Eastern San Joaquin Data Review Notes
Compiled by Revital Katznelson, Ph.D**.**
Final Report
12/21/2017

This document provides a preliminary review of the data currently available on the California Environmental Data Exchange Network (CEDEN), as uploaded by the ESJWQC Project. Section 1 lists the data inventory as retrieved from four of CEDEN's data repositories. Section 2 discusses some of the sampling design and data reliability issues encountered while reviewing the data. Section 3 shows preliminary data plots (graphs) developed for selected analytes, with details about the number of results and percent detection of each analyte

1. Data Inventory

ESJWQC Project's data were queried from CEDEN on December 8, 2017, retrieving the following Matrix/analyte combinations in four separate queries:

- Habitat (field) observations, 34166 records;
- Water conditions (field measurements) and water chemistry (constituent concentrations), 61824 records;
- Sediment chemistry/grain size, 1250 records; and
- Toxicity in water (1166 samples) and in sediments (339 samples).

Time periods: The data span from 2004 to September 2016.

Locations: The data was collected in a total of 42 sampling Stations (plus a few additional sites with less than 6 visits). Six (6) of the 42 stations were designated as "core sites" and were sampled 12 times a year in some years.

2. Monitoring design and data reliability problems

2.1 Sediment monitoring

Monitoring toxic constituents such as heavy metal, pesticides, and herbicides in water and sediments over several decades has indicated that many of these substances are rarely detected in water, but are found in high concentrations in sediments. This knowledge is not reflected in the sampling design implemented in the Eastern San Joaquin Region for over a decade. The trigger-based design, that calls for analyzing sediments for only 10 pesticides and only if toxicity is found, had yielded only 39 pesticide detections and 46 non-detects between 2009 and 2016. The rest of ESJ Coalition's sediment dataset includes total organic carbon and grain size data (which have nothing to do with monitoring for compliance). This extreme paucity of sediment data creates a very serious information gap in what we know about potentially toxic chemicals accumulating in our waterways.

2.2 Dissolved Oxygen

Dissolved oxygen is one of the water characteristics that fluctuates during the 24 hours cycle, with minimum values detected at dawn and maximum values peaking in the mid-afternoon (depending on the available light). Dissolved oxygen measurements at ESJ occurred at various

times during the day, because the Station Visit timing was directed to operations, not to the worst case scenario. Thus, most measurements of dissolved oxygen occurred after several hours of daylight (and photosynthesis).
The dataset includes 1977 records of instantaneously dissolved oxygen measurements, ranging between 0.05 and 104.8 mg/L.

In the context of compliance monitoring, the dataset should be separated into 4 groups:

1. Values below 5 mg/L (264 visits) definitely exceed all water quality objectives (WQOs)
2. Values between 5 and 7 mg/L (292 visits) exceed WQOs for cold waters even at mid-day, and could have exceeded warm water WQOs if measured at dawn;
3. Values between 7 and 13 mg/L (1251 visits) could have exceeded some WQOs if measured at dawn; and
4. Values above 13 mg/L (171 visits), which indicate oxygen supersaturation above 110% (given the temperatures recorded at the Eastern San Joaquin Region). Total dissolved gases above 110% saturation may cause gas-bubble disease in aquatic organisms (U.S. EPA 1976, p.140). However, oxygen supersaturation is normally not regulated by the State Board.

Thus, what can be concluded with confidence now is only that there were 264 (13.3 %) WQOs exceedances of dissolved oxygen. All the other dissolved oxygen data collected in the Eastern San Joaquin Region simply cannot be used to demonstrate compliance because they were collected at a time of day that does not reflect the real risk. To collect dissolved oxygen data that demonstrate compliance, the field crews would have to make the measurements at each Station at dawn – or deploy dissolved oxygen data loggers.

2.3 Failed Station-Visits due to dry streams

Every year, the Coalition prepares a monitoring plan update (MPU) which specifies the number of samples to be collected at each monitoring Station. As planned, the datasets should have the statistical robustness to conduct various data analyses and derive information from the data. However, the existing sampling design does not call for visiting dry waterways again (or visiting alternative, wet sites on the same waterway). In fact, The Coalition can decide that “All ‘Dry’, ‘Too Shallow’, and ‘Non-contiguous’ events are counted as sampled events and reported as 'no exceedances of the WQTLs’” (ESJWQC 2017 MPU p.2).

Failed Station Visits occurred in many Stations during the draught but also during water year 2016. Of the 2433 Station Visits conducted between 2004 and 2016, 461 (19 percent) did not yield water samples (CEDEN 2017). Several monitoring stations were not sampled for an entire monitoring year, or sampled at a fraction of the prescribed frequency. The 461 failed visits were counted by the Coalition as samples that did not exceed WQOs, instead of deleting them from the sample count.

This creates three major problems:

1. Because a failed sampling event represents “no data” rather than “no exceedances”, the Coalition is generating a wrong count of “no exceedances”, which may be misleading.
2. The temporal density of sampling decreases, and with it the chance to find water quality problems, particularly in the vast geographic areas affected by the drought

3. The sample count is diminished and cannot support a statistically robust dataset for detection of change over time.

The scope of this preliminary data review did not include comparison of ESJ results to WQOs, nor was it directed to deciphering how the Coalition calculates their Percent Exceedances. Thus, at this time it is not possible to determine whether percent exceedance is decreasing over time, as the Coalition claims.

2.4 Identification of storm runoff

Collection of rain event runoff is required by the Order. However, the State's data management systems (e.g., SWAMP, CEDEN) do not have placeholders for tagging results from samples that were collected deliberately to represent storm runoff. Thus, the identification of storm runoff in the ESJ dataset is based on an inference from (a) crew's reports regarding their memory of rain amounts (more of less than one inch) during the 24 hours period prior to sampling, and (b) observation of rain during sampling.

This may result in incorrect designation of sample type (as "runoff or as "dry weather"), and thus jeopardize the determination if runoff collection frequency was as required. Moreover, because the properties of storm runoff water are completely different from the water that flows in streams during dry weather, ambiguous designation of sample type makes data interpretation very difficult, and data analysis for each type separately – which is very important in identification of trends - almost impossible

2.5. Data reliability issues

A preliminary review of the data revealed a few oddities, including the following:

<u>Specific Conductance:</u>
There were 50 measurements with result values below 30 uS/cm, and only 11 of them may have been storm runoff. The minimal values were 0.38 and 3.11uS/cm; these cannot be correct data. Just as a reference, pure rain samples collected by the author in the San Francisco Bay Area had specific conductance of 30 uS/cm, and the only values under 10 uS/cm were measured in a Sierra lake that receives annual flushing with snow melt water running off granite terrain (Katznelson, R. unpublished observations).

<u>Outliers</u>
Nutrient concentrations were usually showing a smooth gradient, except a few outlying values that were much higher than the rest. These outliers could be evidence of a very rich discharge. On the other hand, they could have been measured in non-representative samples collected in unusual niches of the waterway (e.g., edges) or too close to a discharging outfall.

