DEVELOPING CENTRAL VALLEY, CALIFORNIA, AGRICULTURAL RUNOFF/DISCHARGES WATER QUALITY MONITORING PROGRAMS[1]

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ABSTRACT: The California Central Valley Regional Water Quality Control Board is developing a Nonpoint Source (NPS) water quality management program. A key component of an NPS water quality management program is monitoring that assesses the water quality – beneficial use impact of stormwater runoff and irrigation tailwater discharges. The authors have recently completed a comprehensive NPS water quality monitoring program for runoff/discharges from California Central Valley irrigated agriculture. This paper summarizes the key components of this program. The initial focus of this program is on waterbodies that were constructed to carry agricultural drainage water as well as natural waterbodies that are dominated by agricultural drainage. The parameters that should be monitored include all chemicals that are added to the agricultural lands to enhance crop production and those that are formed on the agricultural lands such as TDS, TOC and those that are leached from the land that naturally occur in the soils of the area. The water quality monitoring program should assess whether the concentrations of the monitored parameters exceed water quality objectives (standards). Since the US EPA water quality criteria which serve as the basis for the state water quality standards are based on worst-case assumptions, an evaluation should be conducted to determine if the exceedance of a water quality objective represents a significant impairment of the beneficial uses of the waterbody and downstream waterbodies. This evaluation is especially important for agricultural runoff, since many of the potential pollutants in such runoff are in nontoxic, non-available forms.

KEY TERMS: nonpoint; water quality monitoring; irrigated agricultural runoff/discharges; Central Valley, California.

INTRODUCTION

As part of the Central Valley Regional Water Quality Control Board's (CVRWQCB's) implementation of the State Water Resources Control Board's (SWRCB, 2000) Plan for California's Nonpoint Source Pollution Control Program (NPS Program Plan), there is need to develop a nonpoint source water quality monitoring program for the Central Valley of California. Presented herein is a summary of guidance on the development of this monitoring program. Particular attention is given to assessing the potential impacts of irrigated agricultural stormwater runoff and irrigation tailwater and subsurface drain water discharges, as they may impact the beneficial uses of Central Valley waterbodies. This paper is a summary of a comprehensive report by Lee and Jones-Lee (2002a) devoted to these issues.

RECOMMENDED APPROACH

The first step in developing a comprehensive nonpoint source water quality monitoring program is to clearly define the objectives of the program. Once the objectives of the monitoring program have been defined, there is need to determine the desired reliability of defining the water quality impacts of irrigated agricultural stormwater runoff and discharges. With information on the variability of irrigated agricultural runoff/discharges from various types of irrigated agricultural settings, it is possible to begin to develop a water quality monitoring program that will achieve the objectives of the program.

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Organizing a Water Quality Monitoring Program

The development of a comprehensive nonpoint source water quality monitoring program involves consideration of each of the following:

- Clearly establish the objectives of the monitoring program.
- Understand the nature of "water quality," water quality concerns, beneficial uses, and their assessment for the waterbodies of concern.
- Select the parameters to be measured and justify potential significance of each parameter selected.
- Examine previous studies to understand variability in each area of the waterbody to be monitored.
- List factors that can influence results of the monitoring program and how they may influence the results.
- Determine the level of confidence at which the objective is to be achieved.
- For each area of each waterbody to be monitored, determine the number and location of samples to be collected.
- If no data are available from previous studies or if existing data are inadequate to define variability and other characteristics needed to establish a reliable monitoring program, conduct a pilot study of representative areas to define the characteristics of the area that are needed to develop a reliable water quality monitoring program.
- If the purpose of the monitoring program is to determine changes in water quality characteristics, select the magnitude of change that is to be detected and design the monitoring program accordingly.
- Select sampling techniques and methods of analysis to meet the objectives and level of confidence desired.
- Verify that analytical methods are appropriate for each area of the waterbody and at various seasons.
- Conduct studies to evaluate precision of sampling and analytical procedures and technique, reliability of preservation, and variability of the system.
- Critically examine the relationship between present and past studies.
- Determine how the data will be analyzed, with respect to compliance with water quality standards, using existing data or synthetic data that is expected to be representative of the site.
- Screen/evaluate data as they are collected.
- Analyze, interpret and store data, and report on the results of the analysis and interpretation.

Information on each of these issues is provided by Lee and Jones-Lee (2002a).

One of the most important steps in developing a credible monitoring program to assess the impact of constituents derived from a particular source on the beneficial uses of receiving waters is an explicit statement of the objectives of the monitoring program. The CVRWQCB and staff have identified a number of objectives that need to be met in developing a water quality monitoring program to evaluate the impact of constituents in irrigated agricultural stormwater runoff, tailwater and subsurface drain water discharges on receiving water beneficial uses. These include violations of Basin Plan water quality objectives (WQOs), which also include California Toxics Rule criteria and the California Department of Health Services drinking water Maximum Contaminant Levels (MCLs).

