Implementation of the Moro Cojo Slough Management and Enhancement Plan: Restoration of the Core of the Watershed

PROPOSITION 13 COASTAL NONPOINT SOURCE CONTROL GRANT PROGRAM
GRANT AGREEMENT BETWEEN THE
STATE WATER RESOURCES CONTROL BOARD
AND
COASTAL CONSERVATION AND RESEARCH, INC.

I. TITLE PAGE

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PROJECT NAME: Implementation of the Moro Cojo Slough Management and Enhancement Plan: Restoration of the Core of the Watershed

AGREEMENT NO. : 04-140-533-01

Date: 3/28/08

II. PREFACE

Funding for this project has been provided in full or in part through the agreement number 04-140-553-01 with the State Water Resources Control Board pursuant to the Coastal 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 State Water Resources Control Board, nor does mention of the trade names or commercial products constitute endorsements or recommendations for use.

This project was completed as a collaboration between Coastal Conservation and Research and Moss Landing Marine Laboratories. Instrumental logistical and financial support was provided by the Elkhorn Slough Foundation and National Estuarine Reserve.

IIII. GRANT SUMMARY FORM

1.	**Grant Agreement Number:** 04-140-553-01
2.	**Project Title:** Implementation of the Moro Cojo Slough Management and Enhancment Plan: Restoration of the Core of the Watershed
3.	**Project Purpose – Problem Being Addressed:** Our project is to continue to work on overarching goals of the Moro Cojo Slough Management and Enhancement Plan, the Northern Salinas Valley Watershed Restoration Plan, and the Central Coast Regional Toxic Hot Spot Cleanup Plan for Moss Landing Harbor. We will work towards the continued restoration of the existing 300 acres and initiating restoration of additional areas within the Moro Cojo and lower Castroville Sloughs. The restoration of freshwater wetlands is a prescribed Best Management Practice (BMP) by the EPA and outlined in the State's Nonpoint Source Plan as one of the adopted 61 Management Measures. Similarly, the restoration of wetland corridors has been embraced by the Central Coast Regional Water Quality Control Board and documented to significantly improve water quality that has been compromised by numerous nonpoint source pollutants from various land uses. This project will involve the further restoration of multiple sites where restoration has already begun, and the restoration of an additional 200-acres of the Moro Cojo and Castroville Slough watersheds. The project will also involve the restoration of wetlands, riparian corridors, and adjacent upland habitat. This will connect the middle and lower reaches of the Moro Cojo Slough watershed. This wetland corridor will be restored with the primary objectives of improving water quality and obtaining the beneficial uses prescribed for the watershed.
4.	**Project Goals** a. **Short-term Goals:** Plan development, implementation, and monitoring.
	b. **Long-term Goals:** Improved water quality and the restoration of wetland and adjacent habitats for native flora and fauna.
5.	**Project Location:** (lat/longs, watershed, etc.) Moro Cojo Watershed in Monterey County.
	a. **Physical Size of Project:** (miles, acres, sq. ft., etc.) Approximately 500 acres
	b. **Counties Included in the Project:** Monterey
	c. **Legislative Districts:** (Assembly and Senate) Assembly District 27. Senate District 15.
6.	**Which SWRCB program is funding this grant?** Please "X" box that applies. ☒ Prop 13 ☐ Prop 40 ☐ Prop 50 ☐ EPA 319(h) ☐ Other

Grant Contact: Refers to Grant Project Director.

Name: Melanie Gideon **Job Title:** Project Director

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Grant Time Frame: Refers to the implementation period of the grant.

From: July 1, 2004 **To:** March 31, 2008

Project Partner Information: Name all agencies/groups involved with project.

Coastal Conservation and Research, Moss Landing Marine Laboratories

Nutrient and Sediment Load Reduction Projection: (If applicable) We project a reduction in nutrient loads as a direct result of this project.

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V. EXECUTIVE SUMMARY

Water quality and beneficial uses of water courses in California are impacted by nutrients, pesticides, and sediments. As a result, watershed functions that serve to maintain high water quality and wildlife - by filtering pollutants, recharging aquifers, providing flood storage capacity, and habitat have been disrupted. Restoration and enhancement of the core (i.e. main tributary) of the watershed is arguably one of the most technically and scientifically sound for solving many of these problems. This report discusses restoration and monitoring efforts within the Moro Cojo Slough between 2004 and 2008 to address these issues.

1. This project contained the following elements:
    a. Restoration and protection of wetland and upland habitats within the Moro Cojo Watershed.
    b. Monitoring of flora and fauna.
    c. Monitoring of water quality.
    d. Education and outreach.

2. Results are summarized as follows:
    a. Restoration and protection
        i. Work was conducted throughout the Moro Cojo Watershed.
            1. Six ponds and channels were created and encompass approximately 6 acres of open water habitat.
            2. Two ditches were decommissioned.
            3. Water was diverted from Castroville Slough onto the Middle Moro Cojo site flooding approximately 20 acres of the Middle Moro Cojo Site. Flooding will occur primarily

in the winter months when flows from Castroville Slough are high.

4. Approximately 0.5 miles of the Moro Cojo was fenced off from cattle.
5. Wetland and upland vegetation was planted or drill seeded over approximately 12 acres.
6. Work was conducted with local landowners to ensure preservation of natural habitats.

b. Water Quality Monitoring

i. Water quality varies dramatically throughout the Moro Cojo Watershed. We detected ranges of nitrate concentration from o mg/L to 90 mg/L.

ii. Wetlands were very successful in reducing nitrates; results for ammonia, phosphate, and selected pesticides varied. Nitrate levels adjacent to the farm edge at the Middle Moro Cojo site averaged approximately 60 mg/L where as nitrate concentrations at the sampling site furthest from the farm edge at the Middle Site averaged approximately 4 mg/L (Appendix 8).

iii. Concentrations of nutrients varied greatly at all temporal periods measured (hours, days, and months). Results from monitoring clearly indicate that variation in nutrient levels (see appendices 7-27). This has implications for ambient monitoring programs in that programs that consist of relatively few sample periods over time can miss episodic events Our data from the main Moro Cojo channel, in which we collected 1000's of samples approximately 45 times per day over several months, highlight the variation in nitrate concentrations over time (Appendices 19-27).

iv. Agricultural runoff that ran through wetland habitats (created and natural) revealed greatly reduced levels of nitrate (see Figure 5 and Appendices 7-8). These results suggest that wetlands can function as Best Management Practices to reduce nitrate loads.

c. Flora and Fauna

   i. Restored and protected habitats support native flora and fauna. Greater than forty native plant species and twenty two native vertebrates were observed throughout the project sites.

   ii. The following protected species were documented throughout the Moro Cojo Watershed: California Red-legged Frog, California Tiger Salamander, Steelhead, Santa Cruz Long-toed Salamander, Tidewater Goby, and Saline Clover.

d. Education and Outreach

   i. Elementary through graduate level students were involved in educational tours, class projects, and restoration efforts. A watershed worksheet and curriculum was developed using Moro Cojo water quality data (see Appendices 63-64). Over 30 tours to restoration sites were given to numerous private and public groups (see Table 3). No signage or kiosks were created during our project. The original Moro Cojo Slough Management and Enhancement plan does call for public paths; however, access issues through private property and liability concerns are currently hampering these efforts.

   ii. Over 30 tours to restoration sites were given to numerous private and public groups (see Table 3).

VI. CONTRACT SECTION 2.8: A-J

Section 2.8 A: Purpose and Background

Project Purpose and Background

The Elkhorn Slough Foundation, Monterey County Agricultural & Historic Land Conservancy, and several private landowners are dedicated to restoring, enhancing, and protecting natural habitats within the Moro Cojo Slough watershed (Figure 1). Properties within the Moro Cojo Watershed have varied histories, but all have been subject to farming, grazing, diking, or other anthropogenic impacts for the last century or more. As such, their habitat value has been substantially degraded. The Moro Cojo Slough has been identified as an impaired water body and is listed as such on the current California 303d list. The Central Coast Regional Toxic Hot Spot Cleanup Plan (1998) identifies Moro Cojo Slough and its tributaries (Castroville Slough) as an important source of sediments and pesticides to Moss Landing Harbor, which is a State listed Toxic Hot Spot. The Toxic Hot Spot Plan Assessment of Actions required to remedy and restore Moss Landing Harbor identifies restoration of the floodplains as a means for reducing associated runoff into the Harbor.

This project directly targets several environmental and water quality problems identified in the Moro Cojo Slough Management and Enhancement (Lyons and Gilchrist, 1996), Northern Salinas Valley Watershed Restoration (Watershed Institute, 1996), and the Central Coast Regional Toxic Hot Spot Cleanup Plans (Water Quality Control Board, 1998) by implementing measures that address the primary goals and objectives of these plans. Enhancement and restoration of wetlands, floodplains, and adjacent upland habitats of the Moro Cojo increase biological resource values and reduce impacts of human activities on wetland resources (particularly those that affect water quality and loss of wetland habitats). Furthermore, this project demonstrates use and advantages of Best Management Practices (BMPs) for the watershed, while providing natural resource interpretation, educational, and research benefits.

Project Scope and Goals

Specific actions implemented by this project include the enhancement, restoration, and protection of 350 – 600 acres of wetlands, floodplains, and adjacent upland habitats. These actions will increase biological resources and will reduce the human impacts on wetland resources. This project will demonstrate the use and advantages of Best Management Practices (BMPs) to reduce nutrient inputs and restore and enhance natural habitats. This project will also establish important baseline data on water quality and flora and fauna throughout the watershed as well as provide educational opportunities to students and the general public.

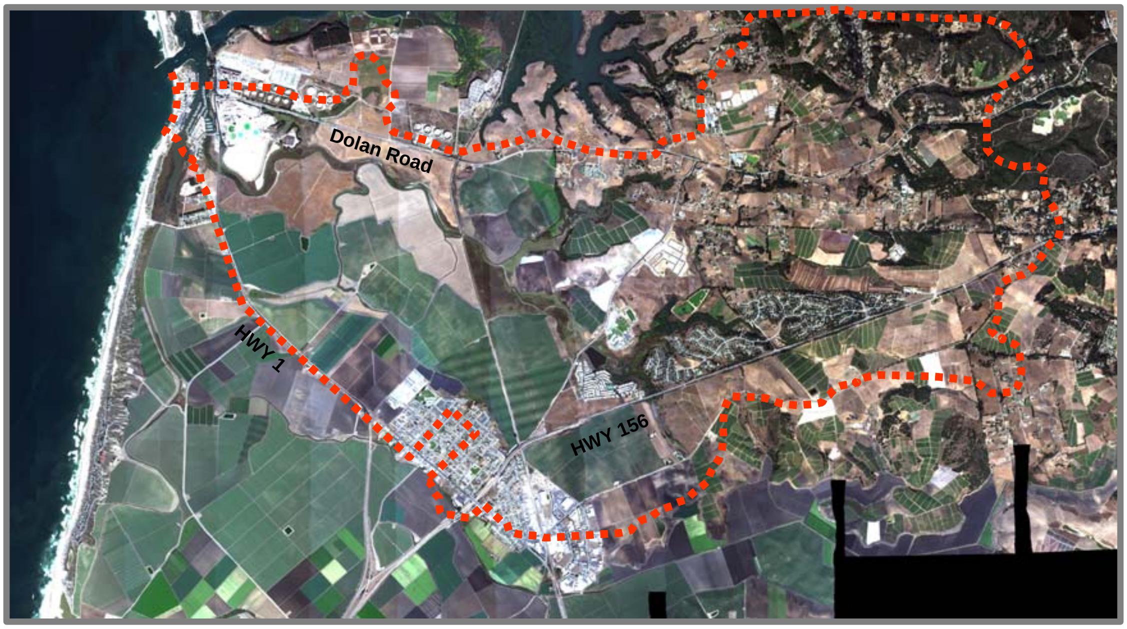


Figure 1. Overview of the Moro Cojo Watershed**.**

Section 2.8 B: Monitoring and Management Work

This section of the report contains information that is relevant to the project and highlights information contained in the report.

Contaminants, including nutrients, pesticides, and heavy metals, enter our rivers and streams from urban, agricultural, and industrial sources. Contaminants can arise from point (direct input) or non-point (input from run-off) sources. These contaminants often have adverse water quality affects in the rivers and streams themselves, as well as in coastal waters where the rivers empty. Restoration of wetland habitat around waterways can help to filter contaminants through abiotic and biotic processes. Excess nutrients can be removed via plant and algal uptake or bacterial fixation. Pesticides and metals can be taken up by vegetation, settle into the sediment, or undergo photodegredation. Through these processes, wetland habitat can help maintain water quality in our watersheds**.**

This section documents the monitoring and management practices implemented during our project. Rather than use USGS 7.5-minute quadrangle maps for our mapping figures we used digitized aerial images and have included graphics with corresponding coordinates. Each implementation measure (i.e. water sampling point, bird survey point, restoration area, etc.) has a unique symbol with corresponding coordinate data in tabular format. This system provides a precise method for the documenting the localities of the various project sites, implementation measures, and sampling points that will enable others to return to localities to monitor long-term changes. We have isolated general tasks (i.e. restoration, water, quality, etc.) into individual sub-sections in order to clearly convey each subject. Figure 2 provides an overview of the sites we conducted work on during the project period.

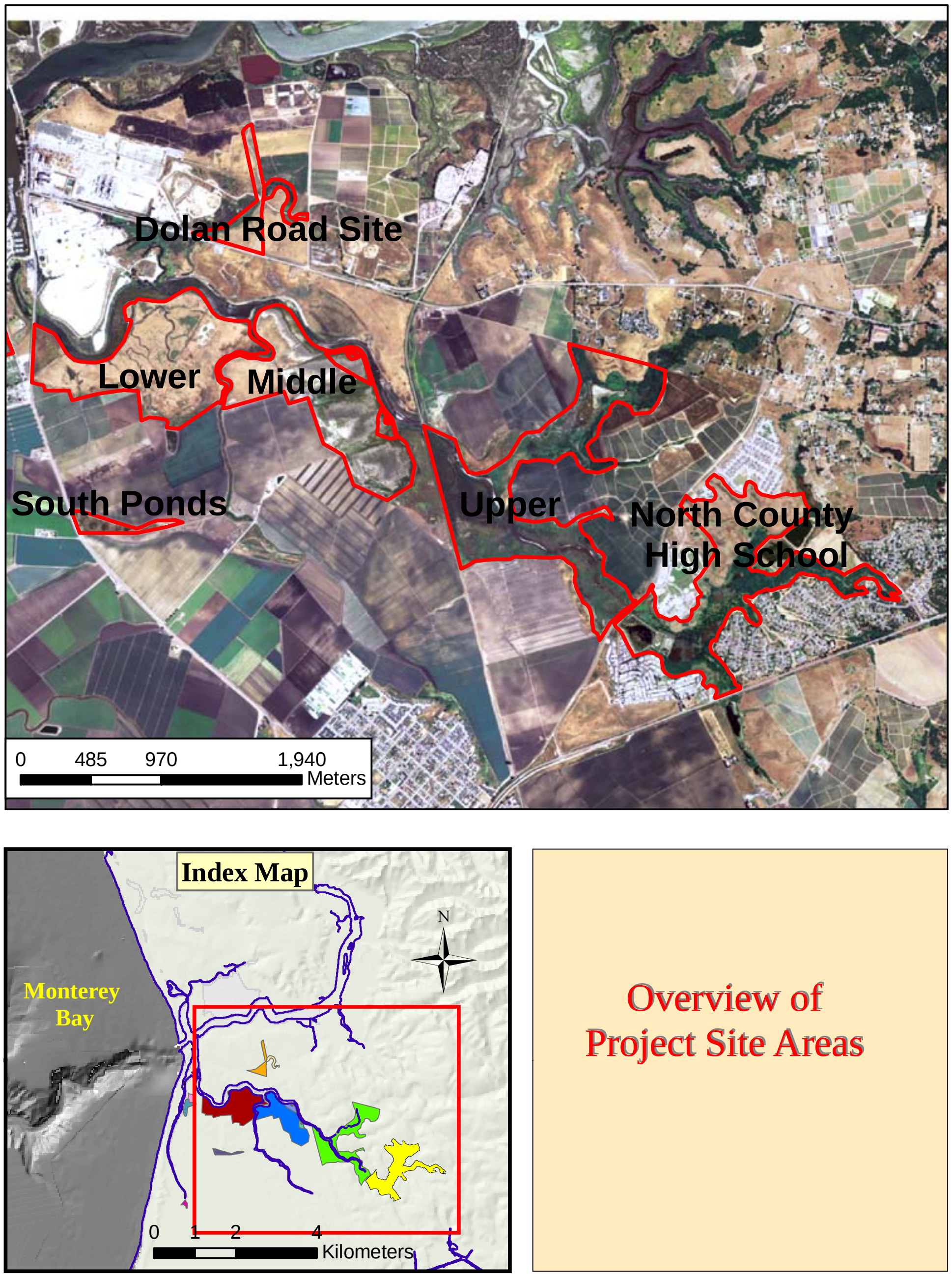


Figure 2. Project sites.

Monitoring and Water Chemistry

<u>Introduction</u>

The Moro Cojo watershed receives non-point source pollution from agricultural and urban runoff. Contaminants that enter the watershed are transported to Monterey Bay.

There has been a reduction of natural habitat throughout the region, which would otherwise help to remove contaminants before they reach the Bay. The creation of wetland habitats along agricultural edges is considered a Best Management Practice by the EPA as both biotic and abiotic factors "clean" agricultural runoff.

The Moro Cojo differs from many other degraded watersheds in that it still contains many areas that can be restored to natural habitat. State and private organizations such as the Elkhorn Slough Foundation, Coastal Conservancy, and Moss Landing Marine Laboratories, have teamed up to purchase and restore wetlands within the watershed. This project sought to implement the restoration and creation of wetland upland habitats in the Moro Cojo watershed in order to reduce contaminants entering Monterey Bay and provide habitat for wetland flora and fauna.

Nutrient Analyses

<u>Methods</u>

Water sampling occurred on a bi-monthly basis (with the exception of when sites were to wet to access or during aerial pesticide application periods) from November 2005 through December 2008 at numerous sites throughout the Moro Cojo Watershed (Figures 3-4; Appendices 1-27). Water was collected in 125-mL plastic bottles and analyzed for nitrate, nitrite, phosphate, and ammonia concentrations. An Alpkem series 300 Rapid Flow Analyzer was used to measure nitrate and phosphate, while nitrite and ammonia were manually analyzed with a Ocean Optic USB 200 spectrophotometer. In addition, the following environmental variables were collected with a YSI 556 multi-probe:

temperature, conductivity, salinity, dissolved oxygen, and pH. Data was uploaded to CCAMP.

Figure 3. Water sampling at Middle Moro Cojo.

We also analyzed nitrate concentrations and water chemistry (temperature, salinity, and dissolved oxygen) in the Moro Cojo at the HWY 1 culvert using a YSI 9600 Nitrate analyzer laboratory and a YSI 6600 extended deployment system. This varies from the other ambient monitoring as we were able to use a continuous data logger in a collaborative effort with Monterey Bay Aquarium Research Institute Scientists.

Figure 4. Placing the YSI automated data loggers in the Moro Cojo Slough.

Results

Nitrate levels decreased dramatically as water passed throughout the Low Moro Cojo and Middle Moro Cojo sites (Figure 5). Water quality throughout the Moro Cojo varied greatly throughout the year ranging from 0 to > 80 mg/L of nitrate (Appendices 7-27). Many of the sites were dry for much of the year only becoming inundated after heavy rainfall or irrigation events; thus, for these sites data is absent. Data contained in appendices 7-27 reveal the variation in water quality parameters at spatial and temporal scales. An example of the variation in nitrate concentrations is illustrated in data captured from the main channel of the Moro Cojo (Appendix 19) where between 1/4/06 and 1/5/06 nitrate concentrations ranged from 2.2 mg/L to 7.8 mg/L. Another example of the temporal variation of nitrate concentrations is capture in Appendix 12 in which nitrate concentrations in water sampled at the same locality (Mid 1) over a 6-hour period ranged from approximately 18 mg/L to 36 mg/L. Over the same period ammonia varied from < 0.26 mg/L to 0.34 mg/L and phosphate ranged from approximately 0.52 mg/L to 0.68 mg/L. These data highlight the tremendous variation in water quality over relatively short time periods.

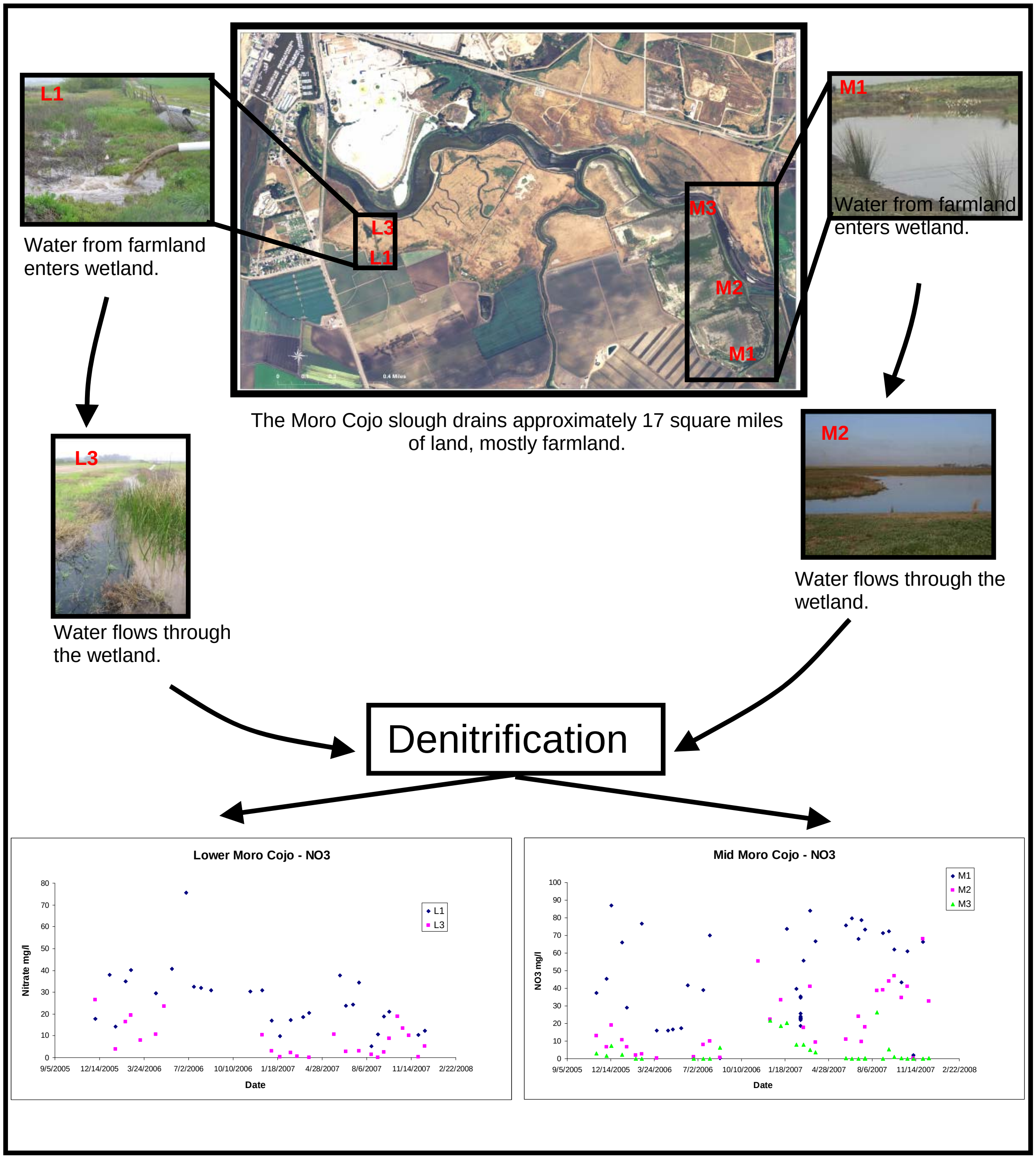


Figure 5. Conceptual model of denitrification at Lower and Middle Moro Cojo.

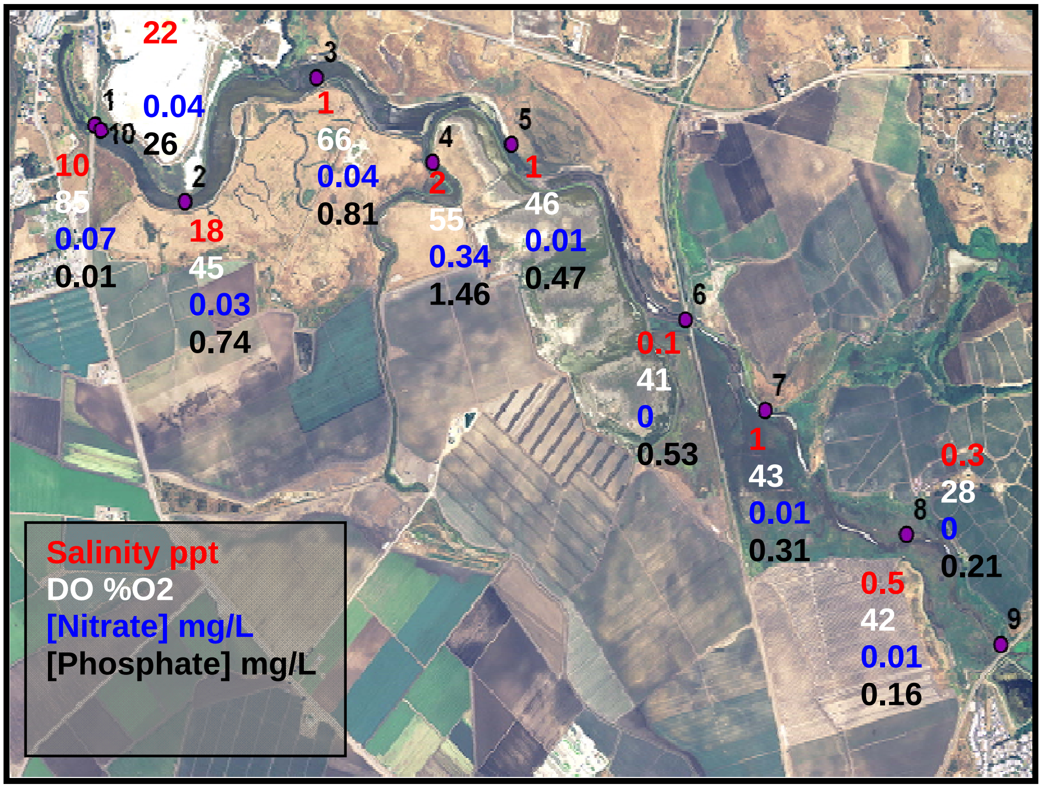


Figure 6. Results from water sampling event up the Moro Cojo over a 4 hour period from 9:00-13:00 in April 2005.

<u>Discussion</u>

The variation in water quality is to be expected and highlights the need for intensive monitoring efforts over discrete periods of time. The intensive sampling efforts conducted throughout our grant period provide an extensive view of ambient water quality conditions within the Moro Cojo. In instances when numerous samples were collected over relatively short time periods, such as in Moro Cojo Slough at HWY 1 (Appendices 19-27) and at Middle site #1 (Appendix 12), we observed significant fluctuations in water quality parameters. These results highlight how variable water quality can be over short periods and caution making statements about water quality conditions based on sparse sampling over long temporal periods.

A primary objective of our study was to examine the role wetlands play in reducing nutrient concentrations. The Lower and Middle Moro Cojo sites provide the best opportunity to quantify how water quality parameters change along a gradient as water enters and moves through a wetland. We observed a strong pattern of decreased nitrate concentrations as agricultural runoff moved through these wetlands (Appendices 7-8). Furthermore, although there was tremendous variation in water quality parameters throughout the sampling period the pattern of decreased nitrates down the spatial gradient of the wetlands remained constant (Appendices 7-8). These results strongly suggest that nitrate levels are significantly reduced as water moves across the wetlands and supports the theory that wetland buffers can serve as Best Management Practices to remove nitrates. Results for ammonia and phosphate did not show strong trends of reduction (Appendices 7-12).

Pesticide analyses

<u>Introduction</u>

The presence of pesticides and herbicides in agricultural run-off can have detrimental impacts on downstream flora and fauna. Over the last several decades, the half-lives of pesticides that widely used in agricultural production have been significantly reduced. However, pesticides still accumulate in the environment as well throughout the food web. Thus, understanding how wetlands can function as biological filters to speed up the degradation of pesticides is an important topic for understanding how to reduce the impacts of non-point source runoff. This is especially true in coastal areas where pesticide-laden waters enter estuarine and marine environments, because pesticides tend to persist for longer durations in marine environments compared to freshwater systems (Bondarenko et al., 2004). While several studies have specifically examined the ability of natural and experimental wetlands to reduce pesticide loads (Penny et al., 2005; Moore et al., 2002; Hong et al, 1997) our objective was to document concentrations of pesticides throughout the Moro Cojo.

Methods

We collected water and soil samples at several localities throughout the Moro Cojo over the extent of our project. Samples were sent either to the Department of Pesticide Regulation (DPR) or Agriculture & Priority Pollutants Laboratories (APPL).

Results

Table 1 summarizes all samples where pesticides were detected during our sampling efforts.

Discussion

Our results indicate that pesticides are present throughout the Moro Cojo; however, most samples were negative. Although we analyzed numerous samples, many of which fell along a runoff gradient, our sample set is too small to make definitive conclusions regarding the capacity of the sampled habitats to “clean up” pesticide runoff. We are currently working with the Department of Pesticide Regulation to collaborate on a study that would focus efforts on a single site and have numerous replicates over a relatively short period. This design would provide us with a better picture of the fate of pesticides as they move through the wetlands.

Table 1. Complete list of pesticide data for all sites where detections were recorded.

Lab Analysis	Water/ Soil	Units	Collection Date	Collection Site	Chlorpyrifos (Dursban)	Diazinon	Dimethoate	Malathion	Methidathion	Ethoprop	4, 4-DDE	Dieldrin	4, 4-DDT
DPR	Water	ppt	05/15/07	DITCH 1	nd	44.8	T	nd	nd	nd	nd	nd	nd
DPR	Water	ppt&ug/L	05/15/07	DITCH 2	21	252	T	nd	nd	nd	nd	nd	nd
DPR	Water	ppt	05/15/07	SEA MIST 3	nd	26.5	nd	nd	nd	nd	nd	nd	nd
DPR	Water	ppt	05/15/07	CATTELUS 1	141	27.6	0.0705	nd	nd	nd	nd	nd	nd
DPR	Water	ug/L	05/15/07	CATTELUS 3	113	42.1	T	nd	nd	nd	nd	nd	nd
DPR	Water	ppt	01/28/07	SEA MIST 1	10.3	nd	nd	nd	nd	nd	nd	nd	nd
DPR	Water	ppt&ug/L	01/28/07	CATTELUS 1	188	11.4	0.227	nd	nd	nd	nd	nd	nd
DPR	Water	ppt	01/28/07	MORO COJO TRAIN	nd	12.2	nd	nd	nd	nd	nd	nd	nd
DPR	Water	ppt	01/28/07	CASTROVILLE PUMP	85.1	51.5	nd	T	T	nd	nd	nd	nd
APPL	Water	ug/L	04/04/06	DITCH A		nd	nd	nd	nd	0.42 J	nd	nd	nd
APPL	Water	ug/L	04/04/06	LOWER 2		1.3	nd	nd	nd	nd	nd	nd	nd
APPL	Water	ug/L	5/15/07	LOWER 1	nd	nd	nd	nd	nd	nd	nd	0.094	nd
APPL	Water	ug/L	5/15/07	LOWER 3	nd	nd	nd	nd	nd	nd	0.071	0.076	nd
APPL	Water	ug/L	04/04/06	MID 1	nd	nd	nd	nd	nd	nd	nd	nd	0.039

Flora Surveys

Introduction

The diverse habitats within the Moro Cojo Watershed support a wide variety of vegetation communities. Although most of the upland grasslands are dominated by non-native grasses, patches of native grasses exists throughout most of the watershed. Upland shrub habitats are dominated primarily by coyote bush and scrub and scattered oak woodlands. Thick stands of hemlock and mustard (both non-native species) occur in patches throughout the watershed; these patches are usually found in highly disturbed areas. Composition of wetland plant communities range from saline indicators (pickleweed) to freshwater emergent vegetation (cattail, sedges, and rushes).

Methods

We conducted on the ground vegetation surveys at each site in order to assess plant diversity and collect baseline information with the goal of creating a plant list for each site. Surveys were focused primarily on documenting species richness and thus were conducted over the entire site and over multiple visits. This strategy was selected over conducting small-scale quadrat or transect samples as our ultimate objective was to obtain information of species richness throughout the entire site.

Results

The sites within the project area contain a wide diversity of plant species ranging from wetland obligates to upland species. Although many of the species are non-native, the

Moro Cojo watershed supports numerous native species. We have compiled the results from our plant surveys as species lists in tabular format (Appendices 28-32).

Discussion

It is important to note that our results are by no means exhaustive. Future detailed studies of the plant communities throughout the Moro Cojo would provide a better picture of the fine scale plant communities. Furthermore, it is highly probable that more species would be detected. This is particularly the case for the Upper Moro Cojo where plant historical surveys on plant communities are virtually non-existent. That said, overall the Moro Cojo provides important habitat for a wide variety of native plants. The enhancement, restoration, and protection of wetland and upland habitats throughout the Moro Cojo Watershed have resulted in a plant community that is in relatively good shape. Future restoration work and continuation of weed control would certainly improve habitat quality and increase the distribution of native species.

Fauna Surveys

Introduction

The Moro Cojo Watershed has been highly degraded and altered from its natural state over the last 200 years. Tide gates at Moss Landing Road restrict flow into and out of the main channel, diking along most of the properties that border the slough channel has removed most of the flood plain habitat, grazing has impacted soils and altered vegetation communities, introduce non-native flora have replaced native flora, conversion of habitats to agricultural lands, construction of roads and the railroad trestle, hunting, and the input of agricultural and urban run-off into waterways have all had impacts on native fauna in the Moro Cojo. Yet, the Moro Cojo still provides important habitat for a wide variety of native fauna. Here we describe our efforts to identify some of the fauna that currently uses the Moro Cojo watershed. This information offers a glimpse into how restoration efforts have the potential to positively impact native fauna within the area.

Methods

Birds. Point counts were conducted at the Lower Moro Cojo, Middle Moro Cojo, Upper Moro Cojo (this site also incorporates portions of the North County High School), and South Pond sites (Appendices 33-36). Surveys were conducted on a monthly basis with the exception of when sites were inaccessible to wet conditions. Survey methods included standing at points for 5 minutes and systematically scanning the area with binoculars. Observations of birds encountered while in transit between points were also noted.

Non-avian vertebrates. Surveys of non-avian vertebrates were conducted during site visits throughout the project period. Methods included ocular searches, cover boards, and looking for tracks. The objective of these surveys was to create a rough species list at each site and provide baseline data on faunal use at each site.

Results

Birds. Here we present graphical and raw data on species richness and abundance of birds throughout the project areas over the survey period as well as species lists for each site (Appendices 37-54). It is important to note that because some sites were not surveyed equally, direct comparisons among sites and years are not valid. Furthermore, abundance numbers can be misleading as sporadic migratory events can significantly increase total numbers. Capturing such episodic events is very meaningful in that we can document the use of habitats by large numbers of birds; however, the failure to detect an infrequent event is extremely likely when sampling events are few. Although we feel the bird data reveals an important picture of how the restoration sites are being used by avifauna we caution against using the data to make strong inferences. That said, the data does show that the sites are being used by a wide variety of bird species and that these areas provide functional habitat.

Non-avian vertebrates. A total of 21 vertebrate species were identified throughout the Moro Cojo during our study (Table 2). This total does not include small mammals and is not an exhaustive list. Several federally threatened or endangered species were observed, these are: Santa Cruz long-toed salamander, California Red-legged Frog, California Tiger Salamander, and Steelhead (Figures 7-12).

Table 2. Vertebrate species list for project sites.

	Lower	Middle	Upper	South Ponds	Dolan Road Site	High School	Moro Cojo Slough*
Ground squirrel			x		x		x
Cottontail	x	x	x		x	x	x
Mountain Lion					x		
Jack Rabbit		x			x	x	
Coyote	x	x	x				x
Mule Deer	x	x	x		x		x
Opossum				x	x		
Raccoon	x	x	x	x	x	x	
Red Fox	x						
Long-tailed Weasel		x			x		
Red-legged Frog			x		x	x	x
CA Tiger Salamander			x				x
Santa Cruz Long-toed Salamander			x				x
Slender Salamander		x			x	x	
Unknown Rana	x						
Pacific Chorus Frog	x	x	x	x	x	x	x
Stickleback	x	x	x	x			x
Mosquito Fish	x	x	x	x	x		x
Arrow Goby							x
Tidewater Goby							x
Longjaw Mudsucker							x
Steelhead							x

*Includes Castroville Slough and along the banks of the main channel of the Moro Cojo Slough

Figure 7. Tidewater Goby captured during vertebrate surveys of the main Moro Cojo Channel. This individual was captured on the upstream side of HWY 1 as it crosses over the Moro Cojo.

Figure 8. Gravid female steelhead captured in the Castroville Slough.

Figure 9. CA Tiger Salamander larva captured in the Moro Cojo below train tracks.

Figure 10. CA Re-legged Frog mass at Dolan Road culvert site.

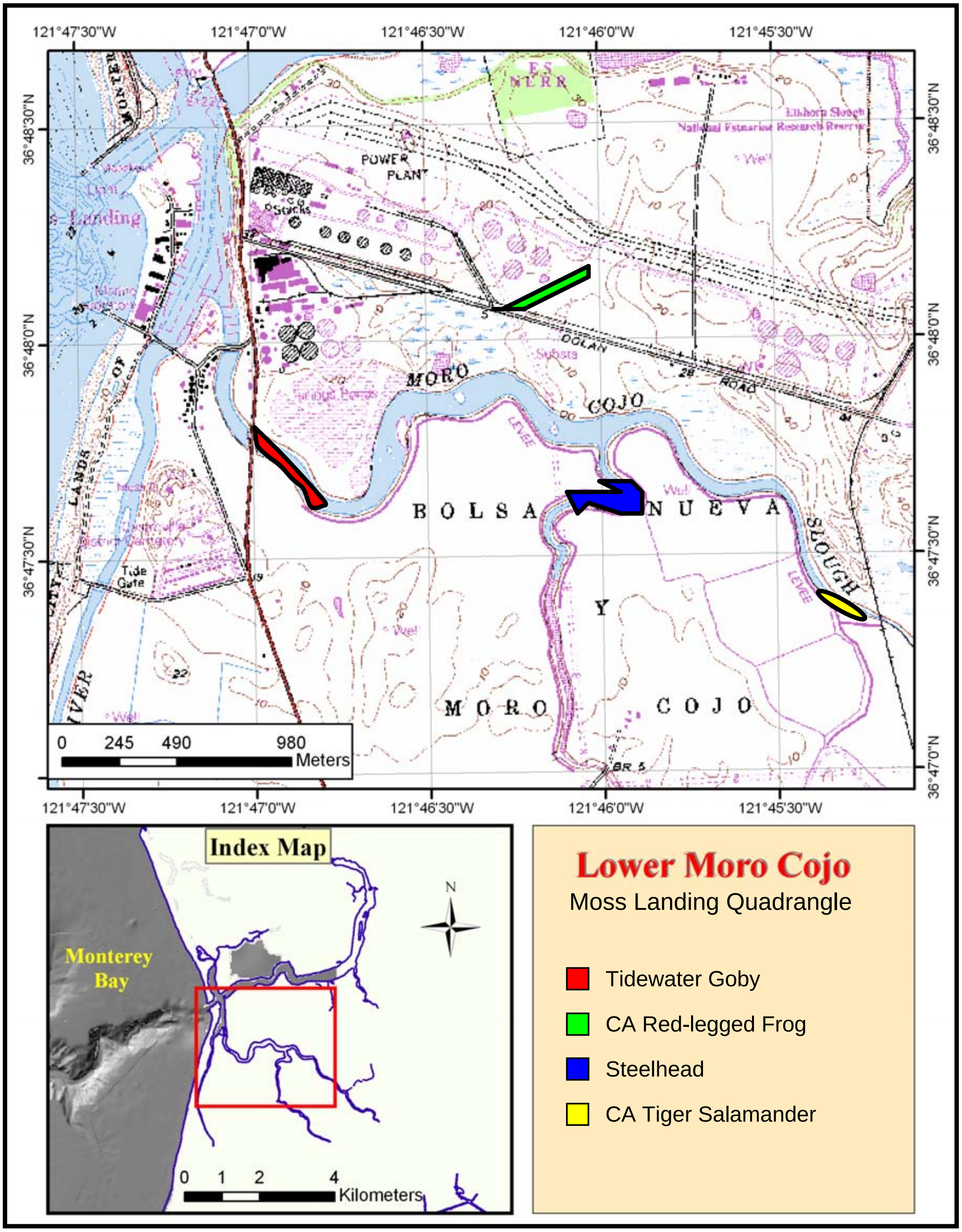


Figure 11. Location of Federally threatened and endangered species in the lower Moro Cojo Watershed.

