify areas of concern, such as significant erosion, poor infiltration due to compaction, excessive irrigation runoff. Prioritize each of these concerns as grower resources may be limited and efforts should focus on areas where the most significant improvements can be made to reduce nutrient losses.

A second key component of a water quality assessment requires the grower to collect and analyze surface runoff from all discharge points identified on their orchard map. If runoff is regularly present, sampling should be frequent enough to determine if nutrient levels fluctuate or remain relatively stable. Samples should be analyzed for at least the following parameters: pH, salinity, nitrate, and phosphate. Although field kits are available for testing the constituents of concern, a professional EPA –approved laboratory provides the grower with results that can be utilized to protect them against scrutiny by environmental groups and water quality regulatory agencies.

9.3 Citrus Orchard Fertilization

Applying fertilizers, whether in a synthetic or organic form, results in a significant increase of nutrient concentrations in soils, most notably nitrogen and phosphorus. The goal of any fertilization program is to provide optimum nutrient levels throughout the year, resulting in the highest possible fruit quality and yield. Although the University of California does not provide specific fertilizer recommendations for citrus, researchers have determined optimum nutrient levels in leaf tissue for a variety of citrus species as well as detailed guidelines on fertilizer timing, application techniques, and selection of optimum nitrogen sources. Specific fertilizer application rates may be obtained from other research institutions, but it should be noted that these rates were developed for production in climates and soil types different than those found in the San Jacinto watershed.

In general, citrus orchards receive between 1 to 2 pounds of nitrogen per tree per year, 1 pound of P per acre, and 1 pound of K per acre. Micronutrient foliar sprays (zinc sulfate and manganese sulfate) are also common during summer and fall flushes at an annual rate of 5 pounds per acre for each micronutrient. However, actual fertilization rates should be determined from leaf tissue analyses performed in the fall (generally done in September or October) on 5- to 7-month old spring flush leaves from nonbearing and nonflushing terminal shoots (Embleton, et al.,1978). Table 1 provides a leaf analysis applicable to most citrus cultivars, except nitrogen in grapefruit and lemons (adapted by CJ Lovatt from Embleton, et al., 1978). Fertilizer applied should “replace” that utilized to produce the current year’s crop. Growers should also take into account alternate bearing citrus cultivars, such as ‘Valencia’, and adjust annual fertilization rates accordingly. Excess fertilization in “off” years wastes

fertilizer and potentially increases the chances for groundwater and surface runoff nitrate pollution.

Table 9-1. Leaf Analysis Guide to Nutrient Status of Most Mature Citrus Cultivars

| Element | Unit | Range ¹ | | | | |
|-----------------|------|--------------------|--------------|--------------|--------------|----------|
| | | Deficient | Low | Optimum | High | Excess |
| N | % | <2.2 | 2.2 to 2.3 | 2.4 to 2.6 | 2.7 to 2.8 | >2.8 |
| P | % | <0.09 | 0.09 to 0.11 | 0.12 to 0.16 | 0.17 to 0.29 | >0.30 |
| K | % | <0.40 | 0.40 to 0.69 | 0.70 to 1.09 | 1.10 to 2.00 | >2.30(?) |
| Ca | % | <1.6(?) | 1.6 to 2.9 | 3.0 to 5.5 | 5.6 to 6.9 | >7.0(?) |
| Mg | % | <0.16 | 0.16 to 0.25 | 0.26 to 0.6 | 0.7 to 1.1 | >1.2 (?) |
| S | % | <0.14 | 0.14 to 0.19 | 0.20 to 0.30 | 0.4 to 0.5 | >0.6 |
| B | ppm | <21 | 21 to 30 | 31 to 100 | 101 to 260 | >260 |
| Fe ² | ppm | <36 | 36 to 59 | 60 to 120 | 130 to 200 | >250(?) |
| Mn ² | ppm | <16 | 16 to 24 | 25 to 200 | 300 to 500 | >1000(?) |
| Zn ² | ppm | <16 | 16 to 24 | 25 to 100 | 110 to 200 | >300 |
| Cu ² | ppm | <3.6 | 3.6 to 4.9 | 5 to 16 | 17 to 22 | >22(?) |
| Mo ³ | ppm | <0.06 | 0.06 to 0.09 | 0.10 to 3.0 | 4.0 to 100 | >100(?) |
| Cl | % | ? | ? | <0.30 | 0.40 to 0.60 | >0.70 |
| Na | % | ? | ? | <0.16 | 0.17 to 0.24 | >0.25 |

¹Ranges are applicable specifically to mature 'Valencia' and navel orange trees, and with the exception of nitrogen values, applicable to grapefruit, lemon, and most likely other commercial citrus cultivars.

²Values not applicable for leaves sprayed or dusted with the particular element in question.

³From fruiting shoots.

Nitrogen applications should be spread out over multiple applications, focusing on supplying nitrogen at critical growth stages, rather than applied at one time. If they have not already done so, growers should eliminate winter fertilizer applications to the soil as the opportunity for nutrient loss is highest at this time. If possible, growers should also select nitrogen sources

such as urea and other slow-release fertilizers, as they are less likely to leach below the root zone, compared to more soluble fertilizers such as ammonium nitrate and ammonium sulfate. Manures are an excellent source of nitrogen, but growers should monitor salt levels closely to avoid plant injury as manures may be significant sources of salts. Care should be taken to avoid excessive leaching as salts can be leached directly into water conveyances or into groundwater.

Citrus growers can reduce nitrate groundwater and runoff pollution and increase profits by using foliar urea fertilization. Lovatt (1995 and 1999) reported that a foliar application of nitrogen could supply a portion of the N to be applied in a given year and thus reduce the amount N application to the soil. The results also demonstrated that a late spring application of low-biuret urea to the foliage is a cost-effective method to fertilize navel oranges. The increase in yield of larger-sized fruits observed in Lovatt's study for the late May foliar application of low-biuret urea resulted in a net increase in return revenue to the grower each year. Since the grower will likely fertilize with N at some point during the year, foliar application of urea in late spring would seem to afford many benefits over soil-applied N.

Proper fertilization of orchards is perhaps the single most effective nutrient management strategy a grower can implement. Nutrient losses are significantly reduced when fertilizers are applied at a rate where most, if not all of the nitrogen, is utilized by the orchard for vegetative and fruit growth and development. Proper irrigation, discussed later in this chapter, also plays a key role in whether or not nutrients remain in the orchard where they were applied. In addition, BMPs implemented to control erosion and sedimentation can play a significant role in nutrient management by producing nitrogen in the case of nitrogen-fixing cover crops or ensuring elements attached to soil particles, such as phosphorus, remain in the field.

Nutrient management should focus on the following key practices:

1. Leaf analyses should be performed in the fall to determine deficiencies and excess levels of nutrients.
2. Winter fertilizer applications to the soil should be eliminated. Foliar applications are a viable alternative to improve yields without the possible water quality impact.
3. Fertilizer applications should be spread out over several months targeting key growth periods to avoid losses to groundwater or surface runoff.

9.4 Irrigation Impacts on Nutrient Movement

The majority of orchard growers in southern California have abandoned furrow irrigation and replaced it with the practice of micro-irrigation. Citrus growers should be utilizing microsprinklers placed underneath the canopy of each tree to improve irrigation efficiency. This practice not only improves irrigation efficiency, reducing water and labor costs, but if managed properly can protect against runoff and groundwater pollution. In addition, this irrigation practice also allows for orchard fertilization through fertigation; improving the delivery of nutrients to each tree and reducing losses into groundwater and in surface runoff.

Poor management of an irrigation system, including microirrigation systems, can result in significant runoff that carries both soluble nutrients, especially nitrates, into nearby storm drains and eventually local creeks or rivers. UC has conducted considerable research on the

proper scheduling of the irrigation of various crops. The implementation and maintenance of micro-irrigation systems is thoroughly covered in the UC Agriculture and Natural Resources publication titled 'Micro-irrigation of Trees and Vines'. Further information on using micro-irrigation for fertigation can be found in UC ANR publication 'Fertigation with Microirrigation'.

Managing irrigation in citrus orchards with the goal of reducing nutrient losses and protecting water quality should address the following:

1. Minimize surface runoff by scheduling irrigation utilizing historical evapotranspiration estimates or calculating real-time evapotranspiration values for your area. Alterations in duration and frequency of irrigation can significantly reduce runoff. Be aware that orchards planted with cover crops will utilize more water than those with bare soils. Information on how to utilize ET can be found in ANR Publication 8212, a free PDF download at <http://anrcatalog.ucdavis.edu/>.
2. Keep irrigation systems maintained to avoid leaks or breaks in source lines and sprinkler heads, especially if system is used to fertigate. Fertilizer storage tanks should also be located as far away from water conveyances as possible and also placed in a secondary containment structure to protect against leaks and spills.
3. Avoid soil compaction as much as possible to maintain an infiltration rate that matches or exceeds the output rate of the irrigation system in use. Information on how to calculate irrigation system application rates, including microirrigation systems, can be found in ANR Publication 8212, a free PDF download at <http://anrcatalog.ucdavis.edu/>.
4. Use cover crops to slow runoff and maintain soil permeability. Planting cover crops with a legume will also provide nitrogen to the soil. Be aware that orchards planted with cover crops will utilize more water, as much as 30% more, than those with bare soils (Schwankl, et al., 2007).

9.5 Erosion Impacts on Nutrient Movement

Controlling erosion in an orchard is imperative to reducing the movement of nutrients and other chemicals associated with soil particles into water conveyances. The most common nutrient associated with soil particles is phosphorus, although soluble forms may also contaminate waterways when used improperly. Fortunately, a multitude of practices are available to the grower to mitigate erosion and sedimentation. UC ANR has produced an excellent publication on managing orchard floors to reduce erosion. The practices discussed in this section are included in greater detail in the publication and have been shown to be effective in reducing erosion by improving the soil's physical properties to increase infiltration, modify runoff flow patterns in the orchard, protect the soil surface from water droplet impact, and enhance aggregate stability (O'Geen, et al., 2006). The entire publication (UC ANR Publication 8202) can be downloaded as a free PDF at <http://anrcatalog.ucdavis.edu/>.

Improving aggregate stability requires the soil to contain a sufficient level of organic matter to bind individual soil particles into aggregates. This is accomplished by the application of

decomposing plant materials such as green waste compost or animal manures. The use of any compost or manure should be preceded by a thorough checking of the source to ensure the material has been properly composted and does not contain high salt levels requiring excessive irrigation to leach the salts below the root zone of the trees. Once again the use of cover crops to slow runoff in the orchard is also a source of organic matter. Information on the selection of an appropriate cover crop and management of that crop can be found at the UC SAREP Online Cover Crops Database (<http://www.sarep.ucdavis.edu/cgi-bin/ccrop.exe>). The database is useful in determining the cover crop best adapted to the orchard where it will be grown by providing information on time of year to sow and seeding rates, annual or perennial crops, and time of year to incorporate as well as other key characteristics.

The addition of a thick layer of mulch protects soil structure by reducing both soil compaction by farm equipment and the impact of water droplets on the surface of the soil. Soil exposed to the impact of water droplets builds up a crusty layer of fine soil particles reducing the soil's infiltration rate and increasing the chance for erosion to occur, especially during rain events. Mulching offers additional benefits such as weed suppression and reduced evaporation rates compared to bare soil.

