Agricultural Baseline Monitoring and BMP Implementation: Steps Toward Meeting TMDL Compliance Deadlines Within the Newport Bay/San Diego Creek Watershed

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Introduction

In 1998, the Santa Ana Regional Water Quality Control Board (RWQCB) passed a Resolution amending the Santa Ana River Basin Plan to include a Nutrient Total Maximum Daily Load (TMDL) for the Newport Bay/San Diego Watershed. The goal of the TMDL is to reduce the nutrient loading capacity to a level at or below the assimilative capacity of the waterbody, returning the impaired waters to a condition where beneficial uses are no longer impacted by nutrients. Development of a TMDL requires the identification of all point and nonpoint sources of pollution. Each identified source receives a pollutant load allocation based on available data at the time of TMDL development.

Due to litigation, nutrient source identification and the estimation of nutrient loading from identified sources proceeded rapidly with little or no baseline data. As a result the nutrient content of agricultural surface runoff was predicted with mathematical models using estimated input values. In order to address this problem, the RWQCB utilized a phased approach that allows for incremental reductions in loads over several years as well as the opportunity to revisit loads previously set when new data becomes available. Currently load reductions have been established for the end of 2002, 2007, and 2012. The final goal is to reduce total nitrogen and phosphorus loading by 50% in 2012.

Objectives

1. Establish a water quality-monitoring program for several representative agriculture sites in the Newport Bay Watershed in order to determine the baseline loads of total nitrogen and phosphorus in surface runoff.
2. Develop and conduct meetings that focus on current TMDL development and provide an opportunity for agricultural producers, nursery operators, and consultants to interact with SARWQCB and UC Cooperative Extension staff in an informal setting.
3. Develop and conduct a series of management workshops that provide hands-on demonstrations and seminars that focus on new technologies and cultural practices that will assist agricultural producers, nursery operators, and consultants in minimizing nutrient movement in surface runoff.

Description

The water quality-monitoring program, established in Spring 2000, involved the selection of agricultural sites based on the following factors: accessibility of the site; the ability to install water monitoring equipment without drastic changes in a grower's existing drainage design; and the willingness of the grower to implement BMPs upon completion of baseline data collection. Each site chosen consisted of two plots for monitoring baseline flow and nutrient data (Table 1). The plots ranged in size from 2 to 32 acres. The grower's existing management practices were implemented on both plots during baseline monitoring. Upon completion of the baseline monitoring, one of the plots received an additional BMP that targeted an area of management that required attention.

The baseline-monitoring program consists of the placement of automatic water samplers in the field once a week to sample surface runoff for a 24-hour period. Surface runoff flow was measured continuously with an area-velocity flow meter thus allowing for the estimation of nitrogen and phosphorus loads. Under conditions when monitoring equipment could not be utilized, such as during field preparation, monitoring was replaced with grab samples in the presence of surface runoff. Water quality parameters consisted of pH, electrical conductivity (EC), $(NO_2 + NO_3)$-N, NH_4-N, TKN, PO_4-P, and total-P. All nutrient analyses were conducted by a local water district's EPA approved water testing laboratory, while EC and pH measurements were completed in the field.

Initially scheduled for completion at the end of 2000, the baseline monitoring was continued through June 2001 in order to capture an entire strawberry production period (October 2000 to June 2001). The implementation of row crop BMPs on treated plots began in 2001 following an evaluation of the baseline flow and nutrient data. Best Management Practices were implemented at the nursery following a short calibration period from March 2000 to July 2000. Existing nutrient baseline data collected by the nursery allowed for earlier implementation of BMPs at the nursery site.

Table 1

Site	Plot	Crop(s)[1]	Flow[2]	Sampling	BMP Implementation
A	R-1	S	March 2000-present	Weekly if present	Sediment Controls (Sandbags/Polyacrylamides)
	R-2	S	March 2000-present	Weekly if present	None
B	R-3	S	March 2000-present	Weekly if present	Sediment Controls (Sandbags/Polyacrylamides) Soil Moisture Monitoring
	R-4	S	April 2000-present	Weekly if present	None
C[3]	R-5	C, B, S	Feb 2000-present	Weekly if present	Sediment Controls (Sandbags/Polyacrylamides)
	R-6	C, B, S	Feb 2000-present	Weekly if present	None
D[4]	R-7	S	October 2000-present	Weekly if present	Sediment Controls (Sandbags/Polyacrylamides)
	R-8	S	October 2000-present	Weekly if present	None
E	N-1 (upstream)	CN	June 2000-present	Weekly if present	None
	N-2 (downstream)	CN	July 2000-present	Weekly if present	Polyacrylamides, Settling trap and pond, Vegetative filter

[1]Crop letter codes: B=Bean, C=Celery, CN=Container Nursery, and S=strawberry
[2]Flow is monitored at sites under production when surface runoff is present.
[3]Site was relocated in March 2000 (following celery harvest) to a field currently used for strawberry production.
[4]Site was relocated in October 2000 from an orchard where surface runoff was absent to a field currently used for strawberry production.