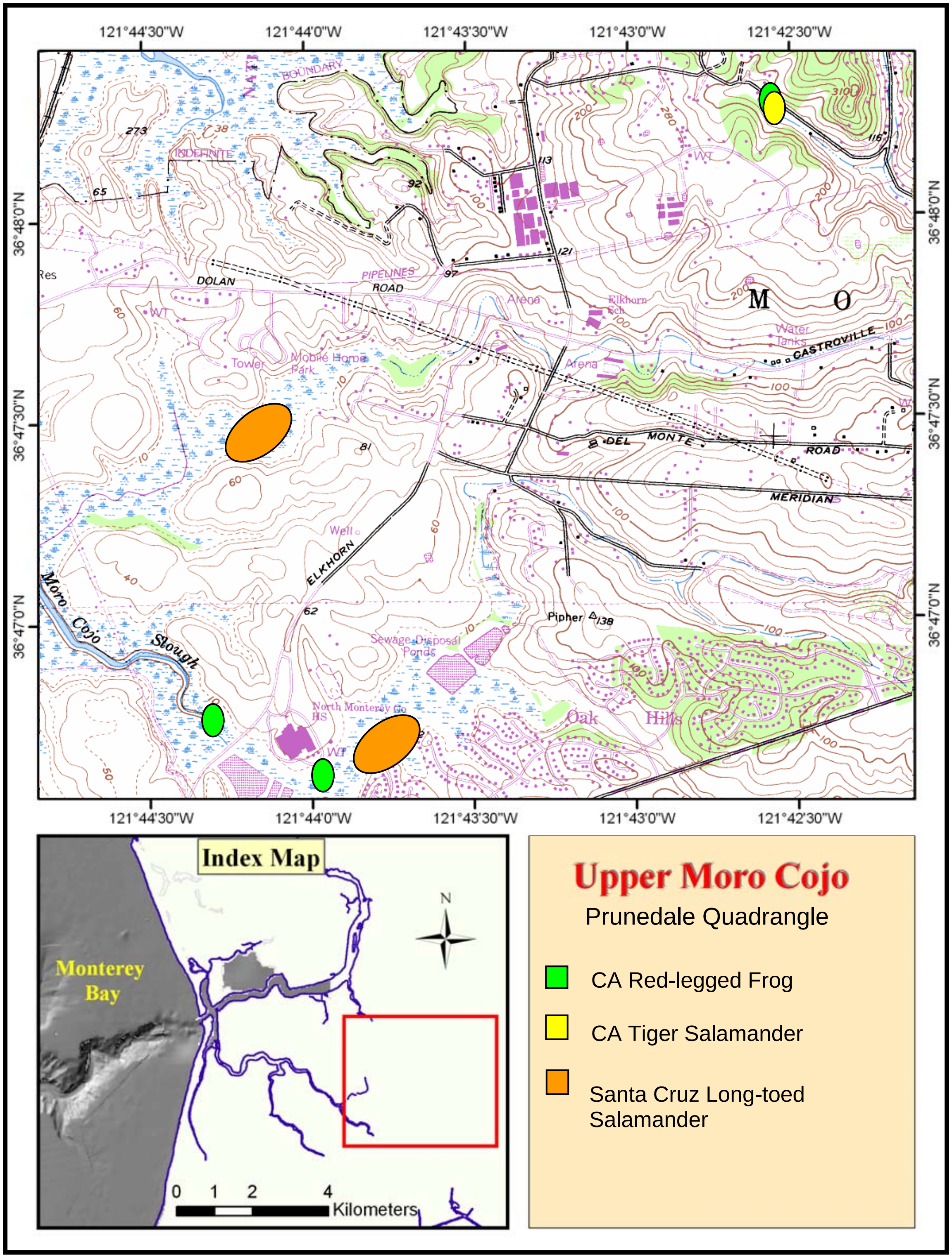


Figure 12. Threatened and endangered species in the upper Moro Cojo.

Discussion

The Moro Cojo Watershed supports a wide variety of wildlife including five federally threatened or endangered species (Figures 7-12). Most of our observations are new localities (i.e. to the best of our knowledge these species have not been reported from these localities before) that provide important information for future studies of wildlife in the Moro Cojo.

To the best of our knowledge, the CA Tiger Salamander and CA Red-legged Frog that we detected on Walker Valley Road which is a tributary that flows into the Upper Moro Cojo (in the Prunedale hills outside of our immediate project area) represent an isolated population located within the Prunedale Hills. The multiple detections of adult CA Tiger Salamanders, anecdotal accounts of juvenile CA Tiger Salamander, and the dead gravid CA Red-legged Frog at this site implied that these species are breeding in a created pond located in a small tributary that eventually flows into the upper Moro Cojo. Although most of our efforts were within the main channel of the Moro Cojo, future wetland restoration/enhancement efforts within similar habitats throughout the Prunedale Hills may have a positive impact on the recovery of threatened and endangered species within Moro Cojo Watershed. The larval CA Tiger Salamander that we detected in the Moro Cojo slough may be hybrid morphs between the introduced Arizona Tiger Salamander and the native California Tiger Salamander (Arizona Tiger Salamander have been reported from this area in 1990).

Re-detection of Santa Cruz Long-toed Salamander in the upper Moro Cojo Slough is a significant finding as this species was last reported from this site in 1990. Our surveys confirm that this population is still extant; furthermore, the habitat seems to be in relatively good shape (although the breeding pool does receive runoff from surrounding agricultural lands and periodic cattle grazing). Our findings, combined with historical accounts of Santa Cruz Long-toed Salamander in the southern finger of the Upper Moro Cojo (ABA, 1990), indicate that the upper reaches of the Moro Cojo Slough may represent important habitat for this species. To the best of our knowledge these two populations represent the southern most extent of this species range. Future efforts to preserve and enhance both wetland and surrounding upland habitat in the upper Moro Cojo should be a priority for protecting Santa Cruz Long-toed Salamander in Monterey County.

The two most surprising detections during the last year were the Tidewater Goby and Steelhead we detected in the Moro Cojo and Castroville Sloughs. Until 2005 Tidewater Goby had not been encountered in the Moro Cojo and are not shown to occur in this water body in the Tidewater Goby Recovery Plan (U.S.W.S, 2005). The only other known detection in the Moro Cojo was a single individual that was encountered in 2005 near the confluence of the Castroville and Moro Cojo Sloughs (Wasson pers. comm.). This species seems to persist in the Lower Moro Cojo Slough because of the brackish condition that is maintained by faulty tide gate structures beneath Moss Landing Road.

The gravid Steelhead that we observed had certainly made a fatal mistake in heading up the Moro Cojo and then into the Castroville Slough. Currently there is no suitable breeding habitat for this species within the entire Moro Cojo Watershed. However, it is very likely that the Moro Cojo Watershed once supported viable steelhead populations. There is a relatively well known anecdotal account from an individual who grew up in the Moss Landing region in the 1920's which indicates steelhead were once common in this area. As a boy this individual used to wake up early in the morning to remove steelhead from his fathers boats (they had jumped in over night as they tried to move up the Moro Cojo) in order to have the boats clean for duck hunting clients who hunted waterfowl further up the slough. Today the main tributaries of the Moro Cojo are silted in, polluted from agricultural runoff, and receive very little freshwater input.

In summary, our survey efforts over the past year have identified several species of wildlife and have revealed new localities for several threatened and endangered species throughout the Moro Cojo watershed as well as reestablished localities for species that had not been detected in over a decade. Within the primary and secondary tributaries of the Moro Cojo (areas that are part of or border the Lower, Middle, and Upper Moro Cojo sites) exist several federally threatened and endangered species that rely on completely different habitats. The Tidewater Goby inhabits brackish water environments where as the amphibians (Santa Cruz Long-toed Salamander, CA Tiger Salamander, and CA Red-legged Frog) require freshwater to breed. The current "management" regime for the Moro Cojo, that influences these species persistence, is regulated entirely by faulty tide gates/culverts beneath Moss Landing Road. Future projects focused on restoring and enhancing both aquatic and upland habitats throughout the entire watershed, as well as actively managing and monitoring the tide gates/culverts at Moss Landing Road, will help protect and enhance threatened and endangered species that exist in this area.

Management Work

Introduction

We conducted extensive planting and weeding throughout the Moro Cojo. All shrubs and trees were grown from local seeds at our greenhouse (Figure 13); grass seeds were purchased from regional suppliers. Weeding was conducted at all sites and consisted of hand weeding, mowing, spraying, and flaming (Figure 14). We constructed approximately 0.5 km of fencing along the main channel of the Moro Cojo (adjacent to the Lower and Middle Moro Cojo Sites), this fence excludes cattle from entering the slough (Figure 15). Our largest efforts were concentrated in the Middle Moro Cojo where we conducted large-scale pond and channel modification along with extensive planting (Figures 16-18) and where there now exists approximately 150 acres of native vegetation (was under agricultural production 5 years ago). Planting and weed control were also conducted at all of the other project sites (Figures 19-20).

Figure 13. Greenhouse and shade cloth area where many of the plants that will be used for restoration in the Moro Cojo were grown.

Figure 14. Weeding efforts along the Moro Cojo Slough. We used tarping, flaming, hand pulling, and herbicide to reduce weed cover and facilitate growth of native species.

Figure 15. Cattle exclusion fence at the Calcagno site along the Moro Cojo.

Figure 16. Panoramic photo of the small pond and swale at the Middle Moro Cojo site.

Figure 17. Panoramic photo of the large pond just prior to planting at the Middle Moro Cojo site.

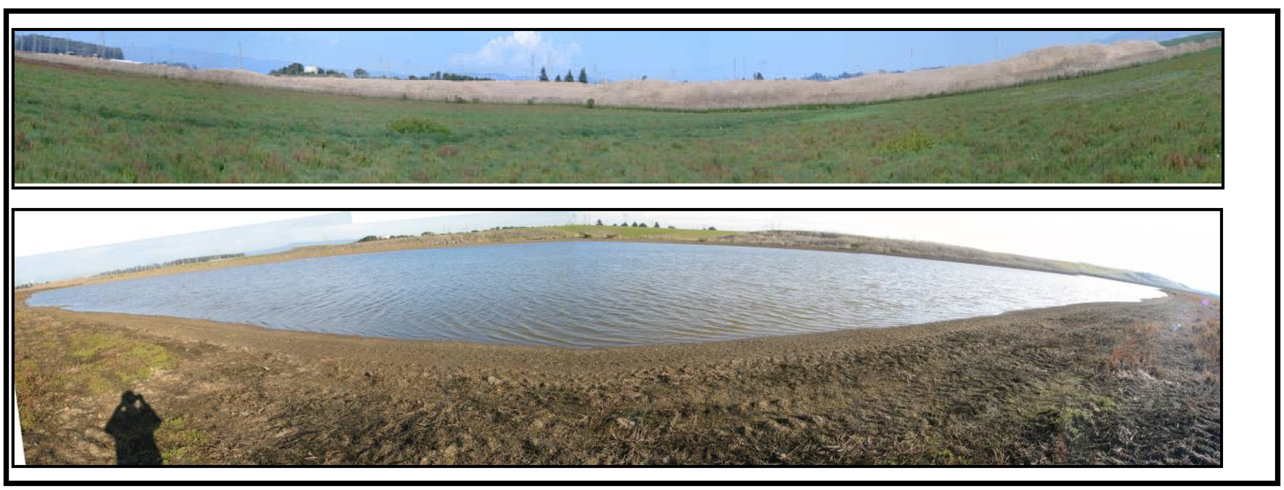


Figure 18. Large pond pre-construction (top) and post-construction (bottom) at the Middle Moro Cojo site.

Figure 19. Plantings at Dolan Road Site.

Figure 20. Weeding at south ponds.

Diverting Water from the Castroville Slough onto the Middle Moro Cojo.

The purpose of this part of the project was to pipe surface runoff water from the Castroville Slough onto an Elkhorn Slough Foundation owned property ("Sea Mist" parcel) in order to enhance wetland habitats and improve water quality. The project required burying a single pipe line of 4-inch PVC pipe approximately 3300 ft at a depth of 2-4 ft beneath the surface on Pacific Gas and Electric owned property with an easement to the Elkhorn Slough Foundation. The pipe transports water from the upper Castroville onto the Sea Mist parcel (Figures 21-22). This part of our project captures some of the surface runoff water that is pumped from the upper half of Castroville Slough and spreads onto the Sea Mist parcel to create wetlands habitat. The pump is designed to capture surface water during times when the county maintained pumps are running. Pumping water onto the parcels will have immediate benefits for wetland flora and fauna as well as water quality. This project returns water to historical wetland habitats and begins to restore the wetland vegetation.

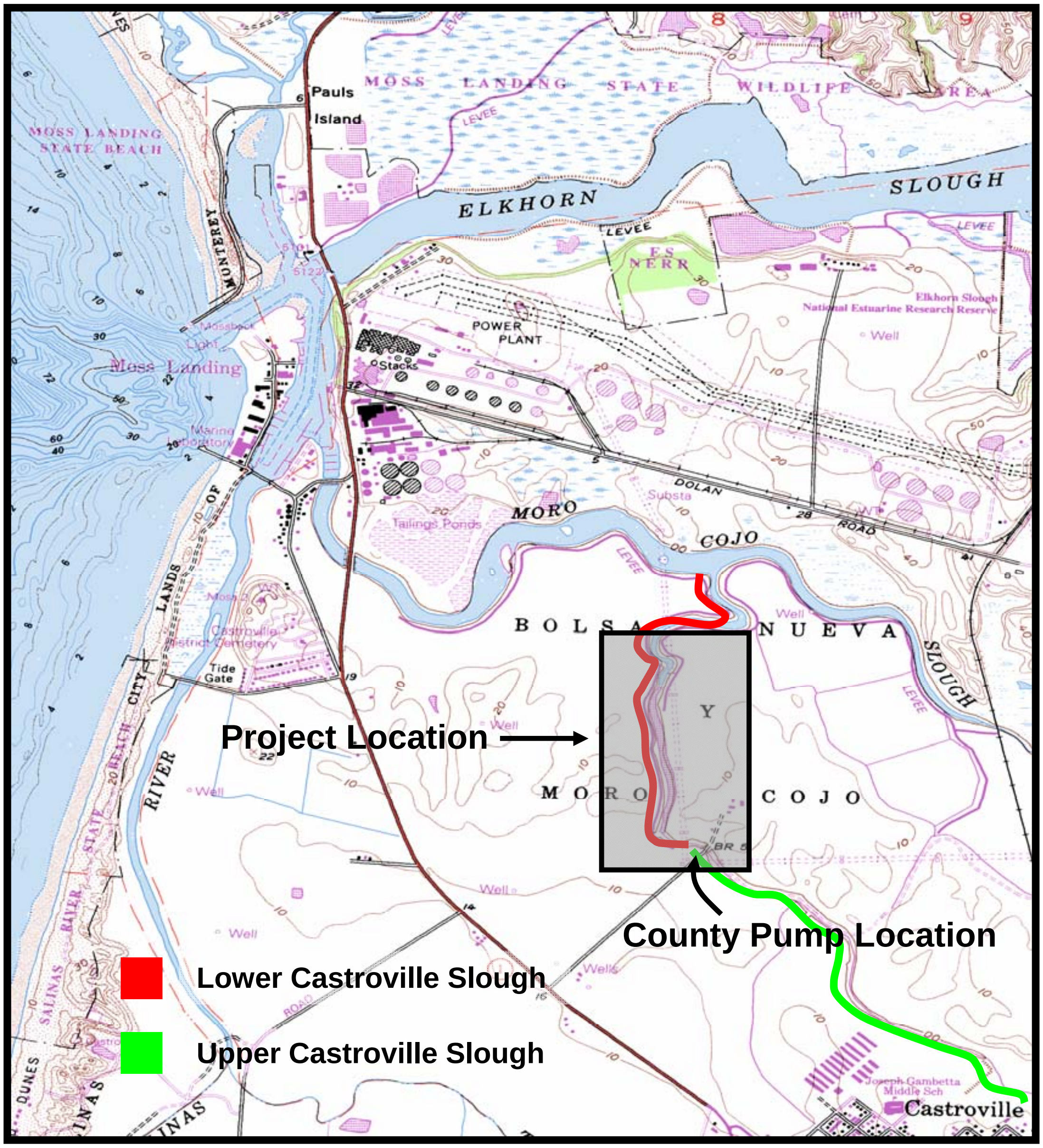


Figure 21. Overview of where water will be diverted from the upper Castroville Slough onto the Middle Moro Cojo Site.

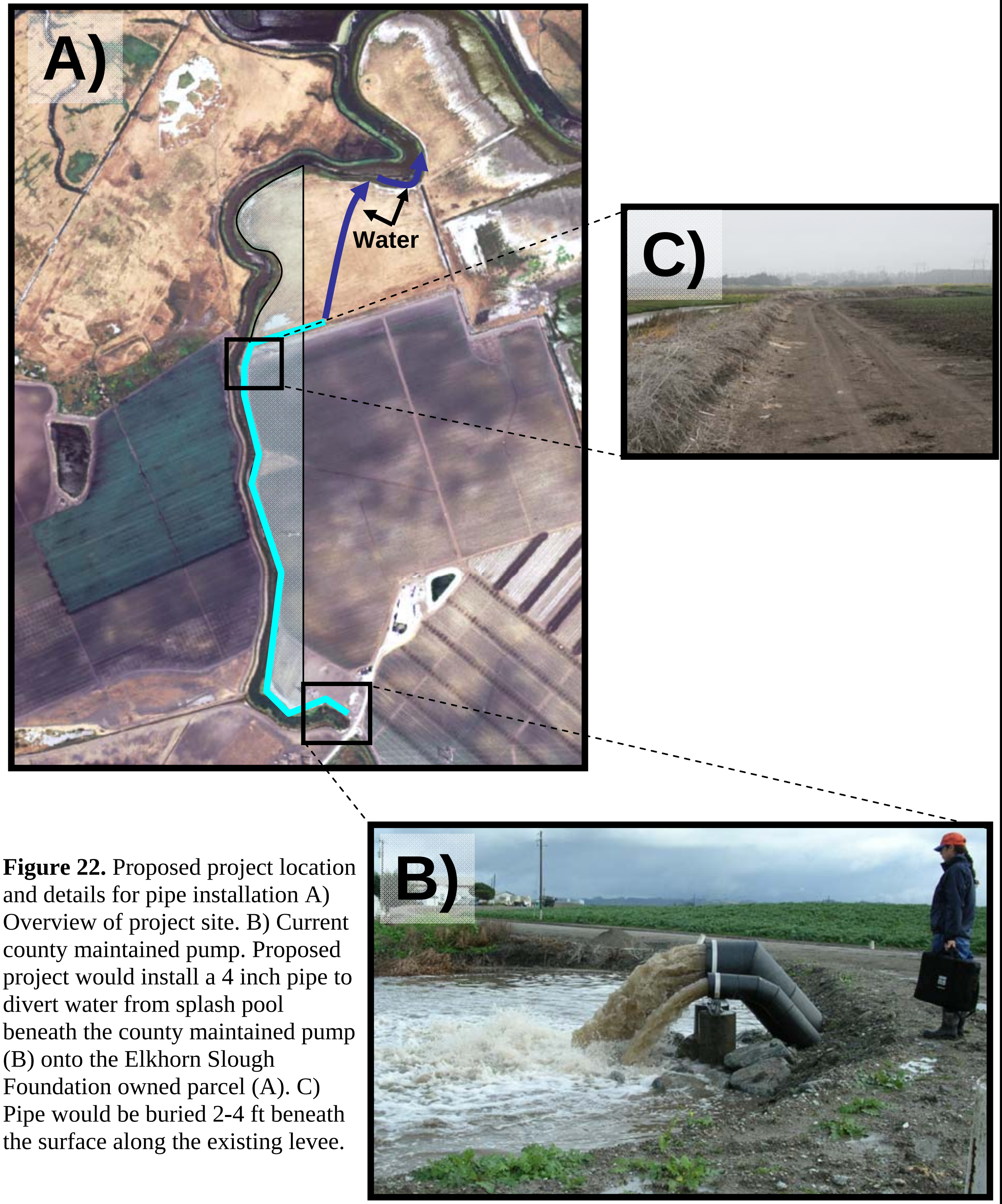


Figure 22. Proposed project location and details for pipe installation A) Overview of project site. B) Current county maintained pump. Proposed project would install a 4 inch pipe to divert water from splash pool beneath the county maintained pump (B) onto the Elkhorn Slough Foundation owned parcel (A). C) Pipe would be buried 2-4 ft beneath the surface along the existing levee.

Photo Monitoring

Annual aerial photos were taken throughout and have been included in digital format on CD and DVD. On-the-ground photos were taken quarterly, except when road conditions or aerial application of pesticides prevented staff from reaching sites, throughout the Moro Cojo Watershed (Appendices 55-61). Photos have been included in digital format on DVD.

Section 2.8 C: PAEP

For this section we have included our original PAEP that was submitted in November, 2005. Original PAEP text is in normal font, revised updated text is in bold and italics. Thus, comments have been added after each section describing to what extent we have reached our desired goals.

Performance Assessment and Evaluation Plan

I. Project Summary

Our project is the implementation of the Moro Cojo Slough Management and Enhancement Plan, the Northern Salinas Valley Watershed Restoration Plan, and the Central Coast Regional Toxic Hot Spot Cleanup Plan for Moss Landing Harbor, through the restoration of more than 650 acres of wet corridor in the Moro Cojo and Castroville Slough watersheds. Most of these lands were isolated from the historic waterways early in the century by the construction of a dike and ditch system to drain the wetlands for conversion to agricultural and livestock uses. Restoration of 300 of these acres began as part of a project supported by the EPA 319 Non Point Source Pollution Implementation program. During the course of that project we have restored seasonal and permanent ponds, vernal pools, and converted large areas dominated by weeds to native wetland, grassland, and upland vegetation. All of these actions are clearly stated as goals in the Moro Cojo, Northern Salinas Valley, and Toxic Hot Spot Cleanup Plans.

We will work towards the continued restoration of the existing 300 acres and the restoration of an additional 350 to 500 acres of the Moro Cojo and lower Castroville Sloughs. The restoration of freshwater wetlands is a prescribed Best Management Practice (BMP) by the EPA and outlined in the State's Nonpoint Source Plan as one of the adopted 61 Management Measures. Similarly, the restoration of wetland corridors has been embraced by the Central Coast Regional Water Quality Control Board and documented to significantly improve water quality that has been compromised by numerous nonpoint source pollutants from various land uses. In addition to acting as a biological filter, degrading contaminants through structural and biological filtration, and chemical and photo-degradation, these restored wetlands provide a significant increase in flood storage capacity, aquifer recharge, and surface water reuse with dramatic improvements in the quality and quantity of wildlife habitats.

Overall, our project was very successful. Our restoration activities in the Middle Moro Cojo, Calcagno's, Dolan Road Site, Upper Moro Cojo, and continued work at South Ponds total approximately 350 acres. However, we were also involved in negotiations with local land owners and assisted with the protection and baseline monitoring of an additional 200 acres in the Upper Moro Cojo (now permanently protected with a conservation easement). Combined, over 700 acres are now protected within the Moro Cojo. These protected lands provide important habitat for native flora and fauna and

also serve as "biological filters" for non-point source runoff from surrounding agricultural fields. Results from water quality monitoring highlight the effectiveness of wetlands in reducing nitrate runoff from agricultural fields.

II. Effectiveness Measurements for Habitat Restoration Activities

1. Does your project include habitat restoration activities? Yes

We will be conducting wetland restoration at multiple sites throughout the Moro Cojo Watershed. We will continue to work on restoring the 300 acres in progress and work towards restoring an additional 350 acres. Effectiveness will be determined by conducting monitoring of the sites throughout the project. Monitoring will include photo documentation (initial and final), vertebrate surveys, water quality analyses (nitrate, ammonia, phosphorus, and certain pesticides).

Accomplished. We conducted restoration activities (creation, enhancement, and weeding) on approximately 300 acres. Monitoring of flora and fauna show that these sites are functional habitat for hundreds of native species. This is especially important to acknowledge when we consider that most of these sites were under agriculture in the not too distant past. Water quality data collected throughout the Moro Cojo indicate that water quality varies tremendously throughout the watershed both on temporal and spatial scales. However, intensive data collected at the Middle Site suggest that these wetlands are having a significant impact on nitrates. Beyond water quality, flora, and fauna surveys we also conducted aerial and on-the-ground photo surveys.

2. List the specific habitat restoration activities from your Scope of Work along with its task number(s)

2.4 Restoration Implementation

2.4.1 Excavate shallow ponds and connecting channels, construct berms and other low structures to protect adjacent farmlands from flooding and/or to divert drainage water into large low areas, repair existing berm structures to retain runoff and to divert water to shallow ponds, ensure that existing berms and water flow structures are impounding the maximum quantity of water, modify existing ditches to allow runoff to pond in low areas, and excavate six (6) additional shallow ponds. All implementation shall be conducted in accordance with the project design plans.

Accomplished. On going disagreements among members of the Elkhorn Slough Foundation and Moss Landing Staff, as to whether or not it was appropriate to create more ponds on the Lower Moro Cojo parcel, prevented pond creation on that parcel. Alternatively, Elkhorn Slough Foundation and Moss Landing Staff, in consultation with Regional Board Staff, decided to focus major restoration efforts on the Middle Moro Cojo Site. Within the Middle Moro Cojo site we conducted extensive restoration efforts that included decommissioning old agricultural ditches, building ponds, diverting water onto the parcel, and connecting wetland habitats. As a result, we created two large ponds, a meandering swale, two temporary ponds that fills during the winter, and two ponded areas in old ditches that were decommissioned. These areas encompass approximately 5 acres of open water.

2.4.2 Document landform changes with Global Positioning System (GPS)/GIS including number of acres affected, and water storage capacity of excavated ponds.

Accomplished. All restoration efforts are mapped and included later in this report. As mentioned previously, we conducted restoration work on approximately 300 acres. The majority of ponded areas fall within the Middle Moro Cojo site (~200 acres in size). Functionally, approximately 180 acres of this site is now a wetland habitat; approximately 20 acres is a non-native weed field which is seasonally flooded from precipitation. It is difficult to calculate exactly the storage capacity of the Middle Moro Cojo; however, because the site is bermed and is functionally now a basin, it can store up to approximately 540 acre feet of water.

2.4.3 Conduct pre, during and post photo documentation in accordance with the SWRCB guidelines.

Accomplished. Photos have been documented and have been included on CD and DVD's along with the final report.

2.4.4 Divert runoff water from the adjacent farms, the Castroville ditch system (which drains upstream farmlands), and the Moro Cojo Slough to excavated ponds and channels.

Accomplished. During the next dry season when the Upper Castroville Slough fills water will now be diverted onto the Middle Moro Cojo site.

2.4.5 Ensure existing berms maximize the quantity of impounded runoff.

Berms remained in tact and are maximizing the quantity of impounded runoff.

Accomplished. Agricultural pumps have been repaired in order to manipulate water level if needed.

2.4.6 Divert water from ditch system to the new ponds.

Accomplished. Ditches within the Middle Moro Cojo parcel were modified to divert water into the new ponds.

2.4.7 Maintain water level in ponds and wetlands at all sites with recycled water, for the initial development period, to establish and maintain wetland vegetation during non-rainy months.

Accomplished. We used recycled water at the South Ponds Site in order to maximize water habitat for waterfowl as well as to maintain wetland vegetation.

2.4.8 Document the quantity of water retained in ponds at each site during the year with staff gauges, GPS, and bathymetric surveys of the ponds.

Accomplished. Because staff gauges were used only at the Lower Moro Cojo site and this site was not actively restored during our project, we did

not quantify depth. Depths within the Moro Cojo were frequently monitored with a YSI data Sonde throughout the project period. Created ponds were graded at specific depths and thus plans (included in the final report) provide a complete picture of the depth of the created ponds. Depth of shallow temporary pools vary significantly with rainfall ranging from completely dry to approximately 3 ft.

2.4.9 Mow, weed-whip, and hand pull non-native plants from all project sites.

Accomplished. We mowed, weed-whipped, hand pulled, sprayed, flamed, and tarped weeds at all of our sites.

2.4.10 Collect native seeds from existing restoration sites and from nearby areas within the watershed. Propagate five thousand (5000) plants at Moss Landing Marine Laboratories (MLML) greenhouses for out planting and production of additional seed stocks. Document target weeds and weed control conducted, and number of native plants propagated.

Accomplished. We collected seeds from native shrubs throughout the watershed and propagated and planted approximately 6,640 native shrubs, trees, and grass plugs. Because we were unable to plant on the Lower Parcel we decided to put resources into drill seeding. We drill seeded 300 lbs of native grass seed.

2.4.11 Identify plant species compositions for each site determined by location within the watershed, topography, hydrology, and existing stands of native vegetation.

Accomplished. Plant species lists were created for each site and have been included in the final report (Appendices 28-32).

2.4.12 Develop a planting schedule and methodology that will include drilling and broadcasting seeds of natives grasses and other plants' seeds; planting riparian trees from cuttings; and establishing trees, bushes, and grasses from local stocks grown at the MLML greenhouses or at local native plant nurseries.

Accomplished. All planting and drill seeding was conducted in late fall through early spring in order to maximize survival. There was no schedule per se other than we timed planting to occur after the ground had been saturated and prior to the major onset of storms for the winter season.

2.4.13 Plant and seed all sites (with the exception of the lower and upper site) with appropriate combinations of native wetlands, riparian, and upland vegetation and irrigate with recycled water until the plants are established.

Accomplished. Sites were planted and/or drill seeded. Water was used at the Dolan Road Site, South Ponds, and on the Calcagno property to facilitate growth of plants.

2.4.14 Plant a minimum of five thousand (5000) trees and shrubs with at least seventy five percent (75%) survival. Seed all newly constructed ponds and waterways with wetland edge and emergent species.

Accomplished. Because we were unable to plant at the Lower Moro Cojo Site (where original plans for several thousand plants were going to go) we shifted some of our efforts to drill seed native grasses at the Middle Moro Cojo and Dolan Road sites. We used a total of approximately 350 lbs of creeping wild rye, California Brome, and California Meadow Barley. Of the plants we planted, 3902 survived through December 2007. The highest mortality was of **Lupine** ***species at the Middle Moro Cojo Site as well as numerous plants at the North County High School. Lupine was planted along the border of the cleared area and the extensive stand of non-native mustard that borders the restoration site at the Middle Moro Coho. Our goal was to use a fast growing native species that would create a barrier to the mustard and inhibit movement into the restoration site. However,*** **Lupine** ***were consumed by deer, and likely rabbits as well. Other species that had high mortalities included willows, cottonwoods, and oaks at the Middle Site. These species were planted near the inflow site and appeared to have died due to drought or perhaps high levels of minerals in the soil. We also had significant mortality at North County High School Site due to mowing. This was an example of poor communication between restoration staff and managerial staff.***

2.4.15 Document the quantity and composition of native trees, shrubs, and grasses and other annuals planted, and with GPS/GIS maps documenting the percent aerial cover of native plant species at each site.

Included in the report is a CD with all of our GIS data. We did not provide a layer that included species specific coverage as this would be highly variable and erroneous. Rather, we believe the aerial images (included on CD) and on-the-ground images (included on CD) provide a better portrayal of the vegetative communities.

3. What do you hope to accomplish with this activity? (in reference to each item listed in number two above)

- Restore wetland and upland habitats in the Moro Cojo Watershed.

  Accomplished (See Section 2.8 B in final report).

- Increase habitat for invertebrates and vertebrates associated with wetland habitats.

  Accomplished. In restoring and enhancing degraded habitats we have increased habitat for native flora and fauna (See appendices 37-54).

- Increase coverage of native vegetation.

  Accomplished. The best examples for the increase in native vegetation are at the Middle Moro Cojo Site where approximately 150 acres are dominated

by native vegetation (this was a hay field 5 years ago), the main stem of the Moro Cojo where cattle exclusion fences, watering efforts, and weeding have resulted in a clear shift from bare ground to native vegetation (See Figure 15), and the Dolan road site where we have planted native vegetation, conducted extensive weeding, and drill seeded seven acres of non-native grasslands.

- Reduce nutrient and pesticide loads entering the Moro Cojo Slough.

  Accomplished (See appendix 8 for example in the Middle Moro Cojo Site).

4. What indicator or parameter will you use to measure whether or not you have accomplished the items listed in 3 above?

- Survey water quality before, during, and after implementation as well at inflow and outflow sites of wetlands.

  Accomplished. The best example of this was at our Middle Moro Cojo site where nitrate levels decreased significantly as water passed throughout the wetland. Nitrate levels at the inflow site were often over 40 mg/L whereas at the outflow site they were almost always less than 10 mg/L (see Figure 5 and appendix 8).

- Before and after photography.

Accomplished.

- Calculate before and after species richness for vertebrate, invertebrate, and plant species.

  Accomplished. This task is difficult to quantify with much reliability due to the survey methods utilized and the relatively short time period of our study. The best example is from bird point survey data where we saw large annual changes in bird species richness and abundance at many of our restoration sites. However, it is important to note that while numbers (of species and individuals) varied species composition also varied on a year to year basis. Thus, although we are confident that these sites now house more native flora and fauna than they did when they were under agricultural production we do not have sufficient data to objectively state that richness and/or abundance has dramatically changed over the time period of our project. Data collected during this project period will play an important role for future comparisons.

III. Effectiveness Measurements for Management Practice Implementation Activities

1. Does your project include management practice implementation activities? NO

N/A

2. List the specific management practice implementation activities from your Scope of Work along with its task number(s)

N/A

3. What do you hope to accomplish with this activity? (in reference to each item listed in two above)

N/A

4. What indicator or parameter will you use to measure whether or not you have accomplished the items listed in 3 above?

N/A

IV. Effectiveness Measurements for Education and Outreach

1. Does your project include education and/or outreach activities? Yes

2. List the specific education and/or outreach activity(ies) from your Scope of Work along with its task number(s)

2.7 Education and Outreach

2.7.1 Develop and document watershed and restoration studies curriculum for elementary, middle and high school grade levels at North Monterey County High School, the Moss Landing Middle School, the Gambetta Middle School, and the Castroville Schools.

Accomplished. We conducted numerous tours of the sites to elementary and high school students at schools throughout Monterey, Santa Cruz, and Santa Clara Counties. Furthermore, we worked with faculty at Moss Landing Marine Laboratories to develop field exercises associated with a watershed curriculum specifically focused on our restoration efforts in the Moro Cojo (see Appendices 62-63).

2.7.2 Provide support and expand watershed and restoration programs in schools in and near the Moro Cojo watershed in cooperation with the Return of the Natives (RON) restoration education program located at the Watershed Institute at California State University Monterey Bay (CSUMB).

Accomplished. Sue Shaw of Creative Environmental Conservation assisted on numerous Return of the Native projects.

2.7.3 Conduct a minimum of four (4) programs, each year of the project period, in order to provide students knowledge of watershed restoration and management.

Accomplished. We conducted more than four programs with elementary, high school, and University level courses (California State University Monterey Bay [CSUMB], San Jose State University [SJSU], and Moss Landing Marine Laboratories [MLML]) each year of the project.

2.7.4 Plant five hundred (500) plants per year, with students at North Monterey County High School at established school greenhouses.

This was done only for two years; however, we planted over 1500 plants and plugs with the students. Furthermore, students were also involved in plant propagation.

2.7.5 Bring five (5) elementary through high school classes or school groups per year to visit restoration sites and assist in planting the five hundred (500) plants.

Accomplished.

2.7.6 Bring five (5) classes from CSUMB and/or MLML to visit the restoration sites and conduct class research projects

Accomplished. Three classes from MLML and six classes from CSUMB visited the restoration sites and conducted class projects. We also had students from SJSU conduct class and masters projects.

3. What do you hope to accomplish with this activity? (in reference to items listed in two above).

Our goal is to substantially meet the criteria in 2.0 above. Meeting these criteria will help to educate the public as to the importance of wetland habitats and their functions.

Accomplished

4. What indicator or parameter will you use to measure whether or not you have accomplished the items listed in 3 above?

We will quantify the number of groups that have participated in education and outreach projects. At the end of each educational and outreach session we will lead a group discussion in which we stimulate a question and answer session with the participants.

We will quantify the number of plants planted to make sure we have met our goals pertaining to planting events that will be held with various groups.

Accomplished. These results are detailed in the Final Report.

V. Effectiveness Measurements for Monitoring

Does your project include water quality or biological monitoring? Yes

We conducted extensive water quality sampling throughout the Moro Cojo Watershed; results are included in this report (Appendices 1-27).

V.1 <u>Watershed Level Monitoring</u>

1. Does your project include watershed level monitoring? No

2. What do you hope to accomplish with this activity?

N/A

3. What indicator or parameter will you use to measure whether or not you have accomplished the items listed in number 2 above?

N/A

V.2 Management Practice Effectiveness Monitoring

1. Does your project include practice effectiveness monitoring? NO

N/A

2. What do you hope to accomplish with this activity?

N/A

3. What indicator or parameter will you use to measure whether or not you have accomplished the items listed in number 2 above?

N/A

V. 3 Pollutant Load Reduction

1. Does your project include pollutant load reduction calculations? No.

Although our project does not include pollutant load reduction calculations we will be monitoring changes in concentrations of nutrients and pesticides. We estimate that native wetland and upland habitats will reduce nutrient and pollutant concentrations (measured by examining inflow and outflow concentrations).

A limitation to this approach is that there may be significant variance in nutrient and pollutant loads during different time periods. However, because we will be sampling throughout the year we hope to capture the variation in concentrations at different time periods. Our sampling design will adhere to a strict schedule in order to replicate samples taken over multiple years. We will use a Seasonal Kendall Test to test for trends in water quality among inflow and outflow sites as well as among seasons.

We were able to see significant reduction in Nitrate levels as they pass through created wetland habitat. However, due to the spatial and temporal variation in nitrate levels, it is very difficult (and erroneous) to try to quantify the reduction in nutrient loads. Tabular and graphic data in our report elucidate the reduction in nitrates along the wetland gradient. At the Middle Moro Cojo we gathered flow data at one of the agricultural pumps over a one month period. During this time a total of 1,126,000 gallons of water flowed onto the Middle Moro Cojo. By extrapolating the volume of

water, and averaging nitrate concentrations at the inflow site (Mid 1) and down the wetland gradient at Mid 3 (see figure 5 for spatial locations), over the tenure of our project one can get a rough estimate of the volume entering the site as well as the nitrate concentrations along the wetland gradient. The mean nitrate concentration at Mid 1 and Mid 3 over the project period was 45.9 mg/L and 4.4 mg/L respectively. This is a 95% reduction between the two sites. Multiplying the water volume entering the site in a single month (4,262,360 L) by 23 (number of months water quality was collected) results in a total of 98,412,829 L of water entering the site. The estimated inflow volume and the mean concentration of nitrate at Mid 1 and Mid 3 can be used to calculate load reductions. Thus:

45.9 mg/l x 98,412,829 L = 4517 kg of nitrate at Mid 1

4.4 mg/L x 98,412,829 L = 433 kg of nitrate at Mid 3.

The result is a net loss of 4084 kg of nitrate. However, because of the variation in flow rates and nitrate concentration over time it is important to note that estimating load reductions with the above assumptions is going to be a very rough estimate and we know that the above assumptions have most likely not been met. All that said, we have observed a significant reduction in nitrate concentrations as agricultural water passes through the created wetlands.

2. What do you hope to accomplish with this activity?

We hope to detect the variation in concentrations of nutrients and pesticides entering and leaving wetland habitats. We anticipate that concentrations of nutrients and pesticides will be reduced by as they pass through wetland habitat.

Our sample size for pesticide analyses were too low to accurately test whether or not wetlands reduced pesticide concentrations. Future studies with extensive sampling over a short temporal period would be provide a better picture of how well wetlands function to reduce pesticide concentrations. As mentioned above, and throughout the final report, the descriptive data (tabular and graphical) clearly highlight the fact the wetlands do reduce nitrate concentrations.

3. What indicator or parameter will you use to measure whether or not you have accomplished the items listed in 2 above?

See monitoring plan pages 3-6.

Our data suggests that Nitrate levels are being significantly reduced as they pass through created wetland habitat.

VI. Summary of Desired Outcomes

Our project directly targets several environmental and water quality problems identified in the Moro Cojo Slough Management and Enhancement, Northern Salinas Valley Watershed Restoration, and the Central Coast Regional Toxic Hot Spot Cleanup Plans.

Specific goals that will be implemented by this project are the enhancement and restoration of the natural resource values of the wetlands, floodplains, and adjacent upland habitats of these watersheds for maximum biological resource values, particularly for species of special status, and it will reduce the impacts of human activities on wetland resources by improving water quality via wetland restoration. Furthermore, the project will provide natural resource interpretation, educational, and research benefits, all of which are stated goals and objectives of these plans. The re-creation of a nearly watershed wide contiguous wet corridor will stabilize wetland/urban and agricultural boundaries, reduce bed loads, increase habitat and flood storage, while improving the quality of the water and watershed, and the spirit of cooperation among stakeholders, ensuring the long term protection and sustainable management of these coastal aquatic resources.

This project is the continuation of an effort that was started in 1996 with the writing of the Moro Cojo Slough Management and Enhancement Plan. This plan called for extensive restoration of the Moro Cojo Slough. As a result, collaborative efforts between Moss Landing Marine Laboratories, Elkhorn Slough Foundation, California State University Monterey Bay, several public and private groups have worked to restore and enhance the Moro Cojo Watershed with the goal of providing habitat for native flora and fauna and cleaning up water. A key player in these efforts have been the local farmers and land owners who, for the most part, have been on board and provided access to lands (via sales and/or use of roads), allowed us to construct fences on their lands, and been advocated for our work. Without this partnership none of our

efforts would have been accomplished. Overall, our project has had positive impacts on native flora and fauna as well as improved the quality of water flowing into the Monterey Bay National Marine Sanctuary.

Section 2.8 D: Lessons Learned

Lesson 1: working with stakeholders and changing goals over time

The largest hurdle overcome during this project was the ability to work with a diverse group of stakeholders towards a consensus on restoration objectives. The Moro Cojo Slough Management and Enhancement Plan is now 12 years old. Over the past 12 years, numerous public and private groups have worked hard to implement portions of the Moro Cojo Plan. Throughout this time we have been able to restore, enhance, and/or protect over 700 acres. One of the difficult issues that our grant faced was whether or not the original Freshwater Alternative objective of the Moro Cojo Slough Enhancement and Management Plan was still a viable objective. The consensus seems to be that it is' however, several people believe that allowing more tidal action is a more appropriate alternative while others believe maintaining upland grasslands, rather than enhancing wetland habitats, is the appropriate management strategy. It is important to note that implementing any one of these particular management strategies will have an impact on how habitats throughout the Moro Cojo. However, with appropriate management, restoration, and enhancement the Moro Cojo can be restored to incorporate components of all of these habitat type.