3 Long-term trend plots

Plots were created in Excel and each included data from all years and all sites, i.e., entire dataset, (except for oxidized Nitrogen – see below). Excel trend-line, apparently calculated from the values included in each plot, was added to visualize the slope (without any statistical tests at this preliminary stage). Some outliers with extremely high values were not included; details are provided for each plot. Removal of outliers did not visibly change the slope of the trend-line.

3.1 Nutrients

Nutrient concentrations were measured in over 1000 samples. Reduced Nitrogen was represented by ammonia predominantly, and by Total Kjeldahl nitrogen (TKN, a.k.a. organic nitrogen) for a limited time. TKN detected concentrations ranged between 0.11 and 0.11 and 90 mg/L. Oxidized nitrogen was represented by nitrate and nitrite (see below).

3.1.1 Total ammonia

Ammonia was measured in 1034 samples and was detected in 640 (62%) of them, with concentration ranging between 0.044 and 152 mgN/L (the detection limits, ranging between 0.04 and 0.08 mgN/L, varied over the years). Figure 1 shows the long-term trend for all ammonia concentrations below 5 mgN/L (20 higher values were not included in the plot).

Ammonia was present year-round, often at concentrations that may be toxic at the prevalent pH values. The trend line's slope was similar for the entire dataset, i.e., it was not affected when the 20 values of >5 mg/N/L were also included. At this time, the data have not been subject to statistical analysis that can determine whether the change over time is significant.

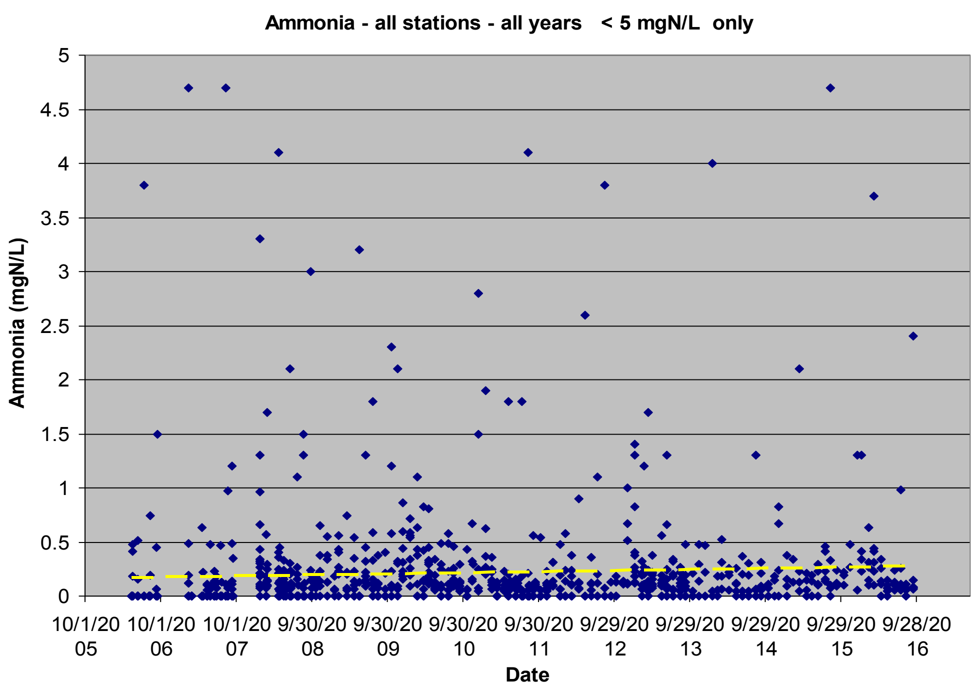

Figure 1 Ammonia Concentrations in Eastern San Joaquin Region, 2006-2016.
Legend: 20 outlier values between 5 and 155 mgN/L were excluded. Non-detects were plotted as 0.001 mgN/L

3.1.2 Nitrate and nitrite

Nitrate and Nitrite were measured separately **between 2004 and 2008**, yielding 347 records each. Nitrate was detected in 303 of these samples, with concentrations peaking at 68 mgN/L (the detection limits, ranging between 0.05 and 0.1 mgN/L, varied over the years and when samples were diluted for analysis). Nitrite was detected much less often and at concentrations <10% of the nitrate in the same sample.

The analytical suite was altered in October 2008, with the implementation of the 2008 WDRs and the introduction of a new analytical method which measures the sum of Nitrate + Nitrite combined. Data collected between September 2008 and 2018 yielded 1021 records, 923 of them above the detection limits, which ranged between 0.02 and 1 mg N/L (depending on sample dilution factor).

Figure 2 shows the results of all analyses of nitrate or nitrate+nitrite obtained between 2006 and 2016. The plot does not include nitrite data collected during 2006-2008. The Region's waterways appear to be nitrate-rich on many occasions over the years, with many values above 10 mg N/L. This preliminary plot does not include any statistical analysis that can determine whether the change over time is significant. However, given the distribution of the data, the tests will probably be unable to demonstrate a significant slope for this dataset.

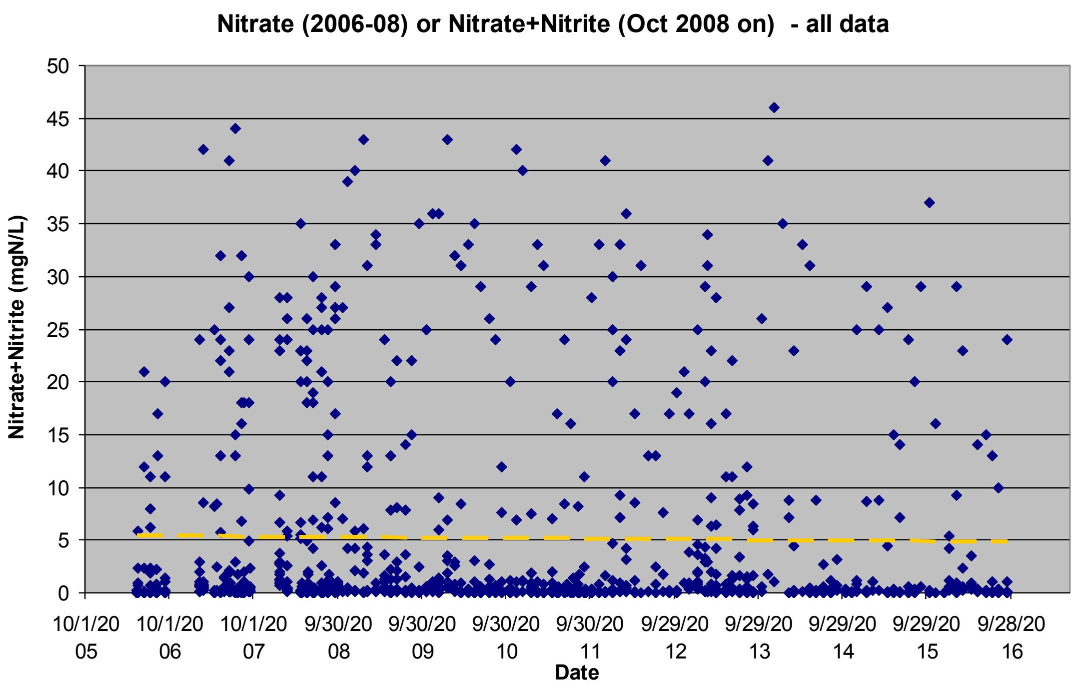

Figure 2: Nitrate + Nitrite Concentrations in Eastern San Joaquin Region, 2006-2016
Legend: One outlier value of 68 mg N/L was not included. Nitrite was usually <10% of Nitrate (when analyzed separately between 2006 and 2008; data not plotted). Non-detects are plotted as 0.01 mg N/L