Although simple tillage of the soil is another option that offers some reduction in erosion, soil structure can easily be damaged by frequent tillage, especially if the organic matter content of the soil is low. As an alternative, synthetic anionic polymers (PAM) can be applied to the soil to flocculate soil particles reducing erosion and downstream sedimentation. Polyacrylamide (PAM) has received a rapid acceptance in recent years as a soil water conservation technology in irrigated agriculture. Application of PAMs to irrigation water or soil has proved effective and economical in stabilizing soil structure, increasing water infiltration, reducing soil erosion, and improving runoff water quality. Various formulations of PAM are available, each with advantages and disadvantages. Granular formulations are easily applied with mechanical spreaders prior to rain events and depending on storm intensity, generally provide a good level of erosion and sediment control. Tablet formulations are also available for use in irrigation furrows or drainage ditches where flow is more concentrated and the tablets can be suspended in porous bag, such as an onion sack. Liquid formulations may be used by injecting them into the irrigation system, but due to the viscosity of the concentrate, it can be difficult for growers to handle.

Regardless of the erosion practices put in place in the orchard, a certain level of erosion and sedimentation will occur near property discharge points. These locations will require the installation of additional management practices to protect adjacent waterways. The most common management practice employed is to hold back surface runoff utilizing sandbags. Although effective at reducing runoff if installed properly, they have the disadvantage of water ponding on-site and breaking down in ultraviolet light over a short time period. Water ponding is not an issue if it occurs occasionally and for a short period of time, but where it results in significant flooding and tree roots are submerged frequently or for extended periods, root diseases will become a problem. An alternative to sandbags is to install straw or coir wattles, gravel bags, or geotextile fabrics/mats which filter sediments, but still allow for runoff to flow through and exit into waterways. Growers should also be aware that these practices are only effective if they are regularly maintained, especially following rain events. If runoff contains nitrate at unacceptable levels (>10 mg N/L), growers need to review their fertilizer practices and determine what additional practices can be implemented to reduce

nutrient losses. Vegetative buffers or swales offer an additional line of defense against the movement of sediment off-site as well as depending on the vegetation selected may also absorb excess nutrients. Assistance in the design and construction of vegetative buffers or swales as well as other erosion and sediment control measures can be found in a technical handbook available from the Riverside-Corona Resource Conservation District. The handbook, 'Best Management Practices Handbook for Erosion and Sediment Control and Stormwater Retention/Detention', contains detailed drawings and instructions on how to install proven soil conservation practices. UC ANR Publication 8195 also provides specific details on vegetative filter nutrient removal efficiencies based on plant species, design, and construction parameters. An important consideration in utilizing vegetation for a buffer or filter is the water requirements to establish and maintain the vegetation during dry periods.

9.6 BMP information from the project

- The average runoff NO₃ 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.
- NH₄ was slightly higher from PAM and Mulch treatment than the Control, but their difference was not significant.
- It is clear that all three of the BMP treatments (mulch, cover crop, and PAM application) are effective in reducing the total nitrate loss from the plots, although the total amount of runoff from the citrus field (lb/Ac) was very small.

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X. Best Management Practices

Vegetables Grown in San Jacinto Watershed

10.0 Nutrient Management for Vegetable Production in San Jacinto Watershed

10.1 Introduction

This best management practice section on vegetables will focus on those practices that will reduce surface and ground water contamination by fertilizer and natural nutrient sources derived from vegetables uses/settings. Proper management can reduce or eliminate surface and ground water contamination. While much of the content in this chapter is common sense, as much as possible is gleaned from scientific research done in California for practical application by growers. The references at the end of this chapter contain further information on best management practices beyond the preservation of water quality – the focus of this chapter.

10.2 Principal Vegetable Crops Grown In the San Jacinto Watershed

It is difficult to identify specifically which vegetable crops are actually grown in the watershed because the Riverside County Agricultural Commissioner only keeps statistics for the entire county. The San Jacinto Watershed is a portion of western Riverside County, but the county statistics would also include vegetable crops grown in the Coachella Valley and in the Blythe region (Colorado River Basin of eastern Riverside County). See Appendix A for crops grown in Riverside County.

We do know that potatoes are the predominant vegetable crop grown in the San Jacinto watershed, but the acreage varies from year to year dependent upon the market for the crop. Other major vegetable crops are: Chinese vegetables, pumpkins, melons, tomatoes and peppers. There are no canning factories or major processing facilities for vegetable(s) in the watershed, so the market is predominantly “fresh market”, with acreage decreasing significantly as the farmland is changed to urban use

10.3 Nutrient Management

10.3.1 Nitrogen Requirements/Efficient Nutrient Application

The nutrient generally required in greatest quantity for plant growth is nitrogen. Thus nitrogen is generally applied in the greatest quantity and often is the major concern for runoff prevention. In the past, nitrogen and other nutrients were applied based upon a fixed plan of applying a certain amount at a certain time. It was known that soil, rainfall, yield goals, and many other factors could affect how much fertilizer was actually needed, so to be safe farmers generally applied more than needed. Because fertilizer costs were low and there was no concern for the fate of nitrogen and other nutrients in the environment, farmers generally accepted over-application of fertilizer.

We now realize that fertilizer is neither cheap nor without environmental consequences. We cannot afford to automatically over-apply fertilizer in either economic or environmental terms. Crop fertility must be based upon providing the plant with the amount needed at the right time. This requires monitoring both the soil and the crop.

Efficient nutrient application can both reduce runoff into surface waters and increase farmer profits. Timing fertilizer application to match crop nutrient demand generally results in the best yield and the least runoff. To do so, we must remember that plant nutrient demand varies throughout the growing season. When plants first emerge, they are largely drawing from seed or seed piece reserves, and slowly begin to send out roots to scavenge for nutrients in the soil. By watching crops grow in the field you have probably noticed that the slow rate of initial growth is followed by a rapid increase in size, that then generally plateaus as the canopy forms. Nutrient demand remains low during the initial establishment phase, and then generally parallels the rate of plant growth, with a great increase in demand as the crop matures.

Thus, applying all of the fertilizer in one early application is inefficient and may lead to runoff of nitrates and other nutrients. A flush of nitrogen released into the soil when plants are small is likely to

be wasted, and may runoff the field and into surface waters. BMPs for fertilizer management require multiple applications of fertilizer. This can be accomplished in several ways. You can apply a part of the fertilizer at planting, and come back and side dress ~~more~~ later in the season. The purpose is to closely match the crop's nutrient demand, as more nitrogen is available when the crop most needs nitrogen. Other options are ground applications of slow release fertilizer, or gradually adding fertilizer throughout the season in the irrigation water, i.e. fertigation.

The method you use depends on the crop and your specific situation. Drip irrigation is more expensive to install and maintain, but melons and other cucurbits respond well to drip and generally yield better. Potatoes are generally grown under sprinklers, with some nitrogen pre-plant incorporated and some applied later through the water. Most of the leafy vegetables can be irrigated by furrow, drip, or sprinkler. The best management practice is to use drip and fertigation when possible, and use frequent soil and plant testing to help determine the amount of fertilizer applied as the season progresses.

Farmers can minimize leaching by minimizing the amount of nitrogen applied preplant, and apply the majority of nitrogen during the crop's rapid growth phase. Table 1 (see page 8 of this presentation) provides approximate weekly guidelines for nitrogen for many vegetable crops. Frequent soil and plant monitoring will allow you to fine-tune the guidelines to the actual requirements of each crop. Remember that plants cannot take up all forms of nitrogen, so both soil and plant tissue tests determine the amount of $\text{NO}_3\text{-N}$, the nitrogen form that plants typically use.

10.3.2 Plant and Soil Analysis

Laboratory analysis of plant and soil samples can be very beneficial but can be costly and the delay in receiving results may be too great to make timely fertilizer application adjustments. For example, pre-season soil samples may indicate how much nitrogen to apply at or before planting, but nitrogen is dynamic and the concentration in the soil changes as the season progresses. As a general rule, soil $\text{NO}_3\text{-N}$ concentrations of 20 ppm or greater in the upper foot of soil is sufficient, but that number can change as the crop takes up the nitrogen or nitrogen is lost to the environment. Re-testing the soil every two weeks will verify the amount of $\text{NO}_3\text{-N}$ available for plant uptake and allow more precise fertilizer applications timed to meet the requirements of the growing crop. Monitoring methods have evolved to make in-season assessments practical for even small farmers, which reduces environmental pollution and saves money regardless of farm size.

Soil testing can estimate how fertilizers and other factors change the soil's $\text{NO}_3\text{-N}$ concentration. Sampling the soil with a probe is recommended as it is inexpensive and collects a more accurate sample than a shovel. Avoid taking samples from the furrow bottom or the zone where fertilizer was banded. In furrow-irrigated crops, discard the dry upper few inches of soil; for drip, only sample from the zone wetted by the emitters. Take at least 12 samples from each sampling area; for fields with zones of differing soil types, sample each zone separately. Combine all twelve samples for each zone into one composite sample prior to sending off for analysis. If the delay to receive results is impractical (more than a day or two during the growing season), consider using a "quick test" (Hartz 2007a). The quick test is fairly simple and uses materials that anyone can obtain. Once you have your materials and have learned the technique, the quick test is easy and economical to use to obtain rapid results. The procedure is described in Hartz 2007a and is available as Appendix 1 in this presentation. The results of soil $\text{NO}_3\text{-N}$ analysis are usually reported in PPM, and can be converted to lb $\text{NO}_3\text{-N}/\text{acre}$ using this formula:

$$\text{___ PPM } \text{NO}_3\text{-N} \times \text{___ depth of sample (inches) depth} \times 0.33 = \text{___ lb } \text{NO}_3\text{-N}/\text{acre}$$

Plant tissue testing determines the crop's current nitrogen status. Low plant tissue values when soil $\text{NO}_3\text{-N}$ is high could indicate a lag in nitrogen uptake due to cold weather or root damage. High plant tissue values and low soil nitrogen may result when earlier soil nitrogen had been sufficient but has since been exhausted by the crop or by leaching, and needs to be replenished with fertilizer application.

Plant total N and NO₃-N concentration can be sampled by taking whole leaf or leaf petiole (the stalk of the leaf) samples. Vegetable growers rely much more on petiole or midrib NO₃-N concentrations than total N. Petiole NO₃-N concentrations fluctuate rapidly and are best used as a measure of current conditions. Whole leaf samples for total N are recommended for giving a better overall, long-term view.

10.3.3 Phosphorus and Potassium Requirements

Phosphorous (P) and potassium (K) are the other two elements most likely to be required by San Jacinto watershed vegetable growers. Phosphorous is not very mobile in the soil, and the crop's entire requirement can usually be satisfied with one pre-season application. Crop potassium needs vary widely depending on which crop is grown. Excessive potassium can have negative effects, e.g. reduced specific gravity of potatoes, so monitor before applying, as our soils often have sufficient potassium. Calcium and magnesium are two other macronutrients often in short supply in areas outside of California, but nearly all our soils are sufficient. Years of micronutrient applications to vegetable fields mean that we rarely see micronutrient deficiencies, and when they appear, the problem is often corrected by adjusting soil pH or flushing the soil of salts. Extensive tables of sufficiency levels and conversion factors can be found in Hartz 2007b, also available online at: <http://vric.ucdavis.edu/>.