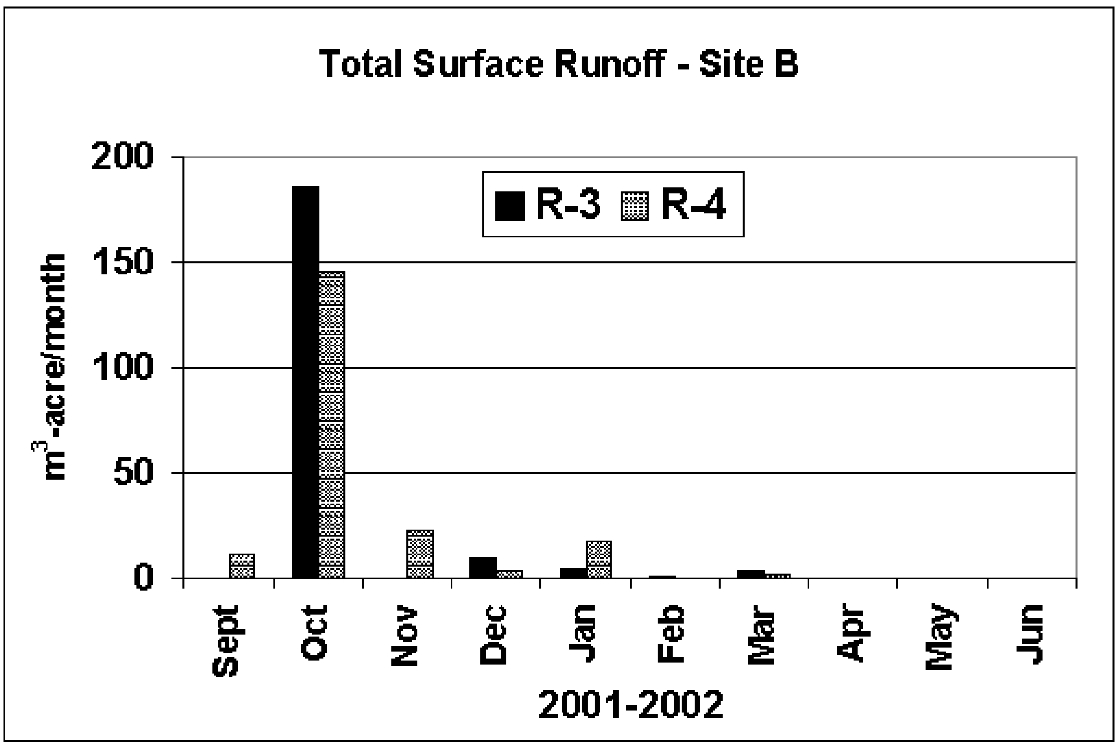
Prior to the completion of the baseline-monitoring program in 2001, the educational component of the project was initiated to begin informing the local growers on the impact of upcoming water quality regulations. Outreach consisted of a series of forums and workshops. Forums consisted of informal short meetings between agriculture operators, nursery growers, UCCE project staff, and representatives from the RWQCB to address a specific water-related issue. The meetings were designed to provide updates on this project as well as a method of updating growers on developing TMDLs or other water quality issues.

Workshops focused on management strategies for both agriculture and nursery operators in reducing nutrient loads in surface runoff. The meetings provided growers with information and demonstrations of new technologies to assist them in sound nutrient management decisions.

