Central Coast Watershed Studies

CCoWS

Agricultural Management Practices and Treatment Wetlands for Water Quality Improvement in Southern Monterey Bay Watersheds:

Final Report

Kelleen Harris[1]
Fred Watson*[1]
Karminder Brown[3]
Rob Burton*[4]
Shana Carmichael[1]
Joel M. Casagrande[1]
Julie R. Casagrande[1]
Miles Daniels[1]
Sam Earnshaw*[2]
David Frank[1]
Emily Hanson*[3]
Laura Lee Lienk*[1]
Peter Martin[1]
Brad Travers[1]
Jessica Watson[1]
Adam Wiskind*[4]

(Overall report produced by Harris & Watson)

* Principal Investigators
[1]Watershed Institute, California State University Monterey Bay
[2]CAFF
[3]RCDMC
[4]MLML

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The Watershed Institute
Division of Science & Environmental Policy
California State University Monterey Bay
http://watershed.csumb.edu

100 Campus Center, Seaside, CA, 93955-8001
831 582 4452 / 4431

1 Signature/Approval Page

PROJECT NAME: IMPROVING COASTAL WATER QUALITY THROUGH WETLANDS RESTORATION AND THE IMPLEMENTATION, DEMONSTRATION, AND MONITORING OF AGRICULTURAL MANAGEMENT PRACTICES IN THE GABILAN WATERSHED

SWRCB Agreement Number: 03-193-553-1

GRANT ORGANIZATION:

Title:	Name:	Signature:	Date:
SJSUF/MLML PI	Adam Wiskind		
CCoWS Co-PI	Dr. Fred Watson		
RCDMC Co-PI	Emily Hanson		
RON Co-PI	Laura Lee Lienk	Laura Lee Lienk	
CAFF Co-PI	Sam Earnshaw	Sam Earnshaw	

REGIONAL BOARD (CCRWQCB):

Title:	Name:	Signature:	Date:
Contract Manager	Amanda Bern		
QA Officer	Karen Worcester		

2 Preface

Funding for this project has been provided in full or in part through Agreement number 03-193-553-0 with the State Water Resources Control Board (SWRCB) pursuant to the Costa-Machado Water Act of 2000 (Proposition 13) and any amendments thereto for the implementation of California's Nonpoint Source Pollution Control Program. The contents of this document do not necessarily reflect the views and policies of the SWRCB, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

An amount of $5,000 was allocated under the agreement for the preparation of the draft and final project report.

This project was completed as a collaboration between Moss Landing Marine Laboratories (MLML), the Watershed Institute at CSUMB, the Resource Conservation District of Monterey County, Community Alliance with Family Farmers, and Coastal Conservation and Research. The UC Davis Granite Canyon Marine Laboratory also participated as a partner in Wetland monitoring.

3 Acknowledgements

The following organizations and staff contributed greatly to the success of this project:

- Agricultural cooperators
- California Coastal Commission
    - Ross Clark
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- Central Coast Regional Water Quality Control Board:
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- Central Coast Watershed Studies:
    - Staff: Brad Travers, Joel Casagrande, Julie Casagrande, Wendi Newman, Dr. Marc Los Huertos, Regina Williams, Joy Larson, Morgan Wilkinson, Dr. Douglas Smith.
    - Students: Miles Daniels, Peter Martin, Jessica Watson, Shana Carmichael, David Frank
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    - Kellie Rey, Cara Clark
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    - Staff: Deborah Nares, Melanie Beretti, Karminder Brown, Rene Aguas, Ruthie Schafer
    - Students: Fernando Quintero
- Return of the Natives:
    - Christina Hurley-McKnew, Peter Nelson, Julie Dustin, Bree Candiloro, Emily Smith and the Greenthumbs
- U.C. Davis Granite Canyon Marine Laboratory:
    - Brian Anderson, John Hunt, Bryn Phillips, Sara Clark, Jennifer Voorhees

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5 Executive Summary

1. This project contained the following elements:
    a. Practice implementation on agricultural lands
    b. Practice effectiveness monitoring in relation to water quality from agricultural lands
    c. Construction of a treatment wetland
    d. Experimental operation and monitoring of the treatment wetland
    e. Education and outreach to both growers and other community members
2. Biological monitoring at the Wetland site to monitor changes in populations of native plants and birds before and after construction, and document establishment of macroinvertebrates.
3. Water quality monitoring results are summarized as follows:
    a. Practice effectiveness monitoring
        i. Sediment loads were reduced by:
            1. Sediment retention basins
            2. Restoration of vegetation to erodible hillsides
        ii. There is not strong evidence that nutrient loads were reduced by most basins monitored.
    b. Wetland effectiveness monitoring
        i. The wetland was effective at removing large fractions of nitrate and suspended sediment inputs within retention times of several days. It was also effective at removing ammonia, phosphate, and diazinon but over longer retention times, and with more variance in the data. The wetland was not effective at removing dimethoate.
        ii. Maximum removal of pollutant load continued to be indicated at the highest pumping rates (corresponding to the shortest retention times). It is thus recommended that actively pumped wetlands be used in preference to passive, low-flow wetlands with respect to the goal of reducing pollutant loads transported to downstream water bodies.
        iii. An initial estimate of the amount of similarly operated wetland required to remove the average total load of the Gabilan Watershed is 300 hectares, or 0.9% of the watershed.

6 Introduction

6.1 Background

The project described in this report was one of the outcomes of the Costa-Machado Water Act of 2000, and the ensuing ballot Proposition 13. Proposition 13, a citizen approved measure, appropriated 100 million dollars for nonpoint source control activities and an additional 90 million for coastal nonpoint source control measures throughout the state of California. The State Water Resources Control Board manages the funding with county responsibilities delegated to regional boards.

The following group of organizations was awarded this grant from Proposition 13 funds to improve water quality flowing from the Gabilan Watershed and surrounding Southern Monterey Bay Watersheds into Monterey Bay coastal waters:

- Community Alliance for Family Farmers (CAFF)
- Resource Conservation District of Monterey County (RCD)
- Moss Landing Marine Laboratories (MLML)
- Coastal Conservation and Research (CC&R)
- The Watershed Institute at CSUMB:
  - Central Coast Watershed Studies (CCoWS)
  - Return of the Natives (RON)

6.2 Project Goals

The primary goal of the project was to improve coastal water quality through wetland restoration and the implementation, demonstration, and monitoring of agricultural management practices. The project includes three components, or actions used to achieve these goals:

- Education, outreach, implementation and monitoring of on-farm management practices aimed at reducing source pollution,
- Water quality monitoring in the Tembladero Slough to develop annual estimates of pollutant loading and,
- The design, construction, monitoring, and use as a demonstration site of a constructed wetland for pollutant remediation.

6.3 Deliverables

Table 6.1 is the complete list of all deliverables submitted for the project.

Table 6.1. Project deliverables submitted.

TASK	SUB-TASK	DELIVERABLE	DUE DATE	DATES COMPLETED
1		**PROJECT ADMINISTRATION**		
	1.2	Progress Reports	06/10/05 and quarterly thereafter	6/10/2005, 9/10/2005, 12/10/05, 3/01/2006, 6/20/2006, 9/20/2006, 12/11/2006
	1.5	Contract Summary Form	3/10/2005	3/10/2005
	1.6	Subcontractor Documentation	06/10/05 and quarterly thereafter	6/10/2005
	1.7	Expenditure/invoice projections	09/10/05 and every 6 months thereafter	12/10/2005
	1.8	Project Survey Form	3/1/2007	To be completed upon report completion
2		**CEQA/NEPA DOCUMENTATION AND PERMITS**		
	2.1	CEQA/NEPA Documentation	12/10/2005	8/10/2005
	2.2	Permits	12/10/2005	12/10/2005
3		**QUALITY ASSURANCE PROJECT PLAN**		
	3.1	Approved and signed QAPP	6/10/2005	6/10/2005, 3/12/2006
	3.2	Approved monitoring plan	6/10/2005	6/10/2005, 11/15/2005
4		**PROJECT ASSESSMENT AND EVALUATION PLAN**		
	4.1	Project Assessment and Evaluation Plan	9/10/2005	3/12/2006, 6/19/2006
5		**IMPLEMENTATION OF AGRICULTURAL BEST MANAGEMENT PRACTICES (BMPs)**		
	5.1.3	Signed landowner agreements.	09/10/05 and quarterly thereafter	6/20/2006, 9/20/2006, 12/11/2006
	5.2.2	Engineering and/or conservation design plans	09/10/05 and as developed thereafter	9/10/2005, 12/10/2005, 6/20/2006, 12/11/2006
	5.3.2	List of native plants propagated	09/10/05 and quarterly thereafter	[illegible] 3/20/2006, 6/20/2006, 9/20/2006, 12/11/2006
6		**WETLANDS/RIPARIAN RESTORATION**		
	6.1.2	Signed landowner agreements.	03/10/05 and quarterly thereafter	6/10/2005
	6.2.2	Restoration project design plans	06/10/05 and as developed thereafter	6/10/2005, 3/20/06
	6.3.2	List of native plants propagated	06/10/05 and quarterly thereafter	6/10/2005, 3/20/2006
	6.5.1	Notification letter	12/10/05 and quarterly thereafter	3/20/2006
7		**MONITORING**		
	7.1.1	Monitoring Plan	6/10/2005	11/15/2005
	7.2.2	Database of all water quality measurements made	3/1/2006	6/19/2006
	7.2.3	Poster map	3/1/2006	6/19/2006
	7.3.1	Photos of restoration sites	06/10/05 and quarterly thereafter	9/10/2005, 12/10/2005, 3/20/2006, 6/19/2006, 9/15/2006, 12/05/2006
	7.4.2	Bird survey data	06/10/05 and quarterly thereafter	3/20/2006, 6/20/2006, 9/15/2006, 12/11/2006
	7.5	Benthic Invertebrate data	06/10/05 and quarterly thereafter	6/10/2005, 12/10/2005, 6/19/2006, 9/19/2006, 12/05/2006
8		**DRAFT AND FINAL REPORT**		
	8.2	Draft Project Report	1/10/2007	1/10/2007
	8.3	Final Project Report	3/1/2007	5/2/2007

6.4 Study Area

6.4.1 General Watershed Description

The project's study area occupies several small watersheds that ultimately drain into southern Monterey Bay (Fig 6.1) including Gabilan, Quail, Chualar, and Carneros creek watersheds.

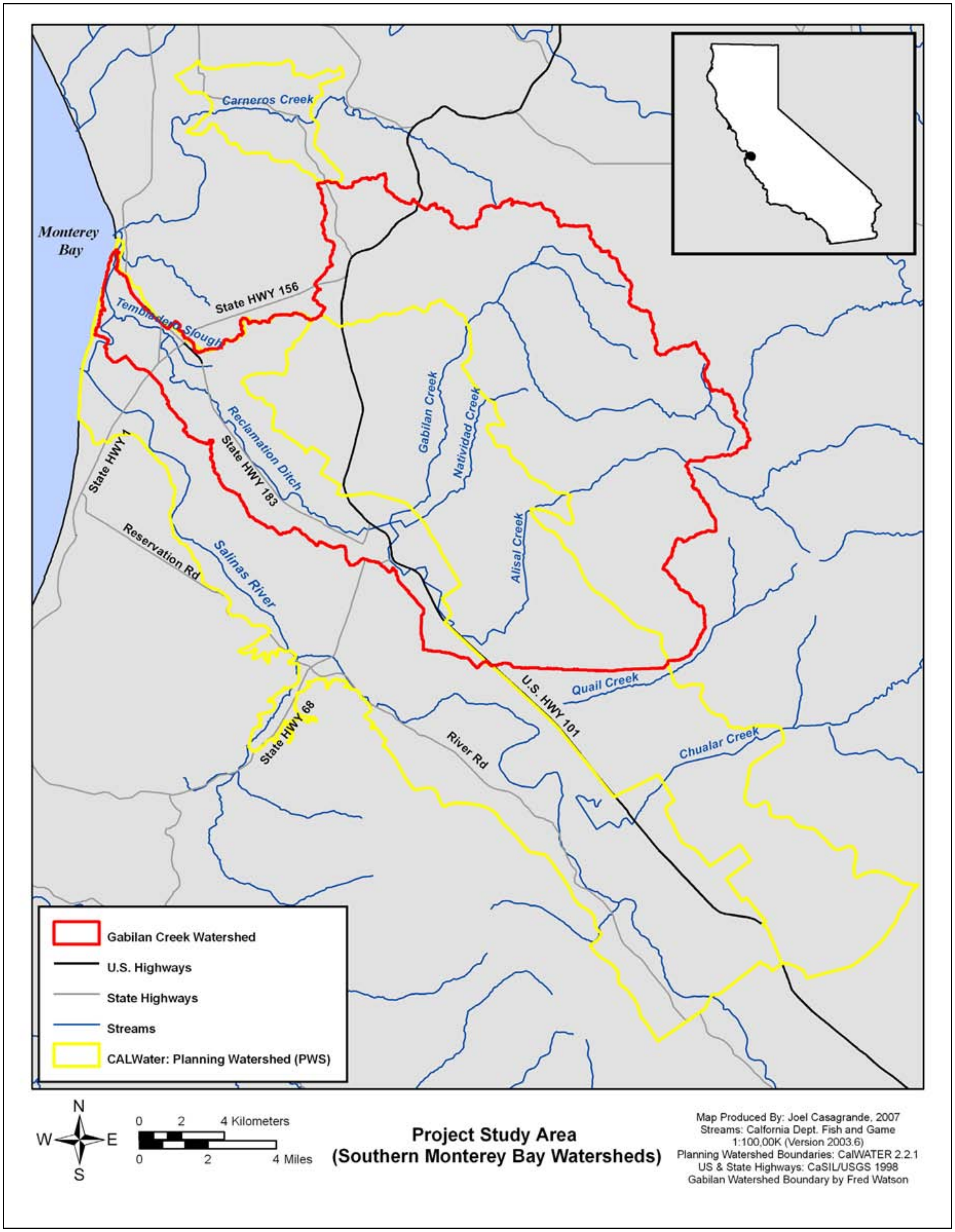


Figure 6.1. The general project study area including the Gabilan Creek Watershed and nearby/overlapping CALWATER "Planning Watershed" boundaries.

6.4.2 Land use

On the valley floor, row crop agriculture is the dominant land use. Primary crops grown in this region include lettuce, broccoli, strawberries, and artichokes. The City of Salinas is also on the valley floor and centered within the project area. To the east lies the Gabilan Range that supports a mixture of oak woodland and chaparral communities used primarily as cattle grazing lands. The northern boundary of the study area is occupied by low rolling hills that support a mixture of agriculture (primarily strawberries and artichokes), oak-savanna grazing lands, and low density residential areas, including the town of Prunedale and neighboring communities.

6.4.3 Climate

The climate of the northern Salinas Valley is consistent with the dominant Mediterranean style observed throughout much of the Central California Coast with mild, wet winters followed by warm and dry summers. Mean annual precipitation varies throughout the study area (figure 6.2) with a majority falling between the months of December and March. Winds generally blow down the valley and serve as a key feature in regulating the overall climate especially during summer months.

6.4.4 Soils

Soil conditions vary throughout the study area as well. In general soils on the valley floor and lower foothill areas consist of deep layers of relatively fine sedimentary deposits of fluvial origin (Fig 6.3). With the exception of the extreme northern most region of the study area, the surface soils have a moderate to high erodibility potential (figure 6.4).

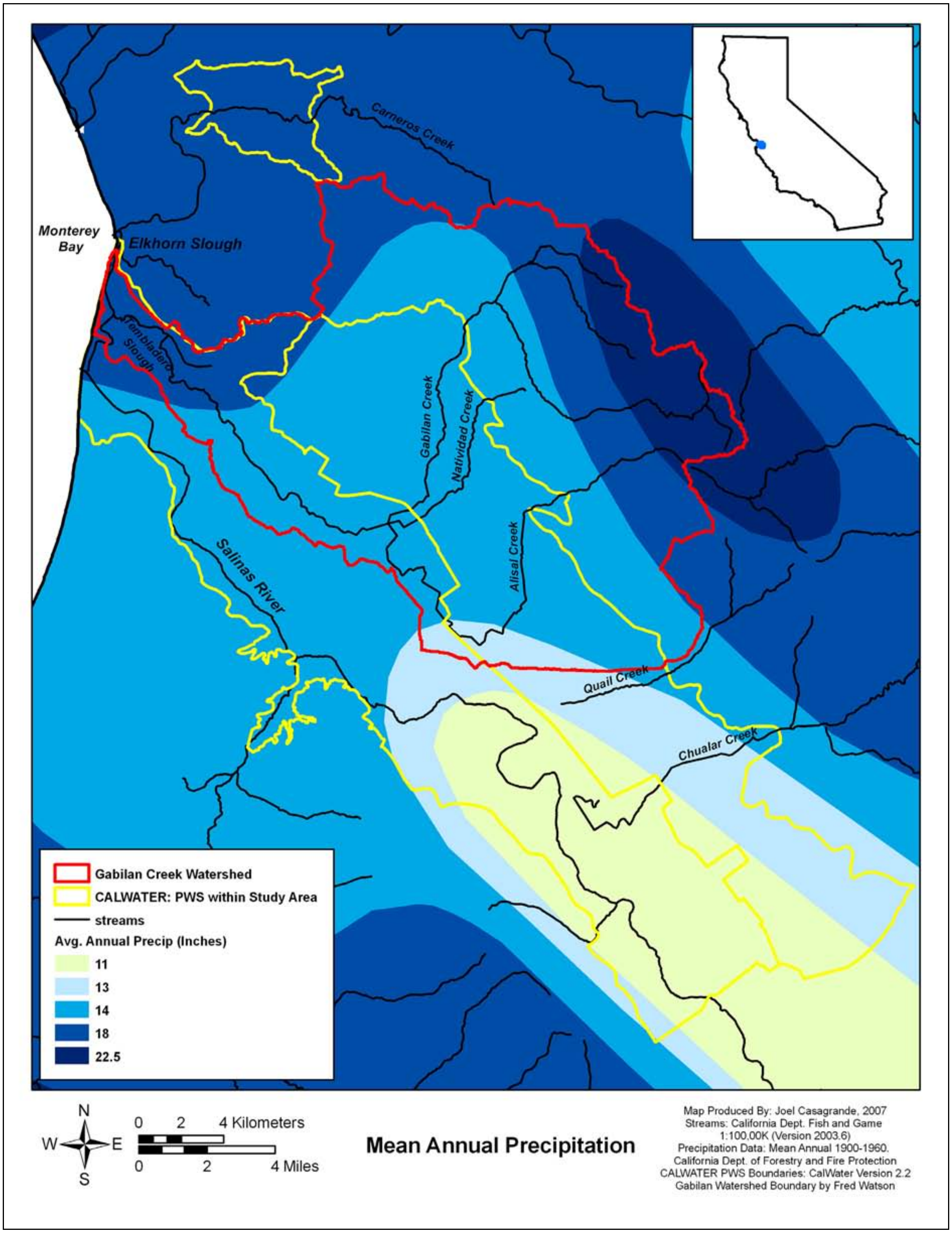


Figure 6.2 Mean annual precipitation for the Northern Salinas Valley.

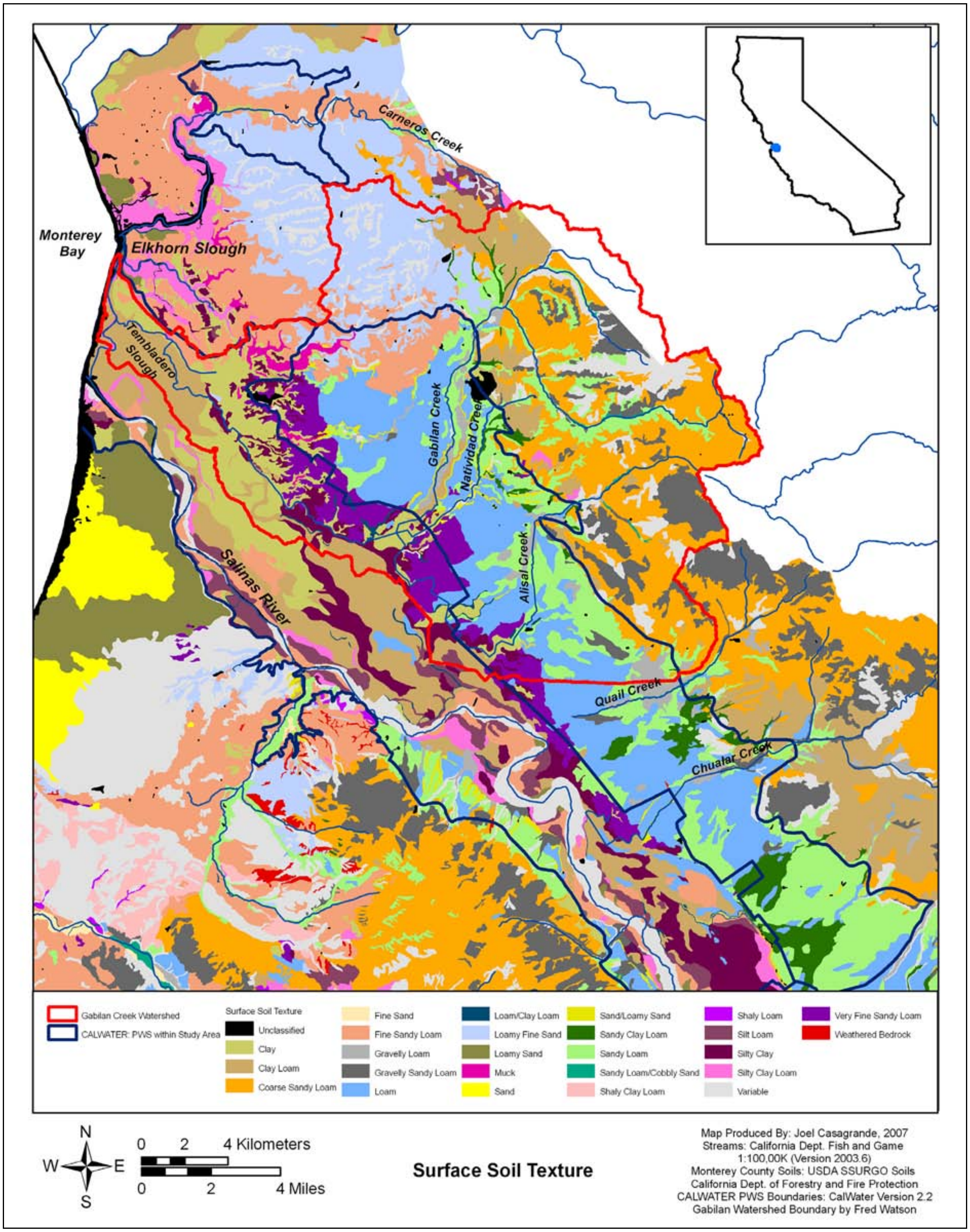


Figure 6.3. Surface soil texture for the Southern Monterey Bay Watersheds including the Gabilan Watershed.

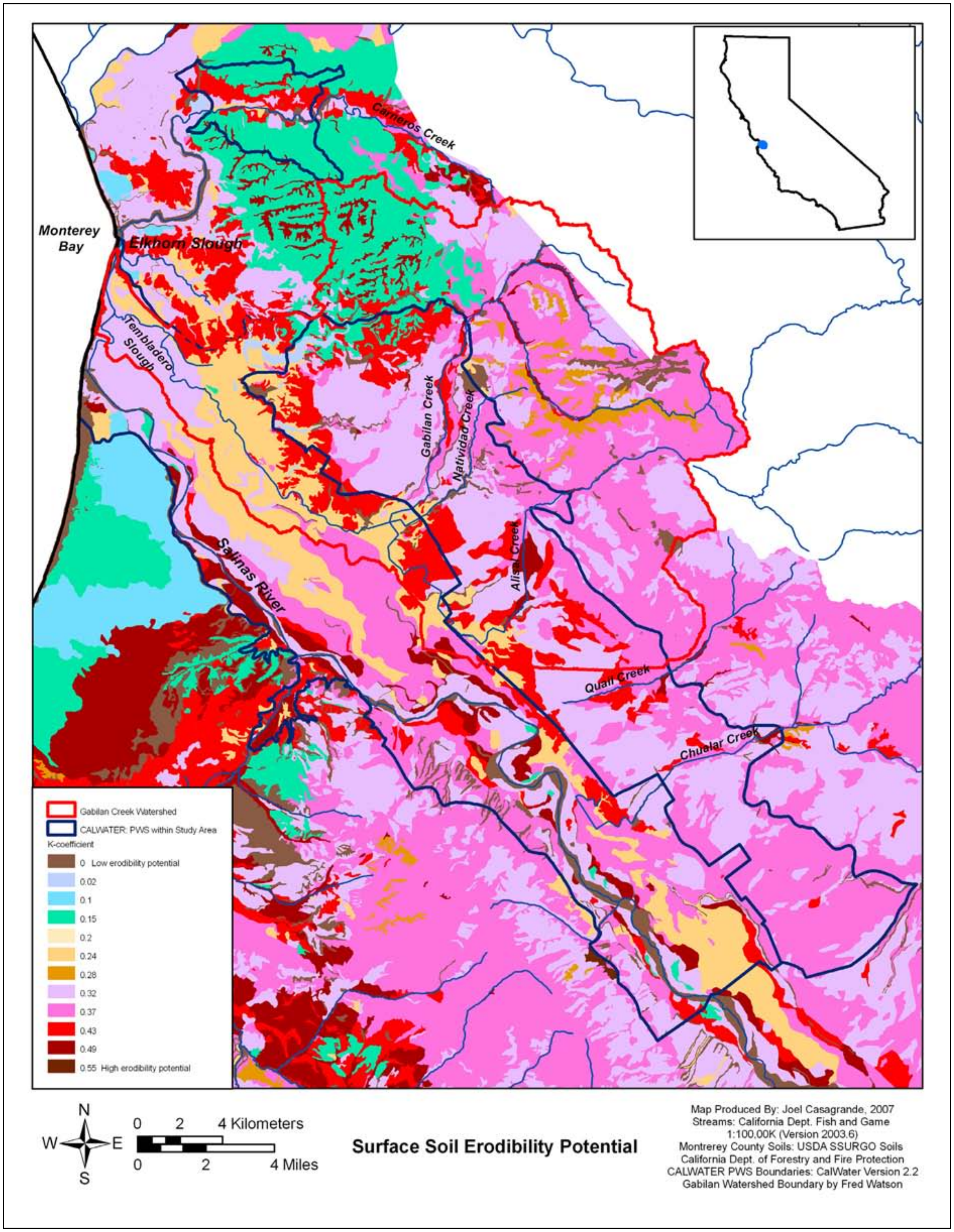


Figure 6.4. Surface soil erodibility potential (KKFACT) for the Southern Monterey Bay Watersheds, including the Gabilan Watershed.

6.4.5 Water Quality Concerns and Water Body Listings

Recent studies have documented numerous water quality concerns and trends throughout the region (SWRCB, 1999; Worcester et al. 2000; Hunt et al. 2002; Anderson et al. 2003a; Anderson et al. 2003b; Anderson et al. 2003; Watson et al. 2003; Kozlowski et al. 2004a; Kozlowski et al, 2004b; and Casagrande and Watson, 2006; Hoover, 2007). Decades of intense land use, particularly agriculture and urban developments and livestock grazing, have resulted in impaired water quality conditions in several water bodies throughout the region. As a result, several local water bodies have been listed on the 303(d) list of impaired waters (under the Federal Clean Water Act, Table 6.2). At present, thirteen water bodies in the Northern Salinas Valley (both source and receiving), containing a total of 38 listings, are on the 303(d)-list.

Moss Landing Harbor and its tributaries (e.g. Tembladero Slough) have also been listed as Toxic Hotspots for pesticides and PCB's on the State Water Resource Control Board's 1999 Consolidated Toxic Hot Spot Cleanup Plan (SWRCB, 1999a,b). These water bodies were rated as "high priority toxic hot spot" to aquatic life due to the sensitivity of the habitat and the high levels of toxicity in both sediment and tissues samples taken from these waters on more than one occasion. The listing for Human Health was considered moderate because no recent health advisories have been posted (SWRCB, 1999b).

Table 6.2. 303d listed water bodies within the study area, their listing, and estimated area affected. Source: www.waterboards.ca.gov/tmdl/docs/303dlists2006/final/r3_final303dlist.pdf

Water Body	Pollutant/Stressor	Estimated Size Affected
Alisal Creek	Fecal Coliform	7.4 miles
	Nitrate	7.4 miles
Blanc Drain	Pesticides	15 miles
Elkhorn Slough	Pathogens	2034 acres
	Pesticides	2034 acres
	Sedimentation/siltation	2034 acres
Espinosa Slough	Priority Organics	1.5 miles
	Pesticides	1.5 miles
Gabilan Creek	Fecal Coliform	6.4 miles
	Nitrate as Nitrate (NO3)	6.4 miles
Moro Cojo Slough	Ammonia (Unionized)	62 acres
	Low Dissolved Oxygen	62 acres
	Pesticides	62 acres
	Sedimentation/siltation	62 acres
Moss Landing Harbor	Pathogens	79 acres
	Pesticides	79 acres
	Sedimentation/siltation	79 acres
Natividad Creek	Nitrate as Nitrate (NO3)	7 miles
Old Salinas Estuary	Ammonia (unionized)	74 acres
	Fecal Coliform	74 acres
	Low Dissolved Oxygen	74 acres
	Nutrients	74 acres
	Pesticides	74 acres
Quail Creek	Nitrate as Nitrate (NO3)	4.2 miles
Salinas Reclamation Canal	Ammonia (unionized)	14 miles
	Fecal Coliform	14 miles
	Low Dissolved Oxygen	14 miles
	Pesticides	14 miles
	Priority Organics	14 miles
Salinas River (lower, estuary to near Gonzales Rd crossing, watersheds 30910 and 30920)	Fecal Coliform	31 miles
	Nitrate as Nitrate (NO3)	31 miles
	Nutrients	31 miles
	Pesticides	31 miles
	Salinity/TDS/Chlorides	31 miles
	Toxaphene	31 miles
Salinas River Lagoon (North)	Nutrients	197 acres
	Pesticides	197 acres
Santa Rita Creek (Monterey County)	Nitrate as Nitrate (NO3)	11 miles
Tembladero Slough	Ammonia (unionized)	5 miles
	Fecal Coliform	5 miles
	Nutrients	5 miles
	Pesticides	5 miles

6.5 Site Locations

Management practices were installed and monitored within and around the Gabilan Watershed, all within areas flowing to the Monterey Bay National Marine Sanctuary. Since site locations are confidential, we refer only to the Gabilan Watershed and its nearby and overlapping CALWATER Planning Watersheds when describing how many installations and monitoring events occurred (Figure 6.5). The squares denote the number of practices installed, and the circles denote the number of practices monitored, within each CALWATER Planning Watershed. The Wetland location is identified on the map. The next figure (6.6) provides a close-up view of the Wetland location and both Tembladero Slough sampling sites.

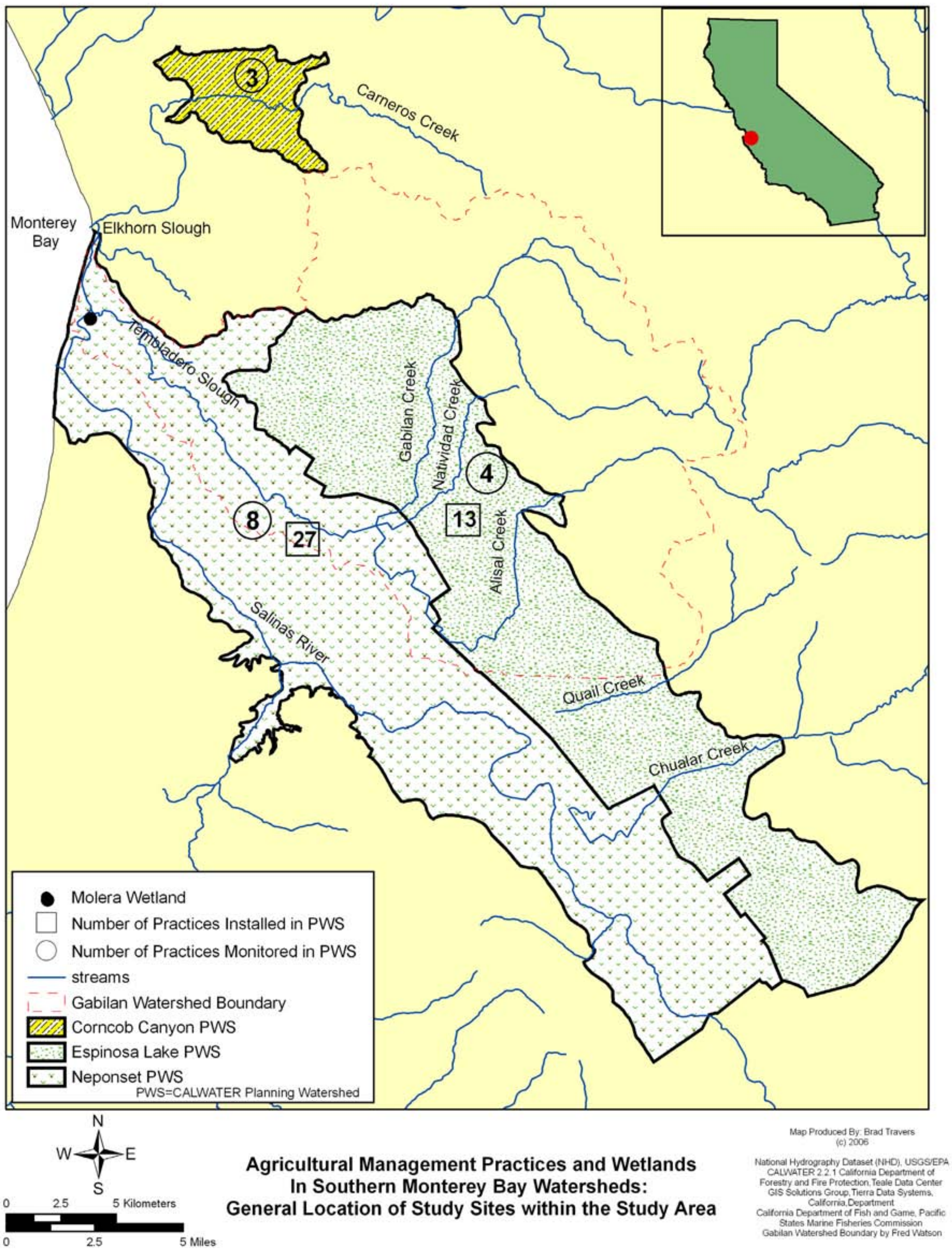


Figure 6.5. The project study area showing CALWATER Planning Watershed boundaries where practices were located and monitored. Each circled number denotes the practices monitored within that Planning Watershed. The numbers in squares are the amount of practices installed.

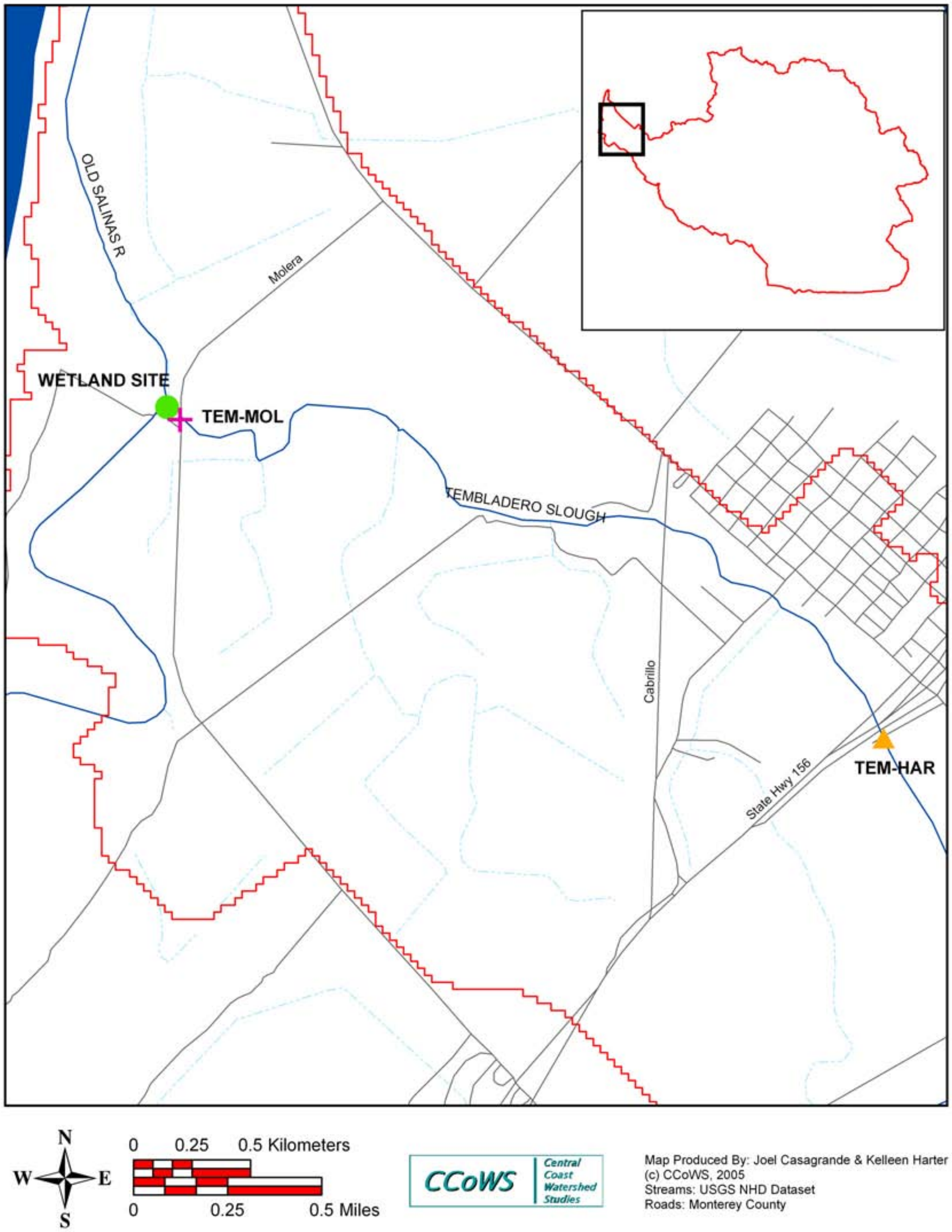


Figure 6.6. Wetland location at the confluence of the Tembladero Slough and the Old Salinas River Channel, and Watershed level sampling site on the Tembladero Slough (CCoWS site TEM-HAR). TEM-MOL was sampled as the source water for the Wetland

7 Project Design

This project was composed of three primary pieces:

- Education and outreach
- Practice Implementation including:
    - Agricultural management practice implementation
    - Constructed wetland installation
- Research and monitoring

The first step was outreach and education within the community to find growers interested in installing management practices. Additionally, a site to place a constructed wetland had to be located. Once this was accomplished, then agricultural management practices were installed throughout the watershed, and the wetland was constructed at its base. Water quality monitoring then took place. The three sub-components of monitoring were:

- Agricultural management practice effectiveness
- Watershed loads
- Constructed wetland effectiveness

Agricultural management practices in use throughout the watershed were tested for their effect on sediment and nutrients in runoff water. Near the base of the Watershed (CCoWS site TEM-HAR) samples to calculate loads of nutrients, sediment and some pesticides were collected over a year-long time span. Finally, the constructed wetland at the base of the watershed was monitored for its effects on water quality.

This report is organized chronologically whenever possible, and from efforts at the top of the watershed to the bottom (source improvement to Wetland site). It starts with the goals of Agricultural practice implementation, the education and outreach effort to growers (CAFF and RCD), how practices were implemented, and a description of how practice demonstration was completed. The next chapter describes education and outreach activities that occurred with the growing of plants for all project sites (RON) and Wetland demonstration. Next are chapters on the agricultural practice monitoring effort including field and laboratory methods and results, Watershed level monitoring, Wetland design and construction, and Wetland photo and biological monitoring. The last chapter is a discussion of how PAEP goals were met.

8 Agricultural Practice Education, Outreach, and Implementation

This section will address goals, how practices were implemented, and provide a list of sites and methods.

8.1 Overall Goals

The overall goal of this task was to address pollutants and sediments entering the watershed from agricultural sites by implementing a range of agricultural best management practices throughout the upper and middle Gabilan Watershed. Specifically, the target was to design and plan the implementation of a minimum of twenty (20) practices, on at least seven (7) properties. Practices were to be determined on a site-by-site basis depending on conditions and could include, but were not limited to, sediment and water retention basins, grassed waterways, filter strips, critical area plantings (establishment of vegetation on steep slopes), and stream bank stabilization. The RCD and CAFF were responsible for providing technical support (and/or referrals, as appropriate) for the implementation of practices, which would occur voluntarily with grower/landowner participation and contribution.

The two main goals of the education and outreach task was for the RCD and CAFF to 1) conduct outreach and educate growers/landowners about the economic and environmental benefits of agricultural best management practices (BMPs), and 2) to follow up with participants in educational events with direct phone calls and/or farm visits and referrals, in order to identify participants for BMP implementation.

8.2 Education and Outreach Activities/Results

8.2.1 Resource Conservation District of Monterey County

During the project period, the RCD conducted the following activities in direct support of the education and outreach task:

- Conducted dry season and rainy season driving tours of the Gabilan watershed with staff and partners to begin the process of identifying suitable sites and potential cooperators for implementation of agricultural conservation practices.
- Developed a Gabilan Watershed Assistance Program brochure for outreach to growers in the project area. The brochure was distributed at outreach and education events during the first 18 months of the project.
- Participated in three Reclamation Ditch (Gabilan) Watershed Assessment Technical Advisory Committee (TAC) meetings.
- Assisted in facilitating a public Stakeholder Meeting to solicit input on the Draft Reclamation Ditch Watershed Assessment and Management Plan.

- Presented information on assistance available through this project at UCCE/CAFF's Irrigation and Nutrient Management Meeting and Cover Crops Field Day in Salinas, February 2005.
- For the 2005 Winter Road-Seeding Program, mailed out postcards to 215 strawberry growers in the Gabilan Watershed to announce the RCD's Program and remind growers about winter preparedness.
- For the 2006 Winter Road-Seeding Program, collaborated with the California Strawberry Commission and ALBA to plan targeted outreach to their members in the Gabilan Watershed.

Throughout the duration of the project, the RCD worked with the agricultural community to conduct one on one outreach and follow-up to referrals to educate growers and landowners in the Gabilan project area about the benefits of integrating agricultural best management practices into their operations. The following RCD outreach and education activities were paid for in part with funds from this grant, leveraged through other state funding, and matched through non-state funding sources:

- Participated in meetings with ALBA and the MCFB to develop a protocol for referring growers to the RCD for technical assistance. The protocol helped facilitate implementation of projects by growers in the Gabilan project area who had completed the Farm Water Quality Short Course and wanted to implement components of their Farm Water Quality Plans.
- Met with MCFB staff and cooperators to strategize expansion of outreach in the Gabilan watershed to demonstrate the potential benefits of vegetated treatment systems in agricultural ditches.
- Gave two presentations: Calidad de Agua en la Costa Central de California (Watershed Function and Local Data) and RCD Technical Assistance at the Spanish-language Farm Water Quality Short Course in Watsonville, January 2005.
- In collaboration with NRCS, set up a display at the AWQA media event in March 2005. The event took place on a Salinas Valley vegetable farm, and highlighted agricultural conservation practices and water quality protection strategies.
- Secured $1,000 from the Central Coast Resource Conservation & Development Council for translation of the RCD-produced Handbook of Agricultural Practices into Spanish. The Handbook was used for outreach in the Gabilan project area.
- Gave the presentation Calidad de Agua en la Costa Central de California (Watershed Function and Local Data) at the Spanish-language Farm Water Quality Short Course in Salinas, April 2005.
- Gave the presentation Riparian Areas and Waterways at the Farm Water Quality Short Course for Nurseries, Salinas, September 2005.
- Coordinated with MCFB staff, UC researchers, and cooperators to sponsor an educational meeting for the Blanco Drain/Alisal Slough Watershed Working Group, which

included an RCD presentation on the potential benefits of vegetated treatment systems, December 2005.
- Gave the presentation Cursos de Agua y Áreas Ribereñas (Riparian Areas and Waterways) at the Spanish-language Farm Water Quality Short Course in Prunedale, December 2005.
- Gave a field presentation on soil erosion control and winter preparedness to ALBA's Spanish-language beginning farmers class in Salinas, January 2006.
- Gave a presentation on RCD technical assistance at the Gabilan & Chualar/Quail Watershed Working Group meeting in Salinas, January 2006.
- Gave a presentation on agricultural conservation practices at the Monterey County Agricultural Commissioner's Spanish-Language Ag Expo in Spreckles, March 2006.
- Finalized, reproduced and compiled the Technical Tool-Kit of Agricultural Conservation Practices and distributed it to technical assistance and outreach partners throughout the project area.
- Gave the presentation Resources and Technical Assistance for Farmers and Ranchers in Monterey County at the MCFB Water Committee Meeting in Salinas, May 2006.
- Participated as an exhibitor at the statewide Sustainable Ag Expo in Monterey, November 2006. Staff discussed technical assistance available through this grant with Salinas Valley growers who visited the RCD booth.

8.2.2 Community Alliance with Family Farmers

Throughout the duration of this project, CAFF staff worked with the press, public and agricultural community to conduct outreach and educate growers and landowners about the benefits of agricultural best management practices. During the project period, CAFF staff conducted the following outreach and education activities, which were paid for in part with funds from this grant through a sub-contract with the RCD, leveraged through state funding, and matched through non-state funding sources:

- Conducted session on conservation plantings at the Western Region Sustainable Agriculture Research and Education (WSARE) project Train the Trainer Workshop, King City, September 2004.
- Announced project and explained vegetated conservation practices at the UCCE Fresh Produce Marketability Program in Watsonville, December 2004.
- Gave a presentation on agricultural conservation practices at the UCCE Organic Vegetable Production Short Course in Salinas, January 2005.
- Gave the presentation Farmscaping and Vegetation Conservation Practices at the Eco-Farm Conference in Asilomar, January 2005.
- Gave the presentation Vegetation Conservation Practices and led a field tour for the Vegetative Restoration class at Cabrillo College, Capitola, May 2005.
- Gave the presentation Vegetation Conservation Practices at the USDA-sponsored Success Strategies for Small and Limited Resource Farmers and Ranchers conference in Burlingame, May 2005.

- Gave a presentation on hedgerows and grassed waterways at the UCCE/ALBA Biocontrol for Farmers workshop in Salinas, September 2005.
- Gave the presentation Farmscaping for Pest Management at the Central Valley Chapter of the California Association of Pest Control Advisors semi-annual meeting in Modesto, October 2005.
- Gave a presentation on farmscaping at the 2005 Sustainable Ag Expo in Paso Robles, November 2005.
- Contributed farmscaping information to the presentation at the Spanish-language Biocontrol for Farmers: How to use Natural Enemies to Control Pests in Central Coast Crops workshop in Salinas, November 2005.
- Gave the presentation, Hedgerows on Central Coast Farms, at the USDA Agricultural Station in Salinas, as part of the Biological Control of Insect Vegetable Pests on the Central Coast Short Course, July 2006.
- Gave a presentation, Farmscaping with Native Plants, at the Spanish-language Biological Control of Strawberry and Vegetable Pests on the Central Coast workshop in Salinas, October 2006.

8.3 Securing implementation sites

In addition to the hundreds of potential cooperators who were reached through RCD and CAFF presentations and workshops at the events listed above, RCD and CAFF staff conducted outreach with many individual farmers and landowners, primarily through site visits and/or follow-up site assessments to evaluate the potential for implementation of agricultural conservation practices.

8.3.1 Individual Outreach

During the project period November 2004 – February 2007, the RCD conducted more than 75 individual outreach contacts (site visits and/or phone calls) to more than 50 individual farmers or landowners. These contacts were listed by cooperator code and summarized in quarterly progress reports, and include multiple contacts with some individual cooperators over the course of the project. Of the more than 50 cooperators who received individual outreach from the RCD, twenty-three (23) of those chose to implement conservation practices on their farms with RCD/CAFF assistance during the project period, resulting in a total of 40 conservation practices implemented in the Gabilan watershed. Details of the practices implemented can be found in Section 8.3.3 Photos and Descriptions of Implemented Practices.

8.3.2 2005-2006 Gabilan Winter Road-Seeding Program

As a result of this grant, the RCD was able to expand the 2005-2006 Winter Road-Seeding Program beyond the strawberry hills of the Elkhorn Slough watershed, to include the increasing number of strawberry farms on the sloped, sandy hillsides of the Gabilan watershed. The

2005-2006 Winter Road-Seeding Program included one-on-one targeted outreach to limited resource strawberry farmers in the Gabilan watershed about a management practice that is both low-cost and highly effective for reducing erosion on farm roads, especially when used in combination with row arrangement.* With funds from this grant, matched with funds from non-state sources, the RCD offered to provide growers with technical assistance, and a portion of the materials (seed & straw) needed to protect their vulnerable farm roads. Through direct technical assistance, cost-share assistance, and demonstration, the program has the ultimate goal of integrating these annual practices into routine production scheduling. Summary information about the road-seeding practices implemented as a result of this outreach, as well as representative photos from each site can be found in Section 8.3.3 Photos and Descriptions of Implemented Practices.