10.4.4 Potato Irrigation and Nutrient Management

There is detailed information on irrigation, nutrient management, and cultural practices for most of the major California vegetable crops from the University of California Vegetable Research and Information Center at: <http://vric.ucdavis.edu/>. However, the major vegetable crop of the watershed, potato, is not included. The unique growth habits of potatoes require special cultural practices that directly affect nutrient and water management. Potatoes in the San Jacinto watershed are sprinkler irrigated. Some of the micronutrients can be applied through the sprinkler system, but applying large amounts of nitrogen risks burning the crop's leaves. Side dressing is possible before tuber initiation, but not later as root damage may occur.

Applying approximately 300 lbs N/acre is a reasonable estimate for good yields of Russet Burbank potatoes (Stark and Westermann 2003). When calculating how much to apply, remember that most soils, and often irrigation water as well, supply significant amounts of nitrogen. For example, organic residue from cover crops or the previous crop is broken down into NO₃-N through a process called mineralization. Stark and Westermann 2003 estimate that for most Idaho soils a reasonable estimate of how much NO₃-N is supplied by mineralization is 60-80 lbs/acre.

There has not been a thorough study of mineralization in the San Jacinto watershed. As with all other crops, pre-plant fertilizer applications should be based on soil samples and crop nutrient needs should be frequently revised based upon in-season soil and plant analyses. Knowing how crop residue and other factors effect nutrient needs is a useful guide to anticipate future needs. Stark and Westermann (2003) adjust their recommendation of 300 lbs N/A based upon crop residues and other factors. If the previous crop was grain straw or corn, their residues will tie up additional nitrogen during mineralization, and an additional 15-60 lbs N/A should be applied. No increase of N is needed if vegetables were the previous crop, and over-fertilization as often happens in vegetable production may even mean more available N than anticipated. If the prior crop was alfalfa, Stark and Westermann (2003) reduce application requirements by 60-80 lbs N/A. The amount of N supplied in irrigation water or added compost or manure can also reduce the amount of fertilizer applied.

Preplant nitrogen applications should be based upon soil test results, and preplant applications based on 20 ppm NO₃-N or greater in the upper foot of soil as sufficient. Apply less than half of the crop's total nitrogen requirement pre-plant, with the bulk of applied N supplied by side-dressing or several small applications in the irrigation water. Soil texture determines the potential for N leaching, and the proportion of N applied pre-plant adjusted accordingly. For sandy soils, apply only 25-30 percent of the

anticipated required total N pre-plant, 30-40 percent for sandy loams, while up to half can be applied pre-plant on clay soils. For best results in terms of nitrogen efficiency and runoff prevention, apply nitrogen and other nutrients based upon leaf tissue and soil test results, and when possible, apply them in several applications rather than in one or two large flushes.

After planting, wait until tuber initiation begins before applying more nitrogen. Leaf sampling should begin at tuber initiation and be used to determine how much fertilizer to apply. A reasonable estimate is that plant uptake of soil N is about 75 percent efficient, meaning that if you apply 4 lbs of N/acre/day, the plant will take up about 3 lbs N/acre/day, which is about what is needed for Russet Burbank potatoes during the bulking phase (Stark and Westermann 2003).

The other element commonly applied to potato fields is phosphorus, P. Phosphorus moves slowly in soil and should be incorporated for crop uptake. The slow soil movement means that phosphorus is unlikely to leach, but can be lost in runoff when soil is eroded. Preplant P can be broadcast, but we recommend banded applications. Banding concentrates P in a narrow zone near the seed piece, making it easier for young plants to take it up and decreasing potential runoff. More P can be applied later through the irrigation water based upon leaf petiole tests. It is important that petiole sampling be done in a consistent manner by taking the fourth leaf from the top of the plant from at least 50 plants. All leaflets should be stripped from the petiole immediately and the petiole placed in a clean bag or container. The petiole should be either immediately dried or kept cool depending on whether the lab accepts dry or live tissue. Phosphorus petiole concentrations of 0.22 ppm indicate sufficient P.

Potassium is the other major nutrient that may be insufficient. Soil test K of 175 ppm and a leaf petiole K of 7-7.5 percent are considered adequate (Stark and Westermann 2003). Potassium is the one nutrient where applying all of the nutrient pre-plant is recommended, as potato yields respond better than if the applications are split. As with the other major vegetables, potatoes in the San Jacinto watershed generally have sufficient levels of sulfur, calcium, magnesium, and the other essential nutrients.

10.4.5 Cover Crops

Cover crops (or green manures) are planted before the cash crop and plowed under to enrich the soil and control pests. Green manures can be legumes, non-legumes, or a mix of both. Legumes are often planted to provide slow-release nitrogen to the cash crop, but any cover crop can take up soil nitrogen for release when the residue is broken down. As growers commonly apply more nitrogen and other nutrients than a crop can absorb during a growing season, cover crops can act as sponges to prevent nitrogen and other nutrients from leaving the field and entering surface waters. Cover crops can help farmers by enriching the soil and decreasing fertilizer and pesticide costs, and help meet water quality goals by trapping nutrients and decreasing agrichemical applications. The University of Idaho reports an increase in net returns for potato rotations that include cover crops (Stark and Westermann 2003), although profitability always depends upon the particulars of each growers' enterprise.

Cover crops can be selected to serve specific purposes. Legumes are often selected because of their ability to convert atmospheric nitrogen into forms that remain in the soil to be used later by the cash crop. The soils of the San Jacinto watershed are generally low in carbon (less than 1%) and often benefit by the addition of organic matter. Rapidly growing cover crops can improve soil nutrient and water retention after they are plowed in and broken down.

Growers can look at the strengths, weaknesses, and unique features of their year-round cropping system to find a cover crop that helps meet their goals. The first question is, "When is there a niche in the crop rotation when a cover crop would fit?" In our Mediterranean climate, we essentially have a warm and a cool season. As with cash crops, the cover crop has to match the season for optimal growth. Two warm season cover crops that grow well in the San Jacinto watershed are sudangrass and cowpea.

Sudangrass is a common warm season forage crop that grows rapidly during our warm summers. Growing it in rotation with potato and other crops can often reduce pest populations and improve soil properties to ultimately improve yield and quality of cash crops. A typical rate for cover crops is about 40 pounds per acre. One variety often selected for cover crops because of its nematode resistance is Trudan 8, but there are many other varieties. Nitrogen and other nutrient requirements for sudangrass are similar to wheat, and sudangrass suffering from low nitrogen will often be less green, shorter, and not grow as rapidly as when fertility is optimal. However, its roots can take up residual nitrogen from the previous crop that can then be released to the soil after the sudangrass is plowed under.

Sudangrass can be cut for forage, allowed to re-grow, and then plowed under to enrich the soil before a subsequent fall crop of wheat or winter vegetables. One to two months of growth during the summer will produce an ample amount of biomass. Sudangrass produces chemicals that can inhibit the growth of weeds and crop plants, so breaking up the stalks by disking, plowing it under, and providing the residue some water and at least a few weeks to break down will protect the main crop and allow the sudangrass to break down and release nitrogen and carbon to enrich the soil. If sudangrass is allowed to grow too long (more than 8 weeks) without cutting, it can form thick stalks that may take too long to break down. A good rule for cover crops is to plant and manage sudangrass to form a thick stand of about 3 feet tall, and then chop and plow it under, adding some water if the soil is dry. After one month prepare the ground as you normally would for the subsequent vegetable or wheat crop.

Sudangrass takes up soil nitrogen and other elements to form a thick stand of biomass. Thus these elements are at least temporarily prevented from entering the watershed. Plowing the biomass under enriches the soil as the residue breaks down. This can trap nutrients into a slow release form for gradual use by subsequent crops; plus the added organic matter can improve our low carbon soils. Soils in the watershed typically have less than one percent organic matter, and adding plant residue often increases productivity.

Fertilizer prices have escalated in tandem with the rise in energy prices, as it takes a quart of diesel fuel to produce one pound of urea-based fertilizer. This has led many farmers to consider planting a legume cover crop to add nitrogen to the soil and decrease fertilizer inputs. Cowpea has been identified as an ideal summer cover crop for our growing conditions (Hall and Frate 1996). Cowpea grows rapidly in our hot summers with a moderate amount of irrigation and generally no added fertilizer, fixes atmospheric nitrogen, and has resistance to nematodes and other pests. The common cover crop variety is Iron Clay, and is generally planted at a rate of 40 pounds per acre. Within two months, the crop can be incorporated into the soil, and generally breaks down in the late summer in moist soil in about two weeks. Cowpea works well in no-till systems, as it can be cut to lie on the surface and the subsequent crop planted into the residue. It is generally estimated that two months summer growth of a solid stand of cowpea can provide 100 pounds of nitrogen per acre to the subsequent cash crop.

Winter is the region's rainfall season, and a cool season cash or cover crop reduces runoff. The standard San Jacinto watershed practice of growing wheat and other cash crops during our rainy season is also a best management practice for water and nutrient management. Winter cover crops would occupy land during the growing period of traditional cash crops such as wheat, alfalfa, or winter vegetables. Because wheat and other cash crops are generally grown in the winter, we rarely see winter cover crops in the watershed. Winter cover crops are common in many other agricultural growing areas, and include peas and other legumes, mustards, and some grasses.

Table 10-2. Nitrogen requirements of vegetable crops.

| Crop | Growth Stage | Approximate weekly nitrogen requirement |
|----------|---------------------------|--|
| | | (pounds/acre) |
| broccoli | early growth | 5-15 |
| | mid-season | 10-20 |
| | button formation | 15-30 |
| | head development | 10-20 |
| cucumber | vegetative growth | 5-10 |
| | early flowering/fruit set | 10-20 |
| | fruit bulking | 10-15 |
| | first harvest | 5-10 |
| lettuce | early growth | 5-10 |
| | cupping | 10-20 |
| | head filling | 15-30 |
| melon | vegetative growth | 5-10 |
| | early flowering/fruit set | 10-20 |
| | fruit bulking | 10-15 |
| | first harvest | 5-10 |
| pepper | vegetative growth | 5-10 |
| | early flowering/fruit set | 15-30 |
| | fruit bulking | 15-20 |
| | first harvest | 5-10 |
| squash | vegetative growth | 5-10 |
| | early flowering/fruit set | 10-20 |
| | first harvest | 5-10 |
| tomato | vegetative growth | 5-10 |
| | early flowering/fruit set | 15-20 |
| | fruit bulking | 10-15 |
| | first harvest | 5-10 |

Credit for this table is to Aziz Baameur, UCCE, Santa Clara County

10.4.6 Soil NO₃-N ‘Quick Test’

Procedure:

- 1) Collect at least 12 soil cores representative of the area surveyed. In furrow-irrigated fields don’t include the top 2 inches of soil, which may be too dry for root activity. Do not sample furrow bottoms or where fertilizer bands are placed. Blend the sample thoroughly.
- 2) Fill a volumetrically marked tube or cylinder to the 30 ml level with .01 M calcium chloride. Any accurately marked tube or cylinder will work, but 50 ml plastic centrifuge tubes with screw caps are convenient and reusable.
- 3) Add the field moist soil to the tube until the level of the solution rises to 40 ml; cap tightly and shake vigorously until all clods are thoroughly dispersed. It is critical that the soil you test is representative of the sample; for moist clay soils that are difficult to blend pinch off and test several small pieces of each soil core. Testing duplicate samples will minimize variability.
- 4) Let the sample sit until the soil particles settle out and a clear zone of solution forms at the top of the tube. This may take only a few minutes for sandy soils, an hour or more for clay soils.
- 5) Dip a Merckquant® nitrate test strip into the clear zone of solution, shake off excess solution, and wait 60 seconds. Compare the color that has developed on the strip with the color chart provided.