Over the last 5 years and early on during this grant period Saline Clover (*Trifolium depauperatum var. hydrophilum)* became very abundant on the lower Moro

Cojo parcel. This was a result of the restoration efforts conducted by the Marine Laboratory in conjunction with the Elkhorn Slough Foundation and other groups. Specifically, Saline Clover seemed to respond positively to disturbances such as flooding and mowing. However, because this species is a species of concern a handful of stakeholders wanted future restoration work halted as they were concerned the species would be negatively impacted. A result of the concerned stakeholders led to two years of meetings in which restoration efforts on the Lower Moro Cojo stopped. Approximately two and a half years ago we worked with Bill Hoffmann (RWQCB) and Mark Silberstein (Elkhorn Slough Foundation) to develop an alternative strategy as it was evident that if meetings were to continue regarding restoration work on Lower Moro Cojo our grant may fail completely (we had already spent two years in discussions). As a result, it was agreed up on to focus on the middle parcel and move forward with intensifying work on parcels other than Lower.

The lessons learned here are difficult. Stakeholders need to be heard; however, this project was moving forward and was halted as a result of a small group of stakeholders who were not involved in the initial planning efforts and on-going restoration over the past 12 years. Yet, they were able to effectively stop the project due to the presence of a species of special concern. This is a tricky situation as restoration efforts need to be evaluated as they proceed forward and changed if originally unforeseen issues arise. In hindsight, it seems that one of the most important facets of restoration efforts is to collect solid baseline data prior to restoration efforts being initiated. This strategy allows stakeholders to objectively and quantifiably assess changes in the system over time. However, it is important to note that distribution data on Saline Clover had been collected and because of its presence the restoration project was halted.

Lesson 2: Upland restoration in weed infested areas

We planted several thousand shrubs and grasses in upland habitats with the goal of increasing native species cover. One of our focused efforts was on the berm of the Sea Mist. This site is directly adjacent to acres of non-native mustard. Our strategy was to plant one-year old shrubs with the goal of having these plants grow to a relatively large size where they then could out compete intrusion by non-native mustards. Essentially, this strategy is "jump starting" succession by eliminating the seedling recruitment stage where competition for resources is high and non-native mustards seem to dominate. At this stage it is too early to definitively determine whether our strategy will succeed. Reexamining the success of the planted shrubs in several years will provide insight into how well this strategy works.

Lesson 3: Long-term funding of restoration sites

Moss Landing Marine Laboratories and other public and private groups have been deeply involved in restoring the Moro Cojo over the past 15 years. These efforts have been incredibly successful; however, the projects and on-going maintenance of the restoration sites have been entirely funded through short-term grants. In order for large-scale restoration efforts to be successful in the long-term (and thus meet the long-term goals of enhancing habitat and cleaning up water) there needs to be institutionalized permanent funding for the maintenance of these sites. Establishing an endowment that could fund a staff member would provide needed support for the continuation, and assurance for, restoration in the Moro Cojo. Currently, scientists from Moss Landing Marine Laboratories, California Coastal Commission, and several state and private entities are working together to establish a working group of wetland scientist for the Central Coast of California. If this group were to obtain permanent long-term funding it could potentially provide support for long-term staff that work to manage and continue the restoration efforts in the Moro Cojo.

Section 2.8 E: Outreach

Throughout the tenure of our project we conducted extensive outreach to public and private sectors. Sue Shaw of Creative Environmental Conservation along with Coastal Conservation and Research and Moss Landing Marine Laboratories staff worked extensively with education outreach. Activities include greenhouse construction, plant propagation, and assisting with school planting and hands on education events. We also worked closely with students and teachers at North Monterey County High School to propagate plants in their greenhouse and plant on-site (Figures 23-24). We led numerous tours to various restoration sites and assisted with teacher workshops, curricula development, and field tours (Figures 25-26, Table 3, Appendix 62-63).

Figure 23. North Monterey County High School students planting upland plants at the North County High School site.

Figure 24. North Monterey County High School students led by Restoration Specialist Kellie Rey (in red) planting upland plants at North County High School.

Figure 25. Students from CSUMB visiting the constructed pond at Middle Moro Cojo during one of the Spring 2007 field trip visits to the site.

Figure 26. Field lecture and hands on workshop as part of Monterey Bay Aquarium's teachers workshop at South Ponds restoration site.

Table 3. List of various groups and students that used and or viewed restoration sites during the project period.

Ag. Trust and Duke Energy	Independent Consultants (multiple visits)
Coastal Conservancy	UCSC Faculty
Watsonville high School Students (multiple visits)	Chemical Oceanography Course (multiple visits)
Monterey Bay Aquarium Teachers workshop	Cabrillo college students (multiple site visits)
High School and Middle School Teachers from around the state	CSUMB Capstone students (Multiple visits)
MLML Teachers Curriculum Staff	Aquatic adventure students (multiple visits)
High School Teachers (country wide; MLML curriculum program)	Fish & Game staff (with John Kenney of ESF)
San Jose State University faculty (multiple visits)	Mosquito abatement staff
Ducks unlimited staff	Coastal Commission staff (multiple visits)
Department of Pesticide regulation staff (multiple visits)	Carmel High School students (multiple visits)
Nature Conservancy Staff	Supervisor Calcagno
Wetland Construction Inc.	CSUMB Ecology course (multiple visits)
Moss Landing Marine Lab Faculty (multiple visits)	Elkhorn Slough Board members (led by Mark Silberstein)
CSUMB faculty(multiple visits)	Gilroy High School (multiple visits)
PG&E staff (multiple visits)	RWQCB staff
General Public (southern CA residents)	MLML Ichthyology students (multiple visits)

Presentations

Beyond field lectures to groups we presented our results in posters and oral presentations at the Wildlife Society Meeting, Elkhorn Slough Watershed Working Group, Moss Landing Marine Laboratory Open House, University of California at Santa Cruz, Laboratory and Field Explorations in Marine Science Workshop, and at the Monterey Bay Aquarium. We are currently working on papers that we will submit for publication to peer-reviewed journals.

Section 2.8 F: Project Funding

A total of $1,097,000 was funded by the Proposition 13 Coastal Nonpoint Source Control Grant Program for this project. The projected cost of the project was $1,097,000 of which $1,096,999.10 was spent. The Elkhorn Slough Foundation also contributed additional funds for this project in staff salaries, equipment costs, as well as planning and consultant fees. No funding sources were leveraged by this project.

Section 2.8 G. Potential Follow Up Activities

The most important next steps are to protect the southern side of the upper Moro Cojo and fence off, or purchase, lands in the middle Moro Cojo where cattle are still allowed to graze in the Moro Cojo. Beyond purchasing, and thus protecting, the remaining lands within the Moro Cojo we believe that the next steps are to either remove or notch the levees that restrict natural flows of the Moro Cojo. We believe that the next step in restoring the Moro Cojo is to decommission levees that block historic flow of the Castroville and Moro Cojo Sloughs onto historic wetland habitat (Figures 27-29). One method would be to place culverts in the constructed levees that block the historical flow of the Moro Cojo and Castroville Sloughs onto the adjacent Sea Mist and Catellus Parcels (Figure 27). Levees were constructed around the parcels by landowners in the mid 20th century in order to restrict water flow onto the site and dry the property so it could be converted into agricultural land. However, farmers failed to completely dry out the properties and they were never productive for agricultural uses. The Elkhorn Slough Foundation purchased these parcels with the goal of restoring wetland habitats and improving water quality by filtering agricultural runoff prior to the water entering the

Monterey Bay Sanctuary. Our proposal would be to notch the levees that impede water flow and restore flow onto these sites. The localities were chosen because breaching the levees at these points will maximize wetland habitat.

The inflow site at the upper end of the parcel would permit fresh water to flow onto the wetland during winter storm events. Water entering the parcel will flow through the extensively restored wetland before it exits the outflow site which is at the low point of the property (Figure 28). On the Lower Moro Cojo Parcel (Cattelus) water will flow into the parcel at two points and move across the parcel before it exits at a low point along the north western boundary of the property (Figure 29). Permitting water to flow naturally across these sites will serve several functions: 1) water will impound on the parcels which will drastically increase freshwater habitat and enhance native wetland associated flora and fauna; 2) "clean" farm runoff emanating from agricultural land up slough of the parcel; and 3) provide flood storage during extreme storm events. We will place culverts in the levee at locations that we have breached. Each culvert will have a control structure that will allow for management of flow which will provide flexibility for future management regimes.

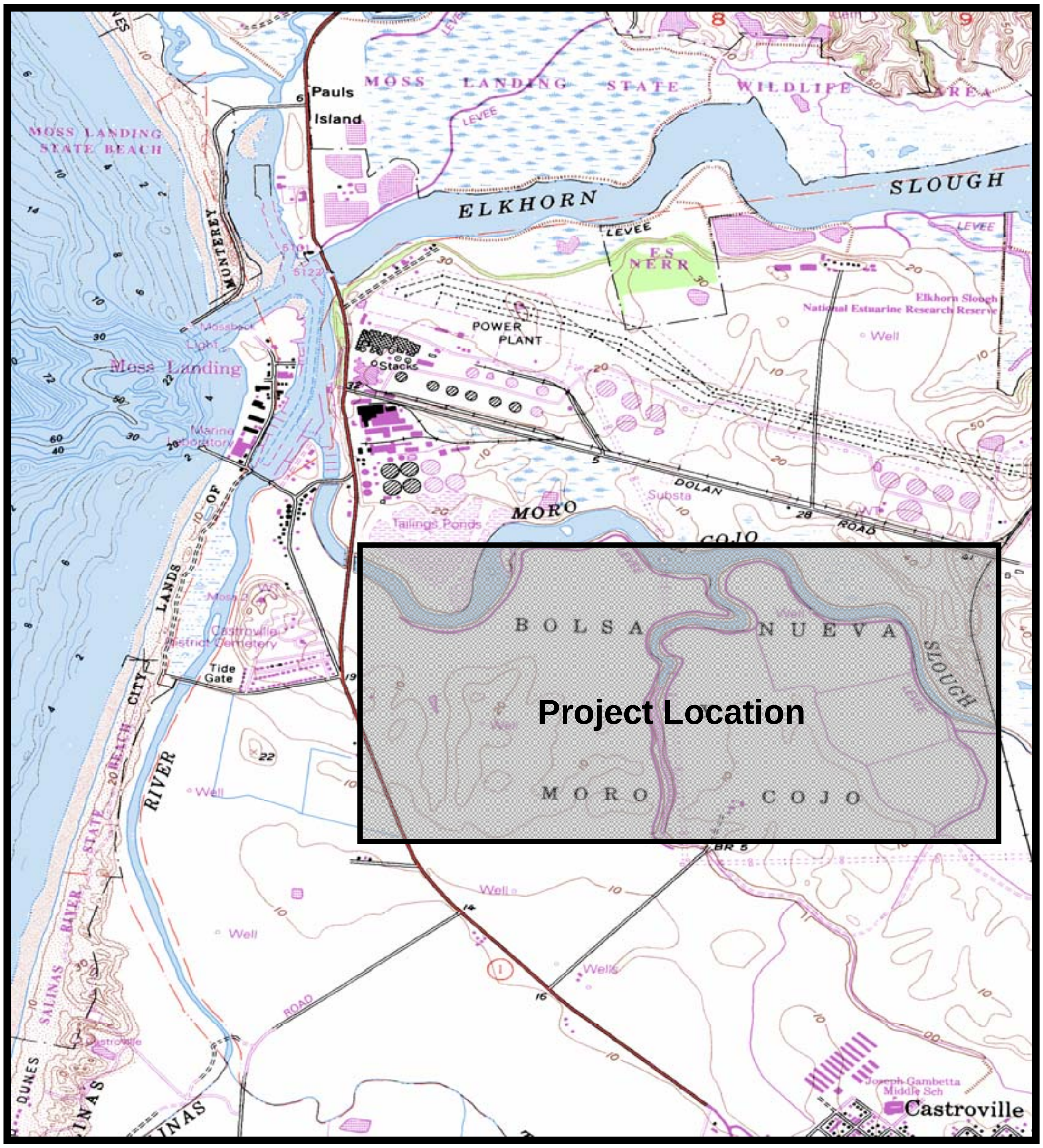


Figure 27. Overview of project location.

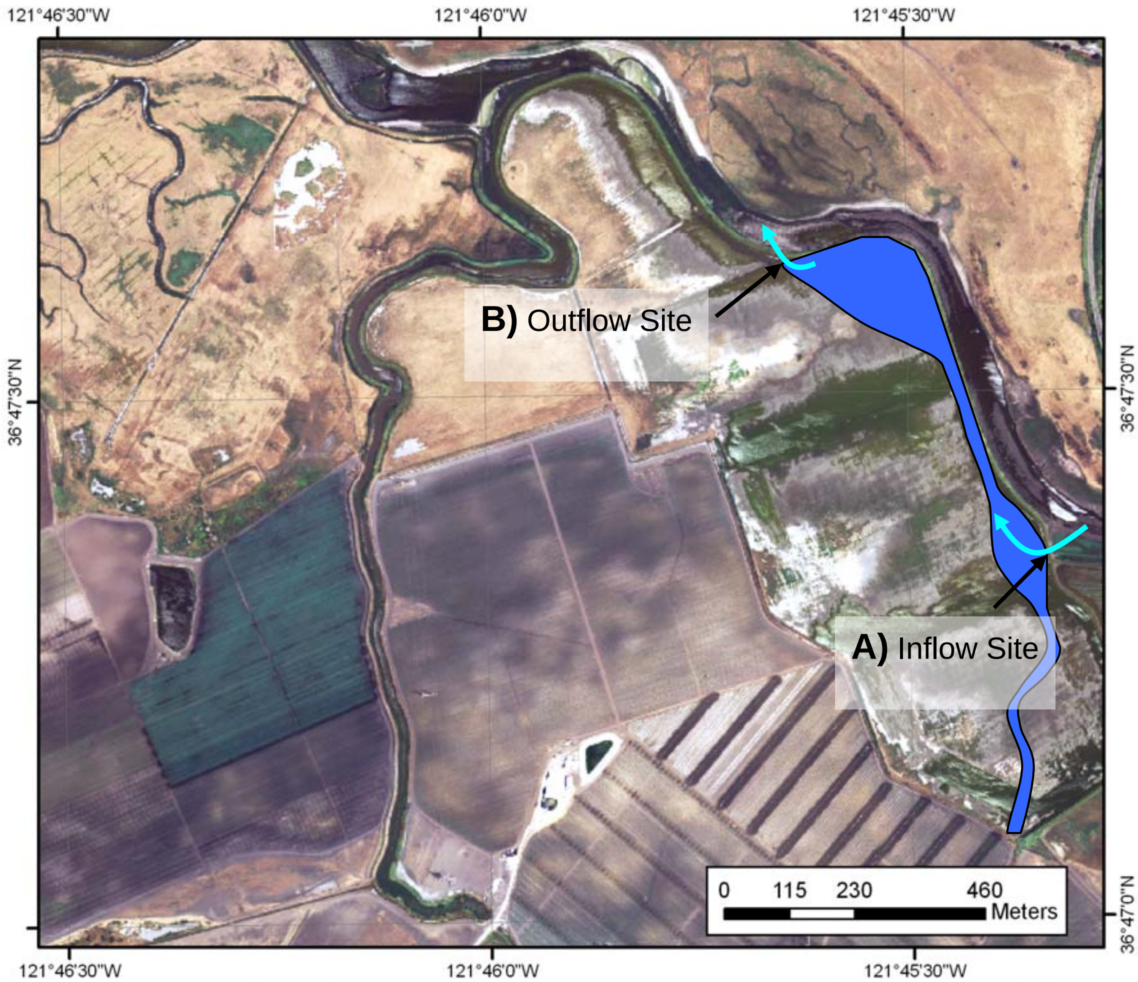


Figure 28. We propose to notch the levee that currently isolates the Sea Mist site from the Moro Cojo Slough in order to restore wetland habitats. A) The inflow site represents the locality where water will flow onto the site through the levee. B) The outflow site is where water will exit the site. The inflow culvert will capture water only during seasonal flood events when freshwater is backed up in the Moro Cojo Slough.

Figure 29. We propose to notch the levee that currently isolates the Catellus parcel from the Castroville Slough in order to restore flow onto this property. A) Locations where water will flow onto the site through the levee B) Locality where water will exit the site. Inflow and outflow will be through culverts that can be managed to store water on site or allow for passive movement. The height of the inflow culvert will capture water only during seasonal flood events when freshwater flow is high due to rain events and upstream pumping.

Section 2.8 H: Aerial Photos

Additional aerial photos have been included on CD and DVD.

Section 2.8 I: Items for Review

All items for review are included throughout this report.

Section 2.8 J: Additional Items

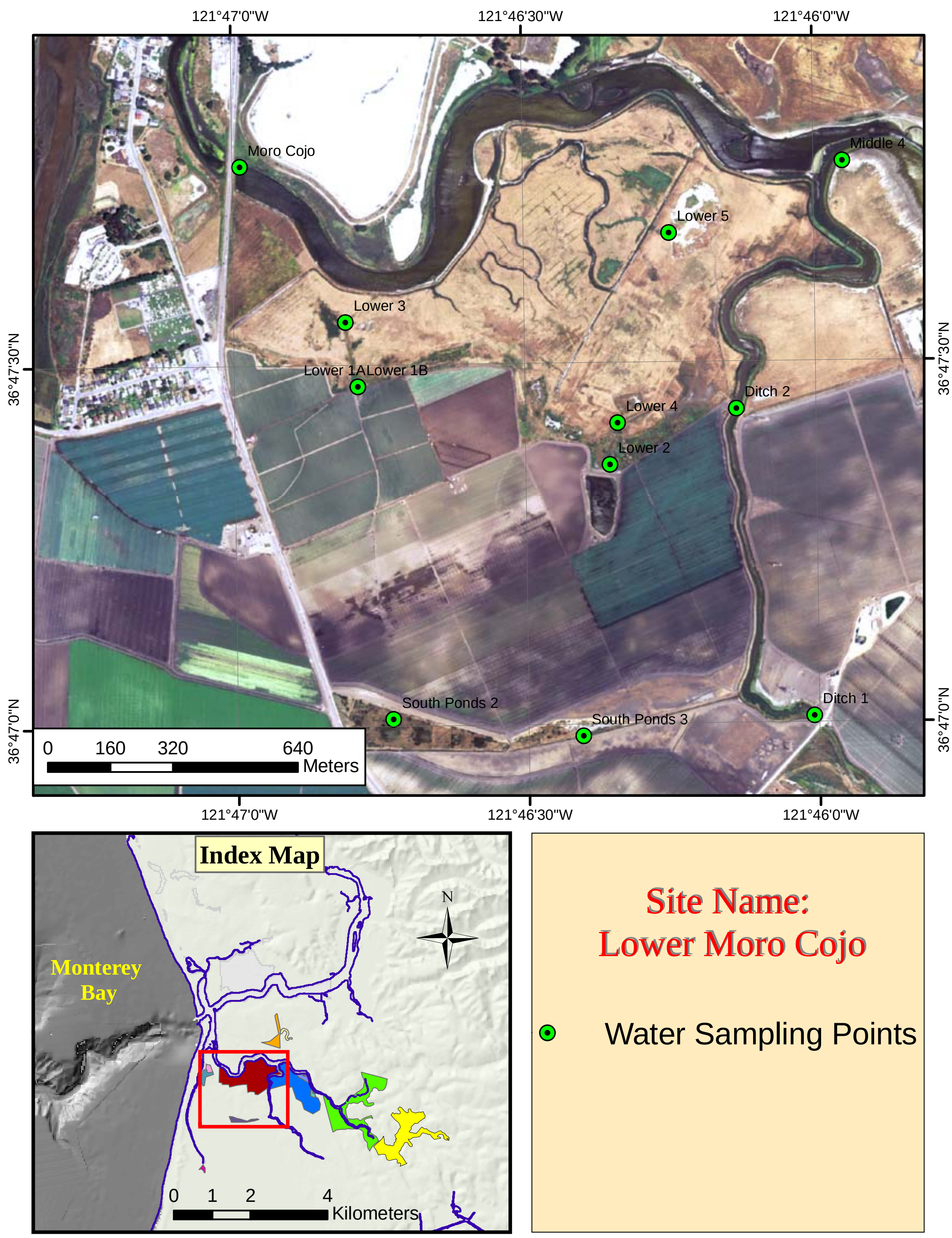
All items are included.

VII. CONCLUSIONS

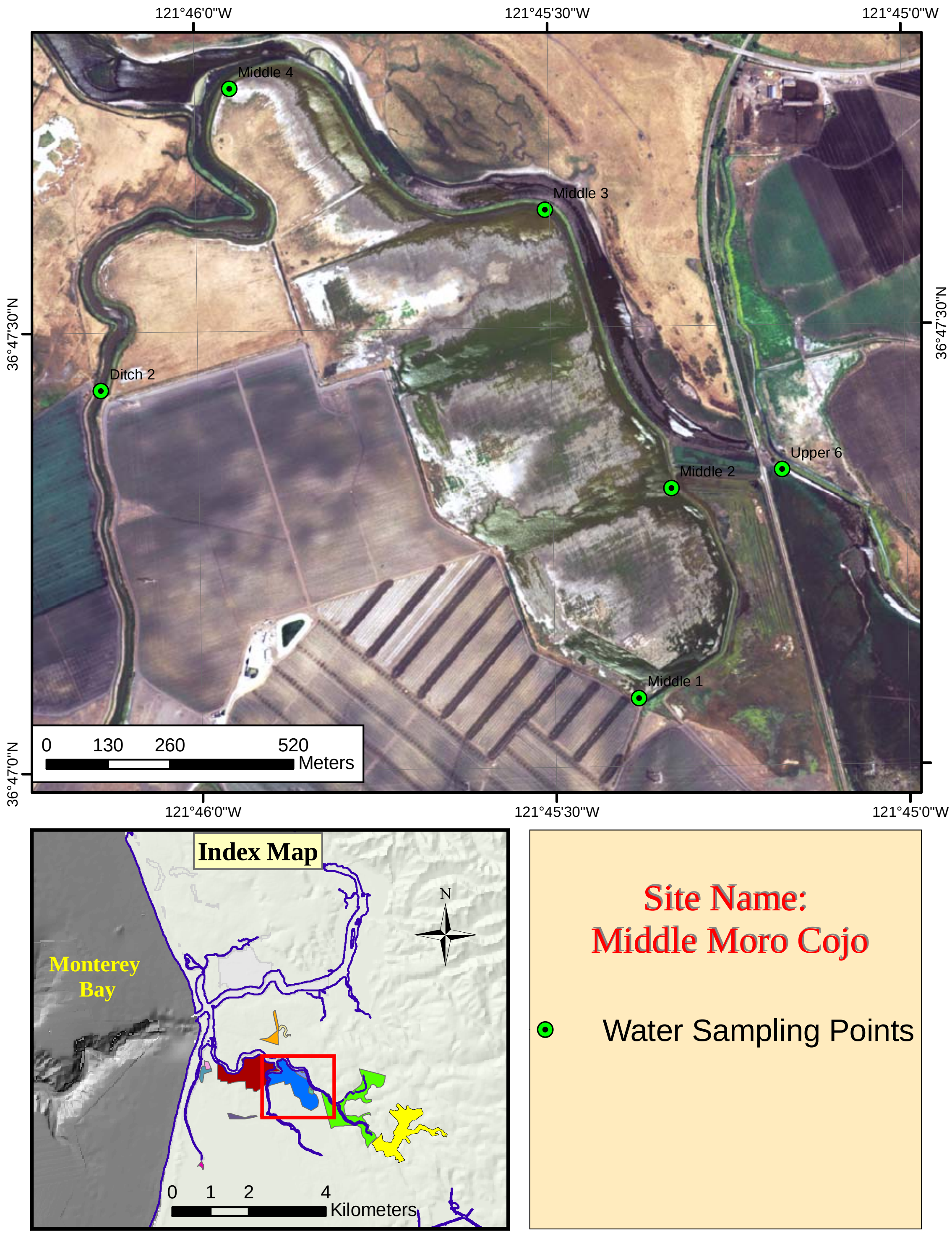
Overall our project was a great success. We were able to conduct large-scale restoration on the middle parcel, smaller restoration activities on other parcels throughout the Moro Cojo, work with landowners to put their property in conservation easements, conduct outreach, and obtain an extensive dataset on water quality in the Moro Cojo watershed. The water quality monitoring work conducted at the Middle Moro Cojo restoration site illustrates the ability of wetlands to reduce nitrate levels as water passes through a created wetland; thus, highlighting the efficacy of wetlands as BMP's for agricultural practices nitrate reduction. It is critical to note that this project would not have been accomplished with out the support and collaboration of landowners and farmers in the Moro Cojo Watershed. Ocean Mist Farms, Moon Glow Dairy, and the Monterey County Agriculture and Historical Land Conservancy provided access to their properties. The Elkhorn Slough Foundation provided access to the Middle Moro Cojo site. Foundation staff and board members were instrumental in collaborating and working with our us to design and implement the restoration efforts on the Middle Moro Cojo parcel, without there assistance and dedication this project would have failed.

VIII. APPENDICES

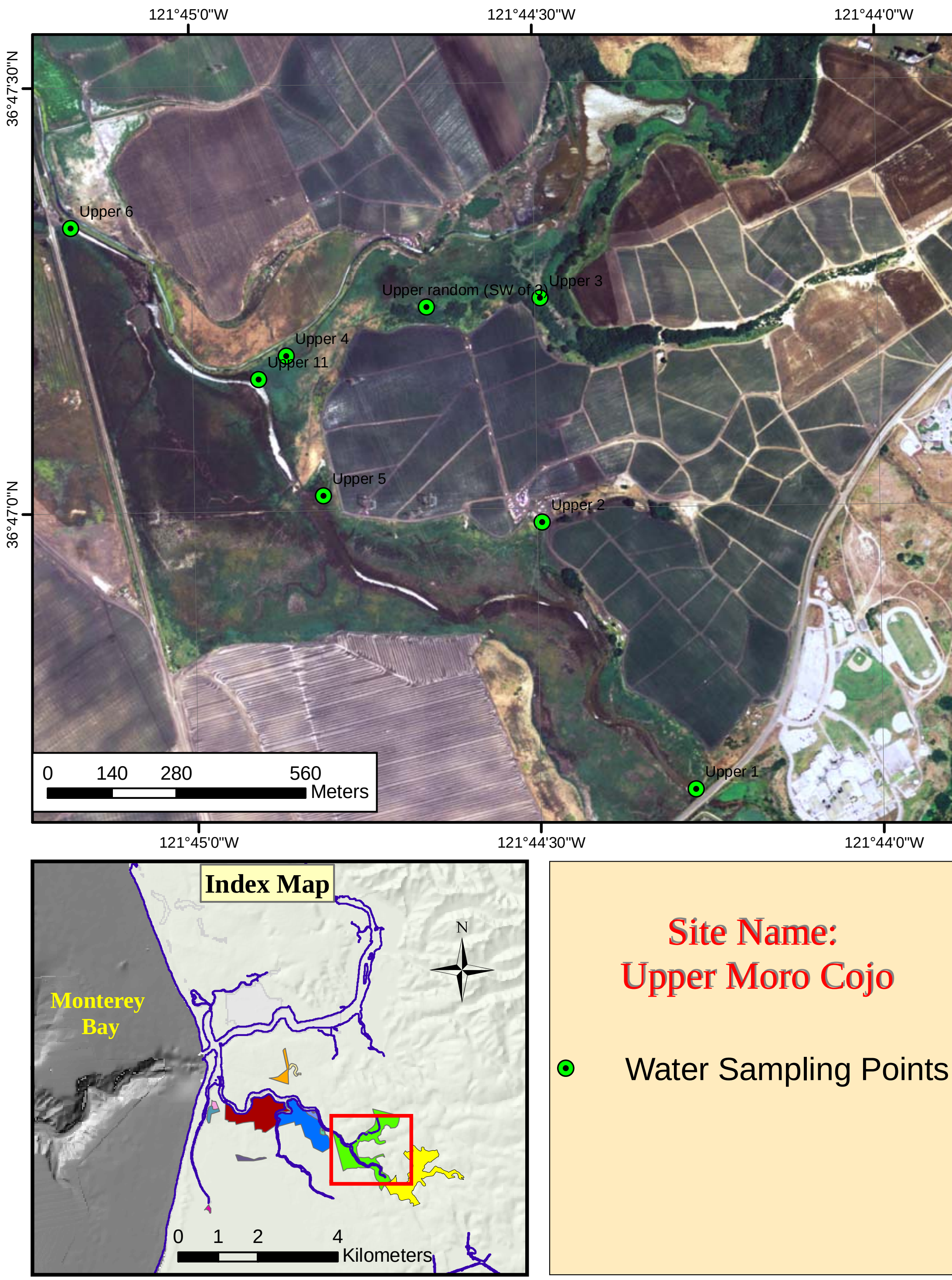
Appendix 1. Water quality sampling points for Lower Moro Cojo.



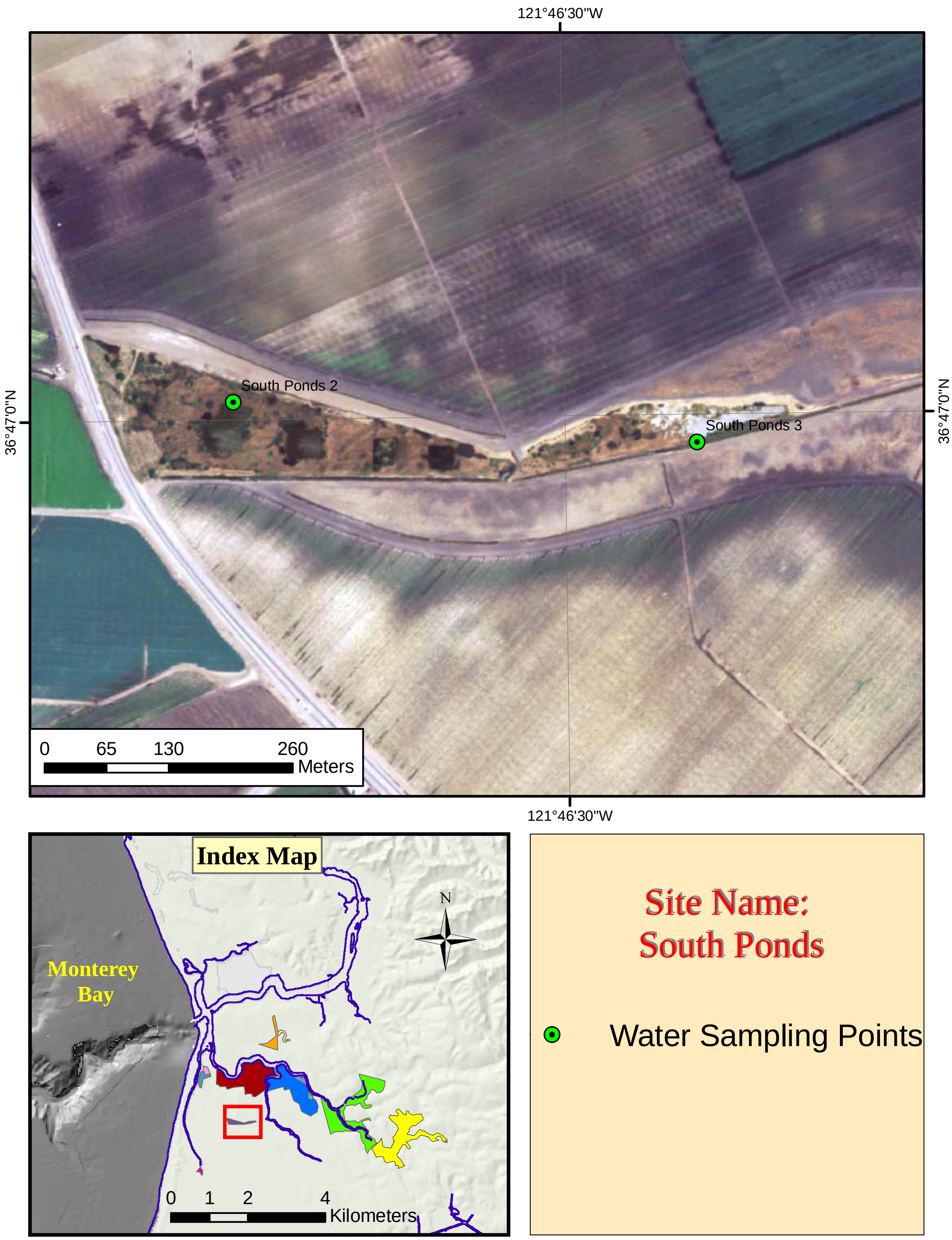
Appendix 2. Water quality sampling points for Middle Moro Cojo.



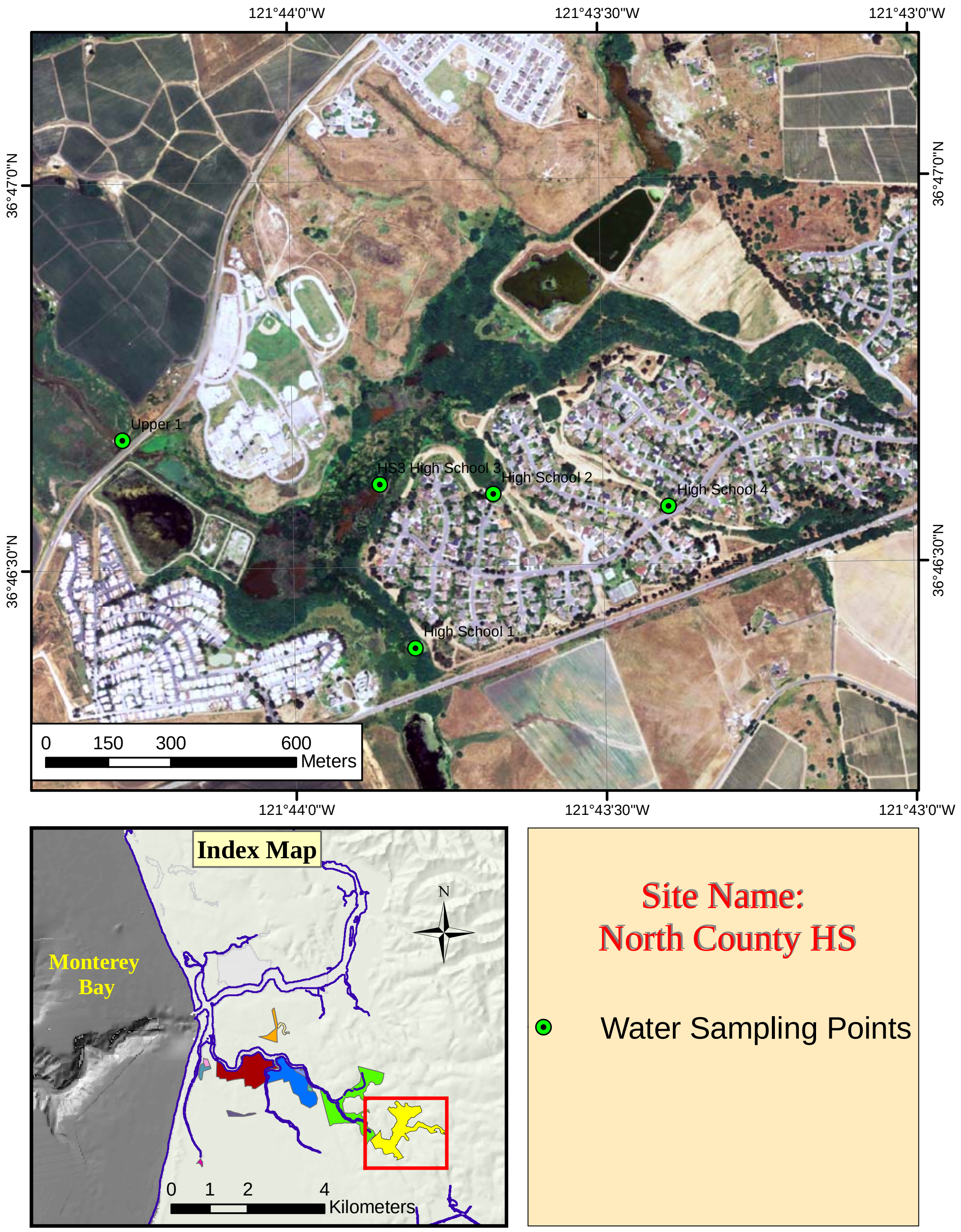
Appendix 3. Water quality sampling points for Upper Moro Cojo.



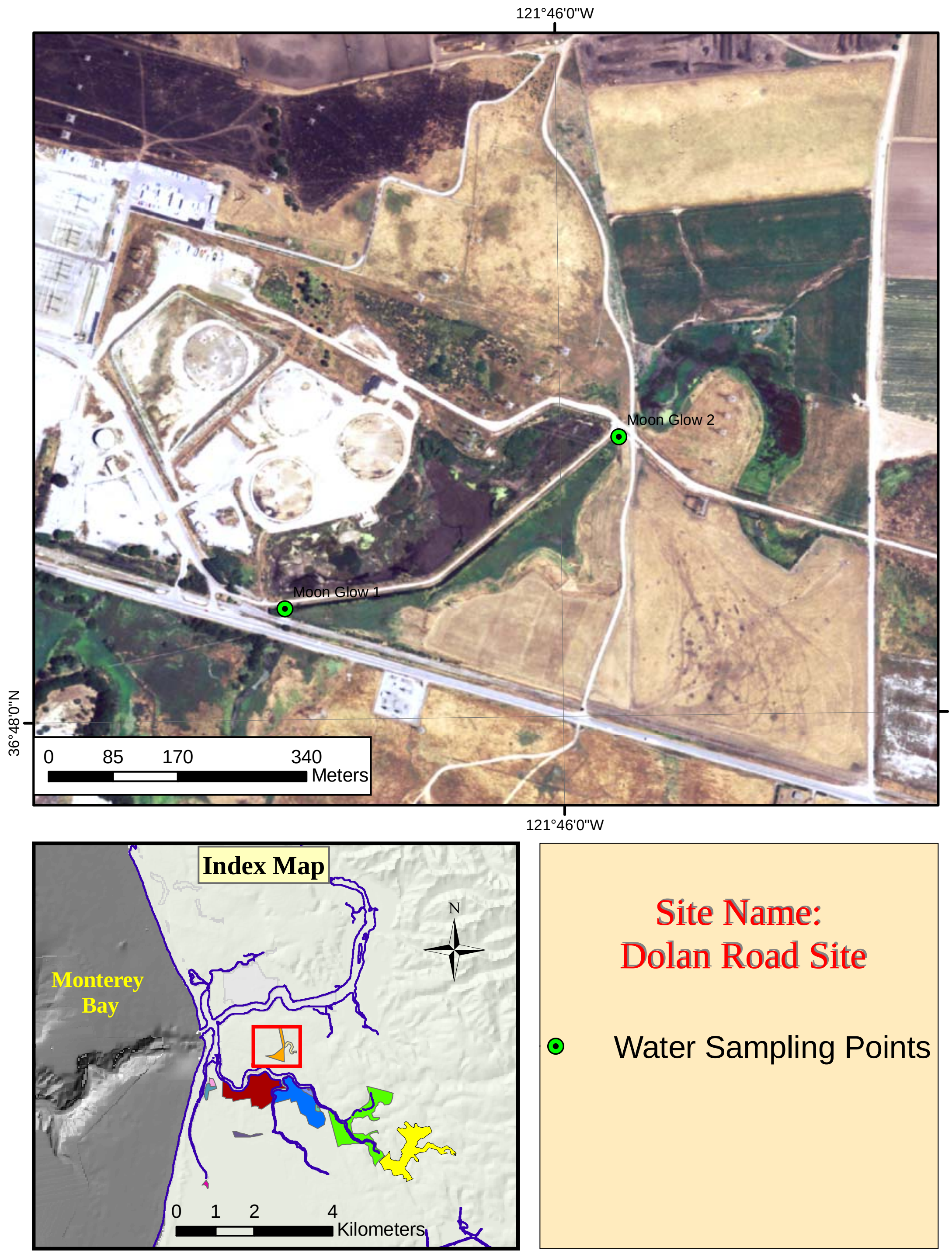
Appendix 4. Water quality sampling points for South Ponds.



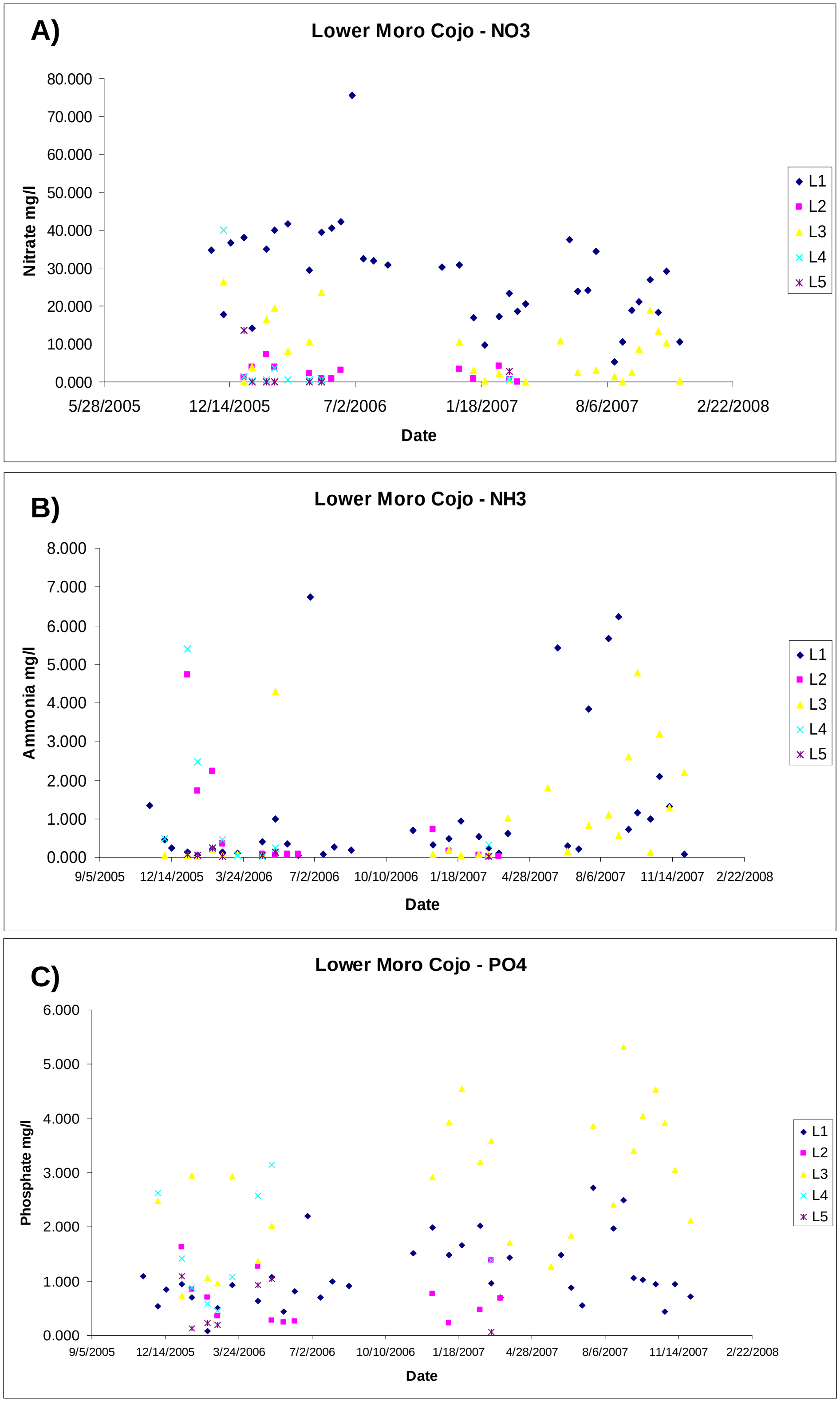
Appendix 5. Water quality sampling points for North County High School site.