Waterbodies of Concern and Site Selection

The waterbodies of greatest initial concern are the constructed facilities that carry agricultural drainage, and natural waterbodies that are dominated by agricultural drainage waters. The selection of a specific site for monitoring of a waterbody, such as a tributary of the San Joaquin River or the

Sacramento River, should be based on an understanding of the agricultural activities conducted upstream of a proposed monitoring location and the plumbing and hydrology of the waterbody's watershed upstream of where the monitoring is proposed. Initially, the focus of the monitoring program will be on the waterbodies of greatest concern – i.e., those that carry the greatest amounts of agricultural runoff/discharges. As information is gained on the role of agriculturally derived discharges/runoff of potential pollutants to these waterbodies, additional waterbodies will need to be added to the list of monitored waterbodies. As the NPS water quality monitoring program develops, particular reference needs to be given to what, if anything, is representative of the watershed upstream of the monitoring point that would cause this waterbody either to be different from other waterbodies or to be representative of a group of waterbodies with similar irrigated agricultural and other land use activities in the watershed.

Each watershed upstream of the sampling point should be characterized based on the agricultural activities conducted within the watershed – i.e., crops produced, chemicals used and other factors that could influence the concentrations of constituents in the stormwater runoff or agricultural irrigation water discharges. The constructed agricultural drains and agriculturally dominated waterbodies should be prioritized with respect to their potential representativeness and importance in impacting the beneficial uses of the waters of the State. This prioritization would be used to determine which waterbodies are monitored based on the funding available. The recommended initial NPS monitoring program includes sampling near the primary and secondary tributary mouths' discharge points to the Sacramento and San Joaquin Rivers. The specific location for the initial monitoring is to be selected after a critical review of the factors that can influence monitoring results. Since the loads of potential pollutants are of concern, the monitoring stations should be located where gaging of the stream/tributary flow can occur.

In order to reliably monitor stormwater runoff-associated constituents and their potential impacts, it is necessary to base the monitoring program on when the constituents of potential concern are applied to the agricultural areas and during stormwater runoff events or other times when there would be expected transport of the constituent of concern from the areas where it was applied. This event-based, episodic monitoring requires a significantly different approach and resources than the traditional monitoring, involving periodic (i.e., weekly or monthly) sampling at a fixed location. However, it is far more reliable for determining the impacts of the agriculturally used/derived potential pollutants than the fixed period monitoring.

The appropriate approach to follow in developing a reliable monitoring program for runoff/discharges from irrigated lands is to first define the constituents that are potentially present in the runoff/discharges that could occur at sufficient concentrations to impair the beneficial uses of the receiving waters for the runoff. Next it is necessary to gain an understanding of when, where and how various chemicals, or sources of potential pollutants, use/apply/release the constituents of concern. Further, there is need to understand, for each constituent defined as a potential pollutant, how that constituent potentially impacts the beneficial uses of a downstream waterbody. With this information, it will be possible to develop a reliable water quality monitoring program to assess whether irrigated agricultural runoff/discharges adversely impact the beneficial uses of the State's waters. Without this critical review and implementation of this approach, the water quality monitoring program can be of limited value in reliably achieving the objectives of the nonpoint source water quality monitoring program, since it has not been properly designed to meet the objectives of the program.

Parameters of Concern

Lee and Jones-Lee (2002b) have recently reviewed the constituents in irrigated agricultural runoff/discharges in the San Joaquin River watershed for which there are TMDLs that are under development or that may need to be developed. At this time, there are 15 constituents of concern in the agricultural runoff/discharges in this watershed for which there is need for information on their occurrence and impacts on the beneficial uses of the State's waters. The Lee and Jones-Lee (2002a) report presents a discussion of the water quality parameters of potential concern in irrigated agricultural stormwater runoff and tailwater discharges for the Central Valley of California. Reasons for the water quality concern and regulatory limits are discussed. The parameters include pH, color, taste and odors, total suspended solids, turbidity, nitrate, nitrite, ammonia, total Kjeldahl nitrogen, biostimulatory substances, phosphorus, boron, total and fecal coliforms, *E. coli*, dissolved oxygen, biochemical oxygen demand, temperature, organophosphate pesticides, organochlorine pesticides, herbicides, other potentially toxic chemicals, unknown-caused toxicity, sediment toxicity, PCBs, dioxins, furans, total organic carbon, dissolved organic carbon, heavy metals (Cu, Zn, Pb, Cd, Ni, Cr), mercury and selenium.