*The RCD provided technical assistance for row arrangement to growers who requested it with matching funds from a non-state funding source.

During winter 2005, the Landowner Agreement was finalized by the RCD following review and approval by the Regional Water Quality Control Board Contract Manager. Landowners who implemented agricultural best management practices with technical assistance and/or materials provided through this project were asked to sign the Agreement. Signed Landowner Agreements were obtained and submitted for all practices listed in Table 8.1.

8.4 Sites and Management Practices

8.4.1 Practice types implemented as part of this project

The following types of agricultural conservation practices were implemented on farms in the Gabilan watershed as a result of outreach, technical assistance and/or cost-share assistance provided by the RCD and CAFF as part of this project:

Critical Area Planting: Planting vegetation such as trees, shrubs, vines, grasses, or legumes, on highly erodible or critically eroding areas. This practice is used to stabilize the soil, reduce damage from sediment and runoff to downstream areas, and improve wildlife habitat and visual resources. Plants may take up more of the nutrients in the soil, reducing the amount that can be washed into surface waters or leached into ground water. During grading, seedbed preparation, seeding, and mulching, quantities of sediment and associated chemicals may be washed into surface waters prior to plant establishment.

Road-seeding: This practice is a type of Critical Area Planting. Roads are one of the most vulnerable areas on the farm for erosion. This is especially true of strawberry farms on the sandy hillsides of the Gabilan watershed. The plastic mulch commonly used on strawberry beds increases the velocity of the water flow and therefore increases the potential for erosion within the furrows and on farm roads. Winter road-seeding with annual grasses provides the following benefits: 1) provides a large root mass that protects roads from washing out; 2) enhances water quality by reducing the amount of sediment in farm runoff; 3) protects bed ends from slumping; and 4) inhibits the growth of weeds. The practice as promoted by the RCD involves planting grasses as soon as roads are cut, soil preparation, broadcast seeding roads and often the ends of each furrow, covering seed with soil, mulching with straw, irrigation to insure establishment, and spring mowing before seed set.

Filter Strip: A strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and wastewater. This practice is used on cropland at the lower edges of fields adjacent to streams, ponds, and lakes to remove sediment and other pollutants from runoff. Installation often requires soil manipulation to remove surface irregularities and prepare for planting. When the field boarders are located such that runoff flows across them in sheet flow, coarser grained sediments are filtered and deposited. Pesticides and nutrients may be removed from runoff through infiltration, absorption, adsorption, decomposition, and volatilization thereby protecting water quality downstream. However, they may not filter out some soluble or suspended fine-grained materials, especially during heavy rain events. Filter strips may also reduce erosion on the area on which they are constructed.

Hedgerow: A hedgerow is a line or group of trees, shrubs, perennial forbs, and grasses that is planted along field edges, fence lines, drainage ditches, or property borders. Native plant hedgerows on farms and ranches use plants adapted to a local geographical region to provide year-round habitat for beneficial insects that can help to control agricultural pests. Other potential benefits of native plant hedgerows include: preventing soil erosion caused by excessive runoff and wind; protecting water quality by reducing erosion and/or pesticide inputs; providing habitat for pollinating insects, birds and other wildlife; reducing weed pressure through competition; and providing a barrier to dust and pesticide drift.

Table 8.1 lists the 40 practices implemented throughout the project area between November 2004- February 2007 and includes a brief description of each practice, their extents, and purposes. Representative pre-and post-implementation photos from each of the 23 project sites follow the tables.

Table 8.1. Management practices installed by the RCD, with extents and purposes.

Cooperator Code	Practice Code	Practice Type	No. of practices	Practice Description	Practice Extent (linear feet, sq. ft, acres)	Purpose	CALWATER Planning Watershed (PWS)
SV-01-1	CAP to stabilize ditch banks 2004-1-4	Critical Area Planting	4	Four long sections of ditchbanks planted with creeping wild rye.	2,000 LF.	Reduce bank erosion/reduce channel down-cutting/reduce sediment transport	Espinosa Lake
ES-602	Road-Seeding 2005-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	18,486 LF	Erosion control/reduce sediment transport from farm roads	Neponset
ES-637	Road-Seeding 2005-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	8,803 LF	Erosion control/reduce sediment transport from farm roads	Neponset
ES-637-3	Road-Seeding 2005-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	6,822 LF	Erosion control/reduce sediment transport from farm roads	Espinosa Lake
G-04	Road-Seeding 2005-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	12,544 LF	Erosion control/reduce sediment transport from farm roads	Neponset
G-04-2	Road-Seeding 2005-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	10,123 LF	Erosion control/reduce sediment transport from farm roads	Espinosa Lake
G-10	Road-Seeding 2005-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	13,204 LF	Erosion control/reduce sediment transport from farm roads	Neponset
G-606-2	Road-Seeding 2005-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	7,923 LF	Erosion control/reduce sediment transport from farm roads	Neponset
G-607-2	Road-Seeding 2005-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	5,502 LF	Erosion control/reduce sediment transport from farm roads	Neponset
SV-01-1	CAP to stabilize ditch banks 2005-1-4	Critical Area Planting	4	Eight sections along 4 separate ditches planted with native grasses.	534 LF	Reduce bank erosion/reduce channel down-cutting/reduce sediment transport	Espinosa Lake
SV-01-2	CAP to stabilize ditch banks 2005-1	Critical Area Planting	1	Two sections of one ditch planted with trial of 3 native grass varieties.	100 LF	Reduce bank erosion/reduce channel down-cutting/reduce sediment transport	Neponset
SV-09-1	Hedgerow 2005-1	Hedgerow	1	Hedgerow planted on berm along field /road edge.	1,565 LF	Integrated pest management/reduce wind erosion/dust control/slope stabilization	Espinosa Lake
SV-208	Filter Strip 2005-1	Filter strip	1	Extension and re-plant of filter strip previously installed in 2004 by NRCS.	3,000 SF	Filtration of sediment and nutrients from farm runoff/reduce erosion/reduce weed pressure/enhance habitat for beneficial insects and wildlife	Espinosa Lake
ES-637-3	Road-Seeding 2006-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	2,500 LF	Erosion control/reduce sediment transport from farm roads	Espinosa Lake
G-12	Critical Area Planting 2006-1	Critical Area Planting	3	Retired Ag field, site 1 ~ planted with perennial native grass and forb mix.	15 acres	Erosion control/slope stabilization/habitat restoration	Neponset
G-12	Critical Area Planting 2006-2			Retired Ag field, site 2 ~ planted with perennial native grass and forb mix.	10 acres		
G-12	Critical Area Planting 2006-3			Retired Ag field, site 4 ~ planted with perennial native grass and forb mix.	6 Acres		
G-14	Road-Seeding 2006-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	2,143 LF	Erosion control/reduce sediment transport from farm roads	Neponset
G-14-2	Road-Seeding 2006-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	2,143 LF	Erosion control/reduce sediment transport from farm roads	Neponset
G-14-3	Road-Seeding 2006-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	2,000 LF	Erosion control/reduce sediment transport from farm roads	Neponset
G-16	Hedgerow 2006-1	Hedgerow	7	Hedgerow of trees/shrubs to buffer residential from farmland.	493 LF	Reduce pesticide drift/reduce wind erosion/enhance habitat for beneficial insects	Neponset
G-16	Hedgerow 2006-2			Hedgerow of trees/shrubs to buffer residential from farmland.	1,065 LF		
G-16	Hedgerow 2006-3			Hedgerow of trees/shrubs to buffer residential from farmland.	472 LF		
G-16	Hedgerow 2006-4			Hedgerow of trees/shrubs to buffer residential from farmland.	209 LF		
G-16	Hedgerow 2006-5			Hedgerow of trees/shrubs to buffer residential from farmland.	130 LF		
G-16	Hedgerow 2006-6			Hedgerow of trees/shrubs to buffer residential from farmland.	552 LF		
G-16	Hedgerow 2006-7			Hedgerow of trees/shrubs to buffer residential from farmland.	760 LF		
G-18	Road-Seeding 2006-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	1,312 LF	Erosion control/reduce sediment transport from farm roads	Neponset
G-19	Road-Seeding 2006-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	6,000 LF	Erosion control/reduce sediment transport from farm roads	Neponset
G-20	Road-Seeding 2006-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	2,857 LF	Erosion control/reduce sediment transport from farm roads	Neponset
G-22	Road-Seeding 2006-1	Winter Road-Seeding	1	Winter road-seeding to control erosion and reduce sediment transport from farm roads.	3,000 LF	Erosion control/reduce sediment transport from farm roads	Neponset
SV-08	CAP for erosion control 2006-1	Critical Area Planting	1	Native grass planting interspersed in hedgerow along ditch/road to reduce erosion and weed pressure.	133 SF	Filter farm runoff/reduce erosion/reduce weed pressure/enhance habitat for beneficial insects and wildlife	Neponset
SV-08	CAP to filter surface water 2006-1	Critical Area Planting	1	Native grass planting adjacent to a sediment basin for purpose of filtering surface water.	1,488 SF	Reduce erosion/reduce weed pressure/enhance habitat for beneficial insects and wildlife	Neponset
SV-14	CAP to stabilize ditch banks 2006-1	Critical Area Planting	1	Agricultural ditch planted with perennial native grasses. Grasses were accidently sprayed. Grower intends to re-plant with annual grasses more appropriate for site.	Planted and failed.	Reduce bank erosion/reduce weed pressure/improve water quality	Neponset
Total farm properties:		23					
Total practices implemented:		40					

8.4.2 Practice types monitored

The following agricultural management practices were installed prior to this project, and their monitoring was conducted as part of this project by the CCoWS team. This approach was approved beforehand by the State's Contract Manager for the project.

Sediment Basins: Basins constructed to collect and store debris or sediment. Sediment basins will trap sediment, sediment-associated materials, and other debris, and prevent undesirable deposition on bottom lands and in waterways and streams. Basins are generally located at the base of agricultural lands. The practice does not treat the source of sediment but provides a barrier to reduce degradation of surface water downstream. Due to the detention of runoff in the basin, there is an increased opportunity for soluble materials to be leached toward the ground water. Basins may also increase groundwater recharge. The design of spillways and outlet works will include water control structures to prevent scouring at discharge point into natural drainage. Typically they are designed to drain and dry out in a period of 24-48 hours following storm events.

Water and Sediment Control Basin: An earthen embankment or a combination ridge and channel generally constructed across the slope and minor watercourses to form a sediment trap and water detention basin. This practice mitigates peak flow runoff and traps and removes sediment and sediment-attached substances from runoff. Salts, soluble nutrients, and soluble pesticides will be collected with the runoff and will not be released to surface waters. Although some ground water recharge may occur, little if any pollution hazard is usually expected. Often located alongside riparian or wetland environments to buffer impact of upslope runoff and sediment prior to release to natural drainage. Basins can be used to reduce concentrated off-site flow and associated erosion by metering out runoff following large storm events. Typically they are designed to drain and dry out in a period of 24-48 hours following storm events.

Pond: In an agricultural setting, a pond is a water impoundment made by constructing a dam or by excavating a pit or dugout. If a dam is constructed, the pond is referred to as an embankment pond; if the pond storage is achieved solely by excavating material, the pond is referred to as an excavated pond. The typical purpose of this type of pond is to provide water for livestock, recreation, and fish and wildlife. Other uses include providing a water supply for uses such as fire control and crop irrigation. Agricultural ponds are designed mainly to hold water, but can also capture sediment. Typically, they have only an emergency spillway (to accommodate the highest of flows to prevent berm failure). They are not designed or intended to require routine maintenance, but will often require periodic maintenance.

8.4.3 Photos and Descriptions of Implemented Practices

The following pages include photos with details about each implemented practice (figures 8.1 through 8.24).

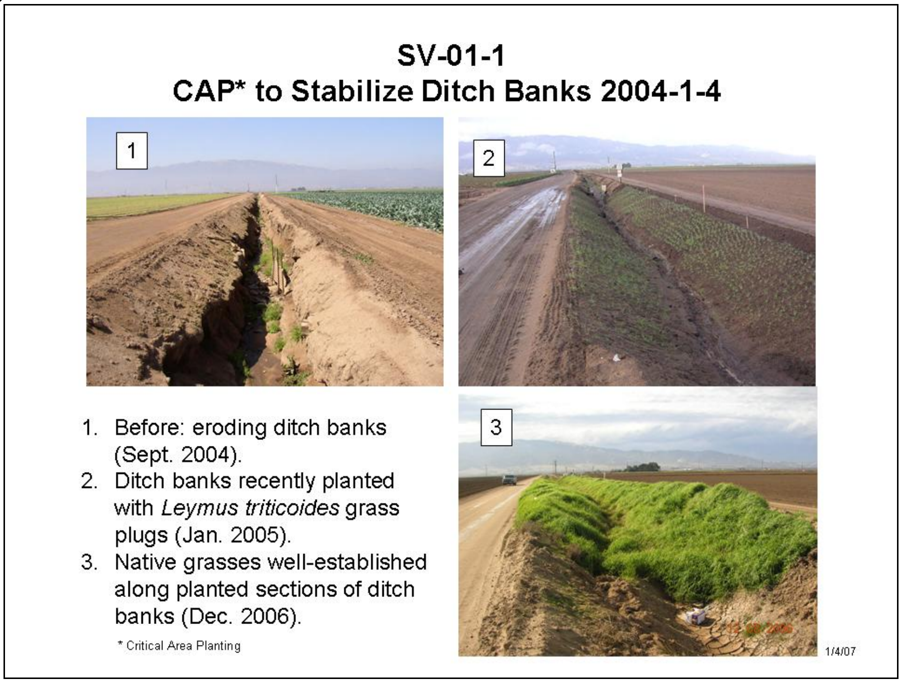


Figure 8.1. SV-01-1 Critical Area Planting 2004.

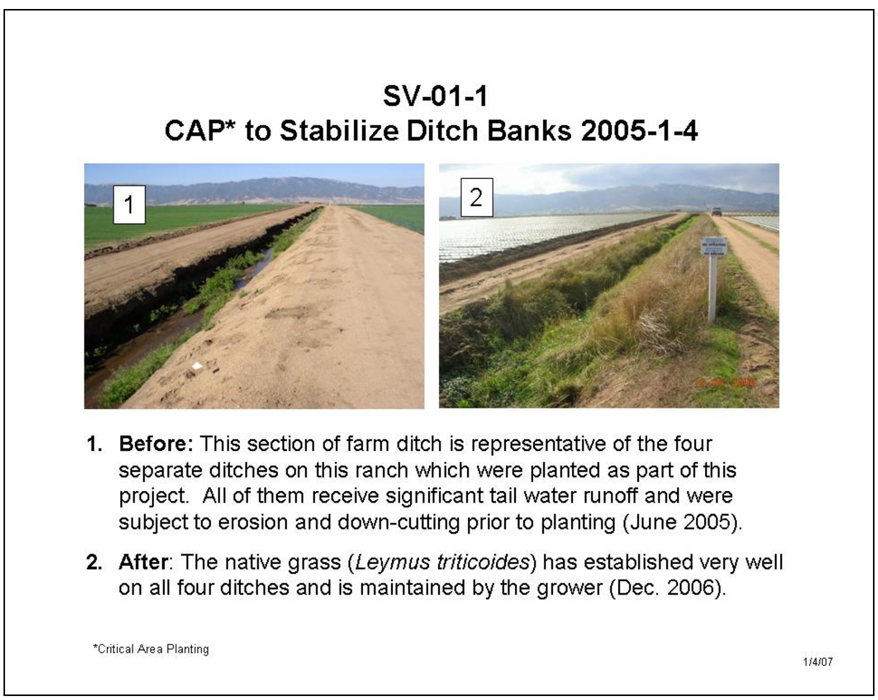
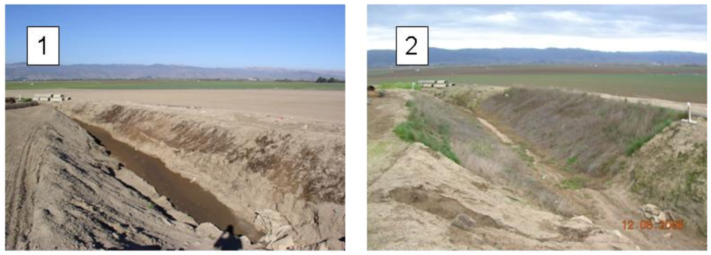


Figure 8.2. SV-01-1 Critical Area Planting 2005.

SV-01-2
CAP* to Stabilize Ditch Banks 2005-1



1. Before: Prior to planting, there was significant erosion and channel down-cutting throughout this agricultural ditch (Aug. 2005).
2. After: The ditches were planted with three trial native grass species (*Horteum brachyantherum*, *Festuca rubra*, and *Distichlis spicata*). Due to the grower's commitment to maintenance, including hand-weeding, the grasses have established well (Dec. 2006).

*Critical Area Planting

1/04/07

Figure 8.3. SV-01-2 Critical Area Planting 2005.

SV-08
CAP* for Erosion Control 2006-1

1. Before: Prior to planting with native grasses, this area between a farm access road and adjacent fields was infested with agricultural weeds (May 2006).
2. After: Creeping Wild Rye (*Leymus triticoides*) well-established and successfully out-competing weeds (Dec. 2006).

*Critical Area Planting

12/15/06

Figure 8.4. SV-09 Critical Area Planting 2006.

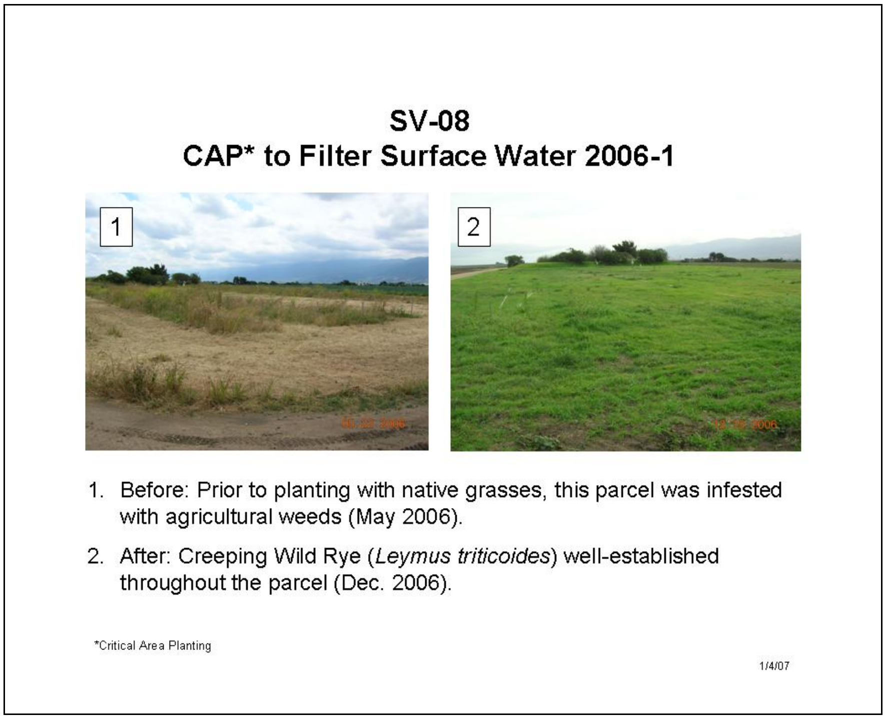


Figure 8.5. SV-08 Critical Area Planting 2006.

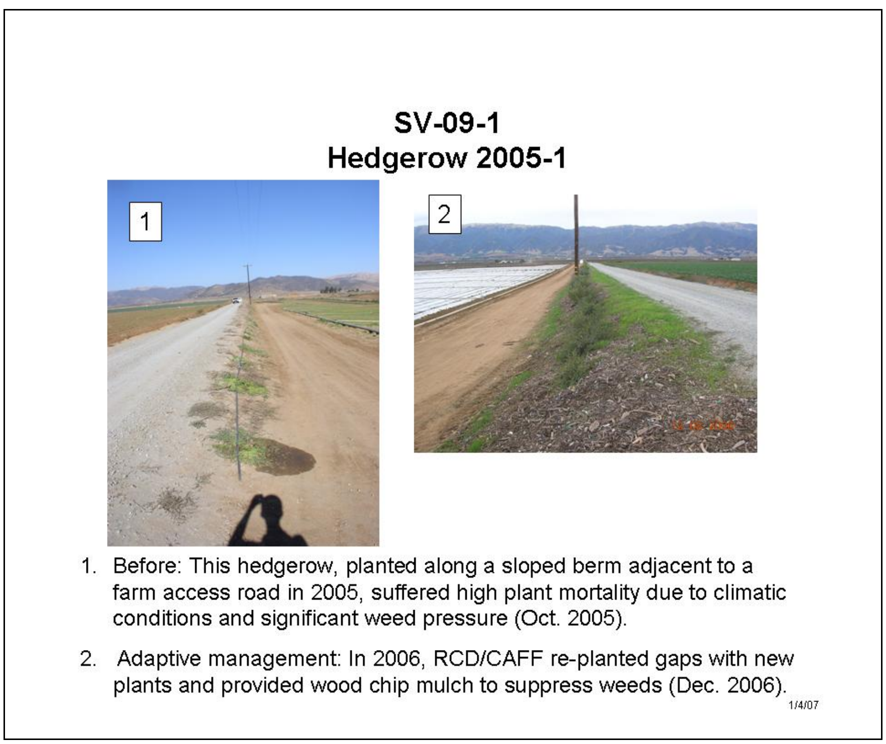


Figure 8.6. SV-09-1 Hedgerow 2005.

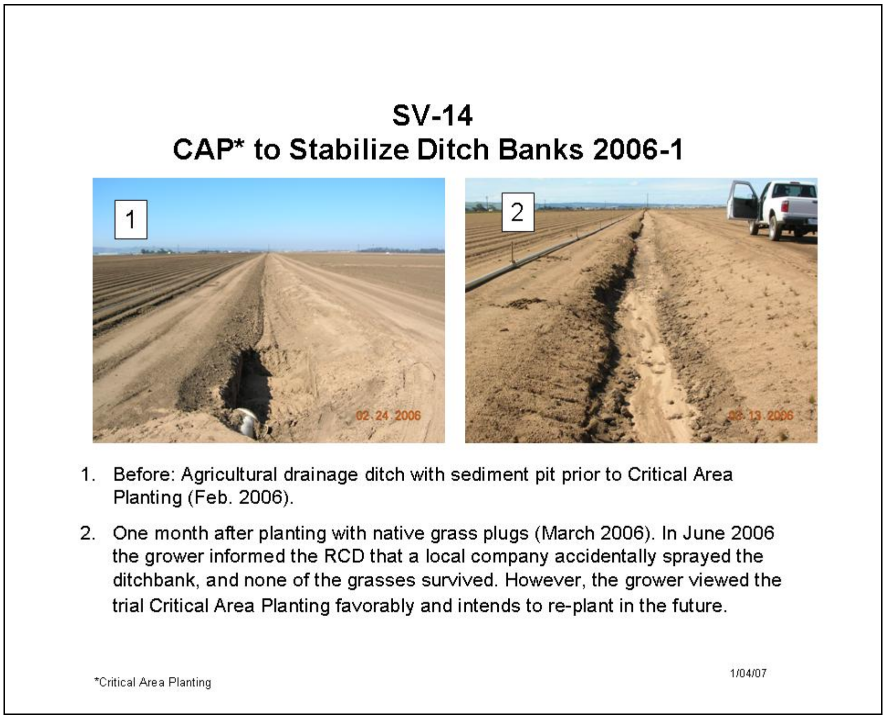


Figure 8.7. SV-14 Critical Area Planting 2006.

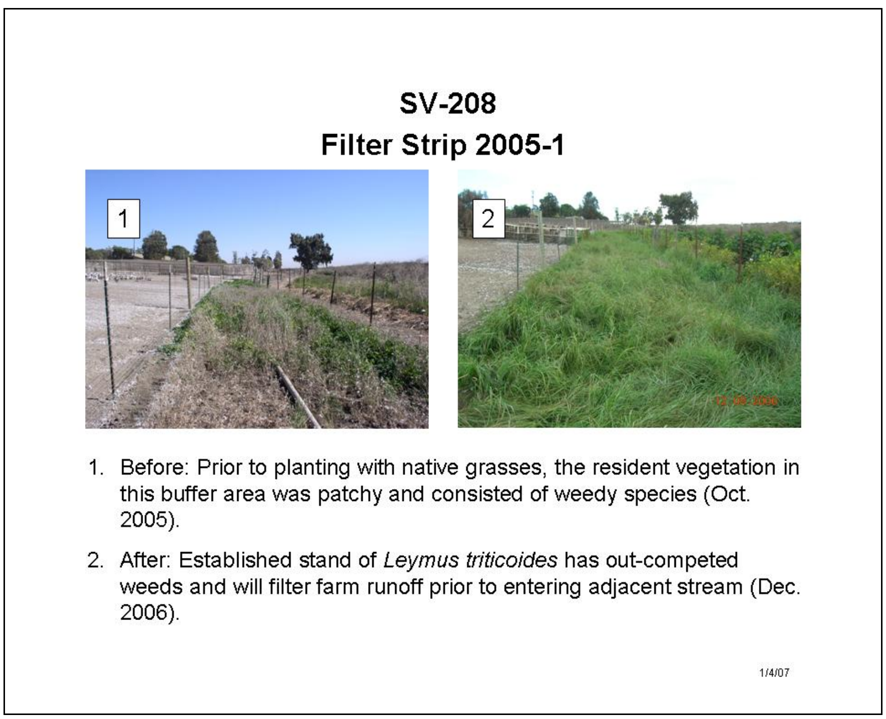


Figure 8.8. SV-208 Filter Strip 2005.

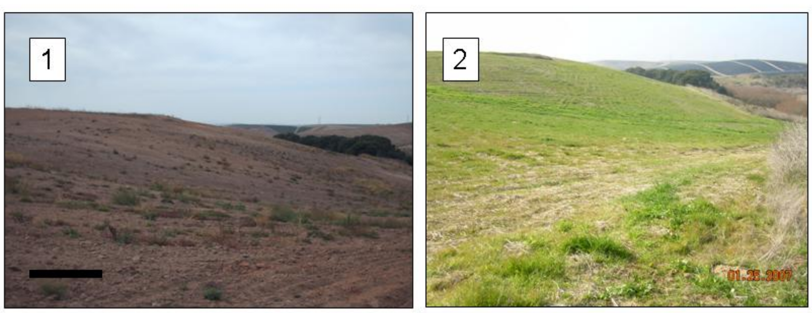
G-12
Critical Area Planting 2006-1

1. Before: This 1.5-acre south-facing parcel is currently fallow. Half of the parcel was farmed in strawberries and was retired from production this year due to steepness of slopes (October 2006).
2. After: Native grass mix was planted in mid-October and has established well with irrigation and maintenance (January 2007). The landowner harvested acorns from adjacent oak woodland, germinated them, and hand-planted them in the lower half of this parcel.

3/15/07

Figure 8.9. G-12 Critical Area Planting 2006-1.

G-12
Critical Area Planting 2006-2



1. Before: This 10-acre north-facing parcel was taken out of strawberrry production two (2) years ago (Oct. 2006).
2. After: A mix of native grass seed was broadcast and straw mulched to conserve soil moisture and reduce erosion. By January 2007 the grass was well-established. The landowner's goal is to restore the site to native oak woodland vegetation.

3/15/07

Figure 8.10. G-12 Critical Area Planting 2006-2.

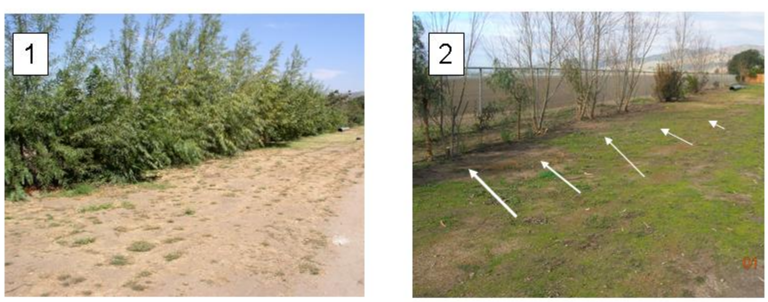
G-12
Critical Area Planting 2006-3

1. Before: This 6-acre parcel with steep slopes was intensely farmed for several years (Oct. 2006).
2. After: The landowner has retired the parcel from agricultural production and has seeded a mix of native grasses to stabilize the slopes, shown here well-established (Jan 2007).

3/15/07

Figure 8.11. G-12 Critical Area Planting 2006-3.

G-16
Hedgerow 2006-1



1. **Before: Existing tree hedge loses leaves during the winter and does not provide adequate wind break.**
2. **After: Plants recently installed in the understory of the existing trees. Hedgerow plants were planted close together to ensure a dense stand of vegetation as barrier to pesticide drift (1/26/07).**

3.13.07

Figure 8.12. G-16 Hedgerow #1.

G-16
Hedgerow 2006-2

1. Before: Existing small shrubs are low and sparse and do not provide adequate wind break from neighboring farm.
2. After: Hedgerow plants replaced old shrubs once. Plant species selected will grow dense and high enough to provide a barrier to pesticide drift from neighboring farm (1/26/07).

3.13.07

Figure 8.13. G-16 Hedgerow #2.

G-16
Hedgerow 2006-3

1. Before: Efforts to block pesticide drift included lining a chain-link fence with corrugated sheet metal.
2. After: Native plants were successfully installed in January 2007 and when fully mature will extend above the existing fence (1/26/07).

3.13.07

Figure 8.14. G-16 Hedgerow #3.

Figure 8.15. G-16 Hedgerow #4.

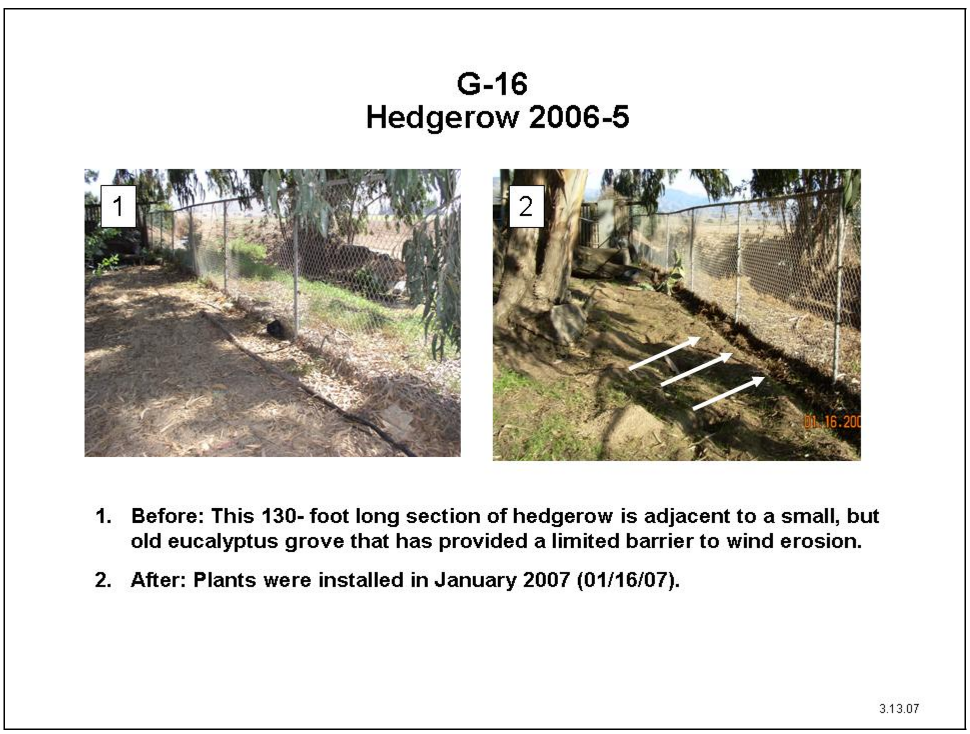


Figure 8.16. G-16 Hedgerow #5.

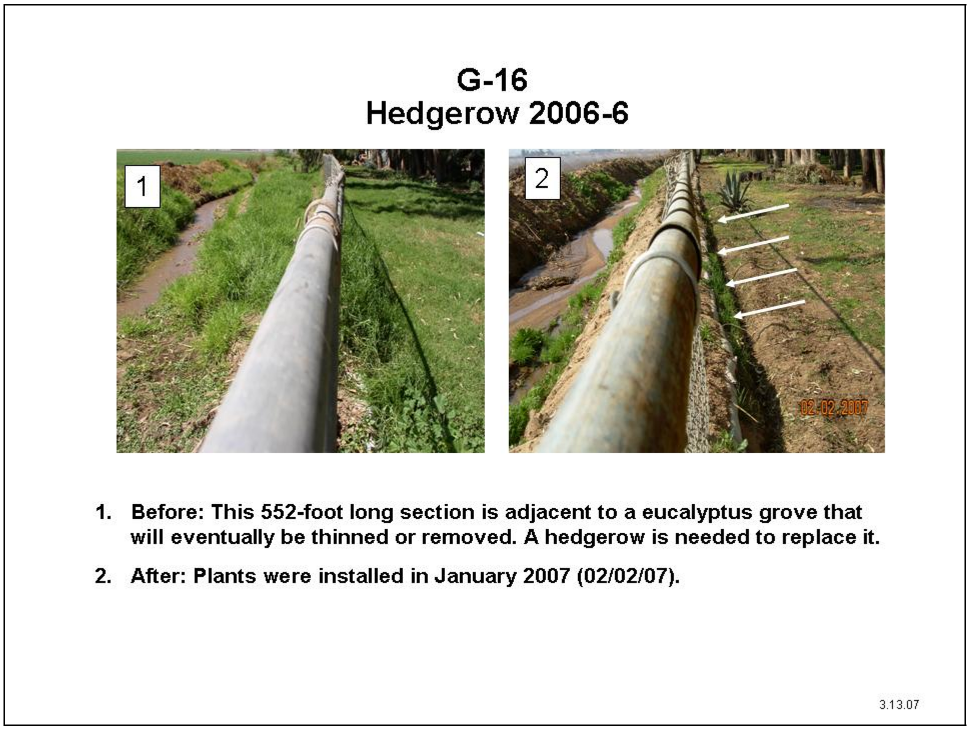


Figure 8.17. G-16 Hedgerow #6.

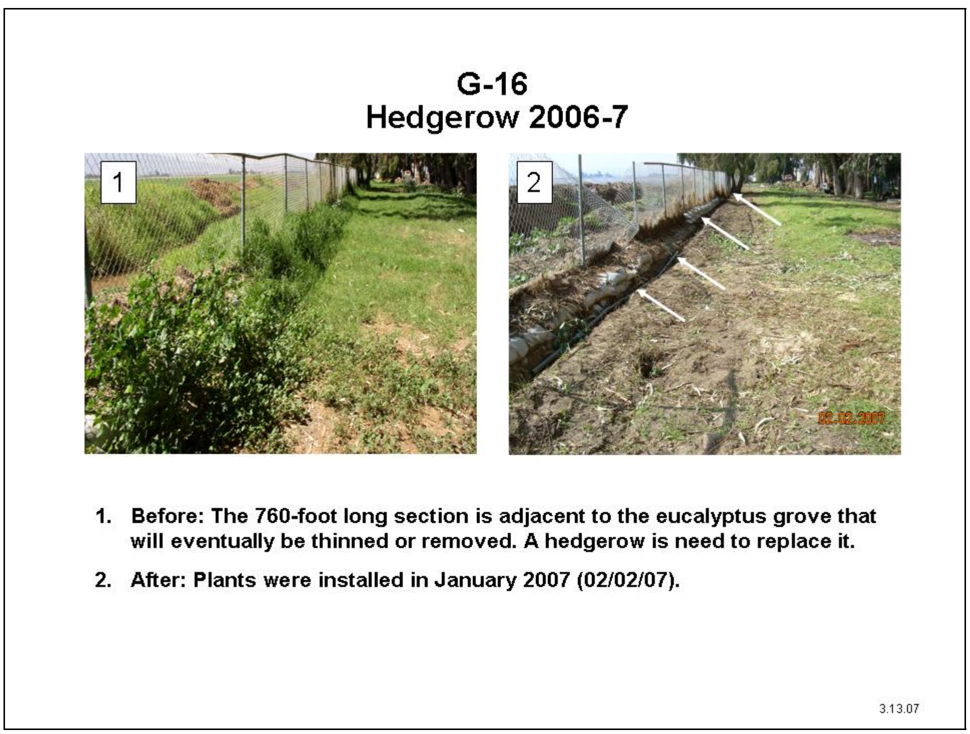


Figure 8.18. G-16 Hedgerow #7.

Figures 8.19, 8.20, and 8.21 illustrate the progression of road seeding. The final pictures are road seeding projects for 2005-2006.

Figure 8.19. Farm roads before road seeding.

Figure 8.20. Farm roads during road seeding.

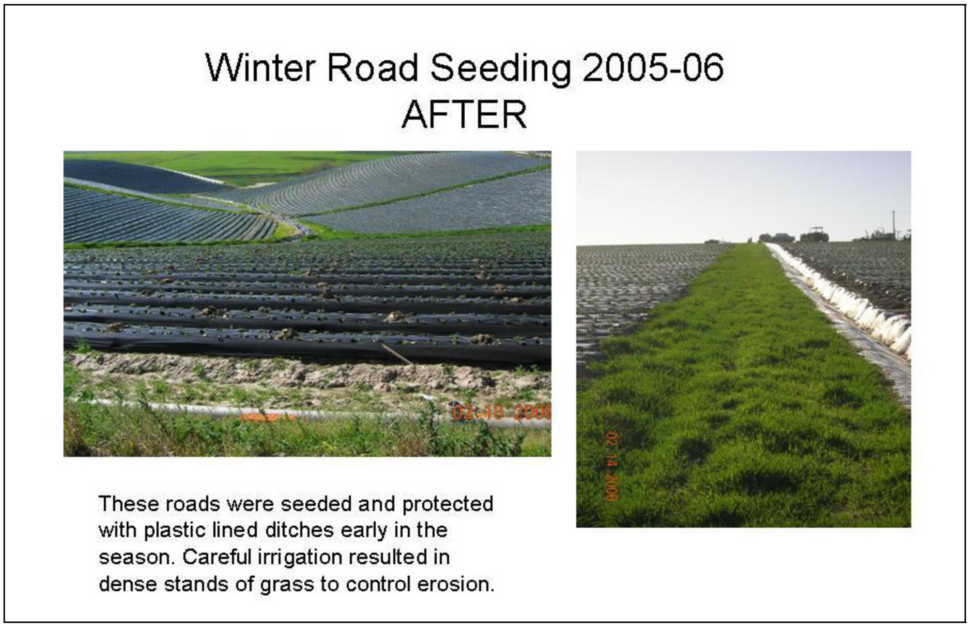


Figure 8.21. Farm roads after successful road seeding.

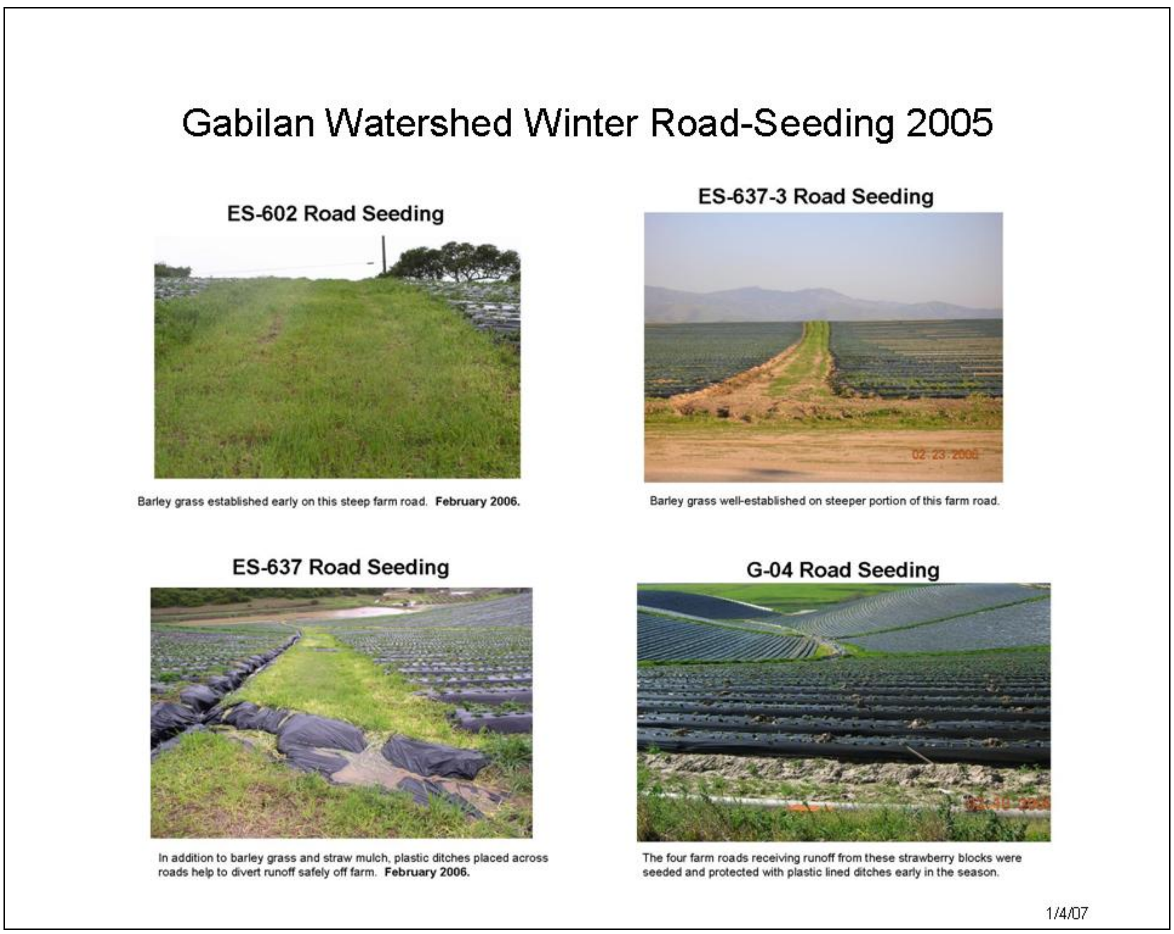


Figure 8.22. Winter road-seeding 2005 (1 of 2).

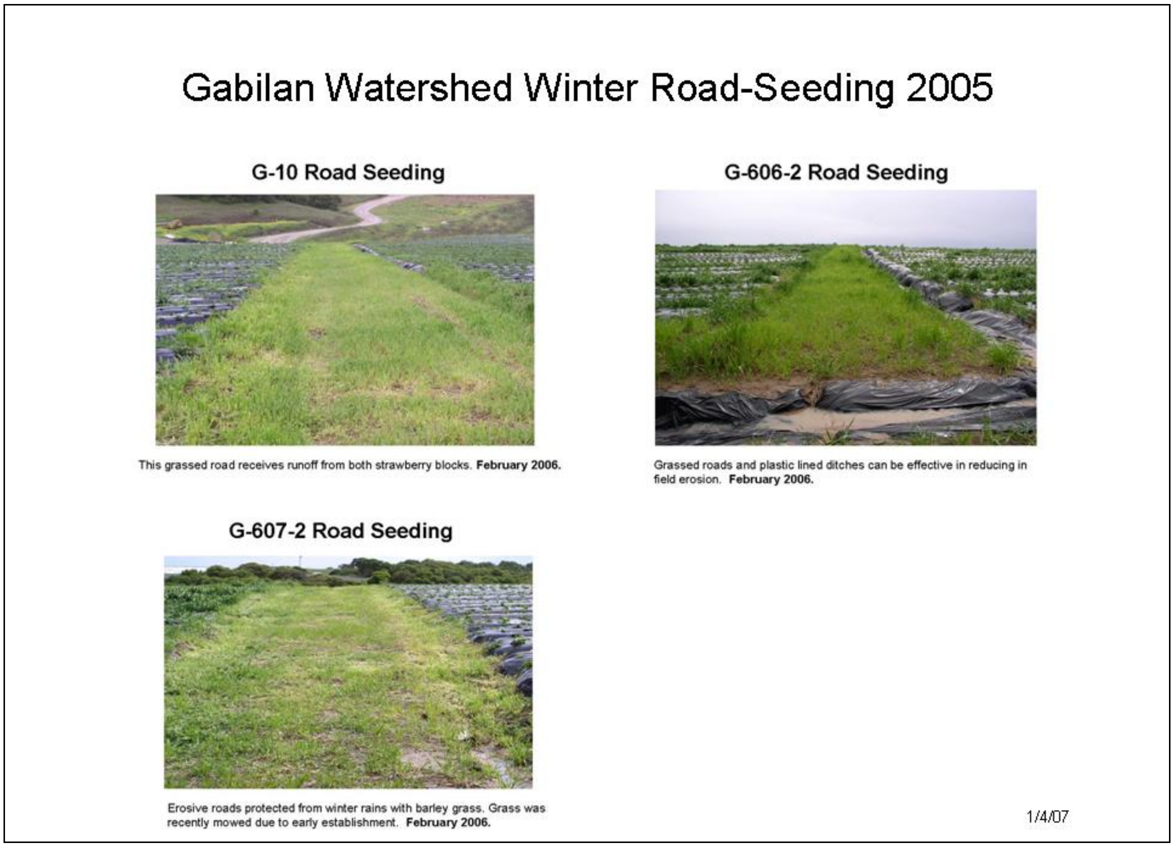


Figure 8.23. Winter road-seeding 2005 (2 of 2).

Figure 8.24. Winter road-seeding 2006.

8.5 Project Demonstration

The goal of this task was to demonstrate the value of implementing BMPs to landowners and other watershed stakeholders. The approach to be used was to invite new potential cooperators to BMP workshops through direct mailings, announcements in partner newsletters, press releases, and other means. The target was for CAFF and the RCD to conduct a minimum of two (2) workshops per year, for a minimum of four (4) workshops over the project period to demonstrate the benefits of vegetated practices and engineered practices. Demonstration sites were to be located in visually prominent and hydrologically important locations.

In support of this task, CAFF organized and conducted the following four workshops:

- **Using Vegetation to Improve Water Quality: Workshop, BBQ and Watershed-Friendly Farming Tour**, Watsonville, November 12, 2004. The all-day workshop and tour demonstrated to farmers, landowners, watershed stakeholders and agricultural resource professionals the environmental and economic value of implementing hedgerows, grassed waterways, filter strips and windbreaks. Approximately 60 farmers and agricultural professionals attended the event, which was co-sponsored by the SWRCB, National Fish and Wildlife Foundation (NFWF), CASFS, ALBA, and other organizations, and was funded in part by this grant, through a subcontract with the CAFF.

- **2005 Irrigation and Nutrient Management Meeting and Cover Crop Field Day**, Salinas, February 22, 2005. Approximately 70 farmers and agricultural professionals attended the all-day workshop and tour, which demonstrated the effectiveness of several types of conservation practices, including hedgerows and cover crops. The event was co-sponsored by UCCE and USDA, and was funded in part by this grant, through a subcontract with the CAFF.

- **2006 Irrigation and Nutrient Management Meeting and Cover Crop & Water Quality Field Day**; Salinas, February 21, 2006. Approximately 50 farmers and agricultural professionals attended the workshop, which included a hedgerow tour. Nine (9) participants attended a post-workshop tour of the Tembladero Slough Wetland Demonstration site, led by Adam Wiskind, MLML. The event was co-sponsored with UCCE and USDA, and was funded in part by this grant, through a subcontract with the CAFF.

- **2007 Irrigation and Nutrient Management and Cover Crop/Hedgerow Workshop and Demonstration Field Day**; Salinas, February 20, 2007. Approximately 65 farmers and agricultural professionals attended the workshop. Participants then had the opportunity to attended the post-workshop tour of the Tembladero Slough Wetland Demonstration site, led by Adam Wiskind. The event was co-sponsored with UCCE and USDA, and was funded in part by this grant, through a subcontract with the CAFF.

At each of the four events listed above, presentations were made by area specialists from UCCE, USDA, CAFF, MCFB, ALBA, and other organizations about a range of agricultural BMPs that improve water quality. Announcements for each of the field days were mailed to a list of over 350 farmers, landowners and agricultural professionals on the Central Coast. Notice of the events was also published in the Salinas Californian, Monterey Herald, Santa Cruz Sentinel, Watsonville Register Pajaronian and CAFF's statewide newsletter, the Agrarian Advocate. The events were covered by the Farm Bureau Ag Alert, Monterey Herald, Watsonville Register Pajaronian and the Salinas Californian, and write-ups were published in the Agrarian Advocate.