Appendix 6. Water quality sampling points for the Dolan Road Site.

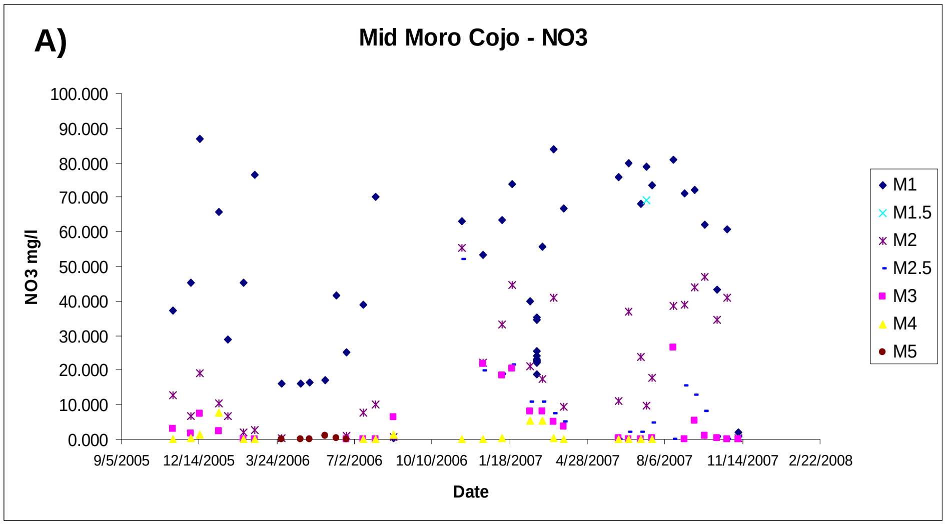


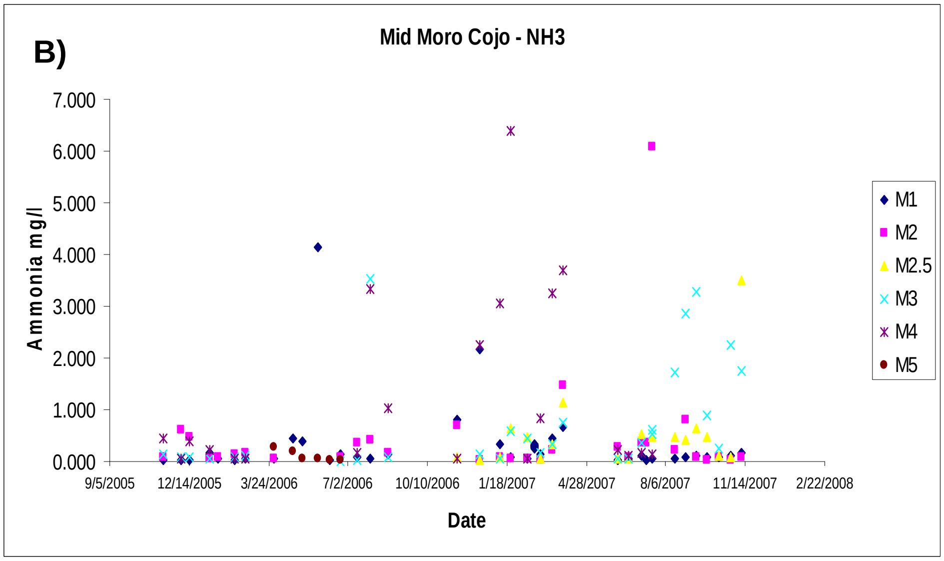
Appendix 7. Nutrients results from Lower Moro Cojo sites.

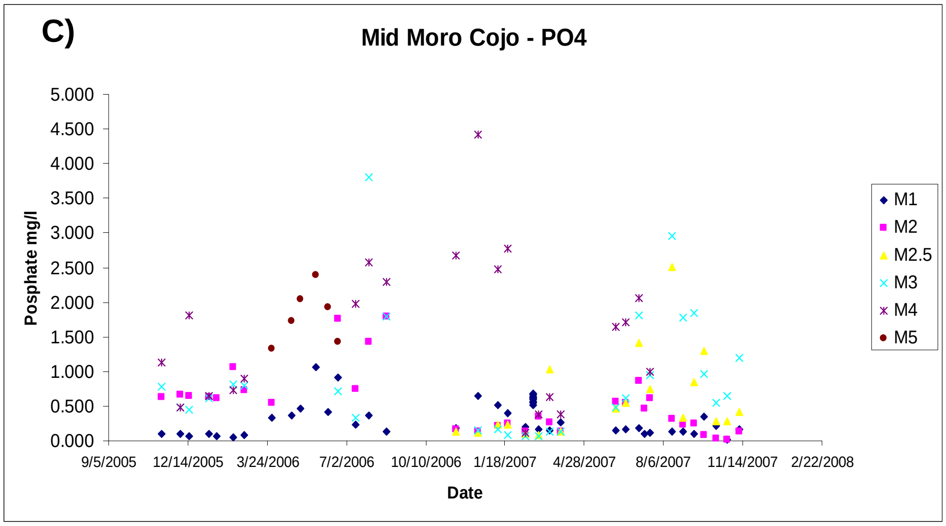


A) Nitrate, B) Phosphate, and C) Ammonia.

Appendix 8. Nutrients results from Middle Moro Cojo sites.

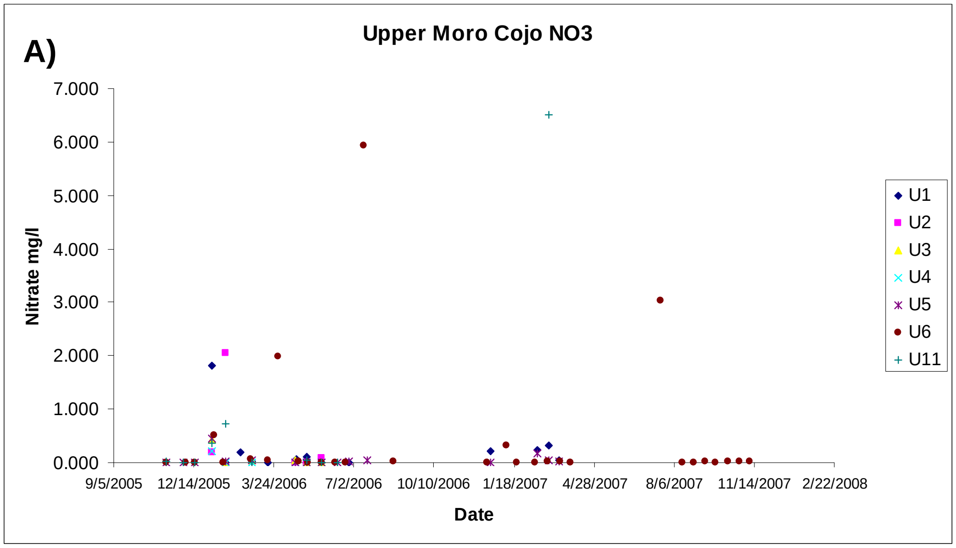


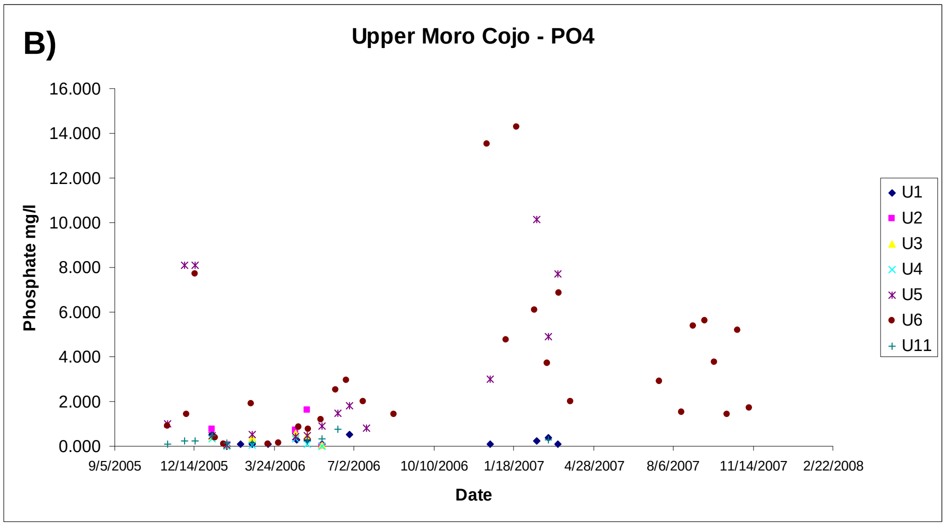


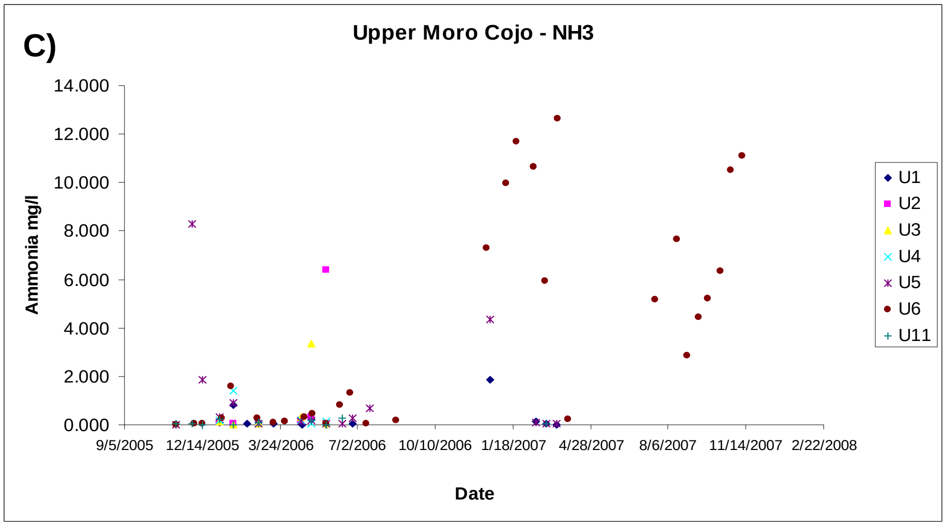


A) Nitrate, B) Phosphate, and C) Ammonia.

Appendix 9. Nutrients results from Upper Moro Cojo sites.

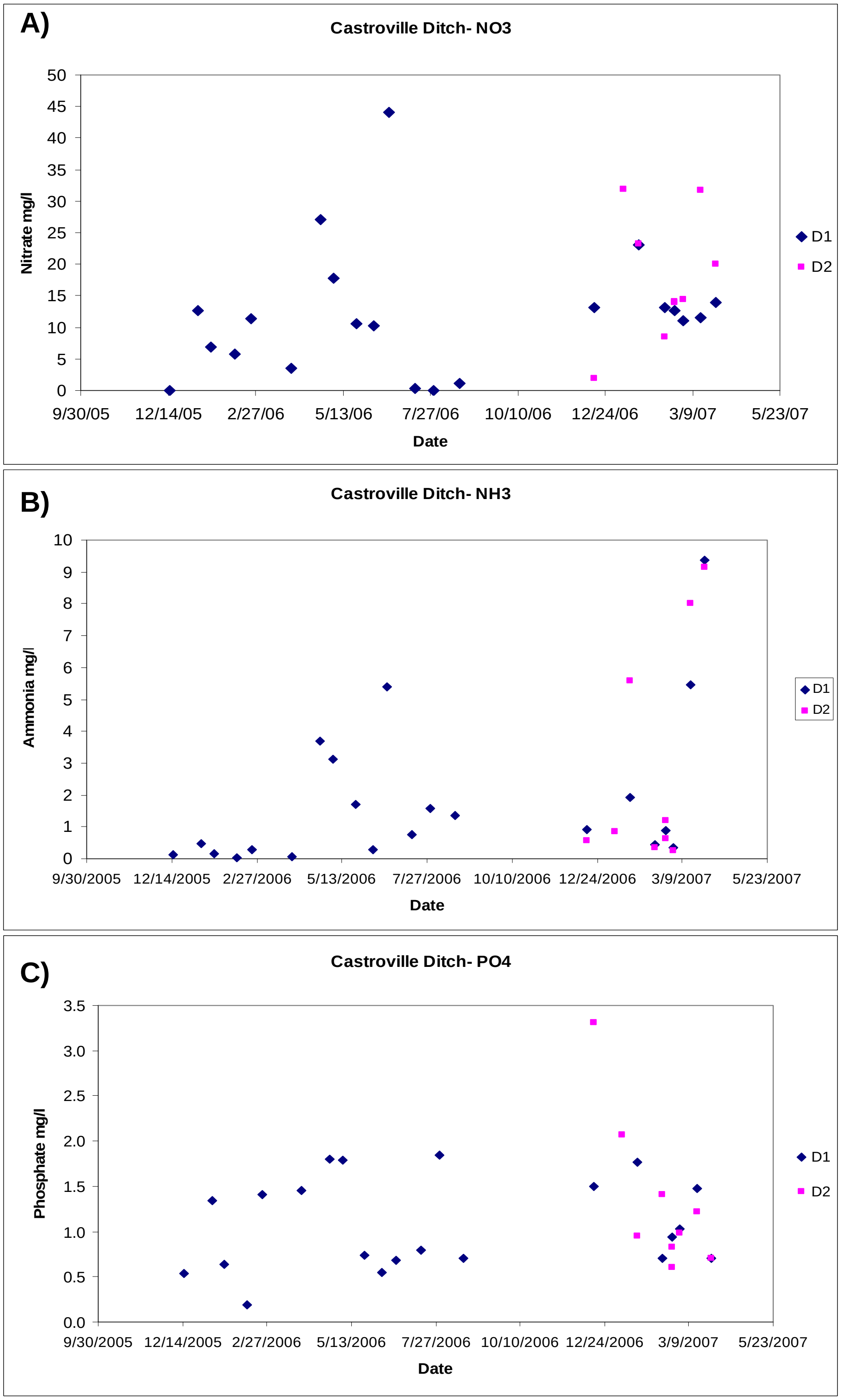






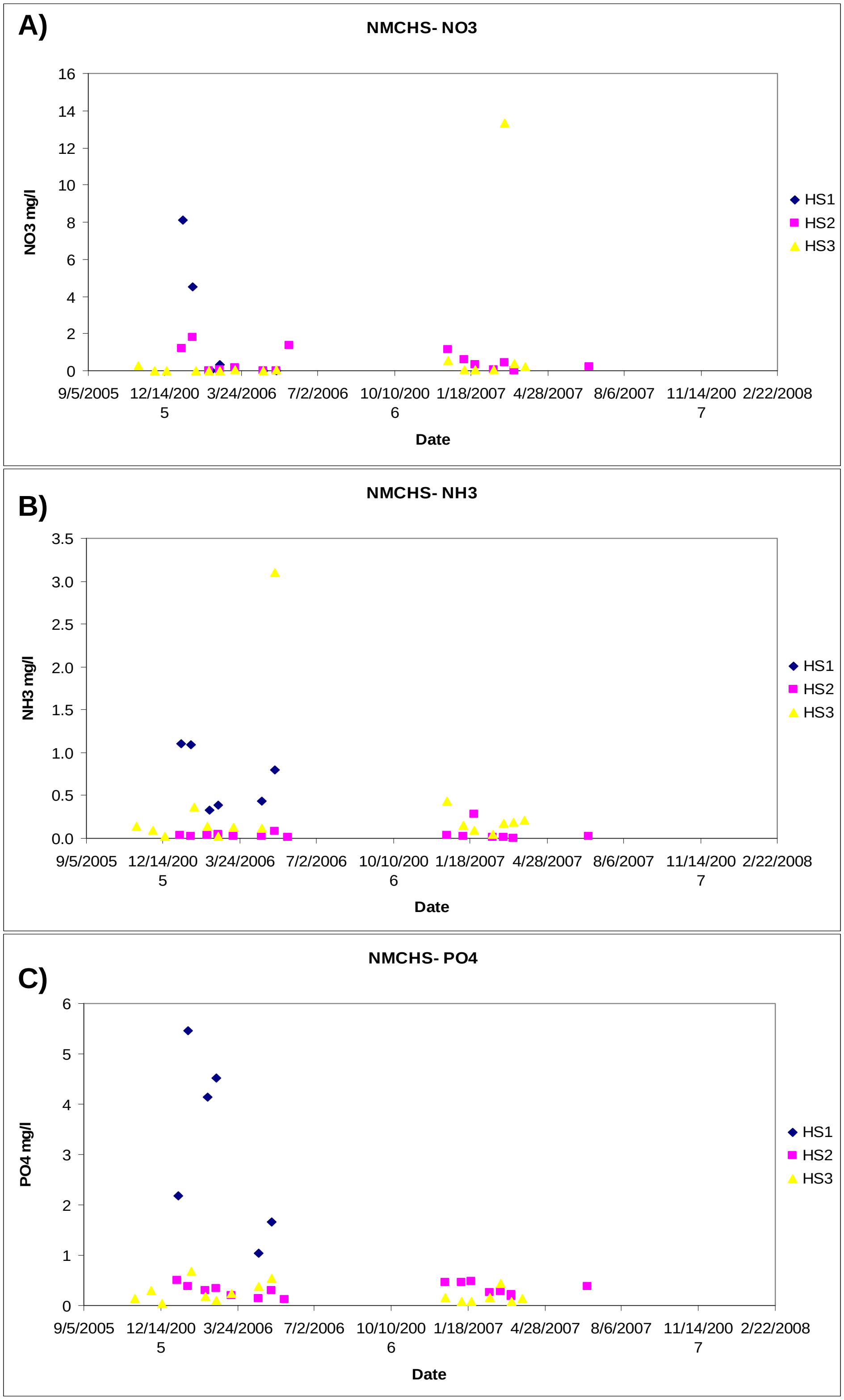
A) Nitrate, B) Phosphate, and C) Ammonia.

Appendix 10. Nutrients results from the Castroville Slough.



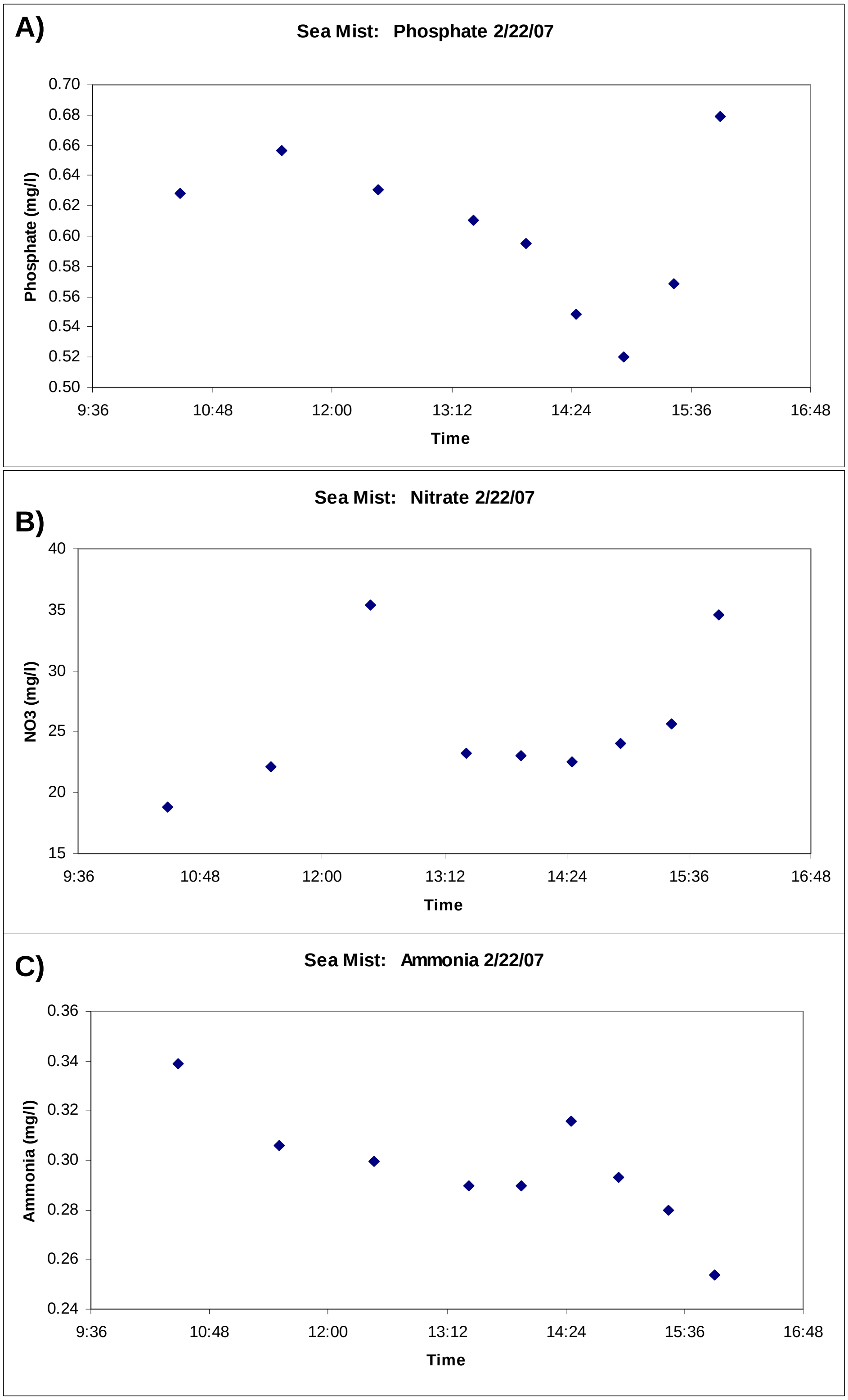
A) Nitrate, B) Phosphate, and C) Ammonia.

Appendix 11. Nutrients results from the North County High School.



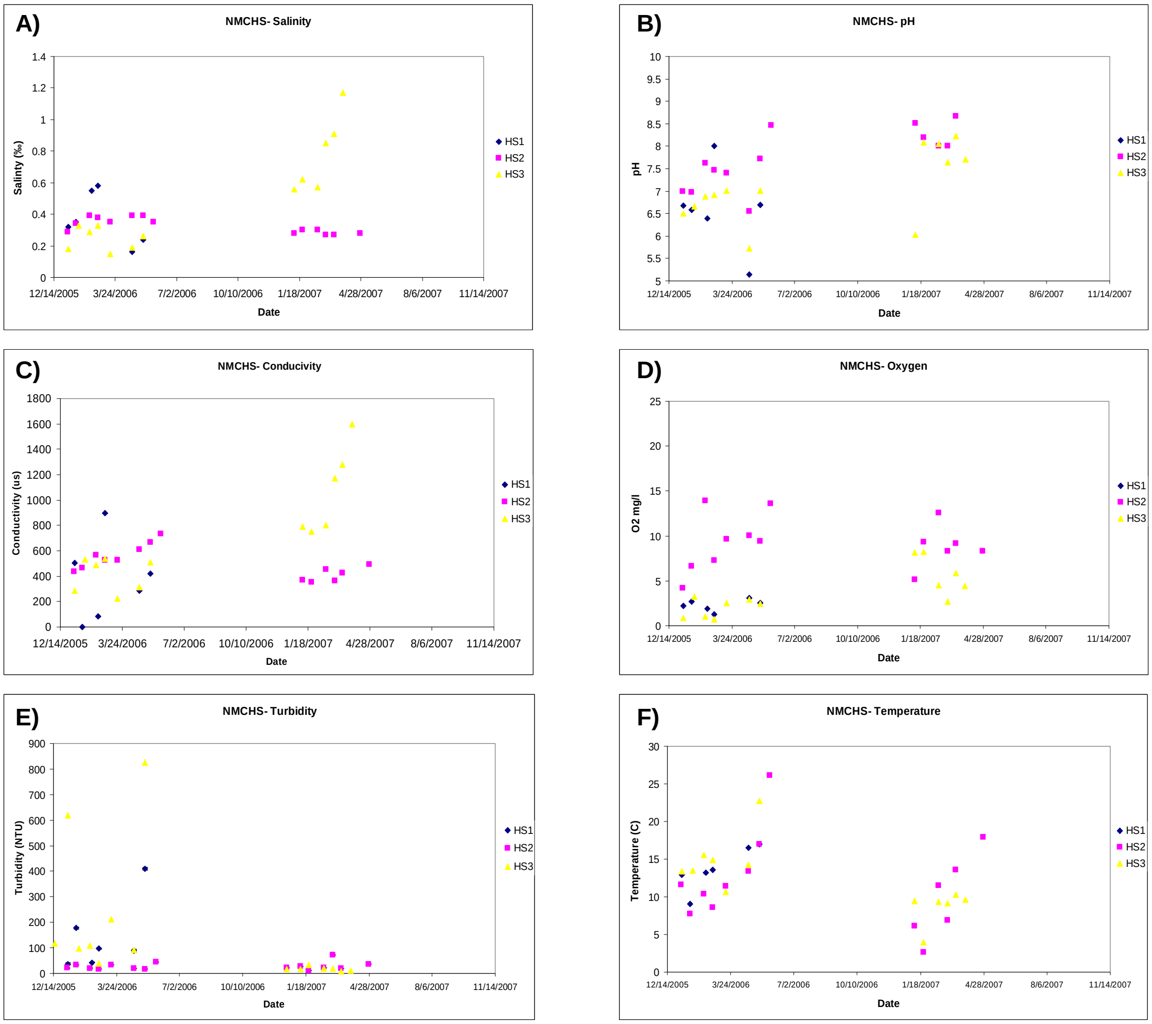
A) Nitrate, B) Phosphate, and C) Ammonia.

Appendix 12. Nutrients results from the Middle Moro Cojo (Sea Mist) over an approximately 6 hour period.



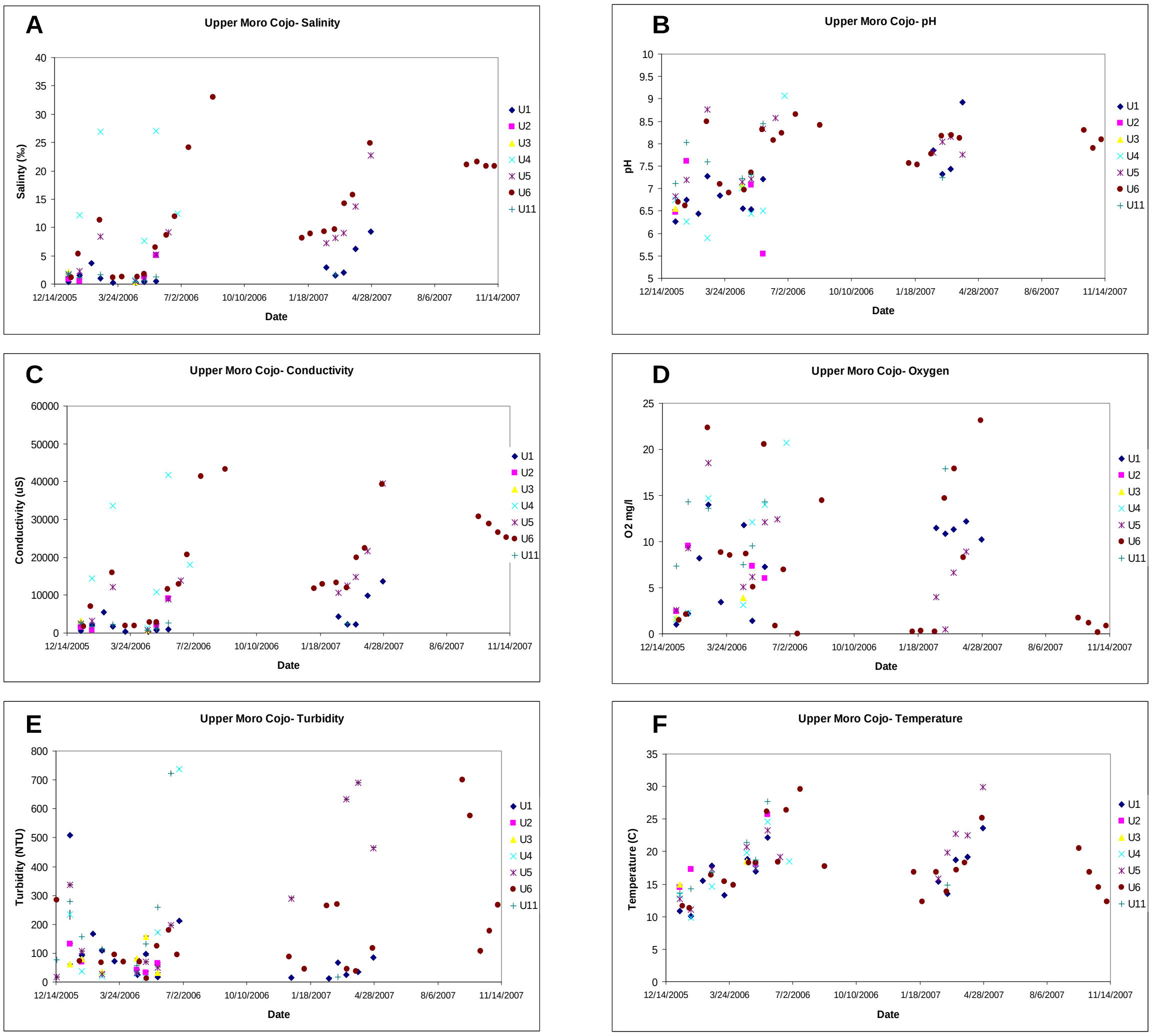
A) Nitrate, B) Phosphate, and C) Ammonia

Appendix 13. Water chemistry data for North County High School.



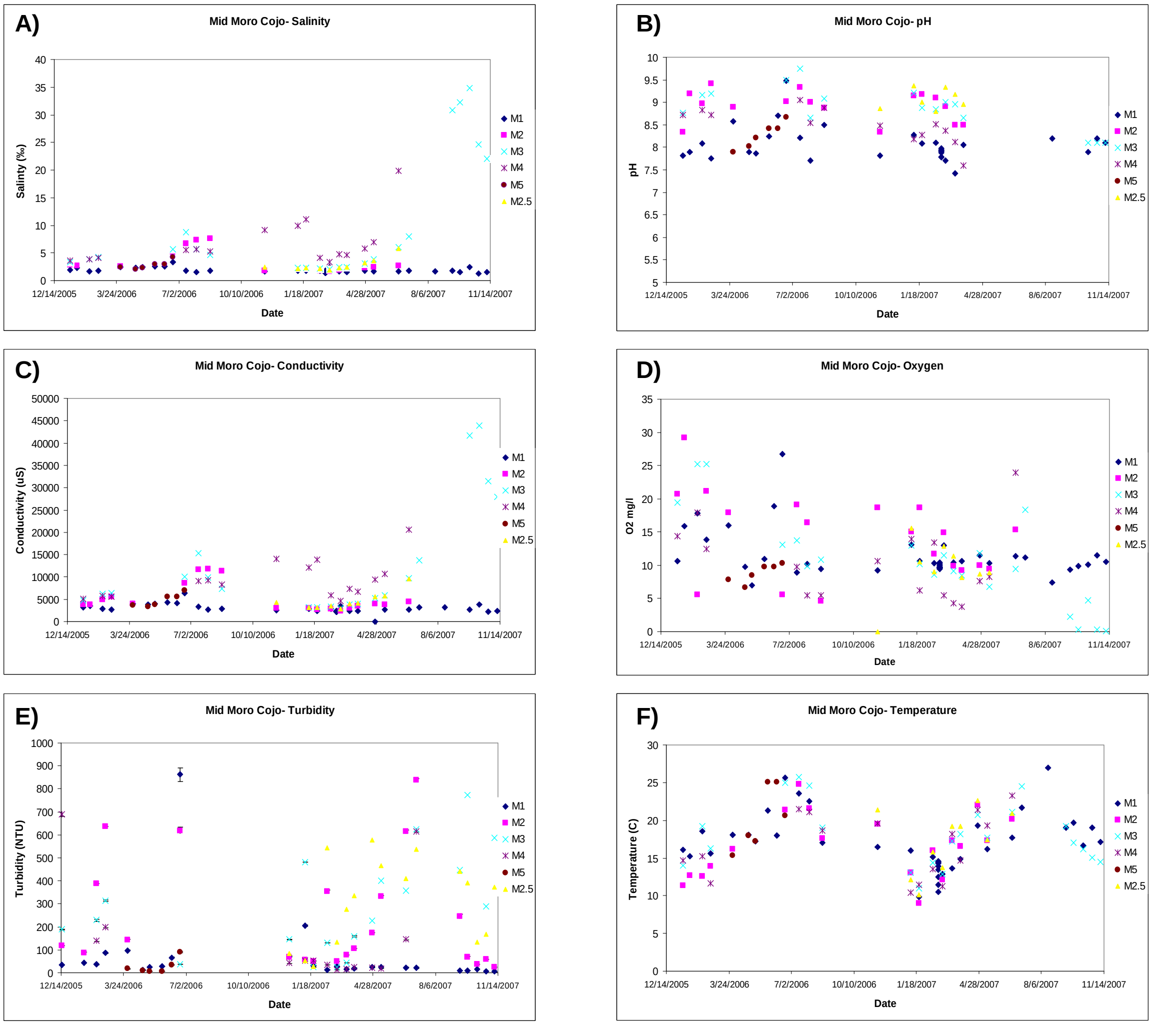
A) Salinity, B) pH, C) conductivity, D) Oxygen, E) Turbidity, F) Temperature.

Appendix 14. Water chemistry data for Upper Moro Cojo.



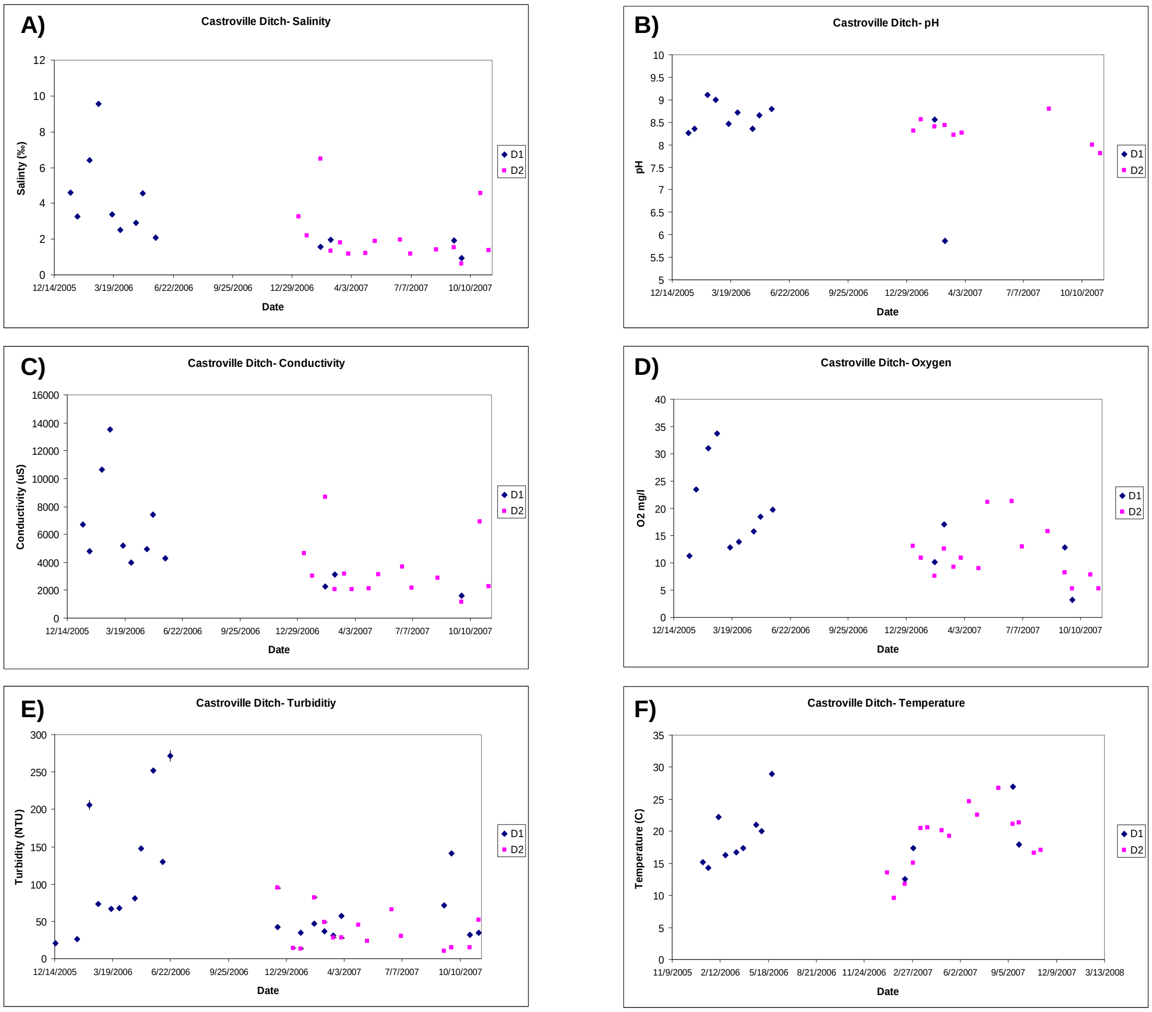
A) Salinity, B) pH, C) conductivity, D) Oxygen, E) Turbidity, F) Temperature.

Appendix 15. Water chemistry data for Middle Moro Cojo.



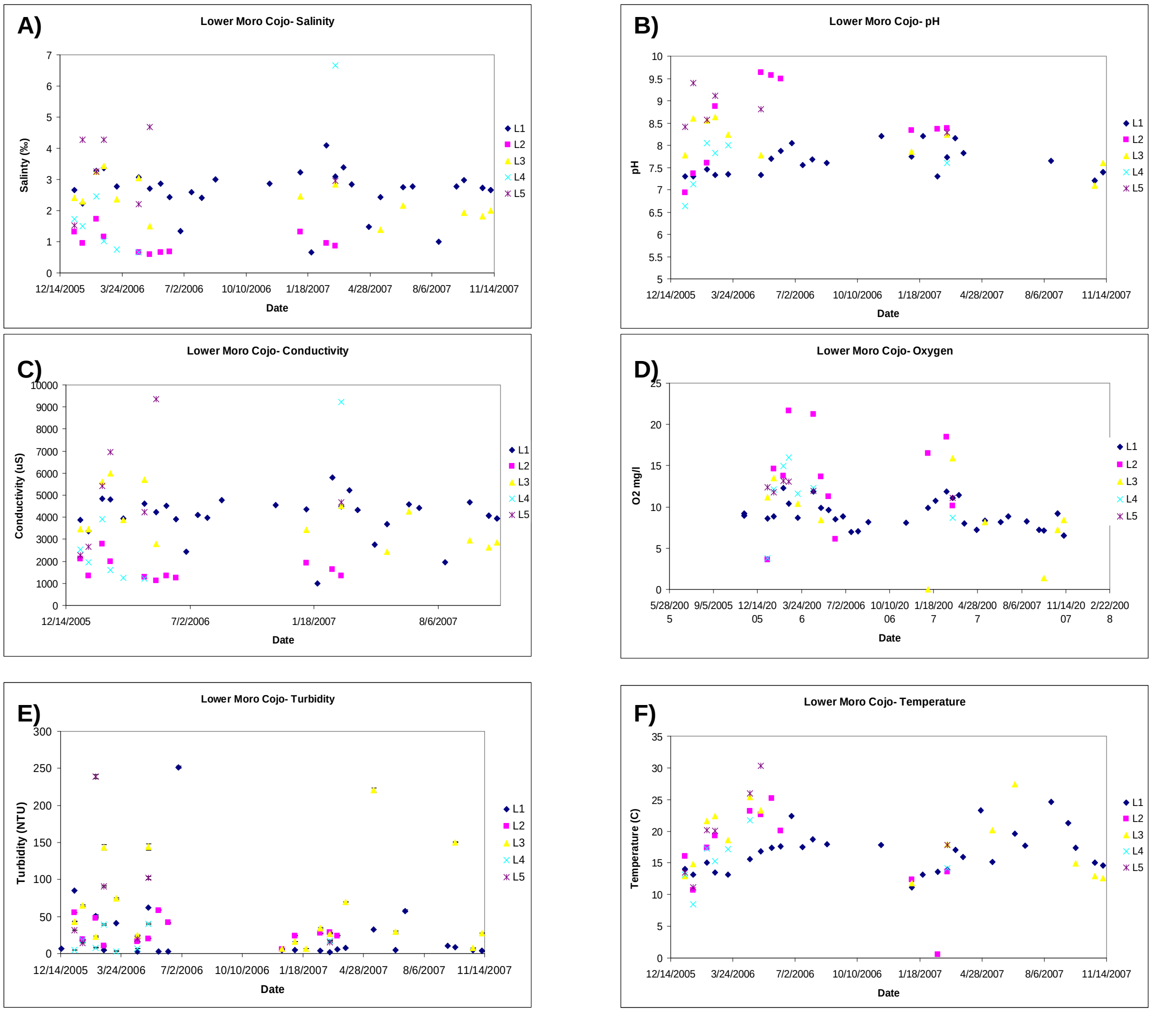
A) Salinity, B) pH, C) conductivity, D) Oxygen, E) Turbidity, F) Temperature.