Results And Conclusion

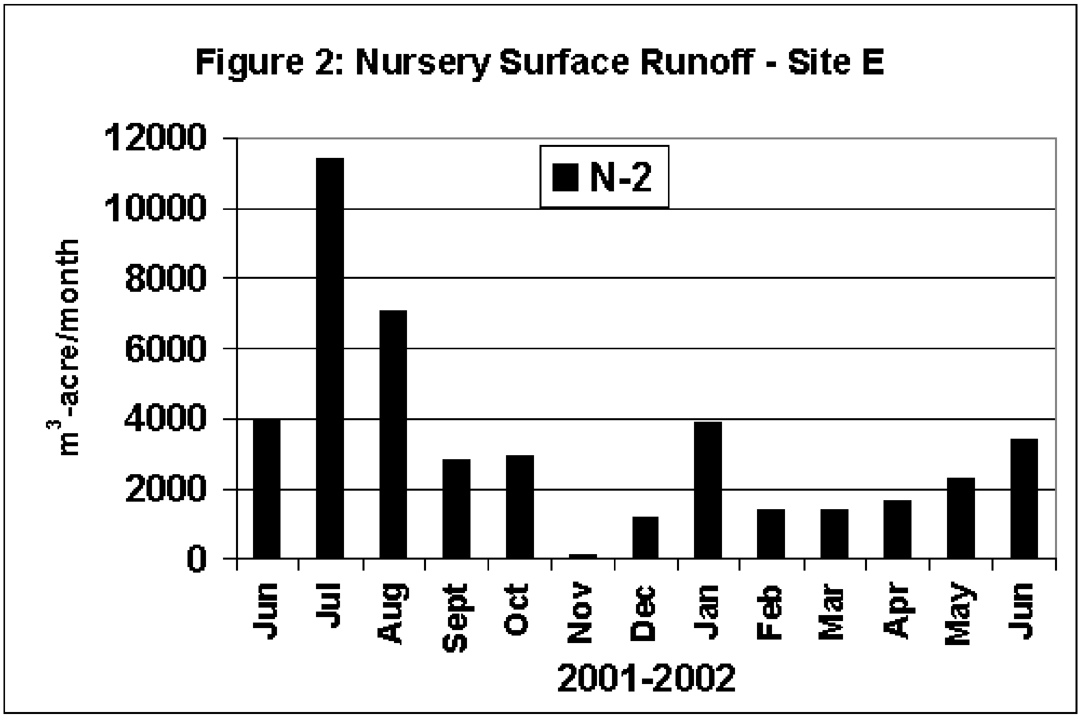
Baseline Flow and Nutrient Loading

Agricultural nutrient load allocations are split into a summer (April-September) and winter (October – March) period in order to reflect differences in wet and dry season flow. The majority of flow and nutrient loading from strawberry fields, the dominant row crop in the watershed, occurs during the winter season as shown in Figure 1. Surface runoff from row crops during the winter season can be attributed to precipitation and the use of overhead sprinkler irrigation under three specific conditions: the establishment of strawberry transplants in late September early October, prevention of plant desiccation during dry Santa Ana Winds, and to minimize frost damage. Irrigation during the remaining period is solely drip irrigation and if managed correctly, results in no surface runoff. The occasional presence of surface runoff during the summer period is a result of leaking irrigation systems, flushing of sand filters, or rain events occurring in April and May.



During the (2000-2001) winter season, a season of normal rainfall, the average discharge of total nitrogen from row crops was sixteen pounds per acre. In contrast, limited rainfall during the (2001-2002) winter season resulted in an average of five pounds per acre of total nitrogen discharged. The winter season load allocation for agriculture was established in 1999 at 38,283 pounds or three and half pounds of total nitrogen per acre by 2012. Agricultural acreage in 1999 was estimated at 11,000 acres, but has decreased to just over 4,000 in 2000. The 2012 winter allocation will likely be reached by further expected reductions in agricultural acreage. Monitoring shows that the 2002 loading allocation for the summer season has been met and if the current acreage remains constant at 4,000 the 2007 load allocation will only be exceeded by 500 pounds.

Surface runoff from the nursery site was present during both the summer and winter seasons (Figure 2). A slightly higher water usage during the summer period resulted in increased surface runoff and nutrient loading. The nursery employs a computer-controlled system to apply short (less than 15 minute) pulses of irrigation in order to reduce the presence of surface runoff and excessive leaching from the containers.