Throughout the duration of this project, CAFF and the RCD worked with the press, public and agricultural community to demonstrate the value of implementing BMPs to landowners and other watershed stakeholders. In addition to the four workshops summarized above, CAFF and RCD staff participated in the following demonstration activities, which were paid for in part with funds from this grant, leveraged through state funding and matched through non-state funding sources:

- Central Coast Agricultural Tour: A Practical Approach to Water Quality Protection; April 12, 2006. Sponsored by CAFF; attended by RCD, SWRCB, and RWQCB staff and other agricultural resource professionals. The tour visited several sites in the Pajaro Valley that had been planted to grassed waterways and hedgerows.
- In May 2006, RCD staff led a tour of one of the practice implementation sites for the RCD Board of Directors. The RCD Board includes several members who farm in the project area and promote agricultural conservation practices among their peers.
- In July 2006, CAFF staff led a demonstration tour of hedgerows at the USDA Agricultural Station in Salinas, as part of the Biological Control of Insect Vegetable Pests on the Central Coast Short Course.
- In October 2006, CAFF staff led a tour of two Critical Area Plantings implemented as part of this project for participants in the Spanish-language Biological Control of Strawberry and Vegetable Pests on the Central Coast workshop in Salinas.
- In October 2006, CAFF staff gave a presentation on agricultural conservation practices to five environmental grantmakers as part of the Environmental Grantmakers Association 2006 Retreat at Asilomar. The presentation was followed by an airplane and helicopter tour that highlighted Salinas Valley agricultural conservation practices from the air.
- In October 2006, CAFF staff gave the presentation Farmscaping: Design Considerations, Techniques, and Issues to resource professionals at the California Society for Ecological Restoration Annual Conference in Santa Barbara.
- In September 2006 an article was published in the Western Farm Press entitled "Farmland hedgerows meet multiple needs." The article cited the work of CAFF, the RCD

and other partners in the Salinas Valley to encourage growers to install hedgerows on their farms.

- In November 2006 an article was published in the Capital Press entitled “Farmers fight pest threats amid hedgerows: Rows of plants can draw pests out of fields, away from valuable crops.” The article cited the work of CAFF, the RCD and other partners in the Salinas Valley to encourage growers to install hedgerows on their farms.

9 Agricultural Practice Water Quality Monitoring

9.1 Monitoring Goal

The goal for agricultural monitoring was to measure management practice effectiveness by answering the following question:

> *To what extent is the implemented practice at each agricultural site resulting in a reduction of water quality constituents (sediment and nutrients) being exported off-site?*

9.2 Monitoring Site Descriptions

Sites were assigned codes assigned by the RCD and CCoWS to maintain confidentiality. Table 9.1 lists these codes and practices monitored, along with a general landscape description, and the dates that monitoring occurred. There was a concerted effort to work with sites located in areas with differing slopes and soil types. In general, the sites labeled *valley* were very close to flat and had soil that was less sandy. Sites labeled *hills* had much greater slopes and more sand. For slopes measured on-site and KKFACT soil types, see table 9.9.

Table 9.1. Agricultural practices and dates monitoring occurred.

Site #	CCoWS Cooperator Code	RCD Cooperator Code	Practice Description	General Landscape Description	Dates Monitored	# practices
1	R009	ES-15-8	Sediment basins	hills	12/1/2005 12/18/2005 12/31/2005	3
2	R010	SV-08	Sediment basin	valley	2/17/2006 2/26-27/2006 3/6/2006 3/17/2006	1
3	R011	SV-09-1	Sediment Basin Water & Sediment Control Basin	valley	3/6/2006 3/20-24/2006	2
4	R013	SV-408-2	Two long water retention ditch/sediment basins leading into a series of two sediment/water retention ponds	valley	3/27-28/2006 4/2/2006	4
5	R014	G-12	Three Critical Area Plantings (CAPs) that were converted from steep cropland to native grass and oak trees. Also, 1 cover of moved weeds left in place to stabilize previously farmed hillside Winter 06/07, in preparation for a CAP next Winter 07/08.	hills	Dec 06-Feb 07	4
7	R012	SV-16-1	Sediment Basin	valley	Jan-Feb 07	1

Site schematics were made for each site where runoff was measured during rain events, to show the water pathways and sample collection locations. The following codes are ones assigned by CCoWS.

9.2.1 R009

This site was 0.13 km² (33 acres) in size, with varying levels of slope from gentle to close to 18%. The soil contained a lot of sand, and the three inter-connected basins were primarily designed to prevent this sand from entering a ditch adjacent to the property that leads to a waterway (Fig. 9.1). This site had historically been used for strawberries, but at the time of monitoring it was fallow. The majority of water flowing off the site went through all three basins, starting with Basin 1 (B1). The red stars denote sampling locations. There was some additional sheet flow coming from the lower fields into B2 and B3, but all efforts to condense that water into a flow that could be measured failed (weirs and sandbags) due to the movable nature of the soil. Therefore these flows could not be included in the totals reported. The pipes leading into and out of B1, and out of B3, had some fall distance, so sediment traveling along the bottom of pipes was captured in SSC samples. The pipes leading into B2 and B3 had no fall, so pipe bedload was present but not collected in samples. Basins 1 and 2 contained a standpipe with drainage holes so that water would flow through the system more slowly. The Basin 3 standpipe didn't have any drainage holes, so water didn't leave the site except during events large enough to fill all three basins, and when the standpipe was overtopped.

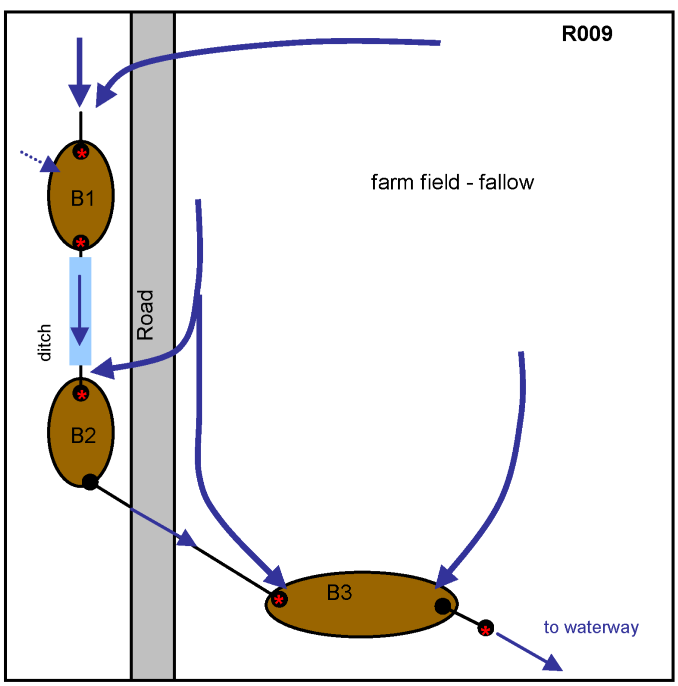


Figure 9.1. Site R009 management practice schematic.

9.2.2 R010

This area of land on this site draining to the sediment basin monitored was approximately 0.25 km^2 (66 acres). The site was essentially flat, and organic. The soil here was less sandy, and sand movement along the bottom of the ditch leading to the basin was not visually obvious. Flow was received from several crop types, with a lot of baby leaf lettuce mix and strawberries (both with plastic and without). There are three sample locations on the schematic (figure 9.2). The flow from the ditch and direct from the field are inlets, but only the ditch is a permanent inflow. The field inflow was a result of workers shoveling a channel during the 3/17/06 event to drain pooled water, and therefore wasn't an input during the 3/6/06 event.

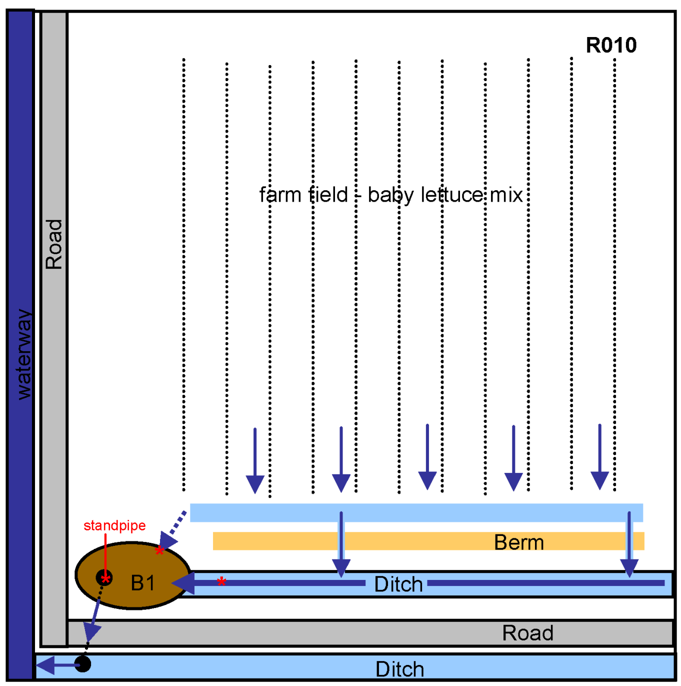


Figure 9.2. Site R010 management practice schematic.

9.2.3 R011

R011 (figure 9.3) was different to other sites because the practices were installed to treat and slow water *before* it flowed onto the site. An area of approximately 3.5 km^2 (1500 acres) with mixed crop types, roads, and some houses drains onto the property via a ditch that drains into the first basin on the site. The first basin is smaller, and leads into the second, larger basin via a culvert. Most of the heavy sediment drops out in the first basin, but a large sediment fan still forms at the entrance to Basin 2. Basin 1 has to be cleaned out several times throughout a Winter season, depending on the severity of rain events. Basin 2 has a standpipe with small orifices, so water is compounded onsite for several days after events and drains slowly. There is no permanent water on the site year-round. The pipes leading into both basins have fall distance in the beginning of events, but then become partially submerged so the composition of SSC samples changes to exclude pipe bedload during any event large enough for submersion. This occurred during both events monitored, leading to a tendency to underestimate sediment load entering the basins.

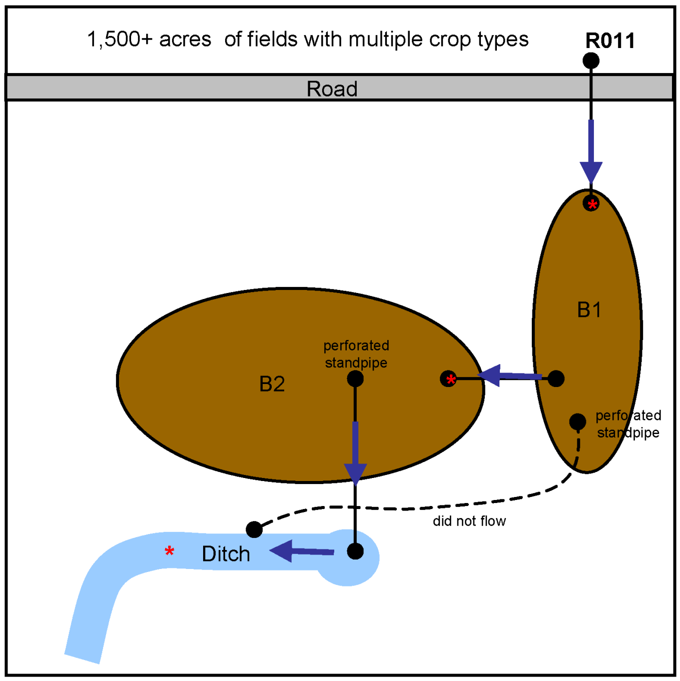


Figure 9.3. Site R011 management practice schematic.

9.2.4 R013

R013 is essentially a flat site with two detention ditches and two retention ponds. Several fields 0.02 - 0.08 km^2 (~5-20 acres) in size drain from pipes into the detention ditches (labeled ND for North Ditch and SD for South Ditch). Some of these pipes were sampled as an example of field values flowing into the practices, although it was impossible to sample all inflows because there were so many. The outflow of each practice was sampled. The outflow from B1 is the inflow to B2. There is one direct field input to B2. The retention basins hold a large volume of water, so during mild to moderate storms no water leaves the site. During monitoring for this project, a smaller 100% containment event was captured, followed by a large event where water had to be pumped off the site.

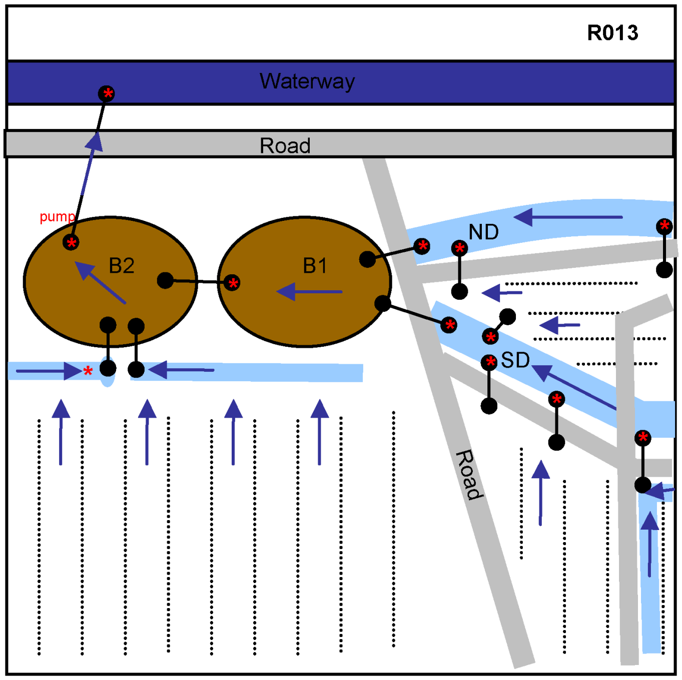


Figure 9.4. Site R013 management practice schematic.

9.3 Relative size of storms monitored

CIMIS data was used to make the following graphs illustrating which storms were monitored throughout the season. The purpose of including them is to illustrate what the size of events were in relation to other events that occurred throughout the year. Each graph looks different because the data is from different stations.

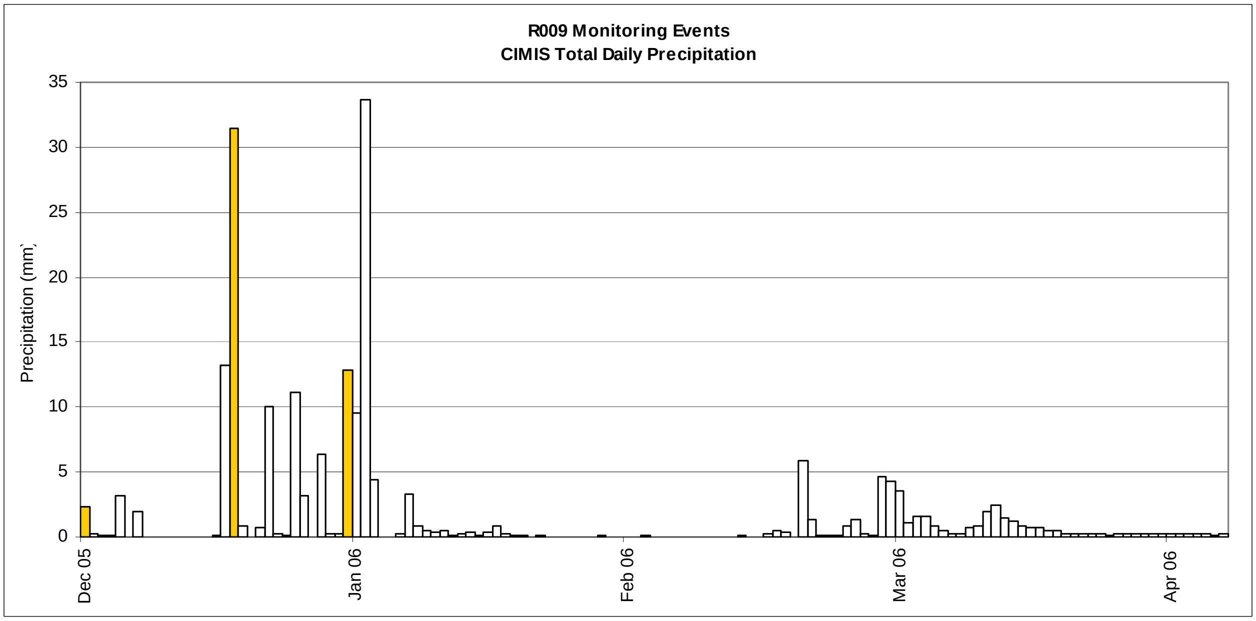


Figure 9.5. R009 events monitored in relation to rainfall throughout the Winter of 2005/2006 Dec 1st, 18th and 31st, 2005. Yellow indicates dates when on-farm monitoring took place.

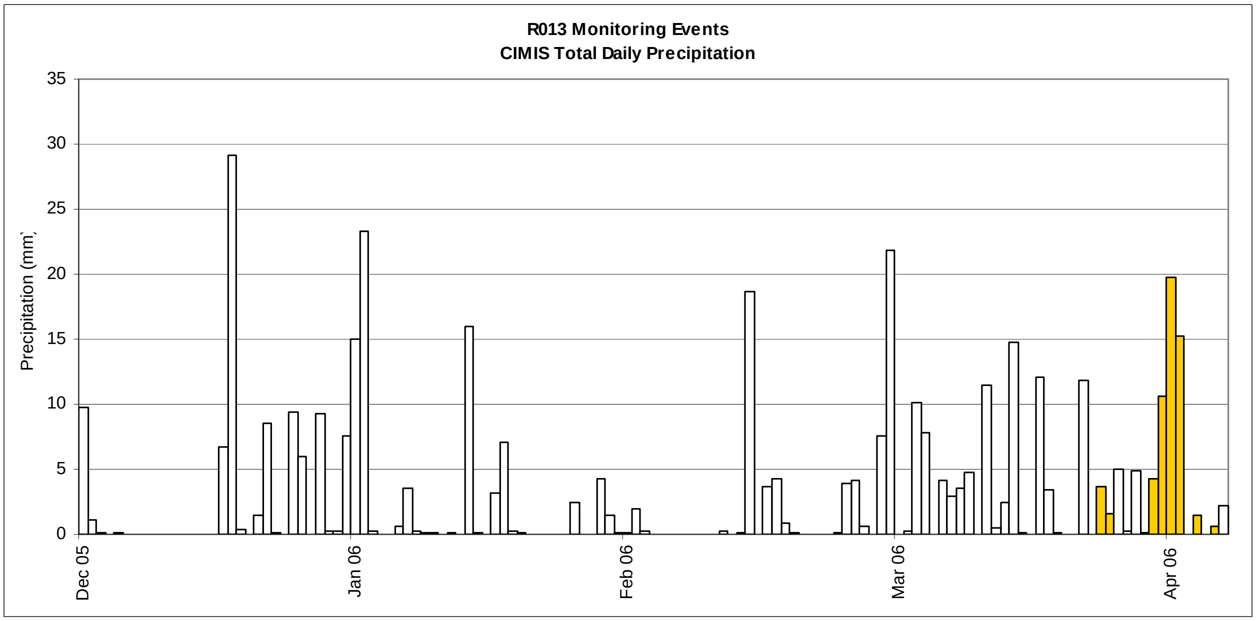


Figure 9.6. R013 events monitored in relation to rainfall throughout the Winter of 2005/2006. March 27-28th, and April 2-9th, 2006.

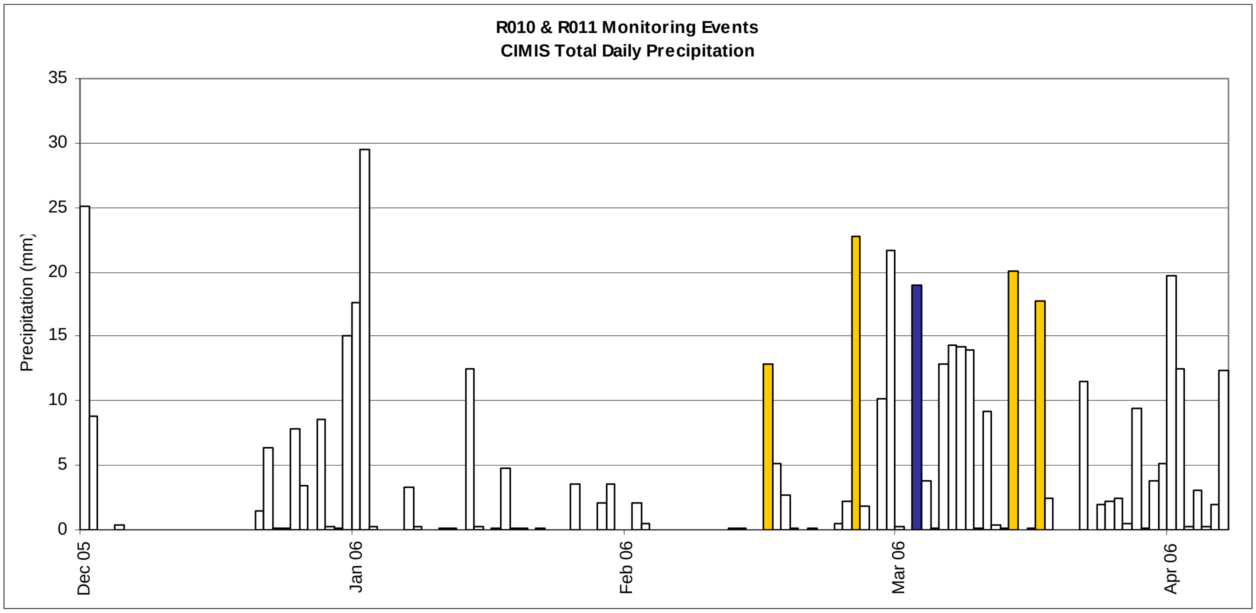


Figure 9.7. R010 and R011 events monitored in relation to rainfall throughout the Winter of 2005/2006. Blue bar denotes an event in which both R010 and R011 were monitored on the same day. Mar 6th (both), 17th (R010), and 20-24th (R011).

9.4 Methods

Agricultural monitoring covered a spectrum of water quality measurements, including: any applicable hydrologic components of each site, nutrients (ammonia, nitrate, orthophosphate), and suspended sediment concentration. Sampling was adaptive depending on site conditions.

9.4.1 Field Data and Sample Collection

9.4.1.1 Predicting storms

Storm events during the wet season were anticipated by using satellite images (NOAA), radar images (NOAA, weatherunderground.com, etc), quantitative precipitation forecasts (QPFs, NOAA), and 10-day weather forecasts (weather.com) available online. Storms predicted to have greater than about 13 mm (0.5 inches) of precipitation were prioritized for monitoring.

9.4.1.2 Measuring rainfall

On-site precipitation was measured with rain gauges. Precipitation data was also obtained after events from the closest California Irrigation Management Information System (CIMIS) weather station to each site.

9.4.1.3 Methods for discharge

Discharge at most sites was collected directly via bucket or bin measurements, or using floats. In both cases, the person measuring was using a stopwatch to measure either how long it took to fill a container of know volume, or for the floats to travel a know distance. At site R013 some submerged flows were unmeasureable, so it was necessary to write a flow model for the site. Theodolite surveys were completed to determine volumes of basins. These volumes were used to determine change in volume of each practice between each sampling time. DEMs for this site and most others are provided in the Appendix (were made for all sites except R009). For all other sites, the DEMs were made only to determine the volume of the practice.

9.4.1.4 Sample collection methods

Water for nutrient analysis was collected as grab samples in 125 mL plastic bottles. These were cleaned with Liquinox and acid washed between uses. The following methods applied:

- Rinse sample bottle & cap in sample water 3 times prior to taking sample.
- Insert the sample bottle just below the water surface with the mouth of the bottle facing into the flow & fill bottle. Take caution not to disturb bottom sediment.
- Measure temperature and pH at the time of sample collection with a thermometer and an Oakton pH Testr 1.
- Store samples in a cooler with ice packs for return to the laboratory.
- Immediately freeze upon return to the laboratory.

Suspended sediment samples were collected in 500 mL plastic bottles. The following methods applied:

- Face into water flow
- Remove from flow just before full so that sand doesn't continue to go in while the water overtops

9.4.1.5 Sediment Fan Measurement Methods

The monitoring of two sediment fans in a retention basin located at site R012 occurred from February 7, 2007 through March 11, 2007. According to the CIMIS website, between 2/7/06 and 3/11/07, 39.9 mm of precipitation fell during this time span. The larger of the two fans drained approximately 12 fields and the smaller fan drained 2 fields.

Stakes were driven into each of the fans in a grid like pattern. The larger of the two fans had a 4 x 4 meter grid pattern, where the smaller fan had a 2 by 2 meter grid pattern. Once the stakes were in each of the fans, they spray-painted at ground level. After the first storm, zip-ties were placed around each stake at ground level. Prior to extraction, another set of zip-ties was placed of each of the stakes.

Each of the stakes was examined visually to see if there was a change in the sediment level. The changes between each storm and the total change that occurred were measured. The values where then used to calculate a volume for each of the fans.

9.4.1.6 CAP Measurement Methods

At site R014, there were 5 different sites that were monitored for sediment movement in CAPs (4 sites and 1 reference site). Of the 5 sites, 3 of them were in the process of being restored to natural habitat, 1 site was Oak Woodland (reference), and 1 site was untouched mostly non-native vegetation that had been mowed (Table 9.2). Each of the sites differed in size, seen in Table 9.3.

Monitoring of 5 sites at R014 occurred from November 17, 2006 through March 6, 2007 (According to the CIMIS website, between, 11/17/06 and 3/6/07 211.5 mm of precipitation fell). Each of the sites varied in size, vegetation (type and percentage), and slope.

At each of the sites, silt fences were installed to catch and measure the amount of sediment transported down the slope during rain events. Each of the silt fences had a length of 1 meter and a height of approximately 0.3 meters. Silt fences were distributed within two different slope classes at each site 8-12 degree slopes and 13-16 degree slopes.

Table 9.2. R014 site descriptions.

Site	Description
1	CAP: Rice straw, native grasses, seeded with acorns
2	CAP: Rice straw, clover, seeded with acorns, and barley
3	Mostly non-native vegetation that was mowed and left in place
4	CAP: Rice straw, clover, native grasses, seeded with acorns
5	Target for CAPS 1 & 4: Oak woodland (undisturbed)

Table 9.3. R014 area of each site.

Site	Area (acres)
1	1.5
2	10
3	7
4	6
5	1

Table 9.4. Number of silt fences per site.

Site	Slope (degrees)	Number of fences
1	8 to 12	6
2	8 to 12	15
3	8 to 12	15
4	8 to 12	15
5	8 to 12	0
1	13 to 16	6
2	13 to 16	15
3	13 to 16	15
4	13 to 16	15
5	13 to 16	6

When the silt fences were installed at sits 1-4, they were placed in an offset grid like pattern (Figure 9.8). The spacing between silt fences differed at site 5 compared to the other sites (Figure 9.9).

Once the silt fences were installed, each silt fence was spray-painted at ground level and pictures were taken. Before the silt fences were removed, visual observations were made to see if sediment had built up. If aggraded sediment was apparent, measurements were taken. Prior to silt fence extraction, the fences were painted again and pictures were taken once again.

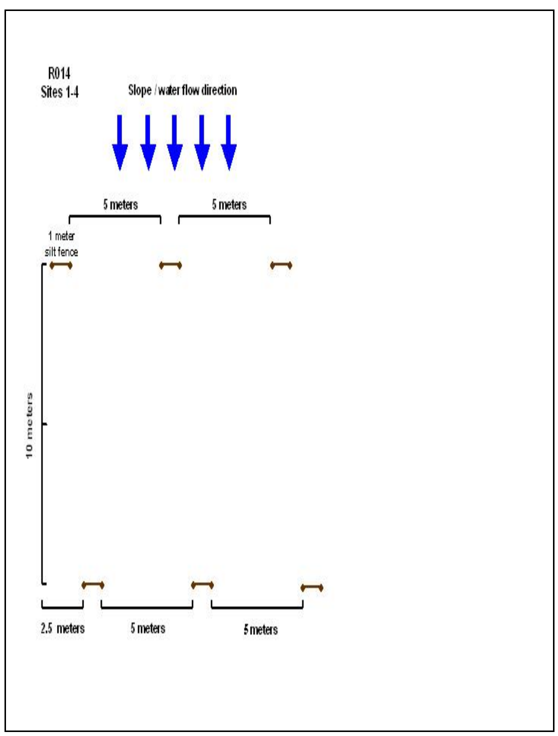


Figure 9.8 Schematic of silt fence cluster with fence spacing representative of sites 1-4.

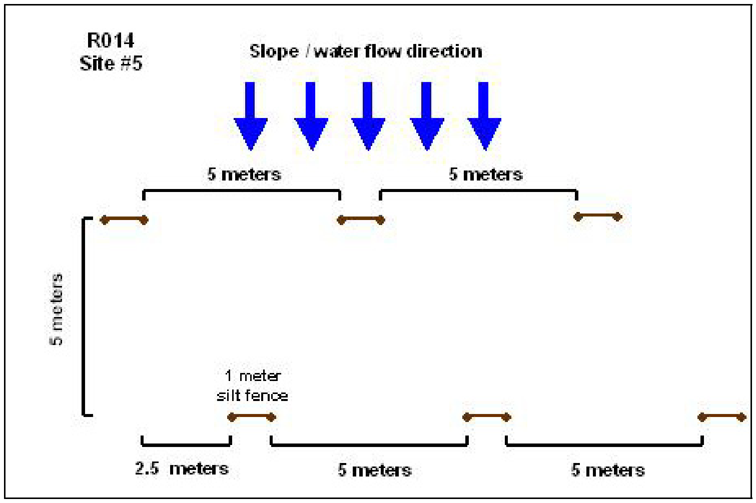


Figure 9.9 Schematic of the silt fence cluster with fence spacing representative of site 5.

9.5 Laboratory Methods

9.5.1 Suspended Sediment

SSC was determined by vacuum filtration comparable to ASTM D 3977, based on Woodward and Foster (1997).

9.5.2 Water Nutrients

Ammonia, Orthophosphate and Nitrate were analyzed using a QuikChem 8500 Series flow injection analyzer made by Lachat Instruments, Inc. An advanced technology called flow injection analysis (FIA) is used by this multiple channel continuous flow analyzer. The auto sampler takes a measured amount of sample and runs part of the sample through each channel where it is mixed with reagents and heated to form the color reaction. The color is then measured photometrically to obtain a concentration of the analyte. To get the concentration a peak forms on the screen expressing the light retention from the photometric data. The area under the peak or curve is then calculated which gives the concentration of the analyte. If an air bubble is introduced then the peak is larger than what it would otherwise be and that replicate it removed from the data. As the samples are analyzed the data is sent to the computer controlling the analyzer and is processed in real time, and then stored on the hard drive.

The QuikChem 8500 is able to detect small quantities of nutrient concentrations with its low detection limits (Table 9.5). The range of nutrient concentrations that can be accurately detected differs for each method. For the Ammonia-N the range is from 0.007 to 5.0 mg L^{-1}, Nitrate-N from 0.01 to 20 mg L $^{-1}$ and Orthophosphate-P from 0.01 to 2 mg L $^{-1}$. If a sample contains concentrations above the calibration range, it is diluted and reanalyzed.

Each sample is analyzed twice, although sometimes air would get into the tubes causing an airspike in the middle of the reading. For these situations the bad concentration was removed and the other concentration value was used. If both concentrations were good then they were averaged and used for further analysis.

Table 9.5. Lachat 8500 Methods and detection ranges.

Nutrient	*Method*	*Detection Range**	*Precision***
Nitrate-N (NO_3^- and NO_2^-)	QuikChem Method 10-107-04-1-A	0.01 - 20 mg L^{-1}	RSD = 0.52%
Total Ammonia-N (NH_3)	QuikChem Method 10-107-06-1-B	0.007 - 5.0 mg L^{-1}	RSD = 0.26%
Orthophosphate-P (PO_4^-)	QuikChem Method 10-115-01-1-A	0.01 - 2.0 mg L^{-1}	RSD= 0.186%

The different analysis methods are explained below:

Nitrate is quantitatively reduced to nitrite by passage of the sample through a copperized cadmium column. The nitrite (reduced nitrate plus original nitrite) is then determined by diazotizing with sulfanilamide followed by coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. The resulting water soluble dye has a magenta color which is read photometrically at 520 nm.

The Ammonia method is based on the Berthelot reaction. Ammonia reacts with alkaline phenol, then with sodium hypochlorite to form indophenol blue. Sodium nitroprusside (nitroferricyanide) is added to enhance sensitivity. The absorbance of the reaction product is measured photometrically at 630 nm, and is directly proportional to the original ammonia concentration in the sample.

The orthophosphate ion reacts with ammonium molybdate and antimony potassium tartrate under acidic conditions to form a complex. This complex is reduced with ascorbic acid to form a blue complex with absorbs light at 880 nm. The absorbance is proportional to the concentration of orthophosphate in the sample.

9.5.3 CAP Analysis

Each fence was examined visually in order to see if sediment had been collected. If there was a change in color, notes were taken and it was measured. Once all the fences were examined, areas were calculated for the locations were sediment had collected. Areas were also calculated for the measurements that were taken in the field.

Once the areas were calculated, the data from each silt fence was analyzed. Since the areas that were being used to calculate the volumes were oddly shaped, an estimated rectangular shape was used. For the fences that had both an area from field observations and from the painted area, the volume of the wedge was calculated. The wedge shape was assumed to be a right triangle. Once these areas were calculated, they were plotted in excel and a trend line was calculated. For the fences that only had an area calculated for the painted area, the equation from the trend line was used to calculate the volume.

9.6 Results and Discussion

A total of ten rainfall events were monitored for suspended sediment and nutrients at six different agricultural locations containing twenty different management practices. Monitoring efforts resulted in the collection of 166 discharge measurements, 213 suspended sediment samples, and 175 nutrient samples.

These measurements help illustrate the effects that different management practices on varied property types have on concentrations of suspended sediment and nutrients. Tables 9.9 through 9.13 summarize field site characteristics including the type of management practices installed, number of practices, soil and slope conditions, runoff, SSC, and nutrient data for each event monitored during the present study. The Event Mean Concentration (EMC) values from these tables are summarized in figures 9.10 – 9.19. Tables 9.6 and 9.7 provide lists of codes used in these tables and graphs.

In addition, this new data has been added to an existing database of on-farm monitoring results (see Table 9.8 for previous on-farm data from Watson et al. 2003). Over time a sufficient number of results may be accumulated that could then be used to draw valid inferences about the region. Whereas, the results of any single study, such as the present one, may represent too small a sample size for regional analyses. We do not attempt to provide a regional analysis here, but only seek to point out the varied value of this type of on-farm data.

Table 9.6. Codes for Ag Event Summary Table.

Event Summary Table Codes		
General:	na	not applicable
	nr	not recorded
	pid	partial inlet data, can't compute
Practice Type:		
	DB	Detention basin
	DD	Detention ditch
	FR, NP	Field Runoff, No practice
	RB	Retention basin
	SFS	Silt Fence Series
Event Type:		
	I	Irrigation
	R	Rainfall
Soil Textures:		
	LFS	Loamy fine sand
	GSL/L	Gravelly sandy loam/Loam
	SL/L	Sandy loam/Loam
	L	Loam
	LS/FSL	Loamy sand/Fine sandy loam
	FSL	Fine sandy loam

Table 9.7. EMC Graph Codes.

EMC Graph Codes
1 - No flow occurred during this event.
2 - Minimal flow data so mean concentrations, not EMCs, used.
3 - Only 1 outflow measurement, not an EMC.
4 - Inlets are NDD and SDD outflows
5 - no flow left the site, 100% containment
6 - flowed but didn't measure because site becomes submerged during large events

Table 9.8 Summary of runoff and sediment data for a variety of agricultural fields under discrete irrigation or rainfall events. Note that linear irrigation systems only apply water to a fraction of the irrigated area at any given instant. The paired values for application rate and duration reflect both instantaneous irrigated areas and total irrigated areas. Reproduced from Watson et al. 2003.

Field	Date	Soil texture	Slope	Slope x surface erodibility	Crop	Crop stage	Soil state	Detention before sampling point?	Irrigation or rainfall	Area water applied to (m2)	App. rate (mm/hr)	Peak app. rate (mm/hr)	App. Duration (min)	Applied (mm)	Runoff (mm)	Runoff Coeff.	Sed. loss (tonnes /km2 /event)	EMC (mg/L)	Loss per net app. (tonnes /km2/mm)
D1	19-Feb-01	L, SL	0% - 2%	0.28%	None	Fallow	Cultivated	None	Rainfall	51230	3.8	13.3	220.00	14.0	1.49	10.7%	54.15	36,310	4.33
B3	28-Jun-00	L	~0-2%	0.28%	Red & green	Mature (last water)	Sealed	None	Linear	14731	34.35 / 5.67	34.35 / 5.67	45.37 / 275	26.0	1.36	5.2%	17.85	13,122	0.73
B2B	28-Jun-00	L	~0-2%	0.28%	Lettuce	Early (2nd water)	Sealed?	None	Linear	21535	46.6 / 4.03	46.6 / 4.03	24.19 / 280	18.8	1.62	9.4%	13.98	8,647	0.81
A2	30-Jun-00	FSL	~0-2%	0.20%	Red & green	Mature - last	Partly sealed	None	Sprinkler	13315	8.7	8.7	188.00	27.2	2.56	9.4%	7.77	3,033	0.32
C1	22-Jul-00	SiCL	0.01%-0.03%	0.01%	Cauliflo wer	Mid (17 days since	Cultivated		Sprinkler	28387	10.1	10.1	301.00	50.4	0.79	1.6%	7.03	8,868	0.14
B2A	22-Jun-00	L	~0-2%	0.28%	Broccol i	Early (2nd water)	Cultivated	None	Linear	15834	31.42 / 3.75	31.42 / 3.75	24.93 / 209	13.1	0.94	7.2%	5.86	6,235	0.48
D1	12-Feb-01	L, SL	0% - 2%	0.28%	None	Fallow	Cultivated	None	Rainfall - tail	51230	5.0	7.5	24.00	2.0	0.46	23.0%	5.53	12,010	3.59
D2	19-Feb-01	L, SL	0% - 5%	0.70%	None	Fallow	Cultivated	None	Rainfall	38490	3.8	13.3	220.00	14.0	0.83	5.9%	5.42	6,561	0.41
C1	02-Aug-00	SiCL	0.01%-0.03%	0.01%	Cauliflo wer	Mid (28 days since	Cultivated		Sprinkler	28387	8.4	8.4	345.00	48.4	1.51	3.1%	4.72	3,127	0.10
D1	11-Feb-01	L, SL	0% - 2%	0.28%	None	Fallow	Cultivated	None	Rainfall - tail	51230	1.6	3.0	137.00	3.8	0.35	9.2%	2.02	5,840	0.59
D2	12-Feb-01	L, SL	0% - 5%	0.70%	None	Fallow	Cultivated	None	Rainfall - tail	38490	5.0	7.5	24.00	2.0	0.20	10.2%	1.16	5,721	0.65
E3	24-Nov-01	LS	1% - 3.5%	0.23%	Brus. Spr.	Mature	Not cultivated	None	Rainfall	18723	4.7	7.2	240.00	16.0	0.10	0.6%	0.97	9,731	0.06
A1	30-Jun-00	FSL	~0-2%	0.20%	Red & green	Mature - last	Partly sealed	None	Sprinkler	14698	8.7	8.7	188.00	27.2	2.30	8.5%	0.88	384	0.04
A2	23-May-00	FSL	~0-2%	0.20%	Leaf lettuce	2 weeks	Mostly sealed	None	Sprinkler (artificial)	31736.5	6.0	6.0	84.00	8.4	0.30	3.6%	0.77	2,541	0.09
A1	23-May-00	FSL	~0-2%	0.20%	Leaf lettuce	2 weeks	Mostly sealed	Some water and	Sprinkler (artificial)	31736.5	6.0	6.0	84.00	8.4	0.11	1.3%	0.39	3,575	0.05
F1	28-29-Nov-01	C	6.8%	0.82%	None	Fallow	Composted, Sealed		Rainfall	42673	1.2	2.5	251.00	5.1	0.07	1.4%	0.35	4,986	0.07
E2	24-Nov-01	LS	1% - 6%	0.35%	Brus. Spr.	Mature	Not cultivated	Wetland	Rainfall	50392	2.0	7.2	240.00	16.0	0.14	0.9%	0.30	2,091	0.02
D2	11-Feb-01	L, SL	0% - 5%	0.70%	None	Fallow	Cultivated	None	Rainfall - tail	38490	1.6	3.0	137.00	3.8	0.14	3.6%	0.28	2,084	0.08
E1	24-Nov-01	LS	1% - 6%	0.35%	Brus. Spr.	Mature	Not cultivated	None	Rainfall	50392	3.7	7.2	240.00	16.0	0.36	2.3%	0.20	544	0.01
E4	24-Nov-01	LS	1% - 6%	0.35%	Brus. Spr.	Mature	Not cultivated	None	Rainfall	75127	7.7	7.2	240.00	16.0	0.03	0.2%	0.01	390	0.00
B1		L	~0-2%	0.28%	None	Fallow	Cultivated	None	Linear		35.66 / 3.57	35.66 / 3.57		31.2	0.00	0.0%	0.00	0	0.00
C1	Pre-5-Jul-00	SiCL	0.01%-0.03%	0.01%	Cauliflo wer	Pre-transplant			Sprinkler	28387	9.0	9.0	540.00	81.0	0.00	0.0%	0.00	0	0.00
F2	28-29-Nov-01	C	8.8%	1.06%	None	Fallow	Composited, Not-sealed		Rainfall	4736	1.2	2.5	251.00	5.1	0.00	0.0%	0.00	0	0.00
G1	28-Dec-01	L, GSL	~2-5%	0.98%	Vines	Dormant	Light grass cover		Rainfall		0.2	0.8	1920.00	5.7	0.00	0.0%	0.00	0	0.00
G1	02-Jan-02	L, GSL	~2-5%	0.98%	Vines	Dormant	Light grass cover		Rainfall		1.3	1.5	540.00	11.3	0.00	0.0%	0.00	0	0.00

Table 9.9 Summary of characteristics for all agricultural sites monitored.

Field	Site Code	Date	Practice type	No. of Practices	Crop / Veg Cover	Crop Stage	Soil state	Soil texture	Slope	Slope x surface erodibility
R009	Basin 1	01 Dec 05	Retention basin	3 in series	none	fallow	cultivated	LFS	10.20%	0.0153
R009	Basin 2	01 Dec 05	Retention basin	3 in series	none	fallow	cultivated	LFS	10.20%	0.0153
R009	Basin 3	01 Dec 05	Retention basin	3 in series	none	fallow	cultivated	LFS	10.20%	0.0153
R009	Basin 1	18 Dec 05	Retention basin	3 in series	none	fallow	cultivated	LFS	10.20%	0.0153
R009	Basin 2	18 Dec 05	Retention basin	3 in series	none	fallow	cultivated	LFS	10.20%	0.0153
R009	Basin 3	18 Dec 05	Retention basin	3 in series	none	fallow	cultivated	LFS	10.20%	0.0153
R009	Basin 1	31 Dec 05	Retention basin	3 in series	none	fallow	cultivated	LFS	10.20%	0.0153
R009	Basin 2	31 Dec 05	Retention basin	3 in series	none	fallow	cultivated	LFS	10.20%	0.0153
R009	Basin 3	31 Dec 05	Retention basin	3 in series	none	fallow	cultivated	LFS	10.20%	0.0153
R010	N/A	06 Mar 06	Retention basin	1	mixed row	varied	cultivated	GSL/L	0.98%	0.003381
R010	N/A	17 Mar 06	Retention basin	1	mixed row	varied	cultivated	GSL/L	0.98%	0.003381
R011	Basin 1	06 Mar 06	Retention basin	2 in series	unknown (mixed)	varied	unknown	SL/L	2.00%	0.0068931
R011	Basin 2	06 Mar 06	Retention basin	2 in series	unknown (mixed)	varied	unknown	SL/L	2.00%	0.0068931
R011	Basin 1	20 Mar 06	Retention basin	2 in series	unknown (mixed)	varied	unknown	SL/L	2.00%	0.0068931
R011	Basin 2	20 Mar 06	Retention basin	2 in series	unknown (mixed)	varied	unknown	SL/L	2.00%	0.0068931
R012	inlet 1	09,23 Feb 07	Retention basin	basin; two separate ditches	none	fallow	cultivated	L	0.74%	0.002380988
R012	inlet 2	09,23 Feb 07	Retention basin	basin; two separate ditches	none	fallow	cultivated	L	0.61%	0.001953564
R013	1	27 Mar 06	None	N/A	lettuce	new transplants	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	2	27 Mar 06	None	N/A	lettuce	6" tall	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	3	27 Mar 06	None	N/A	strawberries (plastic)	mature	mostly sealed - plastic	LS/FSL	~0-0.5%	0.000375
R013	4	27 Mar 06	None	N/A	lettuce	6" tall	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	5	27 Mar 06	None	N/A	strawberries (plastic)	mature	mostly sealed - plastic	LS/FSL	~0-0.5%	0.000375
R013	6	27 Mar 06	None	N/A	artichokes	mature	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	9	27 Mar 06	None	N/A	strawberries (no plastic)	mature	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	ND	27 Mar 06	Ditch/slough	1	mixed	varied	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	SD	27 Mar 06	Ditch/slough	1	mixed	varied	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	B2 Inlet	27 Mar 06	None	2 in series	mixed	varied	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	B2 Outlet	27 Mar 06	None	N/A	mixed	varied	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	1	02 Apr 06	None	N/A	lettuce	new transplants	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	2	02 Apr 06	None	N/A	lettuce	6" tall	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	3	02 Apr 06	None	N/A	strawberries (plastic)	mature	mostly sealed - plastic	LS/FSL	~0-0.5%	0.000375
R013	4	02 Apr 06	None	N/A	lettuce	6" tall	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	5	02 Apr 06	None	N/A	strawberries (plastic)	mature	mostly sealed - plastic	LS/FSL	~0-0.5%	0.000375
R013	6	02 Apr 06	None	N/A	artichokes	mature	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	9	02 Apr 06	None	N/A	strawberries (no plastic)	mature	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	ND	02 Apr 06	Ditch/slough	1	mixed	varied	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	SD	02 Apr 06	Ditch/slough	1	mixed	varied	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	B2 Inlet	02 Apr 06	None	2 in series	mixed	varied	partly sealed	LS/FSL	~0-0.5%	0.000375
R013	B2 Outlet	02 Apr 06	None	N/A	mixed	varied	partly sealed	LS/FSL	~0-0.5%	0.000375
R014	1a	Nov 06 - Feb 07	silt fence series	1	revegetated, seeded with acorns, straw	patchy, not thick	rice straw, vegetated	FSL	8-12.0%	0.032
R014	1b	Nov 06 - Feb 07	silt fence series	1	revegetated, seeded with acorns, straw	patchy, not thick	rice straw, vegetated	FSL	13-16.0%	0.0464
R014	2a	Nov 06 - Feb 07	silt fence series	1	revegetated, seeded with acorns, straw	thick cover	rice straw, vegetated	FSL	8-12.0%	0.032
R014	2b	Nov 06 - Feb 07	silt fence series	1	revegetated, seeded with acorns, straw	patchy, not thick	rice straw, vegetated	FSL	13-16.0%	0.0464
R014	3a	Nov 06 - Feb 07	silt fence series	1	non-natives (mostly)	thick cover	mowed	FSL	8-12.0%	0.032
R014	3b	Nov 06 - Feb 07	silt fence series	1	non-natives (mostly)	thick cover	mowed	FSL	13-16.0%	0.0464
R014	4a	Nov 06 - Feb 07	silt fence series	1	revegetated, clover, native grass, straw	thick cover	rice straw, vegetated	FSL	8-12.0%	0.032
R014	4b	Nov 06 - Feb 07	silt fence series	1	revegetated, clover, native grass, straw	thick cover	rice straw, vegetated	FSL	13-16.0%	0.0464
R014	5b	Nov 06 - Feb 07	silt fence series	1	Oak woodland	mature, dense leaf litter	natural with litter	FSL	13-16.0%	0.0464

Table 9.10 Summary of runoff and sediment loss/retention data for variety of agricultural sites and rainfall events.