Interpretation of results:

The nitrate test strips are calibrated in parts per million (PPM) NO₃⁻. Conversion to PPM NO₃-N in dry soil requires dividing the strip reading by a correction factor based on soil texture and moisture:

$$\text{strip reading} \div \text{correction factor} = \text{PPM NO}_3\text{-N in dry soil}$$

| Correction factor | | |
|-------------------|------------|----------|
| Soil texture | Moist soil | Dry soil |
| Sand | 2.3 | 2.6 |
| Loam | 2.0 | 2.4 |
| Clay | 1.7 | 2.2 |

10.4.7 BMP information from the project:

- In the potato field sprinkler irrigated with recycled water, the most significant difference is that the PAM treatment has the least amount of nitrate and ammonium runoff. It was observed that the samples from the PAM plots had much less sediment runoff than from all the other plots.
- Like the winter wheat, the ammonium runoff from the plots was generally less than the quantity from the control plots.
- 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.

10.4.8 References:

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XI. Best Management Practices

Turfgrasses Grown in Western Riverside County: San Jacinto Watershed

11.0 Nutrient Management for Turfgrass in San Jacinto Watershed

11.1 Introduction

Turfgrasses are one of the most demanding aspects/segments/features/portions of landscapes to manage and to select best management practices for because they are so diverse in their uses, ecology and adaptability to the many different climates in California. What may be suitable for one species may not be for another and when used one way the best management may be very different than when it is used in another geographic setting.

This best management practice section on turfgrasses will focus on those practices that will reduce surface and ground water contamination by fertilizer and natural nutrient sources derived from lawns and other turfgrass uses/settings/ - both issues that proper turfgrass management can reduce or eliminate. While much of the content in this chapter is common sense, as much as possible is gleaned from scientific research done in California for practical application by turfgrass managers. The references at the end of this chapter contain further information on turfgrass best management practices beyond the preservation of water quality – the focus of this chapter.

11.1.1 Grass Species Selection - Which is the Best Turfgrass?

Growing the best adapted grass for your climate and turfgrass use is the first step in assuring that the most efficient and conserving management practices can be used. Trying to grow poorly adapted grasses may require the use of additional water, fertilizer, pesticides and/or physical management (labor) all contributing to the chance of more nutrients escaping the grass environment and finding their way into waterways where they cause algae formation, pollution, toxicity issues and aesthetic degradation of water quality.

Turfgrasses are grouped into two main categories based on the climatic origin of the grass species and the resulting adaptability to similar climates in other parts of the world.

Cool-season turfgrasses are from temperate regions of the world and are adapted to cooler summer climates of California including the coastal zone from Mexico to the Oregon border and mountain regions of California. The most common turfgrasses in this group grown in California include; bentgrasses (creeping, colonial, and Highland bent), Kentucky bluegrass, Perennial ryegrass, Tall fescue, the fine fescues- creeping Red, sheep's, and hard fescues.

Characteristics of cool-season turfgrasses:

- These grasses are mostly planted from seed,
- Green year around except in areas covered in snow in the winter
- Use 80 % of the water predicted by the reference evapotranspiration (ET_o) for the area in which they grow
- Have poor to fair drought tolerance
- Require moderate (4 -6 lbs. actual nitrogen per 1,000 sq. ft. per year) to high (6-12 lbs. actual nitrogen per 1,000 sq. ft. per year) rates of nitrogen fertilizer.
- Physical maintenance is required. It ranges from moderate to high depending on the species and use.

Warm-season turfgrasses are adapted to hot summer climates of California including desert areas, the Great Central Valley and inland valleys of southern California. Turfgrasses in this group commonly available in these regions are; Bermudagrass (seeded and hybrid) Seashore Paspallum, Zoysiagrass, St. Augustinegrass, Buffalograss.

Characteristics of Warm-season turfgrasses:

- These grasses are mostly planted from vegetative sources (sod, stolons, plugs), seeded Bermuda, is the main exception.
- Green in summer and dormant (brown) in winter, except in mild winter areas such as south coast portions of California
- Use 60 % of the water predicted by the reference evapotranspiration (ET_o) for the area they are growing in
- They have good to excellent drought tolerance.
- Require low (2 lbs. actual nitrogen per 1,000 sq. ft. per year) to high (12 lbs. actual nitrogen per 1,000 sq. ft. per year) rates of nitrogen fertilizer depending on the species and use.

The climate of western Riverside County falls into the inland zone (Mediterranean climate) or desert climate (central and eastern Riverside Co.) the San Jacinto mountains are the only area that would be categorized as temperate climate where warm-season grasses would not be recommended. Warm-season turfgrasses are the best adapted grasses for western, central and eastern Riverside County. Although not ideally adapted, the cool-season turfgrass Tall Fescue is only adapted in inland parts of western Riverside County and the mountain areas (San Jacinto mtns).

11.1.2 Irrigation Management

Turfgrass water needs have been scientifically quantified and the State of California has adopted the University of California developed weather station network [California Irrigation Management Information System; CIMIS] that estimates crop water use for over 100 locations in the State. Research has developed specific turfgrass water use coefficients for both warm-season and cool-season grasses for each month of the year. This means that the amount of water a specific grass species needs for each day, week, month or year can be found based on the actual weather conditions for each location that houses a CIMIS weather station. These stations are located in many areas that are close to urban areas that can use these stations to determine landscape (turf) water needs on a daily basis. Managers can use historical averages to come close to the water needs of turfgrasses if using real-time water use is too difficult for a manager to access or use. Many tables using historical reference water use figures and turfgrass water use figures are available for turfgrass water managers and residential lawn caregivers.

Below is one such reference chart that applies to the majority of the San Jacinto watershed.

Table 11-3. Turfgrass Sprinkler Run Times based on Monthly Historical Average Evapotranspiration and Sprinkler output in inches per hour for Southern California Inland Valleys.

| Warm-Season Turfgrasses | | | | | Cool-Season Turfgrasses | | | | |
|-------------------------|---|-------|-------|-------|---|-------|-------|-------|----|
| | Minutes per week to irrigate if Your hourly sprinkler output is: | | | | Minutes per week to irrigate if your hourly sprinkler output is: | | | | |
| | 0.5in | 1.0in | 1.5in | 2.0in | 0.5in | 1.0in | 1.5in | 2.0in | |
| JAN | 42 | 21 | 14 | 10 | JAN | 56 | 28 | 19 | 14 |
| FEB | 57 | 28 | 19 | 14 | FEB | 75 | 38 | 25 | 19 |
| MAR | 80 | 40 | 27 | 20 | MAR | 106 | 53 | 35 | 27 |
| APR | 96 | 48 | 32 | 24 | APR | 128 | 64 | 43 | 32 |
| MAY | 119 | 60 | 40 | 29 | MAY | 159 | 80 | 53 | 40 |
| JUN | 144 | 72 | 48 | 36 | JUN | 193 | 96 | 64 | 48 |
| JUL | 165 | 83 | 55 | 41 | JUL | 221 | 110 | 74 | 55 |
| AUG | 155 | 77 | 52 | 39 | AUG | 207 | 103 | 69 | 52 |
| SEP | 124 | 62 | 41 | 31 | SEP | 165 | 82 | 55 | 41 |
| OCT | 88 | 44 | 29 | 22 | OCT | 117 | 59 | 39 | 29 |
| NOV | 54 | 27 | 18 | 14 | NOV | 73 | 36 | 24 | 18 |
| DEC | 42 | 21 | 14 | 10 | DEC | 55 | 28 | 19 | 14 |

The additional factor that is needed to apply the correct amount of water is the type of sprinklers used for the lawn area; specifically the amount of water they apply per unit of time (per hour). This allows the manager to schedule the sprinkler run-time on an automatic time clock to apply the correct amount of water to keep the grass growing at its maximum rate while maintaining the health of the grass and securing the desired aesthetic qualities of the lawn.

11.2 Water Run-off is a Main contributor to Pollution of surface Streams, Lakes and Reservoirs

There are many factors that determine the success of irrigation application to a turf area. The quantity of water has been discussed above. The next factor is the application to assure the water penetrates into the soil and supplies the grass roots with the needed water. The main goal of this section is to discuss how to avoid waste of water and run-off of water into storm drains or other avenues where it potentially can carry pollutants into streams, lakes and reservoirs that are used for drinking water or recreation or natural environments/resources.

11.2.1 Avoiding Irrigation Run-off

Matching the irrigation application rate with the rate that the soil and lawn can accept the water is the key to avoiding run-off. The following practices will help reduce or eliminate run-off from lawn irrigations:

- Do not plant turf on sloped area that are greater than 1 to 2/2/101?. WHAT IS THIS?) Remove existing turf on areas that have too great a slope and replace with suitable ground cover irrigated with drip or mini-spray irrigation systems that have much lower water application rates.
- To help aid water penetration on mild slopes, aerify the soil with a hollow tined plugger, aerifier, or hand tool to create holes through any thatch layer in the turf and leave them open (do not top-dress and back-fill with soil or sand) to catch as much water as possible).
- Test the existing sprinkler system to see how much run time it takes before water run-off starts. Use this time as the maximum run time for that irrigation station (valve) and schedule repeat start times on the time clock to achieve the correct total watering minutes for the period you are scheduling (daily, every 2 days, every 3 days, weekly etc.).
- Perform regular thatch control (vertical mowing, verticutting) using straight blades on the verticutting reel to maintain less than ½ inch of thatch on grasses that produce thatch (bermudagrasses, bentgrasses, St. Augustine, Zoysiagrass, etc.) Warm-season grasses should be done in the mid-summer, cool-season grasses in the late winter or early spring.
- Situations where soils and or thatch are water repellent (hydrophobic) the use of a commercial water penetrating agent can help increase the rate of water movement into the soil / root zone and reduce surface run-off.

11.2.2 Determining the Sprinkler System Output and Application Uniformity

It is critical to measure the sprinkler system on a lawn area to know how much water it puts on (in inches per hour) and how evenly it covers the area being watered (distribution uniformity). Although you can find output figures in sprinkler manufacturer catalogs, they mean little when applied to an actual installed sprinkler system unless it was perfectly spaced in a lawn area that fits the layout exactly. To determine what the average application rate is over the turf area, do a “can” test to catch the water. Then, measure the volume or directly measure the depth in the cans and average them. The following section gives one easy means of doing a can test and determining the distribution uniformity. This will allow you to make the determination if the system puts water on evenly enough to make it efficient enough to irrigate with. A Distribution Uniformity below 70% is usually deemed inefficient and needs repair, replacement or adjustment to raise its uniformity above the 70% threshold. Visual symptoms of poor uniformity are usually seen as large browning areas in the lawn as opposed to smaller brown dead (2” to 24” diameter) spots that are often roundish in shape caused by fungus diseases.