Appendix 16. Water chemistry data for the Castroville Slough.



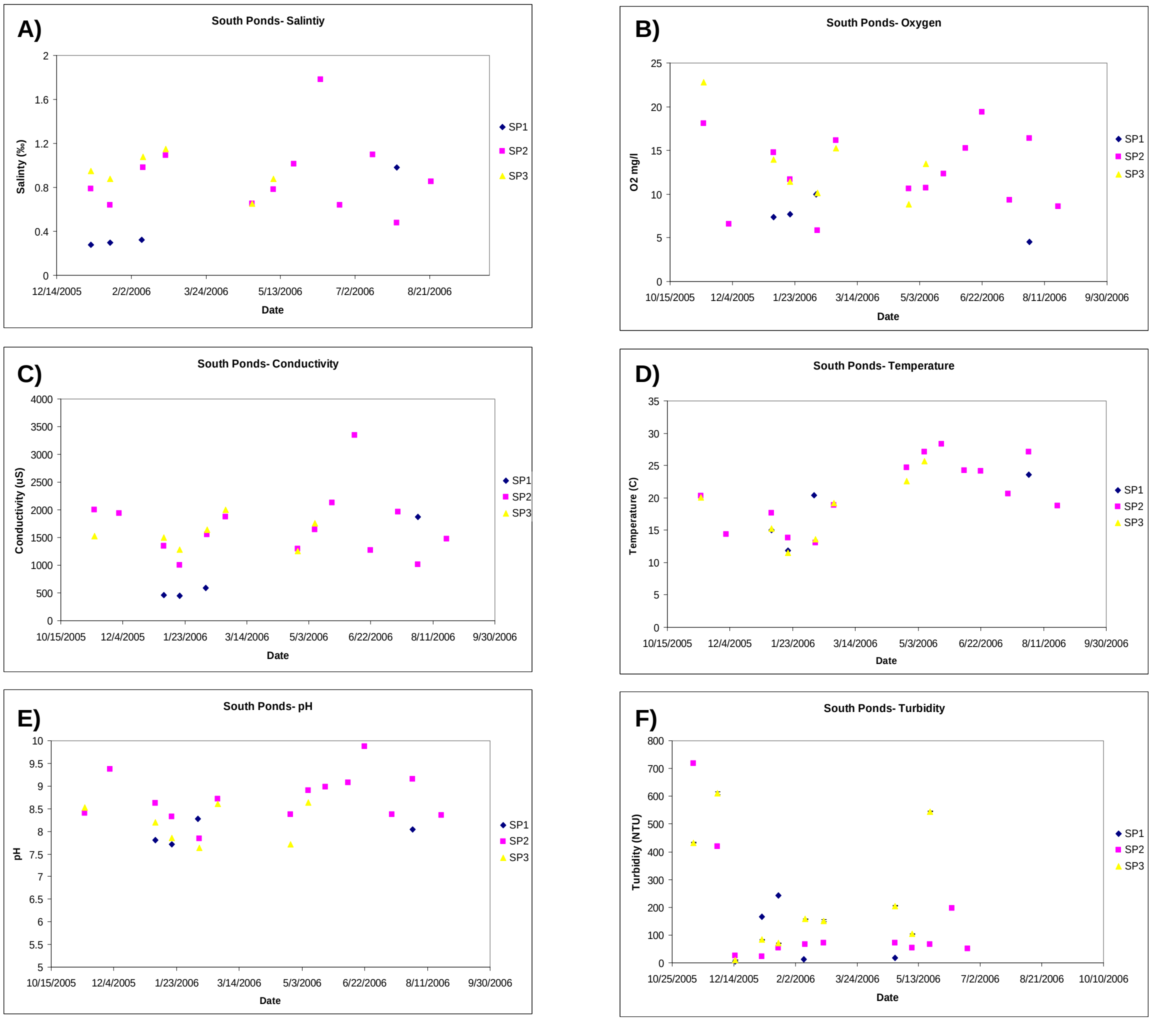
. A) Salinity, B) pH, C) conductivity, D) Oxygen, E) Turbidity, F) Temperature.

Appendix 17. Water chemistry data for Lower Moro Cojo.



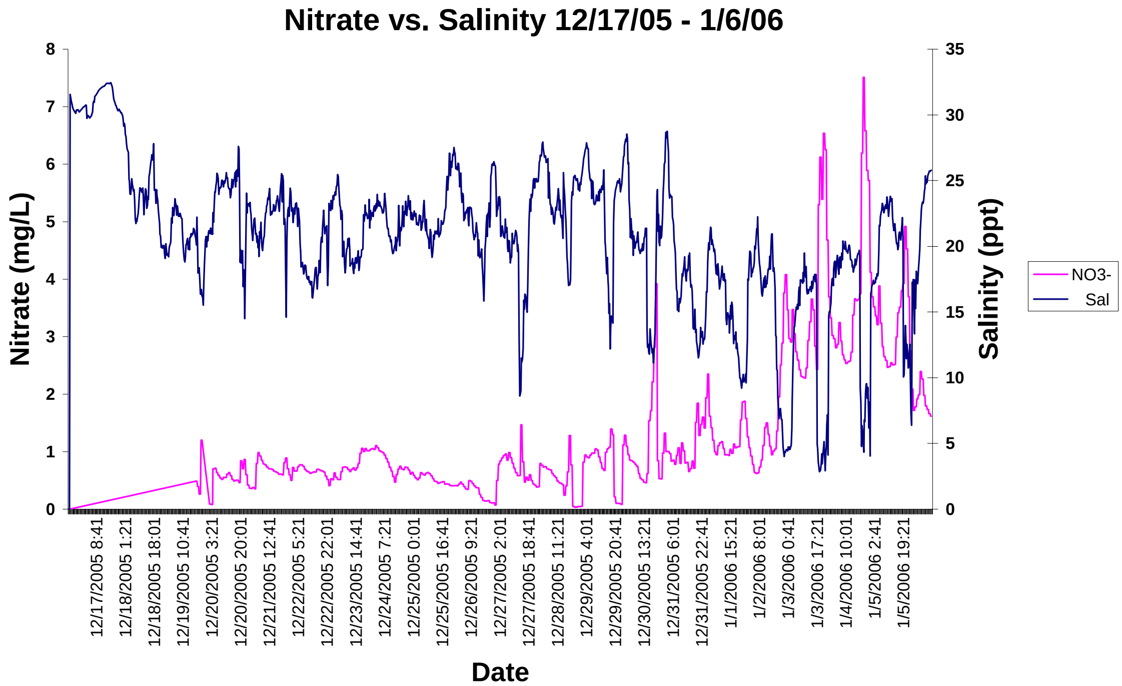
A) Salinity, B) pH, C) conductivity, D) Oxygen, E) Turbidity, F) Temperature.

Appendix 18. Water chemistry data for South Ponds.

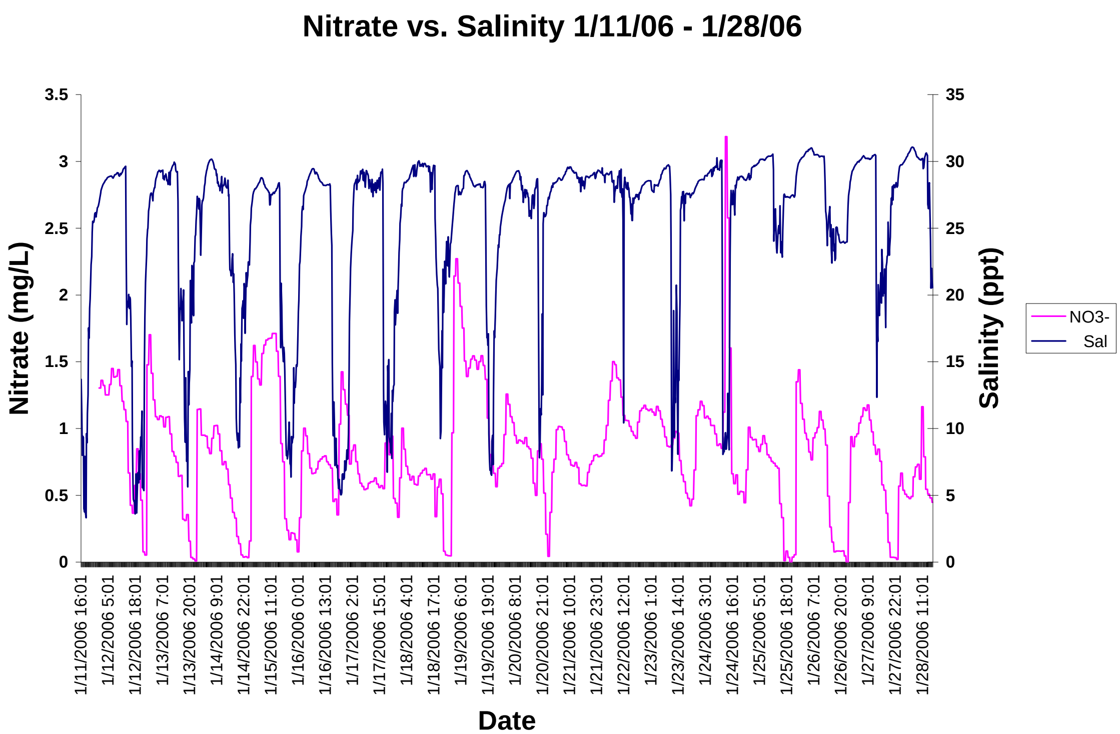


A) Salinity, B) pH, C) conductivity, D) Oxygen, E) Turbidity, F) Temperature.

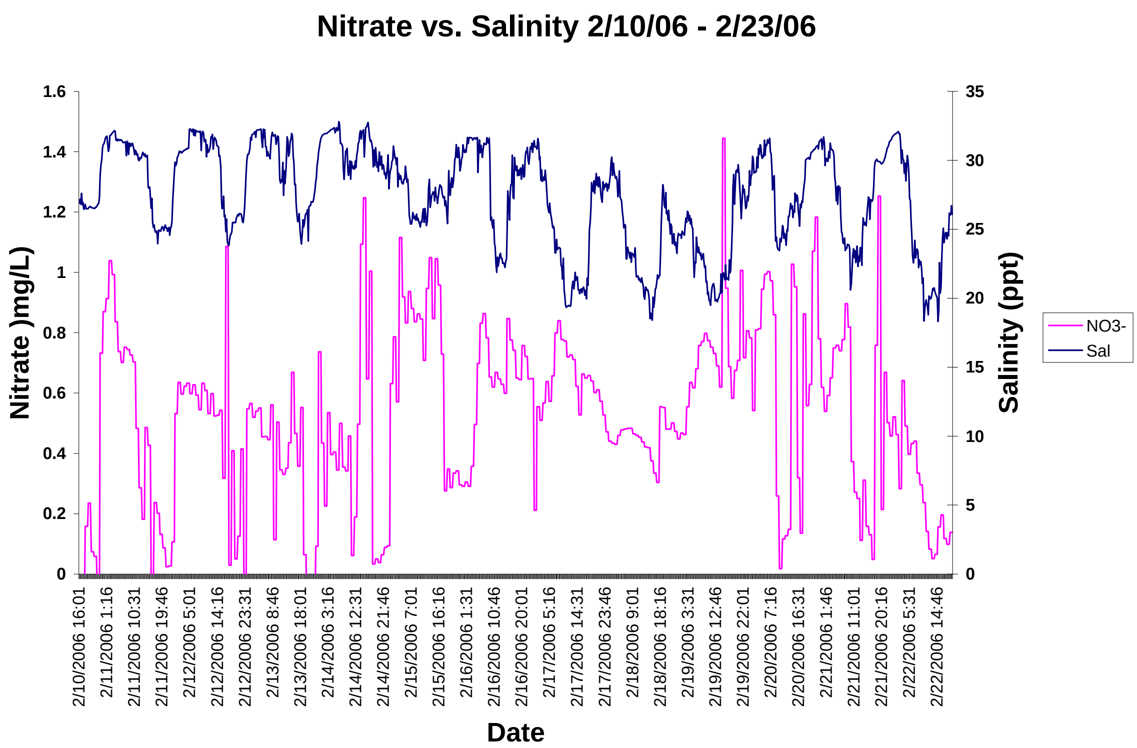
Appendix 19. Nitrate salinity relationships in the Moro Cojo from 12/17/05 – 1/6/06.



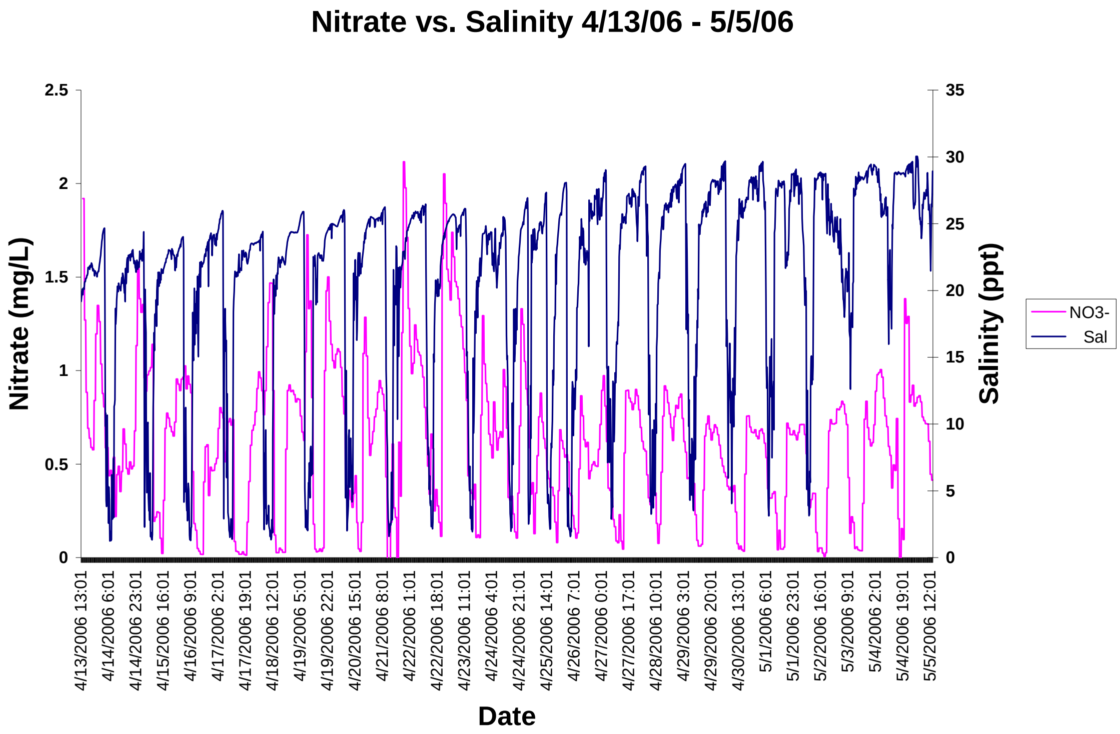
Appendix 20. Nitrate salinity relationships in the Moro Cojo from 1/11/06 – 1/28/06.



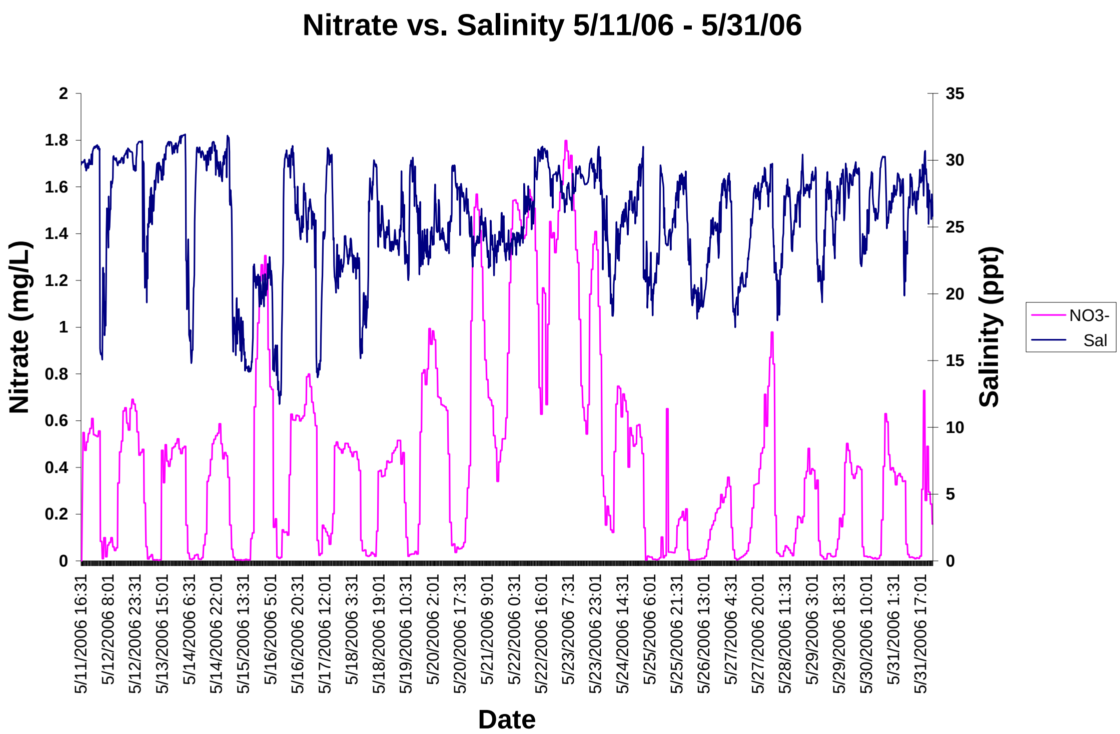
Appendix 21. Nitrate salinity relationships in the Moro Cojo from 2/10/06 – 2/23/06.



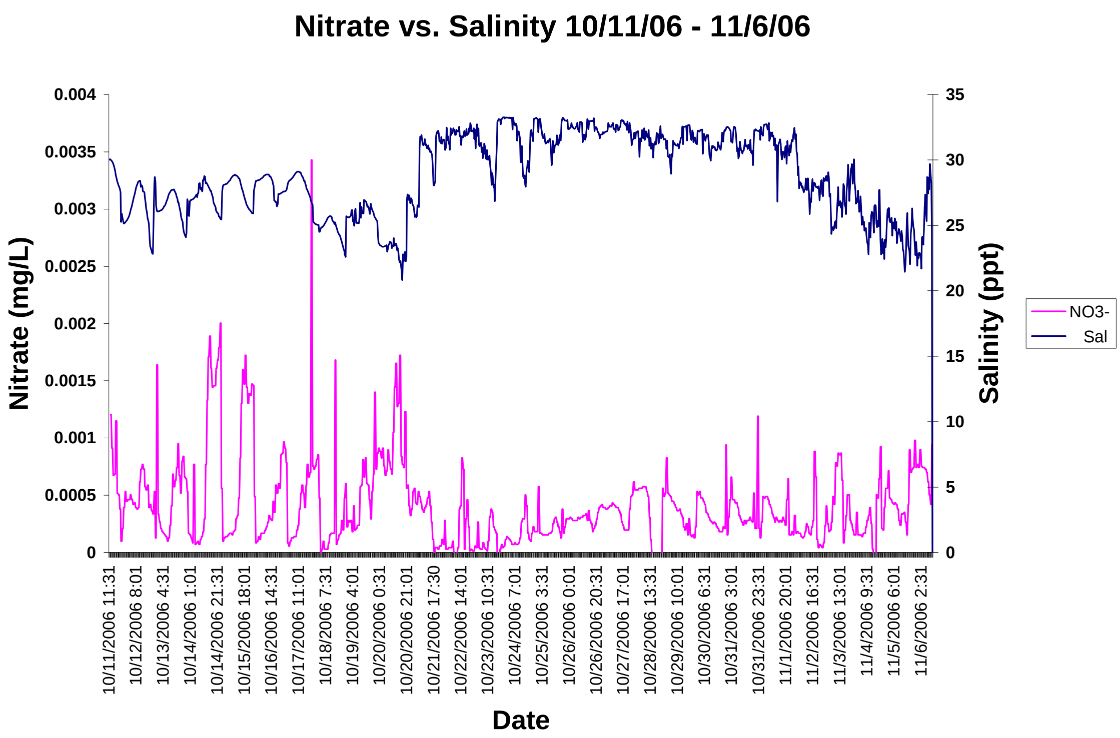
Appendix 22. Nitrate salinity relationships in the Moro Cojo from 4/13/05 – 5/5/06.



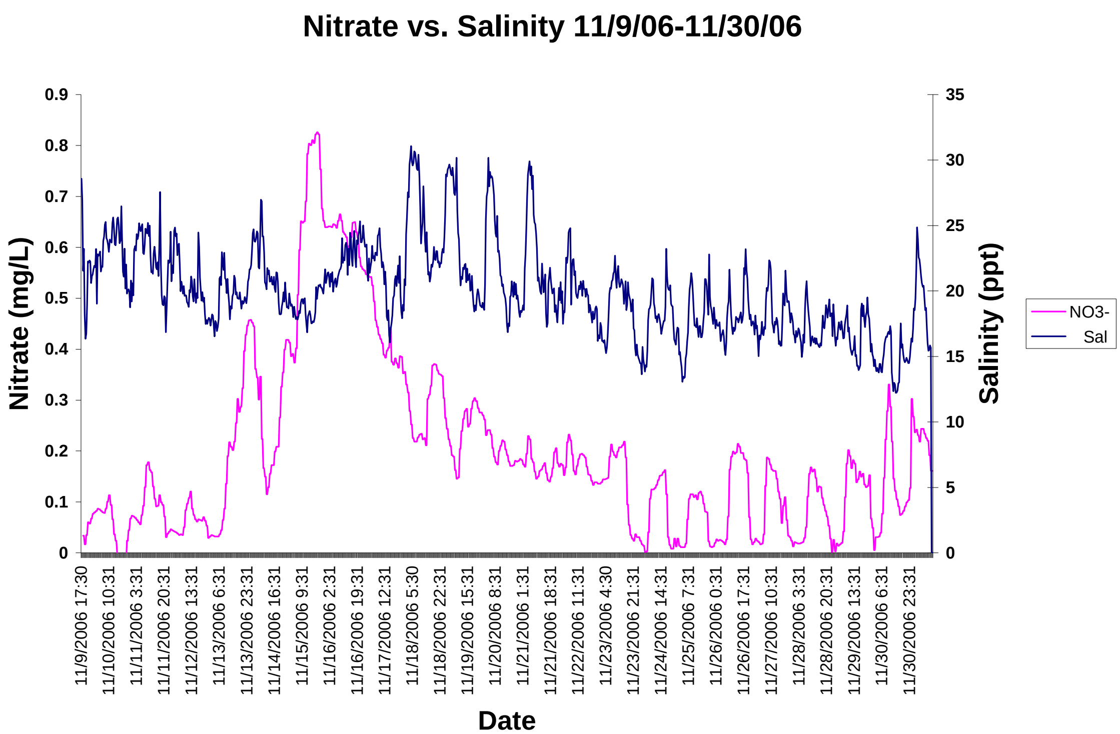
Appendix 23. Nitrate salinity relationships in the Moro Cojo from 5/11/05 – 5/31/06.



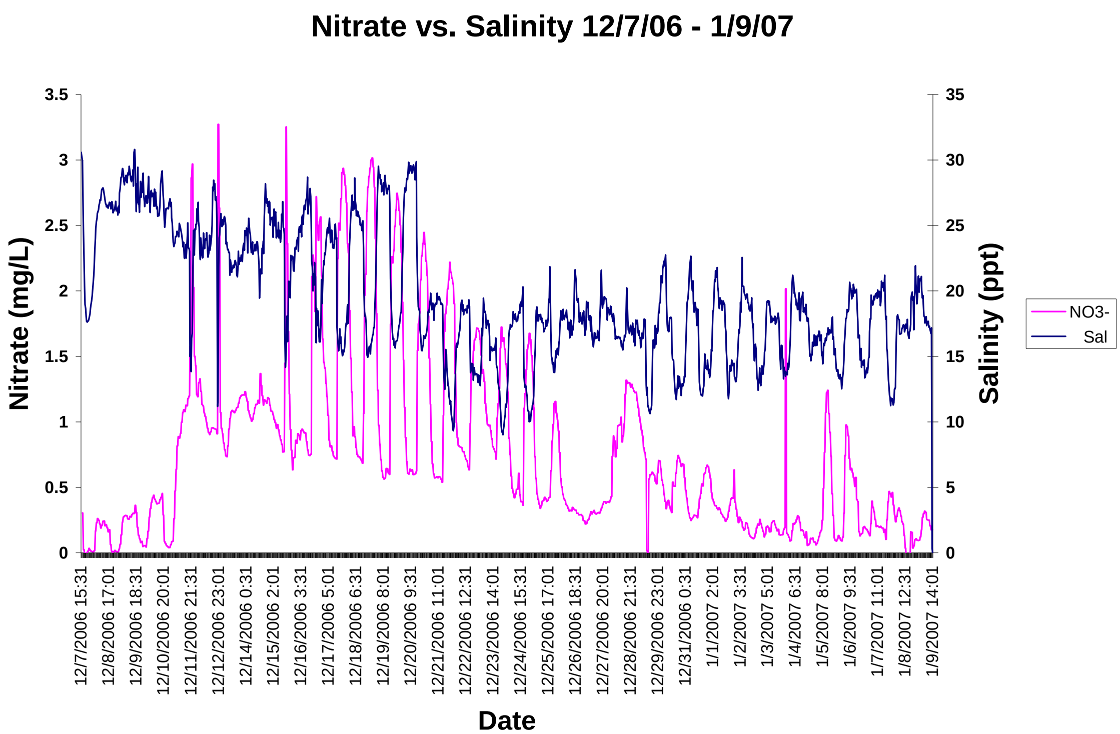
Appendix 24. Nitrate salinity relationships in the Moro Cojo from 10/11/05 – 11/6/06.



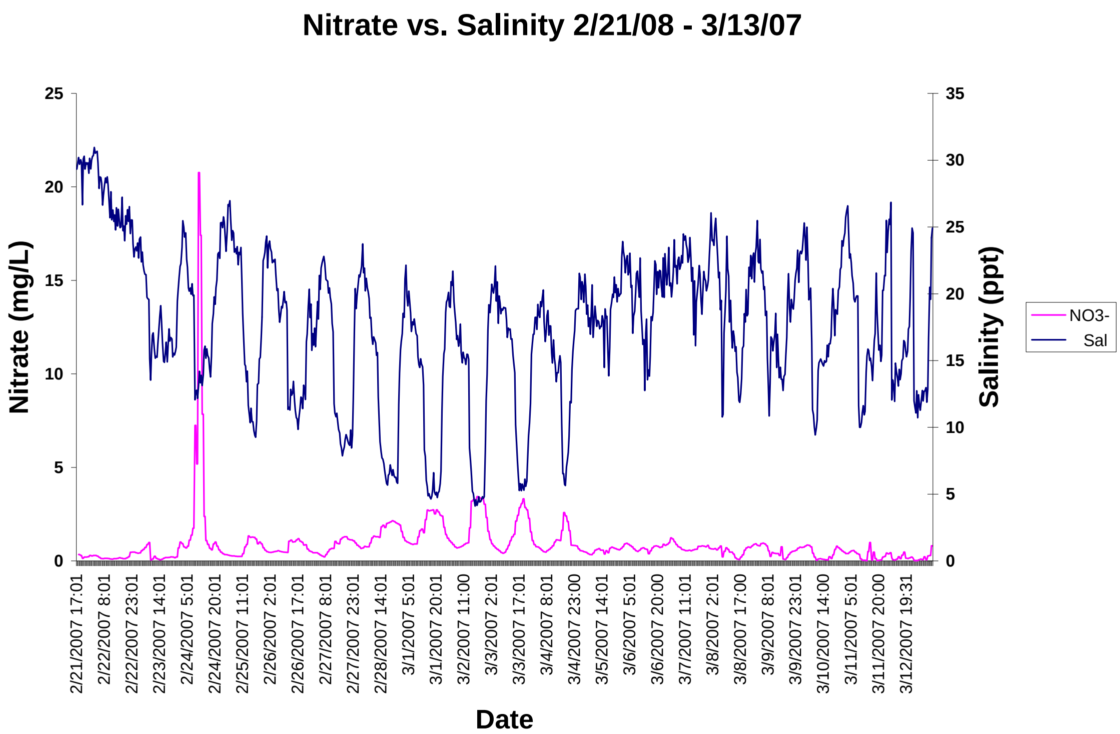
Appendix 25. Nitrate salinity relationships in the Moro Cojo from 11/9/05 – 1/30/06.



Appendix 26. Nitrate salinity relationships in the Moro Cojo from 12/7/65 – 1/9/07.



Appendix 27. Nitrate salinity relationships in the Moro Cojo from 2/21/07 – 3/13/07.



Appendix 28. Plant species list for Lower Moro Cojo.

Scientific name	Common Name
Acer negundo	box elder
Amsinckia menziesii var. *intermedia*	common fiddleneck
*Anagallis arvensis**	scarlet pimpernel
*Atriplex sembiccata**	Australian saltbush
Atriplex triangularis#	spearscale
*Brassica nigra**	black mustard
*Bromus catharticus**	rescue grass
*Bromus diandrus**	ripgut brome
*Bromus hordeaceus**	softchess brome
*Capsella bursa-pastoris**	shepherd's purse
*Carduus pycnocephalus**	Italian thistle
*Chamomilla suaveolens**	pineapple weed
*Chenopodium album**	lamb's quarters
*Cirsium vulgare**	bull thistle
Claytonia perfoliata	miner's lettuce
*Conium maculatum**	poison hemlock
Conyza canadensis	horseweed
*Cotula coronopifolia**	brass buttons
Cyperus eragrostis	tall cyperus
*Digitaria sanguinalis**	crab-grass
Distichlis spicata	salt grass
Eleocharis macrostachya	pale spike-rush
Epilobium ciliatum	California willow-herb
*Erodium cicutarium**	red-stemmed filaree
Frankenia salina	alkali heath
Helenium puberulum	sneezeweed
Heliotropium curassavicum	Chinese pusley
Hordeum brachyantherum	meadow barley
Hordeum marinum ssp. *gussoneanum**	Mediterranean barley
Hordeum murinum ssp. *leporinum**	barnyard foxtail
Juncus bufonius	common toad rush
Juncus mexicanus	Mexican rush
Lasthenia californica	coast goldfields

Scientific name	**Common Name**
Lemna minor	lesser duckweed
*Lepidium pinnatifidum**	pepper-grass
Leymus triticoides	creeping wildrye
*Lobularia maritima**	alyssum
*Lolium multiflorum**	Italian rye
*Lolium perenne**	perennial rye
*Lotus corniculatus**	bird's-foot trefoil
Lupinus arboreus	yellow bush lupine
Lupinus nanus	sky lupine
*Lythrum hyssopifolium**	grass poly

Appendix 29. Plant species list for Middle Moro Cojo.

Scientific Name	Common Name
Atriplex triangularis	Spearscale
Brassica nigra	Mustard
Bromus diandris	Ripgut Brome
Chenopodium macrospermum var. *halophilum*	Coast Goosefoot
Conium maculatum	Poison Hemlock
Cotula coronopifolia	Brass Buttons
Distichlis spicata	Salt Grass
Epilobium ciliatum	Willow Herb
Frankenia salina	Alkali Heath
Hordeum marinum ssp. *gussoneanum*	Mediterranean Barley
Jaumea carnosa	Fleshy Jaumea
Lactuca serriola	Prickly Lettuce
Lemna minor	Duckweed
Lolium multiflorum	Italian Rye
Lythrum californicum	California Loosestrife
Lythrum hyssopifolium	Grass Poly
Medicago polymorpha	Bur-clover
Picris echioides	Oxtongue Thistle
Polypogon monspeliensis	Rabbit's Foot Grass
Raphanus sativus	Radish
Rumex crispus	Curly Dock
Rumex maritimus	Golden Dock
Salicornia virginica	Pickleweed
Sonchus asper	Sow Thistle
Spergularia bocconii	Bocconi's Sand Spurry

Appendix 30. Plant list for Upper Moro Cojo.

Scientific Name	Common Name
Anagallis arvensis	Scarlet Pimpernel
Anthemis cotula	Dog Fennel (Mayweed)
Anthemis cotula	Dog Fennel (Mayweed)
Artemesia biennis	Biennial Wormwood
Atriplex triangularis	Spearscale
Baccharis douglasii	Douglas' (Marsh) Baccharis
Baccharis pilularis	Coyote Bush
Berula erecta	Cutleaved Water Parsnip
Brassica nigra	Mustard
Carex barbarae	Santa Barbara Sedge
Chenopodium ambrosioides	Mexican Tea
Chenopodium macrospermum var. halophilum	Coast Goosefoot
Chenopodium murale	Nettle-leaved Goosefoot
Chenopoduim macrospermum halophilum	Coast Goosefoot
Circium vulgare	Bull Thistle
Conium maculatum	Poison Hemlock
Conyza canadensis	Horseweed
Cotula coronopifolia	Brass Buttons
Cyperus eragrostis	Nutsedge
Distichlis spicata	Salt Grass
Eleocharis macrostachya	Spike Rush
Epilobium ciliatium	Willow Herb
Frankenia salina	Alkali Heath
Gnaphalium straminium	Cotton Batting Plant
Heliotropium curassavicum	Chinese Pusley
Juncus mexicanus	Mexican Rush
Juncus patens	Spreading Rush
Leymus triticoides	Creeping Wild Rye
Lolium multiflorum	Italian Rye
Lythrum californica	California Loosestrife
Lythrum hyssopifolia	Grass Poly
Malva parviflora	Cheeseweed (Mallow)
Phalaris californica	California Canary Grass

Scientific Name	Common Name
Picris echioides	Oxtongue Thistle
Plantago major	Common Plantain
Polygonum spp.	Knotweed
Polypogon monspeliensis	Rabbit's Foot Grass
Potentilla anserina	Silvertip
Rorippa palustris ssp. *occidentalis*	Marsh Yellow Cress
Rubis ursinus	California Blackberry
Rumex conglomeratus	Cluster Dock
Rumex crispus	Curly Dock
Rumex maritimus	Golden Dock
Rumex pulcher	Fiddle Dock
Salicornia virginica	Pickleweed
Salix lasiolepis	Arroyo Willow
Sambucus mexicanus	Elderberry
Scirpus californicus	Bulrush
Scirpus maritimus	Sea Clubrush
Solanum nigrum	Black Nightshade
Solidago spp.	Goldenrod
Sonchus asper	Sow Thistle
Sparganium eurycarpum	Bur-reed
Spergularia bocconii	Bocconi's Sand Spurrey
Trifolium repens	White Clover
Typha latifolia	Cattail
Urtica dioica	Stinging Nettle
Urtica dioica ssp. *Holosericea*	Stinging Nettle
Urtica urens	Dwarf Nettle
Vicia spp.	Vetch
Xanthium spinosum	Spiny Clotbur

Appendix 31. Plant species list for North County High School.

Species	Common Name
Artemisia californica	California Sage
Aster chilensis	Common California Aster
Atriplex triangularis	Spearscale
Avena barbata	Mediterranean Oats
Baccharis pilularis	Coyote Brush
Brassica nigra	Mustard
Carduus pycnocephalus	Italian Thistle
Carex spp.	Sedge
Carpobrotus edulis	Iceplant
Chenopodium album	Lamb's Quarters
Circium vulgare	Bull Thistle
Conium maculatum	Poison Hemlock
Cornus sericea ssp. *occidentalis*	Dogwood
Cynodon dactylon	Bermuda Grass
Distichlis spicata	Salt Grass
Epilobium ciliatum	Willow Herb
Eriogonum parvifolium	Dune Buckwheat
Eriophyllum staechadifolium	Lizard Tail
Eschscholzia californica	California Poppy
Foeniculum vulgare	Fennel
Frankenia salina	Alkali Heath
Gnaphalium stramineum	Cotton-batting Plant
Grindelia stricta	Gumplant
Heterotheca grandiflora	Telegraph Weed
Hordeum brachyantherum	Meadow Barley
Jaumea carnosa	Fleshy Jaumea
Juncus effusus	Common Rush
Juncus mexicanus	Mexican Rush
Juncus patens	Spreading Rush
Juncus tenuis	Slender Rush
Lactuca serriola	Prickly Lettuce
Leymus triticoides	Creeping Wild Rye
Lolium multiflorum	Italian Rye

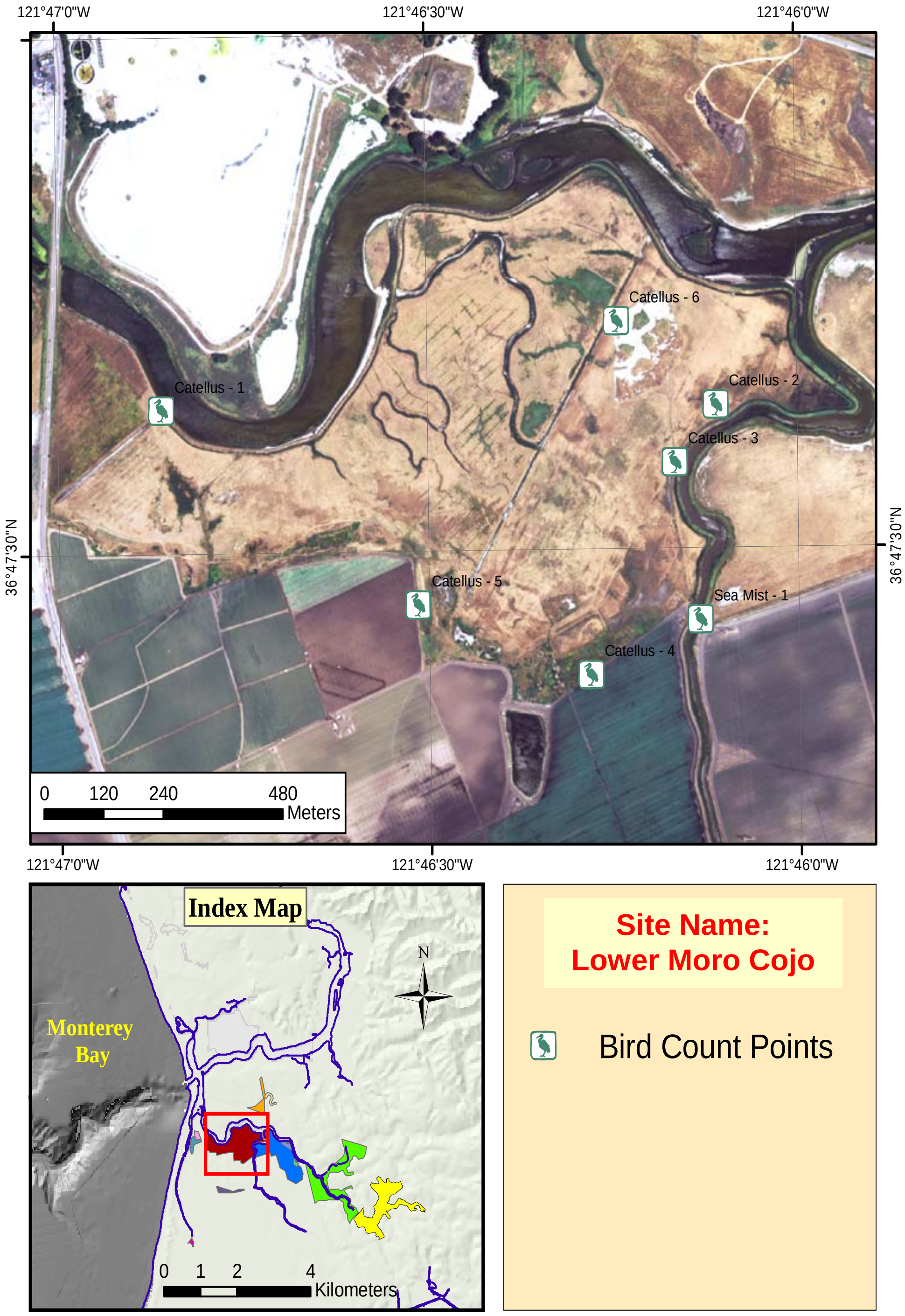
Species	**Common Name**
Lupinus arboreus	Yellow Lupine
Lupinus chamissonis	Silver Bush Lupine
Malva parviflora	Cheeseweed
Medicago polymorpha	Bur-clover
Phalaris aquatica	Harding Grass
Picris echioides	Oxtongue Thistle
Plantago coronopus	Cut-leaved plantain
Plantago lanceolata	English Plantain
Polygonum spp.	Knotweed
Potentilla anserina	Silvertip
Quercus agrifolia	Coast Live Oak
Raphanus sativus	Radish
Rorippa nasturtium-aquaticum	Watercress
Rosa californica	California Rose
Rumex acetosella	Sheep Sorrel
Rumex conglomeratus	Cluster Dock
Rumex crispus	Curly Dock
Rumex maritimus	Golden Dock
Rumex pulcher	Fiddle Dock
Salicornia virginica	Pickleweed
Salix lasiolepis	Arroyo Willow
Salvia mellifera	Black Sage
Scirpus maritimus	Sea Clubrush
Solanum nigrum	Black Nightshade
Solidago californica	Goldenrod
Sonchus asper	Sow Thistle
Sparganium eurycarpum	Bur-reed
Toxicodendron multiflorum	Poison Oak
Typha latifolia	Cattail
Urtica dioica ssp. *Holosericea*	Stinging Nettle
Vicia spp.	Vetch

Appendix 32. Plant species list for South Ponds.