3.2 Metals

Of all metals analyzed in water, copper dominated the exceedance tables (as shown in ESJWQC MPUs 2015-2017, and annual report 2017) as well as the detections dataset.
Dissolved copper was detected in all 602 samples, in concentrations ranging between 0.08 and 44 ug/L (detection limits ranged between 0.06 and 0.15 ug/L). Total copper was detected in all 872

samples, in concentrations ranging between 0.82 and 120 ug/L (detection limits ranged between 0.05 and 0.6 ug/L)

Figures 3 shows the dissolved copper data collected since 2008, when the Coalition began measuring dissolved copper. Dissolved copper data are needed for comparison to water quality objectives, because toxicity is caused by the dissolved form. Dissolved copper concentrations are usually below 5 ug/L. The trend line shows an upwards slope, indicating increasing concentrations over time. Plotting of total copper data for the same time period also indicated an increasing trend (not shown).

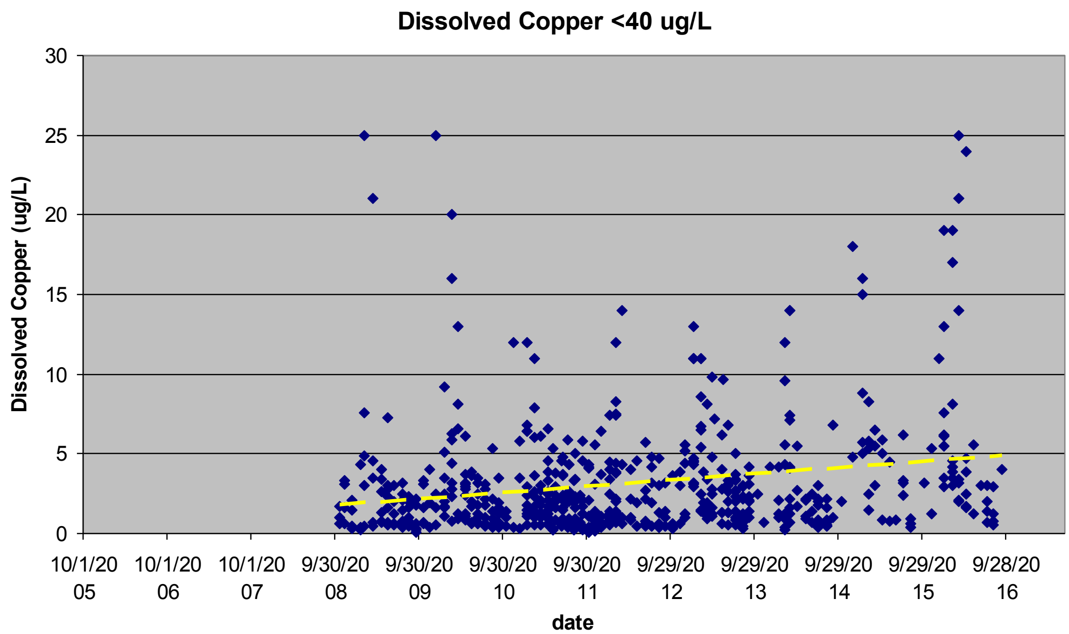

Figure 3: Dissolved Copper Concentrations in Eastern San Joaquin Region, 2008-2016
Legend: Two outliers of 42 and 44 ug/L were not included.

3.3 Pesticides and herbicides

Detection of organic pesticide and herbicides in water sample was rare, particularly in the case of hydrophobic substances that would most often be found in the sediment. The dataset is limited for two reasons:

(a) samples were collected in the represented sites only if triggered by a toxicity event at a core site in the same Zone, and the toxicity test organisms in use may have not been sensitive to some biocides (so their effect - and presence – was missed, and no samples were collected), and

(b) the analytical suite of biocides was not updated fast enough to include new biocides, so not all the biocides that could have been present were analyzed for.

When analyzed, most constituents of the 2004-2016 analytical suites were not detected at all, or detected a few times during the entire monitoring period. The only compounds detected in more than 25 samples were diazinon, chlorpyrifos, diuron, and simazine. In this sparse dataset, only chlorpyrifos was detected often enough to produce an informative plot: Chlorpyrifos was detected in 171 of the 1239 samples analyzed.

Figure 4 shows the concentrations of chlorpyrifos over time. Ten outliers, detected throughout the monitoring period in a variety of sites, were omitted from the plot. Overall, the density of detections appears to diminish over time, and the trend line shows a decrease in concentration. The decrease may reflect the decrease in chlorpyrifos application in the Region during some monitoring years.

