Assessment Monitoring (Management Question 1) Draft Guidance

The following are intended to provide several starting points for discussion about useful and appropriate design guidance for the assessment monitoring component of the MRP (Management Question 1). This guidance is intended to help organize monitoring design efforts so that the resulting designs are technically sound and cost effective, make maximum use of existing knowledge, and balance desired consistency across programs with the flexibility needed to adapt to local circumstances.

One way to envision such guidance is in terms of a performance contract, in which the outcomes or criteria for success are defined and mutually agreed on but the actual methods used to achieve the desired outcomes are flexible, though subject to performance standards.

Basic monitoring design principles

In developing the details of monitoring guidance to address the management questions and their related objectives, three basic principles can provide an overall set of boundary conditions for monitoring design:

- Monitoring should be focused on decision making; data not helpful in making a decision about clearly defined regulatory, management, or technical issues should not be collected. This ideally requires that the method for making the decision be clearly defined
- The level of monitoring effort should reflect the potential for impact, with more monitoring allocated to situations where the potential impact (in terms both of the probability of an impact's occurrence and its extent and magnitude) is higher and less monitoring to situations where such potential is lower or where monitoring is not likely to provide useful information
- Monitoring should be adaptive, in terms of its ability to both trigger follow-on studies as needed and make necessary mid-course corrections based on monitoring findings

Assessment monitoring goal

The primary goal of assessment monitoring is to answer Management Question 1: Are conditions in waters of the State that receive agricultural drainage or are affected by other irrigated agriculture activities within Coalition Group boundaries protective, or likely to be protective, of beneficial uses?

A subsidiary goal of assessment monitoring is to provide the foundation for developing monitoring designs to answer Management Questions 2 – 5.

Prerequisites for monitoring design

Developing the details of an assessment monitoring design requires clearly defining several inputs to the design and then organizing these in a logical framework that supports effective decision making about indicators, site locations, and monitoring frequency. The logical framework should describe:

1. The basic geographic and hydrographic features of the area
2. Agricultural practices and how they are distributed in space and time

3. Knowledge about the transport, fates, and effects of key pollutants, including best- and worst-case scenarios
4. Knowledge about the action of cumulative and indirect effects, and of non-pollutant sources of impact
5. Mechanisms through which agricultural practices could lead to beneficial use impacts, given the basic features of the area (based on 1 – 4)
6. Known and potential impacts of agricultural practices on water quality (based on 1 – 5), ranked in terms of relative risk, magnitude, and severity
7. Information about sources of bias and variability, especially over different time and space scales, that could affect the validity of a monitoring design and/or the reliability of monitoring data

This information should be sufficient to describe basic patterns and processes related to impacts from agricultural drainage. The adequacy of existing information will depend on explicit decisions about:

- The spatial and temporal resolution required for reliable descriptions of basic patterns and processes
- The acceptable level of uncertainty about the sources, mechanisms, locations, and scale of potential impacts
- The data analysis methods used to quantify aspects of condition related to beneficial use
- The set of core indicators needed to ensure a basic level of comparability across all areas

If available information is not adequate to meet the prerequisites described above, then additional monitoring or special studies should be considered to fill these knowledge gaps. In addition, the assessment of Management Question 1 should be repeated on a periodic schedule, using a coordinated monitoring design that incorporates one or more of the approaches suggested below.

Monitoring approaches

Several types of monitoring sites can be combined into one or more basic design approaches. All of these might play a role in an assessment monitoring design, depending on the extent of existing knowledge and the seven types of information listed above. More importantly, the choice of a long-term assessment design should be tightly linked to the agreed-on approach(es) for making judgments about the condition of receiving waters.

Types of monitoring sites include:

- Long-term, usually fixed, bottom of watershed, integrator sites to assess cumulative water quality and aggregate loads
- Spatially extensive, perhaps randomly sited or rotating, stations to support statistically valid comparisons across multiple areas or watersheds
- Targeted sites based on explicit hypotheses about the times and locations where specific types of impacts will be most visible or most severe
- Site-specific stations focused on the status of high-priority locations or habitats of concern

Types of designs that use such sites include:

- **Cumulative effects designs** in which fixed or rotating downstream sites are located at the bottom ends of watersheds or at major confluences to document impacts of upstream sources.