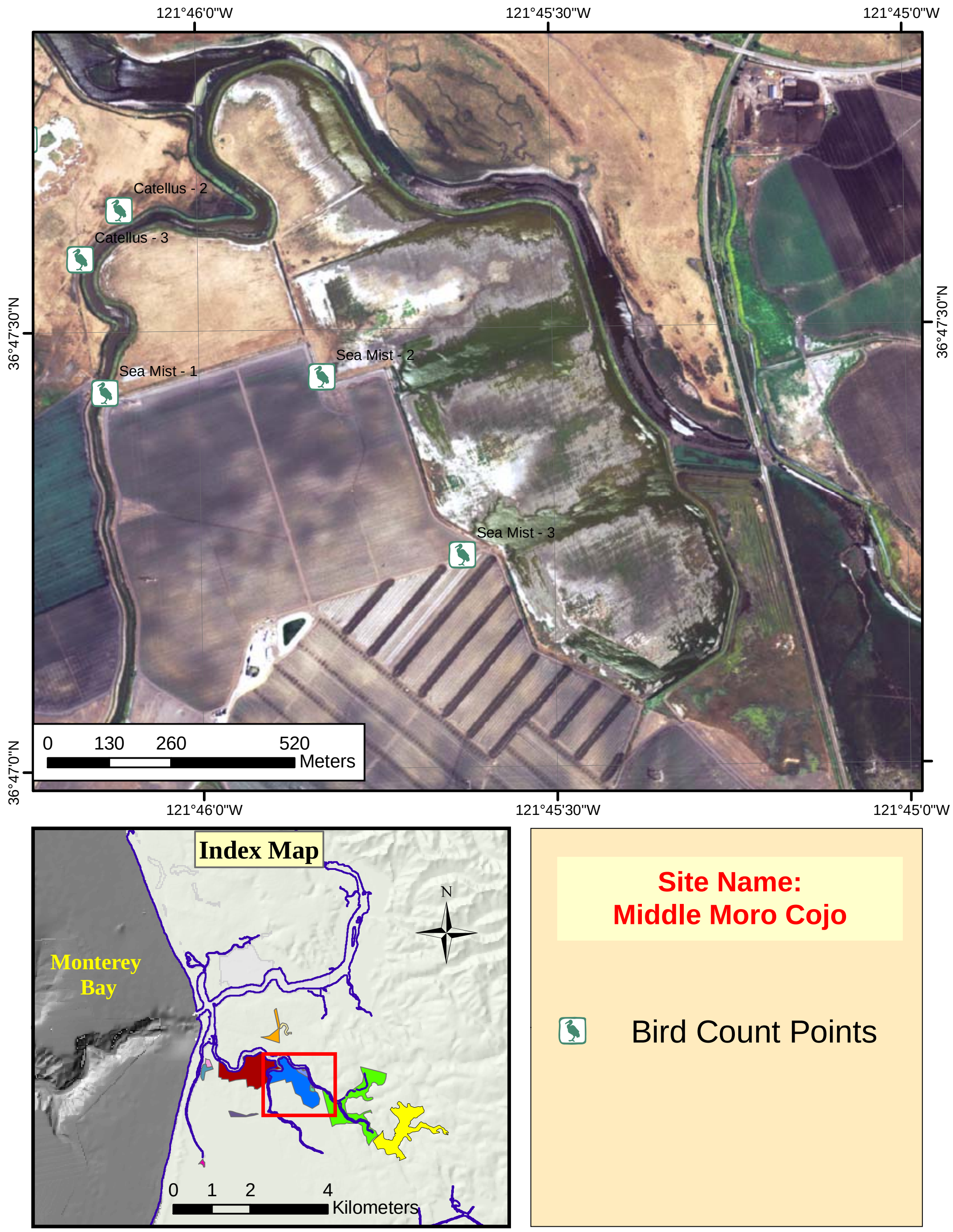
Species	Common Name
Atriplex triangularis	Spearscale
Avena barbata	Mediterranean Oats
Baccharis pilularis	Coyote Brush
Brassica nigra	Mustard
Bromus racemosus	Smooth Flowered Soft Cheat
Circium vulgare	Bull Thistle
Conium maculatum	Poison Hemlock
Conyza canadensis	Horseweed
Cotula coronopifolia	Brass Buttons
Cyperus eragrostis	Nut Sedge
Distichlis spicata	Salt Grass
Eleocharis macrostachya	Spike Rush
Epilobium ciliatum	Willow Herb
Frankenia salina	Alkali Heath
Geranium dissectum	Cut-leaved Geranium
Grindelia stricta	Gumplant
Heliotropium curassavicum	Heliotrope
Hordeum brachyantherum	Meadow Barley
Hordeum murinum ssp. *Leporinum*	Foxtail
Juncus mexicanus	Mexican Rush
Juncus patens	Spreading Rush
Lactuca serriola	Prickly Lettuce
Lemna minor	Duckweed
Leymus triticoides	Creeping Wild Rye
Lolium multiflorum	Italian Rye
Lotus scoparius	Deerweed
Malva parviflora	Cheeseweed
Medicago polymorpha	Bur-clover
Oxalis pes-caprae	Bermuda Buttercup
Picris echioides	Oxtongue Thistle
Plantago coronopus	Cut-leaved plantain
Plantago lanceolata	English Plantain
Polypogon monspeliensis	Rabbit's Foot Grass

Species	**Common Name**
Populus balsamifera	Cottonwood
Pucinellia distans	European Alkali Grass
Raphanus sativus	Radish
Rorippa nasturtium-aquaticum	Watercress
Rumex crispus	Curly Dock
Rumex maritimus	Golden Dock
Salicornia virginica	Pickleweed
Salix lasiolepis	Arroyo Willow
Scirpus californicus	Bulrush
Scirpus maritimus	Sea Clubrush
Sonchus asper	Sow Thistle
Typha Latifolia	Cattail
Vicia spp.	Vetch
Vulpia spp.	Fescue

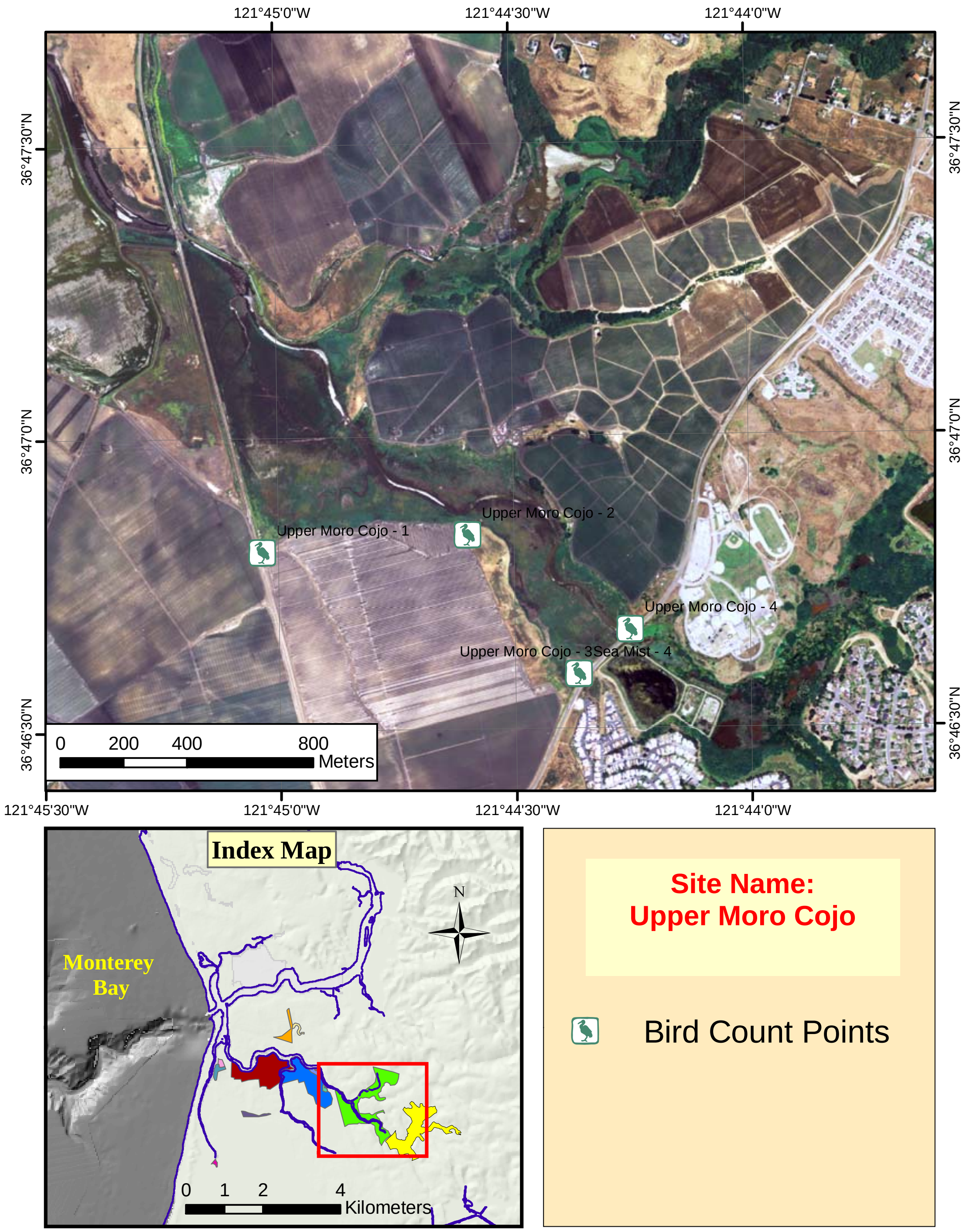
Appendix 33. Point count localities for Lower Moro Cojo.



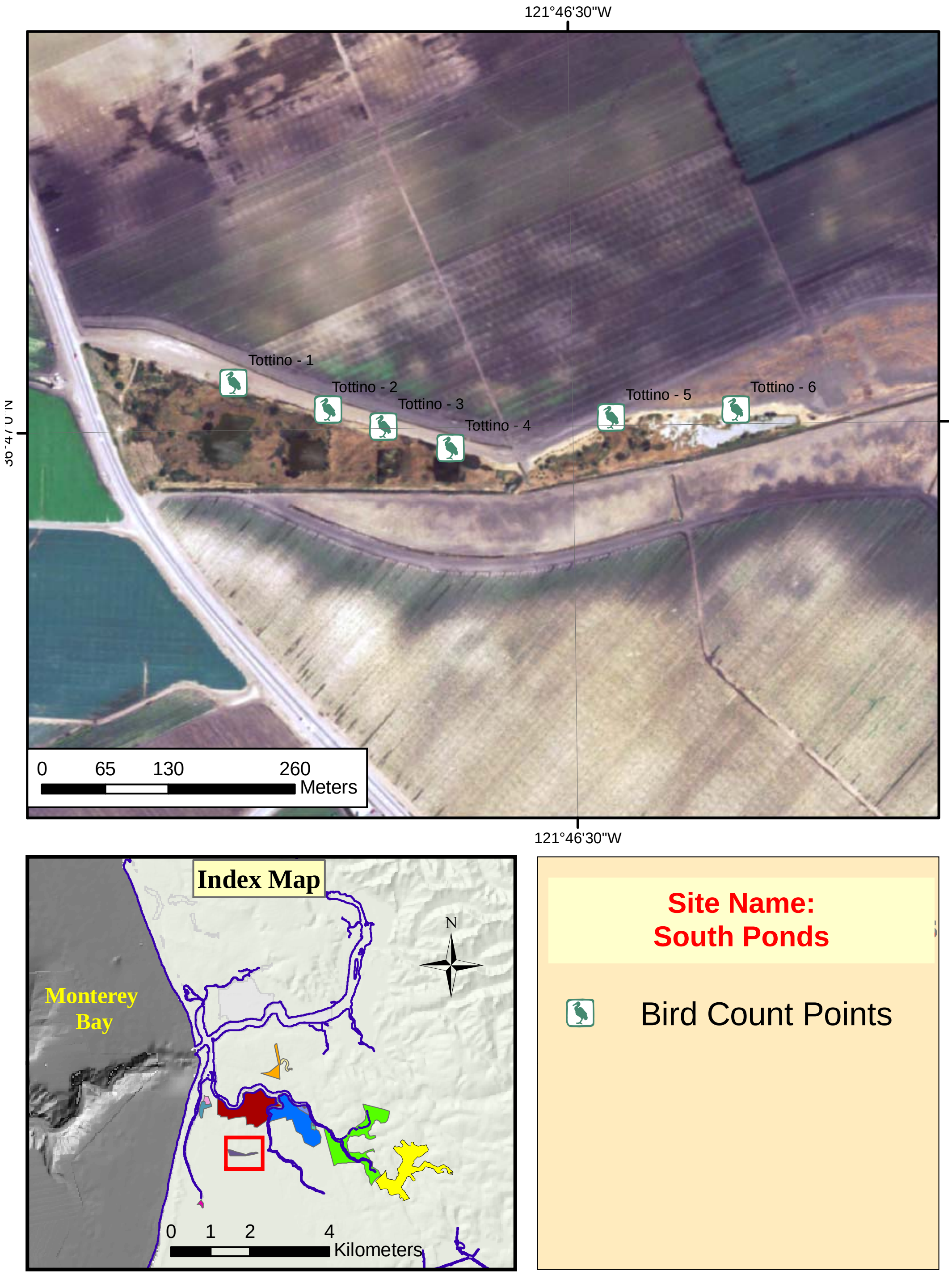
Appendix 34. Point count localities for Middle Moro Cojo.



Appendix 35. Point count localities for Upper Moro Cojo.



Appendix 36. Point count localities for South Ponds.

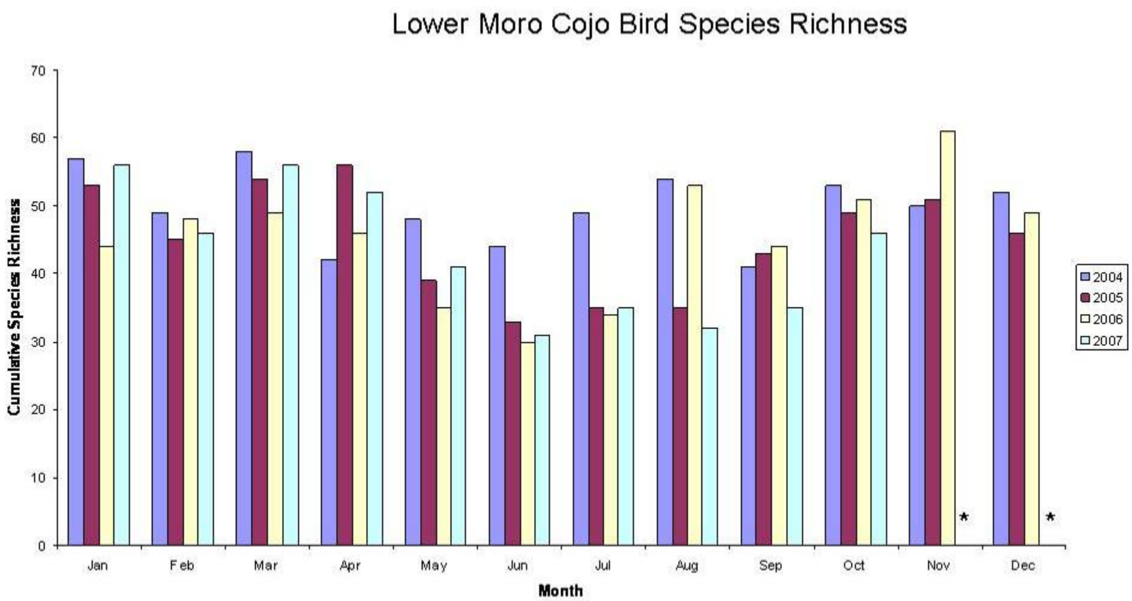


Appendix 37. Bird list for Lower Moro Cojo.

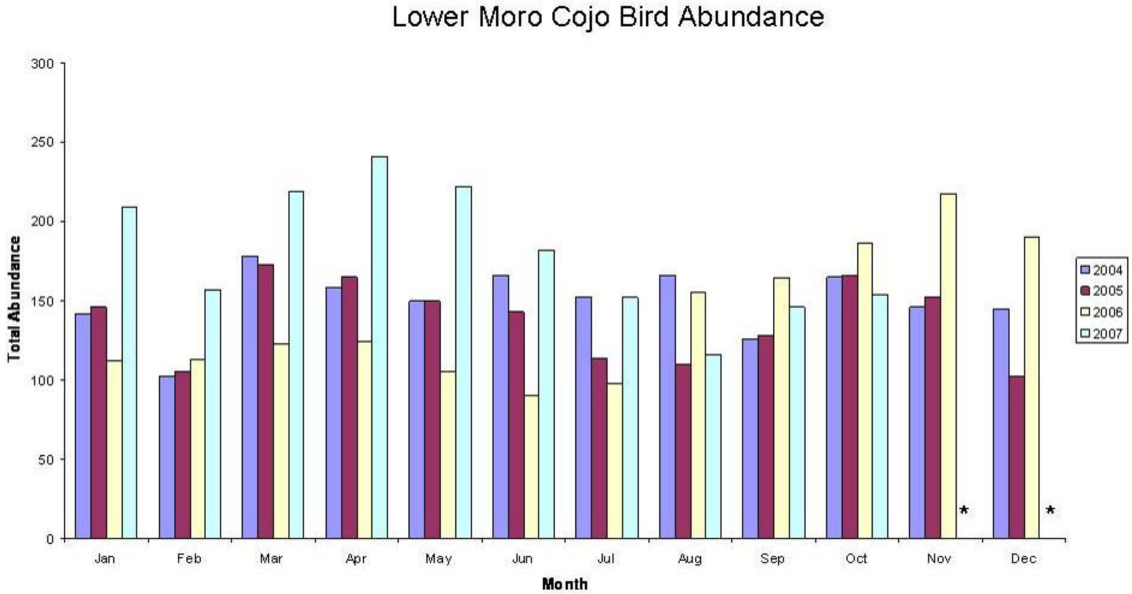
Species		
American Avocet	Cooper's Hawk	Northern Harrier
American Bittern	Double-crested Cormorant	Northern Pintail
American Coot	Downey Woodpecker	Northern Rough-winged Swallow
American Crow	Dunlin	Northern Shoveler
American Goldfinch	Eared Grebe	Osprey
American Kestrel	European Starling	Pectoral Sandpiper
American Pipit	Ferruginous Hawk	Peregrine Falcon
American Robin	Gadwall	Pied-billed Grebe
American White Pelican	Golden-crowned Sparrow	Prairie Falcon
American Wigeon	Great Blue Heron	Purple Finch
Anna's Hummingbird	Great Egret	Red Phalarope
Baird's Sandpiper	Greater Scaup	Red Shouldered Hawk
Bank Swallow	Greater White-fronted Goose	Red-necked Phalarope
Barn Owl	Greater Yellowlegs	Redtail Hawk
Barn Swallow	Green-winged Teal	Red-winged Blackbird
Belted Kingfisher	Hooded Merganser	Ringed-billed Gull
Black Phoebe	Horned Lark	Ross's Goose
Black-bellied Plover	House Finch	Ruby-crowned Kinglet
Black-crowned Night-Heron	Killdeer	Ruddy Duck
Black-necked Stilt	Lapland Longspur	Ruddy Turnstone
Blue-winged Teal	Lark Sparrow	Savannah Sparrow
Bonaparte's Gull	Lawrence's Goldfinch	Say's Phoebe
Brant Goose	Least Sandpiper	Semipalmated Plover
Brewer's Blackbird	Lesser Scaup	Short-billed Dowitcher
Brown-headed Cowbird	Lesser Yellowlegs	Short-eared Owl
Bufflehead	Lincoln's Sparrow	Snow Goose
Cackling Goose	Loggerhead Shrike	Snowy Egret
California Gull	Long-billed Curlew	Song Sparrow
Canada Goose	Long-billed Dowitcher	Sora Rail
Caspian Tern	Mallard Duck	Swainson's Hawk
Cinnamon Teal	Marbled Godwit	Tree Swallow
Cliff Swallow	Marsh Wren	Tricolored Blackbird
Common Goldeneye	Merlin	Tundra Swan

Species		
Common Moorhen	Mew Gull	Turkey Vulture
Common Raven	Mourning Dove	Virginia Rail
Common Yellowthroat	Northern Flicker	Western Grebe
Western Gull		
Western Kingbird		
Western Meadowlark		
Western Sandpiper		
Whimbrel		
White-crowned Sparrow		
White-faced Ibis		
White-tailed Kite		
White-throated Swift		
Willet		
Wilson's Snipe		
Wilson's Warbler		
Yellow Warbler		
Yellow-headed Blackbird		
Yellow-rumped Warbler		

Appendix 38. Monthly species richness counts of avifauna at the Lower Moro Cojo.



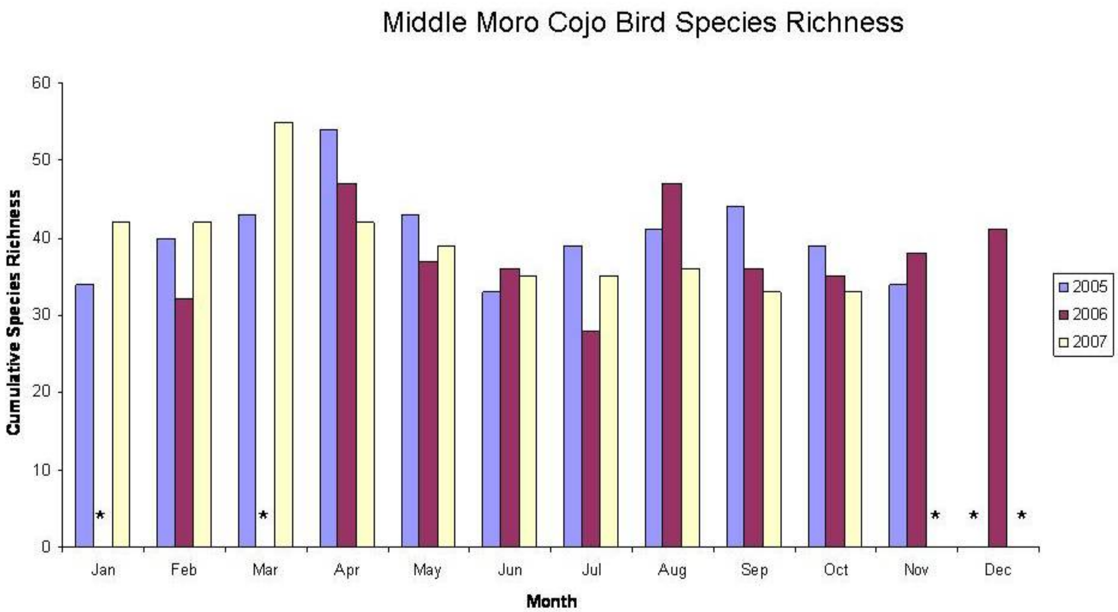
Appendix 39. Monthly abundance counts of avifauna at the Lower Moro Cojo.



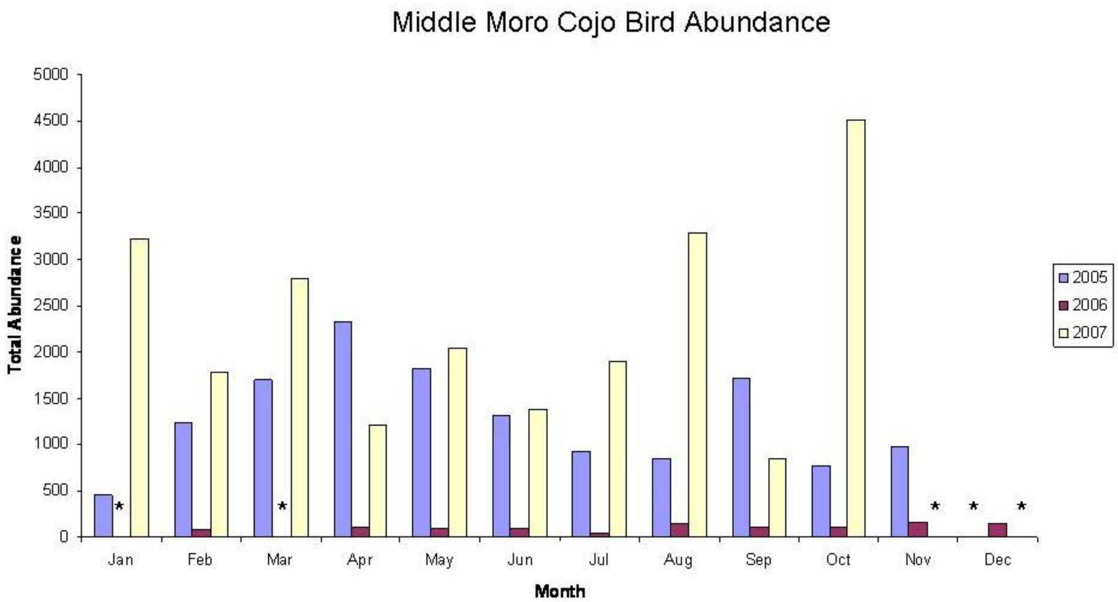
Appendix 40. Bird list for the Middle Moro Cojo.

Species		
American Avocet	European Starling	Rock Pigeon
American Coot	Gadwall	Ruddy Duck
American Crow	Great Blue Heron	Savannah Sparrow
American Goldfinch	Great Egret	Say's Phoebe
American Kestrel	Greater White-fronted Goose	Semipalmated Plover
American Pipit	Greater Yellowlegs	Short-billed Dowitcher
American Robin	Green-winged Teal	Short-eared Owl
American White Pelican	Horned Lark	Song Sparrow
American Wigeon	House Finch	Sora Rail
Baird's Sandpiper	Killdeer	Spotted Sandpiper
Barn Owl	Least Sandpiper	Tree Swallow
Barn Swallow	Lesser Goldfinch	Tricolored Blackbird
Bewick's Wren	Lesser Scaup	Western Kingbird
Black Phoebe	Lesser Yellowlegs	Western Meadowlark
Black-bellied Plover	Lincoln's Sparrow	Western Sandpiper
Black-crowned Night-Heron	Loggerhead Shrike	Whimbrel
Black-necked Stilt	Long-billed Curlew	White-crowned Sparrow
Blue-winged Teal	Long-billed Dowitcher	White-faced Ibis
Bonaparte's Gull	Long-tailed Duck	White-tailed Kite
Brewer's Blackbird	Mallard Duck	Willet
Brown Pelican	Marbled Godwit	Wilson's Phalarope
Brown-headed Cowbird	Marsh Wren	Wilson's Snipe
Burrowing Owl	Merlin	Yellow Warbler
California Gull	Mourning Dove	Yellow-rumped Warbler
Canada Goose	Northern Harrier	Eared Grebe
Caspian Tern	Northern Pintail	Ringed-billed Gull
Cinnamon Teal	Northern Rough-winged Swallow	
Clay-colored Sparrow	Northern Shoveler	
Cliff Swallow	Peregrine Falcon	
Common Raven	Pied-billed Grebe	
Common Teal	Red Knot	
Common Yellowthroat	Red-necked Phalarope	
Copper's Hawk	Redtail Hawk	
Dunlin	Red-winged Blackbird	

Appendix 41. Monthly species richness counts of avifauna at the Middle Moro Cojo.



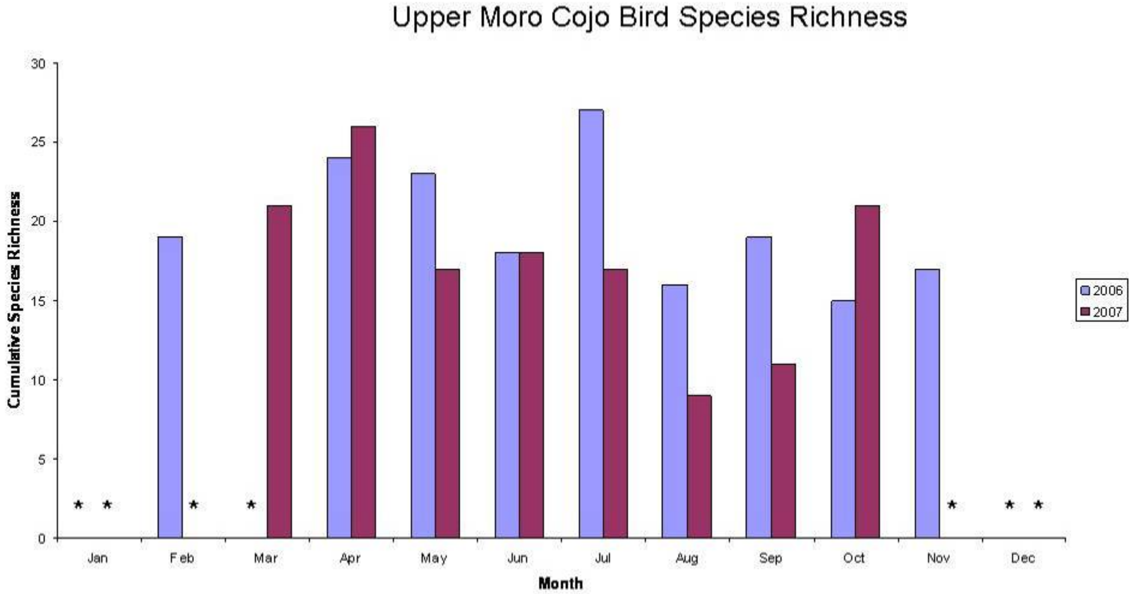
Appendix 42. Monthly abundance counts of avifauna at the Lower Moro Cojo site.



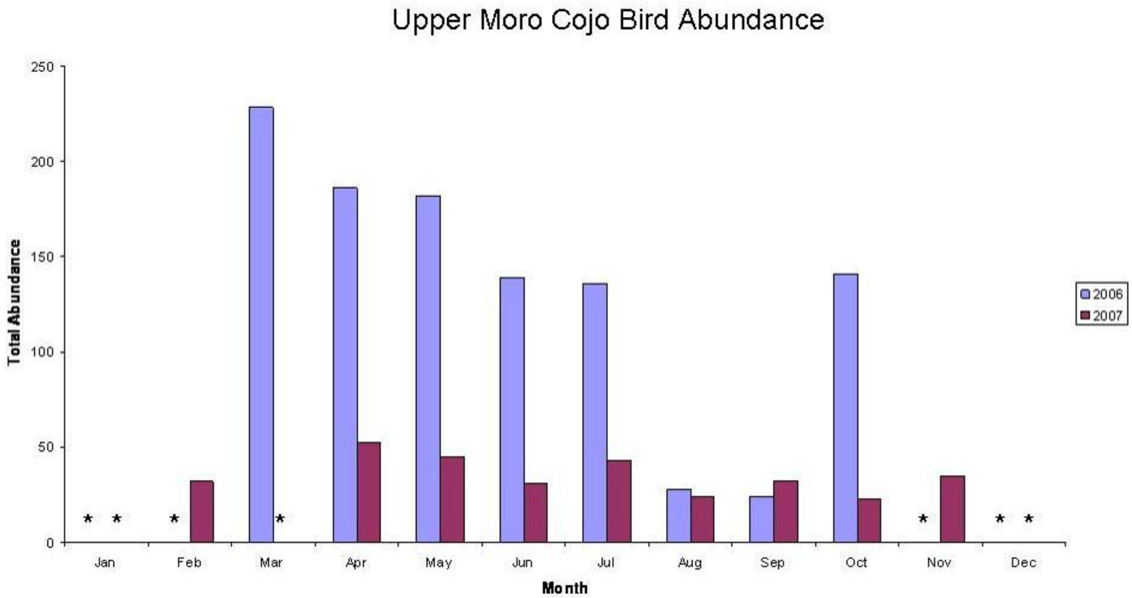
Appendix 43. Bird list for the Upper Moro Cojo.

Species	
American Avocet	Greater Yellowlegs
American Crow	Green-winged Teal
American Goldfinch	House Finch
American Kestrel	Horned Lark
American Pipit	Killdeer
American Wigeon	Lon-billed Curlew
Barn Owl	Lon-billed Dowitcher
Barn Swallow	Lesser Goldfinch
Black-bellied Plover	Least Sandpiper
Black-crowned Night Heron	Lesser Yellowlegs
Bewick's Wren	Loggerhead Shrike
Brown-headed Cowbird	Mallard Duck
Black Phoebe	Marsh Wren
Black-necked Stilt	Mew Gull
Bonaparte's Gull	
Brewer's blackbird	
Buller's Shearwater	
Blue-winged Teal	
Canada Goose	
California Gull	
Canvasback	
Clay-colored Sparrow	
Cinnamon Teal	
Cliff Swallow	
Cooper's Hawk	
American Coot	
Common Raven	
Common Yellowthroat	
Double-crested Cormorant	
European Starling	
Eurasion Wigeon	
Gadwall	
Great Blue Heron	
Golden-crowned Sparrow	
Great Egret	

Appendix 44. Monthly species richness of avifauna at the Upper Moro Cojo site.



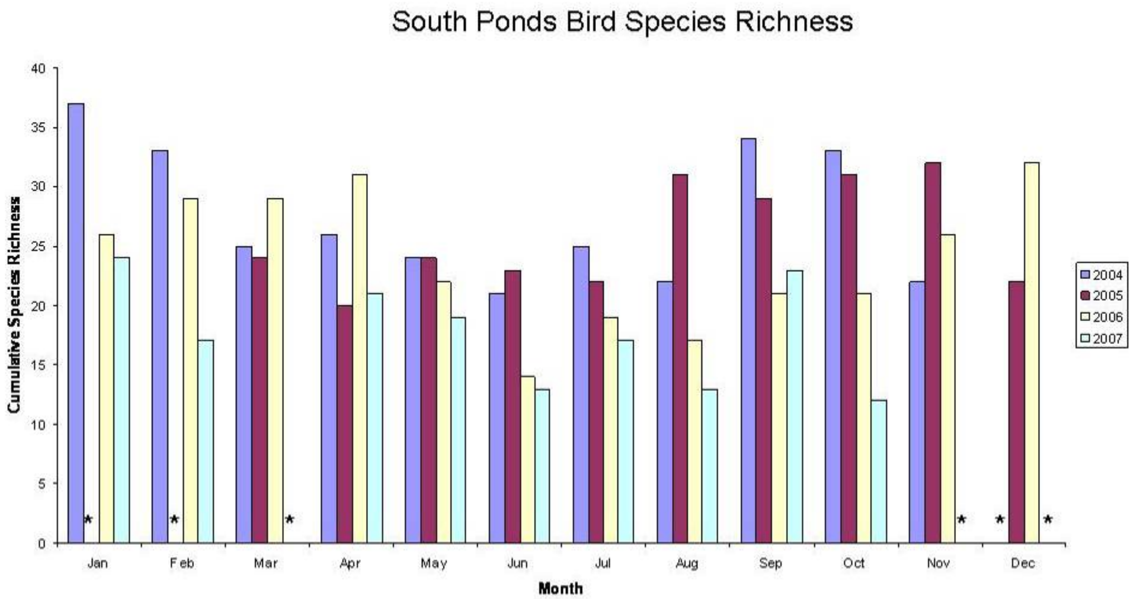
Appendix 45. Monthly abundance counts of avifauna at the Upper Moro Cojo site.



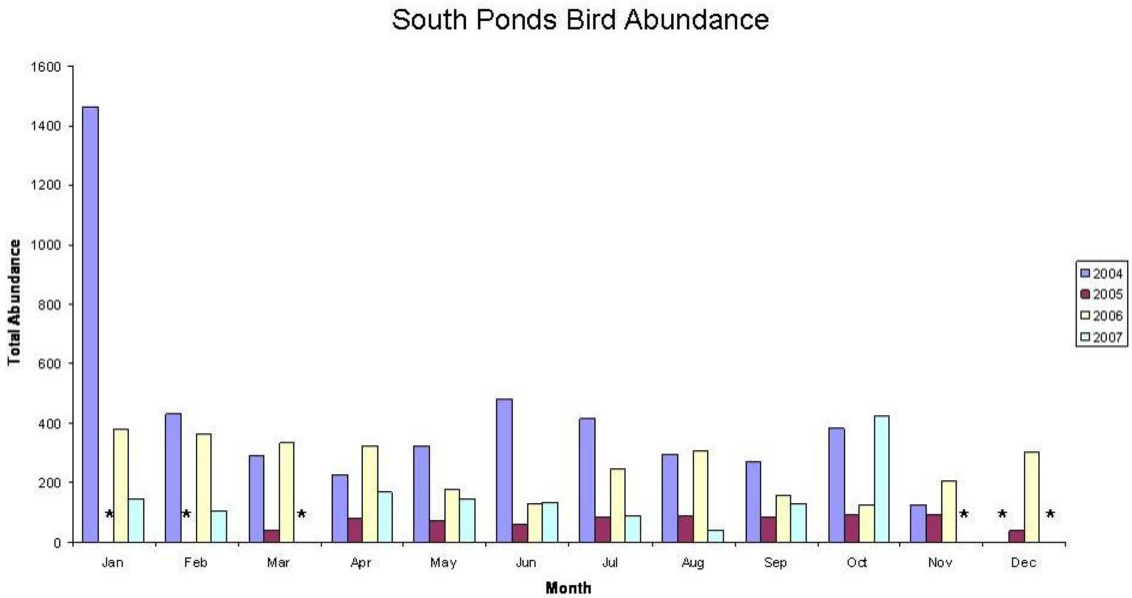
Appendix 46. Bird list for South Ponds.

Species Name	
American Avocet	Ruddy Turnstone
American Crow	Red-winged Blackbird
Barn Swallow	Savannah Sparrow
Black-bellied Plover	Short-billed Dowitcher
Black-crowned Night Heron	Semipalmated Plover
Black Phoebe	Snowy Egret
Black-necked Stilt	Sora Rail
Brewer's Blackbird	Song Sparrow
Cinnamon Teal	Swamp Sparrow
Cliff Swallow	Tree Swallow
Common Moorhen	Virginia Rail
Common Yellowthroat	White-crowned Sparrow
Dunlin	Western Meadowlark
European Starling	White-faced Ibis
Gadwall	Whimbrel
Great Blue Heron	Wilson's Storm Petrel
Golden-crowned Sparrow	Wilson's Snipe
Great Egret	White-tailed Kite
Greater Yellowlegs	
Great-tailed Grackle	
House Finch	
Horned Lark	
Killdeer	
Long-billed Dowitcher	
Least Sandpiper	
Lesser Yellowlegs	
Mallard Duck	
Marsh Wren	
Northern Harrier	
Pied-billed Grebe	
Ring-billed Gull	
Redtail Hawk	
Red-necked Phalarope	
Ruddy Duck	

Appendix 47. Monthly species richness counts of avifauna at the South Ponds site.



Appendix 48. Monthly abundance counts of avifauna at the South Ponds site.



Appendix 49. Lower Moro Cojo Bird Abundance.

Year	Month	Day	Plot1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Total
2003	1	5	375	22	124	47	281	39	888
2003	1	21	164	30	36	25	414	18	687
2003	2	19	72	43	38	105	182	9	449
2003	3	5	252	63	77	30	160	66	648
2003	3	27	211	73	57	67	391	139	938
2003	4	8	168	102	55	109	352	119	905
2003	4	21	72	50	31	49	216	57	475
2003	5	6	78	31	18	32	119	26	304
2003	5	19	53	40	10	28	114	33	278
2003	6	13	78	64	74	146	114	30	506
2003	6	29	68	50	49	49	174	22	412
2003	7	10	70	90	31	17	147	7	362
2003	7	20	55	83	3	42	168	15	366
2003	8	8	50	34	15	23	200	2	324
2003	8	23	35	48	40	28	121	12	284
2003	9	2	76	36	9	27	143	0	291
2003	9	25	56	10	22	69	117	2	276
2003	10	7	85	35	115	12	160	14	421
2003	10	26	154	16	45	10	231	6	462
2003	11	11	92	33	35	6	184	29	379
2003	11	26	102	38	24	105	622	6	897
2003	12	8	123	39	45	4	195	37	443
2003	12	28	440	61	29	92	252	5	879
2004	1	8	295	17	9	6	331	9	667
2004	1	31	134	33	14	25	277	36	519
2004	2	12	232	36	3	2	238	54	565
2004	2	24	58	na	na	na	154	na	NA
2004	3	10	227	61	29	34	369	76	796
2004	3	27	123	51	34	91	177	55	531
2004	4	5	73	39	56	12	297	134	611
2004	4	21	90	39	19	22	135	41	346
2004	5	6	77	31	32	49	174	46	409
2004	5	26	84	49	18	49	221	16	437
2004	6	8	104	55	27	73	167	66	492
2004	6	29	54	116	39	37	181	34	461
2004	7	7	103	26	50	93	204	21	497
2004	7	21	87	172	33	76	153	9	530
2004	8	15	50	9	76	72	209	13	429
2004	8	24	41	54	36	40	174	22	367
2004	9	6	32	66	31	21	162	2	314
2004	9	20	50	92	120	43	247	49	601
2004	10	9	37	63	30	43	243	48	464
2004	10	24	38	58	69	23	209	80	477
2004	11	8	36	48	27	83	183	15	392
2004	11	26	69	143	27	87	79	7	412
2004	12	11	193	180	36	57	242	5	713
2004	12	24	75	181	4	74	159	9	502

Year	Month	Day	Plot1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Total
2005	1	15	141	86	37	27	256	20	567
2005	1	28	72	82	20	110	170	23	477
2005	2	7	100	NA	NA	NA	NA	NA	NA
2005	2	22	118	129	38	43	235	82	645
2005	3	3	139	63	30	55	256	60	603
2005	3	24	116	99	46	28	224	77	590
2005	4	4	95	197	31	38	322	71	754
2005	4	25	61	16	25	18	297	35	452
2005	5	6	72	25	36	33	177	55	398
2005	5	21	89	28	40	37	171	76	441
2005	6	11	94	81	27	23	205	47	477
2005	6	26	110	34	29	40	209	37	459
2005	7	10	109	30	31	34	90	9	303
2005	7	24	112	24	43	21	29	13	242
2005	8	13	27	20	5	27	73	3	155
2005	8	25	44	21	4	57	74	1	201
2005	9	10	26	18	12	164	173	1	394
2005	9	28	90	57	40	98	241	6	532
2005	10	11	82	20	97	92	166	1	458
2005	10	25	107	83	64	58	177	5	494
2005	11	12	96	114	21	92	185	7	515
2005	11	20	137	12	36	46	91	5	327
2005	12	24	45	30	7	11	29	6	128
2006	1	9	68	47	24	149	55	16	359
2006	2	14	49	84	30	11	24	133	331
2006	3	19	56	71	18	69	84	81	379
2006	4	18	36	38	24	35	37	236	406
2006	5	16	58	49	36	34	22	37	236
2006	6	14	33	46	11	81	19	47	237
2006	7	13	23	33	39	30	21	44	190
2006	8	9	35	114	34	19	31	3	236
2006	8	20	53	104	41	25	17	10	250
2006	9	4	56	46	20	47	32	3	204
2006	9	16	34	41	7	6	31	0	119
2006	10	14	28	125	74	13	302	3	545
2006	10	25	2	73	16	18	20	6	135
2006	11	10	72	20	78	27	21	3	221
2006	11	24	134	162	NA	21	104	18	439
2006	12	13	68	5	65	28	20	18	204
2006	12	29	171	33	13	13	10	10	250
2007	1	7	500	100	52	23	61	31	767
2007	1	28	338	34	103	19	21	12	527
2007	2	6	37	30	47	25	9	35	183
2007	2	24	356	44	14	19	11	33	477

Appendix 50. Lower Moro Cojo Bird Species Richness.