In addition to considering the chemicals that are added to/used on irrigated agricultural lands (such as pesticides, fertilizers, soil amendments, etc.), there is also need to consider the chemicals that are released from these lands that are generated on these lands. The monitoring program should include measurements of transformation products of added chemicals, such as nitrate that is formed from the nitrification of ammonia that is added as a fertilizer to the agricultural lands. Total organic carbon (TOC), dissolved organic carbon (DOC), total dissolved solids/electrical conductivity (TDS/EC), total suspended solids (TSS), nitrogen and phosphorus compounds and turbidity should be monitored as part of assessing the potential for constituents generated on or from irrigated agricultural lands to be present at concentrations that could impair the beneficial uses of the receiving waters for runoff/discharges from these lands. Boron, selenium, and other constituents which are present in the soils of the area and are mobilized by agricultural practices so that they occur at potentially significant concentrations in runoff/discharge waters should be included in the monitoring program. The US EPA standard three-species aquatic life toxicity tests (Lewis, *et al.*, 1996) should be conducted to determine if toxicity is present in the runoff/discharge waters from agricultural lands.

There is considerable interest in assessing whether the aquatic organism assemblages in a waterbody potentially impacted by agricultural runoff/discharges are altered by constituents in these discharges. Reliably assessing the impacts of agricultural runoff/discharges on aquatic organism assemblages within Central Valley waterbodies is difficult because of a lack of suitable reference sites, where the numbers and types of organisms present at these sites can be compared to those with similar habitat characteristics that are potentially influenced by agricultural runoff/discharges. Considerable work needs to be done learning how to utilize benthic organism assemblage information in Central Valley waterbodies, in order to be able to reliably interpret whether the cause of an apparently altered organism assemblage is due to agricultural discharges or other factors. A component of this situation is whether the sediments in a waterbody are toxic to benthic and epibenthic organisms because of agricultural discharges of constituents that cause sediments to become toxic. While pesticides that tend to strongly sorb on sediments (such as the pyrethroids) are of concern because of their potential to cause sediment toxicity, agricultural discharges of nutrients which develop into algae that die, settle and become part of the sediments can be an important source of sediment toxicity due to the release of ammonia from the decay of organic nitrogen in the algal cells.

Since a number of the parameters of particular concern (such as TSS, TOC and nutrients) in irrigated agricultural discharges/runoff do not have water quality objectives (standards) that establish specific numeric limits, there is need to establish an approach for interpretation of the data with respect to exceeding narrative water quality objectives, in order to be able to interpret the results of the NPS water quality monitoring program with respect to assessing impairment of the receiving waters for irrigated agricultural discharges/runoff. This would result in the need for a significantly different monitoring program than one that just focuses on measuring the concentrations of potential pollutants at the mouth (or other location) of the agricultural drain or agriculturally dominated waterbody, in order to develop the information needed to interpret narrative water quality objectives with respect to impairment of beneficial uses of the waters. For example, with respect to nutrients, the current CVRWQCB Basin Plan does not have specific numeric concentrations of nitrogen and phosphorus that are considered excessive with respect to impairing the beneficial uses of a waterbody due to excessive growths of algae and/or other aquatic plants. The Basin Plan has a narrative objective for "biostimulatory substances," which requires an assessment of the impacts of excessive growths of aquatic plants on the beneficial uses of a waterbody. Monitoring for nitrogen and phosphorus compounds' concentrations in agricultural drains or agriculturally dominated waterbodies cannot be translated to an impairment of beneficial uses without site-specific studies of the receiving waters' beneficial uses. As discussed by Lee and Jones-Lee (2002c), that approach requires a significantly different type of monitoring program than periodic measurements at a particular location in a waterbody. Similar problems occur with respect to TOC, TSS and other constituents often present in irrigated agricultural runoff/discharges at potentially significant concentrations.

In addition to evaluating the impact of irrigated agricultural stormwater runoff and tailwater releases on surface water quality, there is also need to evaluate the impact on groundwater quality. This is especially true since there is a potential of causing even greater groundwater quality problems than are occurring now, as a result of trying to minimize surface water quality problems associated with irrigated agriculture's ponding of waters to minimize discharges to surface waters.

Evaluation of the Water Quality Significance of Exceedances of Water Quality Standards

A key component of a reliable water quality monitoring program for agricultural runoff/discharges is an evaluation of the beneficial use impacts of the runoff/discharges. It should not be assumed that an exceedance of a US EPA water quality criterion or state standard based on this criterion represents a significant adverse impact on the beneficial uses of receiving waters. In order to avoid unnecessary control programs for agriculturally derived constituents, site-specific studies should be conducted to determine if the exceedance of a WQO is an "administrative" exceedance, related to the worst-case assumptions used in the criteria/standard development, or a real, significant water quality beneficial use impairment. Lee and Jones-Lee (2002a) and Jones-Lee and Lee (1998) have discussed the approach that should be used to make this evaluation. This approach involves the use of Evaluation Monitoring, where the focus is shifted from measuring chemical concentrations, to measuring chemical impacts on the beneficial uses of the receiving waters for agricultural runoff/discharges.

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