				RUNOFF							SSC								
Property-Site Code	Site Description	Date	Practice type	Event Type	Area water applied (km2)	App. Duration (hours)	Applied (mm)	Runoff in (mm)	Runoff out (mm)	Runoff coeff.	No. Samples	Sediment Loss (tonnes/km2) Incoming	Sediment Loss (tonnes/km2) Outgoing	SSC MC (mg/L) Incoming	SSC MC (mg/L) Outgoing	SSC EMC (mg/L) Incoming	SSC EMC (mg/L) Outgoing	Sediment Loss per net app. (tonnes/km2/mm) Incoming	Sediment Loss per net app. (tonnes/km2/mm) Outgoing
R009-01/02	Basin 1	01 Dec 05	DB	R	0.08	3:40	6.3	0	na	0%	0	na	na	na	na	na	na	na	na
R009-03/04	Basin 2	01 Dec 05	DB	R	0.13	3:40	6.3	0	na	0%	0	na	na	na	na	na	na	na	na
R009-05/06	Basin 3	01 Dec 05	DB	R	0.13	3:40	6.3	0	na	0%	0	na	na	na	na	na	na	na	na
R009-01/02	Basin 1	18 Dec 05	DB	R	0.08	1:00	46.0	nr	nr	nr	3, 2	nr	nr	nr	nr	nr	nr	nr	nr
R009-03/04	Basin 2	18 Dec 05	DB	R	0.13	1:00	46.0	nr	nr	nr	2 ,2	nr	nr	nr	nr	nr	nr	nr	nr
R009-05/06	Basin 3	18 Dec 05	DB	R	0.13	1:00	46.0	nr	nr	nr	2, 0	nr	nr	nr	nr	nr	nr	nr	nr
R009-01/02	Basin 1	31 Dec 05	DB	R	0.08	5:00	14.4	1.2	1.1	8.6%	3, 4	104.78	21.34	79036	15225	84995	18741	7.28	1.48
R009-03/04	Basin 2	31 Dec 05	DB	R	0.13	5:00	14.4	2.0	1.2	13.9%	4, 4	29.86	9.50	13273	7847	14909	8084	2.07	0.66
R009-05/06	Basin 3	31 Dec 05	DB	R	0.13	5:00	14.4	1.1	nr	7.7%	1	8.93	nr	7847	3028	8084	nr	0.62	nr
R010-01/02	1 Basin	06 Mar 06	DB	R	0.27	6:41	12.2	1.7	1.9	13.7%	4, 5	4.50	2.53	1929	1194	2674	1306	0.37	0.21
R010-01/03/02	1 Basin	17 Mar 06	DB	R	0.27	12:55	6.9	1.9	2.1	27.4%	14, 12	4.08	3.15	2269	1026	2142	1531	0.59	0.45
R011-01/02	Basin 1	06 Mar 06	DB	R	3.52	9:00	11.8	0.1	0.1	1.0%	3, 2	1.44	0.36	8136	2079	12394	3064	0.12	0.03
R011-03/05	Basin 2	06 Mar 06	DB	R	3.52	9:00	11.8	0.1	0.0	1.0%	2, 2	0.36	nr	2079	1207	3064	na	0.03	nr
R011-01/02	Basin 1	20 Mar 06	DB	R	3.52	17:31	8.6	0.4	0.4	4.3%	6, 3	0.75	0.72	646	2590	2026	2012	0.09	0.08
R011-03/05	Basin 2	20 Mar 06	DB	R	3.52	17:31	8.6	0.4	1.1	4.3%	3, 8	0.72	0.11	2590	125	2012	95	0.08	0.01
R012-01	Basin inlet 1	09,23 Feb 07	DB	R	0.41	18:45	57.2	na	na	na	na	72.73	na	na	na	0	na	1.27	na
R012-02	Basin inlet 2	09,23 Feb 07	DB	R	0.08	18:45	57.2	na	na	na	na	2.49	na	na	na	0	na	0.04	na
R013-01	pipe 1	27 Mar 06	FR, NP	R	0.02	2:54	7.5	na	na	na	na	na	na	na	na	na	na	na	na
R013-02	pipe 2	27 Mar 06	FR, NP	R	0.03	2:54	7.5	0.0	na	0.7%	4	0.08	na	1015	na	1552	na	0.01	na
R013-03	pipe 3	27 Mar 06	FR, NP	R	0.05	2:54	7.5	0.4	na	5.0%	5	0.36	na	833	na	958	na	0.05	na
R013-04	pipe 4	27 Mar 06	FR, NP	R	0.03	2:54	7.5	na	na	na	na	na	na	na	na	na	na	na	na
R013-05	pipe 5	27 Mar 06	FR, NP	R	0.06	2:54	7.5	0.2	na	2.3%	5	0.10	na	431	na	560	na	0.01	na
R013-06	pipe 6	27 Mar 06	FR, NP	R	0.08	2:54	7.5	0.0	na	0.0%	1	0.00	na	543	na	na	na	0.00	na
R013-09	pipe 9 (to B2)	27 Mar 06	FR, NP	R	0.06	2:54	7.5	0.1	na	1.4%	4	0.19	na	1311	na	1763	na	0.02	na
R013-07	North Ditch	27 Mar 06	DD	R	0.56	2:54	7.5	na	0.2	3.0%	4	pid	0.21	nr	518	pid	961	nr	0.03
R013-08	South Ditch	27 Mar 06	DD	R	0.28	2:54	7.5	na	0.2	3.0%	4	pid	0.11	nr	809	pid	494	nr	0.01
R013-10	Basin 2 Inlet	27 Mar 06	RB	R	0.84	2:54	7.5	0.1	na	1.2%	3	0.00	na	83	na	45	na	0.00	na
R013-11	Basin 2 Outlet	27 Mar 06	RB	R	0.89	2:54	7.5	0.0	0.0	na	na	na	na	na	na	na	na	na	na
R013-01	pipe 1	02 Apr 06	FR, NP	R	0.02	9:16	41.8	3.3	3.3	8.0%	4	9.71	na	1839	na	2912	na	0.23	na
R013-02	pipe 2	02 Apr 06	FR, NP	R	0.03	9:16	41.8	nr	nr	2.9%	0	na	na	na	na	na	na	na	na
R013-03	pipe 3	02 Apr 06	FR, NP	R	0.05	9:16	41.8	17.4	17.4	41.7%	9	19.21	na	738	na	1102	na	0.46	na
R013-04	pipe 4	02 Apr 06	FR, NP	R	0.03	9:16	41.8	28.6	28.6	68.4%	7	49.58	na	1202	na	1734	na	1.19	na
R013-05	pipe 5	02 Apr 06	FR, NP	R	0.06	9:16	41.8	1.6	1.6	3.9%	9	1.06	na	313	na	655	na	0.03	na
R013-06	pipe 6	02 Apr 06	FR, NP	R	0.08	9:16	41.8	12.5	12.5	29.8%	7	19.93	na	1055	na	1599	na	0.48	na
R013-09	pipe 9 (to B2)	02 Apr 06	FR, NP	R	0.06	9:16	41.8	8.4	8.4	20.1%	6	9.47	na	800	na	1126	na	0.23	na
R013-07	North Ditch	02 Apr 06	DD	R	0.56	9:16	41.8	13.3	na	32.9%	6	pid	8.16	nr	518	nr	612	nr	0.20
R013-08	South Ditch	02 Apr 06	DD	R	0.28	9:16	41.8	6.8	na	16.2%	6	pid	4.72	nr	524	nr	690	nr	0.11
R013-10	Basin 2 In	02 Apr 06	RB	R	0.84	9:16	41.8	15.7	15.7	37.6%	9	1.55	na	79	na	99	na	0.04	na
R013-11	Basin 2 Out	02 Apr 06	RB	R	0.89	9:16	41.8	15.3	na	36.6%	11	na	1.22	na	53	na	80	na	0.03
R014-1a	1a	Nov 06 - Feb 07	SFS	R	na	~4 months	213.2	na	na	na	na	na	11.9	na	na	na	na	na	na
R014-1b	1b	Nov 06 - Feb 07	SFS	R	na	~4 months	213.2	na	na	na	na	na	2.2	na	na	na	na	na	na
R014-2a	2a	Nov 06 - Feb 07	SFS	R	na	~4 months	213.2	na	na	na	na	na	0.0	na	na	na	na	na	na
R014-2b	2b	Nov 06 - Feb 07	SFS	R	na	~4 months	213.2	na	na	na	na	na	0.8	na	na	na	na	na	na
R014-3a	3a	Nov 06 - Feb 07	SFS	R	na	~4 months	213.2	na	na	na	na	na	0.9	na	na	na	na	na	na
R014-3b	3b	Nov 06 - Feb 07	SFS	R	na	~4 months	213.2	na	na	na	na	na	0.9	na	na	na	na	na	na
R014-4a	4a	Nov 06 - Feb 07	SFS	R	na	~4 months	213.2	na	na	na	na	na	0.2	na	na	na	na	na	na
R014-4b	4b	Nov 06 - Feb 07	SFS	R	na	~4 months	213.2	na	na	na	na	na	0.6	na	na	na	na	na	na
R014-5b	5b	Nov 06 - Feb 07	SFS	R	na	~4 months	213.2	na	na	na	na	na	0.0	na	na	na	na	na	na

Table 9.11 Summary of runoff and nitrate (NO_3–N) loss/retention data for variety of agricultural sites and rainfall events.

				RUNOFF (REPRODUCED FROM TABLE 9.10)							Nitrate-N								
Property-Site Code	Site Description	Date	Practice type	Event Type	Area water applied to (km2)	App. Duration (hours)	Applied (mm)	Runoff in (mm)	Runoff out (mm)	Runoff coeff.	No. Samples	NO3-N (g/km2) Incoming	NO3-N (g/km2) Outgoing	NO3-N MC (mg/L) Incoming	NO3-N MC (mg/L) Outgoing	NO3-N EMC (mg/L) Incoming	NO3-N EMC (mg/L) Outgoing	NO3-N Loss per net app. (g/km2/mm) Incoming	NO3-N Loss per net app. (g/km2/mm) Outgoing
R009-01/02	Basin 1	01 Dec 05	DB	R	0.08	3:40	6.3	0	na	0%	0	na	na	na	na	na	na	na	na
R009-03/04	Basin 2	01 Dec 05	DB	R	0.13	3:40	6.3	0	na	0%	0	na	na	na	na	na	na	na	na
R009-05/06	Basin 3	01 Dec 05	DB	R	0.13	3:40	6.3	0	na	0%	0	na	na	na	na	na	na	na	na
R009-01/02	Basin 1	18 Dec 05	DB	R	0.08	1:00	46.0	nr	nr	nr	3, 2	nr	nr	nr	nr	nr	nr	nr	nr
R009-03/04	Basin 2	18 Dec 05	DB	R	0.13	1:00	46.0	nr	nr	nr	2 ,2	nr	nr	nr	nr	nr	nr	nr	nr
R009-05/06	Basin 3	18 Dec 05	DB	R	0.13	1:00	46.0	nr	nr	nr	2, 0	nr	nr	nr	nr	nr	nr	nr	nr
R009-01/02	Basin 1	31 Dec 05	DB	R	0.08	5:00	14.4	1.2	1.1	8.6%	3, 4	1184	1055	0.96	0.94	0.96	0.93	82.24	73.28
R009-03/04	Basin 2	31 Dec 05	DB	R	0.13	5:00	14.4	2.0	1.2	13.9%	4, 4	1725	992	0.86	0.84	0.86	0.84	119.82	68.91
R009-05/06	Basin 3	31 Dec 05	DB	R	0.13	5:00	14.4	1.1	nr	7.7%	1	932	nr	0.84	0.73	0.84	na	64.73	nr
R010-01/02	1 Basin	06 Mar 06	DB	R	0.27	6:41	12.2	1.7	1.9	13.7%	5, 5	2560	2004	1.44	1.18	1.52	1.03	209.24	163.79
R010-01/03/02	1 Basin	17 Mar 06	DB	R	0.27	12:55	6.9	1.9	2.1	27.4%	7, 7	2051	2005	1.25	0.99	1.08	0.97	295.43	288.78
R011-01/02	Basin 1	06 Mar 06	DB	R	3.52	9:00	11.8	0.1	0.1	1.0%	3, 2	1071	1000	5.86	13.77	9.21	8.59	90.72	84.64
R011-03/05	Basin 2	06 Mar 06	DB	R	3.52	9:00	11.8	0.1	0.0	1.0%	2, 1	1000	na	13.77	8.04	8.59	na	84.64	na
R011-01/02	Basin 1	20 Mar 06	DB	R	3.52	17:31	8.6	0.4	0.4	4.3%	6, 3	17930	6493	17.81	16.53	48.64	18.04	2096.73	759.27
R011-03/05	Basin 2	20 Mar 06	DB	R	3.52	17:31	8.6	0.4	1.1	4.3%	3, 8	6493	17280	16.53	15.24	18.04	15.03	759.27	2020.72
R013-01	pipe 1	27 Mar 06	FR, NP	R	0.02	2:54	7.5	na	na	na	na	na	na	na	na	na	na	na	na
R013-02	pipe 2	27 Mar 06	FR, NP	R	0.03	2:54	7.5	0.0	na	0.7%	4	730	na	12.59	na	14.67	na	96.91	na
R013-03	pipe 3	27 Mar 06	FR, NP	R	0.05	2:54	7.5	0.4	na	5.0%	5	2511	na	7.43	na	6.62	na	333.26	na
R013-04	pipe 4	27 Mar 06	FR, NP	R	0.03	2:54	7.5	na	na	na	na	na	na	na	na	na	na	na	na
R013-05	pipe 5	27 Mar 06	FR, NP	R	0.06	2:54	7.5	0.2	na	2.3%	5	2198	na	11.38	na	12.91	na	291.71	na
R013-06	pipe 6	27 Mar 06	FR, NP	R	0.08	2:54	7.5	0.0	na	0.0%	1	46	na	41.25	na	na	na	6.12	na
R013-09	pipe 9 (to B2)	27 Mar 06	FR, NP	R	0.06	2:54	7.5	0.1	na	1.4%	4	767	na	9.24	na	7.28	na	101.76	na
R013-07	North Ditch	27 Mar 06	DD	R	0.56	2:54	7.5	na	0.2	3.0%	4	946	946	5.25	5.25	pid	4.24	pid	125.58
R013-08	South Ditch	27 Mar 06	DD	R	0.28	2:54	7.5	na	0.2	3.0%	4	1889	1889	9.95	9.95	pid	8.46	pid	250.70
R013-10	Basin 2 Inlet	27 Mar 06	RB	R	0.84	2:54	7.5	0.1	na	1.2%	3	433	na	10.97	na	4.76	na	57.40	na
R013-11	Basin 2 Outlet	27 Mar 06	RB	R	0.89	2:54	7.5	na	0.0	na	na	na	na	na	na	na	na	na	na
R013-01	pipe 1	02 Apr 06	FR, NP	R	0.02	9:16	41.8	3.3	3.3	8.0%	4	90952	na	26.40	na	27.28	na	2176.76	na
R013-02	pipe 2	02 Apr 06	FR, NP	R	0.03	9:16	41.8	nr	nr	2.9%	0	na	na	na	na	na	na	na	na
R013-03	pipe 3	02 Apr 06	FR, NP	R	0.05	9:16	41.8	17.4	17.4	41.7%	5	162235	na	13.14	na	9.31	na	3882.81	na
R013-04	pipe 4	02 Apr 06	FR, NP	R	0.03	9:16	41.8	28.6	28.6	68.4%	6	207058	na	9.51	na	7.24	na	4955.56	na
R013-05	pipe 5	02 Apr 06	FR, NP	R	0.06	9:16	41.8	1.6	1.6	3.9%	8	23265	na	16.97	na	14.43	na	556.82	na
R013-06	pipe 6	02 Apr 06	FR, NP	R	0.08	9:16	41.8	12.5	12.5	29.8%	6	302369	na	38.99	na	24.25	na	7236.65	na
R013-09	pipe 9 (to B2)	02 Apr 06	FR, NP	R	0.06	9:16	41.8	8.4	8.4	20.1%	5	103555	na	25.28	na	12.32	na	2478.40	na
R013-07	North Ditch	02 Apr 06	DD	R	0.56	9:16	41.8	13.3	na	32.9%	5	nr	133931	pid	12.53	pid	10.04	pid	3205.39
R013-08	South Ditch	02 Apr 06	DD	R	0.28	9:16	41.8	6.8	na	16.2%	5	nr	81166	pid	17.97	pid	11.87	pid	1942.55
R013-10	Basin 2 In	02 Apr 06	RB	R	0.84	9:16	41.8	15.7	15.7	37.6%	7	173710	na	11.89	na	11.06	na	4157.44	na
R013-11	Basin 2 Out	02 Apr 06	RB	R	0.89	9:16	41.8	15.3	na	36.6%	9	na	164453	na	10.21	na	10.75	na	3935.89

Table 9.12 Summary of runoff and ammonia (NH_3–N) loss/retention data for variety of agricultural sites and rainfall events.

				RUNOFF (REPRODUCED FROM TABLE 9.10)							Ammonia-N								
Property-Site Code	Site Description	Date	Practice type	Event Type	Area water applied to (km2)	App. Duration (hours)	Applied (mm)	Runoff in (mm)	Runoff out (mm)	Runoff coeff.	No. Samples	NH3-N (g/km2) Incoming	NH3-N (g/km2) Outgoing	NH3-N MC (mg/L) Incoming	NH3-N MC (mg/L) Outgoing	NH3-N EMC (mg/L) Incoming	NH3-N EMC (mg/L) Outgoing	NH3-N Loss per net app. (g/km2/mm) Incoming	NH3-N Loss per net app. (g/km2/mm) Outgoing
R009-01/02	Basin 1	01 Dec 05	DB	R	0.08	3:40	6.3	0	na	0%	0	na	na	na	na	na	na	na	na
R009-03/04	Basin 2	01 Dec 05	DB	R	0.13	3:40	6.3	0	na	0%	0	na	na	na	na	na	na	na	na
R009-05/06	Basin 3	01 Dec 05	DB	R	0.13	3:40	6.3	0	na	0%	0	na	na	na	na	na	na	na	na
R009-01/02	Basin 1	18 Dec 05	DB	R	0.08	1:00	46.0	nr	nr	nr	3, 2	nr	nr	nr	nr	nr	nr	nr	nr
R009-03/04	Basin 2	18 Dec 05	DB	R	0.13	1:00	46.0	nr	nr	nr	2 ,2	nr	nr	nr	nr	nr	nr	nr	nr
R009-05/06	Basin 3	18 Dec 05	DB	R	0.13	1:00	46.0	nr	nr	nr	2, 0	nr	nr	nr	nr	nr	nr	nr	nr
R009-01/02	Basin 1	31 Dec 05	DB	R	0.08	5:00	14.4	1.2	1.1	8.6%	3, 4	54	61	0.05	0.05	0.04	0.05	3.78	4.20
R009-03/04	Basin 2	31 Dec 05	DB	R	0.13	5:00	14.4	2.0	1.2	13.9%	4, 4	58	34	0.03	0.04	0.03	0.03	4.05	2.39
R009-05/06	Basin 3	31 Dec 05	DB	R	0.13	5:00	14.4	1.1	nr	7.7%	1	32	nr	0.04	na	0.03	na	2.25	nr
R010-01/02	1 Basin	06 Mar 06	DB	R	0.27	6:41	12.2	1.7	1.9	13.7%	5, 5	291	363	0.19	0.19	0.17	0.19	23.76	29.66
R010-01/03/02	1 Basin	17 Mar 06	DB	R	0.27	12:55	6.9	1.9	2.1	27.4%	7, 7	373	503	0.17	0.21	0.20	0.24	53.68	72.50
R011-01/02	Basin 1	06 Mar 06	DB	R	3.52	9:00	11.8	0.1	0.1	1.0%	3, 2	4	8	0.03	0.06	0.03	0.06	0.30	0.64
R011-03/05	Basin 2	06 Mar 06	DB	R	3.52	9:00	11.8	0.1	0.0	1.0%	2, 1	8	na	0.06	0.04	0.06	na	0.64	na
R011-01/02	Basin 1	20 Mar 06	DB	R	3.52	17:31	8.6	0.4	0.4	4.3%	6, 3	86	38	0.08	0.10	0.23	0.10	10.05	4.39
R011-03/05	Basin 2	20 Mar 06	DB	R	3.52	17:31	8.6	0.4	1.1	4.3%	3, 8	38	47	0.10	0.05	0.10	0.04	4.39	5.54
R013-01	pipe 1	27 Mar 06	FR, NP	R	0.02	2:54	7.5	na	na	na	na	na	na	na	na	na	na	na	na
R013-02	pipe 2	27 Mar 06	FR, NP	R	0.03	2:54	7.5	0.0	na	0.7%	4	32	na	0.65	na	0.64	na	4.22	na
R013-03	pipe 3	27 Mar 06	FR, NP	R	0.05	2:54	7.5	0.4	na	5.0%	5	26	na	0.05	na	0.07	na	3.47	na
R013-04	pipe 4	27 Mar 06	FR, NP	R	0.03	2:54	7.5	na	na	na	na	na	na	na	na	na	na	na	na
R013-05	pipe 5	27 Mar 06	FR, NP	R	0.06	2:54	7.5	0.2	na	2.3%	5	10	na	0.06	na	0.06	na	1.39	na
R013-06	pipe 6	27 Mar 06	FR, NP	R	0.08	2:54	7.5	0.0	na	0.0%	1	0	na	0.13	na	na	na	0.02	na
R013-09	pipe 9 (to B2)	27 Mar 06	FR, NP	R	0.06	2:54	7.5	0.1	na	1.4%	4	5	na	0.05	na	0.05	na	0.68	na
R013-07	North Ditch	27 Mar 06	DD	R	0.56	2:54	7.5	na	0.2	3.0%	4	pid	276	0.69	0.69	pid	1.24	pid	36.60
R013-08	South Ditch	27 Mar 06	DD	R	0.28	2:54	7.5	na	0.2	3.0%	4	pid	27	0.11	0.11	pid	0.12	pid	3.64
R013-10	Basin 2 Inlet	27 Mar 06	RB	R	0.84	2:54	7.5	0.1	na	1.2%	3	10	na	0.25	na	0.11	na	1.33	na
R013-11	Basin 2 Outlet	27 Mar 06	RB	R	0.89	2:54	7.5	na	0.0	na	na	na	na	na	na	na	na	na	na
R013-01	pipe 1	02 Apr 06	FR, NP	R	0.02	9:16	41.8	3.3	3.3	8.0%	4	10161	na	2.75	na	3.05	na	243.18	na
R013-02	pipe 2	02 Apr 06	FR, NP	R	0.03	9:16	41.8	nr	nr	2.9%	0	na	na	na	na	na	na	na	na
R013-03	pipe 3	02 Apr 06	FR, NP	R	0.05	9:16	41.8	17.4	17.4	41.7%	5	839	na	0.04	na	0.05	na	20.07	na
R013-04	pipe 4	02 Apr 06	FR, NP	R	0.03	9:16	41.8	28.6	28.6	68.4%	6	2486	na	0.15	na	0.09	na	59.49	na
R013-05	pipe 5	02 Apr 06	FR, NP	R	0.06	9:16	41.8	1.6	1.6	3.9%	8	39	na	0.03	na	0.02	na	0.94	na
R013-06	pipe 6	02 Apr 06	FR, NP	R	0.08	9:16	41.8	12.5	12.5	29.8%	6	4342	na	0.17	na	0.35	na	103.91	na
R013-09	pipe 9 (to B2)	02 Apr 06	FR, NP	R	0.06	9:16	41.8	8.4	8.4	20.1%	5	265	na	0.03	na	0.03	na	6.35	na
R013-07	North Ditch	02 Apr 06	DD	R	0.56	9:16	41.8	13.3	na	32.9%	5	pid	7109	pid	0.92	pid	0.53	pid	170.13
R013-08	South Ditch	02 Apr 06	DD	R	0.28	9:16	41.8	6.8	na	16.2%	5	pid	906	pid	0.19	pid	0.13	pid	21.69
R013-10	Basin 2 In	02 Apr 06	RB	R	0.84	9:16	41.8	15.7	15.7	37.6%	7	5189	na	0.33	na	0.33	na	124.19	na
R013-11	Basin 2 Out	02 Apr 06	RB	R	0.89	9:16	41.8	15.3	na	36.6%	9	na	4844	na	0.24	na	0.32	na	115.94

Table 9.13 Summary of runoff and orthophosphate (PO_4–P) loss/retention data for variety of agricultural sites and rainfall events.

				RUNOFF (REPRODUCED FROM TABLE 9.10)							Orthophosphate-P								
Property-Site Code	Site Description	Date	Practice type	Event Type	Area water applied to (km2)	App. Duration (hours)	Applied (mm)	Runoff in (mm)	Runoff out (mm)	Runoff coeff.	No. Samples	PO4-P (g/km2) Incoming	PO4-P (g/km2) Outgoing	PO4-P MC (mg/L) Incoming	PO4-P MC (mg/L) Outgoing	PO4-P EMC (mg/L) Incoming	PO4-P EMC (mg/L) Outgoing	PO4-P Loss per net app. (g/km2/mm) Incoming	PO4-P Loss per net app. (g/km2/mm) Outgoing
R009-01/02	Basin 1	01 Dec 05	DB	R	0.08	3:40	6.3	0	na	0%	0	na	na	na	na	na	na	na	na
R009-03/04	Basin 2	01 Dec 05	DB	R	0.13	3:40	6.3	0	na	0%	0	na	na	na	na	na	na	na	na
R009-05/06	Basin 3	01 Dec 05	DB	R	0.13	3:40	6.3	0	na	0%	0	na	na	na	na	na	na	na	na
R009-01/02	Basin 1	18 Dec 05	DB	R	0.08	1:00	46.0	nr	nr	nr	3, 2	nr	nr	nr	nr	nr	nr	nr	nr
R009-03/04	Basin 2	18 Dec 05	DB	R	0.13	1:00	46.0	nr	nr	nr	2 ,2	nr	nr	nr	nr	nr	nr	nr	nr
R009-05/06	Basin 3	18 Dec 05	DB	R	0.13	1:00	46.0	nr	nr	nr	2, 0	nr	nr	nr	nr	nr	nr	nr	nr
R009-01/02	Basin 1	31 Dec 05	DB	R	0.08	5:00	14.4	1.2	1.1	8.6%	3, 4	323	231	0.3	0.2	0.3	0.2	22.47	16.04
R009-03/04	Basin 2	31 Dec 05	DB	R	0.13	5:00	14.4	2.0	1.2	13.9%	4, 4	503	296	0.2	0.2	0.3	0.3	34.92	20.58
R009-05/06	Basin 3	31 Dec 05	DB	R	0.13	5:00	14.4	1.1	nr	7.7%	1	278	nr	0.2	na	0.3	na	19.33	nr
R010-01/02	1 Basin	06 Mar 06	DB	R	0.27	6:41	12.2	1.7	1.9	13.7%	5, 5	1173	1480	0.7	0.8	0.7	0.8	95.84	121.01
R010-01/03/02	1 Basin	17 Mar 06	DB	R	0.27	12:55	6.9	1.9	2.1	27.4%	7, 7	1251	1457	0.7	0.7	0.7	0.7	180.12	209.86
R011-01/02	Basin 1	06 Mar 06	DB	R	3.52	9:00	11.8	0.1	0.1	1.0%	3, 2	33	31	0.4	0.3	0.3	0.3	2.79	2.63
R011-03/05	Basin 2	06 Mar 06	DB	R	3.52	9:00	11.8	0.1	0.0	1.0%	2, 1	31	na	0.3	0.3	0.3	na	2.63	na
R011-01/02	Basin 1	20 Mar 06	DB	R	3.52	17:31	8.6	0.4	0.4	4.3%	6, 3	403	133	0.5	0.4	1.1	0.4	47.09	15.59
R011-03/05	Basin 2	20 Mar 06	DB	R	3.52	17:31	8.6	0.4	1.1	4.3%	3, 8	133	510	0.4	0.5	0.4	0.4	15.59	59.67
R013-01	pipe 1	27 Mar 06	FR, NP	R	0.02	2:54	7.5	na	na	na	na	na	na	na	na	na	na	na	na
R013-02	pipe 2	27 Mar 06	FR, NP	R	0.03	2:54	7.5	0.0	na	0.7%	4	24	na	0.5	na	0.5	na	3.17	na
R013-03	pipe 3	27 Mar 06	FR, NP	R	0.05	2:54	7.5	0.4	na	5.0%	5	118	na	0.4	na	0.3	na	15.64	na
R013-04	pipe 4	27 Mar 06	FR, NP	R	0.03	2:54	7.5	na	na	na	na	na	na	na	na	na	na	na	na
R013-05	pipe 5	27 Mar 06	FR, NP	R	0.06	2:54	7.5	0.2	na	2.3%	5	60	na	0.4	na	0.4	na	7.95	na
R013-06	pipe 6	27 Mar 06	FR, NP	R	0.08	2:54	7.5	0.0	na	0.0%	1	1	na	1.0	na	na	na	0.15	na
R013-09	pipe 9 (to B2)	27 Mar 06	FR, NP	R	0.06	2:54	7.5	0.1	na	1.4%	4	16	na	0.2	na	0.2	na	2.12	na
R013-07	North Ditch	27 Mar 06	DD	R	0.56	2:54	7.5	na	0.2	3.0%	4	pid	48	pid	0.49	pid	0.2	pid	6.38
R013-08	South Ditch	27 Mar 06	DD	R	0.28	2:54	7.5	na	0.2	3.0%	4	pid	73	pid	0.45	pid	0.3	pid	9.71
R013-10	Basin 2 Inlet	27 Mar 06	RB	R	0.84	2:54	7.5	0.1	na	1.2%	3	90	na	1.1	na	1.0	na	11.93	na
R013-11	Basin 2 Outlet	27 Mar 06	RB	R	0.89	2:54	7.5	na	0.0	na	na	na	na	na	na	na	na	na	na
R013-01	pipe 1	02 Apr 06	FR, NP	R	0.02	9:16	41.8	3.3	3.3	8.0%	4	3738	na	0.9	na	1.1	na	89.45	na
R013-02	pipe 2	02 Apr 06	FR, NP	R	0.03	9:16	41.8	nr	nr	2.9%	0	na	na	na	na	na	na	na	na
R013-03	pipe 3	02 Apr 06	FR, NP	R	0.05	9:16	41.8	17.4	17.4	41.7%	5	4194	na	0.6	na	0.2	na	100.38	na
R013-04	pipe 4	02 Apr 06	FR, NP	R	0.03	9:16	41.8	28.6	28.6	68.4%	6	21819	na	0.7	na	0.8	na	522.21	na
R013-05	pipe 5	02 Apr 06	FR, NP	R	0.06	9:16	41.8	1.6	1.6	3.9%	8	773	na	0.5	na	0.5	na	18.50	na
R013-06	pipe 6	02 Apr 06	FR, NP	R	0.08	9:16	41.8	12.5	12.5	29.8%	6	15922	na	1.3	na	1.3	na	381.05	na
R013-09	pipe 9 (to B2)	02 Apr 06	FR, NP	R	0.06	9:16	41.8	8.4	8.4	20.1%	5	2973	na	0.5	na	0.4	na	71.16	na
R013-07	North Ditch	02 Apr 06	DD	R	0.56	9:16	41.8	13.3	na	32.9%	5	pid	11472	pid	1.0	pid	0.9	pid	274.57
R013-08	South Ditch	02 Apr 06	DD	R	0.28	9:16	41.8	6.8	na	16.2%	5	pid	6800	pid	1.2	pid	1.0	pid	162.75
R013-10	Basin 2 Inlet	02 Apr 06	RB	R	0.84	9:16	41.8	15.7	15.7	37.6%	7	17693	na	1.2	na	1.1	na	423.44	na
R013-11	Basin 2 Outlet	02 Apr 06	RB	R	0.89	9:16	41.8	15.3	na	36.6%	9	na	15689	na	1.0	na	1.0	na	375.49

EMCs were calculated for sediment and nutrients for each event, whenever possible. If there were not enough flow measurements or samples to calculate an EMC, a conventional mean (i.e. not flow-weighted, as in EMC) was used. This, and other important notes, are denoted by numeric codes described in Table 9.7.

9.6.1 Suspended Sediment EMCs

Suspended sediment concentration was reduced at every site during every event.

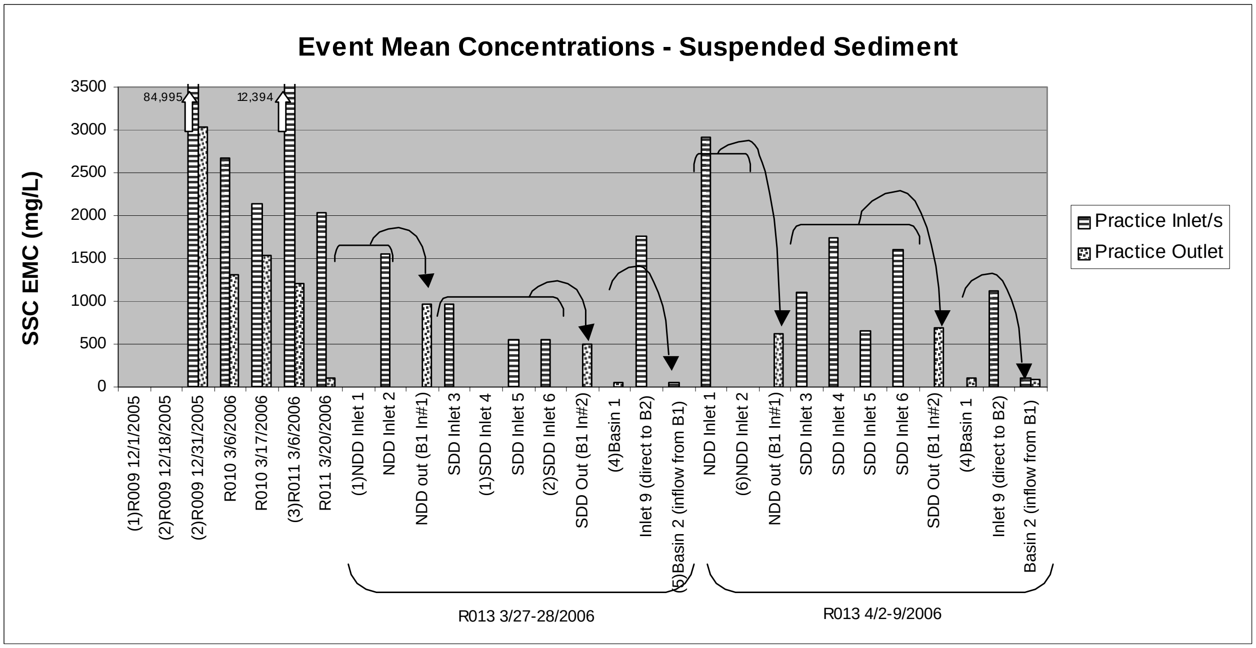


Figure 9.10. Suspended Sediment EMC Results from event monitoring of basins. See Table 9.7 for numeric codes.

<u>R009:</u> The 12/31/05 R009 event, for example, had an EMC of 84,995 mg/L at the first basin inlet, and a value of 3000 mg/L at the outlet of the 3rd basin in series. Although this value is still higher than the inlet values at all but one other site, it is a reduction of 96%. And although sand is largely responsible for such large SSC concentrations at the site, the basins also captured quite a lot of fine clay material. Figure 9.11 photo was taken at Basin 1.

Figure 9.11. Fine sediment captured in Basin 1.

Figure 9.12 illustrates a sediment fan spreading across Basin 2.

Figure 9.12. R009 Basin 2 sediment fan.

R010: R010 was a single basin, and much smaller, but it still had reductions of 51% and 29% on 3/6 and 3/17, respectively. The basin was relatively full of sediment during the time of monitoring, and was scheduled to be cleaned out in the Summer of 2006. Therefore, the results found are associated with shorter retention times due to decreased volume. Figure 9.13 illustrates what inlet and outlet water looked like at R010 for the 3/17 event. The inlet water was probably lighter than outlet water at the end of the event because inflow was so slow that less sediment was being transported into the basin. Outlet water, however, still was mixed with earlier flows of higher values. It's difficult to see, but SSCs revealed that the samples on the right contained ~1/3 less sediment.

Figure 9.13. R010 suspended sediment samples from the 3/17/06 rain event.

<u>R011:</u> The two R011 events look quite different because they represent different parts of storm events. On 3/6 the beginning of a event was measured when flow and SSC values were highest. For the 3/20-24 event, measurements started a few hours after flow commenced, likely missing the usual ‘first-flush’ plug of high-sediment-concentration flow. This event was monitored for four days, and shows how over that time the basin drained slowly and most of the sediment had time to settle out. This was quite visually obvious from the samples (figure 9.13). This site employs a standing pipe in the second basin with orifices to drain the water out slowly. If some water compounded longer-term in the basin wasn’t undesirable, the initial highest values of SSC could be further reduced by leaving a bottom section of the drain pipe without any orifices.

Figure 9.14. R011 Suspended sediment samples from the 3/20-24/06 rain event.

R013: Monitoring at this site was complex because of the numerous inputs and ditches, ultimately draining to two large basins in series. Two events are described here, enclosed by the brackets underneath. There were several pipes directly draining fields with no intervening retention basin. These are labeled “inlets” 1-6, and 9. These flow into the North Detention Ditch (NDD) and South Detention Ditch (SDD), with one pipe (9) flowing directly into the second basin. In all cases, the values flowing out of the NDD and SDD were lower, with sediment having had time to partially settle out. Basin 1 then flowed directly into Basin 2. The 3/27-28 event was small enough that the entire amount of runoff water could be contained onsite, resulting in 100% containment. By the time that the water flowed out of Basin 1 during both events, the sediment had been reduced so much that additional settling didn’t appear to be possible, at least during the sampling timeframe. Basin 2 served simply as additional runoff storage, enabling water to be retained onsite for all but the largest events. The 4/2-9 event was several days of unrelenting rain. The maximum EMC for that event was 2912 mg/L, and the outflow from the site was at 80 mg/L. More suspended sediment was flowing off the fields on the 4th than on the 3rd, but the system was able to handle the additional load (figures 9.15 and 9.16).

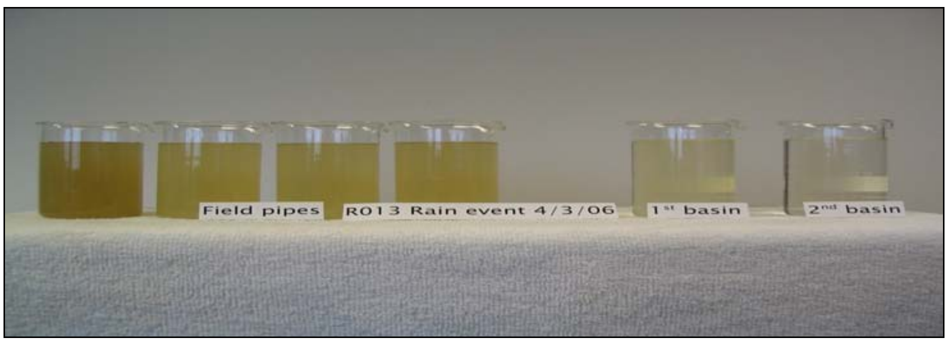


Figure 9.15. R013 suspended sediment samples for 4/3/06.

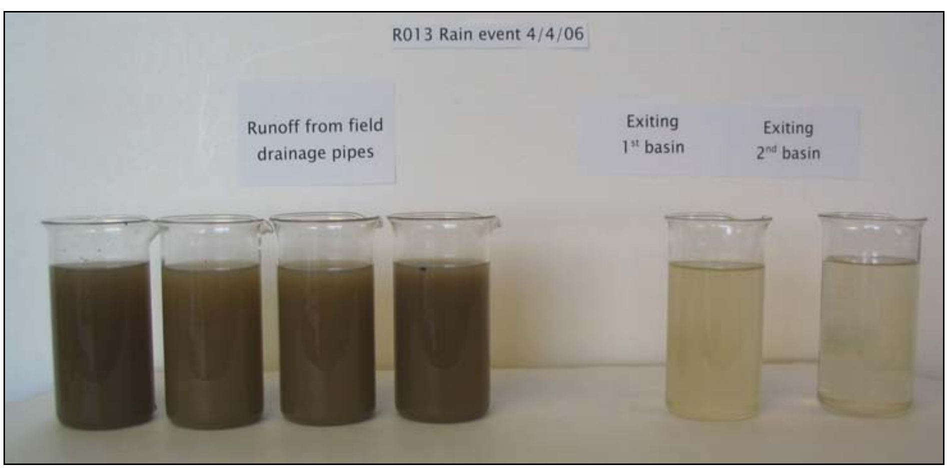


Figure 9.16. R013 suspended sediment samples for 4/4/06.

9.6.2 Nutrients

A significant change in nutrient concentrations in sediment basins was not expected, but seemed possible in some of the larger ones, especially if water was compounded for a period of days (as opposed to just minutes or hours). No vegetation for the installed purpose of water quality improvement was present in any of the basins, however, some underwater vegetation was present at R013 in both Basins since these always hold water (the detention ditches at this site drain completely/almost completely after events). Due to constant moisture, it was thought that the soil in these basins may also have denitrifying bacteria.

The following conclusions are drawn from looking at figures 9.17, 9.18, and 9.19. Nitrate inputs were low at R009 and R010, and look unchanged at the outlets. Ammonia and orthophosphate also appear unchanged. R011 appears to experience reductions in all nutrients when monitored over several days (3/20-23 event), but not over the span of a few hours (3/6 event). This larger basin (2) had water in it at least at a low level for some time due to previous rains during the season that may have facilitated bacteria for denitrification. Since there were no other less-concentrated sources of water to the basins, the reductions could not have been due to dilution. For R013, there doesn't seem to be any evidence that nutrients are being reduced within the basins. The values coming into Basin 1, and into and out of Basin 2 remained essentially the same. However, it is clear that the ability of the site to compound a lot of water serves to dilute flows from fields with higher nutrient levels with lower ones from other fields, resulting in lower overall values leaving the site than were observed from some fields.

In conclusion, we found minimal evidence only of nutrient removal from water passing through the retention basins considered during the study, except at R011. This is not unexpected, as nutrient removal is not the designed function of these sediment retention basins.

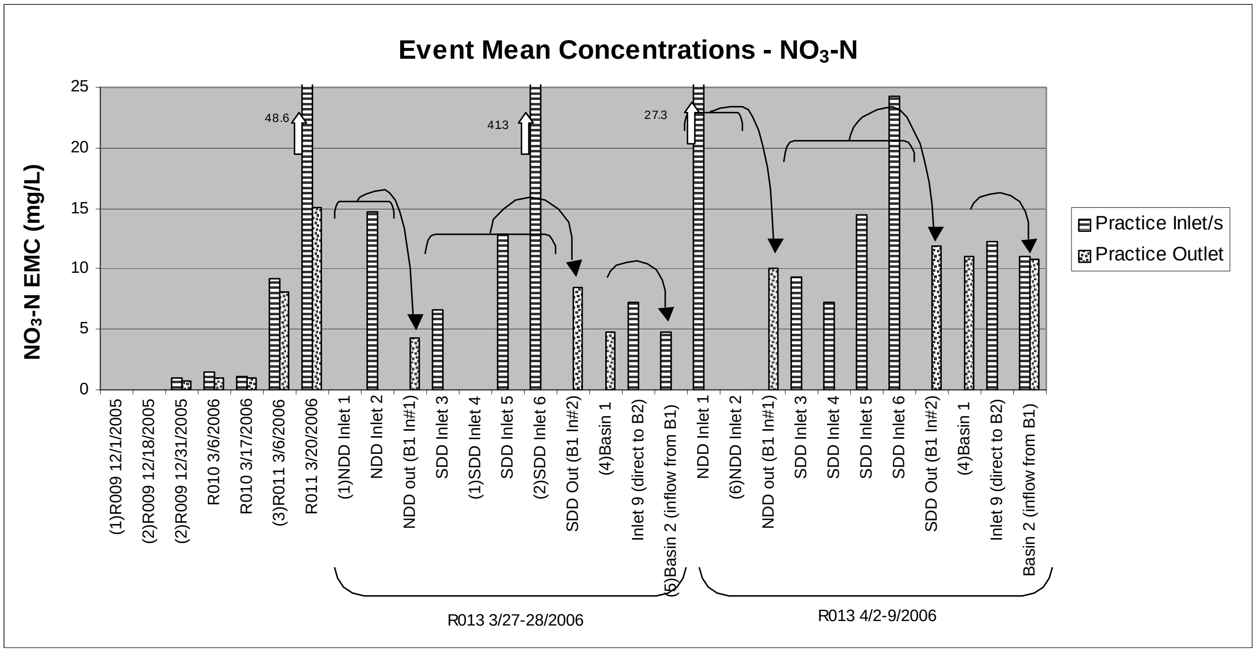


Figure 9.17. Nitrate-N EMC Results from event monitoring. See Table 9.7 in the beginning of the Results section for numeric codes.

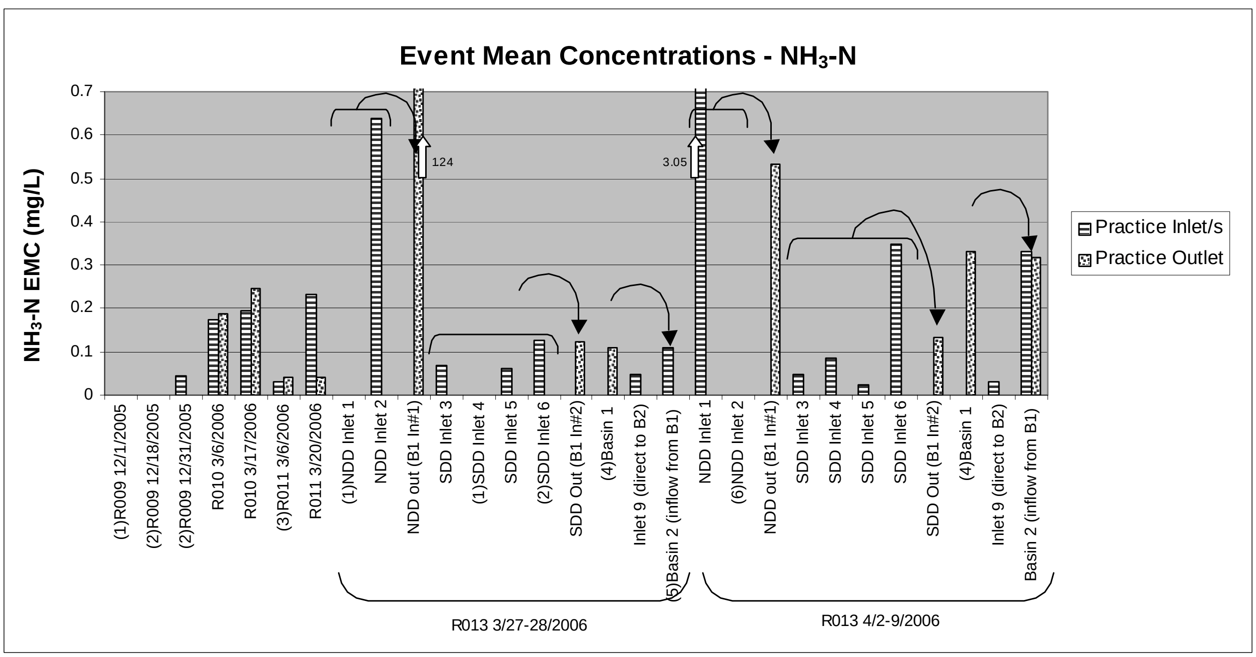


Figure 9.18. Total Ammonia-N EMC Results from event monitoring. See Table 9.7 in the beginning of the Results section for numeric codes.

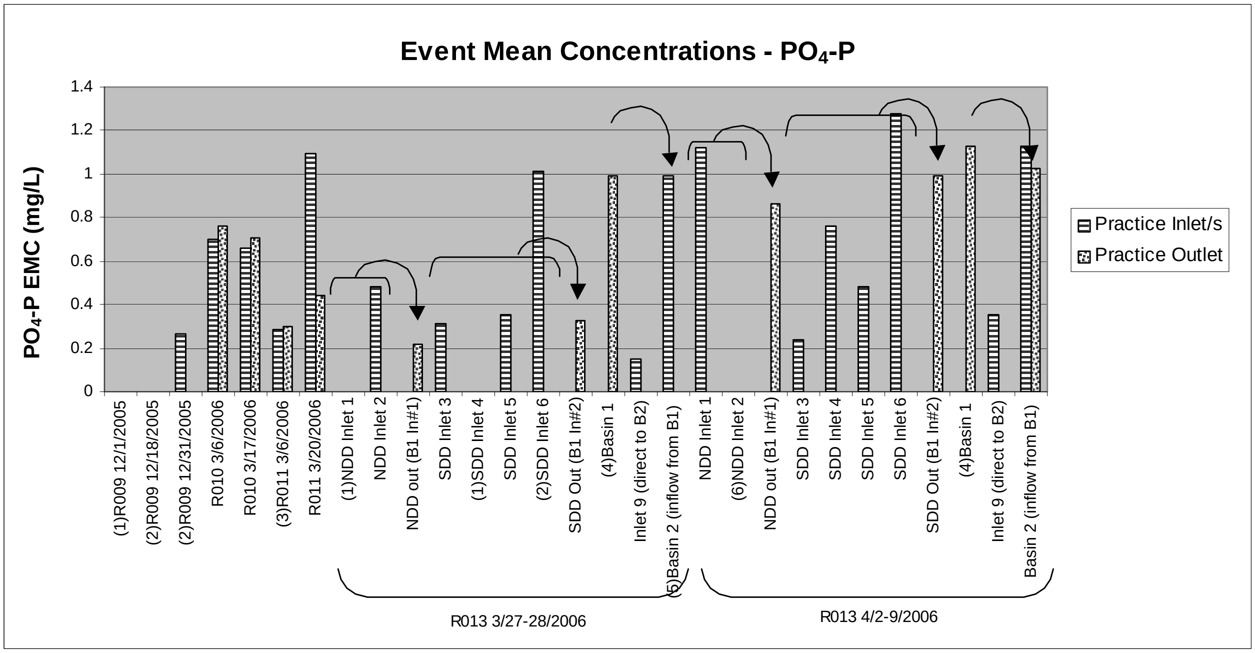


Figure 9.19. Orthophosphate-P EMC Results from event monitoring. See Table 9.7 in the beginning of the Results section for numeric codes.