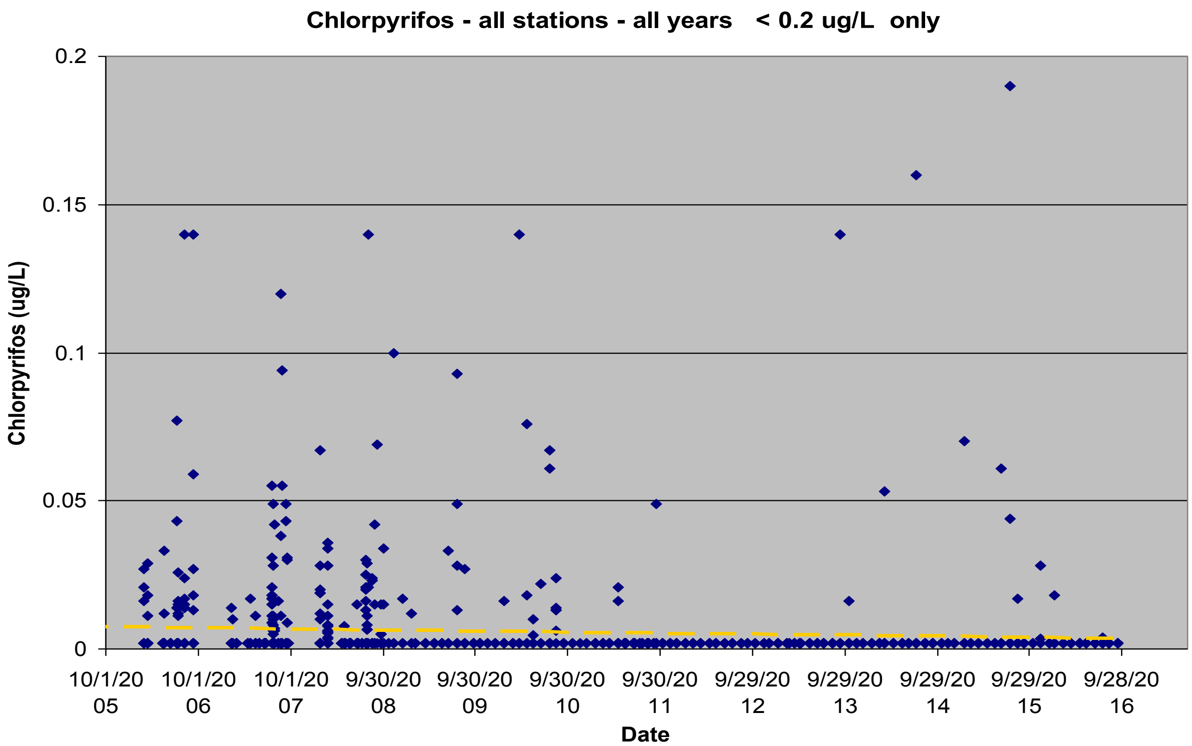

Figure 4; Chlorpyrifos Concentrations in Eastern San Joaquin Region, 2005-2016
Legend: 10 values 0.2 to 4.2 ug/L not included. Non-detects were plotted as 0.002 ug/L

3.4 Toxicity

Toxicity testing is an effective way to detect harmful substances without extensive analysis of toxic constituents. The monitoring efforts included testing water samples with three test species (the crustacean *Ceriodaphnia dubia*, the *alga Selenastrum capricornutum*, and the minnow *Pimephales promelas*) as well as testing of sediment samples with the amphipod *Hyalella azteca*.

Ceriodaphnia dubia toxicity was tested in 1166 samples, 65 or which caused significant mortality. Figure 5 shows the effect of water samples on *C. dubia* over time. The percent mortality was calculated from percent survival endpoints and plotted in a way that shows the magnitude of the problem (i.e. higher value is more harmful). The trend line in this preliminary plot shows a slight reduction in percent mortality over the years, but its significance needs to be determined by statistical analysis of this incremental dataset.

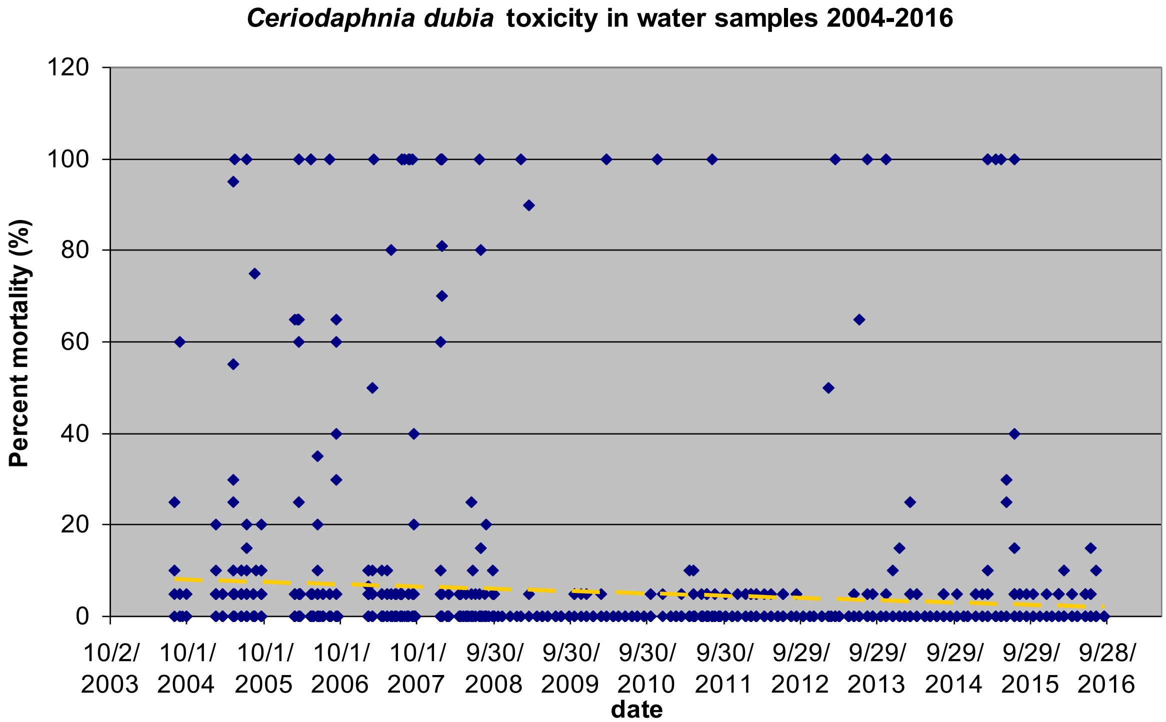

Figure 5 Percent mortality of C. dubia in Eastern San Joaquin Region water samples, 2004-2016

Figure 6 shows the results of sediment toxicity tests with *H. azteca*, as percent mortality. The trend line shows decreased toxicity to *H. azteca* as well. Significant *H. azteca* mortality was observed in 70 sediment samples of the 339 samples tested