Such designs are based on the assumption that pollutants, and the impacts they cause, accumulate along the upstream-downstream gradient, rather than become diffuse, overlap, or interact with other impacts in nonlinear ways. While cumulative impact designs can require fewer sampling sites than the other designs described, they run the risk of not being able to capture sporadic or intermittent impacts, resolve overlapping impacts, or provide enough detail to provide an adequate starting point for source identification studies.

- **Probability based designs** in which stations are located randomly in order to provide the ability to draw statistically valid inferences about an area as a whole, rather than just the site itself. Such designs, for example, can permit statements about the percentage of the area that is above/below particular levels of different indicators. Such designs can allocate monitoring sites randomly throughout the entire region, or can subdivide the region into a number of strata that are relatively homogeneous. Strata can be defined on any number of grounds, depending on the questions or concerns motivating the program. For example, watershed strata could be based on types of agricultural practices, relative amount of urbanization, general habitat type, or channel morphology, among others. Whatever the stratification scheme, the basic design principle is that samples are allocated randomly among strata, with the number of samples per stratum based on a consistent weighting factor (e.g., area of the respective strata). The level of sampling effort required in probability based designs depends, as in all designs, on the specific questions being asked, the underlying levels of variability in the data, and on the level of precision needed for decision making
- **Systematic designs** in which stations are located at set intervals along one or more underlying spatial or conceptual frameworks. For example, regional stations could be located on a 1-mile grid, every 1-mile along each river, creek, or stream, at every major discharge into rivers, and so on. One value of systematic designs is that they allow for more detailed mapping of indicator levels across a region. In addition, if resources permit, systematic designs can provide more thorough coverage than do probability based designs. The sampling requirements in systematic designs are typically based on the degree of spatial resolution desired
- **Hypothesis-testing designs** in which monitoring sites are located at times and places to test explicit expectations about where specific types of impacts will be most visible or most severe. Such designs can be more efficient than the other designs described, because they not only increase the probability of detecting impacts but also of rigorously evaluating the presumed mechanisms that lead to impacts. Hypothesis-testing designs contrast with the other three types of designs in being based directly on mechanistic assumptions about how impacts occur. Thus, they incorporate information about crop types, hydrography, drainage characteristics, pesticide application, management practices and other factors that directly or indirectly affect receiving water impacts. In addition, hypothesis-testing designs typically involve upstream, edge-of-field sampling as opposed to the downstream sampling in the cumulative effects designs. While it can be challenging to identify appropriate sites that are representative of the range of impact conditions, hypothesis-testing designs allow for the use of powerful statistical methods (e.g., ANOVA, regression) that focus on direct assessment of presumed impact mechanisms
- **Rotating designs** in which a different subset of stations is sampled during each sampling event, with the goal of sampling the entire set of stations over a certain period of time. Such designs have the virtue of maximizing the impact of limited monitoring resources because the entire suite of monitoring stations need not be sampled each time. However, because conditions change over time, rotating designs have a diminished ability to support valid comparisons between sets of stations sampled at different times in the rotation schedule. This can be compensated for to some extent by defining comparisons of interest during the design process and then ensuring that such stations are sampled during similar index periods or

seasons. The location of stations in rotating designs can be random, systematic, or early warning depending on the kinds of questions being asked

There is no set monitoring frequency that is necessarily appropriate for each type of design. In general, however, cumulative designs monitor at a regular frequency or focus on major discharge events, while probability-based designs typically monitor once or twice a year during some standard index period. Systematic designs regular intervals or at an index period, hypothesis testing at a frequency based on underlying impact mechanisms being evaluated, rotating same as probability. These patterns are summarized in Table 1.s

Coordination with other monitoring efforts

A number of other monitoring efforts occur in or adjacent to Coalition areas that could provide opportunities for data and cost sharing. The following language has been suggested for the MRP as a statement of principle encouraging collaboration with other monitoring programs:

The RWQCB encourages the Coalitions to establish working relationships with other monitoring efforts (e.g., NPDES point source, NPDES stormwater, TMDL monitoring, independent watershed groups, SWAMP) within the Coalition boundaries, and whenever possible, to develop a watershed-based monitoring approach. The RWQCB will work directly with parties to eliminate, whenever possible, hurdles that exist between regulatory programs (e.g., permit revisions) that prohibit or delay the development of integrated watershed-based monitoring designs.

Table 1. Monitoring frequencies typical of various potential monitoring design approaches.

Design approach	Regular	Index period	Discharge events	Re impact mechanisms
Cumulative effects	X		X	
Probability-based		X		
Systematic	X	X		
Hypothesis-testing			X	X
Rotating	X	X		