9.6.2.1 CAPs

Each of the sites had sediment that was caught by the silt fences except for the reference established Oak Woodland site (5), which did not have any (figure 9.20). There were no fences installed at site 2 or 5 on an on an 8-12 degree slope, and the values for site 5 for the 13-16 degree slope were 0. There were a few silt fences where it was apparent that sediment had collected (figures 9.21 - 9.22). There was not evidence that sediment collected on most of the fences. Vegetation growth around the fences seemed to play a large role on whether or not the silt fences caught sediment. A lot of the silt fences had vegetation completely surrounding them (figures 9.23 - 9.28). At every site vegetation grew well around the fences.

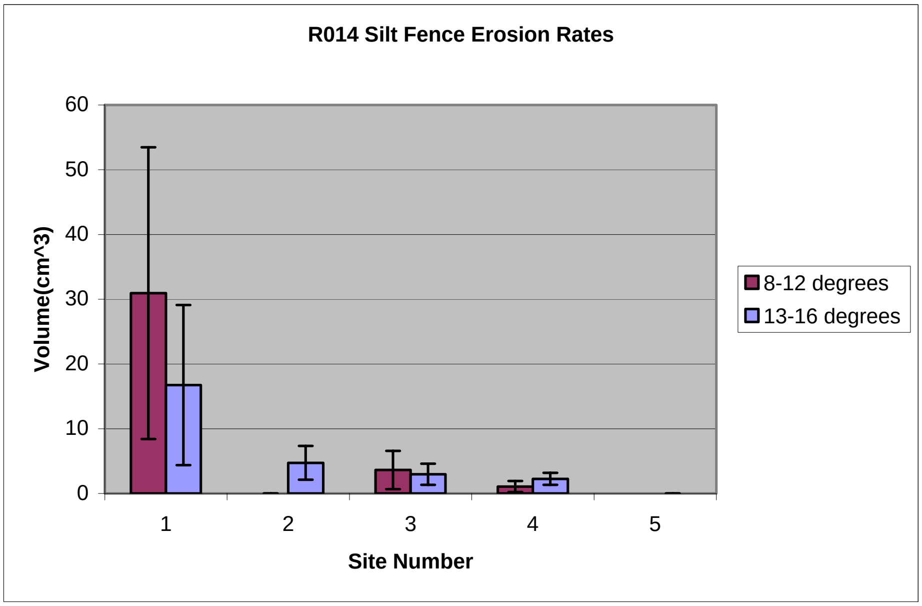


Figure 9.20. R014 mean values of sediment caught in the fences for each site.

Figure 9.21. Sediment caught in a fence at site 1.

Figure 9.22. Another fence at site 1 with accumulated sediment.

Figure 9.23. Fence "C" at site 1 when newly installed.

Figure 9.24. Fence “C” at site 1 completely surrounded by vegetation.

Figure 9.25. Fence "JJ" at site 3 when newly installed.

Figure 9.26. Fence "JJ" at site 3 surrounded by vegetation.

Figure 9.27. Fence "M" at site 4 when newly installed.

Figure 9.28. Fence "M" at site 4 surrounded by vegetation.

10 Watershed Level Monitoring – Tembladero Slough

10.1 Monitoring Goals

Watershed level monitoring sought to answer the follow question:

How much wetland area would be required to mitigate the average daily watershed nutrient load?

To answer this question, an estimate of the average daily watershed load is required. This chapter describes the estimation of average watershed nutrient load from measurements of nutrient concentration over a range of discharges during the winter of 2005-6.

10.2 Methods

10.2.1 Sampling site

Sampling was conducted at a single public access site, Haro Road Bridge across Tembaldero Slough (TEM-HAR) in Castroville, California where the Slough runs under Highway 156 (Fig 2.2.1). This site was the farthest downstream location to measure loads delivered from the watershed where access is safe (in relation to storm hazards and traffic). The channel was wide and too deep for wading to take flow measurements and collect samples, so all sampling activity took place from the bridge. We installed a pressure transducer to record stage in meters at the site every 20 minutes (Fig 2.2.2). A USGS gauging site was located a few kilometers upstream from TEM-HAR, with several confluences occurring in the intervening reaches (Merritt, Espinosa, and Santa Rita).

10.2.2 Overall approach

Our overall approach for estimating total nutrient load was: (1) construct nutrient rating curves (NRC) relating concentration to discharge at TEM-HAR; (2) estimate daily discharge at TEM-HAR by regression measured discharge against daily records at a nearby USGS gauging site (REC-JON); (3) estimate daily load as the product of daily discharge and the NRC; and (4) take the average of daily loads.

10.2.3 Sampling Design

Measurements were made at TEM-HAR according to a stratified sampling design. The first level of stratification was a dicotomous division of effort into ambient and storm events in order to ensure even representation with respect to discharge. The second level was to stratify by time within each event – so as to minimize effects of short-term variation and bias due associated with the rising and falling limbs of storm hydrographs.

Ambient events were defined as having no measurable precipitation in the five days prior to and through out the collection of samples and having sustained a flow rate less than 18 cfs at the REC_JON USGS site through the final day of sampling. Sampling during ambient events involved three sets of samples collected every other day for five days at the same hour each day.

Storm events were defined as the period during which discharge increased from ambient levels and returned back to ambient conditions. A storm event was sampled with six sets of samples. Using multiple weather forecasts, live radar images and real time flow rate data from the REC-JON USGS gage, the timing of the six samples was spaced such that two series would sample the increase in flow, two samples were used to sample the peak in flow and the final two series were used to sample the recession in the flow.

10.2.4 Discharge measurement

Discharge was measured using a small crane (Four-Wheel Truck, model 4350, Rickly Hydrological Company) that suspends a 'fish' (a weight designed to stabilize flow measuring equipment within the stream channel) with a USGS AA-MH Model 6215 current meter that measures velocity (Fig 2.4.1). A meter tape was laid across the bridge, starting at the true right bank, flow measurements were made every 0.5m from that point across the channel at 60% of the total stream channel depth (from the surface) for each point. Total discharge was estimated as the sum products of individual velocity measurements with their representative width and depth.

10.2.5 Sample collection

Water samples were collected as surface grabs using an extending pole from a point marked on the bridge denoting the center of the channel (Fig 2.6.1). The sample bottle was lowered to just below surface level with the opening of the bottle facing up stream. The bottle was filled and dumped three times with the bottle being poured out away from the center of the channel so as not to interfere with the proceeding sample. The bottle was then filled a fourth time and collected. It was labeled and placed in an ice cooler. Once samples were collected and placed in the icebox they were returned to the lab where they were frozen and stored.

10.2.6 Laboratory Methods:

All samples were analyzed in the CCOWS lab. Table 2.7.1 summarizes the tests that were used, their accuracy, precision and recovery requirements for replicates and spikes. Procedures for all tests are detailed in the *HACH Odyssey* DR/2500 Spectrophotometer Procedure Manual (te/dk 04/01 2ed).

- New syringes, Millex 0.45 μm filters and disposable vials
- *HACH Odyssey* DR/2500 Spectrophotometer
- Safety glasses and rubber gloves

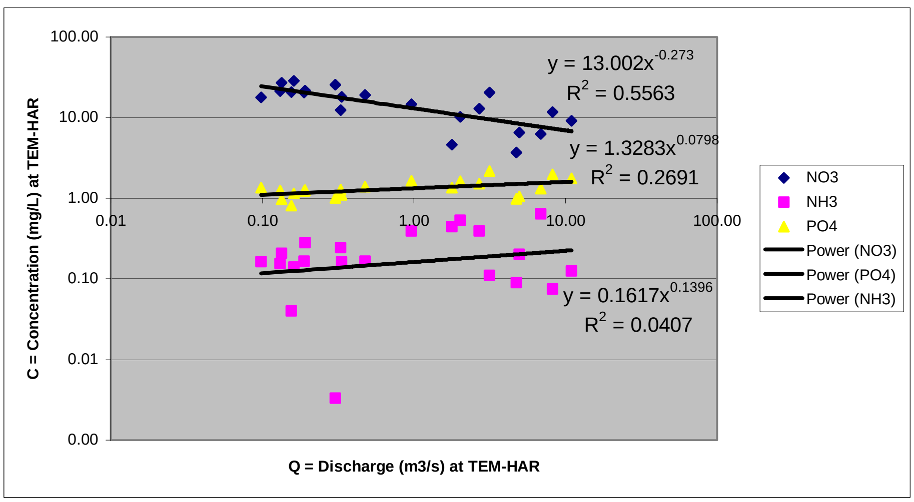
- Hach Orthophosphate test kit (method 8048), Nitrogen test kit (method 10020) and Ammonia test kit (method 10023)

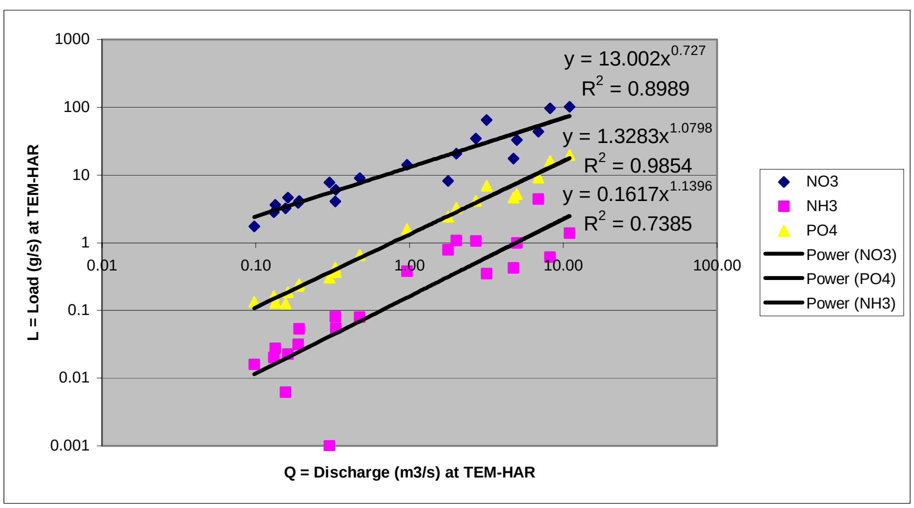
Watson et al. (2005) details the quality assurances protocols. The following is a list of quality control procedures that were adhered to during nutrient analyses:

- Method/Reagent blanks: 1 per sample run
- Standards/Controls: 3 per sample run, per analysis
- Bottle blank: 1 per sample run
- Sample replicates: at least 1 per sample run or 5% of samples
- Sample spikes: at least 1 set per sample run or 5% of samples

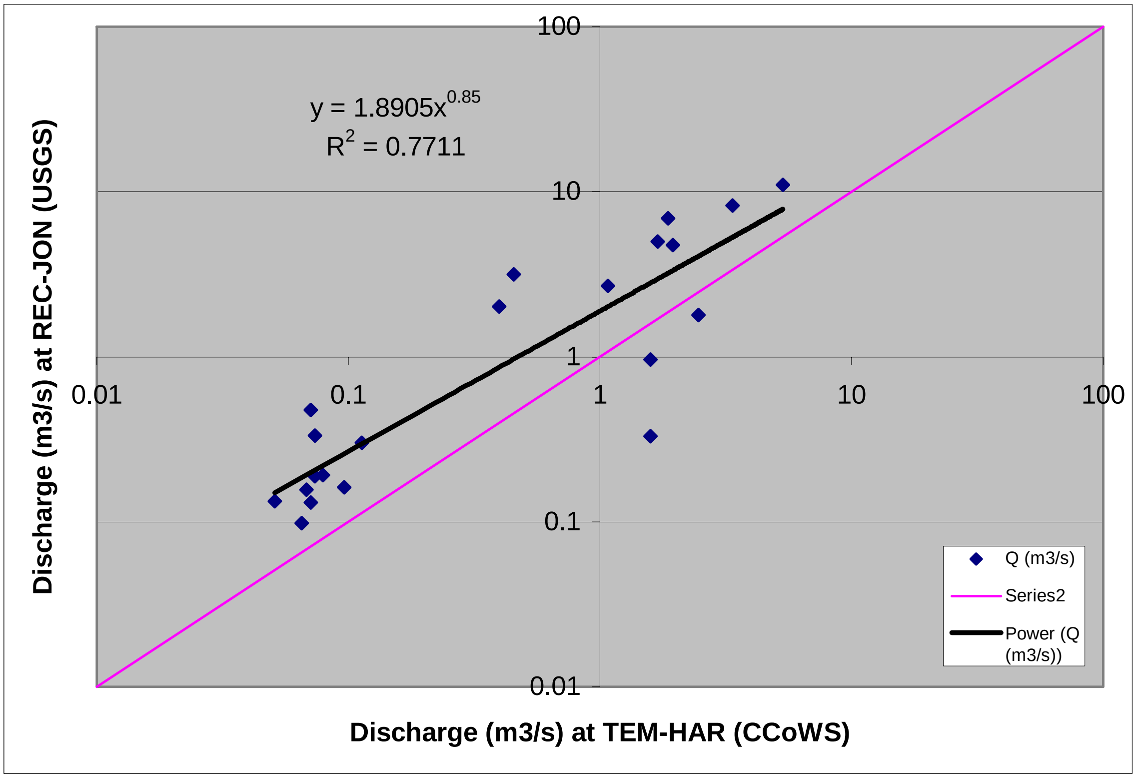
10.3 Results

Nutrient rating curves for concentration and load are given in the following two figures.





We estimated daily mean discharge at TEM-HAR by regressing our instantaneous measurements of discharge at TEM-HAR against daily mean values reported by USGS at REC-JON. The following figure gives the resulting estimation equation:



We multiplied estimates of mean daily discharge at TEM-HAR by the nutrient rating curves from the previous page to get a time-series of daily loads at TEM-HAR. This comprised 7390 daily values, spanning the period from October 1970 to April 2007, with a gap in the USGS record from February 1986 to May 2002.

The mean daily loads thus estimated were:

- 861 kg/day NO3-N
- 13 kg/day NH3-N
- 105 kg/day PO4-P

11 Education and Outreach – Return of the Natives Activities & Wetland Site Demonstration

11.1.1 Student Involvement

During the autumn quarters of this project, Return of the Natives worked with a total of twenty three (23) local schools in the propagation of native plants for this project. Thirteen (13) of these schools had greenhouses on their school sites, the other ten (10) schools participated in propagation activities in their classrooms with the seedlings that they planted being transported back to the “mother” greenhouses at the Watershed Institute at CSUMB. RON staff visited each of these 23 schools at least two times every fall and those students had the opportunity to join RON staff to outplant some natives on restoration sites outside of the scope of this project as it was not possible to take these students to private farmlands identified by CAFF and the Monterey County RCD. Each autumn students produced about 3500 native plants, mainly native bunch grasses, for the project. These 3500 plants became part of Return of the Natives’ constant inventory of between 6600 and 7200 native plants available for partners on this project.

While the students were learning about propagating native plants, they also were learning about the important role of native plants in halting erosion and in uptaking of nutrients and pollutants.

Figure 11.1. CSUMB Service Learning Students worked with Seaside High School sophomores to make a poster featuring native grasses.

Daily maintenance of the native plants at the Watershed Institute greenhouse fell to CSUMB student assistants and volunteers from our "Greenthumb Program". The Greenthumbs are developmentally disabled adults from the Gateway Program and the Monterey County Office of Education and they were responsible for transplanting at least 80% of the natives for this project.

Figure 11.2. The Greenthumbs group.

Figure 11.3. A Greenthumb member planting natives.

Figure 11.4. Watershed Institute Plants.

Over the three years of the project thousands of volunteers produced plants for this project; 1800 K-12 students each of three autumns, 600 Greenthumb volunteers each year, and 30 CSUMB student and high school volunteers each year. This total number of volunteers is 7290 (+/- 100 volunteers). Each of these volunteers learned about the power of native plants in combating erosion and guarding our water supply.

Overall, thirty-five (35) species and 6035 plants, from cone-size to 5-gallon plants were provided to 8 different sites in the Gabilan Watershed (Table 11.1). At the conclusion of the project an inventory of about 5000 plants exists and is being maintained for planting by the project partners in the Gabilan Watershed.

Table 11.1. Return of the Natives Plants sent to Project Sites. This does not include 5000 native plants being held at the Watershed Institute (March 15, 2007) for future use by partners in the Gabilan Watershed.

Prop. 13: Plants out						
Site / Date	**CONES/RP**	**4IN**	**DPOT**	**1GAL**	**5GAL**	
Molera Wetland 12/05-03/06		96	200	355	30	
SV-14 02/06	1568					
Molera Wetland 03/06-05/06				265		
SV-09-1 05/06				195		
G-16 01/07				704	121	
Molera Wetland 02/07				778		
SV-09-1 03/07				57		
SV-22 03/07				508		
Sanborn Creek 2/3/2007				44	48	
Natividad Creek 2/16/2007	10			133	5	
Upper Carr Lake 2/17/2007	49	80	40	155	10	
Upper Carr Lake 2/28/2007		96		88	12	
Upper Carr Lake 3/9/2007	107			197	8	
Upper Carr Lake 3/10/2007	5			64	7	
No. of individual plants	*1739*	*272*	*240*	*3543*	*241*	***6035***
						Total

11.1.2 Educational Tours of the Wetland for Community Members

MLML in conjunction with CAFF and USDA led tours of the Molera Wetland for participants in the 2006 and 2007 Irrigation and Nutrient Management Meeting and Cover Crop and Water Quality Field Days in Salinas. The objective of the field tours was to educate growers and agency staff in the benefits to water quality from installing treatment wetlands. Participants toured the site and received handouts summarizing the project. Twelve participants attended the tour in 2006 and nine attended the tour in 2007.

12 Wetland Photo and Biological Monitoring

12.1 Photo monitoring

Photo monitoring was conducted quarterly at the Wetland throughout the project period.

12.1.1 Methods

Figure 12.1 illustrates the location of photo points in the wetland.

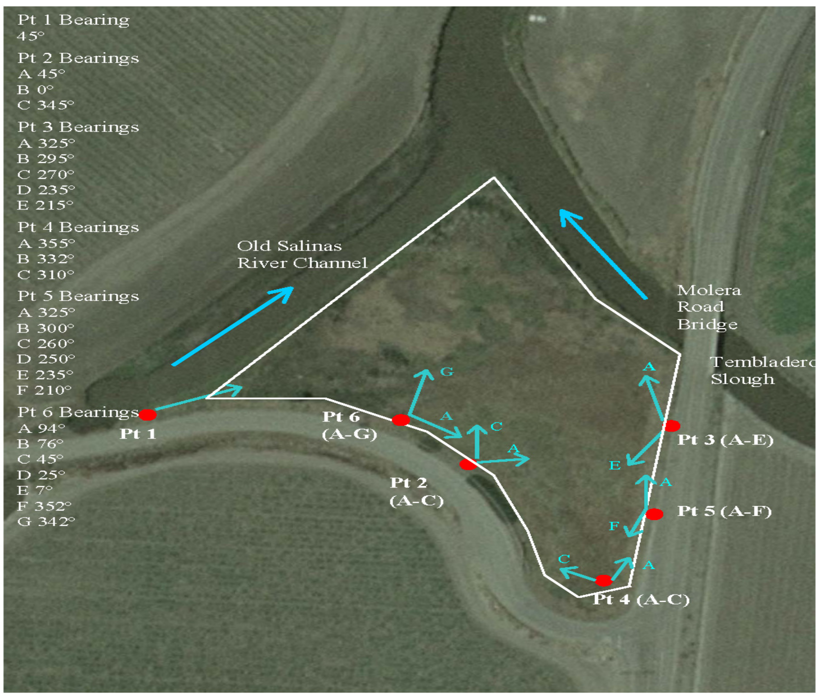


Figure 12.1. Map illustrating wetland photo point locations.

12.1.2 Results and Discussion

A selection of before/after photos is presented in this section.

Figure 12.2. Upper photo taken 7/7/05. Lower photo taken 7/11/06. No construction took place here. The difference is that water was always being refreshed and was present on-site. Also, plants in the flooded areas lived all the way through the summertime, creating bird habitat.

Figure 12.3. The upper photo is Pt 2 before construction taken 7/7/05. The site was dominated by weeds and ponded water did not collect in this upper portion. The lower photo is Pt 2 after construction on 7/11/06. In addition to all of the work that went into the main wetland area, Iceplant was also removed from alongside the road and replaced with natives (lower left corner of photos).

Figure 12.4. Upper photo is Pt 3 before construction, taken 7/7/06. Lower photo is after construction, taken 7/11/06.

12.2 Native Plant Restoration

12.2.1 Methods

Weed control in the form of hand pulling, flaming, mowing and weed whipping was completed several times throughout the project period. Native plant species were propagated from nurseries at MLML and the Watershed Institute, and planted throughout the site. Planting was focused along all the berm edges and the periphery of the project site (figures 12.5 and 12.6). Before wetland construction, a vegetation survey was completed using GPS. This same survey was repeated in the Fall of 2006 (figure 12.7).

Figure 12.5. Planting beginning at the wetland site. December 2005.

Figure 12.6. Planted berms establishing nicely. 05 May 2006.

12.2.2 Results and Discussion

Native plant species diversity and abundance at the wetland has increased as a result of project activities. Weed control has reduced the seed bank at the site. The propagation and planting of native plant species (table 12.1) has bolstered existing native plant populations and re-introduced native species that are typical of the dune and brackish marsh habitats at the site (figure 12.7). The plant diversity list (table 12.2) shows the results of a plant inventory conducted at the beginning and end of the project.

Table 12.1. Type and number of plants planted at the Wetland site.

		Size			Source					
Species	Common Name	# yellow cones	# Gallon Pots	# 4-inch Pots	# D-pots	Trays	Direct	MLML	Ft. Ord	RCD (Ft.Ord)
Achillea millefolium	Yarrow		40							
Artemisia californica	California Sage		103						*	*
Carex barbarae	Santa Barbara Sedge		164	43				*		*
Distichlis spicata	Salt Grass		172						*	
Eleocharis macrostachya	Spike-rush spp.		36					*		
Ericameria ericoides	Mock Heather		5						*	
Eriogonum parvifolium	Coast Buckwheat		16	50					*	
Eriophyllum staechadifolium	Lizard Tail		119	50					*	
Grindelia stricta	Gumplant		393						*	
Hordeum brachyantherum	Meadow Barley		20						*	
Juncus (patens or effusus)	Rush spp. (various)		100	32	200					*
Juncus mexicanus	Mexican Rush		40					*		
Juncus xiphoides	Iris-leaved Rush		119	96					*	*
Leymus triticoides	Creeping Wild Rye		214			14			*	
Lupinus arboreus	Yellow Lupine	415							*	
Lupinus chamissonis	Silver Lupine	85							*	
Potentilla anserina	Silvertip		63							
Salvia mellifera	Black Sage		12							*
Scirpus californicus	Bulrush		51				376	*	*	
Scrophularia californica	Bee Plant		4							
Solidago californica	Goldenrod		16							*
Totals	3032	500	1671	271	200	14	376			

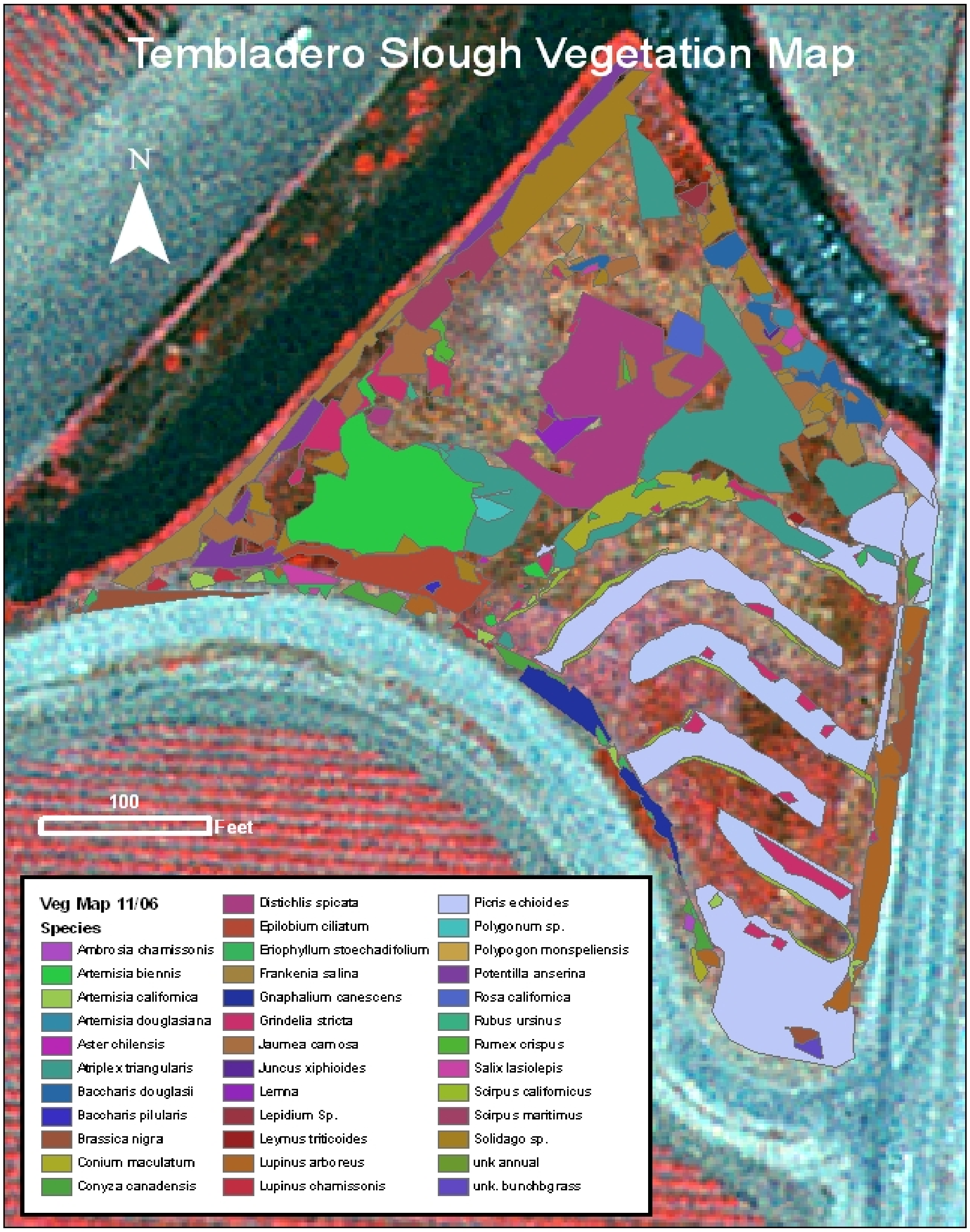


Figure 12.7. Wetland vegetation map completed in November 2006 by CC&R and MLML.

Table 12.2. Wetland plant diversity list.

Wetland Plant Inventory				
2/1/05 present	11/1/06 still present	Native* Y/N	11/1/06 new species	Native* Y/N
Artemisia biennis	yes	no	Achillea millifolium	yes
Artemisia californica**	yes	yes	Ambrosia chamissonis	yes
Artemisia douglasiana	yes	yes	Anagalis arvensis	no
Atriplex triangularis	yes	yes	Artemisia pycnocephala	yes
Baccharis douglasii	yes	yes	Aster chilensis	yes
Baccharis pilularis	yes	yes	Bromus diandrus	no
Berula erecta	yes	yes	Camissonia cheiranthifolia	yes
Brassica nigra	yes	no	Carex barbarae**	yes
Carpobrotus edulis	not present	no	Carpobrotus edulis	no
Conium maculatum	yes	no	Chenepodium macrospermum-halophylum	no
Conyza canadensis	yes	yes	Cirsium vulgare	no
Distichlis spicata	yes	yes	Eleocharis macrostachya**	yes
Epilobium ciliatum	yes	yes	Eriogonum latifolium	yes
Ericameria erichodes	yes	yes	Gnaphalium californicum	yes
Eriophyllum stoechadifolium**	yes	yes	Juncus mexicanus**	yes
Euthamia occidentalis	yes	yes	Juncus patens*	yes
Frankenia salina	yes	yes	Juncus xiphoides**	yes
Gnaphalium canescens	yes	yes	Lemna sp.	unk.
Grindelia stricta	yes	yes	Lepidium Sp.	unk.
Hordeum brachyantherum	yes	yes	Leymus triticoides	yes
Jaumea carnosa	yes	yes	Lupinus arboreus**	yes
Lepidium latifolium	yes	no	Lupinus chilensis**	yes
Lupinus chamissonis	yes	yes	Picris echioides	no
Medicago polymorpha	yes	no	Plantago coronopus	no
Polygonom sp.	yes	no	Plantago lanceolata	no
Polypogon monspeliensis	yes	no	Raphanus sativa	no
Potentilla anserina	yes	yes	Rosa californica**	yes
Rumex crispus	yes	no	Rubus ursinus	yes
Rumex maritimus	yes	yes	Rumex conglomeratus	no
Salix lasiolepis	yes	yes	Scirpus maritimus	yes
Scirpus californicus	yes	yes	Scrophularia californica**	yes
Scirpus pungens	yes	yes	Sonchus asper	no
Euthamia occidentalis	yes	yes	Vulpia sp.	no
Typha latifolia	yes	yes		
Verbena lasiostachys	yes	yes		
Total native species =		26	**Total native species =**	19
Total non-native species =		9	**Total non-native species =**	13
* Plants native to California				
** Planted at site				

12.3 Macroinvertebrate Monitoring

12.3.1 Methods

Macroinvertebrate samples were collected from the Tembladero Slough and within the Wetland. The purpose was primarily to provide a general characterization of the ecology of the wetland relative to that of the slough, and answer the question:

> *Does macroinvertebrate community composition and abundance vary between the wetland and the adjacent Tembladero Slough? Does it vary within the wetland? Do these patterns change over time?*

It was expected that differences would exist due to a number of factors, including: substrate, depth, vegetation, inter-specific competition, salinity, dispersal, succession, and water quality.

Sampling for macroinvertebrate occurred during low flow conditions, at least 6 weeks following any major storm event, except for the sampling that took place on June 21, 2006. (According to the CIMIS website, between 6/9/2006 and 6/10/2006 2.19 inches of precipitation fell at the North Salinas Station #116.) Five sampling events occurred between 6/2/2006 and 11/1/2006 with 6 total samples taken each time, 3 in the wetland and 3 in the Tembladero Slough below the TEM-MOL Bridge, alongside the wetland.

Sampling techniques were chosen using methods outlined by Larson et al. (2005). Random transect locations were chosen along the stretch from the Molera Road bridge to the Old Salinas River confluence. A transect tape was laid along the riverbank and a random number generation method yielded random locations along the slough. Samples were obtained from those points by doing a 180-degree sweep through the water column, and then extending the sampling pole and dragging it along the top of the substrate towards the individual. The net was emptied after each sweep and drag to form one composite sample for each site. This was completed two more times, walking 1 m towards the center of the channel each time. A total of three sweeps and three drags were completed per sample.

Random sampling in the Wetland employed a similar method, but instead the transect tape was placed along three straight stretches of the upper channel system. The samples were obtained almost the same as in the slough, but because space was limited collection techniques were shortened a sweep of one meter was used, and the space from the shore to the center of the channel was divided into three sections, rather than moving 1 meter from the shore each time. Composite samples were formed in the same way.

Macroinvertebrate samples were analyzed in the CCoWS laboratory via methods adapted from Harrington and Born (2000). Samples that were too large to count were sub-sampled for analysis (Fig. 12.8).

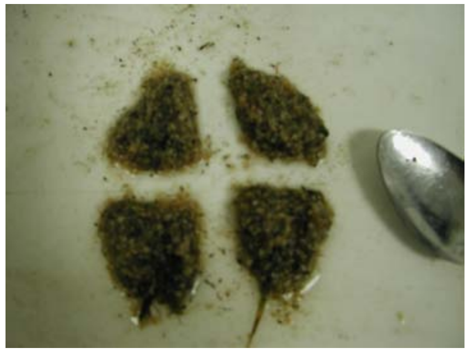


Figure 12.8. Macroinvertebrate sub-sampling.

12.3.2 Results and Discussion

The two sites varied in composition and abundance of macroinvertebrates, and there were changes over time:

There was an immediate bloom of Daphnidae observed in 6/2 Wetland samples with totals in the thousands. They still showed up in large numbers in the Wetland for the next sampling on 6/21. This was followed by a sharp decrease for 7/2 and none for the last two sampling dates. Conversely, in the Tembladero Slough less than 100 were found on 6/21 and one individual was found on 7/24.

Chironomids always occurred in the Wetland samples in the low hundreds, the exception being 6/21 where there were only about 10-30 per sample. There was a noticeable spike in numbers for the 8/11 sampling to almost 2000 in one sample. In the Slough, the highest number ever found in one sample was 16.

Corixidae were found ranging from ~ 25-250 individuals per Wetland sample for the first three sampling dates, and were almost not present for the last two sampling dates. Their numbers were always low in the Slough for every sampling date, never exceeding more than 10 in one sample.

Conversely, there were a more Corophiidae and Nereididae found in the Slough than in the Wetland. Corophiidae populations remained steady for all months in the Slough, ranging from about 40-250 individuals per sample (with one spike on 6/21 to 956), while they hardly appeared at all in the Wetland except for on 11/1. Corophiidae was the dominant taxa found in the Slough. Nereidae were usually less than 10 in the Slough with one spike on 6/21. Only 1 individual was ever found in the Wetland.

Overall, macroinvertebrate abundance in the slough was lower and more stable, perhaps due to the influence of fish predators that were largely absent in the wetland (Fig. 12.9). Variations in salinity may explain the intermittent absent of salinity-intolerant taxa such as daphnidae and corixidae.

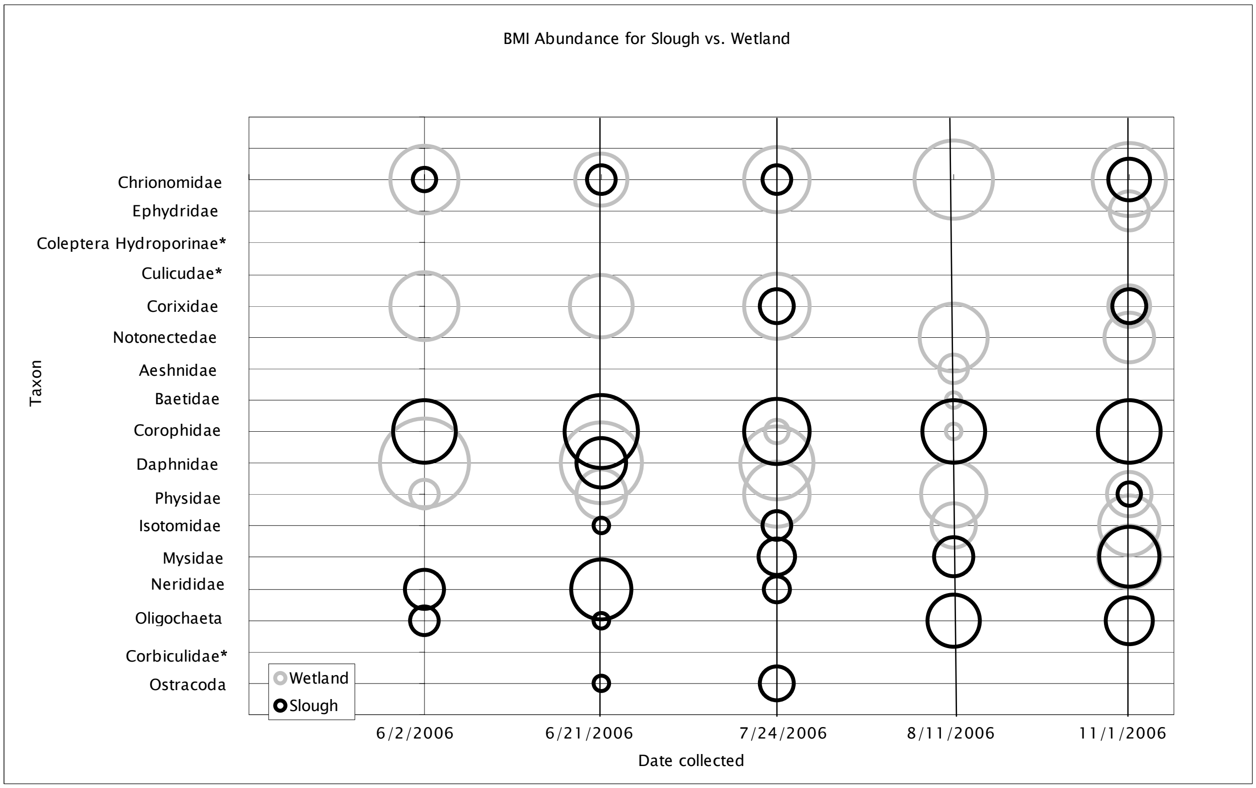


Figure 12.9. Abundance for macroinvertebrate conglomerate samples for the Wetland and Tembladero Slough sites. Size of bubbles represents abundance collected on each date (average of three transects). Data were log transformed to facilitate presentation of a wide range of abundances on a single plot. *Appeared in the samples, but three or less were present.

12.4 Bird Monitoring

Bird surveys were conducted by Rick Fournier (pers. comm.).

12.4.1 Methods

Monitoring was conducted from April 2005 to March 2007. Three fixed monitoring plots were established on the site (figure 12.10). Every month an observer visited the site and surveyed for birds from his vehicle. After all birds that were seen from the vehicle were counted, the observer stepped out of the vehicle to complete the count. All birds at the site were identified and counted. Birds that flew over the site without stopping were noted as “flyovers”. Each visit was completed within an hour. Data was collected and compared for 8 months before wetland construction and for the same months after construction.

Figure 12.10. Bird monitoring plots at the wetland site. Plot #1 is near where Dunes Colony Rd crosses over the Old Salinas River Channel. Plot #2 is adjacent to Molera Rd, and Plot #3 is at the confluence of the Old Salinas River Channel and the Tembladero Slough.

12.4.2 Results and Discussion

The construction of the wetland at the Molera Road site has changed the diversity and abundance of bird species that use the site for nesting and foraging. Post construction the number of species and the overall number of birds using the site increased during 7 of 8 months (Fig. 12.11) while the number of birds using the site increased during 6 of 8 months (Fig. 12.12). There were a total of 53 bird species found at the site during the survey period, 9 unique species found only before construction and 21 unique species found only after construction (table 12.3).

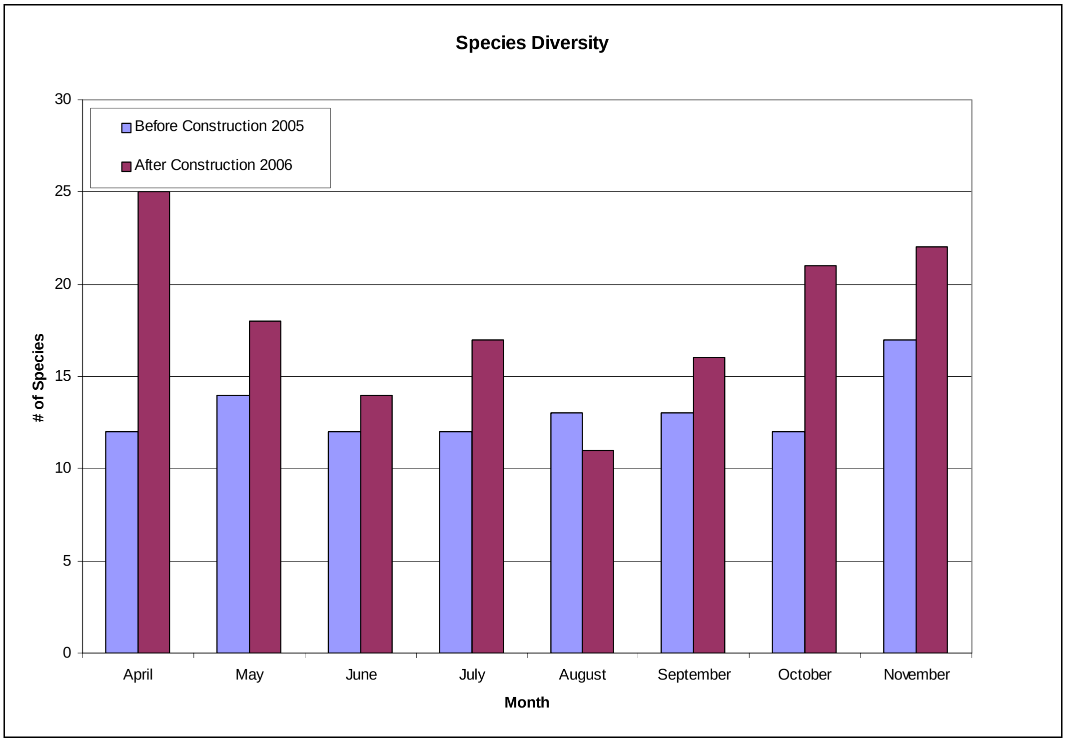


Figure 12.11. Bird species diversity at the wetland site.

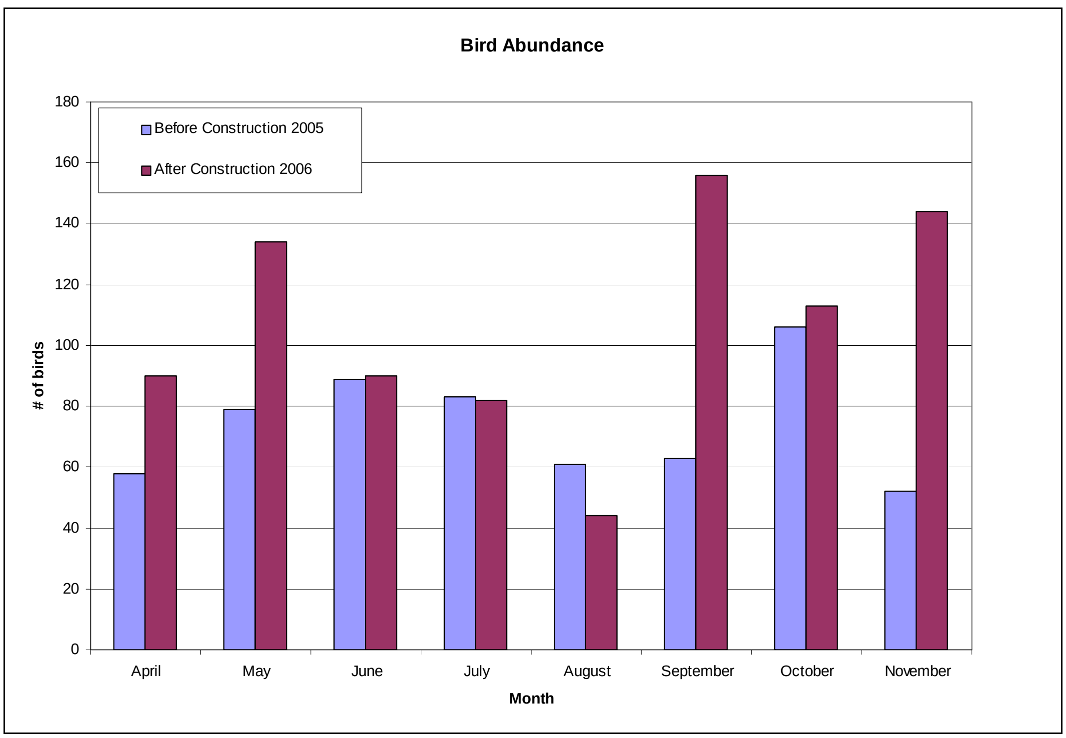


Figure 12.12. Bird abundance at the wetland site pre and post-construction.

Table 12.3. Unique bird species list.

Species sighted at site	Total = 56	Unique to 2006	Total = 21	Unique to 2005	Total = 9
AMAV	American Avocet	AMAV	American Avocet	BCNH	Black-crow ned Night-Heron
AMGO	American Goldfinch	BNST	Black-necked Stilt	BUSH	Bushtit
AMKE	American Kestrel	CAGO	Canada Goose	GBHE	Great Blue Heron
AMPI	American Pipit	CINN	Cinnamon Teal	HUMMER	Hummingbird
ANHU	Anna's Hummingbird	COMO	Common Moorhen	NOHA	Northern Harrier
BASW	Barn Sw allow	DUNL	Dunlin	OSPR	Osprey
BCNH	Black-crow ned Night-Heron	EUST	European Starling	ROPI	Rock Pigeon
BHCO	Brow n-headed Cow bird	LBDO	Long-billed Dow itcher	SAPH	Say's Phoebe
BLPH	Black Phoebe	NRSW	Norther Rough-Sw allow	TUVU	Turkey Vulture
BNST	Black-necked Stilt	PGPL	Pacific Golden Plover		
BRBL	Brew er's Blackbird	VARA	Virginia Rail		
BUSH	Bushtit	SORA	Sora Rail		
CAGO	Canada Goose	SNEG	Snow y Egret		
CINN	Cinnamon Teal	SASP	Savannah Sparrow		
CLSW	Cliff Sw allow	RNPH	Red-necked Phalarope		
COMO	Common Moorhen	ROGO	Ross's Goose		
COOT	American Coot	VGSW	Violet-green Sw allow		
COYE	Common Yellow throat	WEME	Western Meadow lark		
DUNL	Dunlin	WESA	Western Sandpiper		
EUST	European Starling	WFIB	White-faced Ibis		
GADW	Gadw all	WISN	Wilson's Snipe		
GBHE	Great Blue Heron				
GCSP	Golden-crow ned Sparrow				
GREG	Great Egret				
HOFI	House Finch				
KILL	Killdeer				
LBDO	Long-billed Dow itcher				
LESA	Least Sandpiper				
LISP	Lincoln's Sparrow				
MALL	Mallard Duck				
MAWR	Marsh Wren				
MODO	Mourning Dove				
NOHA	Northern Harrier				
NRSW	Norther Rough-Sw allow				
OSPR	Osprey				
PGPL	Pacific Golden Plover				
RNPH	Red-necked Phalarope				
ROGO	Ross's Goose				
ROPI	Rock Pigeon				
RWBL	Red-w inged Blackbird				
SAPH	Say's Phoebe				
SASP	Savannah Sparrow				
SNEG	Snow y Egret				
SORA	Sora Rail				
SOSP	Song Sparrow				
TRSW	Tree Sw allow				
TUVU	Turkey Vulture				
VARA	Virginia Rail				
VGSW	Violet-green Sw allow				
WCSP	White-crow ned Sparrow				
WEME	Western Meadow lark				
WESA	Western Sandpiper				
WFIB	White-faced Ibis				
WISN	Wilson's Snipe				
YRWA	Yellow -rumped Warbler				

Figure 12.13. Three bird species commonly observed in the wetland: Black-necked stilt, Red-necked Phalarope, and Killdeer. Photos Oct 1, 2006 by Wylie Harter.

13 Wetland Water Quality Monitoring

13.1 Monitoring Goals

This part of the project evaluates the effectiveness of the water quality treatment wetland from May to November of 2006. Specifically, the goal of this study was to answer the following questions:

- To what extent does the wetland remove water quality constituents (ammonia, nitrate, orthophosphate) from the waters passing through it? i.e. what is the load (g/day) removed by the wetland?
- What are the optimal retention times, inflow-loading rates and depth to achieve maximum removal?

The answers to these questions will serve to optimize efforts to use wetlands to address pollution in the Gabilan Watershed and the surrounding region.

13.2 Introduction

The coastal floodplains of Central California are intensively farmed and developed for urban expansion at the fringe of the San Francisco Bay region. The streams draining through these floodplains are polluted by excessive levels of nutrients, pesticides, pathogens, metals, hydrocarbons, salts, and sediment (Casagrande & Watson, 2006).

Natural wetland systems are often cited for their beneficial effects on water quality (Kadlec & Knight, 1996; Mitsch & Gosselink, 2000). The attendant processes may be diverse, including deposition and retention of settleable solids, volatilization of reactive nitrogen by denitrifying bacteria, plant uptake of nutrients, oxidation and photolyzation of pesticide molecules.

In developed coastal watersheds, we often view wetlands as being located in relatively low-lying areas at the downstream end of a watershed, potentially receiving pollutants in water flowing from the upstream portions of the watershed, and usually allowing throughflow to waters further downstream. In viewing wetlands as having a water quality treatment function, we imply a goal of either 'cleaning up' the water in the wetland itself, or reducing the amount of pollutant flowing downstream to receiving waters. We term these as '*in situ*' and 'throughflow' goals respectively. In the former case we would generally measure the effect of the wetland as a reduction in pollutant concentration (e.g. in mg L^{-1}) . In the latter case we would measure the effect of the wetland as a reduction in pollutant load (e.g. in g day^{-1}). In this paper, we emphasize throughflow wetlands, because our study area is characterized by receiving waters with great environmental value - including the Monterey Bay National Marine Sanctuary and the Elkhorn Slough National Estuarine Research Reserve.

In the historical development of many coastal areas, channels were excavated through wetlands, replacing the biochemical benefits of the wetlands with the land reclamation and flood control benefits of channelized systems. More recently however, with the increasing emphasis on clean water and biodiversity, wetland restoration is sought as part of the solution to pollution and habitat scarcity.

A key challenge is to derive wetland-based solutions without compromising existing land reclamation and flood control benefits. For example, replacing hydraulically efficient channels with surface water throughflow wetlands (which are usually designed to spread out and slow down water), will generally increase flood risk upstream. Moving the wetland offline and leaving the channel unmodified would tend to alleviate the flood risk, but in low gradient coastal areas, may suffer from poor throughflow due to the lack of hydraulic head driving the movement of water through the system, resulting in a relatively ineffectual throughflow wetland that treats a negligible amount of water very well.