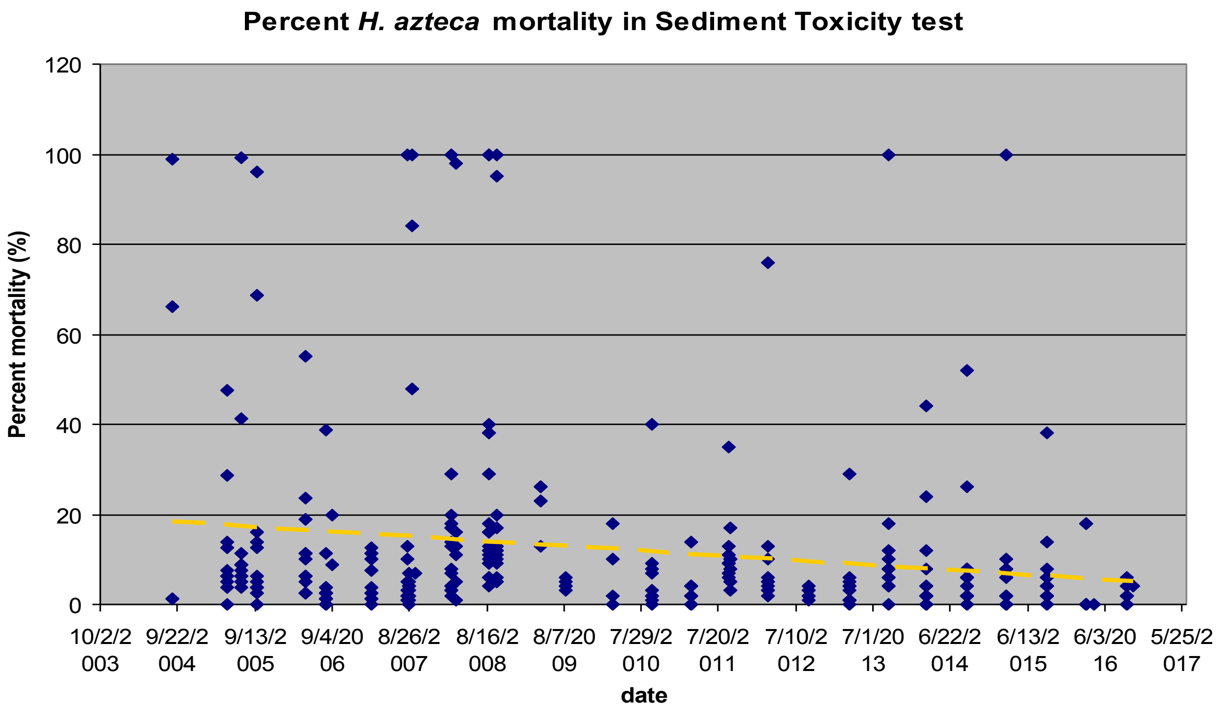

Figure 6 Percent mortality of *H.azteca* in Eastern San Joaquin Region Sediment samples, 2004-2016

References

U.S. Environmental Protection Agency (U.S.EPA) 1976. Quality Criteria for Water. U.S. Environmental Protection Agency, Washington, D.C. 20460. EPA 440-9-76-023 (the Red Book). 501 pp.

Revital Katznelson, Ph.D.

Revital Katznelson received her B. Sc. in biology, M.Sc. in microbial ecology, and Ph.D. in biochemistry from the Hebrew University of Jerusalem, Israel. She has over 30 years of experience in performing, interpreting, and assuring quality of field and laboratory analyses of chemical, biological and bacteriological water quality characteristics. She also has hands-on experience in toxicity testing using a variety of test organisms. Beyond the laboratory, Dr. Katznelson has decades of experience using a wide array of field instrument and kits, and she is proficient with the use of enzyme-linked immunosorbent assay (ELISA) kits and the sealed-well technology (e.g., Colilert) used to count indicator bacteria.

Dr. Katznelson has led numerous ecological studies in a variety of aquatic systems including creeks, ponds, lakes, marshes, lagoons, and reservoirs, and has developed innovative methods to assess - and to increase - the representativeness of samples collected in these types of waterbodies.

In the National arena, Dr. Katznelson has been part of the Water Quality Data Elements Workgroup and the Aquatic Sensors Workgroup of the Methods and Data Comparability Board (affiliated with the National Water Quality Monitoring Council) for several years, and was the lead person in the development of quality assurance guidance for field measurements and telemetry using various water quality sensors.

As a technical liaison at the California State Water Resources Control Board, and a member of the Clean Water Team affiliated with the Surface Water Ambient Monitoring Program (SWAMP), Dr. Katznelson has introduced an array of concepts and tools for training, guidance, data management, documentation, and quality assurance to the realm of water quality monitoring in California. She has successfully applied elaborate instructional design principles, and her unique ability to teach basic scientific concepts, to the construction of her citizen monitoring workshops, her national presentations, and her quality assurance workshops for SWAMP. She also was the co-developer of the SWAMP Advisor, a web-based expert system for compilation of a SWAMP-comparable Quality Assurance Project Plan. Dr. Katznelson was the lead, and primary author, of the SWAMP Field Methods Distance Learning Course Part 1, which was delivered on CDs and on-line in 2005. In the late 2000s, Dr. Katznelson was deeply involved in implementing, troubleshooting, and interpreting the SWAMP physical habitat assessments and algae protocols as they were developing, and she eventually created all contents of the SWAMP Field Methods Distance Learning Course Part 2 (physical and biological assessment) published in 2012. She is currently writing interpretive monitoring reports, providing technical support services, and assisting citizen groups with their environmental monitoring as a volunteer.

Since the late 1970s, Dr. Katznelson has taught in many environments including undergraduate classrooms/labs/field activities at the university, specialized methodology courses and training workshops, and individual mentoring. She uses the current Water Quality Monitoring Design course, provided by UC Berkeley Extension twice a year, to share her decades of experience with her students.

Dr. Katznelson's latest publications and a link her resume (with full publication list), are available on her website at:
http://www.water-science-etc.net/PRODUCTS-pubs.htm

Comments on Surface Water Monitoring Requirements in the Eastern San Joaquin Region's Agricultural Areas and Monitoring Design Recommendations

by Revital Katznelson, Ph.D.

Final Report

12/20/2017

Summary

Modern agriculture, which makes intensive use of irrigation and of chemicals, has a potential to cause adverse environmental effects if the discharge of harmful substances into adjacent waterways is not regulated. Since 2003, the Central Valley Region Water Quality Control Board (RB5) and State Water Resources Control Board (SWRCB or State Board) have implemented California's Irrigated Lands Regulatory Program. The Waste Discharge Requirements (WDRs) developed by this Program must protect the waterbodies that receive agricultural discharges. The WDRs must be consistent with water quality objectives and protect beneficial uses. Water quality monitoring to assess whether WQOs have been met is the cornerstone of this regulatory process.

The State Board's proposed Order, R5-2012-0116-R4 (which modifies the 2012 Waste Discharge Requirements General Order No. R5-2012-0116 for Growers Within the Eastern San Joaquin River Watershed that are Members of the Third-Party Group) is a key component of the regulatory process. The Order's monitoring and reporting program (MRP) establishes the methods that must be used to ensure Eastern San Joaquin Growers are in compliance with the WDRs. For several reasons, the monitoring requirements in the Order are not sufficient, and are not specific enough, to assure that data collection will achieve its goals.

Given the variability of agricultural practices and hydrological features in the ESJ Region, the sampling and analyses effort required by the Order does not provide adequate coverage in space and time, rendering water quality problems undetected. The monitoring strategy, in which the majority of the Region's drainage area is **not monitored unless triggered** by detection of a problem far downstream (e.g., exceedance of a water quality benchmark), will miss detection of many exceedances. This strategy also causes a very long delay, often by more than a year, in identification of the sources of problematic constituent(s). And this, in turn, further delays the implementation of management practices that may alleviate the problem.

Discharges of harmful chemicals are episodic by nature. The monitoring efforts designed to capture them need to be **deliberate, knowledge-based, and activity-driven**. The Order's criteria of when and where to collect water samples - in the attempt to capture problematic constituents - are not sufficient. These problems could be addressed now, as detailed below. Chapter 3 presents an alternative monitoring framework that enables collection of more information, and better coverage of the Region, for a similar level of funding.