FORMULAE USED FOR CALCULATION OF DISTRIBUTION UNIFORMITY AND PRECIPITATION RATE

CATCH CAN TEST ANALYSES FOR TURF SPRINKLER SYSTEMS

The Distribution Uniformity (DU) is one of the best and most commonly used measure of uniformity. To calculate the DU from the catch can data, first determine the average catch by adding all catch value and then dividing by the number of catches. Next determine the average of the lowest 25% of the catches (low quarter). For example, if there were 40 catches, for the average catch: sum all 40 values then divide by 40. For the average of the low quarter: sum the 10 lowest catches and divide by 10.

The DU is then calculated by dividing the average of the low quarter by the average catch.

$$DU = \frac{\text{Average of the Low Quarter}}{\text{Average of all Catches}}$$

The Average Precipitation, the Rate (PR) in inches per hour is determined from the Average Catch, the test time, and the area of the catch can using of the following formulae. The formula you use depends on how the water was measured.

1. Water measured in Ounces
Area of the catch can opening in Square Inches

$$PR \text{ (In/Hr)} = \frac{\text{Average catch in Ounces} \times 108.3}{\text{Catch Can Area in Square Inches} \times \text{Test Time in Minutes}}$$

2. Water depth measured Inches
Catch can with straight sides (area not needed)

$$PR \text{ (In/Hr)} = \frac{\text{Average depth in Inches} \times 60}{\text{Test Time in Minutes}}$$

11.2.3 Equipment selection and maintenance

The best way to assure that water application is slow enough to penetrate the lawn area is to match the sprinkler application rate with the water infiltration (penetration) rate of the soil the turf is growing in. Figure 1 shows the water holding capacity of different textured soils, with clays being the slowest soil to accept water and sand being the fastest.

Many other factors can affect the water penetration rate into turf areas including:

- If the soil is compacted by heavy traffic, water moves in more slowly (aerification with hollow tined tools that remove plugs of soil leaving an open hole, will temporarily overcome the effects of compacted soil)
- If the soil has a chemical problem caused by high sodium content (sodic soils) it will reduce the pore space size to the point that water won't penetrate the soil. (Addition of gypsum to supply large amounts of calcium (Ca) and leaching irrigations can help correct this problem and improve the structure of the clay soils)

- Selecting sprinklers that put water on more slowly are good choices for heavier soils such as clay soils. The chart below gives general application rates of common sprinkler types. Read the specifications from the product manufacturer to get a more specific water application rate for a particular sprinkler or nozzle.

| Sprinkler type | Pressure range | Application Rate (inches/hr.) | Typical use |
|------------------------|----------------|-------------------------------|------------------------------------|
| Pop-up spray | | 1.5 – 2” | residential |
| Pop-up scream nozzle | | 0.5” | residential |
| Stream rotor | | 0.5” | Commercial, residential |
| Impact head (Rainbird) | | 0.5 – 1.0” | Ag., commercial, large residential |
| Gear-driven Rotor | | 0.5 – 1.00” | Commercial, golf |

11.3 Fertilizer Application & Timing

All lawns need added nitrogen fertilizer to maintain health, growth, density and aesthetic appearance including acceptable green color. The main sources of water pollution being addressed in this BMP article are Nitrogen and to a lesser degree, Phosphorus, both applied in lawn fertilizers sometimes signally but often in complete fertilizers along with potassium. Sometimes other nutrients such as iron, sulfur, and micronutrients are in lawn fertilizers. Nitrogen is often applied in soluble fertilizer sources that dissolve immediately in the soil water and in applied irrigation water or rain. If the dissolved nitrogen runs off the lawn into waterways it is a source of water pollution.

The following practices will reduce the likelihood of nitrogen moving off the lawn into surface streams or lakes. Additional practices listed will assure that soluble nitrogen will not move in the soil water deep below the grass roots and into ground water where it poses a health risk to drinking water in the ground-water supplies used for potable water in our urban and rural areas of Riverside County.

Lawn fertilizer needs: Different species of grass have different nitrogen requirements to produce acceptable quality. Most warm-season types go dormant in the winter, thus need no nitrogen because they are not growing at all. The chart below lists the average nitrogen needs of each common grass used in the western Riverside County area. These figures are based on UC research conducted in the past five years at UCR and at SCREC in Irvine, CA. It should be noted that grasses grown in a sports turf or under heavy traffic or wear will need more nitrogen than these average amounts needed for an average use lawn area such as a residential lawn, park, commercial turf or highway roadside planting. Timing of the applications (in 1 lb. actual nitrogen increments) is also shown for the inland valleys of southern California.

Table 11-4. Common Turfgrasses Used in Inland Southern California Valleys and their Annual Nitrogen Fertilizer Requirements and Suggested Application Timing. Each “X” signifies a one pound actual nitrogen application

| Turf Species | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|----------------------|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|
| Seeded Bermuda | | | x | | x | | x | | x | | | |
| Hyb. Bermuda | | | x | x | x | x | x | x | x | | | |
| Zoysiagrass | | | | x | | | | | x | | | |
| Seashore Paspalum | | | x | | x | | | x | x | x | | |
| Buffalograss | | | x | | x | | x | | x | | | |
| Tall Fescue | x | | x | | x | | 1/2x | | x | | x | |

Research on Tall Fescue conducted at UC Riverside from 2003 – 2006 showed that the best management practices involving fertilizer formulation or sources of nitrogen that are termed “slow-release” are less likely to dissolve in the soil water and be leached below the turfgrass root zone and be carried down into ground water causing pollution of drinking water. Table 11-5 shows the common fertilizers used in lawn fertilization and their solubility’s as well as their % nitrogen, and other practical information to assure safe and efficient use.

Table 11-5. Information on selected commercial fertilizers used on lawns

| Fast Release Remarks | Analysis | Amount needed to apply 1 lb | Amount needed to apply 0.5 kg | Relative cost/lb |
|--|-------------|---------------------------------------|------------------------------------|---------------------|
| Soluble nitrogen | (% N-P-K) | actual N/1,000 sq ft (lb. approx.) | actual N/100 sq m (kg. approx.) | of actual N |
| ammonium nitrate Can burn. Contains immediately available nitrate. Used winter nitrogen fertilization. | 33-0-0 | 3.0 | 1.5 | low |
| ammonium Used mainly as a preplant fertilizer for phosphate sulfate soil incorporation. | 16-20-0 | 6.0 | 3.0 | low |
| ammonium sulfate Acidic soil reaction. Can burn turf if over applied. | 21-0-0 | 5.0 | 2.5 | low |
| calcium nitrate Quickly available. Can burn turf. Used for winter fertilizer. | 15.5-0-06.5 | | 3.3 | low |
| urea quickly in soil to available ammonium nitrogen. Very high burn potential. | 45.0-0 | 2.0 | 1.0 | low |
| Natural organic materials and | % N | | | |

fertilizers

| | | | | | |
|--|-------|----|----|------|------|
| activated biosolids | 4.7 | 20 | 10 | high | |
| Significant phosphorus and moderate (sewage sludge) nitrogen; some potassium present | | | | | |
| digested biosolids | 1.5-3 | 40 | 20 | high | Low |
| nitrogen availability; some (sewage sludge) phosphorus present. | | | | | |
| poultry manure | 3-4 | 30 | 15 | high | Good |
| source of nitrogen, phosphorus. Odor may be rather strong. | | | | | |
| steer Manure | 2 | 50 | 25 | high | Low |
| nitrogen, good source of phosphorus, and potassium, but not a favored turf weed fertilizer. May introduce weed seeds and/or increase salinity. | | | | | |

Slow Release fertilizers %N

| | | | | | |
|--|--------|---------|---------|----------|---------|
| coated/soluble fertilizer | varies | varies* | varies* | high | Foot |
| traffic and mowing equipment may crush coated fertilizer and destroy slow-release properties especially on putting greens. | | | | | |
| ESN (neutralized) | varies | varies* | varies* | high | |
| Coating is semi-permeable. Allowing ionic elastomers release of dissolved ureas through membrane for up to 6 months. | | | | | |
| IBDU (isobutyl-enediurea) | varies | varies* | varies* | high | |
| Nitrogen released by slowly dissolving in soil water. Long-lasting response | | | | | |
| methylene-urea | varies | varies* | varies* | high | |
| Similar to UF but quicker nitrogen release. | | | | | |
| polymer-coated ureas | varies | varies* | varies* | high | |
| More controlled release than SCU with addition of plastic to sulfur coat. | | | | | |
| Sulfur-coated urea | 32-41 | 2.5-3.0 | 1.3-1.5 | moderate | Release |
| can be up to 16 weeks For some formulations. | | | | | |
| UF (ureaform) | 38 | 3.0 | 1.5 | high | |
| Nitrogen released by soil microorganisms. Poor winter release; faster summer release. | | | | | |

11.4 Avoiding Water Pollution

The misapplication of lawn fertilizer can contribute to surface water pollution if the fertilizer is carried into storm drains. By dropping fertilizer onto sidewalks, driveways, streets, or bare soil, home gardeners and landscape workers can unknowingly contribute to this serious urban pollution problem. Restricting fertilizer to grass areas helps prevent nutrient runoff and channels movement of the dissolved fertilizers into the soil where they can be quickly taken up by turfgrass roots.

To prevent fertilizer pollution:

- Apply fertilizer with care to turfgrass.
- Sweep, blow, or wash fertilizer off concrete or asphalt areas (hardscape) and back onto lawns—not down storm drains or into gutters / streets.
- Soon after applying, water fertilizer into lawns in a controlled manner to prevent dissolved fertilizers from running off the lawn area into gutters and storm drains.

Most municipal storm drain systems empty into streams or large drain channels that feed into bays, lakes, rivers, or the ocean, where the fertilizer (mainly nitrogen and phosphorus) encourages growth of unwanted algae and problematic aquatic plants that slow water flows, create navigational hazards, and degrade the environment.

Rotary fertilizers spreaders are best used on large turf areas where they will not throw fertilizers beyond lawn areas onto hardscape and streets. Using drop spreaders along the edges of large turf areas and for small lawns greatly reduces overthrow and the need for additional labor to clean fertilizer from concrete surfaces.

11.6 REFERENCES

Green, Robert and Laocheng Wu, David Burger, Grant Klein, Janet Hartin. 2007. Development of BMPs (Best Management Practices) for Fertilizing Lawns to Optimize Plant Performance and Nitrogen Uptake While Reducing the Potential for Nitrate Leaching. Grant Report: California Department of Food and Agriculture Fertilizer research and Education program.

Hartin, Janet and Mike Henry. 2001. Reusing Turfgrass Clippings to Improve Turfgrass Health and Performance in Southern California. California Integrated Waste Management Board.

Hartin, Janet, Pam M. Geisel, Carolyn L. Unruh. 2001. Lawn Watering Guide for California. University of California Cooperative Extension, Publication 8044.

Henry, J. Michael, Victor A. Gibeault, Vincent F. Lazaneo. 2005 revised. Practical Lawn Fertilization. University of California Cooperative Extension, Publication 8065.

Shaw, David et al. 2003. Landscape Irrigation System Evaluation and Scheduling for Southern California. University of California Cooperative Extension.

4.5.6 FOR MORE INFORMATION

You'll find more information on lawn care in the following ANR sources:

California Master Gardener Handbook, Publication 3382, 2002

Lawn Aeration and Thatch Control, Publication 2586, 1973.