Year	Month	Day	Plot1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Cumulative
2003	1	5	26	6	7	11	31	2	46
2003	1	21	30	9	5	8	29	2	43
2003	2	19	11	8	7	9	18	3	29
2003	3	5	16	10	8	7	16	5	30
2003	3	27	27	11	7	16	27	7	47
2003	4	8	19	10	9	11	22	8	39
2003	4	21	15	11	10	13	24	4	46
2003	5	6	19	8	7	5	15	4	27
2003	5	19	9	10	6	7	21	7	31
2003	6	13	13	9	5	5	16	6	23
2003	6	29	16	6	9	18	18	4	29
2003	7	10	15	10	6	5	18	4	28
2003	7	20	11	5	1	10	18	4	31
2003	8	8	13	6	7	6	25	4	31
2003	8	23	13	9	6	7	9	4	24
2003	9	2	16	11	6	7	17	0	29
2003	9	25	14	7	10	12	26	1	32
2003	10	7	18	8	14	6	23	3	31
2003	10	26	25	8	5	8	27	1	39
2003	11	11	21	10	7	4	26	3	37
2003	11	26	19	9	5	10	24	3	7
2003	12	8	24	4	9	3	21	3	39
2003	12	28	31	4	7	11	27	1	46
2004	1	8	26	5	4	4	24	6	42
2004	1	31	18	9	5	5	33	5	42
2004	2	12	26	9	2	2	27	11	46
2004	2	24	13	na	na	na	23	na	NA
2004	3	10	23	9	8	10	30	10	46
2004	3	27	18	10	10	8	30	12	41
2004	4	5	17	10	15	6	25	12	37
2004	4	21	17	12	7	6	21	9	33
2004	5	6	17	12	8	8	23	4	37
2004	5	26	17	12	7	11	25	3	35
2004	6	8	17	13	8	12	24	9	36
2004	6	29	16	13	9	10	28	4	37
2004	7	7	19	6	8	13	32	5	39
2004	7	21	19	11	6	7	22	3	37
2004	8	15	18	8	8	11	33	4	44
2004	8	24	17	10	6	10	29	9	41
2004	9	6	17	5	6	8	21	1	30
2004	9	20	13	6	13	5	21	9	34
2004	10	9	17	9	10	11	24	5	36
2004	10	24	15	9	13	10	29	11	46
2004	11	8	17	6	8	10	31	5	41
2004	11	26	22	6	7	8	19	5	35
2004	12	11	23	7	10	10	31	3	47

Year	Month	Day	Plot1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Cumulative
2004	12	24	15	11	4	5	21	4	37
2005	1	15	19	8	5	9	32	7	41
2005	1	28	15	9	5	10	17	6	38
2005	2	7	13	NA	NA	NA	NA	NA	NA
2005	2	22	15	15	8	11	18	11	44
2005	3	3	13	10	5	12	30	9	42
2005	3	24	18	14	10	11	26	13	44
2005	4	4	18	11	10	13	36	11	48
2005	4	25	10	6	9	8	22	9	35
2005	5	6	17	8	10	5	23	8	31
2005	5	21	14	12	8	8	20	13	29
2005	6	11	16	11	6	8	20	9	28
2005	6	26	15	9	10	10	19	9	28
2005	7	10	14	8	7	13	15	3	28
2005	7	24	15	6	8	8	10	5	28
2005	8	13	11	7	3	10	20	2	28
2005	8	25	15	9	2	14	15	1	29
2005	9	10	10	6	4	11	16	1	25
2005	9	28	20	12	6	15	20	4	36
2005	10	11	19	10	10	14	22	1	38
2005	10	25	23	9	8	16	27	3	41
2005	11	12	17	7	5	16	26	4	36
2005	11	20	25	4	7	11	24	4	43
2005	12	24	11	3	6	7	11	2	28
2006	1	9	13	11	3	12	15	5	31
2006	2	14	12	9	7	6	12	9	33
2006	3	19	9	9	8	7	11	10	29
2006	4	18	15	9	8	9	13	11	30
2006	5	16	12	11	10	8	10	6	23
2006	6	14	11	9	6	8	7	6	20
2006	7	13	10	8	11	7	8	6	27
2006	8	9	11	4	5	4	9	3	24
2006	8	20	14	9	11	8	6	3	31
2006	9	4	7	12	8	5	7	2	22
2006	9	16	13	15	5	4	6	0	26
2006	10	14	12	15	6	7	9	2	29
2006	10	25	2	10	7	12	7	4	25
2006	11	10	15	6	5	11	8	3	35
2006	11	24	14	10	NA	10	13	1	32*
2006	12	13	13	4	6	10	8	3	24
2006	12	29	12	7	7	6	6	5	26
2007	1	7	17	11	8	6	9	8	35
2007	1	28	11	6	8	7	5	4	16
2007	2	6	7	7	6	4	5	5	23
2007	2	24	8	8	5	5	8	6	27

Appendix 51. Middle Moro Cojo Bird Abundance.

Year	Month	Day	Plot1	Plot 2	Plot 3	Plot 4	Total
2004	11	1	28	153	140	108	429
2004	11	21	35	221	161	114	531
2004	12	1	35	576	198	82	891
2004	12	20	26	386	59	93	564
2005	1	21	54	314	53	32	453
2005	2	6	62	163	144	114	483
2005	2	26	57	317	254	133	761
2005	3	11	39	256	333	192	820
2005	3	18	50	517	236	72	875
2005	4	3	136	405	594	134	1269
2005	4	18	96	298	493	176	1063
2005	5	3	112	220	377	221	930
2005	5	15	152	237	324	178	891
2005	6	8	29	255	190	263	737
2005	6	22	26	199	189	162	576
2005	7	5	68	218	90	160	536
2005	7	31	38	140	102	107	387
2005	8	10	35	96	45	98	274
2005	8	27	80	165	200	123	568
2005	9	4	111	214	396	156	877
2005	9	18	31	99	212	495	837
2005	10	10	49	162	118	55	384
2005	10	24	98	209	65	17	389
2005	11	2	132	247	66	85	530
2005	11	16	6	133	123	184	446
2006	2	13	45	62	190	43	340
2006	4	25	48	626	1257	873	2804
2006	5	24	64	243	136	211	654
2006	6	5	39	119	194	181	533
2006	7	20	19	65	84	211	379
2006	8	12	26	25	29	102	182
2006	8	27	28	3	23	15	69
2006	9	10	27	27	29	90	173
2006	9	28	18	13	5	10	46
2006	10	14	15	24	89	59	187
2006	10	30	49	8	20	50	127
2006	11	8	64	50	315	207	636
2006	11	19	31	16	10	35	92
2006	12	1	9	210	83	134	436
2006	12	20	26	129	22	127	304
2007	1	2	10	37	27	170	244
2007	1	21	85	22	22	167	296
2007	2	5	7	6	5	88	106
2007	2	17	2	14	549	145	710

Appendix 52. Middle Moro Cojo Bird Richness.

Year	Month	Day	Plot1	Plot 2	Plot 3	Plot 4	Cumulative
2004	11	1	9	19	19	10	32
2004	11	21	11	18	17	9	28
2004	12	1	11	20	14	10	25
2004	12	20	10	16	13	9	22
2005	1	21	18	24	18	14	34
2005	2	6	7	17	11	15	25
2005	2	26	10	25	21	18	38
2005	3	11	9	21	28	18	34
2005	3	18	15	27	18	12	34
2005	4	3	17	32	31	22	34
2005	4	18	14	28	24	25	39
2005	5	3	16	20	28	20	34
2005	5	15	13	18	25	16	33
2005	6	8	10	20	18	14	35
2005	6	22	9	16	8	13	26
2005	7	5	15	22	10	16	29
2005	7	31	12	12	20	17	33
2005	8	10	9	20	19	19	34
2005	8	27	11	18	20	15	31
2005	9	4	15	19	19	15	34
2005	9	18	10	20	15	10	33
2005	10	10	12	15	18	15	25
2005	10	24	11	21	20	9	35
2005	11	2	5	19	13	15	25
2005	11	16	4	18	18	13	28
2006	2	13	11	17	16	12	29
2006	4	25	10	26	26	23	42
2006	5	24	12	12	10	10	25
2006	6	5	8	9	9	10	20
2006	7	20	9	7	9	14	23
2006	8	12	9	6	9	14	25
2006	8	27	8	2	9	8	20
2006	9	10	7	5	7	9	21
2006	9	28	9	7	3	7	20
2006	10	14	9	6	5	9	18
2006	10	30	11	4	4	10	22
2006	11	8	15	8	6	8	21
2006	11	19	17	7	4	9	25
2006	12	1	8	11	10	11	23
2006	12	20	11	7	7	11	24
2007	1	2	6	6	5	15	23
2007	1	21	7	6	5	13	24
2007	2	5	4	6	5	9	18
2007	2	17	2	9	7	12	20

Appendix 53. South Ponds Bird Abundance.

Year	Month	Day	Plot1	Plot 2	Plot 3	Plot 4	Plot 5	Total
2001	5	12	66	41	27	45	86	265
2001	5	25	52	23	26	25	56	182
2001	6	5						0
2001	6	20	65	114	92	67	32	370
2001	7	6	71	47	132	56	57	363
2001	7	14	59	89	184	155	34	521
2001	7	24	29	31	47	18	17	142
2001	8	3	48	32	64	33	27	204
2001	8	29	66	27	34	38	33	198
2001	9	6	55	34	77	147	130	443
2001	9	14	33	39	62	24	61	219
2001	9	29	102	62	114	21	45	344
2001	10	11	29	62	93	50	18	252
2001	10	21	41	14	52	64	26	197
2001	10	28	96	56	86	33	65	336
2001	11	8	75	17	65	64	16	237
2001	11	20	63	21	51	29	22	186
2001	12	29	256	8	94	100	343	801
2002	1	17	424	39	43	103	130	739
2002	2	18	139	22	42	55	403	661
2002	3	3	157	21	174	106	618	1076
2002	3	18	299	36	45	66	299	745
2002	4	3	309	77	95	88	246	815
2002	4	20	266	55	81	49	206	657
2002	5	11	86	29	42	30	120	307
2002	5	25	72	84	35	35	127	353
2002	6	4	61	12	77	61	118	329
2002	6	26	63	44	45	47	120	319
2002	7	10	35	43	55	33	120	286
2002	7	24	49	39	16	33	132	269
2002	8	7	33	29	44	51	115	272
2002	8	24	59	25	70	61	228	443
2002	9	9	92	17	58	123	173	463
2002	9	30	33	61	10	22	132	258
2002	10	10	70	89	34	45	218	456
2002	10	24	39	94	30	66	233	462
2002	11	6	83	11	14	164	261	533
2002	11	23	58	35	30	34	631	788
2003	1	11	147		58	14	89	308
2003	1	20	75	17	10	0	597	699
2003	2	2	37	22	23	5	23	110
2003	2	18	34	5	25	13	23	100
2003	3	3	44	16	10	26	40	136
2003	3	24	74	8	13	11	37	143
2003	4	4	51	14	18	14	42	139
2003	4	26	46	15	23	17	11	112

Year	Month	Day	Plot1	Plot 2	Plot 3	Plot 4	Plot 5	Total
2003	5	13	16	12	16	14	9	67
2003	5	30	32	20	16	1	4	73
2003	6	2	41	14	11	32	132	230
2003	6	19	37	21	10	19	4	91
2003	7	4	71	24	9	2	8	114
2003	7	19	33	24	65	12	18	152
2003	8	1	74	26	51	0	44	195
2003	8	21	54	97	21	27	83	282
2003	9	16	57	25	19	22	119	242
2003	10	1	59	33	47	22	109	270
2003	10	21	52	17	13	39	169	290
2003	11	4	116	20	24	15	19	194
2003	11	17	50	16	26	31	26	149
2003	12	2	88	16	12	6	30	152
2003	12	17	94	23	8	12	23	160
2003	12	24	108	54	27	4	6	199
2004	1	4	105	39	66	17	915	1142
2004	1	18	134	17	17	20	134	322
2004	2	1	177	7	35	16	57	292
2004	2	15	70	33	6	13	19	141
2004	3	10	78	20	9	9	30	146
2004	3	21	41	18	22	4	61	146
2004	4	5	29	17	27	5	52	130
2004	4	19	47	9	9	6	26	97
2004	5	4	37	14	17	8	70	146
2004	5	16	51	33	29	9	55	177
2004	6	8	56	52	8	8	72	196
2004	6	21	41	59	19	22	144	285
2004	7	6	51	50	18	11	25	155
2004	7	19	26	38	24	14	160	262
2004	8	1	33	20	57	5	19	134
2004	8	18	20	21	33	12	76	162
2004	9	2	66	10	20	9	9	114
2004	9	14	64	16	19	10	45	154
2004	10	4	38	84	6	6	44	178
2004	10	17	38	84	6	6	44	178
2004	11	2	58	13	11	8	37	127
2005	3	22	42	20	7	3	194	266
2005	4	1	54	14	15	14	45	142
2005	4	11	36	18	14	13	211	292
2005	5	2	34	14	7	18	42	115
2005	5	14	32	10	8	21	55	126
2005	6	10	51	19	39	6	15	130
2005	6	26	44	6	2	0	82	134
2005	7	6	74	16	22	22	61	195
2005	7	23	57	38	22	5	116	238
2005	8	3	21	79	25	16	34	175
2005	8	16	120	47	110	26	38	341
2005	9	1	54	64	27	24	23	192

Year	Month	Day	Plot1	Plot 2	Plot 3	Plot 4	Plot 5	Total
2005	9	19	59	47	12	7	25	150
2005	10	3	45	51	10	19	39	164
2005	10	17	32	14	32	6	61	145
2005	11	3	59	15	23	35	65	197
2005	11	15	23	13	11	22	53	122
2005	12	11	71	15	6	10	34	136
2006	1	5	112	24	29	5	211	381
2006	2	7	81	57	33	28	165	364
2006	3	24	53	30	19	118	114	334
2006	4	9	49	28	29	34	186	326
2006	5	8	30	9	51	16	72	178
2006	6	4	46	19	13	4	47	129
2006	7	3	153	24	41	11	19	248
2006	8	7	44	26	14	6	219	309
2006	9	3	69	29	15	5	42	160
2006	10	2	8	36	11	15	55	125
2006	11	12	68	45	56	12	27	208
2006	12	14	105	42	63	58	34	302
2007	1	10	30	45	15	43	12	145
2007	2	7	20	22	47	10	7	106

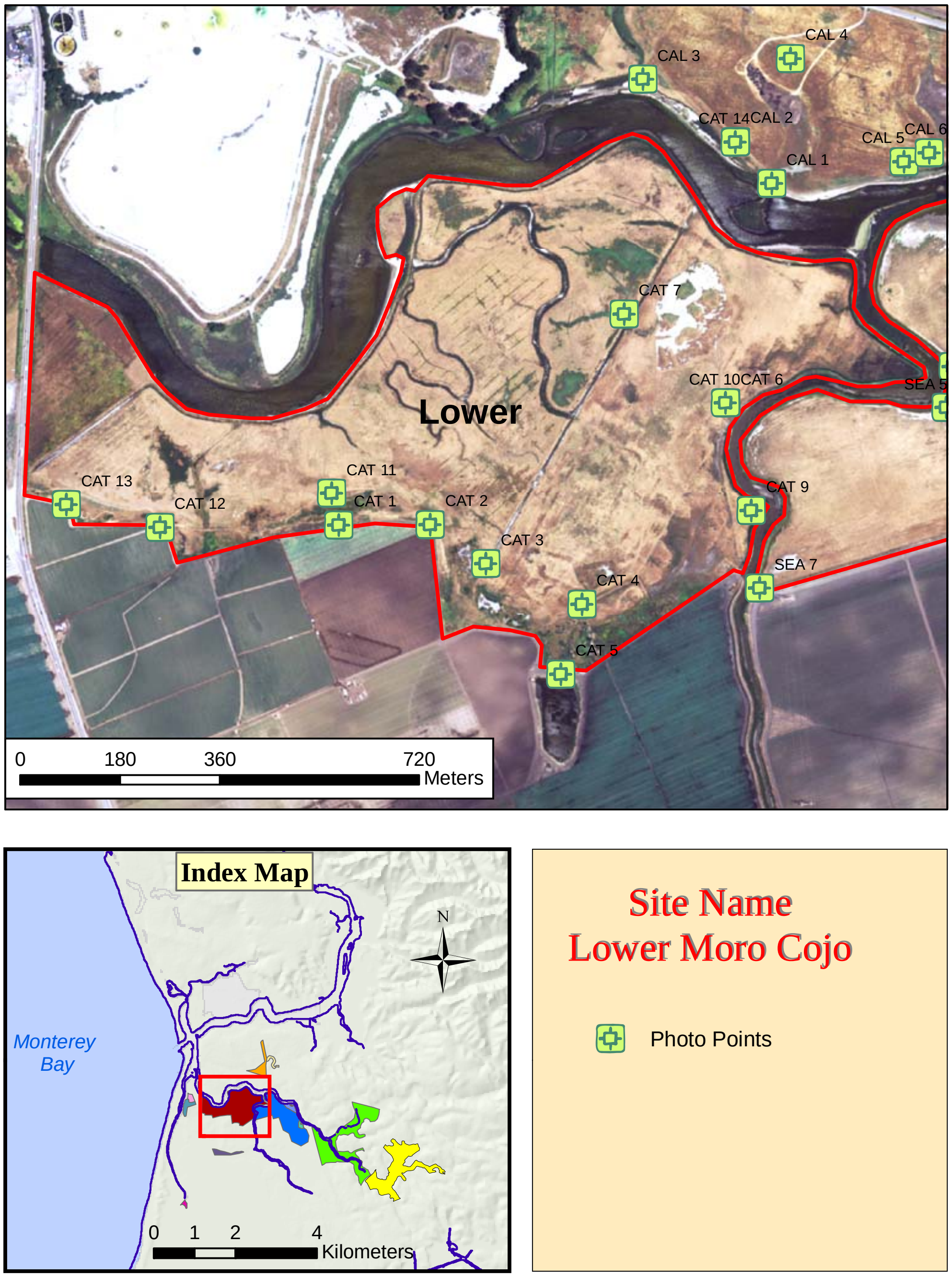
Appendix 54. South Pond Bird Richness.

Year	Month	Day	Plot1	Plot 2	Plot 3	Plot 4	Plot 5	Cumulative
2001	5	12	15	13	8	12	14	29
2001	5	25	14	6	5	8	11	20
2001	6	5	25	13	8	9	7	30
2001	6	20	19	11	9	6	8	26
2001	7	6	13	10	21	7	8	29
2001	7	14	12	9	17	7	7	26
2001	7	24	14	4	12	6	5	18
2001	8	3	14	8	10	8	4	26
2001	8	29	20	4	9	11	10	31
2001	9	6	14	6	11	9	8	26
2001	9	14	9	10	12	6	7	23
2001	9	29	14	11	14	6	9	26
2001	10	11	12	15	14	9	5	27
2001	10	21	9	9	10	10	8	24
2001	10	28	9	10	13	8	8	23
2001	11	8	12	5	16	11	8	23
2001	11	20	14	8	12	5	6	24
2001	12	29	18	4	9	9	16	38
2002	1	17	29	8	7	16	15	34
2002	2	18	19	6	11	4	17	30
2002	3	3	19	4	9	10	25	38
2002	3	18	28	7	11	11	14	44
2002	4	3	27	11	6	10	18	36
2002	4	20	23	8	14	6	17	34
2002	5	11	14	7	8	7	15	22
2002	5	25	13	11	9	8	14	23
2002	6	4	23	7	8	5	23	30
2002	6	26	12	8	8	9	16	28
2002	7	10	9	8	10	8	10	22
2002	7	24	13	7	8	7	17	29
2002	8	7	9	7	8	8	18	31
2002	8	24	11	7	10	10	19	30
2002	9	9	18	9	13	17	23	43
2002	9	30	11	8	6	10	14	25
2002	10	10	16	8	8	4	17	24
2002	10	24	11	11	10	12	27	33
2002	11	6	14	6	9	17	22	31
2002	11	23	18	10	8	11	22	30
2003	1	11	13	0	7	5	9	20
2003	1	20	12	6	5	0	19	27
2003	2	2	10	6	4	2	3	18
2003	2	18	8	2	3	4	6	16
2003	3	3	15	4	2	6	5	16
2003	3	24	10	4	5	4	11	20
2003	4	4	14	5	9	5	9	19
2003	4	26	13	6	7	6	3	16

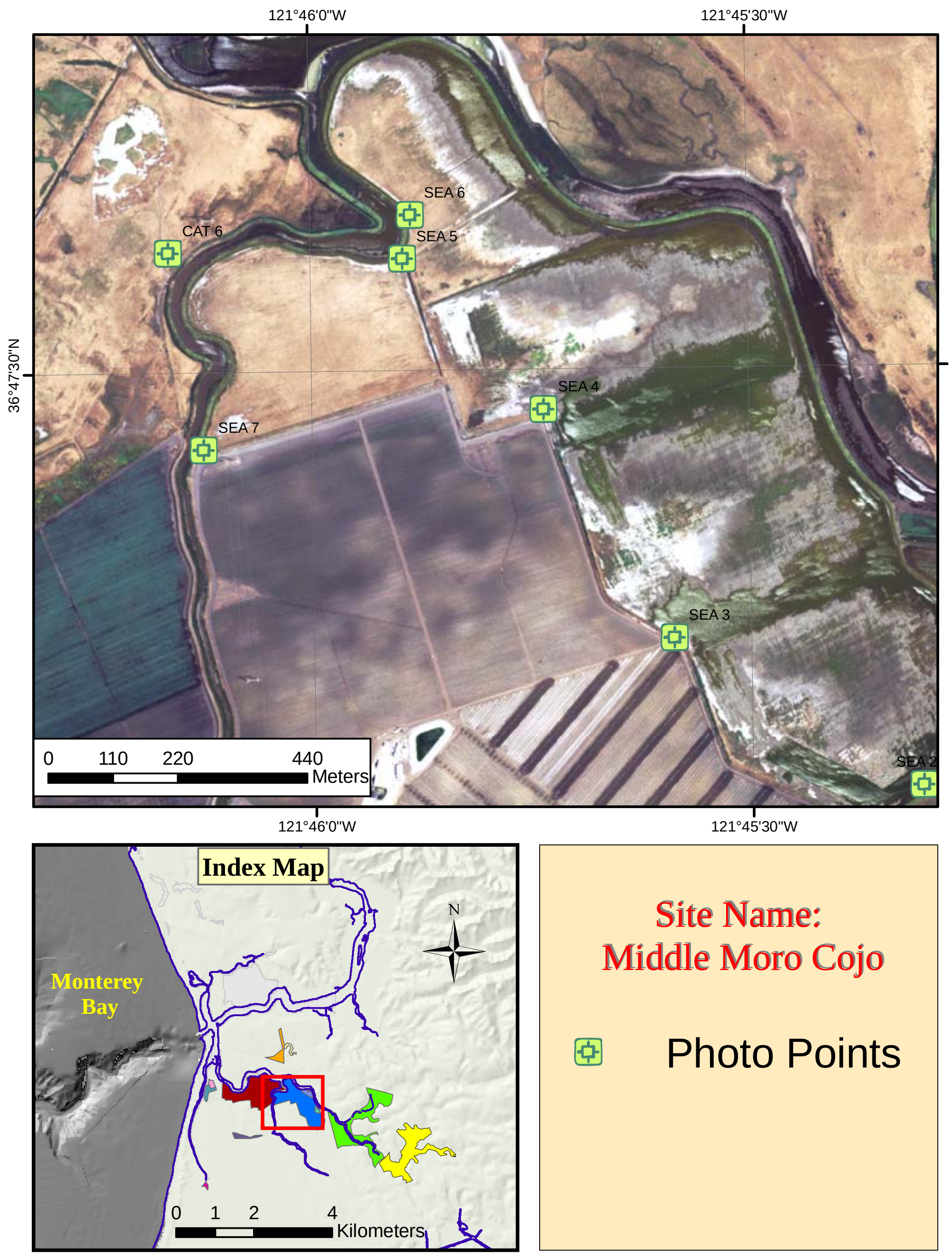
Year	Month	Day	Plot1	Plot 2	Plot 3	Plot 4	Plot 5	Cumulative
2003	5	13	8	6	7	5	3	13
2003	5	30	8	4	4	1	4	11
2003	6	2	9	6	6	3	3	10
2003	6	19	7	8	6	3	3	13
2003	7	4	10	5	3	1	4	15
2003	7	19	9	7	4	5	6	15
2003	8	1	10	5	10	0	9	18
2003	8	21	12	12	6	8	13	23
2003	9	16	9	8	9	6	16	19
2003	10	1	16	10	7	10	13	25
2003	10	21	15	5	7	11	19	29
2003	11	4	17	7	6	4	7	27
2003	11	17	16	5	6	9	9	25
2003	12	2	20	8	6	4	10	28
2003	12	17	20	4	4	2	8	25
2003	12	24	18	5	5	1	4	21
2004	1	4	12	13	6	4	8	30
2004	1	18	17	8	7	8	9	33
2004	2	1	16	4	9	4	11	29
2004	2	15	15	7	5	6	7	21
2004	3	10	13	8	3	4	6	17
2004	3	21	10	7	6	3	12	19
2004	4	5	11	7	5	5	12	22
2004	4	19	13	4	5	3	8	16
2004	5	4	13	5	5	5	11	17
2004	5	16	14	5	7	6	10	19
2004	6	8	11	7	4	4	11	15
2004	6	21	10	6	9	7	9	15
2004	7	6	8	11	8	5	6	21
2004	7	19	10	6	9	6	10	19
2004	8	1	12	7	8	5	7	21
2004	8	18	10	5	4	4	5	15
2004	9	2	14	7	6	5	5	25
2004	9	14	10	7	9	4	15	23
2004	10	4	13	10	3	2	16	26
2004	10	17	11	10	3	8	12	23
2004	11	2	11	4	5	4	13	22
2005	3	22	10	6	6	2	18	24
2005	4	1	11	5	6	8	9	17
2005	4	11	10	7	5	5	14	17
2005	5	2	13	7	3	7	9	20
2005	5	14	8	4	4	7	10	15
2005	6	10	12	6	9	3	5	18
2005	6	26	9	5	1	0	12	17
2005	7	6	11	5	6	6	12	16
2005	7	23	14	9	6	2	12	19
2005	8	3	6	7	8	8	9	21
2005	8	16	16	10	5	6	8	22
2005	9	1	18	6	7	9	4	24

Year	Month	Day	Plot1	Plot 2	Plot 3	Plot 4	Plot 5	Cumulative
2005	9	19	9	15	6	6	5	20
2005	10	3	15	9	6	10	8	26
2005	10	17	8	12	10	4	11	26
2005	11	3	12	6	9	11	11	23
2005	11	15	9	5	7	11	14	24
2005	12	11	16	4	4	4	10	22
2006	1	5	16	5	5	3	13	26
2006	2	7	16	11	8	10	14	29
2006	3	24	14	12	7	9	16	29
2006	4	9	15	13	10	9	18	31
2006	5	8	11	4	7	9	18	22
2006	6	4	9	9	4	3	6	14
2006	7	3	14	7	8	6	8	19
2006	8	7	9	8	4	3	10	17
2006	9	3	14	12	3	4	9	21
2006	10	2	5	10	5	5	16	21
2006	11	12	19	11	9	4	10	26
2006	12	14	20	8	9	10	10	32
2007	1	10	15	7	6	10	7	24
2007	2	7	6	5	7	4	5	17

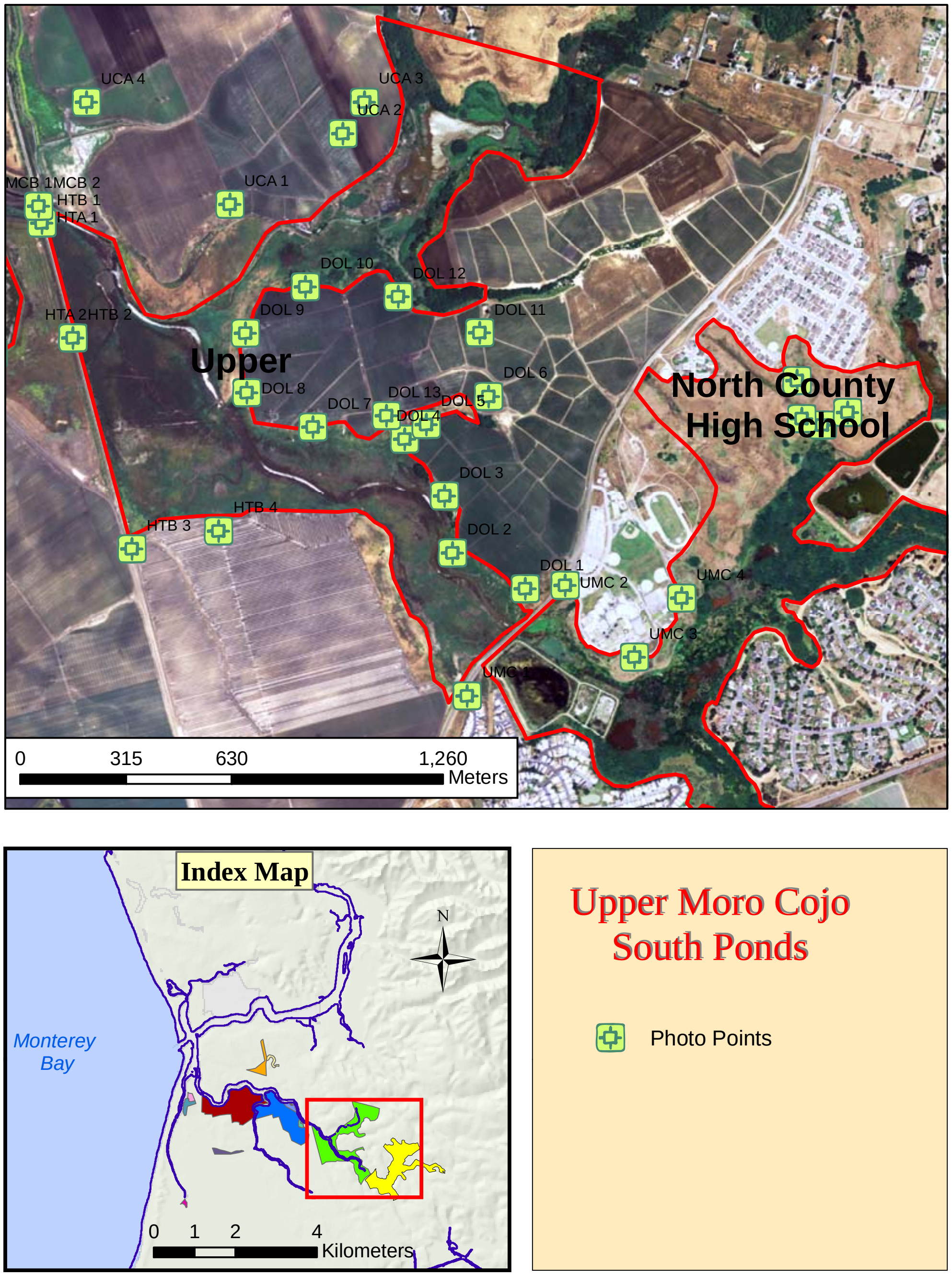
Appendix 55. Photo monitoring points for the Lower Moro Cojo.



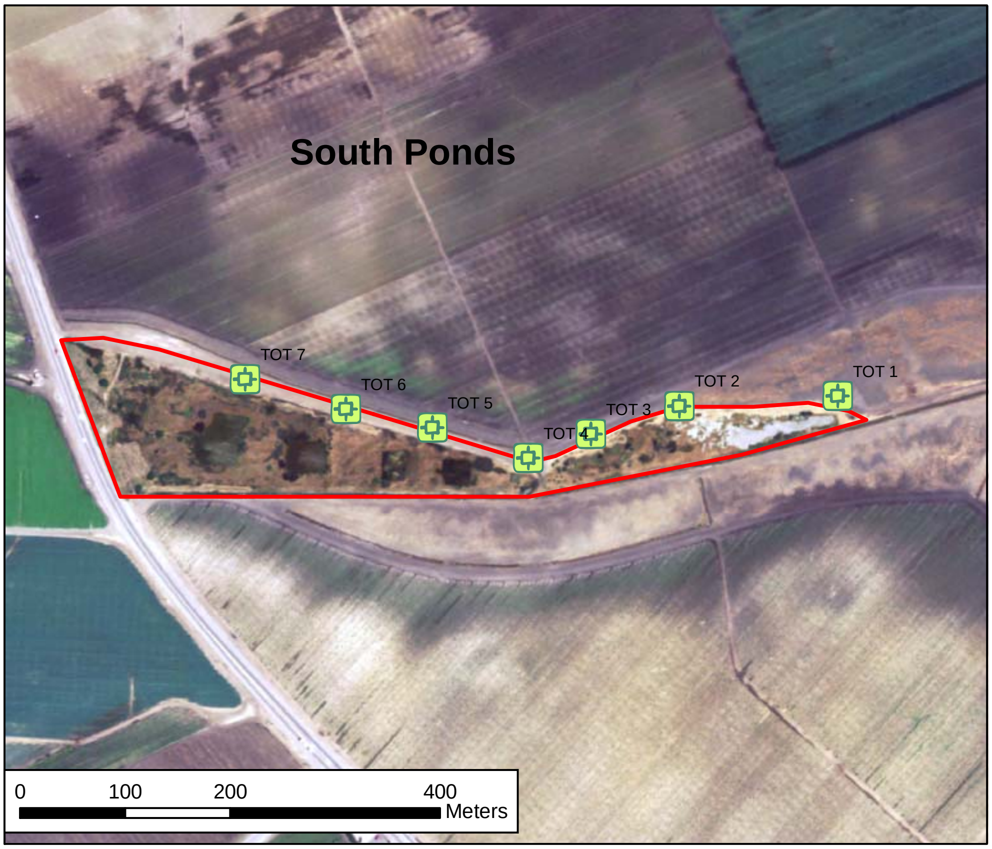
Appendix 56. Photo monitoring points for the Middle Moro Cojo.

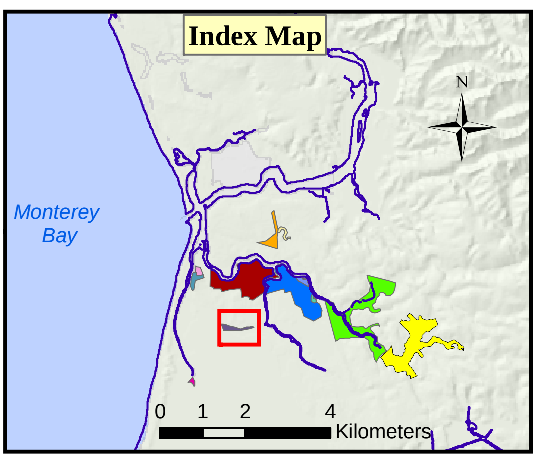


Appendix 57. Photo monitoring points for the Upper Moro Cojo and High School.



Appendix 58. Photo monitoring points for South Ponds site.





Appendix 59. Photo point data for Lower Moro Cojo.

Station #	Northing	Easting	1st Bearing	Last Bearing	# of Photos	Description
CAT 0	36.794509	-121.786770	75	115	5	MLML HILL LOOKING AT CATTELUS
CAT 1	36.791599	-121.777240	295	65	7	ON TOP OF LUPINE HILL 4X4 POST WITH X
CAT 2	36.791589	-121.775390	305	105	7	TRACTOR CORNER AT 4X4 POST
CAT 3	36.790939	-121.774270	195	55	8	WHERE ROAD CROSSES MAIN CENTRAL DITCH
CAT 4	36.790259	-121.772340	55	235	6	NW CORNER OF JUANS POND, FIRST PICTURE 55DEG NE ALONG BERM FACING LOWER JUANS POND
CAT 5	36.789129	-121.772790	315	105	5	FARMERS RETENTION POND AT VALVE
CAT 6	36.793506	-121.769375	0	360	10	ON HILL SOUTH OF POND (GOOSELAKE)
CAT 7	36.794976	-121.771413	220	30	6	AT OWL BOX ON MAIN DITCH STARTING WITH DITCH LOOKING SOUTH TO DITCH LOOKING NORTH
CAT 9	36.791750	-121.768887	200	300	4	AT SW CORNER ALONG CASTROVILLE SLOUGH. TRIANGLE SHAPED OLD FENCE (1ST STATION YOU COME UPON IN WALK FROM SEA MIST)
CAT 10	36.793509	-121.769380	10	120	10	ZOOMED IN TO AREA W/SWALLOW BOXES AND BIG POWER POLE IN CENTER CASTROVILLE SLOUGH ON R DITCH W/ PLANK ON L
CAT 11	36.792119	-121.777380	145	225	6	NEW STATION FACING LUPINE HILL AT BIRD PERCH ZOOMED IN
CAT 12	36.791599	-121.780860	70	180	5	NEW STATION AT FENCE CORNER NEAR ROBS POND WHERE ROAD GOES BETWEEN TWO FENCE POSTS
CAT 13	36.791989	-121.782750	280	170	8	FENCE CORNER NEAR ATRIPLEX, FIRST CORNER IN FROM GATE

Appendix 60. Photo point data for Middle Moro Cojo.

Station #	Northing	Easting	1st Bearing	Last Bearing	# of photos	Description
SEA 1	36.784616	-121.756349	330	60	4	ON BERM NEAR 1ST PUMP STATION
SEA 2	36.785233	-121.755084	230	20	5	when too full to access ACROSS CHANNEL ON BERM, SE CORNER. otherwise adjacent to channel looking NW 240-60 degrees
SEA 3	36.787527	-121.759810	300	100	6	AT BERM CROSSING AG DITCH, OVERLOOKING ALKALI FLAT, NEAR EASTERNMOST LINEAR DITCH
SEA 4	36.791050	-121.762252	280	120	9	CORNER OF BERM NEAR FIRST "NO HUNTING" SIGN
SEA 5	36.793386	-121.764916	310	160	8	WESTERN MOST SIDE OF SITE AT TIRE WITH PIPE STICKING OUT (NEAR CASTROVILLE DITCH) NEXT TO OLD WOODED POWER POLE
SEA 6	36.794051	-121.764759	70	260	7	CORNER OF 2 AG DITCHES @ CURVE IN CASTROVILLE DITCH NEXT TO RUST/WHITE STAKE
SEA 7	36.790487	-121.768739	20	80	3	SOUTHERNMOST CORNER NEAR POWER POLE AND CASTROVILLE DITCH

Appendix 61. Photo point data for Upper Moro Cojo and High School.