We thus explore the utility of active offline treatment wetlands. In such a system water is actively pumped from an unmodified polluted waterway of interest into an offline wetland, and then allowed to flow back into the waterway after having passed through the wetland. Active pumping allows throughflow to be controlled, and optimized for maximum removal of pollutant load. Keeping the system offline from the target waterway alleviates a manifold of legal and physical problems associated with channel hydro-modification in developed areas. The only disadvantage is the cost of pumping. In the short-term, we view this as relatively insignificant because shallow groundwater pumping is already used to keep land well drained throughout approximately 100 km^2 of our study area. In the long term, pending the successful outcomes of pilot efforts such as the present study, we would seek sustainable pumping technology either using solar or wind power.

Since it requires an external energy source, an active treatment wetland is effectively a hybrid between a natural wetland with all its attendant habitat benefits, and a fully engineered water treatment plant, with maximum water quality effects, but no *in situ* habitat benefit.

13.3 Approach

Our approach in this study was to design, construct, and operate an active offline treatment wetland, to monitor its effectiveness, and to experimentally determine its optimal throughflow. We sought a final result whereby we could state that an optimally pumped active offline treatment wetland of area, A (km^2), could sustain a certain removal load, L_p (g day^{-1}), of pollutant, p. This would then be comparable to an estimated average daily load of that pollutant in the target waterway, $L_{w,p}$, such that the area of wetland, A_p^* (km^2), required in order to treat the entire target waterway load of pollutant p would be:

$$A_p^{\ *} = A\frac{L_{w,p}}{L_p} \quad (1)$$

The practical realism of restoring and maintaining A_p^* km^2 of active wetland would be an indication to those involved in regional planning as to the feasibility, or unfeasibility, of wetlands in general as part of the solution to pollution in the region's coastal watersheds.

13.4 Pollutants of interest

We were interested in wetland treatment function with respect to the following substances of interest in the study area:

- Dissolved inorganic nutrients:
    - nitrate plus nitrite
    - total ammonia
    - orthophosphate
- Pesticides
    - organophosphates
    - organochlorines
    - pyrethroids
- Suspended sediment

13.5 Wetland design

We constructed a treatment wetland on a 1.2 hectare parcel of public land nestled between the confluence of Tembladero Slough and the Old Salinas River Channel in the northwest; and the intersection of two roads in the southeast (see Chapter 11, and Fig. 13.1). Before construction, the site exhibited approximately 1.5 m of relief over 200m from a weedy, ruderal upper area between the roads in the southeast, down to an intermittent wetland with native vegetation adjacent to the waterways in the northwest. We limited the construction of new wetland area to the weedy upland - about half of the total area. We left the pre-existing lower wetland area unmodified except for installation of a monitoring weir at its outlet. This conserved existing onsite environmental benefits, and provide some opportunity for comparison between constructed and natural systems. For practical reasons, we designed the upper wetland to flow into the lower wetland, and thereafter back into the neighboring waterways.

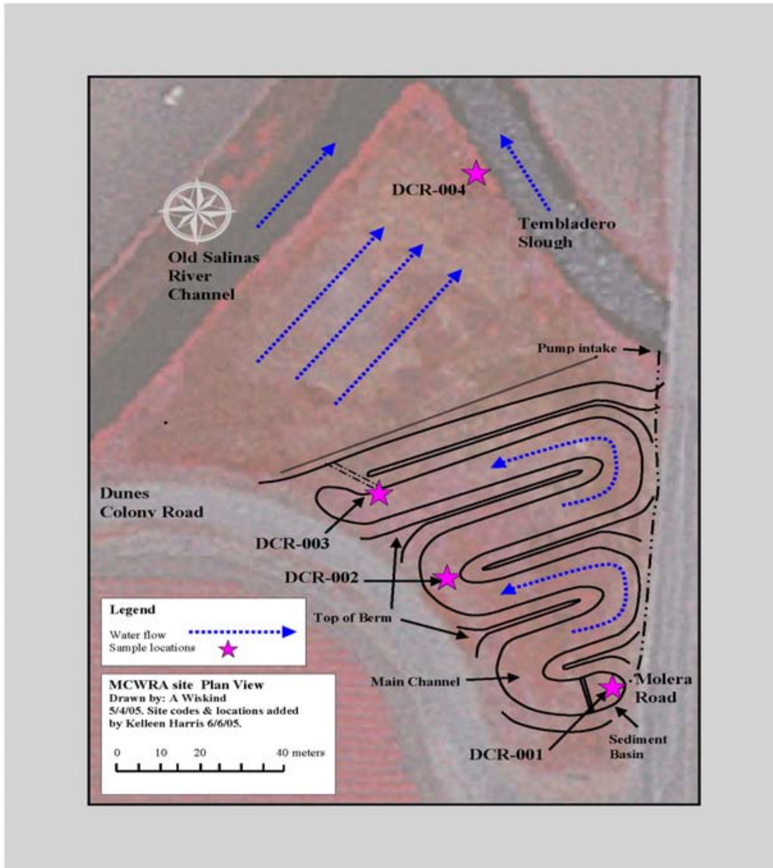


Figure 13.1. Wetland schematic illustrating sampling locations.

We sought to ensure that all water entering the wetland would be forced to pass through most of the wetland before being released, and to avoid the possibility that any part of the inflow could 'short-circuit' the system by flowing through in a shorter period of time than the remaining water. To facilitate this 'plug-flow' outcome, we specified the constructed wetland to have a high length-to-width ratio, resulting in a long sinuous snake-shaped channel with earthen berms separating the reaches of the channel. A broad pond would achieve a greater total water surface area, but would be subject to the risk of developing circulation patterns characterized by short-circuiting jets from the inlet to the outlet, within a matrix of relatively stagnant backwaters.

The design was determined from the optimization of channel length given the following estimated constraints:

- Area available for channel and berms: 2500 m^2
- Minimum channel depth, to exclude emergent vegetation: 0.45 m
- Minimum berm height, for stability and resistance to flooding: 1 m
- Bank width:height ratio, for bank stability: 3:1
- Minimum combined channel/berm width, for excavation logistics: 11 m

This resulted the following specifications:

- Channel thalweg length: 227 m
- Water surface width at 0.45 m depth: 8.35 m
- Water surface area at 0.45 m depth: 1898 m^2
- Length:width ratio: 27:1
- Trapezoidal wetted cross-sectional area at 0.45 m depth: 3.45 m^2
- Volume at 0.45 m depth: 785 m^3

In practical consideration of the residence times that we wished to achieve in experimental use of the wetland, we gave priority to the potential of the wetland to remove or otherwise neutralize nitrate and pesticides with half-lives on the order of 5 days. The literature indicates that 90% reductions in nitrate can be achieved with residence times on the order of 5 days (Kadlec & Knight, 1996, p. 406). So, to span this range, we specified that we should be able to achieve residence times of between 0.5 and 5 days. Assuming Thackston et al's (1987) equation for near-plug-flow, this would require throughflow ranging from 15.3 L s^{-1} down to 1.5 L s^{-1} respectively. This was achieved with an affordable gasoline irrigation pump small enough to be secured within a small hut on cement foundations that we built onsite. This range of flows translates to mean cross-sectional velocities of between 4.4 mm s^{-1} and 0.44 mm s^{-1}, which we assumed was slow enough that there was no risk of bank erosion.

We did not design the wetland for substantial sediment retention. To avoid undesired sedimentation, we designed the intake from Tembladero Slough to minimize sediment intake by being raised above the Slough's muddy bottom. We also specified the wetland to have an inlet sump – a deeper area for the first 5 meters of channel, such that any coarse sediment that did get entrained in the intake would settle out early, in a confined area that could be relatively easily excavated during period maintenance every few years. We anticipated that finer sediments would settle in the remainder of the channel, and that in the long-term an equilibrium would be reached between their deposition and re-suspension motivated by the flow energy supplied to the system as a result of active pumping. We left for further work the question of how to ensure that this equilibrium occurs at a channel volume where the system still functions as a stable channel, without anastomosing.

13.6 Wetland construction

Earthen construction of the upper wetland was completed using a small bulldozer in late 2005 (see photos in Chapter 11). Several thousand native plants were planted in early 2006, including bulrushes (*Scirpus* spp.)on the banks and on 1-meter wide submerged berms installed across the channel in several places. By the end of the study in late 2006, the bulrushes were approaching 3 m in height, lining approximately 75% of the length of the channel bank.

A digital elevation model (DEM) of the post-construction configuration was produced using field topographic survey with a total station and 966 sample points (Fig. 13.2). Bathymetric curves relating elevation to volume and water surface area were constructed from the DEM. These analyses revealed the following realized properties of the constructed wetland, that we viewed as being well within design tolerances:

- Channel thalweg length: 282 m
- Water surface width at 0.45* m depth: 6.9 m
- Water surface area at 0.45* m depth: 1949 m^2
- Volume at 0.45* m depth: 556 m^2
- Length:width ratio: 41:1

* Approximate depth.

13.7 Wetland operation

Ideally, the wetland would be operated as a continuous throughflow system. This would facilitate experimental determination of optimal throughflow rates because treatment effects measured at a given throughflow rate would be subject to zero variance in that throughflow rate during the period of measurement. We would expect that variance in actual throughflow rates for a given nominal average throughflow rate would introduce unwanted biophysical process variation into the experimental situation.

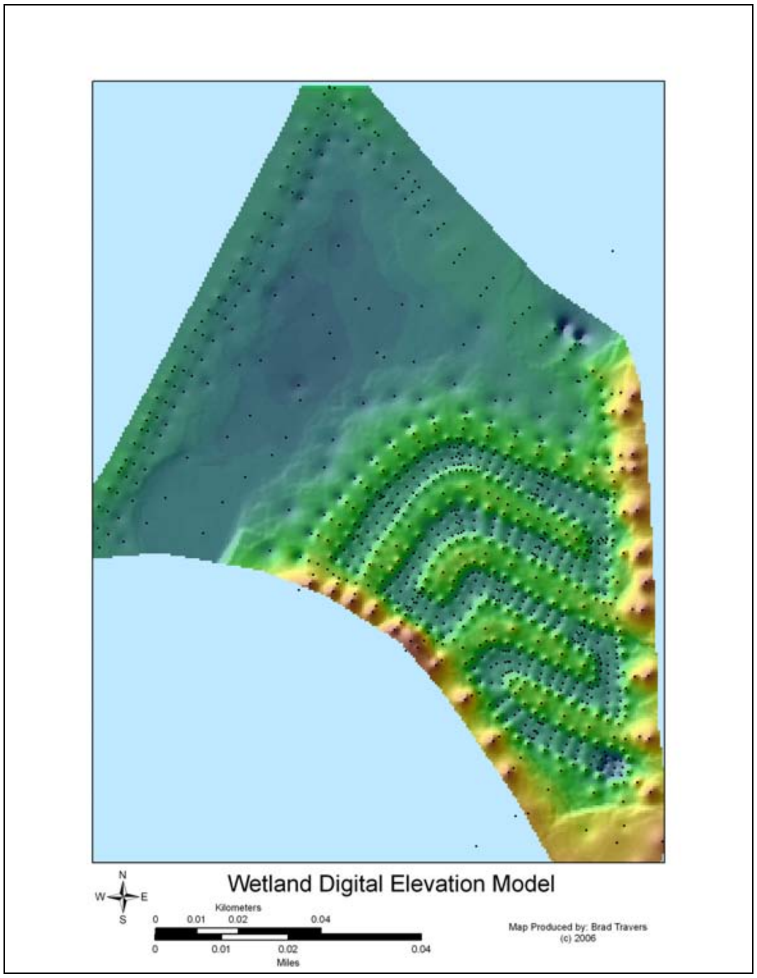


Figure 13.2. Digital elevation model constructed from total-station survey, and used to generate hypsometric curves for the wetland.

However, continuous throughflow at arbitrary rates is logistically difficult to achieve. Commonly available pumps operate at a fixed power, with throughflow dependent on power, pipe diameter, pipe length, and head. In our system, pumping head was subject to tidal variation. To achieve a specified continuous throughflow rate with a single pump, a system for tidal compensation would need to be devised. To achieve a range of such rates below some maximum rate achievable with the pump, excess water would need to be continuously bled from the system at all but the maximum rate. The excess would be about half of the total pumped, assuming that the specified range of pumping rates extended from near zero, up to the maximum. We considered this to be unnecessarily wasteful for an experiment running approximately one year. Finally, we found that keeping any pump running continuously in the field for 24 hours per day was impossible due to an array of unforeseen, but not unexpected problems such as fuel line blockages, miss-calculation of fuel needs, accidental exhaust recirculation, air-contamination of the intake, difficult holiday maintenance schedules, and total pump failure.

We therefore decide to operate the system as a pulsed-inflow / continuous-outflow system. We pumped water into the upper wetland for a specified number of hours each day, and allowed it to discharge continuously at a rate throttled by a slide gate on a culvert installed beneath the berm at the terminus of the upper-wetland. We selected a pump that could deliver the highest desired average daily throughflow with just over 18 hours of pumping per day, and the lowest desired throughflow with just under 2 hours pumping per day. To keep track of variations in pump efficiency, we installed a 'totalizer' gage that measured the total inflow volume pumped.

We developed a simple spreadsheet-based continuous water balance simulation model of the hydrology of the wetland in order to both predict successful operation of the wetland, and to estimate throughflow at the outlet. Operational requirements in the predictive sense were that the wetland should never overflow or completely dry up, and that the daily average water depth should be invariant with daily average throughflow rate. We achieved this by varying the outlet throttle each time the daily average pump rate was changed. In each case, the appropriate throttle setting was predicted using the hydrologic model. Note that we could have achieved almost constant water depth by using a spillway at the outlet instead of a throttled culvert, however, this would have lead to pulsed outflow and more variance from our continuous throughflow ideal.

The hydrologic simulation model was developed in Microsoft Excel, and accounted for change in storage (ΔS, m^3) in the upper wetland at discrete 10-minute time steps for all of 2006:

$$\Delta S = Q_{in} - Q_{out} - Q_{loss} \tag{2}$$

where Q_{in} (m^3 day^{-1}) is the pumped inflow, Q_{out} (m^3 day^{-1}) is the outflow through a gated culvert through the berm at the terminus of the upper wetland, and Q_{loss} (m^3 day^{-1}) is a loss term representing evaporation and leakage to shallow groundwater. We were able to independently measure ΔS using the bathymetric curves developed from the DEM. We measured Q_{in} using the totalizer gage checked against the integral of nominal pump capacity and hours pumped. We developed a sub-model for L_{out} by conducting a loss estimation experiment. We allowed the wetland to drain from an initially full state by loss alone, with Q_{out} throttled to zero. As the wetland drained, we measured stage (h, m) periodically, and used the bathymetric curves to derive observations of the downward trend in S and surface area (a, m^2). The following equation fit the data, as illustrated in Fig. 13.3:

$$Q_{loss} = Q_E + Q_G \tag{3}$$

with $Q_E = e_0 \times a$ and $Q_G = g \times (h - h_0)$ (4)

where e_0 is an assumed evaporation coefficient of 0.002 m day^{-1}, g is a fitted groundwater leakage coefficient of 257 m^2 day^{-1}, and h_0 = –0.150 m is a fitted coefficient representing the stage at which groundwater leakage would be zero.

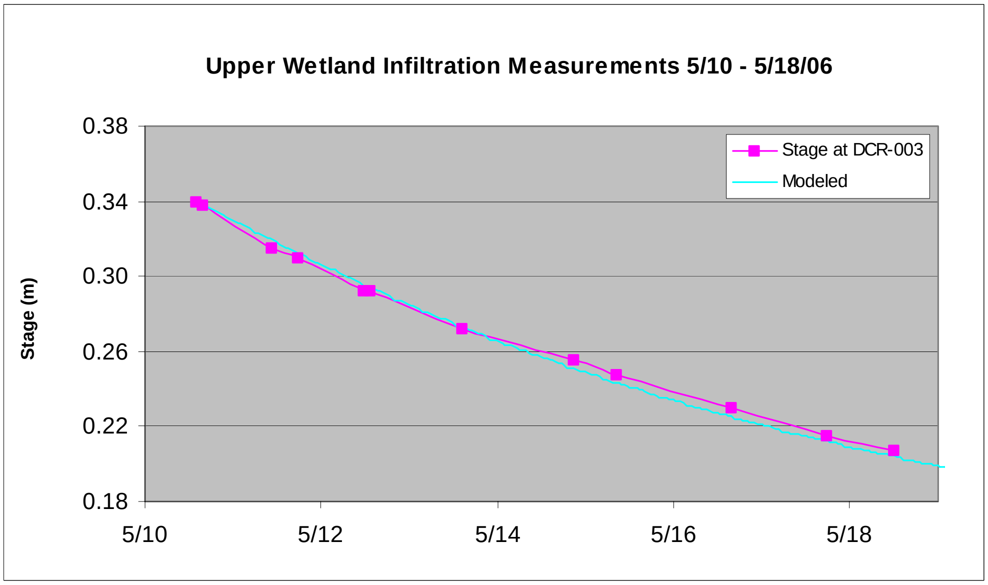


Figure 13.3. Wetland Infiltration measurements and the model calibrated to these data.

We modeled Q_{out} as the product of the head difference, d_{out} (m), between the elevation of the water surface at the intake for the outlet and the elevation of the outlet itself, and a throttle parameter, T (m^3 day^{-1} m^{-1}), that we empirically related to the amount of opening in the slide gate.

$$Q_{out} = d_{out}\,T \qquad (5)$$

In predictive mode on a daily basis, we set the throttle by selecting the value of T that the model estimated would lead to no change in stage in the following 24 hours. In retrospective mode, for deriving estimates of total throughflow, we recorded h twice per day, measured Q_{out} every two weeks, and re-adjusted T to ensure that the model reproduced the instantaneous observations of h and Q_{out}.

13.8 Experimental design

We conducted an experiment to test the response of wetland effectiveness to throughflow rates and their inverse, the residence time of parcels of water as they moved through the wetland. We operated the wetland at eight different throughflow rates, changing the daily average throughflow rate once every two weeks, for a total of 16 weeks, not including down time between two-week cycles due to pump maintenance.

At the end of every two-week cycle, we measured pollutant concentrations synchronously at four sites (Fig. 13.1) along the length of the wetland. We assumed that two weeks would be sufficient time for wetland function to have somewhat equilibrated to each change in throughflow rate. We sought to infer treatment effectiveness from observed reductions in concentration and load with respect to distance from the inlet. Ideally, such observations would not be made synchronously, but would be shifted in time so as to track each parcel of water as it entered the wetland and thereafter moved toward the outlet. However, this would have over-extended our resources because of the logistical difficulties of sampling at odd hours for many months, and limitations on the holding time of samples before they must be analyzed in the laboratory. In adopting synchronous sampling as a compromise, we accepted that differences in concentrations between any two sites might be affected not only by target effect, residence time, but also by temporal variation of inflow concentration.

To avoid the time of year becoming a potential confounding effect, we randomized the order in which we operated the wetland at the 8 throughflow rates. This was achieved by listing a large number of random orderings of the numbers 1 to 8, and selecting the first ordering that had low correlation with the ordered numbers. We also screened for low auto-correlation, to confound effects due to previous throughflow rates affecting subsequent ones should two-weeks have been insufficient time for re-equilibration. Finally, we avoided sequences that required the highest throughflow rates to be used in the first month of operation, to avoid potential training complications with 18-hour daily pumping times at the outset of the experiment. The resulting sequence was {2,3,7,5,8,4,1,6} where the numbers {1,…,8} index increasing throughflow rates from lowest to highest.

In the first order, wetland treatment function could be characterized simply by the rate of change, dC/dt (mg L^{-1} day^{-1}), of pollutant concentration, C (mg L^{-1}), over time, t (days), and the possibility that this rate in turn responds to C. We postulated that this response might occur in four possible ways:

- P_1: $dC/dt = 0$
- P_2: $dC/dt = -k, \;\; C > 0$
- P_3: $dC/dt = -r\,C$
- P_4: $dC/dt = -k\,(1 - \exp(-r\,\underline{C}))$

These postulates and their consequences are illustrated in Figure 1. The first postulate is no response. The second is a simple constant response at a rate, k (mg L^{-1} day^{-1}), with a threshold at zero. The third makes the response dependent on concentration, according to a rate, r (day^{-1}), and would occur whenever pollutant availability limits the treatment process itself. The fourth is like a combination of the second and third. It has a linear response at low C, and reaches a constant maximum at $C = k$.

Solving P_1 through P_4 for C gives:

- P_1: $C = C_0$
- P_2: $C = C_0 - k\,t$
- P_3: $C = C_0 \exp(-\,r\,t)$
- P_4: $C = \ln(1 + \exp(-\,k\,r\,(t + c))) / r$, $c = -\ln(-1 + \exp(r\,C_0)) / (k\,r)$

where C_i is the concentration of a given pollutant (e.g. mg L^{-1}) at Site i, and Site 0 is the inlet at the beginning of the wetland (Note: Sites 0,1,2,3 here correspond to Sites DCR-001, DCR-002, DCR-003, and DCR-004 in Fig. 13.1.

We can derive formally comparable hypotheses from these postulates by adding an error term, and relating t to position in the wetland by assuming that water flows through the wetland over time t from Site 0 to Site i under a plug flow:

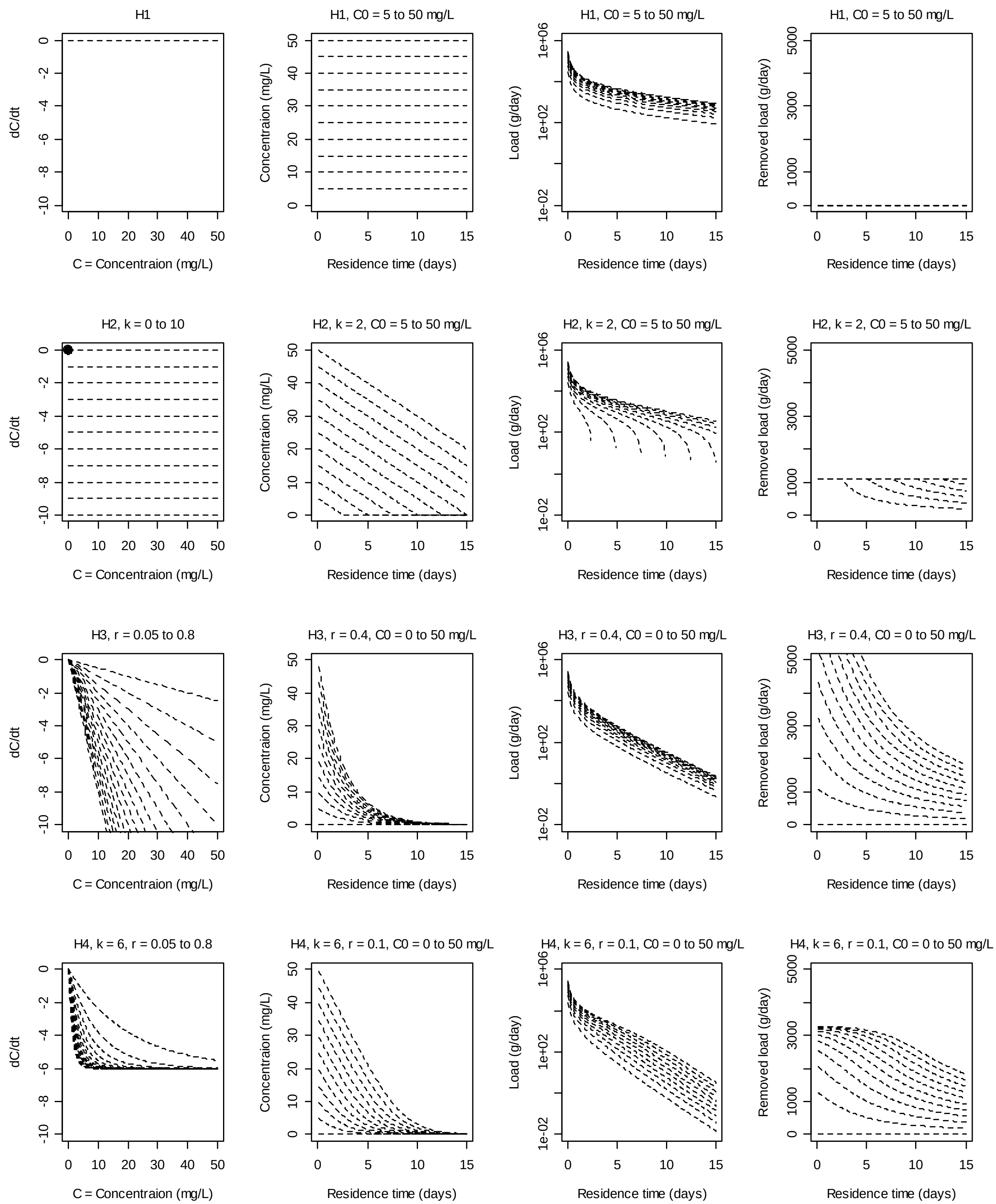
- H_1: $C_i = C_0 + N(0,\sigma^2)$
- H_2: $C_i = C_0 - k\,t_i + N(0,\sigma^2)$
- H_3: $C_i = C_0 \exp(-\,r\,t_i) + N(0,\sigma^2)$
- H_4: $C_i = \ln(1 + \exp(-\,k\,r\,(t_i + c))) / r + N(0,\sigma^2)$, $c = -\ln(-1 + \exp(r\,C_0)) / (k\,r)$

- Response variable: C_i
- Predictor variable: t_i
- Parameters: k, r, σ^2
- Known input: C_0

where t_i (days) is the residence time, or the time taken for a parcel of water to have reached Site i from Site 0. $N(0,\sigma^2)$ is a normally distributed random error with variance σ^2, reflecting both sampling error and temporal variation in C_0 between t_0 and t_i.

We compared H_1 through H_4 using information theoretic methods (Burnham & Anderson, 2002) with maximum likelihood estimates of parameters derived using function *nlm()* in the R statistical package (R Development Core Team, 2006).

Figure 1. Four postulates on the dependency of dC/dt on C, and their consequences for the dependency of pollutant load reduction on pumping rate and residence time.



The above postulates can be extended to estimate wetland treatment function with respect to reducing pollutant load. The load of pollutant, L_i (g day^{-1}), at Site i is:

$$L_i = C_i \, Q_i \qquad (6)$$

with C_i determined from the above solutions at time t, and Q_i determined from the hydrologic model.

The removal of pollutant load from the water is:

$$L_0 - L_i - L_{G,i} \qquad (7)$$

where $L_{G,i}$ is the pollutant load lost to shallow groundwater leakage. We make the conservative assumption that this load is returned to the original waterway, and thus does not count toward treatment effectiveness. We estimated its magnitude as:

$$L_{G,i} = Q_G \, (C_0 + C_i) \; / \; 2 \qquad (8)$$

with Q_G determined from the hydrologic model.

This derivation has consequences for the question of the optimal throughflow rate of wetlands. Depending on which mode of response is in effect, there is either no optimum until the pollutant is depleted (H_2), a distinct optimum at the fastest throughflow times (H_3), or a more gradual optimum at fast throughflow, presumably gradual enough such that operational costs might dictate the *practical* optimum.

13.9 Field sampling methods

During each sampling run, staff plate readings were taken at two locations (DCR-003 and in the center of the lower wetland). Flow into the Wetland was recorded by taking readings from a permanently installed McCrometer Propeller flow meter. This provided both instantaneous flow and daily totals in gallons. Instantaneous flow at the outlets was quantified by using volumetric discharge methods, such as a calibrated bin, or a timed surface float (Fig. 13.5).

Collection procedures for nutrient sampling were to use an extendable pole with a polyethylene bottle attached when sampling at sites that were an open channel (TEM-MOL and DCR-002), or by taking the sample by hand when sampling at sites that were distribution pipes (DCR-001, DCR-003, and DCR-004). At sites TEM-MOL and DCR-002, the bottle was lowered into the water surface with spout facing down directly in the middle of the channel or near the pump intake. The bottle was then tipped and filled when it was at the middle of the water column to obtain a representative sample. This procedure was repeated until the bottle was filled and dumped three times for quality control and assurance measures; the fourth fill was the nutrient sample collected for analysis. For sites DCR-001, 003, and 004, sample collection occurred by taking grab samples directly from the center flow of distribution pipes. Immediately after nutrient collection occurred, samples were stored in an ice chest with ice packs and frozen at arrival at the CCoWS laboratory until analysis.

Figure 13.4. Taking nutrient samples at the upper Wetland exit (DCR-003) and the mid-point of the upper section (DCR-002). Photos: Brianne Bieschke, 2006.

Figure 13.5. Measuring flow into and out of the Wetland. (Photo: Miles Daniels, 2006).

Pesticide sampling was performed and described by Hunt et al. (2007). The following text has been provided from that document:

"Water samples were collected in 2.5-liter amber glass bottles. Bottles were rinsed three times with site water before filling." At sites TEM-MOL, DCR-001 and DCR-002 "bottles were filled at least one cm below the surface to avoid floating debris and the surface microlayer." At DCR-003 and DCR-004 the bottles were filled directly from the outlet pipes. "Bottles were immediately placed in coolers with sufficient wet ice to adjust and maintain the temperature at 4 ± 3° C during transport to the Marine Pollution Studies Laboratory (MPSL)."

13.10 Laboratory analysis methods

13.10.1 Suspended Sediment

Method previously described in section 9.5.1.

13.10.2 Nutrients

Methods previously described in section 9.5.2.

13.10.3 Pesticides

Pesticides samples were collected by Granite Canyon Marine Laboratory and analyzed by the California Department of Fish and Game Laboratory in Rancho Cordova by GCMS.

13.10.4 Toxicity in Water

Samples for toxicity at the Wetland site were analyzed by Granite Canyon Marine Laboratory. The following analysis methods were provided from Hunt et al., 2007:

"Water samples were stored at 4 ± 3° C for no longer than 48 hours prior to toxicity test initiation. After a minimum of 16 hours in storage, water samples were decanted to separate overlying sample from settled particulates. Decanted water was poured through a 25-µm Nitex® screen to remove fauna and larger buoyant particulates. A separate screen was used for each sample. Samples were placed in the constant temperature room at test temperature to acclimate for 24 hours prior to testing."

"Water toxicity was evaluated using the 7-day chronic *Ceriodaphnia dubia* toxicity tests (U.S. EPA 2002). Each undiluted sample was tested using 10 replicates containing one *C. dubia* neonate (< 24-h-old obtained from in-house cultures). Survival and reproduction were monitored daily. Water quality parameters including conductivity, hardness, alkalinity, pH, dissolved oxygen, and ammonia were measured at the beginning of each test. Test solutions were renewed daily, and dissolved oxygen and pH were measured on the old solution. Dissolved oxygen was measured on the new solution."

"Water quality parameters of dissolved oxygen, pH and conductivity were measured using a Hach SensION selective ion meter with appropriate electrodes; and ammonia, nitrate, and phosphate were measured using a Hach 2010 spectrophotometer. Temperature was measured using a continuously recording thermograph and thermometer."

When conductivity was too high in the Wetland for the tolerance of *C. dubia*, *Hyalella azteca* 10-day survival and growth tests were used.

13.10.5 Toxicity Data Interpretation

"Samples were defined as toxic if the following two criteria were met: 1) there was a significant difference ($p<0.05$) in mean organism response (e.g., percent survival) between a sample and the negative laboratory control, as determined using a separate-variance *t*-test, and 2) the difference in organism response between the sample and control was greater than 20% (Phillips et al. 2001)."

13.10.6 Quality Assurance

"Toxicity testing precision was evaluated by conducting duplicate tests on eleven samples and by evaluating reference toxicity tests in relation to past test performance. Reference toxicant tests were conducted using the standard protocol on a dilution series of copper for *C. dubia* and cadmium for *H. azteca*."

13.11 Results and Conclusions

13.11.1 Nutrients and Pesticides

Table 13.1 summarizes the key quantitative data resulting from the experiment. Of all pesticides sampled, only diazinon and dimethoate were above detection limits in all samples. Therefore, we eliminated the remaining pesticides from the statistical analysis.

Although we nominated throughflow rates that were intended to achieve residence times between 0.5 and 5.0 days, the actual residence times estimated (using the hydrologic model) to have been achieved were longer, because of our ability to account for losses once we had completed the loss experiment. Thus, residence times ranged from 0.90 days up to 8.84 days, in an approximately geometric sequence rising in powers of $1/7^{th}$.

Table 13.1. Summary of quantitative results. Note: Load reductions (e.g. from Site 0 to 1) are reported after removing estimated groundwater leakage.

						Concentration						Load					
Pumping index	End date	Residence Time (days)	Site	Dist-ance (m)	Flow (m3/day)	NO3 (mg/L)	NH3 (mg/L)	PO4 (mg/L)	Diaz (ug/L)	Dimeth (ug/L)	SSC (mg/L)	NO3 (g/day)	NH3 (g/day)	PO4 (g/day)	Diaz (g/day)	Dimeth (g/day)	SSC (g/day)
1	17-Oct-06	0.00	0	0	77.68	16.95	0.13	0.49	0.0346	0.149	162	1317	9.7	38.1	0.0027	0.0116	12602
		4.52	1	141	62.49	13.95	0.02	0.34	na	na	66	872	1.0	21.4	na	na	4113
		8.84	2	276	47.29	2.87	0.02	0.26	0.0482	0.330	71	136	1.1	12.4	0.0023	0.0156	3368
		12.04	3	376	27.42	0.14	0.05	0.72	0.0348	0.280	81	4	1.3	19.6	0.0010	0.0077	2217
		4.52	0 to 1	141	-15.20	-3.00	-0.11	-0.15	na	na	-96	-315	-8.1	-13.1	na	na	-7527
		8.84	0 to 2	276	-30.39	-14.08	-0.10	-0.23	0.01	0.18	-91	-991	-7.7	-19.5	0.7	4.0	-7550
		12.04	0 to 3	376	-50.27	-16.81	-0.08	0.23	0.00	0.13	-81	-1111	-7.2	-8.3	1.0	6.5	-8081
2	05-Jul-06	0.00	0	0	113.89	43.74	0.06	0.49	0.3020	0.104	181	4982	6.3	55.8	0.0344	0.0118	20605
		3.03	1	141	96.86	37.65	0.16	0.52	na	na	78	3647	15.7	50.0	na	na	7543
		5.92	2	276	79.82	30.90	0.12	0.34	0.1980	0.141	53	2467	9.4	27.5	0.0158	0.0113	4236
		8.07	3	376	59.54	16.70	0.23	0.33	0.0870	0.100	41	994	13.9	19.5	0.0052	0.0060	2441
		3.03	0 to 1	141	-17.03	-6.09	0.11	0.03	na	na	-103	-965	10.4	-1.2	na	na	-11885
		5.92	0 to 2	276	-34.07	-12.84	0.06	-0.15	-0.10	0.04	-128	-1834	5.1	-20.1	4.5	2.2	-14478
		8.07	0 to 3	376	-54.35	-27.04	0.18	-0.16	-0.22	0.00	-140	-3108	11.1	-25.3	5.7	3.2	-15881
3	18-Jul-06	0.00	0	0	133.60	38.85	0.01	0.45	0.1520	0.128	220	5190	2.0	59.9	0.0203	0.0171	29393
		2.02	1	141	111.85	40.95	0.17	0.56	na	na	120	4580	18.5	62.6	na	na	13415
		3.95	2	276	90.10	31.59	0.03	0.09	0.1050	0.072	111	2846	2.4	8.1	0.0095	0.0065	9983
		5.38	3	376	70.06	11.95	0.22	0.20	0.1400	0.425	118	837	15.4	14.0	0.0098	0.0298	8296
		2.02	0 to 1	141	-21.75	2.10	0.15	0.11	na	na	-100	-260	17.3	7.0	na	na	-14484
		3.95	0 to 2	276	-43.51	-7.26	0.01	-0.36	-0.05	-0.06	-109	-1692	1.7	-45.4	2.2	1.7	-16770
		5.38	0 to 3	376	-63.54	-26.90	0.21	-0.25	-0.01	0.30	-102	-3523	15.7	-38.3	3.2	3.8	-17519
4	04-Oct-06	0.00	0	0	227.62	23.46	0.10	0.59	0.0736	0.248	203	5340	23.6	135.2	0.0168	0.0564	46259
		1.45	1	141	210.59	13.88	0.09	0.50	na	na	112	2922	19.7	104.5	na	na	23489
		2.85	2	276	193.56	11.30	0.03	0.47	0.0418	0.354	190	2187	5.8	90.4	0.0081	0.0685	36714
		3.88	3	376	183.86	4.82	0.10	0.38	0.0516	0.322	115	886	19.0	69.9	0.0095	0.0592	21160
		1.45	0 to 1	141	-17.03	-9.59	-0.01	-0.10	na	na	-92	-2241	-3.0	-25.5	na	na	-21278
		2.85	0 to 2	276	-34.06	-12.16	-0.07	-0.13	-0.03	0.11	-14	-2845	-16.3	-34.9	1.1	5.7	-6358
		3.88	0 to 3	376	-43.76	-18.64	0.00	-0.21	-0.02	0.07	-88	-4077	-2.5	-51.8	1.5	8.6	-20598
5	06-Sep-06	0.00	0	0	242.19	35.81	0.02	0.42	0.1520	0.210	163	8672	4.2	101.5	0.0368	0.0509	39448
		1.39	1	141	225.94	9.14	0.00	0.17	na	na	196	2064	0.0	39.2	na	na	44290
		2.72	2	276	209.68	23.91	0.02	0.27	0.1832	0.140	121	5014	4.4	56.1	0.0384	0.0293	25288
		3.70	3	376	194.77	11.80	0.19	0.24	0.1724	0.133	75	2298	36.6	45.9	0.0336	0.0259	14674
		1.39	0 to 1	141	-16.25	-26.67	-0.02	-0.25	na	na	33	-6420	-4.1	-59.8	na	na	6338
		2.72	0 to 2	276	-32.51	-11.90	0.00	-0.15	0.03	-0.07	-42	-3276	0.4	-40.6	2.8	2.9	-11495
		3.70	0 to 3	376	-47.42	-24.01	0.17	-0.18	0.02	-0.08	-88	-5829	33.6	-48.6	4.4	4.1	-21221
6	01-Nov-06	0.00	0	0	338.48	17.35	0.13	0.49	0.0270	0.072	208	5873	43.5	165.9	0.0091	0.0244	70522
		0.89	1	141	306.63	16.70	0.07	0.44	na	na	114	5121	20.3	133.5	na	na	34840
		1.75	2	276	274.78	10.80	0.07	0.31	0.0340	0.054	120	2968	18.2	86.5	0.0093	0.0148	32968
		2.38	3	376	249.60	8.49	0.15	0.26	0.0370	0.031	115	2118	37.3	65.0	0.0092	0.0077	28611
		0.89	0 to 1	141	-31.85	-0.65	-0.06	-0.05	na	na	-95	-583	-22.2	-27.9	na	na	-34083
		1.75	0 to 2	276	-63.70	-6.55	-0.06	-0.18	0.01	-0.02	-88	-2608	-23.5	-71.2	0.6	1.2	-34627
		2.38	0 to 3	376	-88.88	-8.87	0.02	-0.23	0.01	-0.04	-94	-3369	-3.5	-90.0	0.9	1.6	-37906
7	23-Aug-06	0.00	0	0	548.49	23.60	0.51	0.38	0.0732	0.069	195	12942	282.1	206.0	0.0401	0.0378	107227
		0.48	1	141	540.68	25.68	0.45	0.42	na	na	94	13885	244.9	225.8	na	na	50905
		0.94	2	276	532.88	20.25	0.48	0.32	0.1726	0.234	95	10791	258.2	172.7	0.0920	0.1246	50728
		1.29	3	376	497.17	16.40	0.34	0.34	0.2100	0.300	66	8154	169.3	168.9	0.1044	0.1492	32962
		0.48	0 to 1	141	-7.81	2.09	-0.06	0.04	na	na	-101	1187	-32.3	23.8	na	na	-54886
		0.94	0 to 2	276	-15.61	-3.35	-0.03	-0.05	0.10	0.16	-100	-1691	-14.3	-25.9	2.5	3.1	-53956
		1.29	0 to 3	376	-51.32	-7.20	-0.17	-0.04	0.14	0.23	-129	-4121	-98.5	-26.0	4.7	6.1	-70806
8	20-Sep-06	0.00	0	0	791.28	22.00	0.14	0.42	0.0906	0.204	190	17408	110.0	334.5	0.0717	0.1614	150037
		0.46	1	141	753.03	30.96	0.04	0.44	na	na	138	23314	33.7	329.5	na	na	103618
		0.90	2	276	714.79	24.00	0.11	0.45	0.0696	0.153	93	17155	76.5	321.7	0.0497	0.1091	66366
		1.23	3	376	672.75	17.88	0.19	0.35	0.0750	0.158	90	12025	130.0	232.1	0.0505	0.1060	60246
		0.46	0 to 1	141	-38.24	8.96	-0.09	0.01	na	na	-52	6234	-75.2	0.3	na	na	-44393
		0.90	0 to 2	276	-76.49	2.00	-0.03	0.03	-0.02	-0.05	-97	382	-31.1	-2.0	2.0	4.4	-80203
		1.23	0 to 3	376	-118.52	-4.13	0.05	-0.08	-0.02	-0.05	-100	-4491	24.3	-86.7	2.8	6.3	-85206

Figure 13.6 summarizes the changes in concentration of each pollutant as the flow moved through the wetland, for each of the 8 pumping regimes. Clear reductions in concentration were observed for nitrate, phosphate, and suspended sediment. The results for ammonia, diazinon, and dimethoate appeared more ambiguous.

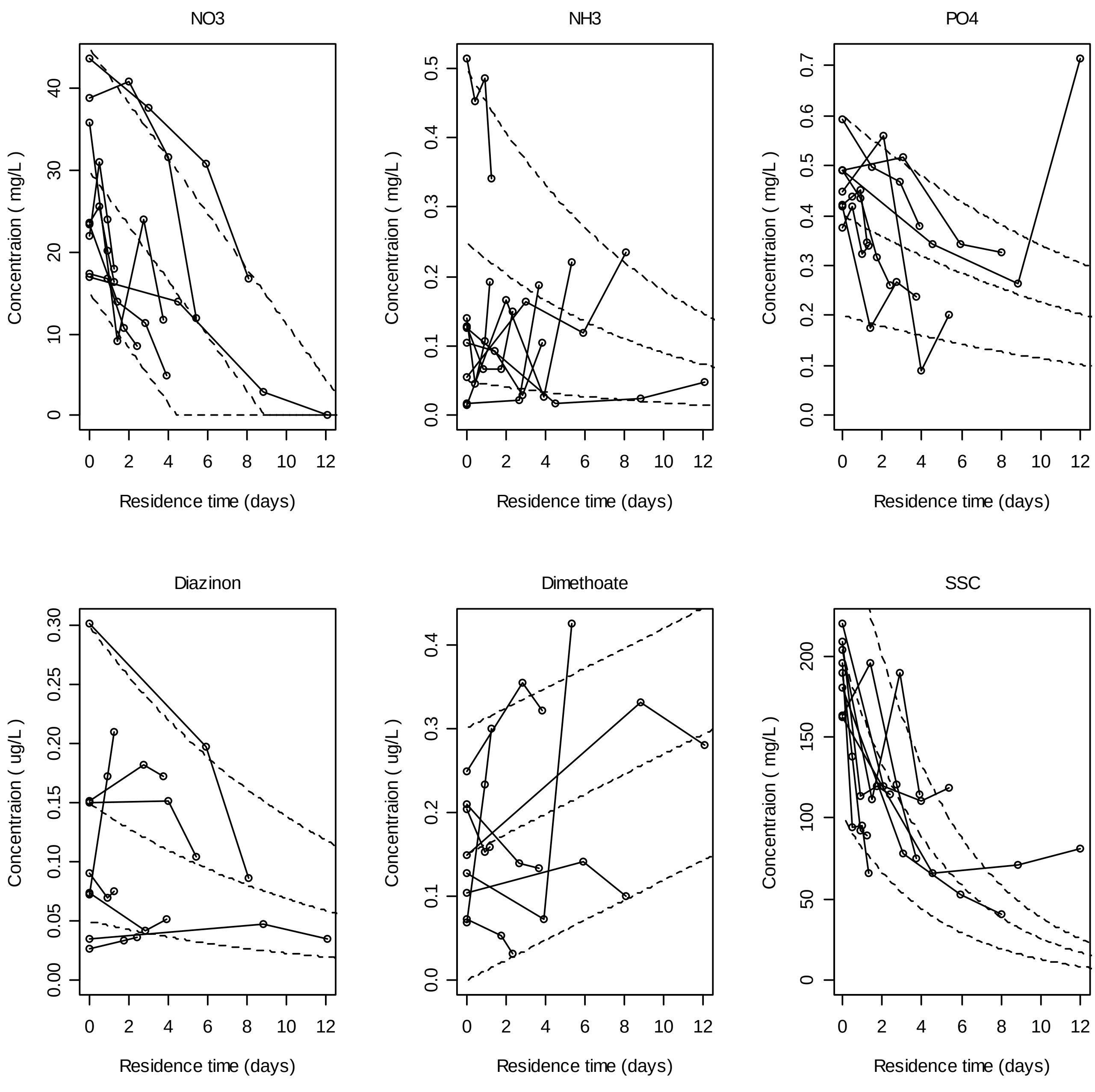


Figure 13.6. Reduction in concentration, and best supported models.

Table 13.2 summarizes the comparison of the four hypotheses for each pollutant in terms of Akaike Information Criterion weights (including correction for small sample size) (Burnham & Anderson, 2002). The weights theoretically range from 0 to 1, and represent the relative support for the different hypotheses. The nitrate data were most consistent with H_2 (constant reduction), although there was also moderate support for H_3 and H_4 (concentration-dependent reduction; and maximum-limited concentration-dependent reduction). The ammonia data were most consistent with H_3, although the no-response hypothesis (H_1) received almost as much weight. The phosphate and diazinon data were also most consistent with H_3, with only weak alternatives. The dimethoate data were roughly equally supported by H_2 and H_3, but the coefficients were negative, indicating an increase in concentration. The suspended sediment data were very clearly supported by H_3.

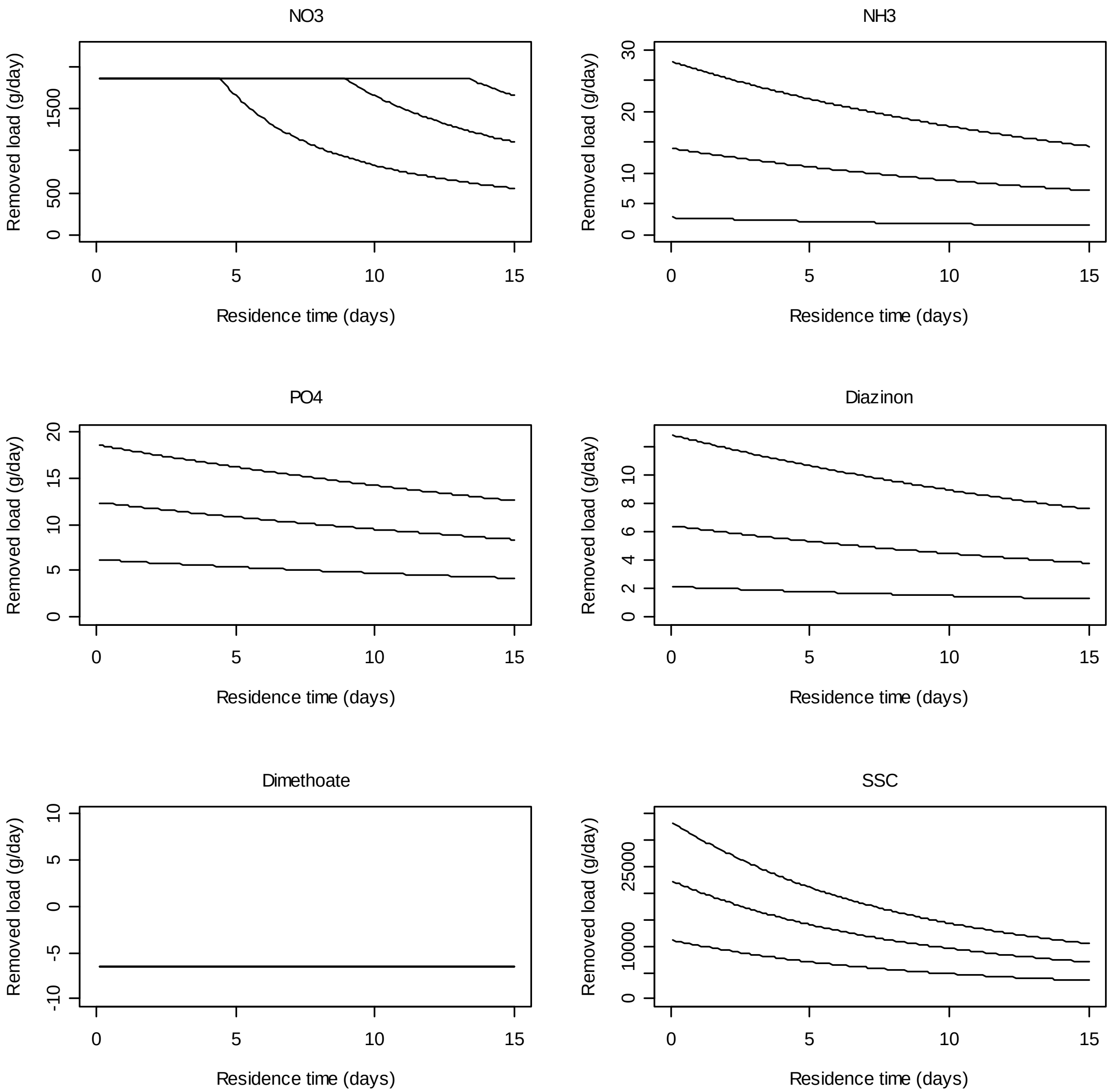
Both phosphate and diazinon are transported at least in part through adsorption to suspended sediment (Kadlec & Knight, 1996, p. 75; Kozlowski et al., 2004). This may explain the fact that all three of these pollutants supported H_3, since settling occurs at a rate that decreases over time (Kadlec & Knight, 1996, p. 320). The only apparent reduction in the rate of nitrate removal was when the concentration closely approached zero. This suggests that the process governing nitrate removal (e.g. dentrification) is not nitrate-limited.