Lawn Diseases: Prevention and Management: Pest Notes for the Home Landscape, Publication 7947, 2002

Lawn Watering Guide for California, Publication 8044, 2001

Managing Lawns in Shade, Publication 7214, 1996

Mowing Your Lawn and Grasscycling, Publication 8006, 1999

Turfgrass Pests, Publication 4053, 1989.

Turfgrass Selection for the Home Landscape, Publication 8035, 2001

UC Guide to Solving Garden and Landscape Problems (CD-ROM) Publication 3400, 2000.

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XII. PUBLIC OUTREACH

WRCAC will continue to provide appropriate outreach as needed through various resources:

- Workshops with the agricultural operators
- An aggressive approach to grant writing for stakeholders, both Federal and State funding, is key to WRCAC's success and the assistance needed for agricultural operators to meet regulatory requirements as we move forward.
- Agrarian newsletter information and updates
- Web-based tool for inputting BMPs
- Web-based BMP information
- Website development in 2010

Stakeholder outreach includes:

- WRCAC members
- LESJWA TMDL Task Force
- San Jacinto River Watershed Council
- Santa Ana Watershed Association of Resource Conservation Districts
- NRCS
- Santa Ana Watershed Projects Authority
- Eastern Municipal Water District
- Santa Ana RWQCB
- Riverside County Flood Control & Conservation District
- And other watershed stakeholders

2.2.2 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

In its December 31, 2010 letter to the Regional Board, LESJWA stated that stakeholders had narrowed the list of candidate in-lake remediation projects for Canyon Lake to the following:

- *Hypolimnetic Oxygenation System (HOS)* – Implementation of a HOS would directly oxygenate the lower depths of Canyon Lake and prevent the reducing conditions that allow phosphorus to be released from sediments. The benefits of a HOS would benefit both Canyon Lake (directly improve water quality in the lake) and Lake Elsinore, through a reduction in phosphorus loads transferred from Canyon Lake to Lake Elsinore during wet years.
- *Phoslock Application* – Phoslock is a commercially available, modified bentonite clay product containing the naturally occurring element lanthanum that has been shown to be effective in the treatment of excessive internal nutrient loading in lakes and reservoirs. It has been successfully used in a number of waterbodies around the world. Phoslock is applied to the waterbody at the surface in the form of a slurry which may take several days to settle to the bottom. As it settles, the Phoslock interacts with bioavailable phosphorus (phosphate) in the water column, binding the lanthanum and phosphate into the highly stable mineral Rhabdophane. Phoslock is applied in quantities great enough to form a sediment cap of no less than 0.5 mm thickness. This capping effect prevents the bioavailable phosphorus in the sediment from recycling back into the water column. Phoslock, which is effective over a wide range of naturally pH values, has shown to have no toxicity to aquatic organisms at the recommended application rates. However, there has been insufficient testing of the material to show that it is 100 percent non-toxic. Phoslock has also been shown to be somewhat effective in reducing nitrogen cycling from the sediment, although no quantitative estimates are available or claimed by the manufacturer.

Additional information regarding these two remediation project candidates is provided in Attachment C. Attachment C also provides information regarding two other chemical solutions (alum and zeolite) that were evaluated as alternatives to Phoslock application.

Based on the Agricultural and dairy operators evaluation of the Canyon Lake candidate strategies, the AgNMP includes the following implementation strategy for in-lake remediation of nutrients:

- Agricultural and dairy operators are preliminarily committed to the planning, design, construction and operation of a HOS for Canyon Lake, consistent with Alternative 10b³. Implementation of HOS will require additional planning and design as well as extensive coordination with a number of agencies to fulfill CEQA and permitting requirements. WRCAC believes that funding the HOS system will be necessary in the early years to meet Canyon Lake compliance and has budgeted appropriately to support whatever strategy is agreed upon for implementation. However, we do not believe that agriculture and dairy will be major stakeholders as we reach the 2020 target date due to attrition and other BMP implementation. However, we are open to all alternatives and strategy opportunities and dependent upon load reduction needs will participate at some level.
- The effectiveness of in-lake remediation using HOS will be evaluated as part of the adaptive management process incorporated into this AgNMP (see Section 2.4). In the event that HOS does not provide the expected water quality benefits for nutrient offsets, the agricultural stakeholders may augment HOS with the addition of either Phoslock or Zeolite (see Attachment C for discussion of pros and cons of each chemical additive).

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).

Agricultural and dairy operators believe that WLAs can be met through the fishery management program. It is WRCAC's intent to pursue discussions with the City of Lake Elsinore for future fishery management needs.

Additionally, with regards to in-lake remediation strategies for either Canyon Lake or Lake Elsinore, the agricultural stakeholders are continuing to evaluate alternative compliance options (such as the application of Zeolite) should the agricultural operators determine that an alternative compliance approach is needed to achieve in-lake response targets. If the agricultural operators determine that an alternative compliance approach is necessary, the agricultural operators may propose revisions to this AgNMP to incorporate the alternative compliance approach.

2.2.3 Monitoring Program

³ See *Canyon Lake Hypolimnetic Oxygenation System, Preliminary Design Phase 1 Report* prepared for LESJWA by Pace, April 2011

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 the CWAD agricultural specific requirements of agricultural operators. WRCAC anticipates that in-lake monitoring will continue through the TMDL Task Force or in 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 2-1 summarizes the currently approved Phase 1 monitoring program elements.

Table 2-1. 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 redox potential | Chlorophyll <i>a</i> , 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) | | | |
| San Jacinto River Watershed | Station C10 (east bay) | 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 3 - Salt Creek at Murrieta Rd | | | |
| | 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 | | | |

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 2-1). The agricultural and dairy operators also propose to eliminate existing in-lake monitoring programs through the same period to ensure that resources are dedicated to facilitating and constructing the Canyon Lake HOS or other remediation projects. The agricultural and dairy operators will propose a revised comprehensive watershed and in-lake monitoring program that meets both TMDL and CWAD requirements by December 31, 2014 for implementation no later than fiscal year 2015-2016 .

2.2.4 Special Studies

As resources allows, the agricultural and dairy operators may implement a number of studies during AgNMP implementation to provide additional data to support TMDL implementation

efforts. Aerial mapping is a good example of special studies that are likely recurring. Additionally, projects that quantify manure management practices and manure agronomic rates will be beneficial as we near the compliance date of 2020. 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, manure management agronomic rates, 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.

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

Figure 2-2 shows the overall tasks and schedule for AgNMP implementation. this figure illustrates the relationship among tasks over the period from 2012 through the December 31, 2020 compliance date. The implementation schedule includes tasks associated with each of the following elements:

- **Watershed-based BMPs – This element includes** : an approach to assist individual agricultural operators with BMP implementation as well as potential regional agricultural BMPs.
- *Ag Operator BMPs*-There are hundreds of individual agricultural operators in the San Jacinto watershed. BMPs will be varied and numbered and ultimately be the responsibility of individual agricultural operators.
- *Regional agricultural projects-gasification projects with diesel conversion, composting, digesters, manure backhaul systems,etc.....*
- *In-Lake Remediation Activities*
 - *Lake Elsinore* –The agricultural operators propose to support fishery management activities in Lake Elsinore to meet their WLAs. This may be in the nature of carp removal and/or stocking of fish depending upon the need and conditions of the lake
 - *Canyon Lake* – The MS4 permittees propose to implement a HOS in Canyon Lake. The schedule establishes a development period (design, CEQA, permits and construction) that is expected be completed by the end of 2014. This schedule is dependent on obtaining all required regulatory approvals for construction of HOS in a timely manner. The agricultural and dairy operators anticipate participating in assisting in the development of the HOS. WRCAC believes that with grant funding this is a viable option and will likely occur. However, without the assistance of grant funding, we do not believe stakeholders will find this an affordable long-term investment.

As noted in Section 2.2.2, the agricultural operators along with other watershed stakeholders will continue to evaluate potential use of an alternative compliance approach, e.g., use of Zeolite or Phoslock, to comply with agricultural WLAs in either lake. If an alternative approach is determined to be viable to achieve compliance, a proposal to modify the in-lake remediation activities will be prepared and presented to the RWQCB. Current remediation strategies for Canyon Lake have concentrated on a HOS project

which affects the deep water areas of Canyon Lake. From agriculture's perspective, the east bay remediation will likely need an alternative such as Phoslock or Zeolite to address shallow water remediation.

Monitoring Program – In-lake monitoring activities are expected to occur at a reduced level while the proposed HOS is being developed. Watershed-based monitoring will continue as approved under the Phase I watershed monitoring program through fiscal year 2014-2015. By the end of 2014, the agricultural and dairy operators will propose a revised comprehensive watershed and in-lake monitoring program. If approved, this revised program will be implemented no later than fiscal year 2015-2016. WRCAC will coordinate the monitoring program development to meet both TMDL and CWAD monitoring program requirements.

- *Special Studies* – The AgNMP identifies special studies that may be implemented by the agricultural operators. The schedule for implementation of various studies is related to the need for new information that may be used to support the 2015 compliance assessment, need for any revisions to the AgNMP, and anticipated TMDL triennial reviews.
- *Adaptive Implementation* – This element includes TMDL implementation activities that could affect other stakeholders (e.g., TMDL revision, Task Force activities, Pollutant Trading Plan implementation) and the potential need to revise the AgNMP based on the findings from monitoring activities. The TMDL triennial review dates are based on the assumption that a triennial review will occur in 2012 and then every three years beyond 2012.

2.5 Water Quality Standards Attainment

The TMDL WLAs are based on a 10-year average nutrient load to Lake Elsinore and Canyon Lake. However, in reality nutrient loading to these lakes occurs asymmetrically with the most significant loading occurring during extreme wet weather events. When these extreme events occur, the nutrient load reaching the lakes could be substantially higher than the capacity of the lakes to absorb the nutrients with a corresponding response that results in non-attainment of water quality standards (e.g., algal blooms, low dissolved oxygen).

Modeling results show that non-attainment of water quality standards would have occurred even under predevelopment conditions. For example, model results for 1993, 1998 and 2005 show that the nutrient loads from wet years would likely have caused temporary non-attainment of water quality standards even if there was no development in the watershed. The AgNMP, when implemented, provides the basis for achieving compliance with the 10-year average WLAs applicable to agricultural discharges. However, because of asymmetric loading, even with full AgNMP implementation Lake Elsinore and Canyon Lake may still not be in attainment with water quality standards at times for reasons beyond the control of the Agricultural and dairy operators. While temporary non-attainment may still occur following extreme wet weather events, AgNMP implementation is expected to reduce the potential duration and magnitude of impact from these events resulting in longer periods of attainment over 10-year average periods.

2-2 Implementation Schedule

The Ag NMP should be reviewed and updated on a regular basis by all affected stakeholders, WRCAC and other interested parties to incorporate new trends and new technologies as deemed appropriate.

WRCAC has been awarded a 319 grant for agricultural pollutant trading feasibility assessment and the development of a webNMP tool that will link to a WRCAC website (to be designed in 2010). The webNMP tool will allow agricultural operators to input BMP data for their parcels into a database and calculate nutrient load. The data will then be used on a watershed-wide agricultural basis in determining load reduction for agriculture in the San Jacinto watershed. Additionally, an economic suitability analysis will be done for non-point source to non-point source trading as well as with point sources. This project will also tie in nicely with the CWAD program which is in development at the SARWQCB. Good coordination between WRCAC and the SARWQCB will ensure that a close symbiotic relationship exists between the CWAD program and the Ag NMP. This close coordination will provide cost savings to ag operators in the implementation process and ultimately achieve the same mutual goal.