Station #	Northing	Easting	1st Bearing	last Bearing	# of photos	Description
DOL 1	36.778738	-121.737410	215	300	7	ON HILL FARM ROAD PARALLEL TO CASTROVILLE BLVD.
DOL 2	36.779728	-121.739820	140	320	7	ON FARM ROAD AT PEAK OF CURVE IN ROAD (WHERE IT IS FURTHEST OUT INTO THE WETLAND)
DOL 3	36.781262	-121.740065	140	320	5	ON FARM ROAD AT BOTTOM OF HILL NEAR WILLOWS
DOL 4	36.782799	-121.741373	280	60	5	WHERE RD SPLITS ONE GOING UP ONE CONTINUING. VIEW TOWARDS PARKINGLOT/SHACK HILL
DOL 5	36.783188	-121.740650	200	240	4	ON SOUTH SIDE OF FINGER UP ON HILL BTWN LARGE OAK TREE AND SMALLER OAK/SNAG
DOL 6	36.783918	-121.738550	100	240	2	ON HILL ABOVE SOUTH FINGER TO NE SIDE UP FARM ROAD ABOVE WILLOW THICKET AT TOP OF DRAINAGE
DOL 7	36.783158	-121.744440	210	350	5	NEAR POWER LINES/FARM EDGE
DOL 8	36.784099	-121.746630	180	20	5	SOUTH END OF DOLAN PROPERTY: LOW POINT/DRAINAGE FROM FIELD COW POND LOOK FOR X IN FENCE
DOL 9	36.785704	-121.746649	290	330	8	CONTINUE ALONG FARM ROAD UP THE HILL LOOKING BACK TOWARDS DOL 8
DOL 10	36.786935	-121.744623	30	280	8	CONTINUE ALONG FARM ROAD AROUND BEND TO OVERLOOK LARGE WETLAND AT LOW VALLEY NEAR X IN FENCE
DOL 11	36.785630	-121.738816	0	160	5	ABOVE SOLITARY OAK IN WASHED OUT DRAINAGE DIRECTLY ABOVE MAIN DRAINAGE
DOL 12	36.786632	-121.741534	285	20	3	NEW POINT ON OTHER SIDEW OF WILLOE FINGER ABOVE ELDERBERRY TO RGHT
DOL 13	36.783438	-121.741980	210	60	7	OVERLOOKING HEMLOCK AND TRASH

Station #	Northing	Easting	1st Bearing	last Bearing	# of photos	Description
						FILLED SWALE
HTA 2	36.785638	-121.752420	180	320	5	ON RR TRACKS NEXT TO PILE OF LOGS/TRASH IN DISCED FIELD, 5 POLES N OF MAIN POWER LINE, 6 POLES S OF RR BRIDGE POLE HAS HUBCAP ATTACHED.
HTB 2	36.785638	-121.752420	10	130	5	SAME POSITION AS HTA 2, BUT LOOKING EAST
HTB 3	36.779948	-121.750540	350	30	2	CORNER OF WETLAND AND FARM PROPERTY AT RAILROAD, CACTUS AND WILLOW TREE
HTB 4	36.780398	-121.747630	310	50	13	IN FRONT OF SCIRPUS STAND ON FARM ROAD UP HILL ABOVE MARSH. FIRST PHOTO TOWARDS POWER POLE
UCA 1	4072218	611786	100	210	6	LOWER PART OF LARGE FINGER FROM FARM HILL (SMALL ZOOM)
UCA 2	4072229	611984	60	160	9	FARM HILL ABOVE DAM/TRUCK PARKING LOT
UCA 3	4072523	612187	70	180	13	UPPER PART OF LARGE FINGER, LOOKING OVER
UCA 4	4072522	611358	170	300	19	ON FARM HILL OVERLOOKING DISCED WETLAND BETWEEN FARM AND RR TRACKS
CHA 1	4073304	597437	350	150	5	ON HILL TO WEST OF DRAINAGE
CHA 2	4072415	612791	240	340	4	NEXT TO ERODED DRAINAGE NEAR POWER LINES
CHA 3	4071598	613629	200	20	6	ON FLAT HILL NEXT TO WASTEWATER PONDS BETWEEN POWER LINES AND TELEPHONE POLES
CHA 4	4071579	613492	0	140	5	ON HILL TO WEST OF MAIN LOWER DRAINAGE, VIEWING JUNCTION OF TWO DRAINAGES
HTA 1	36.788738	-121.753400	200	280	3	FROM RAILROAD AT CORNER NEAR SIGNAL. 22 RR TIES S OF SIGNAL
HTB 1	36.788738	-121.753400	0	130	4	SAME POSITION AS HTA 1 ON RR. 22 RR TIES S OF SIGNAL POLE. LOOKING OPPOSITE DIRECTION

Station #	Northing	Easting	1st Bearing	last Bearing	# of photos	Description
MCB 1	36.789198	-121.753510	200	320	5	MORO COJO BRIDGE AT RAILROAD LOOKING WEST FROM DIRECT CENTER OF BRIDGE.
MCB 2	36.789198	-121.753510	20	120	4	MORO COJO BRIDGE AT RAILROAD SAME POSITION AS ABOVE BUT LOOKING EAST
UMC 1	36.775878	-121.739400	310	0	4	UPPER MORO COJO FROM CASTROVILLE BLVD. LOOKING WEST FROM TRUCK BED
UMC 2	36.778808	-121.736090	200	210	2	UPPER MORO COJO FROM HIGH SCHOOL BY FENCE AT CASSTROVILLE BLVD.
UMC 3	36.776858	-121.733800	100	290	6	HIGH SCHOOL LOOKING DOWN BERM ACROSS WETLAND NEAR PORTABLES
UMC 4	36.778428	-121.732190	110	190	3	HIGH SCHOOL ON HILLL NEXT TO TRAILER ON DIRT PULLOUT, PICTURES FROM TRUCK BED

Appendix 62. Photo point for South Ponds.

Station #	Lat	Long	1st Bearing	Last Bearing	# of photos	Description
TOT 1	36.783569	-121.772380	60	50	20	AT OPEN FIELD, END OF PONDS 360 PANORAMA
TOT 2	36.783499	-121.774070	110	250	4	WHERE SMALL POND SIDE ROAD DIVERGES FROM FARM ROAD
TOT 3	36.783269	-121.775020	100	240	4	NEXT TO ROW OF WILLOWS
TOT 4	36.783069	-121.775690	100	250	5	AT CULVERT POND 2
TOT 5	36.783339	-121.776710	140	280	5	DIRECTLY ACROSS FROM 7TH BIRD PERCH ON FARMERS ROAD
TOT 6	36.783509	-121.777630	130	270	5	ACROSS FROM 4TH BIRD PERCH
TOT 7	36.783779	-121.778700	50	270	5	POND 1

Appendix 63. Curriculum development program.

Lab and Field Explorations in Marine Science Schedule June 25 – 29, 2007

Monday 25th		Presenter
9:00 am	Moss Landing Marine Labs: Welcome and sign-in (MLML Main Blg. Room 101)	
	▪ MLML and Marine science careers	Simona
9:30 am	Tour of MLML	Elsie
9:50 am	Evaluation and pre-assessment	Traci
10:15 am	Workshop overview	Simona
10:30 am	Break	
10:45 am	Our Marine Environment	Simona
11:00 am	Presentation: Water Quality	Gage
	▪ Preparation/directions for field trip	
	▪ Assignment of groups and passing out handouts	
12:00 pm	Lunch	
1:00 pm	Field trip to Moro Cojo Slough: Water quality	Gage, Elsie
	▪ Two sites	
	▪ Using kits and field equipment	
2:30 pm	Lab (MLML Room 508)	Gage, Elsie
	▪ Using lab equipment	Erinn, Sarah
	▪ Break	
	▪ Data sets	
	▪ Handouts	
4:30 pm	Prep for next day	
5:00 pm	End	

Tuesday 26th:		
9:00 am	Discussion of Water quality conclusions (MLML Rm. 214)	Elsie, Simona
9:30 am	Watershed and Water Quality lesson planning	Laurie, Traci
10:30 am	LiMPETS: Environmental monitoring presentation (Long-term Monitoring Program & Experiential Training for Students)	Lisa
	▪ Sandy beach monitoring overview	
	▪ Break	
	▪ Viewing monitoring data (MLML Room 202)	
	▪ Directions and preparation for field trip	
11:30 am	Lunch	
12:30 pm	Field trip to Salinas River beach: LiMPETS	Lisa, Ashley
	▪ Field activity (2.4 tide at 1:31 pm)	
3:00 am	Return to MLML - Break	
	▪ Looking for parasites (MLML Room 214)	Lisa, Ashley
	▪ Entering monitoring data (MLML Room 202)	Lisa, Ashley
4:00 pm	Presentation: Elasmobranchs (MLML Room 214)	Ashley

4:30 pm	Prep for Monterey Bay Aquarium (MBA) trip	Ashley, Danielle
	▪ Directions/parking/meeting place/lunch details	
	▪ Instructions for morphology/behavior activity	
	▪ Instructions for tracking activity	
5:00 pm	End	

Wednesday 27th:

8:00 am	MBA: begin morphology/behavior activity	Ashley, Simona
9:30 am	Lab activity (MBA Ocean View Conference Room)	Ashley, Danielle
	▪ Current research and tracking data of sharks	
	▪ Time/depth and location/bathymetry data	
10:00 am	LiMPETS and Elasmobranchs lesson planning	Laurie, Traci
11:00 am	Lunch (on your own)	
12:30 pm	Sea Urchin fertilization (Hopkins Marine Station - Agassiz 12)	Pam, Danielle
	▪ Background	
	▪ Lab activity - fertilization & embryology	
	▪ Break	
	▪ Inquiry-based approach to investigations:	
	• Biomonitoring/pollutant effects	
3:30 pm	Prep for next day	
4:00 pm	End	

Thursday 28th:

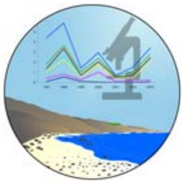
9:00 am	Virtual Urchin computer-based labs (MLML Room 202)	Pam, Danielle
10:30 am	Break	
10:45 am	SIMoN presentation (MLML Room 202) (Sanctuary Integrated Monitoring Network)	Chad, Danielle
	▪ Online Resources	
	▪ Integrating photo, natural history and beachcast data	
12:00 pm	Lunch	
1:00 pm	Sea urchin and SIMoN lesson planning (MLML Room 214)	Laurie, Traci
2:00 pm	Time for lesson planning, networking and reflection (Rm. 101)	Simona, Laurie
	▪ Participants bring lessons to share	
	▪ Other MLML curricula	
2:45 pm	Break	
3:00 pm	Elkhorn Slough National Estuarine Research Reserve (ESNERR)	Kenton, Cindy
	▪ Overview of Estuarine areas (MLML Rm 101)	
	▪ History, monitoring, tidal scour of Elkhorn Slough	
4:00 pm	Invasive Species presentation	Danielle, Elsie
	▪ Prep for field trip	
5:00 pm	End	

Friday 29th:

7:00 am	Field trip to Kirby Park	Danielle, Elsie, Kenton
	▪ Transects and counting snails	
	▪ Transects for terrestrial invaders	Laurie
9:00 am	Invasive species and management at ES (on site)	Kenton, Cindy
9:30 am	Break and drive to MLML	
10:00 am	Lab (MLML Room 214)	Danielle, Elsie
	▪ Parasites under the microscope	
	▪ Data sets	

- Handouts

11:30 am	Lunch	
1:00 pm	Graphing data within larger data sets (MLML Room 214)	Danielle, Elsie
1:30 pm	Estuarine and Invasive species lesson planning	Laurie, Traci
2:30 pm	Evaluation and wrap-up	Traci, Simona
3:00 pm	End	



Introduction: Water Quality

Water quality monitoring is an important component of ecosystem management. The establishment of appropriate biological, physical, chemical, and toxicological parameters enables scientists to track the health of aquatic ecosystems and control the impact of anthropogenic activities. Although water quality monitoring guidelines are determined by the Environmental Protection Agency, monitoring programs are often collaborations between federal, state, and local agencies, as well as volunteers. A healthy watershed can remove contaminants from waterways through both biotic and abiotic processes.

History of the slough:
The Moro Cojo Slough (a slough is a tidal salt marsh) is a watershed in the Elkhorn Slough/Salinas River area. The Moro Cojo Slough receives non-point source pollution (not from a direct pipeline) from urban and agricultural runoff. Moro Cojo drains a small watershed—approximately 17 square miles—to the south of Elkhorn Slough and to the north of the Salinas River. Moro Cojo degradation began with the grazing of cattle ranches in the 18^{th} century. Over the past100 years, the addition of structures which inhibit tidal flow has severely limited flow of saltwater into and out of the slough. A restoration plan for the watershed was developed in1996.

Our experiment:
Moro Cojo receives large nitrogen inputs from the farmlands of central coastal California. Although nitrogen is a critical nutrient for plant and animal growth, the environmental impact of excessive concentrations remains greatly unknown. A known consequence is eutrophication—the enrichment of water with nutrients—which leads to plant growth and decay and a high biological demand for oxygen.

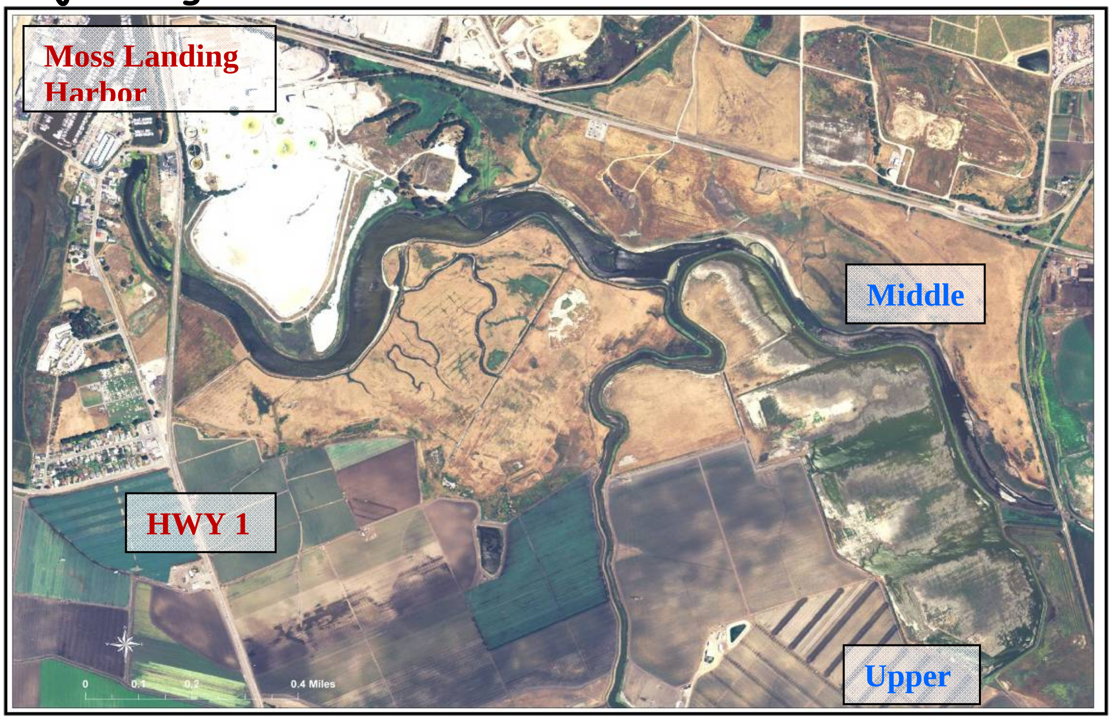
We will monitor several physical/chemical water quality parameters in two locations within Moro Cojo—the upper and middle slough. We will take some measurements *in situ* as well as collect water for spectrophotometric nitrate analysis to be conducted in the lab. Our results will be combined with data collected by the Benthic Lab at Moss Landing Marine Labs (along with the Central Coast Wetland Working Group, the Elkhorn Slough Foundation, and the California Coastal Commission) over the past year and a half. These data enable researchers to evaluate the potential effectiveness of the watershed in cleaning runoff water before it reaches the Monterey Bay.

By combining past and present data sets, we will construct a likely mechanism by which some biological, physical, and chemical water quality parameters work synergistically to control the functioning of aquatic ecosystems.

For more information:
Moro Cojo Slough: http://science.csumb.edu/morocojo/about.html
GREEN Water Quality Monitoring Kit: http://www.earthforce.org/section/programs/green/handson/

FIELD and LAB EXERCISE: Water Quality in Moro Cojo Slough

Moro Cojo Slough



Part 1: Formulating a Hypothesis

A. Observations:

Begin formulating your hypothesis by observing the map of the Moro Cojo Slough. What is the physical nature of this slough? What types of contaminants would you expect to be entering the slough? What types of changes might exist throughout? Keep in mind the parameters we've discussed.

1. Make at least three observations, questions, or comments:

B. Predictions:

2. Think about each of the following water quality parameters before constructing your hypothesis. **Circle the site you think will have the higher value** for each of the following parameters. Circle both if you predict no difference.

Water depth	Upper	Middle
Temperature	Upper	Middle
Turbidity	Upper	Middle
Salinity	Upper	Middle
pH	Upper	Middle
Dissolved O_2	Upper	Middle
Nitrate (NO_3)	Upper	Middle
Nitrite (NO_2)	Upper	Middle
Phosphate (PO_4)	Upper	Middle

3. With your group, formulate a hypothesis regarding differences between the sampling locations in the Moro Cojo Slough for your assigned parameter.

Parameter:____________________________

How might the values of your parameter differ from the upper to the middle slough?
____
____
____
____

State your hypothesis:
____
____
____
____

State your reasoning:
____
____
____
____

Part 2: Field Exercise

A. Observations:

Think about how each factor may affect your hypothesis as you make notes.

1. General field observations—notes on weather conditions.

Date______________________

Time______________________

Air temperature	Hot	Warm	Cool	Cold
Cloud cover	Sunny	Clouds	Hazy	Foggy
Precipitation	No rain	Light rain	Rain	Stormy
Recent precipitation	No rain	Light rain	Rain	Stormy

2. General field observations—notes on wildlife. List the plants and animals you observe at the field sites. Record behavior.

____
____
____
____
____
____

3. Specific field observations—notes on field site. Since these are qualitative notes and not quantitative measurements, approximate or describe to the best of your ability.

	Upper Slough	**Middle Slough**
Water appearance		
Water odor		
Width of channel		
Bank erosion		
Soil grain size		
Soil odor		

B. Measurements:

4. Record the measurement for each water quality parameter in the table below:

GREEN Low Cost Water Monitoring Kit

Sampler(s) ____

	Depth (m)	Temp (°C)	Turbidity (JTU)	pH	Dissolved O_2 (ppm)	Nitrate (ppm)	Phosphate (ppm)
Upper							
Middle							

YSI probe

Sampler(s) _____________________________________

	Depth (m)	Temp (°C)	Salinity (ppt)	pH	Dissolved O_2 (mg/L)
Upper					
Middle					

C. <u>Results:</u>

5. Is there a difference between parameters when measured with the kit versus the instrument? Which ones?

____
____
____
____

6. Calculate the percent difference between the upper and middle slough values of nitrate:
(mean upper) – (mean middle) / (mean upper + mean middle) = ____________________

7. Calculate the percent difference between the upper and middle slough values of your parameter:
(mean upper) – (mean middle) / (mean upper + mean middle) = ____________________

8. How does your parameter differ between the upper and middle slough?

____
____
____
____

Part 3: Lab Exercise

A. Pre-Lab:

1. What does a spectrophotometer measure?

 ____
 ____
 ____
 ____

2. What wavelength is used for measuring nitrate? ____________

B. Protocol overview:

I. Filter field water through to remove particulates.
II. Separate filtered water into two samples for later comparison. In one sample gross nitrite will be measured and in the other pre-existing nitrite will be measured.
III. Add reagents to each sample in order to change sample color and wait for reaction to take place.
IV. Use the spectrophotometer to measure the absorbance in each sample.

C. Measurements & Results:

3. Sample nitrate concentrations are determined by using the "best-fit" line equation from the standard curve graph. The equation is in the form y = mx + b, where x = sample concentration and y = absorbance. Record the following values in the table:

 AU = raw absorbance value recorded from spectrophotometer for each sample
 Net AU = AU_{sample} - AU_{blank}
 Gross [NO_2^-] = Plug in the sample absorbance value into the appropriate standard curve equation to calculate Gross NO_2^- concentrations.
 Pre-existing [NO_2^-] = Plug in the sample absorbance value into the appropriate standard curve equation to calculate Pre-existing NO_2^- concentrations.
 Total [NO_3^-] = Calculate by subtracting Pre-existing NO_2^- from Gross NO_2^-.

Spectrophotometer					
	AU	Net AU (AU-blank)	Gross [NO_2^-] (uM)	Pre-existing [NO_2^-] (uM)	Total [NO_3^-] (uM)
Blank					
Upper1					
Upper 2					
Middle1					
Middle 2					

4. Convert Total NO_3^- from units of uM to units of mg/L using the following conversion:

mg/L NO_3^- = [(uM NO_3^-) x 62]/ 1000

Calculate the mean Total NO_3^- (mg/L) for both upstream and downstream samples.

Mean upper slough NO_3^- (mg/L): ________________

Mean middle slough NO_3^- (mg/L): ________________

5. How do measured nitrate concentrations vary between the water quality kit and the spectrophotometer?

____
____
____
____

6. Calculate the percent difference between the kit and the spectrophotometric values of nitrate. Use the mean upper slough value and the mean middle slough value.

(mean upper kit) – (mean upper spec) / (mean upper kit + mean upper spec) =

Upper slough:_________________

(mean middle kit) – (mean middle spec) / (mean middle kit + mean middle spec) =

Middle slough:________________

7. Was the percent difference between the upper and middle slough when calculated from kit measurements (Part 2C, #6) greater than the difference between sampling methods? What does this tell you?

____
____
____
____

Part 4: Analysis and conclusions

A. Reflections on your results:

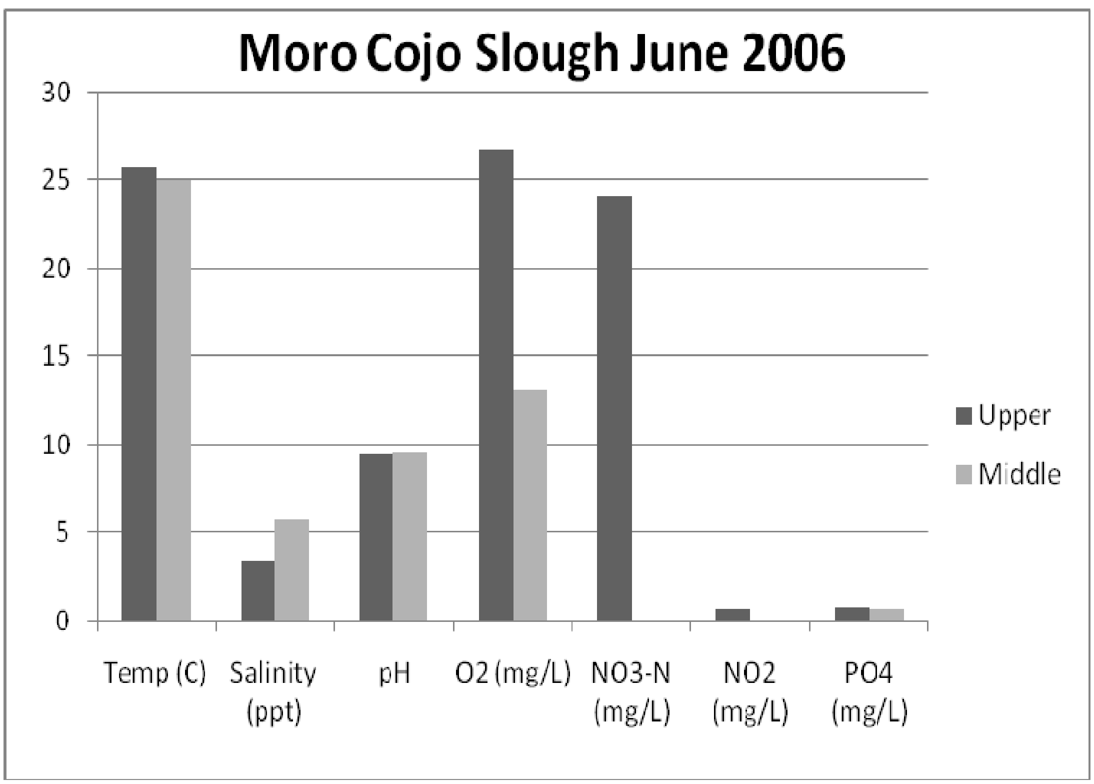
1. Return to the chart of your predictions for each parameter (Part 1, Q#1). Using a different colored pen, circle the results for each parameter. Check with other groups if you are missing data. If different methods have given you different results, select the results you trust the most. Think about why you trust some methods more than others.

2. Did the results for your parameter match your expectations? Explain.

____
____
____
____
____
____
____

B. Comparisons to other data:

The Benthic Lab at Moss Landing Marine Labs measures the water quality parameters of the Moro Cojo Slough monthly. Their measurements from June 22, 2006 are plotted on the graph below. Additional graphs of 2006 data are attached. For your parameter, compare upstream and downstream values from the graph of 6/07. Evaluate your data for trend consistency.



3. Do your data show the same trend as the data of the Benthic Lab? If not, how do they differ?

____

4. Why do you think this is so?

C. Group Conclusions:
Conclusions should be based upon both existing and new data, and should address any discrepancy between them.

5. Do the data suggest that the Moro Cojo Slough has an impact on the water travelling into the Monterey Bay? Explain.

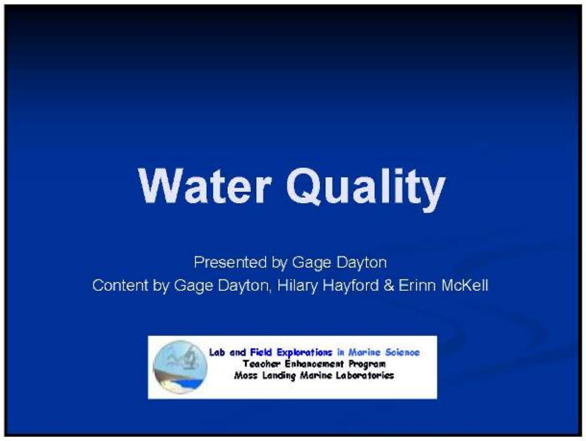
6. Discuss your conclusions with at least one other group. Which water quality parameter was most impacted? Why do you think this is so?

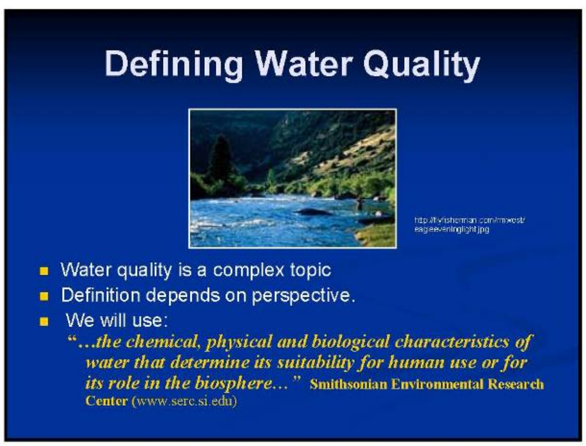
D. Individual Conclusions:
A critical part of your discussion of any conclusions should note problems/concerns with your experiment or results and to suggest future research that may expand the understanding of your research system. (This component is often mistakenly overlooked!)

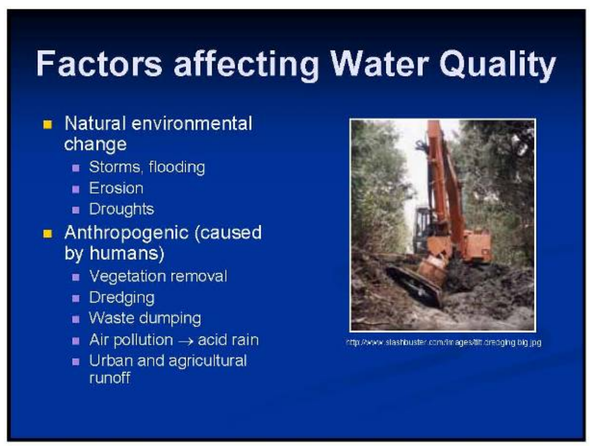
7. What is one way that sampling could be improved to make it more accurate or more pertinent to your hypothesis?

8. Formulate at least one new hypothesis based upon your results or the system as a whole. You might want to consider the impact of factors such as season, rainfall, agricultural regulations, tidal influx, etc. Alternatively, you may consider sampling protocol, location, or chosen parameters.

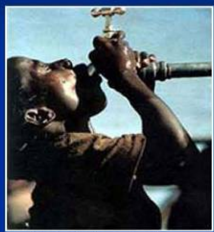
Appendix 64. Presentation to for the High School curriculum teachers workshop.







Water Quality affects People



http://academic.evergreen.edu

- Consequences:
  - Waterborne illness & infection
  - Exposure to chemicals through water and food contamination
  - Reduced fish/shellfish availability
  - Recreation area loss
  - Damaged wild lands - outside of water-sport areas

Water Quality affects the Environment

- Input of fertilizers leads to overgrowth of aquatic plants
  - plant decay removes oxygen from water
- Pesticides cause mutations and deaths
- Chemical compounds can accumulate up the food chain

http://www.sanctuaries.nos.noaa.gov/news/features/images

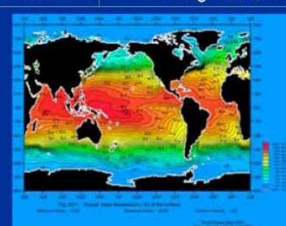
Monitoring Parameters

- Parameters that can be used in water quality monitoring are:
  - physical
  - chemical
  - biological
    - bacterial coliform
    - benthic macro-invertebrates

www.lewiscreek.org/DataCollection.htm

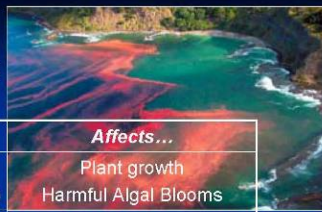
Physical Parameters

What	*Affects…*
Turbidity	Light penetration (euphotic depth)
Temperature	Plant growth, animal life



http://metoceanengineers.com/products_services/water_temp/watertemp.gif

Chemical Parameters

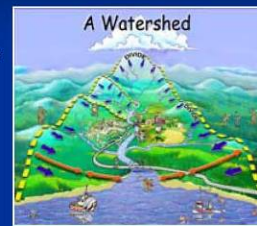


What	Affects…
NO_3^- (nitrate) PO_4^{3-} (phosphate)	Plant growth Harmful Algal Blooms
pH	H_2O acidity (metal toxicity)
Salinity	Animal and plant life
Dissolved Oxygen (D.O.)	Animal life Nutrient cycling

Above photo from : http://www.niwascience.co.nz/pubs/wa/13-2/images/bloom1_large.jpg

Water Quality & Watersheds

- The water quality of a region is confined to, and determined by, its watershed
- A watershed is a drainage basin consisting of:
  - bodies of water
  - surrounding land that drains surface water



http://www.recycleworks.org/images/watershed_800.jpg

Wetlands

- Wetland habitat can help water quality. As water moves through the wetland abiotic and biotic factors remove contaminants:
  - Excess nutrients can be removed by plants, algae, or bacteria
  - Chemicals can be removed by vegetation, sediments, or photo-degradation

Wetlands

- The creation of wetlands along agricultural edges is considered a Best Management Practice by the EPA as both biotic and abiotic factors "clean" agricultural runoff.

Reprinted from Mitsch et al. 2001

Additional References

- www.benthic.mlml.calstate.edu/habres
- www.epa.gov/watertrain/cwa/
- en.wikipedia.org/wiki/Clean_Water_Act
- www.lamotte.com/pages/edu/lesson/lamotte.html
- www.lamotte.com/pages/edu/curricul/index.html
- www.sciencestuff.com

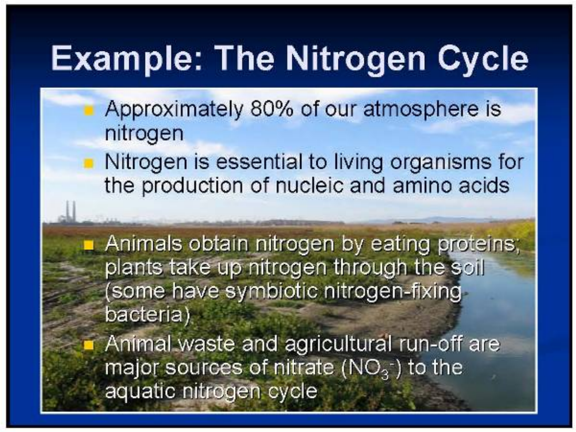
Middle School Standards (6th-8th)

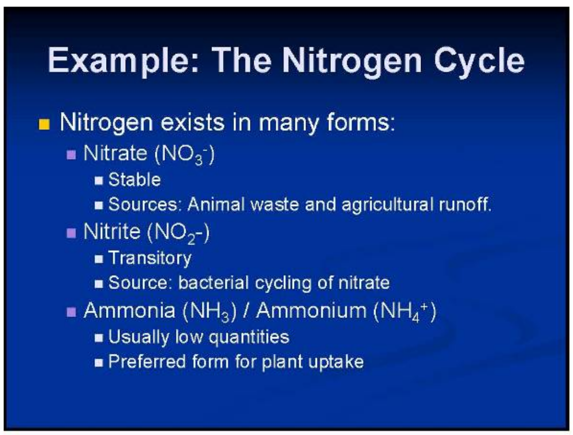
- 6th:
  - Earth Science 2b;
  - Ecology 5a,b,e;
  - Investigation & Experimentation 7a-e
- 7th:
  - Physical Sciences 6a,f (spectrophotometry supplement);
  - Investigation & Experimentation 7a-e
- 8th:
  - Chemistry 3b,c, 5a-e, 6b,c;
  - Investigation & Experimentation 7a-e

High School Standards (9th-12th)

- Chemistry
  - Chemical structure and properties 1a,d,g,j, 2b, 3a,e,f;
  - Acids & bases 5a,d;
  - Solutions and chemical equilibrium 6a,c,d;
  - Organic chemistry, biochemistry10a-c;
- Biology
  - Stability in the ecosystem 6a,b,d,e;
- Physics
  - Electromagnetic waves 4e (spectrophotometry supplement);
- Earth Sciences
  - Properties of the ocean 5d;
  - Biogeochemical cycles 7a,c;
- Investigation & Experimentation 1a-n

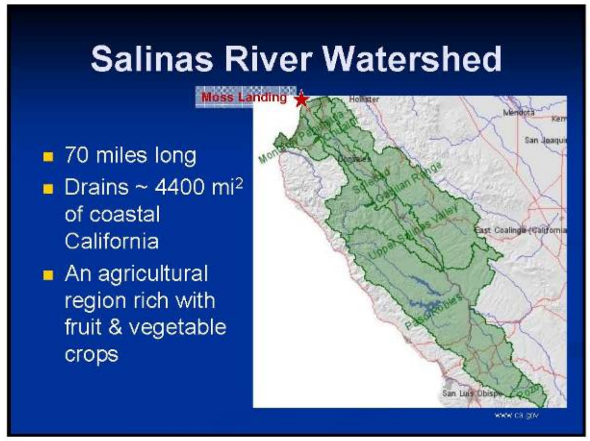

Nutrient Cycling can "Clean" Water
Biogeochemical cycles are pathways by which molecules move through biotic and abiotic parts of an ecosystem.

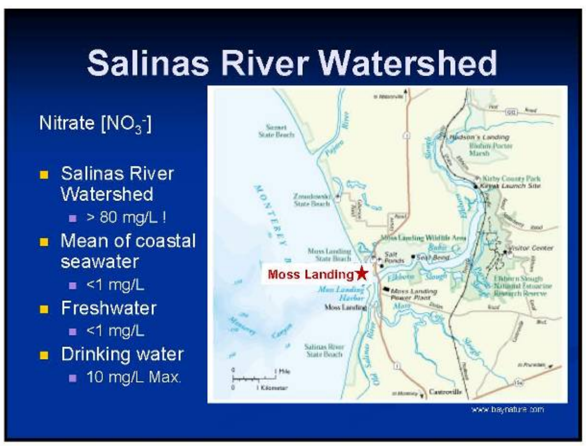

Example: The Nitrogen Cycle
Approximately 80% of our atmosphere is nitrogen
Nitrogen is essential to living organisms for the production of nucleic and amino acids
Animals obtain nitrogen by eating proteins; plants take up nitrogen through the soil (some have symbiotic nitrogen-fixing bacteria)
Animal waste and agricultural run-off are major sources of nitrate (NO_3^-) to the aquatic nitrogen cycle


Example: The Nitrogen Cycle
Nitrogen exists in many forms:
Nitrate (NO_3^-)
Stable
Sources: Animal waste and agricultural runoff.
Nitrite (NO_2-)
Transitory
Source: bacterial cycling of nitrate
Ammonia (NH_3) / Ammonium (NH_4^+)
Usually low quantities
Preferred form for plant uptake


Purpose of Our Experiment
To examine contaminant levels upstream and downstream in a local polluted wetland undergoing restoration.
Contaminants arise from point (direct input) and non-point (run-off) sources
These contaminants can affect rivers and streams, as well as coastal waters where rivers empty


California Watershed Regions
North Coast
North Lahontan
Sacramento River
San Francisco Bay
San Joaquin River
Moss Landing
Central Coast
Tulare Lake
South Lahontan
Colorado River
South Coast
www.ca.gov


Salinas River Watershed
Moss Landing
70 miles long
Drains ~ 4400 mi2 of coastal California
An agricultural region rich with fruit & vegetable crops
www.ca.gov


Salinas River Watershed
Nitrate [NO3-]
Salinas River Watershed
> 80 mg/L !
Mean of coastal seawater
<1 mg/L
Freshwater
<1 mg/L
Drinking water
10 mg/L Max.
Moss Landing
www.baynature.com


Moro Cojo Slough
Moss Landing
Middle
Upper
Water quality is monitored in Moro Cojo Slough to understand how wetlands reduce pollution.

Moro Cojo Slough

- Pollution from agricultural and urban runoff
- Contaminants transported to Monterey Bay
- Reduction of natural habitat throughout the region over the past 150 years
- Many areas of the watershed could still be restored to natural habitat

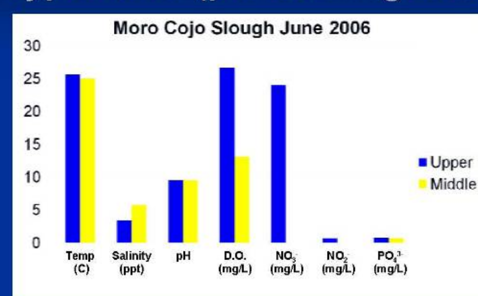
Overview

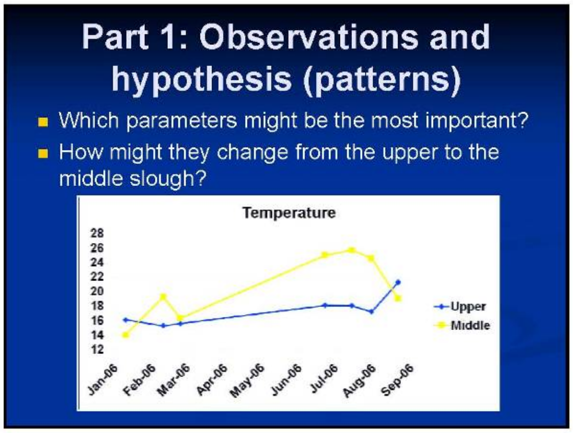
- Background
  - Water Quality
  - Need for Research
  - Monitoring Parameters
  - Watersheds and Wetlands
  - Nutrient Cycling
  - Study system - Salinas River & Moro Cojo Slough
- Water Quality Activity:
  - Part 1: Observations and Hypothesis
  - Part 2: Field Sampling
  - Part 3: Lab Analysis
  - Part 4: Results and Conclusions

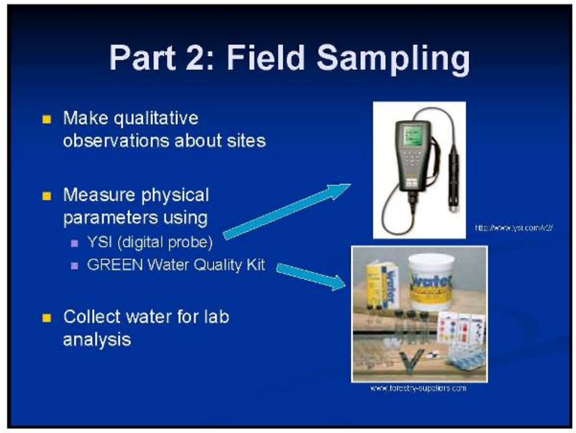
Part 1: Observations and hypothesis

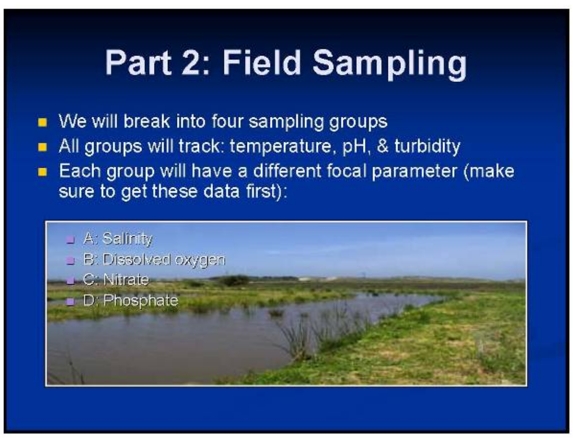
- Observations
  - Scientific context
    - Watershed ecology
    - Nutrient cycling
  - History of region
    - Watershed degradation
    - Wetland restoration
  - Characteristics of field site
    - Surrounding land use
    - Size and shape of waterway
    - Appearance of water

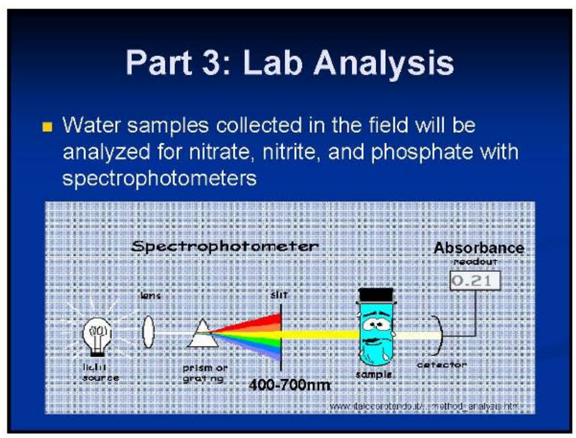
Part 1: Observations and hypothesis (pre-existing data)




Part 1: Observations and hypothesis (patterns)
Which parameters might be the most important?
How might they change from the upper to the middle slough?
Temperature
28
26
24
22
20
18
16
14
12
Jan-06
Feb-06
Mar-06
Apr-06
May-06
Jun-06
Jul-06
Aug-06
Sep-06
Upper
Middle


Part 2: Field Sampling
Make qualitative observations about sites
Measure physical parameters using
YSI (digital probe)
GREEN Water Quality Kit
Collect water for lab analysis


Part 2: Field Sampling
We will break into four sampling groups
All groups will track: temperature, pH, & turbidity
Each group will have a different focal parameter (make sure to get these data first):
A: Salinity
B: Dissolved oxygen
C: Nitrate
D: Phosphate


Part 3: Lab Analysis
Water samples collected in the field will be analyzed for nitrate, nitrite, and phosphate with spectrophotometers
Spectrophotometer
Absorbance
readout
0.21
lens
slit
light source
prism or grating
400-700nm
sample
detector

Part 4: Results and Conclusions

- Compare Data:
  - GREEN WQ kit v. YSI digital probe
  - GREEN WQ kit v. Spectrophotometer
  - Our data v. pre-existing data
- Evaluate your hypothesis
- Propose improvements on the experimental design
- Develop a future hypothesis

Part 4: Anticipated Results

- What trends would you expect to find as you move downstream through the slough?

3dparks.wr.usgs.gov/.../html/ElkhornSlough.htm

End

All photos, text and graphics are the property of Moss Landing Marine Labs unless otherwise noted.

Funding for this project provided by State Water Control Board and the National Science Foundation.

Monitoring Agencies

- Federal, State and Local agencies…and volunteers!
- USGS: U.S. Geological Service (surface, ground H2O)
- NOAA: Nat'l Ocean & Atmospheric Administration
  - NERRS: National Estuarine Research Reserve System
- CA Dept. of Fish & Game
- EPA: Environmental Protection Agency
  - Clean H2O Act Standards

http://green.uwex.edu/images/j0321110.jpg