Today, water quality monitoring is a well-advanced science that spans many types of activities, instruments, and analytical tools. These tools help us learn about our environment. Visual observations – if well documented – can be an integral part of this science. Better yet, anybody, not just scientists, can make documented observations. Field measurements with inexpensive thermometers and pocket meters have provided immense value when used by citizen-science groups in California, particularly after the operators received a very basic training in quality assurance (which enabled them to deliver data of known and documented quality). Another group of monitoring tools is comprised of hundreds of analytical field kits (e.g., for ammonia, nitrate, etc.) that can provide extremely valuable information in real time and inform sample-collection decisions in real time.

Chapter 1, Section 1.2 below further elaborates on the various tools for data collection, including options that can be used by non-scientists. Unfortunately, the proposed Order refers to the field measurements and sample collection and laboratory analysis aspects of monitoring exclusively and does not mention other opportunities for data collection by Growers and other members of the public. Chapter 2 presents a hypothetical case study which demonstrates how a Grower, armed with a smart phone and connected to a technical support crew member, can contribute to the identification of water quality problems in real time and to the triggering of responsive actions. Chapter 3 lays out an alternative monitoring framework for the Eastern San Joaquin Region, which also incorporates commodity-based monitoring sites, focus on constituent transport events and on sediment sampling, and cost-effective methods for source identification and for evaluation of management practices effectiveness.

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List of Comments

Introduction: An Overview of Water Quality Monitoring

Waste Discharge Requirements must protect the surface water and the groundwater of the Eastern San Joaquin ("ESJ") Region. Irrigated agriculture is associated with intense use of fertilizers and biocides (i.e., materials that kill agricultural pests and disease organisms such as pesticides, herbicides, fungicides, rodenticides, etc.). Water discharged from cultivated areas can adversely impact surface and groundwater that receive these discharges ("receiving waters"). Growers are using copious amounts of water, nutrients, and biocides to assure and increase yield. The use of surplus water, the application of excess nutrients, or the application of unnecessary biocides can happen, particularly when the needs are unknown. It takes knowledge and technological advances to prevent this excess, and it requires ATTENTION. But even when all excess use is eliminated, irrigated agriculture activities still have the potential to impact the receiving waters, and there are still many management practices that need to be implemented to prevent such harm. The science of management practices is rich, diverse, and knowable; it is the responsibility of the growers to make the best use of it.

Receiving waters are geographical features, and Waters of the State is a designated status given to those that need to be protected. But there is a problem: agriculture has transformed the hydrology of the Central Valley so profoundly that it is often very hard to identify the original, pristine waterways that we want to preserve. Most of the receiving waters in the ESJ Region are designated as Waters of the State. Protection of these waterways from nutrients and biocides that are discharged from irrigated lands requires compliance with water quality objectives (i.e., concentrations that are deemed safe for supporting each beneficial use); this is ascertained by measuring chemical concentrations or testing the toxicity of the water. While it may not be efficient for each grower collect and analyze water samples, it makes sense to require each grower to pay attention and to collect evidence that they are paying attention via reported observations. It also makes sense to require that growers monitor for pests on their crops, and to require evidence for the presence of pests that had triggered treatment with biocides.

The word "monitoring", which can mean "to watch, observe, or check for a special purpose" (Webster on-line dictionary), is often used as "sampling and analysis" in the strict sense when applied to water quality. In the irrigated agriculture arena, one can refer to **three separate aspects** of "monitoring":

1. **Needs assessment**: A farmer visits the field often to look for pests and treat if needed ("IPM Monitoring"). Needs Assessments also include sampling soil and foliage for analyses of nitrogen, phosphorus, potassium, etc., testing nitrogen concentrations in irrigation water, and measuring water tension in soil or foliage to determine when to irrigate and how much water to provide. Needs assessments are, indeed, the Best Management Practices. Reporting of the information and data collected for needs assessment is seldom required.
2. **Field observations** and simple field measurements: There is a treasure of knowledge, understanding, and proof in low-effort information collection, especially when done very frequently. A series of pictures of a staff gage in a ditch, which document water level fluctuations over time, can help identify a discharge event. Water level rise or overland flow pictures – if reported in real time – can trigger responsive field measurements (using simple instruments and kits such as pH strips, pocket conductivity meters, or nutrient kits). Findings can trigger sampling for definitive analyses (see type 3 below). Reporting of field observations/measurements in real time should be required.
3. **Sampling and analyses** in the laboratory: This is the way chemical concentration and toxicity data are collected for comparison with water/sediment quality benchmarks. This high-effort aspect of monitoring requires funding and expertise, and is best done by

professional operators who provide services to a large group of growers. Reporting of analytical results is required.

Chapter 1 Comments on Order No. R5-2012-0116-R4 dated Oct 10, 2017

Context: The State Board's **"2017 Proposed Order" -** Order No. R5-2012-0116-R4 ("Order") includes 4 levels of nested documents: L1: State Board Review; L2: Appendices A through E; L3: Attachments to Appendices; and L4: Appendices to the Attachments. **Appendix A** (L2) includes the General WDRs ("Waste Discharge Requirements General Order No. R5-2012-0116-R4 for Growers Within the Eastern San Joaquin River Watershed that are Members of the Third-Party Group") plus three **Attachments** (Information Sheet, Monitoring and Reporting Program (**MRP**), and CEQA Mitigation Measures, L3s). The Comments in this Chapter are focused on the surface water monitoring components as presented in the State Board Review (L1), the General WDRs (L2), and the MRP (L3), all referred to as "the Order".

The legal, regulatory, proof of compliance and procedural aspects of the Order have been reviewed extensively for Draft 1 (CCKA 2016a,b, The Otter Project 2016) .This Chapter is responding to the surface water monitoring requirements proposed in the Oct 10, 2017 MRP. Preparation of this report was informed by the Order documents plus a number of publications, including the 2010 Central Coast Conditions Report (CCRWQCB 2010) and the 2007 Monitoring Design Guidance compiled by the Central Valley Regional Board staff, Irrigated Lands Regulatory Program's Technical Issues Committee (TIC), and Brock Bernstein of Southern California Coastal Water Research Project (SCCWRP) (CVRWQCB 2007). Much was also gleaned from the East San Joaquin Water Quality Coalition ("Coalition") publications, including the four recent Monitoring Plan Updates (MPU, ESJWQC 2014, 2015, 2016, 2017), Surface Water Quality Management Plan (SQMP, ESJWQC 2015), and the Annual Report for the October 2015-spetember 2016 data (ESJWQC 2017). The monitoring data review included all Eastern San Joaquin 2004-2016 data that were available on CEDEN.