Implementation of BMPs

Row Crops

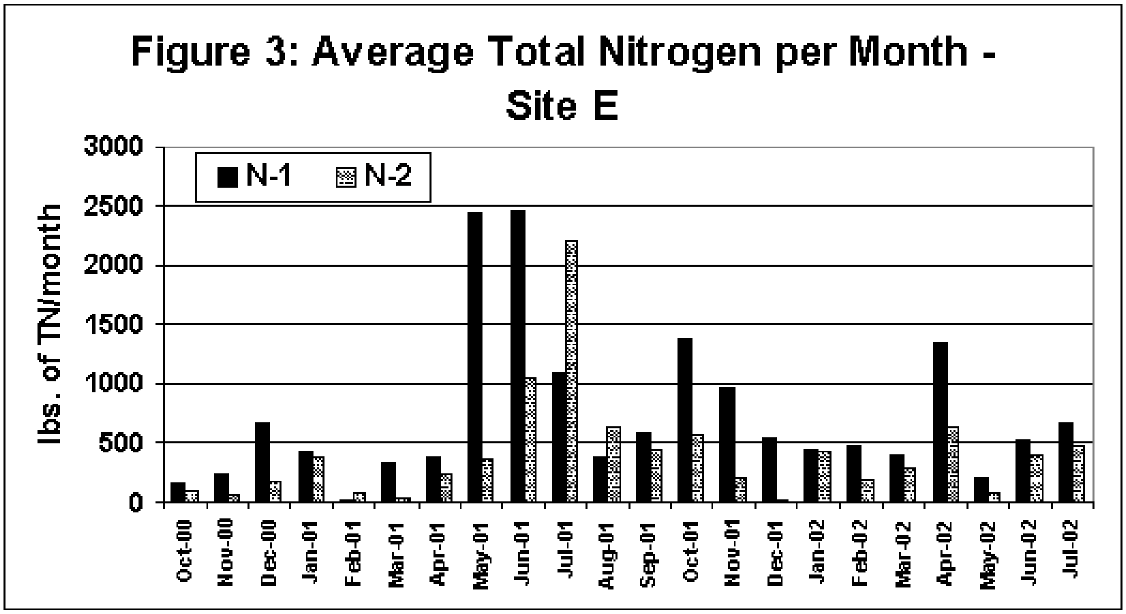
The monitoring program coupled with observational data taken by field staff revealed that growers needed to improve management practices related to erosion and sediment control. Sediment control is important in minimizing soil loss as well as reducing the movement of chemical compounds bound to the sediment, such as phosphorus and some pesticides. Polyacrylamides (PAM) were utilized on the treated plots to reduce the amount of sediment moving off-site. A granular formulation was tested on treated plots to determine the degree that sediment movement could be reduced in tail furrows. Further testing is needed to determine the frequency of application required to maintain a reasonable rate of sediment flocculation. Two row crop growers have adopted the use of polyacrylamides as one of their management practices as a result of this demonstration project.

Additional research is being proposed to look at reducing the application frequency and rate of overhead irrigation during the establishment of strawberry transplants. Targeting this phase of production should result in a significant reduction in surface runoff and sediment.

Container Nursery

Surface runoff from the nursery (Site E) was treated with a series of mitigation practices in an effort to improve its quality prior to leaving the site. The installation of a vegetative filter in a concrete-lined channel was installed to act both as a biological active filtration system as well as a source for the production of plant material. The vegetative filter consists of baskets of Canna lilies sunk directly into the channel. The channel is divided into smaller basins allowing for the harvesting of one basin every eight weeks with the goal of maintaining the vegetative filter with a significant portion of mature plants at all times. The vegetative filter covers 186 m^2 of the concrete channel.

During both the summer season and the winter season, the vegetative filter strip is effective in reducing the average lbs. TN/month leaving the nursery (Figure 3). The concentration of nutrients in the runoff remains fairly constant from inflow to outflow monitoring stations, but the overall flow is significantly less at N-2 compared to N-1. The result is lower nitrogen loading at N-2. During the winter season, rainfall and cooler temperatures reduces the effectiveness of the vegetative filter due to reduced root and shoot growth of the Canna lilies. Occasionally, a higher load of total nitrogen was detected at N-2 compared to N-1 as a result of inputs below the N-1 monitoring station. Inputs ranged from rainfall events, drainage from roads, and excessive irrigation of plant material adjacent to the filter.



A settling pond and trap installed upstream of the vegetative filter act as reservoirs for sediment. Surface runoff is treated upstream of the reservoirs with a 10 ppm solution of polyacrylamide to flocculate the sediment and remove it prior to the vegetative filter where its removal is more difficult. Polyacrylamide application was not initiated until January 2002.