The best-supported model of reduction in concentration (mg L^{-1}) for a range of initial conditions is overlaid with the observations in Figure 13.6. The same models are illustrated in terms of pollutant removal rates (g day^{-1}) in Figure 13.7. This illustration supports the postulate that the greatest pollutant removal in terms of mass-per-time (g day^{-1}) is achieved by pumping as fast as possible, for the lowest retention times. This is clearly the case for ammonia, phosphate, diazinon, and suspended sediment. It is less so for nitrate, since under the best-supported hypothesis (H_2) a reduction in removal rate at low pumping rates only occurs due to exhaustion of nitrate supply once retention times exceed 5 to 15 days (depending on inflow concentration). But note that H_3 and H_4 were moderately supported by the nitrate data, so it would not be imprudent to operate the wetland for nitrate removal under the assumption that any residence time longer than one day would be sub-optimal.

Table 13.2 Comparison of hypotheses for reduction in concentration of pollutants over the length of the upper wetland from Site 0 to Site 3. Boldface indicates the best model of those compared for each pollutant, based on the highest AIC_C weight (Burnham & Anderson, 2002). Broadly, comparison of weights is analogous to comparison of likelihoods that the data arose from the respective models, with a penalty against models with more parameters, i.e. degrees of freedom (df).

					Maximum likelihood estimates of parameter values		
	df	**AIC_c**	**ΔAIC_c**	**AIC_w**	**σ**	**k**	**r**
NO3							
H_1	1	196.0	28.09	0.000	13.71		
H_2	**2**	**167.9**	**0**	**0.481**	**7.26**	**3.39**	
H_3	2	169.0	1.12	0.275	7.44		0.130
H_4	3	169.2	1.36	0.244	7.07	3.71	0.117
NH3							
H_1	1	-41.1	0.13	0.369	0.098		
H_2	2	-39.1	2.15	0.134	0.097	-0.00273	
H_3	**2**	**-41.2**	**0**	**0.392**	**0.093**		**0.102**
H_4	3	-38.6	2.63	0.105	0.093	1.45E+06	7.01E-08
PO4							
H_1	1	-15.9	5.36	0.038	0.166		
H_2	2	-19.7	1.50	0.261	0.146	0.0181	
H_3	**2**	**-21.2**	**0**	**0.553**	**0.141**		**0.0563**
H_4	3	-18.6	2.63	0.148	0.141	1.31E+06	4.30E-08
Diazinon							
H_1	1	-34.9	7.60	0.017	0.0757		
H_2	2	-37.0	5.47	0.050	0.0652	0.0120	
H_3	**2**	**-42.5**	**0**	**0.768**	**0.0550**		**0.0776**
H_4	3	-39.4	3.08	0.165	0.0550	813	9.54E-05
Dimethoate							
H_1	1	-18.4	1.65	0.175	0.127		
H_2	**2**	**-20.0**	**0**	**0.398**	**0.111**	**-0.0119**	
H_3	2	-19.7	0.31	0.342	0.112		-0.0602
H_4	3	-17.0	3.08	0.086	0.111	-0.012	298.0
SSC							
H_1	1	288.7	30.16	0.000	94.6		
H_2	2	265.3	6.85	0.026	55.4	26.1	
H_3	**2**	**258.5**	**0**	**0.813**	**48.0**		**0.204**
H_4	3	261.7	3.25	0.160	45.9	3.22E+06	5.46E-08

Figure 13.7. Removal rate dependency on residence time / pumping rate



13.11.2 Nutrients and Pesticides

1. The wetland removed dissolved inorganic nutrients and sediment from the water flowing through it. At low input concentrations the lower wetland contributed ammonia to the flow.
2. Organophosphate pesticides were both removed at low rates from the flow (diazinon), and apparently also added to the flow (dimethoate).
3. Residence time had a positive effect on reduction in pollutant concentration
4. Reductions in pollutant concentration occurred both at a constant rate (nitrate) and a concentration-dependent rate (ammonia, phosphate, diazinon, suspended sediment).
5. A no-response hypothesis was never the best supported, of four alternatives considered for each pollutant.
6. A maximum-limited concentration-dependent hypothesis was never the best supported. But we expect that it would be supported by data obtained over a larger range of input concentrations and residence times.
7. Net removal of pollutants from the water stream in mass-per-time was maximized at the highest pumping rates, corresponding to residence times of just under one day.
8. In the upper (constructed) wetland, A minimum residence time of 0.90 days was achieved by pumping 790 m^3 day^{-1} in to a mean wetland volume of 635 m^3 with a mean wetted surface area of 2050 m^2 (equivalent to a hydraulic loading rate of 39 cm day^{-1}), occupying a land surface area (including berms) of approximately 0.5 ha.
9. The best models fitted to the data at this minimum residence time predict continuous reductions in nitrate load by the upper wetland of 1.4 kg day^{-1}.
10. Assuming a mean daily nitrate load for the entire Gabilan watershed upstream of the wetland (approx. 36 000 ha) of 860 kg day^{-1}, an initial estimate for the area of wetland thus required to treat the entire watershed nitrate load is 300 ha, or about 0.9% of the watershed (Eqn 1).
11. These conclusions do not address seasonal variation, long-term storage and re-mobilization, or pollutant transformations such as conversion of nutrients from dissolved inorganic forms to organic forms that may have been retained in the water stream.
12. The concept of actively pumped offline treatment wetlands was supported by the experiment. The actively pumped wetland we constructed achieved higher reductions in pollutant load for a given wetland area than could be expected of a passive wetland subject to the lower throughflow that is characteristic of our low gradient coastal study area.

13.11.3 Toxicity

The following results were observed by the Granite Canyon laboratory researchers. The full analysis can be found in Hunt et al., (2007). This text was borrowed directly from that final report:

"A number of interesting results were observed. Water samples from the Tembladero Slough (which was pumped into the constructed wetland VTS) were toxic to *C. dubia*. This toxicity appeared related to total organophosphate pesticide concentrations. In early surveys using *C. dubia*, toxicity and pesticide concentrations decreased with distance traveled through the constructed wetland."

13.12 Follow-up: Staggered sampling

As stated earlier, the primary experiment described in this chapter involved synchronous sampling at the end of each two-week pumping period. This was expected to introduce unaccounted variance into removal results because of variance in the inflow. Ideally a better approach would be to follow a 'parcel' of water as it moved through the wetland and staggering the sampling times accordingly. For the main experiment, we avoided this because of the logistical difficulties involved with staggered sampling.

Inflow variance was very high, as evidenced by values of σ in Table 13.2 sometimes as high as the inflow concentrations themselves (analogous to coefficients of variation of approximately 100%). We thus decided as a follow-up to test a staggered sampling approach for a single 'event' during the storm season.

The storm event occurred from January 28-31 of 2007. The wetland could not be subjected to a constant hydraulic loading rate for two weeks prior to sampling due to the difficulty of forecasting storms two weeks in advance. Rather, the event began once a storm system was selected to monitor. Once selected, a constant hydraulic loading rate was held until the plug (parcel) of water considered to be "storm water" entered and exited the system. We used the hydrologic model to estimate the location of the parcel at any given time subsequent to it being input to the system. We sampled both at the predicted location of the parcel, and also 25 meters in front of and behind of the predicted location, in order to allow for prediction error. The lower section of the wetland was not monitored for this event because plug flow does not occur there.

The results are shown in the following three figures. Strong reduction in nitrate and phosphate was indicated, whereas ammonia tended to increase. This broad pattern was similar to that observed during the main experiment. As predicted, there appears top be less variance in the estimated rate of nutrient reduction. It is likely that support for specific hypotheses would be stronger in the absence of effects due to inflow variance.

We thus recommend that future monitoring seriously consider staggered sampling as opposed to synchronous sampling, preferably preceded by a tracer experiment to calibrate the prediction of the location of inflow parcels as they move through the system.

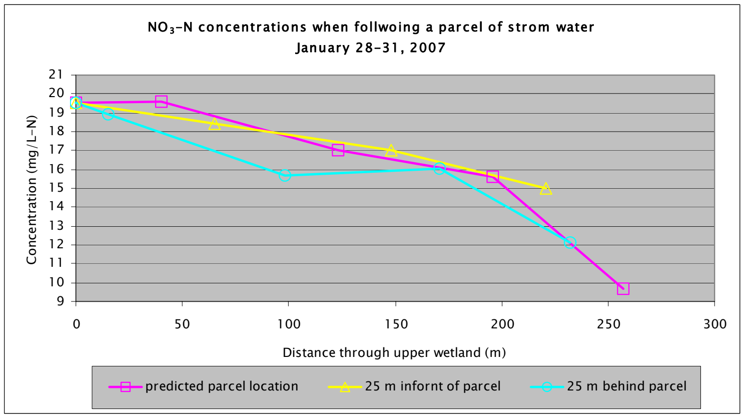


Figure 13.8. Nitrate-N tracking in a storm parcel.

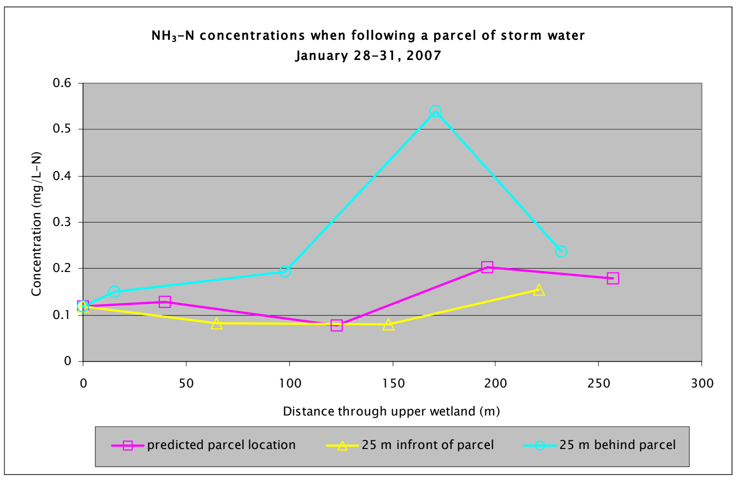


Figure 13.9. Total Ammonia-N tracking in a storm parcel.

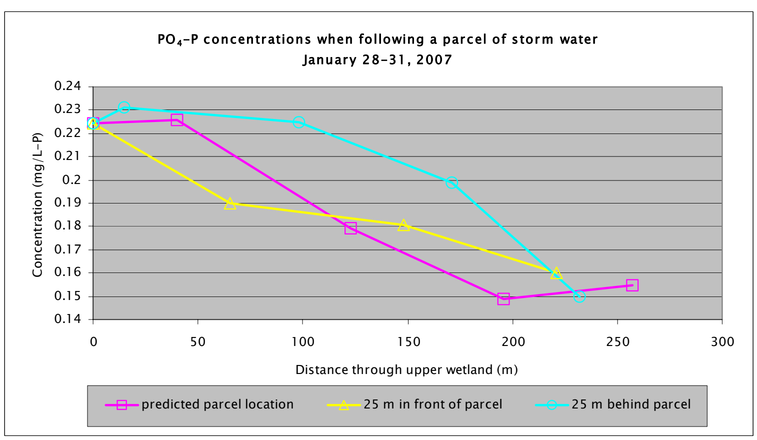


Figure 13.10. Orthophosphate-P tracking in a storm parcel.

14 Project Assessment & Evaluation

This section will discuss project results in relation to goals set out in the Project Assessment and Evaluation Plan (PAEP). This project was quite large and contained many components. The project was broken down into four general areas of goals, based upon the requirements for the PAEP document. These four areas of work were:

- Habitat Restoration Activities
- Management Practice Implementation Activities
- Education and Outreach
- Research and Monitoring

14.1 Habitat Restoration

The Habitat Restoration section addressed activities that were occurring at the Wetland site. Other Wetland goals such as water quality are not discussed in this section. At the wetland site, it was hoped that an "overall enhancement of wetland ecosystem functioning" would be achieved. To do this, the goals were to create:

- a functioning treatment wetland
- a thriving native plant community and reduce non-natives
- a space that more birds would use than prior to the project
- habitat where an *in situ* macroinvertebrate community can exist

Table 14.1 contains a list of targets for the PAEP for Habitat Restoration.

Table 14.1. List of targets for habitat restoration at the Wetland site.

Targets	Mesurement Tools & Methods from PAEP	Target achieved?	Notes
Sinuous wetland for water quality monitoring with the following attributes: - Volume = 785m3 - Surface area = 2500m2 - Depth of upper portion = 45cm	Photo monitoring	Yes	A survey was also completed to determine the finished dimenstions of the Wetland (figure 13.2)
Increase in native plant cover & reduction in non-native plant cover	GIS survey (comparison of pre- vs post-project % plant cover of non-native and native plants & photo monitoring	Yes	GIS map in the Wetland Photo and Biological Monitoring, Chapter 12
Increased use by birds and greater species diversity	Monthly bird monitoring by MLML	Yes	Results of bird monitoring in graphs in the Wetland Photo and Biological Monitoring, Chapter 12
A BMI community in greater or equal numbers to that which exists in the Tembladero	BMI sample collection	Yes	There was a thriving BMI community. Results in the Wetland Photo and Biological Monitoring, Chapter 12

14.2 Management Practice Implementation

The Management Practice Implementation section addressed activities related to the work that the RCD planned to do to install management practices on agricultural properties. The goal was to design, plan and implement 20 practices on 7 properties throughout the Gabilan Watershed to improve water quality. To achieve this, the steps were to:

- obtain signed landowner agreements
- design and plan the practices
- submit design plans for review to SWRCB's project representative, and
- implement a range of management practices at participating sites and provide support to landowners when needed

Each of these steps was completed. A full list of site codes for implemented practices and a summary table of practice descriptions and extents are presented in the Agricultural Practice Education, Outreach and Implementation chapter.

Targets	Mesurement Tools & Methods from PAEP	Target achieved?	Notes
100% of planned management practices installed (20 on 7 properties)	% of the 7 properties on which practices were implemented and % of the 20 practices implemented	Yes	See table in Agricultural Practice Education, Outreach and Implementation, Chapter 8 40 practices; 23 properties

14.3 Education and Outreach

This project contained a lot of education and outreach activities, and involved the work of CAFF, the RCD, RON, and MLML. The goals set out in the PAEP were to:

- gain participation for agricultural management practices and wetland installation, as well as, raise the level of knowledge about management practices throughout the watershed
- provide education and enrichment to school children about the role of native plants in agricultural land management
- demonstrate water quality and habitat benefits of wetlands to local agricultural landowners

14.3.1 RCD

The best indicator that outreach and education activities were sufficient and effective in gaining participation to install management practices and raise knowledge among agricultural operators and landowners is that the target of "20 practices on 7 properties" was not only met, but exceeded. A total of forty (40) practices were implemented on twenty-three (23) properties by the end date of the project. The RCD has also reported that as a result of outreach funded by this project, additional conservation practice implementation is planned for 2007 in the Gabilan watershed with leveraged funds from other sources.

14.3.2 RON

RON wanted to determine if knowledge of native plants (for use in agriculture) had increased in school children because of their participation in the project. Because of the human subjects requirements necessary for doing pre-post surveys of children and because of the number of children involved in this project, it was decided that teachers who worked with the school green house growing project would provide insightful comments. Teachers were interviewed in February and March of 2007. The resulting report and analysis sections bring to light the teacher interview responses (Appendix – RON results of teacher surveys.16.6).

14.3.3 CAFF/MLML

The water quality and habitat benefits of wetlands were demonstrated to local agricultural landowners via a tour of the Wetland site during the February 2006 field day workshop. A nice handout was also created to give to participants summarizing the goals of the Wetland portion of the project (should add this to appendix?).

Targets	Mesurement Tools & Methods from PAEP	Target achieved?	Notes
20 practices installed on 7 properties	Final # of installed practices, phone calls to individual landowners, number of attendees, and media coverage	Yes	Implemenation of all practices is the best indicator of successful outreach. Attendee sheets were submitted from CAFF to RCD for each workshop. Workshop announcements: 4 appeared in newspapers Articles: 1 about Wetland site, 4 post workshop, 1 about water quality
Increase knowledge for school children of the role of native plants in an agricultural setting	A pre-post evaluation procedure based on grade specific CA science education standards	Yes	Interviewed teachers instead to achieve equilavent goal. Interview results in Appdx 16.6.
Increase in awareness of water quality and habitat benefits of wetlands as well as implementation of suggested practices to some degree	Phone calls to individual landowners to discuss the value of the activity	Yes	February 2006 and 2007 Wetland tours and handout for workshop attendees, Appdx 16.5.

14.4 Research and Monitoring

The goals for the Research and Monitoring portion of the project were:

- Management practice effectiveness monitoring at both agricultural sites and the Wetland
- Determine pollutant load reduction provided by the Wetland
- Watershed level monitoring to determine annual pollutant loads exiting the watershed.
- Biological monitoring in the Wetland including birds and macroinvertebrates

To achieve these goals, intensive monitoring occurred at agricultural sites, the Wetland, and the Tembladero Slough from November 2005 to January 2007.

Targets	Mesurement Tools & Methods from PAEP	Target achieved?	Notes
Quantitative annual load estimates for sediment, nutrients and pesticides for Gabilan Watershed	Flow measurements, suspended sediment, nutrient, and pesticide samples in Tembladero Slough	Yes	Results in Watershed Level Monitoring – Tembladero Slough, Chapter 10
Quantitative answers to questions 1,2,3,5,and 7 from Monitoring Plan & Qualitative/investigatory answer to question 4 from Monitoring Plan.	suspended sediment, nutrient, pesticide, and toxicity samples	Yes	Results for Q1 in Agricultural Practice Water Quality Monitoring, Chapter 9 Results for Q2,3,5,7 in Wetland Water Quality Montoring, Chapter 13 Q4 is currently being addressed with additional research funding at CCoWS
Determine if bird species diversity, community composition, relative abundance of species, or habitat use changes after Wetland construction, & Determine if the developing BMI community in the Wetland varies in composition and abundance between the Wetland and adjacent Tembladero Slough.	Monitoring three fixed plots for bird usage and flyovers and BMI sampling in the Wetland and Slough	Yes	Results of bird monitoring and BMI sampling in Wetland Photo and Biological Monitoring, Chapter 13

15 Literature Cited

Anderson, B., J. Hunt, B. Phillips, P. Nicely, K. Gilbert, V. De Vlaming, V. Connor, N. Richard, and R. Tjeerdema. 2003a. Ecotoxicologic impacts of agricultural drain water in the Salinas River, California, USA. Environmental Toxicology & Chemistry 22(2003). 10 pp.

Anderson, B., J. Hunt, B. Phillips, P. Nicely, V. De Vlaming, V. Connor, N. Richard, and R. Tjeerdema. 2003b. Integrated assessment of the impacts of agricultural drainwater in the Salinas River California, USA. Environmental Pollution 124(2003) 10 pp.

Anderson T., F. Watson, W. Newman, J. Hager, D. Kozlowski, J. Casagrande, J. Larson. 2003. Nutrients in surface waters of southern Monterey Bay watersheds. Watershed Institute at California State University Monterey Bay, Report No. WI-2003-11. Prepared for the Central Coast Regional Water Quality Control Board. 106 pp. + appendix.

Burnham, K. P., and D. R. Anderson. 2002. *Model selection and multimodel inference*. Second edition. Springer-Verlag, New York, New York, USA.

Casagrande, J. and F. Watson. 2006. Reclamation Ditch Watershed Assessment and Management Plan: Part A – Watershed Assessment. Monterey County Water Resources Agency and The Watershed Institute, California State University Monterey Bay. 283 pp.

Hoover, B. 2007. Snapshot Day Report May 6th 2006: Results of a Sanctuary-wide water quality monitoring event. Monterey Bay Sanctuary Citizen Watershed Monitoring Network, 19 pp. http://www.montereybay.noaa.gov/monitoringnetwork/pdf/ss2006.pdf

Hunt, J, Anderson, B, Phillips, B, Largay, B. 2007. Effectiveness of agricultural management practices in reducing concentrations of pesticides associated with toxicity to aquatic organisms: Data Analysis and Summary Report. California Regional Water Quality Control Board, Central Coast Region.

Hunt, J.W., B.S. Anderson, B.M. Phillips, P.N. Nicely, R.S. Tjeerdema, H.M. Puckett, M. Stephenson, K. Worcester, V. De Vlaming. 2002. Ambient toxicity due to chlorpyrifos and diazinon in a Central California Coastal Watershed. Environmental Monitoring and Assessment 82: 83-112, 2003

Kadlec, R.H. & Knight, R.L. (1996) *Treatment Wetlands*. Lewis Publishers, Boca Raton, USA, 893 pp.

Kozlowski, D., F. Watson, M. Angelo, J. Larson. 2004a. Monitoring of chlorpyrifos and diazinon in impaired surface waters of the Lower Salinas Region, Watershed Institute at California State University Monterey Bay, Report No. WI-2004-03. Prepared for the Department of Pesticide Regulation (DPR). 59 pp. + appendix.

Kozlowski, D., F. Watson, M. Angelo, & S. Gilmore. 2004b. Legacy pesticide sampling in impaired surface waters of the Lower Salinas Region. Report to Central Coast Regional Water Quality Control Board, Watershed Institute at California State University Monterey Bay, Report No. WI-2004-02. 46 pp.

Larson, J., Watson, F., Casagrande, J., & Pierce, B.et al. (2006) Carmel River Lagoon Enhancement Project: Water Quality and Aquatic Wildlife Monitoring, 2005-6 Report to California Department of Parks and Recreation. The Watershed Institute, California State University Monterey Bay, Publication No. WI-2006-06, 102 pp.

Mitsch, W.J. & Gosselink, J.G. (2000) *Wetlands*. 3rd ed. John Wiley & Sons, New York, USA, 920 pp.

R Development Core Team (2006). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

State Water Resource Control Board (SWRCB). 1999a. Consolidated Toxic Hot Spots Cleanup Plan Volume I: Policy, Toxic Hot Spot List and Findings. 42 pp.

State Water Resource Control Board (SWRCB). 1999b. Consolidated Toxic Hot Spots Cleanup Plan Volume II: Regional Cleanup Plans. 376 pp.

Thackston, E.L., Shields, F.D., Jr., and Schroeder, P.R. (1987). Residence time distribution of shallow basins. *Journal of the Environmental Engineering Division ASCE* 113(6), 1319-32

Watson, F., M. Angelo, T. Anderson, J. Casagrande, D. Kozlowski, W. Newman, J. Hager, D. Smith, B. Curry. 2003. Salinas Valley Sediment Sources. Report No. WI-2003-06, The Watershed Institute, California State University Monterey Bay. Prepared for the Central Coast Regional Water Quality Control Board. 239pp.

Worcester, K., D. Paradies, M. Adams, D. Berman. 2000. Central Coast Ambient Monitoring Program: Salinas River Watershed Characterization Report 1999. 97 pp.

16 Appendices

16.1 Acronym List

ALBA	Agricultural Land-based Training Association
AWQA	Agricultural Water Quality Alliance
CAFF	Community Alliance with Family Farmers
CC&R	Coastal Conservation and Research
CCoWS	Central Coast Watershed Studies
MCFB	Monterey County Farm Bureau
MLML	Moss Landing Marine Laboratories
NRCS	Natural Resources Conservation Service
RCD	Resource Conservation District of Monterey County
RON	Return of the Natives
UC CASFS	Center for Agroecology and Sustainable Food Systems
UCCE	University of California Cooperative Extension

16.2 DEMs of basins monitored – used to determine volumes.

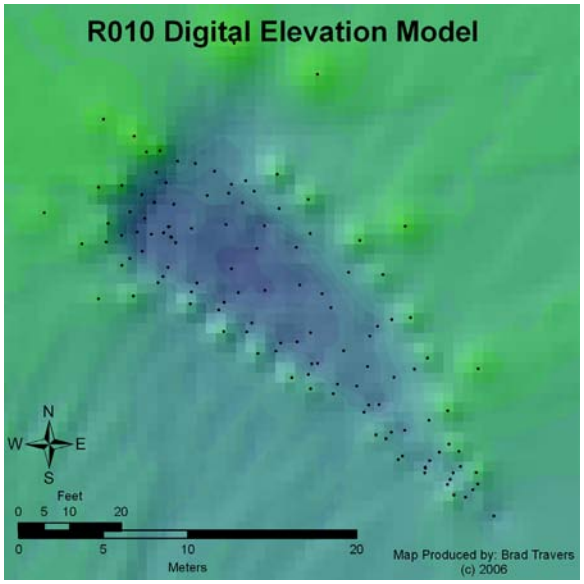


Figure 16.1. R010 sediment basin.

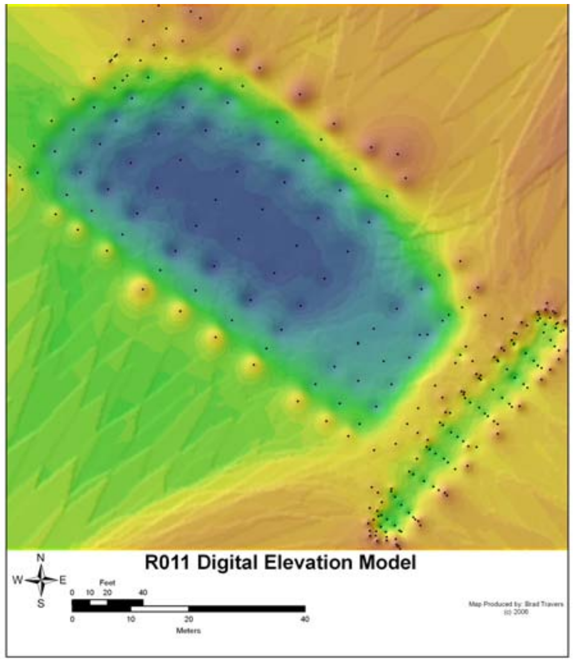


Figure 16.2. R011 two linked sediment/water retention basins.

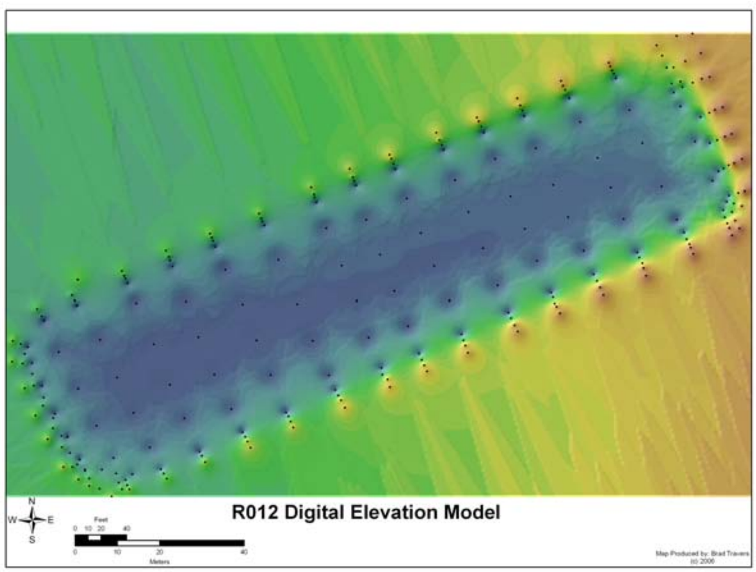


Figure 16.3. R012 sediment/water retention basin.

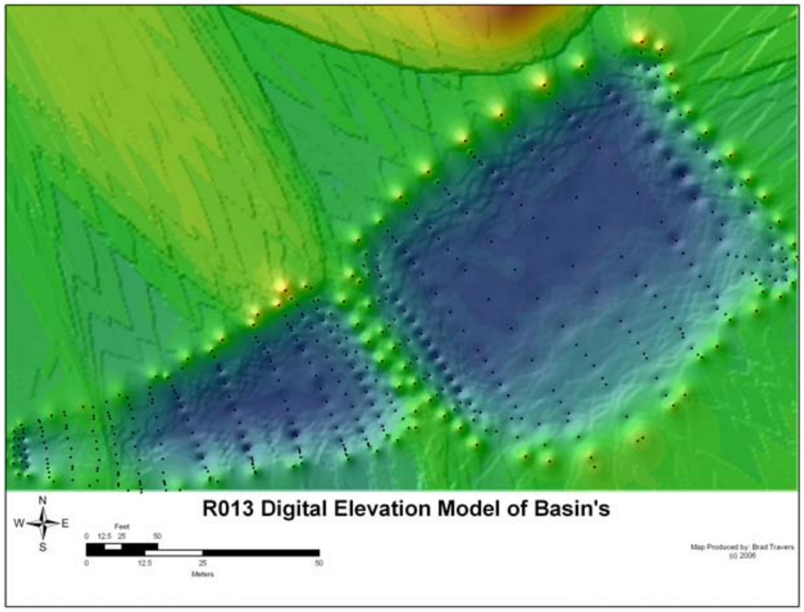


Figure 16.4. R013 two linked sediment/water retention ponds.

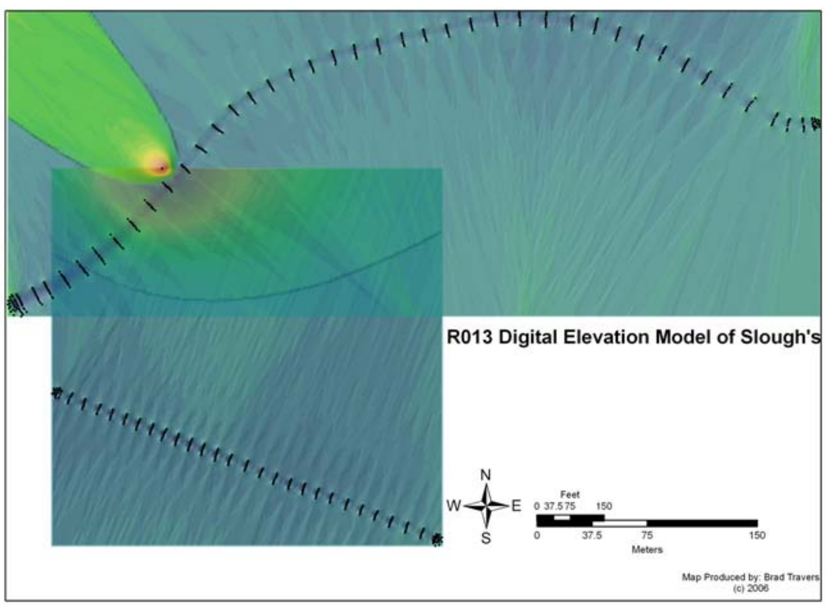


Figure 16.5. R013 two long detention ditches.

16.3 Additional Agricultural event graphs

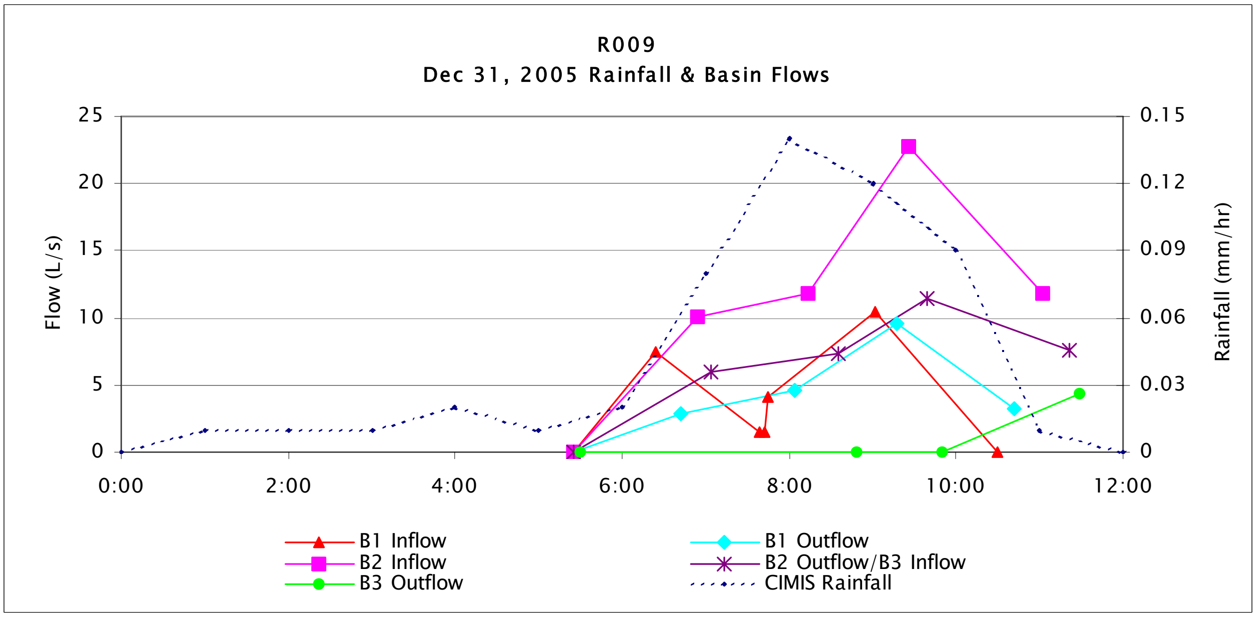


Figure 16.6. Rainfall rate and basin flows at R009 during the December 31, 2005 storm event.

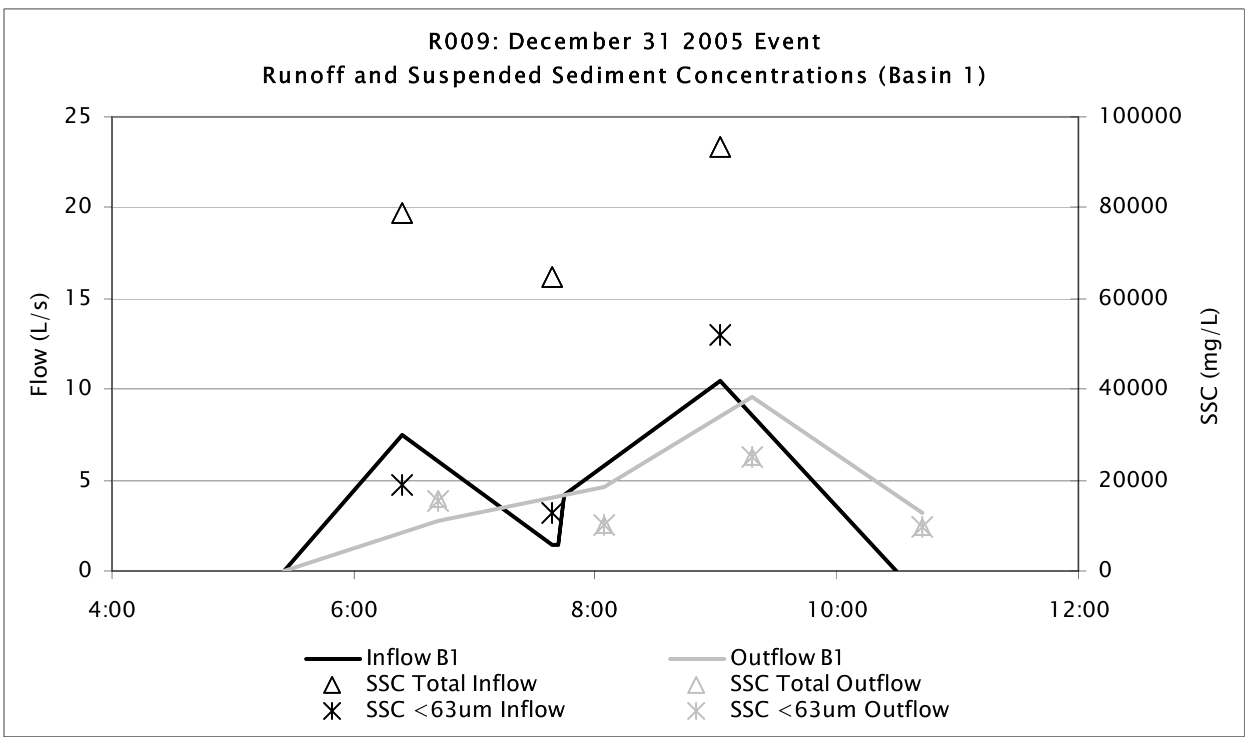


Figure 16.7. Basin 1 Inflow, Outflow, and suspended sediment concentrations during the Dec 30-31, 2005 storm event.

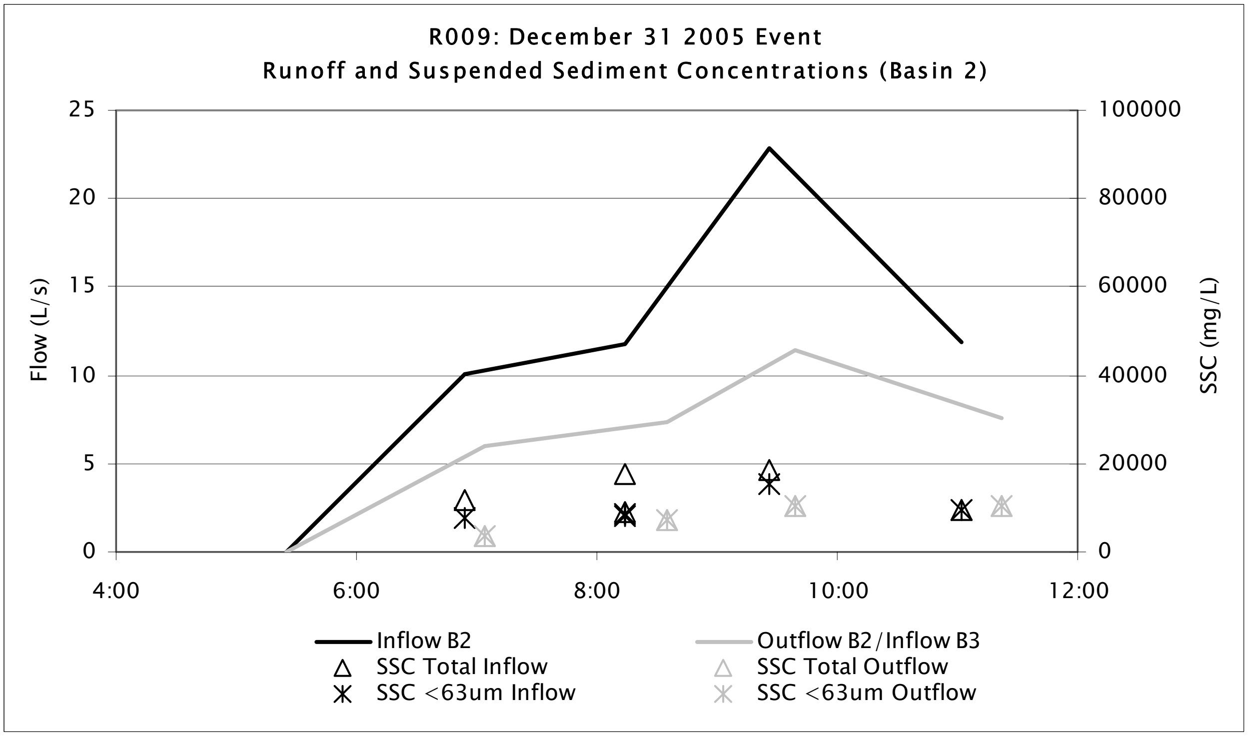


Figure 16.8. Basin 2 Inflow, Outflow, and suspended sediment concentrations during the Dec 31, 2005 storm event.

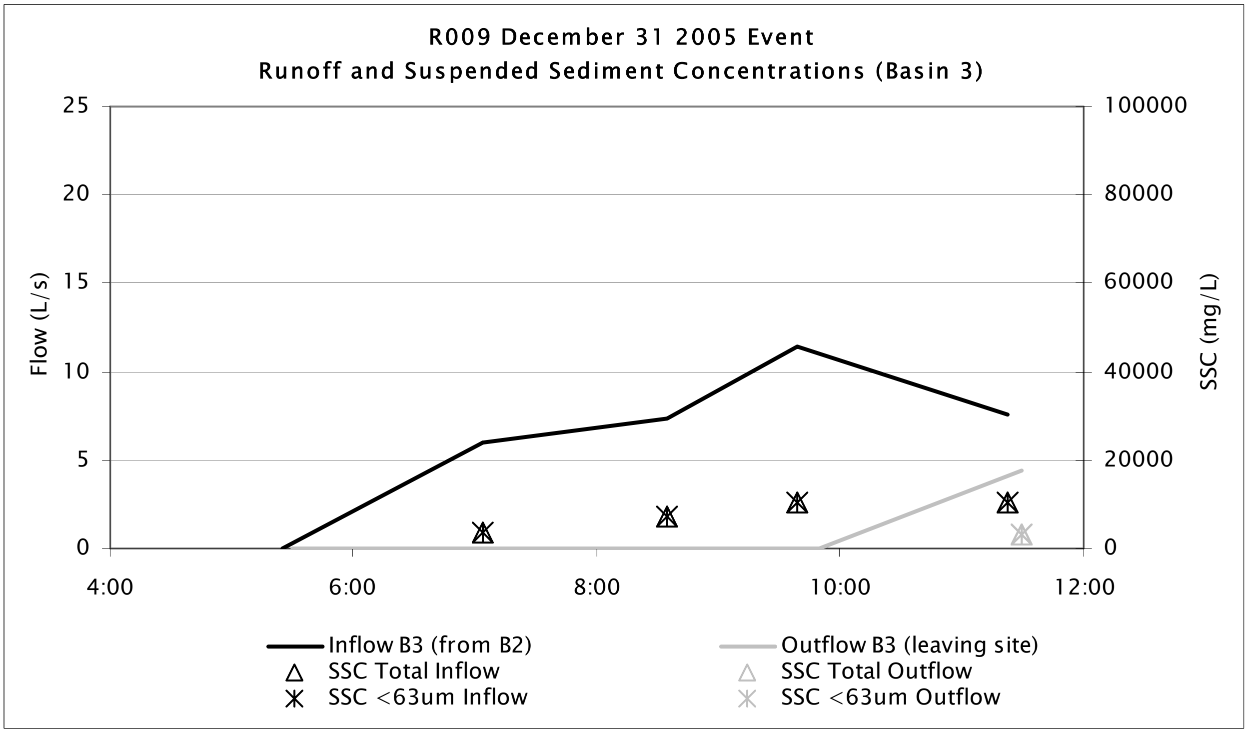


Figure 16.9. Basin 3 Inflow, Outflow, and suspended sediment concentrations during the Dec 31, 2005 storm event.

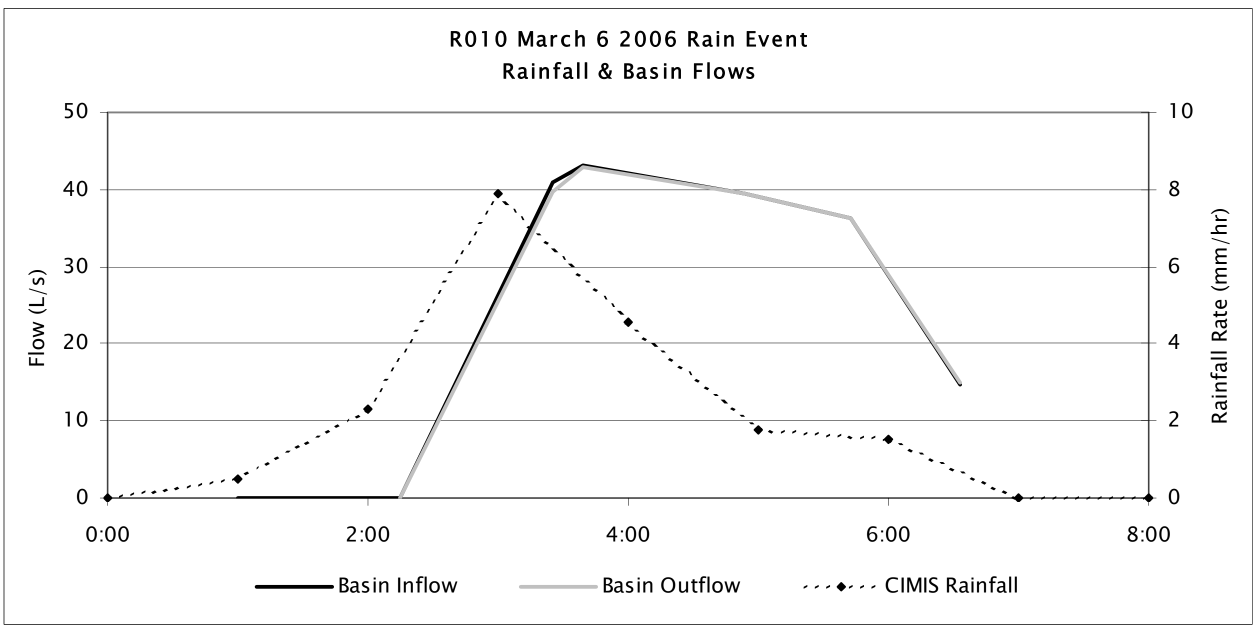


Figure 16.10. Rainfall and basin flows during the March 6, 2006 rain event.

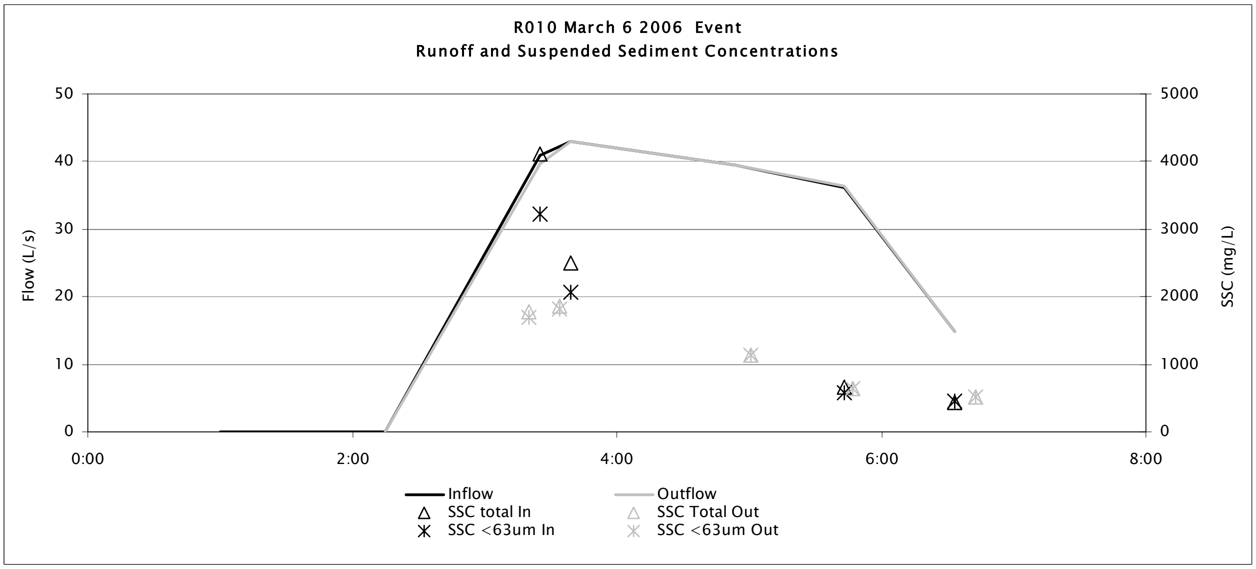


Figure 16.11. Inflow, Outflow, and suspended sediment concentrations during the March 6, 2006 storm event.