IMPLEMENTATION SCHEDULE

| ACTION/RESPONSIBLE PARTY | START DATE | COMPLETION DATE |
|--|--------------|----------------------------|
| 1. AgNMP submitted to RWQCB | | December 31, 2011 |
| 2. Approved AgNMP/RWQCB | | Estimated at March 2012 |
| 3. Determine applicability of Blue Water Satellite technology for phosphorous for SJ Watershed | June 2012 | December 2012 |
| 4. Contract with Blue Water imaging for phospho soil imagery | | |
| 5. Analyze data and overlay with AIS agricultural mapping-new 2010 mapping | January 2012 | March 2012 |

Section 3 • Compliance Analysis

| | | |
|--|--|---|
| 6. Develop tiered process for agricultural nutrient loading | | |
| 7. BMP workshops/links/stakeholder outreach | As needed and in conjunction with C program | |
| 8. Develop cafeteria style tier based BMP implementation schedule | | |
| 9. Assist RWQCB in CWAD development | Ongoing | |
| 10. Coordinate sampling/monitoring with others in watershed | Ongoing | |
| 11. Develop WRCAC website for stakeholder outreach of BMPs | spring 2012 | |
| 12. Begin 319 grant-agricultural pollutant trading feasibility assessment with webNMP tool | Began in 2011WebNMP start February task | June 2012 |
| 13. Manure Management | | |
| 15. Develop handbook of BMPs | Cost to do this may be prohibitive? Perhaps we could do this with SEP funding or some small foundation grant At minimum-we could post all BMPs on website? | |
| 16. Salt offset plan development/add into future cycle? *Central Valley template? | Ongoing | Target-September Realistically will longer |
| 17.Periodic updates of AgNMP | | |

Section 3

Compliance Analysis

3.1 Introduction

The TMDL sets WLAs for agricultural and 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 Concentrated Animal Feeding Operation (CAFO) sources. This compliance analysis only addresses agricultural 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 an allowable per acre loading rate in Table 3-1, are used to evaluate compliance with the Canyon Lake TMDL for WRCAC sources. Compliance analysis using per acre loading rates allows for the evaluation of compliance in future years, when significant changes to the land use distribution 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) | Allocation (kg/ac/yr) |
|-------------|----------|--------------------|-----------------------|
| Agriculture | TP | 1,183 | 0.021 |
| | TN | 7,583 | 0.136 |
| CAFO | TP | 132 | 0.017 |
| | TN | 1,908 | 0.243 |

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 washoff translate to reductions in loads delivered to Canyon Lake? Section 3.3.2 describes the estimation of decay factors to account for loss of nutrients between from 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 washoff 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.
- What in-lake nutrient control strategy is recommended to address remaining load reduction requirements after accounting for watershed load reduction? Section 3.4.1 (Lake Elsinore) and 3.4.2 (Canyon Lake) summarize in-lake nutrient control recommendations and demonstrate how the selected strategy will provide the necessary load reduction to achieve compliance with the LAs and WLAs for WRCAC agriculture and CAFO sources.
- The AgNMP is designed to reduce long-term average (running 10-year) annual nutrient load for WRCAC agriculture and CAFO sources. Conversely, response targets for nutrient related impairments are based on shorter-term annual or seasonal averages. Section 3.5 characterizes potential temporal variability in nutrient loading and its potential impact to Lake Elsinore and Canyon Lake under a natural and post-development condition.

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).

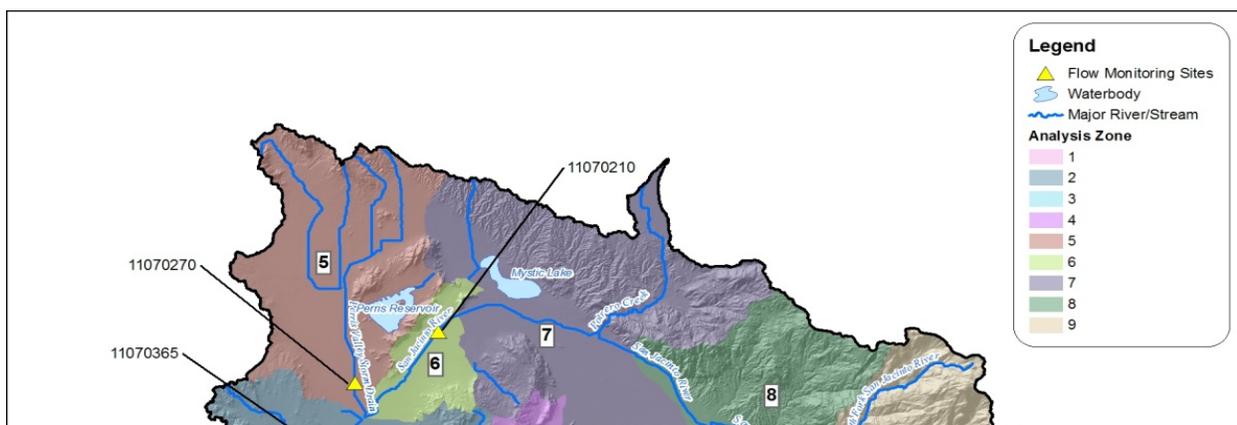


Table 3-2. Estimation of Decay Factors for Agriculture and CAFO Land Uses for Portion of Watershed Nutrient Washoff that is Expected to Reach Canyon Lake

| Watershed Analysis Zone | Watershed Washoff | | Loads to Lake (kg/yr) | | Decay Factor | |
|---|-------------------|------------|-----------------------|------------|--------------|---------|
| | TP (kg/yr) | TN (kg/yr) | TP (kg/yr) | TN (kg/yr) | TP | TN |
| Canyon Lake below Mystic Lake (Zones 2-6) | 17,624 | 47,216 | 7,837 | 26,609 | 44% | 56% |
| Above Mystic Lake (Zones 7-9) | 12,715 | 33,106 | 1.0 | 2.1 | < 0.01% | < 0.01% |

**Figure 3-1
San Jacinto River Watershed Analysis Zones**

The computed decay factors show that roughly half 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 decay 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 Agriculture and CAFO Sources

The load reduction to Canyon Lake necessary to demonstrate compliance with the LAs and WLAs for agriculture and CAFO 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 and CAFO land use.

Applying the ratios of WRCAC to total washoff (from Table 3-3) to watershed loads into Canyon Lake from all agriculture and CAFO 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 and CAFO sources (prior to formation of WRCAC) 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 and CAFO 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 and CAFO 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) |
| CAFO | TP | Existing / Estimated Load | 494 | 56 | 50 | 43 |
| | | Allowable Load ³ | 132 | 2 | 2 | 1 |
| | | Required Reduction / (Credit) | 362 | 54 | 48 | 42 |
| | TN | Existing / Estimated Load | 2,783 | 142 | 126 | 109 |
| | | Allowable Load ³ | 1,908 | 25 | 22 | 19 |
| | | Required Reduction / (Credit) | 875 | 117 | 104 | 90 |

1) Based on TMDL LA and WLA for agriculture and CAFO sources

2) Loads shown represent WRCAC members only

3) Allowable load is equal to the TMDL per acre LAs and WLAs and current and projected WRCAC member agriculture and CAFO land uses

For the AgNMP, the rate of attrition for agriculture and CAFO 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 forecast⁴ 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. Attachment X provides a full breakdown of existing and future land use, including division of agriculture and CAFO acreage between WRCAC members and non-members for the Canyon Lake watershed downstream of Mystic Lake.

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 credit. This credit could be used to offset required reductions from CAFO sources (see Section 2.X). Both agriculture and CAFO sources require a reduction in TP loads to achieve compliance with the TMDL; however, load reduction requirements are reduced over time as attrition lands occur (Figure 3-3).

⁴ http://www.dot.ca.gov/hq/tpp/offices/eab/socio_economic_files/2011/Riverside.pdf

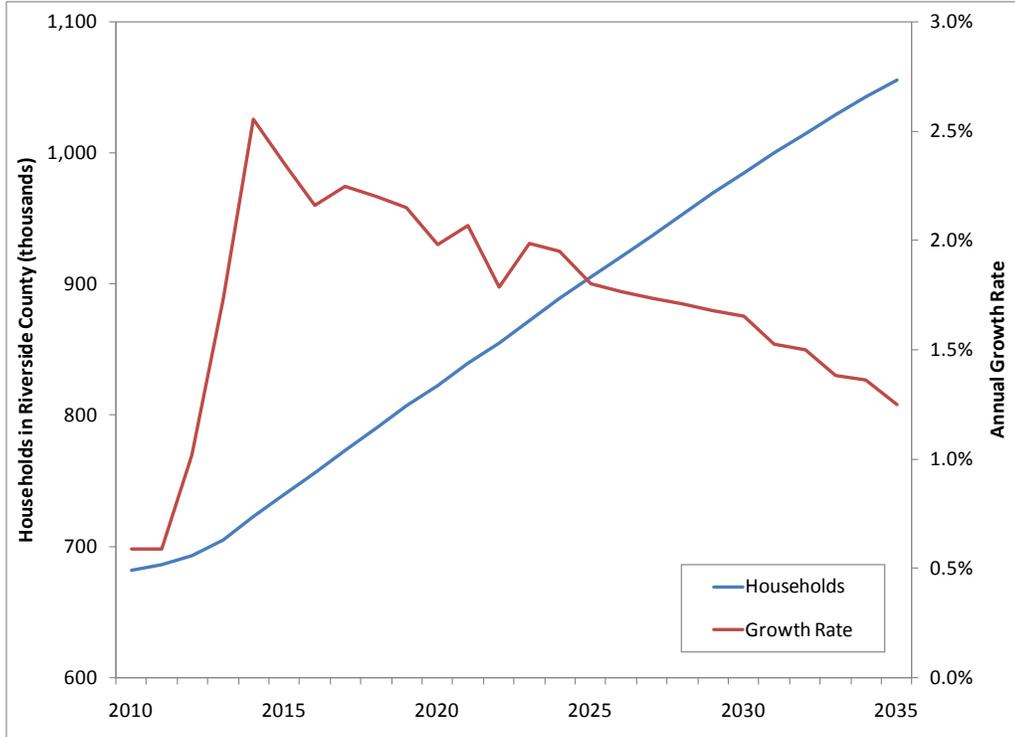


Figure 3-2
Projected Growth Rate for Urban Development in Riverside County (from Caltrans, 2011)