Outreach

On January 19th, 2001, a frost protection forum was held at the South Coast Research and Extension Center. Several of growers expressed interest in improving their knowledge about using irrigation for frost control. Dr. Rick Snyder, a UC Davis biometeorologist, presented growers with basic information on frost and how irrigation can be utilized to protect plants from frost damage. The format allowed growers to pose questions relevant to their own situations. Eighteen growers attended the forum.

The first in a series of workshops was held on November 16, 2000 at the South Coast Research and Extension Center in conjunction with California Certified Crop Advisors, Orange County Farm Bureau and the South Coast Resource Conservation & Development Area. Focusing on nutrient management and attended by 66 agricultural operators, PCAs, nursery operators, and certified crop advisors, the workshop's goal was to present an overview of nutrient management for various crops as well as provide hands-on demonstrations of soil and tissue nutrient testing equipment and techniques. All attendees received a handbook containing information on TMDLs, a copy of the ANMP, speaker handouts, and a catalog of University of California Cooperative Extension publications relating to water and nutrient management.

The second workshop, held on February 20th, 2001, focused on irrigation management. The workshop was held in conjunction with the Southern California Chapter of Certified Crop Advisors, Orange County Farm Bureau, and the South Coast Resource Conservation & Development Area. The morning session consisted of presentations by experts from the University of California on irrigation scheduling, efficiency, and technology. Hands-on demonstrations were conducted in the afternoon on proper use of soil moisture monitoring equipment, new irrigation technologies, and injection mechanics. Forty-one growers, PCAs, and consultants attended the workshop. Each attendee received a handbook containing speaker handouts, relevant research literature, and additional information on irrigation

The final workshop was held on November 28th at Edison International Field in Anaheim. The workshop focused on a combination of nutrient and irrigation practices that will assist growers in reducing nutrients in runoff or reduce the volume of runoff generated on their site. Seminars included such topics as the contribution from nutrients from composting, using reclaimed water in agriculture and horticulture, the utilization of soil wetting agents, maximizing water use efficiencies, current water quality issues in Ventura and Santa Barbara counties, and BMPs to reduce nutrients and pesticides in run off water.

A self-appraisal workshop for row crop growers in the Newport Bay Watershed was held on July 25th at the South Coast research and Extension Center. Growers prior to attending a summary meeting completed a self-assessment survey with the assistance of project staff. The survey included areas of irrigation, fertilization, and cultural practices that impact the quantity and quality of surface runoff. At the summary meeting, growers were given their individual results as well as a presentation on the overall results of growers in the Newport Bay Watershed. The goal of the workshop was to have each grower assess their current practices to determine the areas where they need to make improvements in order to minimize surface runoff contamination. The second half of the meeting allowed growers and project staff to discuss the logistics and economical feasibility of suggested BMPs.

A forum meeting was held on March 4th exclusively for nursery growers in the Newport Bay/San Diego Creek Watershed. A total of eight nursery growers attended the meeting to hear from a representative from RWQCB and Cooperative Extension staff on current water quality issues affecting nurseries. The growers were also shown a video demonstrating the use of polyacrylamides to reduce sediment and erosion. Each attendee received a pocket pH/EC for testing source irrigation water and surface runoff. The meter provides a quick method for measuring two water quality parameters that can be utilized as indicators for further testing. For example, salinity levels that are above normal may indicate that the runoff contains high levels of nutrients.

Field staff has continued visiting farming operations in the watershed to assess grower practices and look for areas where the University of California can provide assistance in reducing or eliminating surface runoff. Thirty-eight site evaluations have been completed to date. Under a continuing project, the completed assessments will be entered into a database in order to track changes that are made by growers over the next year. The main goals of the assessments are to identify areas were UCCE could offer technical assistance to improve runoff quality or reduce its quantity, promote communication between growers and the project staff, and document the adoption of additional BMPs.

A quarterly newsletter was also initiated in June 2002 to provide the latest water quality information such as updates on nursery waste discharge permits or the status of TMDL development in the watershed.

Conclusions

The agricultural baseline-monitoring program and the accompanying outreach program successfully provided growers in the Newport Bay/San Diego Creek Watershed with vital information on the nutrient loads found in surface runoff during the production of row crops and container nursery plants. At the same time, the program created grower awareness on the impact of their management decisions on water quality. Although the program initially targeted reductions in nutrient loading to receiving waters, the mitigation practices implemented should also assist in the reduction of off-site movement of sediment and sediment-bound toxics. Post BMP monitoring will continue for an additional one-year period in order to provide further evidence of BMP effectiveness.