1.1 Monitoring strategy

1.1.1 Responsive monitoring versus adaptive monitoring – the time frame.

Comment 1: The Order does not require observations or field measurement triggers for responsive monitoring.
The order does not mention responsive monitoring, nor does it define triggers for sample collection that are perceivable or measurable in the field or allow for collecting samples **immediately** at the triggered location. This approach differs from the triggered monitoring as done by the Coalition, where results of a given sampling and analyses event inform subsequent sampling many weeks or even months after the event (see "undefined time-frame" comment below). It also differs from adaptive monitoring where results from one year are used to alter sampling locations and analytical suites in the subsequent monitoring year (e.g., Exceedance in a Core station triggers monitoring in Represented sites in the same zone a year or more later (ESJWQC 2017 MPU p. 1).
Recommendation: The Order should require frequent observations (sensory information) and basic measurements (e.g., staff gage reading; Specific Conductivity measurements) to inform responsive monitoring. These observations and measurements should always be augmented by time- and date-stamped photo-documentation. Sample collection should be triggered when oddities are observed during routine observations, or can be associated with known events (e.g., extra flow at the end of an irrigation cycle; rainfall runoff; end of spraying activity in the field upstream of the Station). Responsive monitoring should be immediate.

Comment 2: The Order requires a public review process but does not specify a time limit for approval of Surface Water Quality Management Plans (SQMPs) (WDR Section VIII.I.1, MRP Sections V.D and E, Appendix MRP-1 Section II.A p.7). This creates an undefined time-frame for any response to exceedance problems.
In other words, even if a SQMP is submitted by the Coalition within 60 days of exceedance discovery (which **is** ordered in the WDR VIII.I.1, p.36), and sampling must occur within 90 to 180 days after SQMP approval (ESJWQC 2015 SQMP, Table 18 p. 71), there is no requirement that follow-up monitoring in case of exceedance is conducted **within a given period of time**. The current Comprehensive SQMP, which took years to develop and approve, does not show any avenue for **immediate** response.
Recommendation:
Develop a defined schedule of SQMP development.

1.1.2 Number of samples, spatial and temporal density of data, and statistical power of the dataset.

Comment 3: The Order concurs with the experts' opinion that the "spatial and temporal density of data" is inadequate for compliance monitoring, but it does not concur with the experts' opinion that increased number of samples and sampling locations should be ordered now.
The existing data coverage, geographically and over the years, appears to be inadequate for capturing exceedances. However, the Order does not require an increase in sampling density, or alteration of the sampling design and the monitoring strategy.

Comment 4: The Order (including the MRP) does not specify the number of "regular" samples to be collected.
This number is determined by the Coalition, and the information is provided in the Coalition's annual Monitoring Plan Update (MPU). Year after year, the routine sampling at core sites dominates the plan, with constituent-driven, very limited coverage elsewhere.

Comment 5: The Order does not require that dry waterways be visited again, or that alternative, wet sites be found on the same waterway.
The Coalition can decide that "All Dry," "Too Shallow," and "Non-contiguous" events are **counted as sampled events** and reported as 'no exceedances of the WQTLs'" (ESJWQC 2017 MPU p.2). The problem with this statement is that <u>a failed sampling event represents "no data" rather than "no exceedances"</u>.

In fact, several monitoring stations were not sampled for an entire monitoring year(!), or sampled at a fraction of the prescribed frequency. Examples include the following:

- Eleven (11) samples for copper analysis were required for Station 545XBSAAE (Berenda Slough along Ave 18 1/2) in water-year 2015, but none was collected;
- During the same water year, 12 samples were planned for Station 545XCCART (Cottonwood Creek @ Rd 20) but none collected (all Station Visits recorded a dry stream).
- In Stations 535XDCAGR (Deadman Creek (Dutchman) @ Gurr Rd) and 535DMCAHF (Deadman Creek @ Hwy 59), a total of 14 visits were planned for water-year 2015, but only 4 visits yielded samples.

Failed Station Visits occurred in many other Stations during the drought but also during water year 2016. Of the 2433 Station Visits conducted between 2004 and 2016, 461 (19 percent) did not yield water samples (CEDEN 2017). The diminished support for a statistically robust dataset for trend analysis is not addressed by the Order.

Comment 6: The order requires collection of only two sediment samples a year in each Station monitored during that year, to be tested for *H. azteca* toxicity.
This low frequency, especially in light of the paucity of constituent concentrations data in sediments, provides insufficient information about the risk of sediment toxicity.

Comment 7: The Order requires collection of only two Stormwater samples a year in each Station monitored during that year.
This is not sufficient for adequate representation of storm runoff due to extremely high variability between storms, particularly when a considerable fraction (20.4%) of planned storm-water sampling events was not performed (because the creek bed was dry when the crews arrived). Given that storm runoff is the major force that transports constituents and soils from land to waterways, elevated concentrations (which may exceed water quality objectives and may cause harm) are expected in storm runoff samples more than in dry weather samples. Thus, harmful conditions will be missed if not enough storm runoff sample are collected.
Recommendation:
Field crews should plan their monitoring events to **deliberately** capture **one** of three condition-groups:

1. Rain runoff (see timing considerations in Section 1.2.5c below)
2. Irrigation discharge events
3. Dry weather flows

The resulting data should be tagged with condition-type in the database. Any statistical analysis for comparison or trend analysis should use these types of samples **separately**, because they represent totally different situations.

Comment 8: The Order does not specify how to report long-term trends in water quality.
The Coalition is reporting long-term trends in terms of multi-year reduction of **percent exceedances** for lumped characteristic groups, not as a change in concentrations of a single constituent over time. Scientists know that trend monitoring does not apply to percent exceedance for "all pesticides" or "all metals"; this lumping can be misleading particularly when the quantities of applied pesticides change over time - and there is no monitoring data (i.e., no new exceedances) for the new substances that have replaced out-of-use pesticides.

1.1.3 Management decisions support

Comment 9: The State Water Board concluded that the current density (spatial and temporal) of sampling and analysis efforts is insufficient for adequately identifying water quality problems in the East San Joaquin region (p. 47-50 of the draft Order). However, the State Board refrained from requiring an increase in monitoring density. At this time, the State Board defers the question of monitoring framework's adequacy to a future Expert Panel, which will begin by making a list of management decisions.
This deferment lacks transparency (the State Board does not indicate the future management decisions) and delays required actions that could be taken now (because the Expert Panel process takes years). As stated in the Order, there is already ample expertise to support a water quality monitoring framework that will accomplish its major objectives, particularly if **existing** monitoring resources are channeled in a more focused way. In other words, there is no need for an Expert Panel because there is sufficient knowledge to develop several monitoring designs, each intended to address one of the major goals (compliance; sources; management practices effectiveness evaluations; and trends).

Recommendation:
The Order should dictate more explicit criteria regarding the sampling locations, the temporal situations when samples should be collected, and the constituents to be analyzed for each situation. The State Board should also direct the Regional Board to create a monitoring plan that fulfills the major goals quickly and by a specified date.