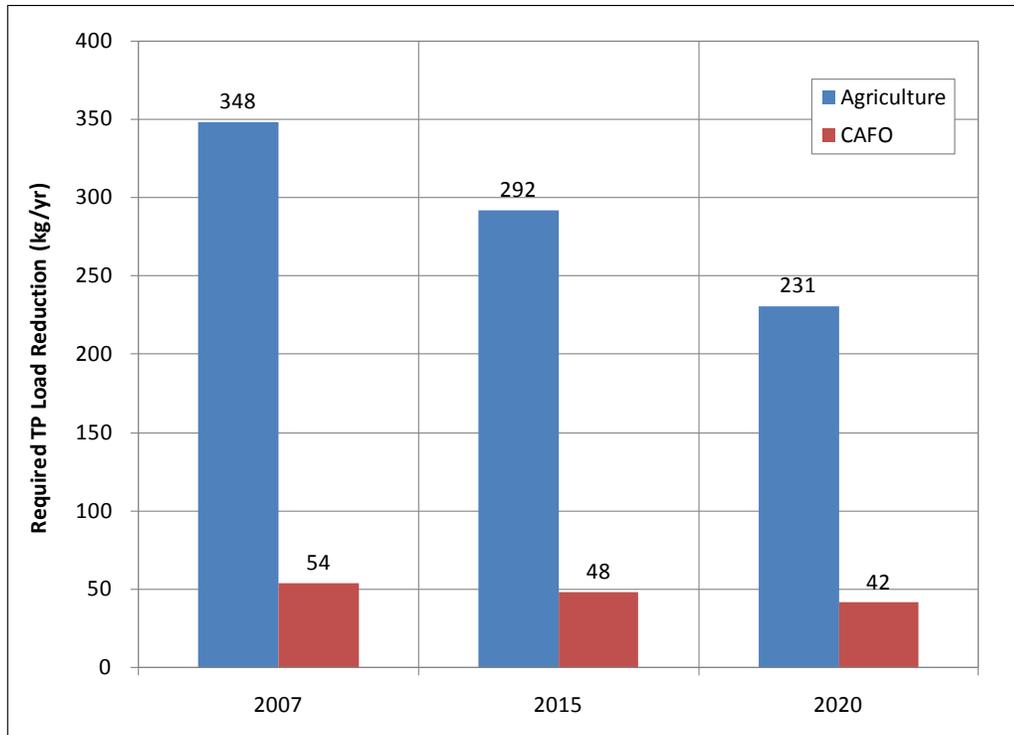


Figure 3-3
TP Load Reduction Needed from WRCAC Members in the Canyon Lake below Mystic Lake Watershed (no TN reduction is required)

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 and CAFO 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)
- Manure management practices

3.3.1 Conditional Waiver for Agricultural Discharges (CWAD)

The CWAD Program will require existing farms to implement 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 3-4. 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.

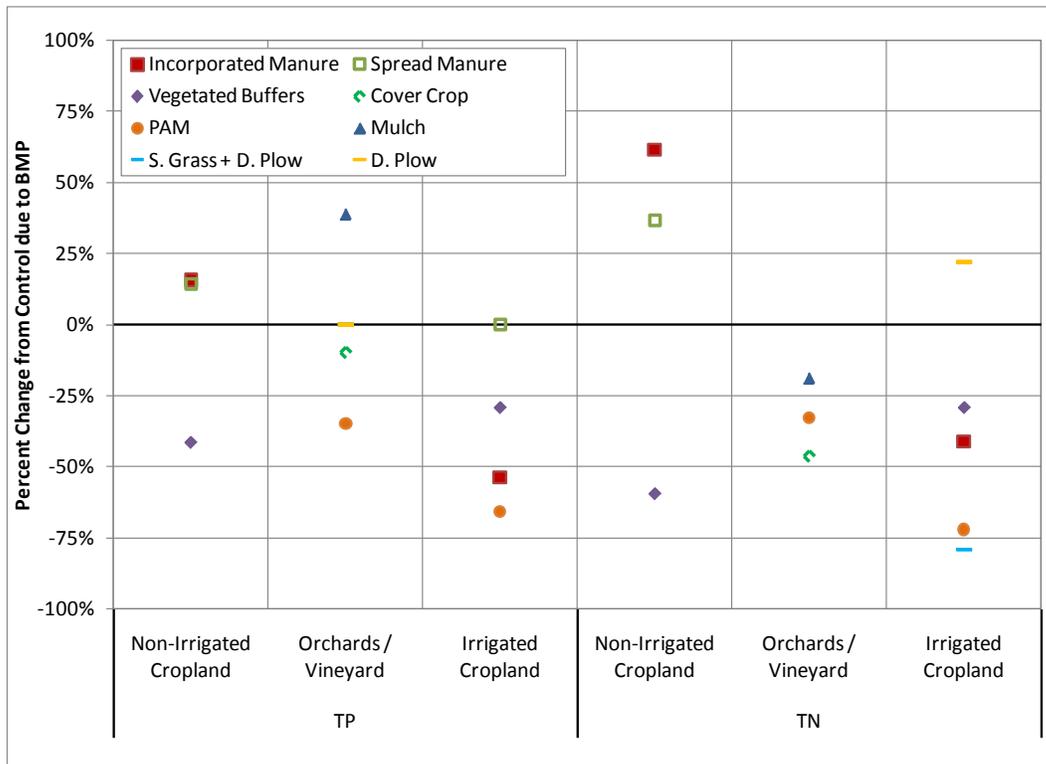


Figure 3-4 Effectiveness of Agricultural BMPs for TP and TN Loading Rate Reduction (data from UCR, 2011)

Table 3-5. TP and TN Washoff Reduction from Existing BMPs and Projected Implementation of BMPs Required by the CWAD

| 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 X). 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 the CWAD requirements, thus washoff reductions for retention BMPs are also included in the AgNMP compliance analysis (Table 3-5).

3.3.2 Manure Management

Manure management is planned for both CAFOs and agricultural operators. For CAFOs in Zones 2-6, there are only three existing WRCAC member CAFO operators, all of which have BMPs in place 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.

For agricultural 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 agricultural operators 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 manifests and special studies (see [Section 2.x.x](#)).

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 30 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 was 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 1.1 kg TP and 5.9 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 that use 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 | 20,598 | 115,392 | 0 | 0 |
| 2015 | 16,584 | 92,905 | -257 | -1,440 |
| 2020 | 12,205 | 68,372 | -284 | -1,590 |

1) Nutrients in spread manure are estimated as a function of manure application rate of 30 tons/acre, wet concentrations of TP and TN in manure of 1,000 mg/kg and 6,000 mg/kg, respectively, and 10 percent of irrigated agriculture in 2010 and projected for 2015 and 2020

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 and CAFO 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.

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 | -257 | -1440 | -468 | -1,786 |
| 2020 | -241 | -401 | -284 | -1590 | -525 | -1,991 |

1) Negative values indicate an increase of watershed nutrient washoff. Washoff reduction accounts for attrition of agricultural lands over the 2010 to 2020 period

Reductions of watershed nutrient washoff (using the appropriate decay 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 | -60 | -125 | 288 | -624 |
| 2015 | 292 | -993 | -208 | -835 | 84 | -1,828 |
| 2020 | 231 | -927 | -233 | -933 | -3 | -1,860 |

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 decay factor of 44 percent for TP and 56 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

Reduction of internal nutrient loads can offset reductions required from agriculture and CAFO sources that cannot be achieved with existing and planned watershed BMPs. The Task Force is developing a Pollutant Trading Plan (PTP) that describes the approach to be used by all stakeholders to offset watershed load reductions using in-lake BMPs (see Attachment X). In addition to the PTP, other pollutant trading arrangements between individual sources are planned, such as between agricultural and CAFO sources (see Section 2.X). The following sections describe existing in-lake remediation activities ongoing in Lake Elsinore and in-lake remediation project planned for Canyon Lake.

3.4.1 Lake Elsinore

Three in-lake remediation projects (or BMPs) are being implemented currently in Lake Elsinore: operation of an aeration 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 fishery management is sufficient to achieve in-lake nutrient load reduction needed to offset baseline sediment nutrient reduction requirements in Lake Elsinore. WRCAC will pursue fishery management with the City of Lake Elsinore to meet Lake Elsinore compliance.

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 system was planned for implementation at the time of TMDL adoption, a 35 percent TP reduction was assumed to create assimilative capacity and allow for development of LAs and WLAs for external sources. This assumed reduction in TP requires that achieve load reductions within Lake Elsinore equal to 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% | 0 |
| | Canyon Lake ² | 12% | 1,418 |
| CAFO | Local Lake Elsinore | 0% | 0 |
| | Canyon Lake ² | 0.1% | 17 |
| Total | | 12% | 1,435 |

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.

Anderson, 2006 showed that management of Carp populations in Lake Elsinore could reduce releases of TP by approximately 1,600 kg/yr. This in-lake remediation strategy would offset all of the baseline sediment nutrient load reduction required from WRCAC agriculture and CAFO sources.

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 construct a Hypolimnetic Oxygenation System (HOS) within Canyon Lake. Based on the MS4 Permittee CNRP, there will be sufficient TP offset capacity remaining to allow for this partnership (Table 3-10).

Table 3-10. Internal Nutrient Load Reduction from Implementation of HOS in Main Body of

| Nutrient | Lake Segment | TMDL Estimate of Sediment Nutrient Flux (kg/yr) | HOS Effectiveness (kg/yr) | Load Reduction (kg/yr) | Load Reduction Needed from MS4 Permittees (kg/yr) | Load Reduction Needed from WRCAC Ag (kg/yr) |
|--------------------------------|-----------------------|---|---------------------------|------------------------|---|---|
| Nitrogen as NH ₄ -N | Main Body | 8,578 | 35% | 3,002 | 2,800 | 0 |
| | East Bay ¹ | 4,971 | n/a | n/a | | |
| Phosphorus as SRP | Main Body | 2,685 | 70% | 1,880 | 500 | 150 |
| | East Bay ¹ | 1,940 | n/a | n/a | | |

1) Proposed HOS does not extend into shallower East Bay of Canyon Lake. Sediment nutrient flux would only be achieved in the Main Body

3.5 Uncertainty of Compliance Analysis

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. Many of these aforementioned documents are known to contain errors and other flaws due to various reasons, typically related to a lack of accurate and up to date land use information, water quality and/or other data for the watershed and lakes. However, these documents and studies represent the best available data regarding the lakes, their impairments, and potential remediation strategies. This compliance analysis relies on this available information and attempts to address known issues where feasible. However, this analysis is still an approximation based on best available data.

The AgNMP is expected to achieve compliance with long-term average annual LAs and WLAs for agriculture and CAFO sources. The AgNMP is conservative in its approach as evidenced by the presence of several additional watershed nutrient control BMPs that were not part of the quantification of washoff reduction (see [Section 2.X](#)). These BMPs will likely provide a significant margin of safety for compliance with the LE/CL nutrient TMDL. 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 given the 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 the HOS in Canyon Lake and fishery management in Lake Elsinore are based on limited data, empirical modeling, and incubation studies.

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WRCAC is committed to provide guidance and strategic planning for agricultural operators in the San Jacinto watershed. WRCAC believes this holistic watershed approach to the AgNMP is the appropriate approach. A tiered based schedule based upon various levels of nutrient loading and rewarding those who implement BMPs. The cafeteria style approach to selecting individual BMPs also has merit and we believe an incentive-based approach will garner positive results.

Respectfully submitted,

Pat Boldt
The Western Riverside County Agriculture Coalition

Project Director
December 31, 2011

Appendix Documents

- 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**
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- F. **Tetra Tech Report–Management Practices to Reduce Nutrient Loads from Agricultural Operations in the San Jacinto Watershed**
 - G. **Equestrian-Related Water Quality Best Management Practices**
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- H. **Poultry Production Best Management Practices (BMPs)**
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