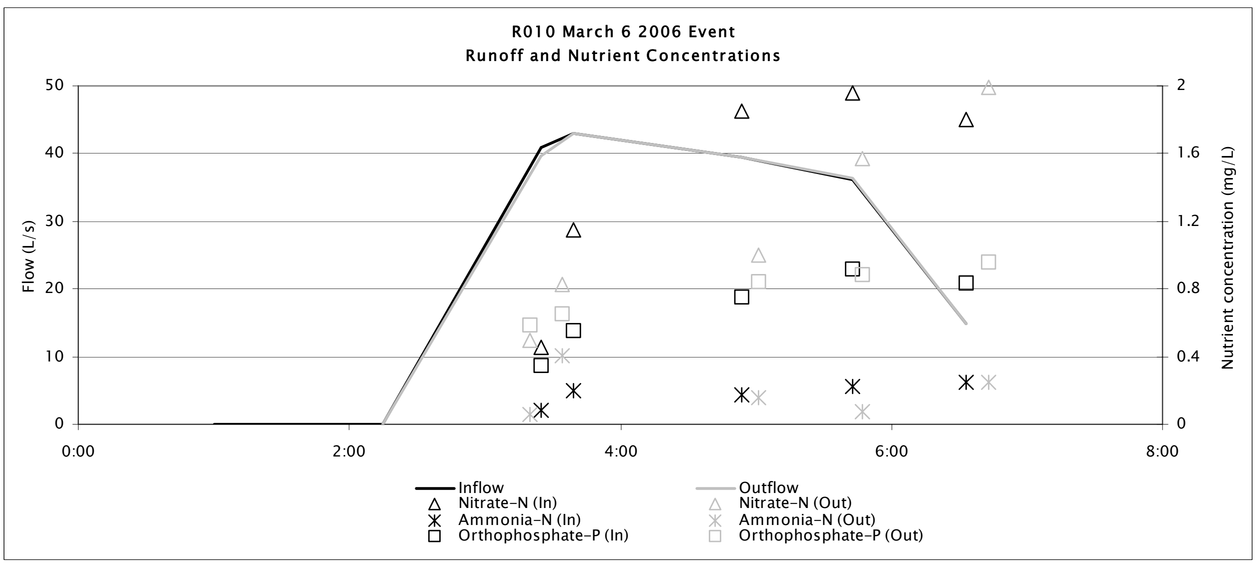


Figure 16.12. Inflow, Outflow, and nutrient concentrations during the March 6, 2006 storm event.

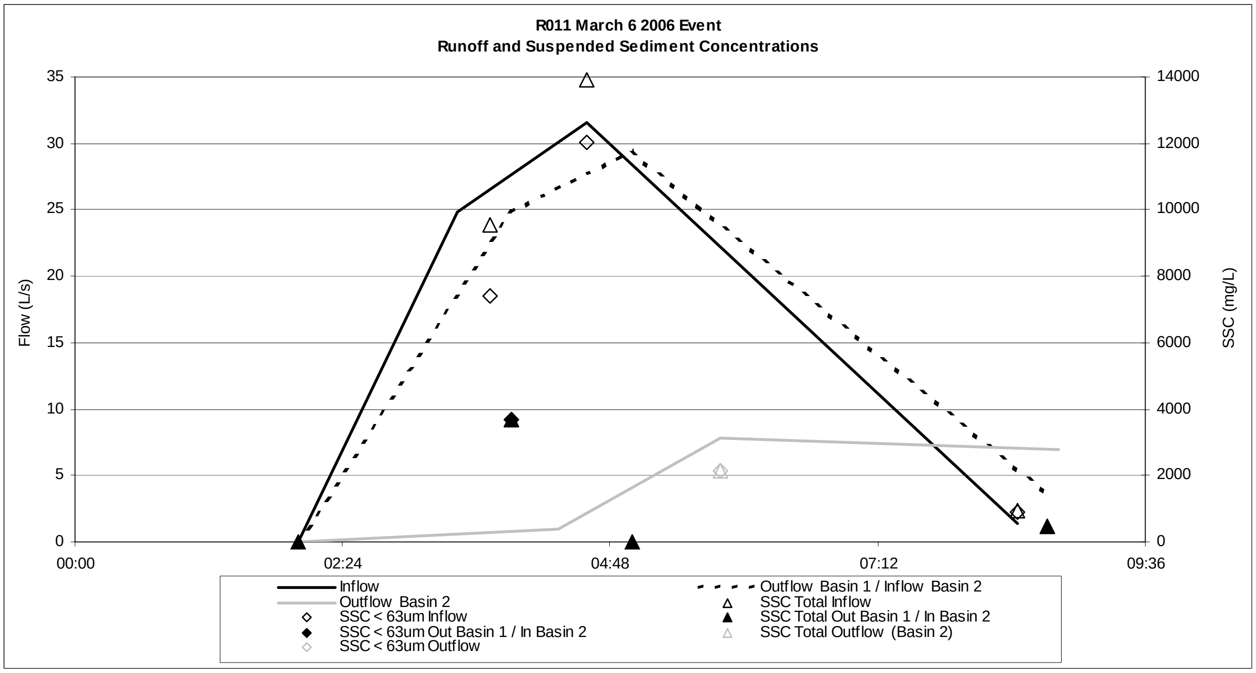


Figure 16.13. R011 3/6/2006 rain event SSC.

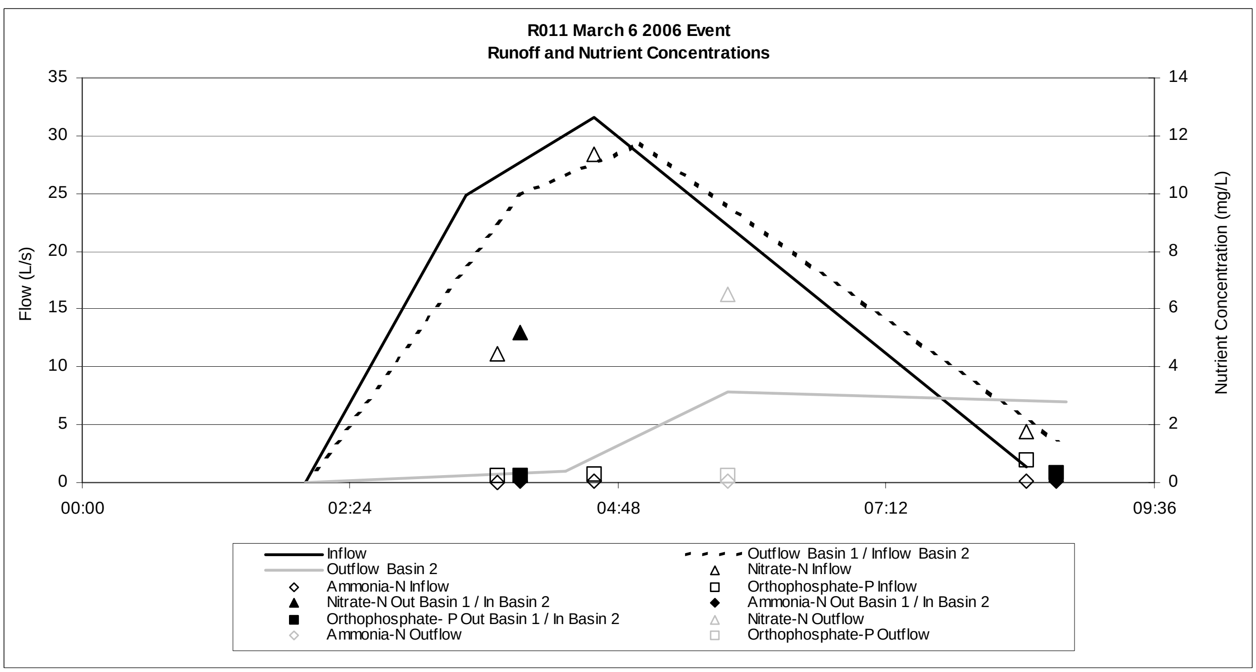


Figure 16.14. R011 3/6/2006 rain event runoff and nutrients.

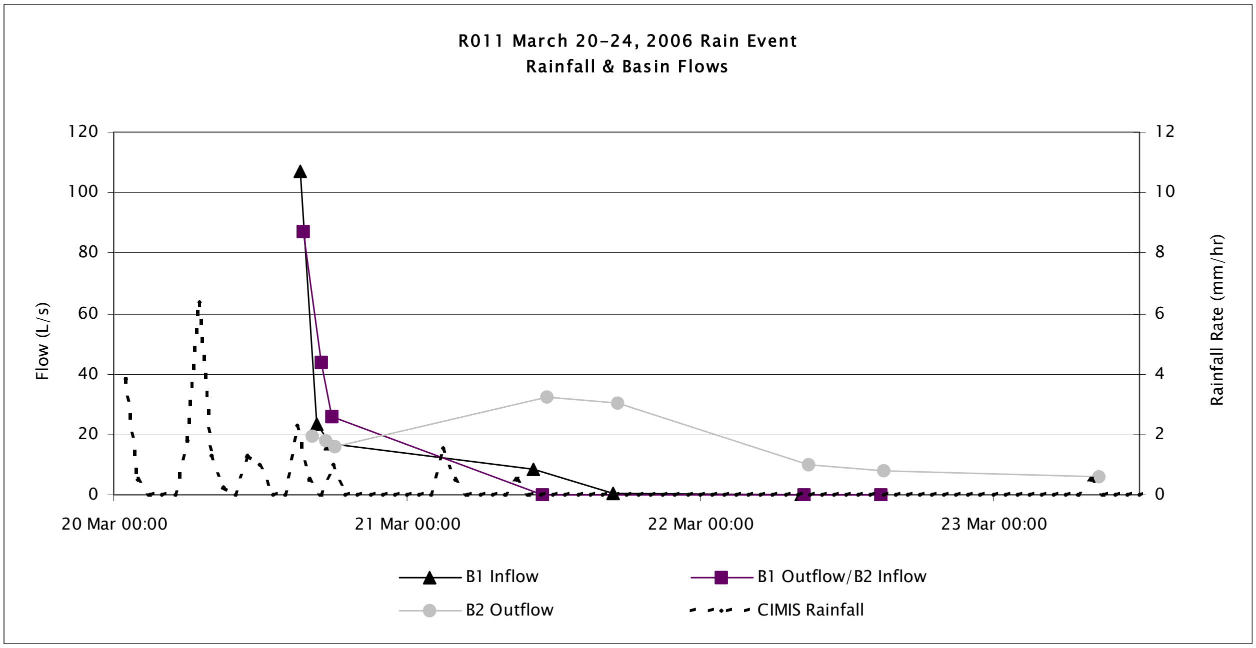


Figure 16.15. Rainfall rate and both basin flows at R011 during the March 20-24, 2006 storm event.

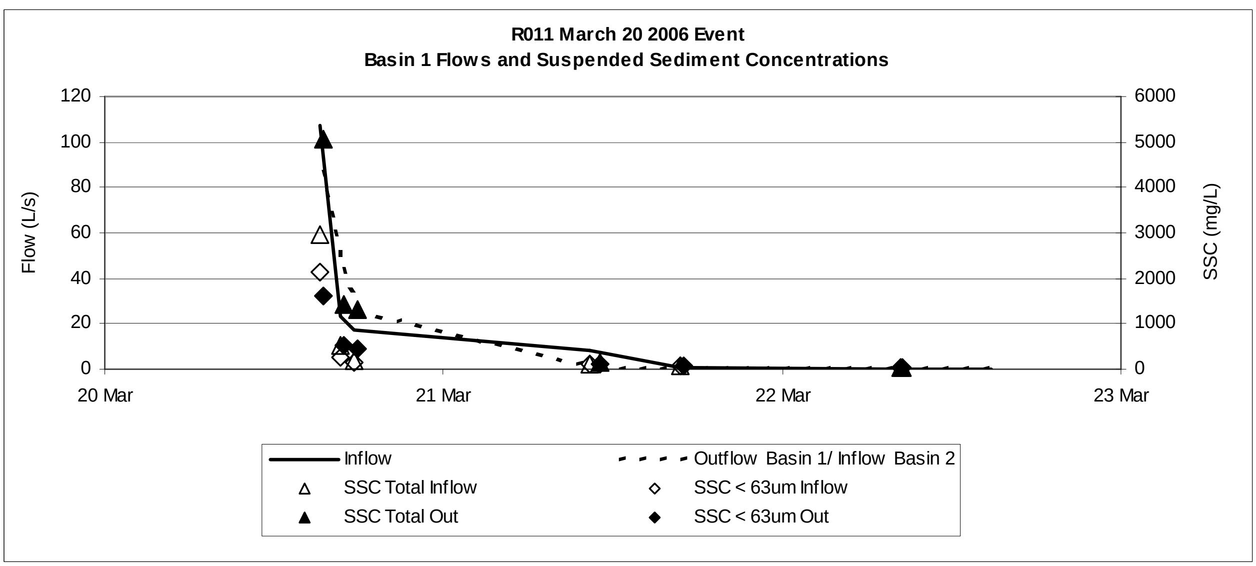


Figure 16.16. **Inflow, outflow, and suspended sediment concentrations for Basin 1 during the March 20-24, 2006 storm event.**

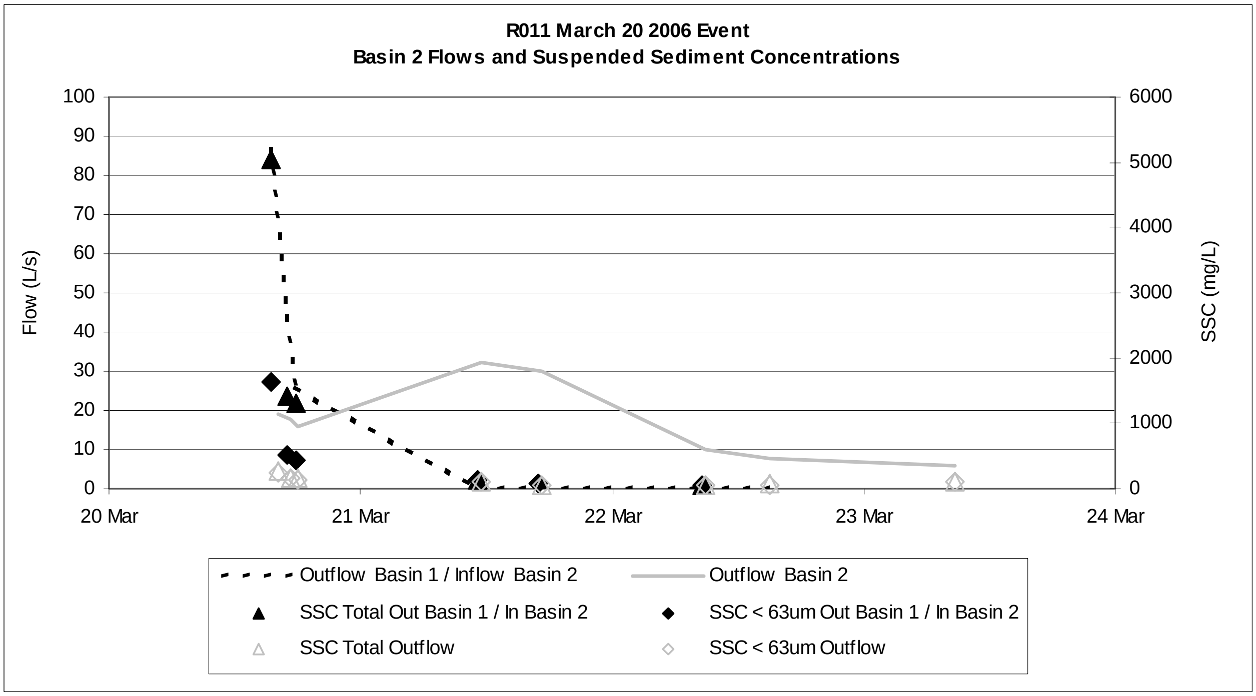


Figure 16.17. Inflow, outflow, and suspended sediment concentrations for Basin 2 during the March 20-24, 2006 storm event. Note the change in scale for flow from the previous graph.

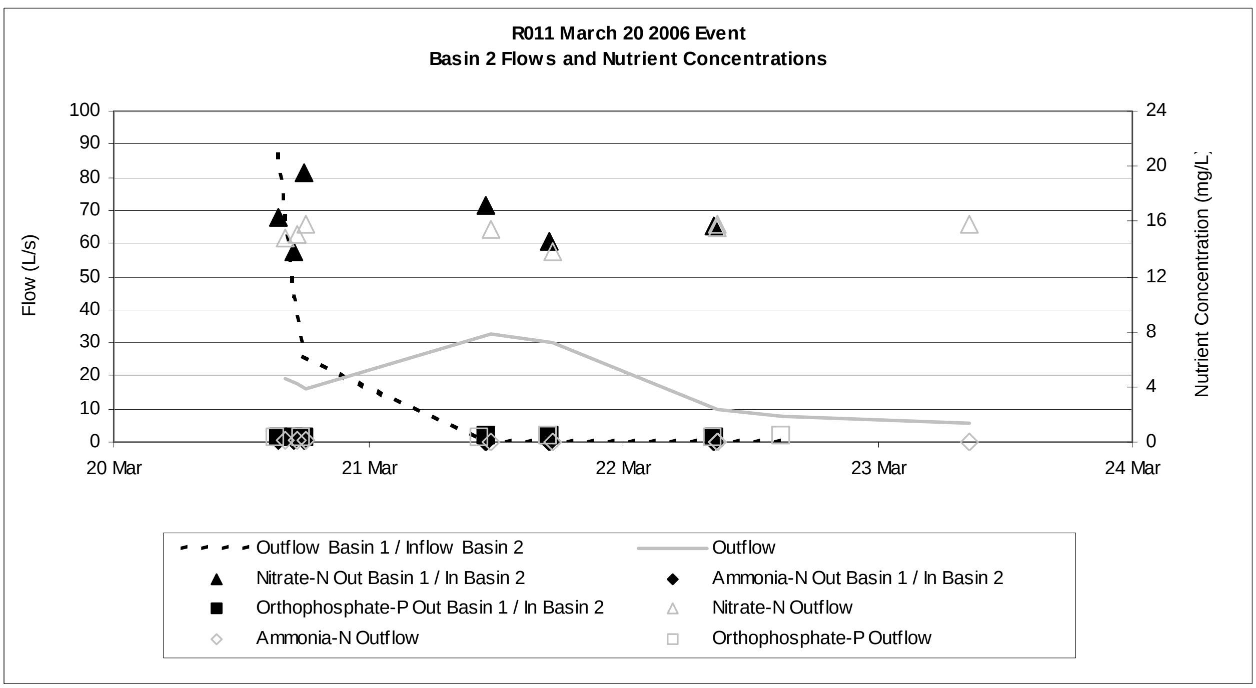


Figure 16.18. Basin 1 Flows and Suspended Sediment Concentrations.

16.4 Plant species lists for Return of the Natives

Plants out to Molera Wetland				**12/01/05-3/1/06**	
Common Name	**Latin Name**	**D-pot Trays (20 cones per tray)**	**4IN Tray (16 pots per tray)**	**1 GAL**	
Beeplant	*Scrophularia californica*			4	
Black Sage	*Salvia mellifera*			12	
California goldenrod	*Solidago californica*			16	
California sage	*Artemesia californica*			73	
Iris Leaved Grass	*Juncus xiphiodes*		6		
Juncus Species	*Juncus patens, effusus*	10		100	
Santa Barbara Sedge	*Carex barbarae*			150	
	Trays	10	6		
	No. of individual plants	*200*	*96*	*355*	***651***
					Total

Figure 16.19 Species and number planted at the Molera Wetland on 01 Dec 05 and 01 Mar 06.

Plants out to SV-014		**Feb-06**
Common Name	**Latin Name**	**Cone Trays (98 cones per tray)**
Creeping Wild Rye	*Leymus tritichoides*	5
Meadow barley	*Hordeum brachycantherum*	8
Red Fescue	*Festuca rubra*	3
	Trays	16
	No. of individual plants	***1568***
		Total

Figure 16.20 Species and number planted at site SV-14 in February 2006.

Plants out to Molera Wetland		**3/1/06 - 5/31/06**
Common Name	**Latin Name**	**1 GAL**
Beeplant	*Scrophularia californica*	50
California rose	*Rosa californica*	25
California sage	*Artemesia californica*	50
Coyote Brush	*Baccharis pilularis*	24
Mugwort	*Artemesia douglasiana*	100
Sticky Monkeyflower	*Mimulus auranticus*	16
	No. of individual plants	***265***
		Total

Figure 16.21 Species and number planted at the Molera Wetland 01 Mar 06 and 31 May 06.

Plants out to SV-09-1		5/22/06
Common Name	**Latin Name**	**1 GAL**
Black Sage	*Salvia mellifera*	39
California rose	*Rosa californica*	10
California sage	*Artemesia californica*	9
Ceanothus Species	*griseus, thyrsiflorus, Julia Phelps*	19
Coffeeberry	*Rhamnus californica*	15
Coyote Brush	*Baccharis pilularis*	14
Coyote Bush (Dwarf)	*Baccharis pilularis*	14
Gooseberry	*Ribes speciosum*	10
Lizard tail	*Eriophyllum staechadifolium*	13
Pajaro Manzanita	*Arctostaphylos pajaroensis*	10
Saltbush	*Atriplex lentiformis*	8
Sandmat Manzanita	*Arctostaphylos pumila*	4
Toyon	*Heteromoles arbutifolia*	10
	No. of individual plants	***175***
		Total

Figure 16.22 Species and number planted at site SV-09-1 on 22 May 2006.

Plants out to G-16			Jan-07	
Common Name	**Latin Name**	**1 GAL**	**5 GAL**	
Ceanothus Species	*griseus, thyrsiflorus, Julia Phelps*	35		
Coast Live Oak	*Quercus agrifolia*	100	120	
Coffeeberry	*Rhamnus californica*	250		
Coyote Brush	*Baccharis pilularis*	70	1	
Monterey Cypress	*Cupressus macrocarpa*	19		
Pajaro Manzanita	*Arctostaphylos pajaroensis*	5		
Saltbush	*Atriplex lentiformis*	25		
Toyon	*Heteromoles arbutifolia*	200		
	No. of individual plants	*704*	*121*	***825***
				Total

Figure 16.23 Species and number planted at site G-16 in January 2007.

Plants out to Molera Wetland		Feb-07
Common Name	**Latin Name**	**1g**
Beeplant	*Scrophularia californica*	13
Blue Wild Rye	*Elymus glaucus*	100
California rose	*Rosa californica*	16
California sage	*Artemesia californica*	98
Coast Buckwheat	*Eriogonum Latifolium*	25
Creeping Wild Rye	*Leymus tritichoides*	200
Dune Sedge	*Carex pansa*	26
Little leaf buckwheat	*Eriogonum parvofolium*	25
Meadow barley	*Hordeum brachycantherum*	100
Mock Heather	*Ericameria ericoides*	25
Mugwort	*Artemesia douglasiana*	100
Santa Barbara Sedge	*Carex barbarae*	50
	No. of individual plants	***778***
		Total

Figure 16.24 Species and number planted at the Molera Wetland in February 2007.

Plants out to SV-09-1		Mar-07
Common Name	**Latin Name**	**1g**
California Fuschia	*Epilobium Canum*	8
California rose	*Rosa californica*	9
Ceanothus Species	*griseus, thyrsiflorus, Julia Phelps*	10
Coast Buckwheat	*Eriogonum Latifolium*	7
Coffeeberry	*Rhamnus californica*	10
Coyote Bush (Dwarf)	*Baccharis pilularis*	5
Gooseberry	*Ribes speciosum*	8
	No. of individual plants	***57***
		Total

Figure 16.25 Species and number planted at site SV-09-1 in March 2007.

Plants out to SV-22-1 & SV-22-2		SV-22-1	SV-22-2	Mar-07
Common Name	**Latin Name**	**1g**	**1g**	
Black Sage	*Salvia mellifera*		9	
Blue Wild Rye	*Elymus glaucus*	20		
California Buckwheat	*Eriogonum fasiculatum*		9	
California rose	*Rosa californica*		9	
California sage	*Artemesia californica*		9	
Coast Buckwheat	*Eriogonum Latifolium*	30		
Coffeeberry	*Rhamnus californica*		9	
Coyote Bush (Dwarf)	*Baccharis pilularis*	30		
Creeping Wild Rye	*Leymus tritichoides*	20		
Deergrass	*Muhlenbergia rigens*	40		
Dune Sedge	*Carex pansa*	40		
Gooseberry	*Ribes speciosum*		9	
Hairgrass	*Deschampsia caespitosa*	40		
Iris Leaved Grass	*Juncus xiphiodes*	40		
Juncus Species	*Juncus patens, effusus*	40		
Lizard tail	*Eriophyllum staechadifolium*		9	
Meadow barley	*Hordeum brachycantherum*	20		
Mock Heather	*Ericameria ericoides*		9	
Pajaro Manzanita	*Arctostaphylos pajaroensis*		9	
Red Fescue	*Festuca rubra*	20		
Saltbush	*Atriplex lentiformis*		9	
Santa Barbara Sedge	*Carex barbarae*	40		
Sticky Monkeyflower	*Mimulus auranticus*		9	
Toyon	*Heteromoles arbutifolia*		9	
White yarrow	*Achillea millefolium*	20		
	No. of individual plants	*400*	*108*	***508***
				Total

Figure 16.26 Species and number planted at sites SV-22-1 & SV-22-2 in March 2007.

Plants out to Caesar Chavez Park			02-03-07	
Common Name	**Latin Name**	**1GALT**	**5GAL**	
Box Elder	*Acer negundo*		16	
California Buckeye	*Aesculus californica*		10	
Coast Live Oak	*Quercus agrifolia*	40		
Cottonwood, Black	*Populus balsamifera spp. trichocarpa*		20	
Dogwood, Creekside	*Cornus sericea*	4		
California Sycamore	*Platanus racemosa*		2	
	No. of individual plants	*44*	*48*	***92***
				Total

Figure 16.27 Species and number planted at Caesar Chavez Park on 03 Feb 2007.

Plants out to Natividad Creek Park					02/16/07	
Common Name	**Latin Name**	**CONE**	**1GAL**	**1GALT**	**5GAL**	
Black Sage	*Salvia mellifera*			1		
Blue Wild Rye	*Elymus glaucus*		20			
California Blackberry	*Rubus ursinus*		3			
California sage	*Artemesia californica*			1		
Coast Live Oak	*Quercus agrifolia*			4		
Coffeeberry	*Rhamnus californica*			8		
Coyote Bush	*Baccharis pilularis*			2		
Deergrass	*Muhlenbergia rigens*		25			
Dogwood, Creekside	*Cornus sericea*				5	
Hairgrass	*Deschampsia caespitosa*		20			
Naked Buckwheat	*Eriogonum nudum*		20			
Purple Needle Grass	*Nassella pulchra*		25			
Red Fescue	*Festuca rubra*	10				
Toyon	*Heteromoles arbutifolia*			4		
	No. of individual plants	*10*	*113*	*20*	*5*	***148***
						Total

Figure 16.28 Species and number planted at Natividad Creek Park on 16 Feb 07.

Plants out to Upper Carr Lake							2/17/07	
Common Name	**Latin Name**	**CONE**	**4IN**	**DPOT**	**1GAL**	**1GALT**	**5GAL**	
California Buckeye	*Aesculus californica*						5	
California Fuschia	*Epilobium Canum*					3		
Coast Live Oak	*Quercus agrifolia*					8		
Coffeeberry	*Rhamnus californica*					4		
Deergrass	*Muhlenbergia rigens*				25			
Dogwood, Creekside	*Cornus sericea*						5	
Hairgrass	*Deschampsia caespitosa*				25			
Iris Leaved Grass	*Juncus xiphiodes*		80					
Naked Buckwheat	*Eriogonum nudum*				20			
Purple Needle Grass	*Nassella pulchra*				25			
Red Fescue	*Festuca rubra*	39			20			
Rushes	*Juncus sp.*			40				
Santa Barbara Sedge	*Carex barbarae*				25			
Yellow Bush Lupin	*Lupinus arboreus*	10						
	No. of individual plants	*49*	*80*	*40*	*140*	*15*	*10*	***334***
								Total

Figure 16.29 Species and number planted at Upper Carr Lake on 17 Feb 07.

Plants out to Upper Carr Lake				**2/18/07**	
Common Name	**Latin Name**	**4IN**	**1GAL**	**5GAL**	
Cottonwood, Black	*Populus balsamifera spp. trichocarpa*			6	
Dogwood, Creekside	*Cornus sericea*			6	
Hairgrass	*Deschampsia caespitosa*		28		
Iris leaved grass	*Juncus xiphiodes*	96			
Meadow Barley	*Hordeum brachycantherum*		20		
Red Fescue	*Festuca rubra*		40		
	No. of individual plants	*96*	*88*	*12*	***196***
					Total

Figure 16.30 Species and number planted at Upper Carr Lake on 18 Feb 07.

Plants out to Upper Carr Lake					**03-09-07**	
Common Name	**Latin Name**	**RP**	**CONE**	**1GAL**	**5GAL**	
Beeplant	*Scrophularia californica*	10				
Box Elder	*Acer negundo*				3	
California Buckeye	*Aesculus californica*				3	
California Fuschia	*Epilobium Canum*	8				
California Poppy	*Eschscholzia californica*	2				
Coast Live Oak	*Quercus agrifolia*				2	
Coyote Bush (Dwarf)	*Baccharis pilularis*	11				
Deergrass	*Muhlenbergia rigens*		58			
Mock Heather	*Ericameria ericoides*	3				
Purple Needle Grass	*Nassella pulchra*			25		
Red Fescue	*Festuca rubra*			122		
Smallflower Melicgrass	*Melica imperfecta*			50		
Sticky Monkey Flower	*Mimulus auranticus*	11				
Yellow Bush Lupine	*Lupinus arboreus*	4				
	No. of individual plants	*49*	*58*	*197*	*8*	***312***
						Total

Figure 16.31 Species and number planted at Upper Carr Lake on 09 Mar 07.

Plants out to Upper Carr Lake					**03-10-07**	
Common Name	**Latin Name**	**CONE**	**DPOT**	**1GAL**	**5GAL**	
Cottonwood, Black	*Populus balsamifera spp. trichocarpa*				7	
Creeping Wild Rye	*Leymus tritichoides*					
Deergrass	*Muhlenbergia rigens*	5				
Purple Needle Grass	*Nassella pulchra*			15		
Red Fescue	*Festuca rubra*			19		
Rushes	*Juncus sp.*		20			
Santa Barbara Sedge	*Carex barbarae*			20		
Smallflower Melicgrass	*Melica imperfecta*			10		
	No. of individual plants	*5*	*20*	*64*	*7*	**96**
						Total

Figure 16.32 Species and number planted at Upper Carr Lake on 10 Mar 07.

16.5 Appendix – Agendas for CAFF/RCD Education and Outreach meetings and Wetland Handout

Using Vegetation to Improve Water Quality: Workshop, BBQ, and Watershed-Friendly Farming Tour

Workshops at UC Ag. Extension Auditorium
1432 Freedom Blvd., Watsonville
BBQ & Tour to begin at High Ground Organic Farms, Watsonville

Friday, November 12, 2004
9:30 AM - 4:30 PM

Workshop speakers:
Dave Moeller, Santa Cruz County Agricultural Commissioner: "Update on Laws & Regulations"
Sam Earnshaw, CAFF: "Overview of SWRCB Vegetative Conservation Practices Project"
Josh Fodor, Central Watershed Council: "Planting & Monitoring Habitat Plantings for Water Quality"
Tamara Doan, Coastal Watershed Council: "Monitoring Habitat Plantings for Water Quality"
Janet Bryer, UCSC CASFS: "Monitoring Hedgerows for Insects"
Laura Tourte, UCCE: "Cost Estimates for Planting Hedgerows"
Kaitilin Gaffney, The Ocean Conservancy: "Clean Water Land-Sea Connections"
Dawn Mathes, Coalition of Central Coast County Farm Bureaus: "Central Coast Ag Waiver Program"
Sean Swezey, UCSC CASFS: "Trap Crops in Strawberry Production Systems"
TOUR OF FOUR FARM HABITAT PLANTING SITES

Sponsored by: CAFF, SWRCB, NFWF, UC CASFS, Agricultural Land-Based Training Association (ALBA), Wild Farm Alliance, Santa Cruz County Agricultural Commissioner's Office

DPR/CCA/SWRCB Water Quality Credits Available - 6 Hours

RSVP: Sam Earnshaw (831) 722-5556

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9:30 AM - 4:30 PM

Workshop speakers:
Dave Moeller, Santa Cruz County Agricultural Commissioner: "Update on Laws & Regulations"
Sam Earnshaw, CAFF: "Overview of SWRCB Vegetative Conservation Practices Project"
Josh Fodor, Central Watershed Council: "Planting & Monitoring Habitat Plantings for Water Quality"
Tamara Doan, Coastal Watershed Council: "Monitoring Habitat Plantings for Water Quality"
Janet Bryer, UCSC CASFS: "Monitoring Hedgerows for Insects"
Laura Tourte, UCCE: "Cost Estimates for Planting Hedgerows"
Kaitilin Gaffney, The Ocean Conservancy: "Clean Water Land-Sea Connections"
Dawn Mathes, Coalition of Central Coast County Farm Bureaus: "Central Coast Ag Waiver Program"
Sean Swezey, UCSC CASFS: "Trap Crops in Strawberry Production Systems"
TOUR OF FOUR FARM HABITAT PLANTING SITES

Sponsored by: CAFF, SWRCB, NFWF, UC CASFS, Agricultural Land-Based Training Association (ALBA), Wild Farm Alliance, Santa Cruz County Agricultural Commissioner's Office

DPR/CCA/SWRCB Water Quality Credits Available - 6 Hours

RSVP: Sam Earnshaw (831) 722-5556

UNIVERSITY *of* CALIFORNIA

Agriculture & Natural Resources

Cooperative Extension • Monterey County

University of California Cooperative Extension, Monterey County and USDA

2005 Irrigation and Nutrient Management Meeting and Cover Crop Field Day

Tuesday, February 22

8:00 a.m. to 3:00 p.m.

RAIN OR SHINE

Irrigation and Nutrient Management Meeting: Monterey County Agricultural Center, 1432 Abbott Street, Salinas

8:00 ***Update on the Agricultural Waivers and UC Short Courses.***
Traci Roberts, Monterey County Farm Bureau

8:15 ***Use of Polyacrylamide (PAM) to Improve Water Quality***
Mike Cahn, Irrigation Farm Advisor, Monterey County

8:35 ***Optimizing Phosphorus Fertilization of Vegetables for Yield and Preserving Water Quality***
Richard Smith, Vegetable Crop and Weed Science Farm Advisor, Monterey County

9:00 ***Salinity Effects on Lettuce Yield***
Mike Cahn, Irrigation Farm Advisor, Monterey County

9:30 ***Impact of fumigation on soil microbiology and nutrient availability***
Husein Ajwa/Susanne Klose, Vegetable Research Program

10:00 ***Break and Travel to Field Demonstration Site***

PAM Field Demonstration: USDA Spence Vegetable Research Station, 1572 Old Stage Road

10:30 ***Polyacrylamide (PAM) Demonstration and Discussion***
Mike Cahn, Irrigation Farm Advisor, Monterey County

12:00 ***Lunch –Equipment Yard***
Pizza lunch provided by CAFF

Cover Crop Field Day:USDA Spence Vegetable Research Station, 1572 Old Stage Road

1:00 ***Specialty Crops Experiment. How do Cover Crop Seeding Rate and Variety Impact:***
-Cover Crop Biomass Production and Weeds
Eric Brennan and Nathan Boyd, USDA Organic Program, Salinas Vegetable Research Station
-Water Usage
Mike Cahn, Irrigation Farm Advisor, Monterey County
-Nitrogen Mineralization and Vegetable Crop Yield
Richard Smith, Vegetable Crop and Weed Science Farm Advisor, Monterey County

2:30 ***Hedge Row Planting Demonstration***
Sam Earnshaw, Community Alliance with Family Farmers

3:00 ***Conclusion***

Sponsors: University of California Cooperative Extension; United States Department of Agriculture; and Community Alliance with Family Farmers (CAFF)

1432 Abbott Street
Salinas, CA 93901

phone 831.759.7350
fax 831.758.3018
4-H 831.759.7360

email:
cemonterey@ucdavis.edu
website:
cemonterey.ucdavis.edu

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University of California and U.S. Department of Agriculture cooperating.

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2006 Irrigation and Nutrient Management Meeting and Cover Crop and Water Quality Field Day

Tuesday, February 21

7:45 a.m. to 3:00 p.m.

RAIN OR SHINE

Irrigation and Nutrient Management Meeting: Monterey County Agricultural Center, 1432 Abbott Street, Salinas

7:45 **Registration and Refreshements**

8:00 ***Phosphorus Fertilizer Form, Rate and Application Timing Studies on Romaine***
Richard Smith, Vegetable Crop and Weed Science Farm Advisor, Monterey County

8:20 ***Studies on the use of Polyacrylamide (PAM) to Reduce Sediment Loss from Production Fields***
Mike Cahn, Irrigation Farm Advisor, Monterey County

8:40 ***Plant Nutritional Studies on Caneberries***
Mark Bolda, Strawberry and Caneberry Farm Advisor, Santa Cruz County

9:00 ***What tissue testing can (and cannot) tell you about soil nutrient status***
Tim Hartz, Extension Vegetable Specialist, UC, Davis

9:30 ***Stopping Seawater Intrusion in the Pajaro Valley***
Charlie McNiesh, Pajaro Valley Water Management Agency

10:00 ***Break and Travel to Field Demonstration Site***

Cultural Practices to Reduce Sediment Loss: Cover Crop, Furrow Dike and PAM Field Demonstration: USDA Spence Vegetable Research Station, 1572 Old Stage Road

10:30 ***Impact of Cultural Practices on Winter Runoff***
Mike Cahn, Richard Smith and Tim Hartz, University of California Cooperative Extension

12:00 ***Lunch –Equipment Yard***
Pizza lunch provided by CAFF

Cover Crop Field Day:USDA Spence Vegetable Research Station, 1572 Old Stage Road

1:00 ***Long-term Effect of Cover Crops on Yield of Vegetables; and Nematodes as Indicators of Soil Health***
Eric Brennan, USDA Organic Program, Salinas Vegetable Research Station
Howard Ferris, Nematology Professor, Dept. of Nematology, UC, Davis

2:30 ***Vegetation Conservation Practices: Hedgerows and Grassed Waterways***
Sam Earnshaw, Community Alliance with Family Farmers

3:00 ***Conclusion***

* **Sponsors:** University of California Cooperative Extension; United States Department of Agriculture (USDA); Community Alliance with Family Farmers (CAFF); and Agriculture and Land-Based Training Association (ALBA)
* **Continuing Education, Certified Crop Advisor and Water Quality Credits have been requested**
* **Spanish translation will be available**
* **For more information call Michael Cahn 759-7377 or Richard Smith 759-7357**

1432 Abbott Street
Salinas, CA 93901

phone 831.759.7350
fax 831.758.3018
4-H 831.759.7360

email:
cemonterey@ucdavis.edu
website:
cemonterey.ucdavis.edu

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2007 Irrigation and Nutrient Management Meeting and Cover Crop and Water Quality Field Day

Tuesday, February 20

7:45 a.m. to 3:00 p.m.

RAIN OR SHINE

Irrigation and Nutrient Management Meeting: Monterey County Agricultural Center, 1432 Abbott Street, Salinas

7:45	**Registration and Refreshments**
8:00	***Drip Germination of Lettuce*** Mike Cahn, Irrigation Farm Advisor, Monterey County
8:30	***Release of Nitrogen from Compost & Cover Crops and Their Impact on Broccoli Fertility*** Joji Muramoto, Research Scientist, UCSC Richard Smith, Vegetable Crop and Weed Science Farm Advisor, Monterey County
9:00	***Phosphorus Transformation in Soil*** Husein Ajwa, Extension Specialist in Soil and Water Management, UC, Davis
9:30	***Tipburn in lettuce: nutritional and varietal studies*** Tim Hartz, Extension Vegetable Specialist, UC, Davis
10:00	Break
10:30	***Water Quality Effects on Food Safety in Vegetable Production*** Trevor Suslow, Extension Specialist in Microbial Food Safety, UC, Davis
11:00	***Pyrethroid Runoff Issues in the Salinas Valley*** Don Weston, Professor of Integrative Biology, UC, Berkeley
11:30	***Impact of Cover Crops: Results from a Long-Term Study*** Eric Brennan, USDA Organic Program, Salinas Vegetable Research Station

Cultural Practice Demonstration and Discussion on How to Control Storm Water Runoff and Sediment Loss
USDA Spence Vegetable Research Station, 1572 Old Stage Road

12:30	***Lunch –Equipment Yard*** Pizza lunch provided by CAFF
1:15	***Field Demonstration and Discussion*** ***Identifying Storm Runoff Control Practices for the Salinas Valley:*** ***Cover Crops, Furrow Dike, Hedge Rows, Filter Strips, Vegetated Roads, Sediment Traps and Basins*** Mike Cahn, Mark Bolda and Richard Smith, University of California Cooperative Extension; Sam Earnshaw, Community Alliance with Family Farmers; and NRCS, TBA
2:30	***Conclusion***

* **Sponsors:** University of California Cooperative Extension; United States Department of Agriculture (USDA); Community Alliance with Family Farmers (CAFF); and Agriculture and Land-Based Training Association (ALBA)
* **Continuing Education, Certified Crop Advisor and Water Quality Credits have been requested**
* **For more information call Michael Cahn 759-7377 or Richard Smith 759-7357**

Post Workshop Tour
Tembladero Wetlands Demostration Site
3:30 to 5:00 Call Sam Earnshaw 831-722-5556

1432 Abbott Street
Salinas, CA 93901

phone 831.759.7350
fax 831.758.3018
4-H 831.759.7360

email:
cemonterey@ucdavis.edu
website:

Tembladero Wetland Demonstration Site

What is it?
Located at the corner of Molera Road and Dunes Colony Way near Castroville, this wetland system is composed of two sections. The top section (1.65 acres) is a 1000 ft long, 20 ft wide sinuous channel populated by emergent wetland plants and separated by vegetated berms. The lower section (1.45 acres) is a marsh wetland that is intermittently flooded by the adjacent Old Salinas River Channel and Tembladero Slough. The system was constructed to both provide a location to conduct applied research on freshwater coastal wetlands and to enhance native plant and wildlife habitat.

What's the big idea?
The quality of water flowing as runoff from the Old Salinas River Channel, Elkhorn, Moro Cojo and Tembladero Slough negatively impacts the ecology of Moss Landing Harbor and the Monterey Bay. High levels of sediment, nutrient and pesticide constituents are found in these water bodies especially following winter flooding events. Scientific literature suggests that water quality can be considerably improved by exposing contaminated water to freshwater wetland systems. This demonstration site is being used to document changes in nutrient and pesticide levels in water from the Tembladero Slough as it passes through the wetland system. The results of these small-scale experiments can be used to model solutions to these water quality issues across the entire Salinas Valley.

Agriculture and development occupy the vast majority of the Salinas Valley that was historically freshwater wetland. Plants, birds and animals that once used these wetlands are faced with diminishing quality and quantity of habitat. This project is intended to use native plant species to create a small amount of high quality freshwater habitat and to serve as a demonstration for future habitat restoration projects that can co-exist with agricultural production within the Valley.

What are some of the water quality research questions being answered on the site?
How do changes in nutrient and pesticide levels in water passing through the wetland system differ from changes in water flowing through Tembladero Slough? Do the changes in water quality affect the toxicity of the water to aquatic bugs?

If there is a filtering effect to the water passing through this wetland system, how many similar systems would need to be created to have a significant impact on water quality entering Monterey Bay through the Moss Landing Harbor?

Who is involved? The project is a collaboration between Moss Landing Marine Laboratories, California State University Monterey Bay, Resource Conservation District of Monterey County, Community Alliance with Family Farmers and the Monterey County Water Resources Agency. The project is funded by the California State Water Resources Control Board.

For further information contact: Adam Wiskind, Project Director Moss Landing Marine Laboratories (831) 771-4495

February 2006

16.6 Appendix – RON results of teacher surveys.

Return of the Natives Restoration Education Project
Greenhouse Growing Project

Oral Interviews conducted by Emily Smith and Laura Lee Lienk, Watershed Institute, CSU Monterey Bay. Six (6) of thirteen (13) schools engaged in school Greenhouse Growing Project interviewed March 1 and 2, 2007.

Question #1: How do you see working with the RON greenhouse growing program as meeting state educational standards? How do you facilitate standards integration into the greenhouse program?

Teacher A. Resource Teacher—I don't have the standards in front of me at present so can't quote exactly. Fourth grade—contributions of Native Americans. Then she went on to talk about how they are a NCLB Program Improvement School and that she sees the greenhouse as a means for "bringing science into reading and language acquisition" programs. Even though the school has science equipment there is no time to set up science labs so the greenhouse growing program is that lab.
Teacher B. Grade 2. Standards around life cycles and adaptations. How does she do it. She reviews the standards and sets up goals and objectives for the students when they work in the greenhouse growing program. Then she summarizes at the end of the lesson.
Teacher C. Grade 5. Can't say standards from the top of her head. Greenhouse growing program reinforces what is done in the classroom. She feels that there is a correlation with 5th grade standards.
Teacher D. Grade 2. Feels greenhouse growing program meets state standards. She does reading and writing around the program. Read about plants. Wrote thank you letters. Learning English met 7 standards especially around sequencing.
Teacher E. Grade 4-5-6 Science. Teachers love doing this. A big emphasis in 6th grade.
4th/5th grade native plants connect to lessons.
Teacher F. Grade 3 Good social studies connections. Native peoples and native plants.

Analysis: All agreed that standards are important. All seemed able to make the standards connections—especially around language arts and social studies.

Question #2: Is there anything besides meeting standards that motivates you to become involved in the RON greenhouse growing program?

Teacher A. Service to community. More pride and connection with rest of community. Aesthetics-making life more pleasant. Sustainable project.

Teacher B. Lots of things, Kid buy in. They are an eager audience when they have something to nurture. Concrete involvement. Exciting to follow the life of something. Not a quick fix like a video or an ice cream cone-sustained project—good for kids. Connects to life around them. Can do growing projects at home.
Teacher C. Expand contact with natural world. She feels that getting kids into natural settings, ie., Ft. Ord Backcountry is important.
Teacher D. And hands-on activities. Kids loved planting. Connects them with earth and their world in a really meaningful way.
Teacher E. Hands on gives more meaning.
Teacher F. He lives in the community. Mission is for students to become stewards of the land near his school (BLM lands)

Analysis: Importance placed on hands-on experience and on meaningful community service even though the results are long-term and not immediate.

Question #3: What do your students gain in terms of science understanding

Teacher A. Littlest kids—5 senses and insects.
Food Chains, sun/shade.
An opportunity for open-ended research projects.
Teacher B: Plant needs. Life Cycles. Adaptations. Camouflage. Habitats. Weather.
Teacher C. Habitat. Food Chains. Watersystems
Teacher D. They are not allowed to teach science—reading, writing and English only. She sees science as a motivator to learn English. Plant life cycle.
Teacher E. Students don't realize that they are doing science when in greenhouse. Students ask: Why are we calling some grasses a weed and others we are planting? Why here? Why are we tossing others out?
Teacher F. Growth cycle of plants. Stewards of the land. Play in dirt in a professional way. Apply what they learn about native plants to veggies. Promoting gardening and the aesthetics of gardening.

Analysis: Life (growth) cycles of plants important, weather. Garden also place for observations and open-ended questions.

Question #4 What other watershed related lessons do you do?

Teacher A. The resource teacher—she says that it depends on the interest and background of the teachers.
Teacher B. Many of her language arts lessons are around the greenhouse.
Teacher C. She team teaches with other teachers who teach about watersheds.

Teacher D. Not these days—in the past she taught about water cycle
Teacher E. About invasive plants. She mentions an invasive plant “bean” activity about population explosions.
Teacher F. Rivers, lakes, landforms—these are social studies standards. Use of water. Says that other 3rd grade teachers talk about water cycle and the environment.

Analysis: In spite of RON staff being in the classrooms several times per year, and these classes having the opportunity to go on field trips to restoration projects (not necessarily from the Prop 13 funded project) that these teachers are not teaching science lessons to their students.

Question #5: What other plant related lessons do you do with your children?

Teacher A. Food chains, hummingbird gardens, sensory gardens
Teacher B. Growing in the classroom. Reads science books. Schoolyard observation.
Teacher C. Not much. She has gone to the garden 2x
Teacher D. Wait until big tests are done. Gardening in May. Growing grass for Easter. Math measuring and graphs
Teacher E. Invasive plant eradication message to community of parents. She sends flyers home to the parents—ie., about French broom and pampas grass.
Teacher F. Trips to San Lorenzo County Park-King City. Video on how water gets to us in California. Farming History and methods. Grown bean sprouts on paper towel. Plant growth chart. Changing light bulb (blue or green) experiments.

Analysis: It is evident that the teachers queried for the most part are involved in doing other plant (and perhaps ecology) lessons, projects or activities with their students.

Summary analysis: From all these questions, it might be generalized that the teachers are involved in the greenhouse growing project not for how the project focuses on the required standards, but more from the hands-on service experience their students receive.

Miscellaneous Comments:
Teacher A. Doing grant proposal around greenhouse/garden
Teacher B. Help is needed for teachers to share the burden of the kids going outside. She also thought that a simple binder of standards-based language arts lessons for teachers to use around the greenhouse would be great.
Teacher C. Adults did the watering in greenhouse at Kamman School. After the planting she did not take her kids there again. She needs greenhouse management skills. She feels overwhelmed.
Teacher D. Tied in trip to Carmel Lagoon with story about Lagoon.
Teacher E. Hands-on students get it much better.