1.2 Monitoring design: the Why, Who, What, Where, When, and How

Monitoring design, i.e., where, when, and what will be monitored, has to be tailored to monitoring intent (the Why) very early in the monitoring planning phase. Well-designed study is the only way to achieve a successful and cost-effective monitoring effort. However, sometimes some of these design aspects are unknown during the planning phase. In that case, an Order can replace locations/times/characteristics with criteria for selecting them, as the conditions on the ground dictate. It is very clear that the Order cannot take the place of a Monitoring Plan; these plans need to be developed on a case-by-case basis. However, the Order can and should provide specific criteria that must be met when locations, times, characteristics are selected. Examples: include collection of samples immediately downstream of a discharge point; sample during the time period of the highest risk (MRP III.A.2); or require analyses of all pesticides known to be in use in a given drainage.

The following comments pertain to more then one aspect of monitoring design, and are discussed in more detail in Sections 1.2.1 to 1.2.6 below.

Comment 10: The Order considers only water-related transport mechanisms and does not address other pathways of constituent movement from irrigated lands to waterways.
Although the spread of agrochemicals via dust, spray drift, and volatilization is not directly related to irrigation, a number of constituents reach waterways via these pathways, sometimes at toxic concentrations (e.g., diazinon in rain, Bailey *et al* 2000).
Recommendation:
Add requirements for monitoring of **aerial deposition, wet and dry**, during February (the month of dormant spray application) in geographical areas of intense almond and stone-fruit cultivation.

Comment 11: The Order does not specify the timing and frequency of sample collection; rather, it defers to the Coalition to determine these variables.
It is critical to direct the sample collection timing to what is known about the actual times of constituents release or transport in order to encounter water quality problems (see Section 1.2.5 below). By deferring it to other entities, the Water Board has no voice in how it should be done. In other words, the phrase “time periods of highest risk” is good but not specific enough.
Recommendation:
At a minimum, the order should use explicit language linking timing and frequency to agricultural commodities and to common cultivation practices such as plowing, sowing, planting, irrigating, spraying, harvesting, etc.

1.2.1 The Why (monitoring intent)

Comment 12: the Order does not prescribe a specific study design for each monitoring goal.
As explained elsewhere in this report, monitoring goals cannot be achieved using only one study design. Goals (prescribed by the State Board) and appropriate designs (prescribed by the Regional Board) must be linked.
Recommendations:

a) Monitoring design must be tailored to the goal, which is, overall, **finding adverse effects** – or assuring there are none. We need to target the **worst case scenario** if we want to "catch" damage, e.g., collect fine sediments where deposition occurs for pesticide analysis, measure dissolved oxygen at 5 AM during low flow, etc.
b) If problematic discharges are found, a new question arises: where is it coming from? The monitoring intent would be **source identification**, and the study design would call for sampling tributaries up the waterways network to find the source. Because discharge events are episodic by nature, the use of field kits in real time is highly recommended.
c) Implementation of **management practices** to reduce the impact of pollutants requires monitoring to evaluate the **effectiveness** of these management practices in reducing concentrations For this intent, the study design would involve monitoring before and after implementation, or upstream and downstream of the discharge point, or – in the case of structural management practices – at the inlet and outlet of the structure (with consideration of the retention time).
d) Identification of **long-term trends**, particularly overall reduction of pollutant concentrations as a result of implemented management practices, calls for generation of a statistically-robust dataset. The study design for this intent would be high-frequency measurements/sampling at a few selected sites. Field instruments and kits are useful for this intent as well. It is easier to detect significant change in smaller and less complex drainage areas (rather than in a large basin with multiple sources of problematic constituents).

1.2.2 The Who (operators)

Comment 13: The Order does not require individual growers to participate in documentation of real-time, frequent observations and of discharge events.
Growers are present in the fields to conduct their business and it is not a huge burden for them to document what they are seeing at key locations around their plots.
Recommendation:
Establish an observation and reporting system that encourages growers to pay attention and report what they see to help the Program identify potential problems.

Comment 14: There is no provision for real-time technical support to growers.

Recommendation:
The Growers' documentation activity should be combined with highly **Mobile Technical Support Unit** members, funded and trained by the Coalition, who work with the growers to implement responsive monitoring. These knowledgeable, experienced people will look at field observations in real time (e.g., receive text/email pictures from growers) and, as needed, immediately visit the site to test the water with field kits or and/or to collect samples for laboratory analyses.

1.2.3 The What (characteristics and analytes)

(Note: recommendations for the next three comments are grouped below)

Comment 15: The required analytical suite for water samples is not updated fast enough.
Comment: The required analytical suite for water samples is not updated fast enough.
The process of updating the list of pesticides to be monitored took a very long time; some pesticides have been in use for a number of years but will only be analyzed for in water-year 2018 (however, the toxicity tests have not been updated to included species sensitive to new pesticides). It is expected that the 2018 water-year monitoring efforts will address all the new pesticides such as surfactants and adjuvants.

Comment 16: Monitoring of sediment quality is utterly deficient. Sediment samples required by the Order are not analyzed for a myriad of potentially harmful chemicals, except for a selected suite of 10 - and only if toxicity was observed in that sample.
The sediment data collected in the ESJ Region since 2004 are not merely sparse; they are virtually non-existent. The Order ignores the fact that many of the agrochemicals applied to irrigated crops are very transient in water (and are rarely detected), but accumulate in sediments, often to harmful concentrations. The water comes and goes, but the sediment remembers.

Comment 17: The order does not require field observations (beyond those done during site visits for sample collection) and does not mention the need for documentation of overland flow events.
In other words, the Order does not require the growers to pay attention, and alert the sampling crews they see water and soil moving from their property to adjacent waterways.

Recommendations:
This group addresses the comments 15, 16, and 17 above, listing the recommended ***additions*** *to monitoring types and tested analytes.*

a) Add: Frequent **field observations** and photo-documentation, and add reporting pathways (e.g., pictures go to Coalition's mobile tech-support unit immediately; also see Sections 1.2.6 and 3.6 below). Field observations and photo-documentation should be done by the growers themselves. They are present at the scene, and it will help them pay attention to the consequences of their activities.

b) Add: **Field measurements**, using instruments and field kits, that can be used by the growers or by mobile tech-support crew members in response to observed triggers.
-- test strips for pH and other constituents
-- thermometers
-- pocket meters for conductivity/salinity, temperature, and pH
-- Ammonia, nitrate+nitrite, and orthophosphate field kits are useful for tracking nutrient sources and runoff
-- Surfactant kits (surfactants are widely used in biocide formulations. Detection of surfactants with field kits should trigger immediate collection of samples for pesticide analyses and toxicity testing.)

c) Add: All **chemicals** (and their breakdown products) applied to each Station's drainage area (or individual field if monitoring edge-of-field) to the analytical suite. This includes (but not limited to) biocides, fertilizers, surfactants, soil amendments, etc. Surfactants are widely used and should be reported as total ("MBAS") or as specific families of compounds.
Important: Measure the concentrations of biocides and metals in **sediments**, not just in water. And not only after toxicity was observed.

d) Add **toxicity** test organisms for water and sediment toxicity testing in freshwater, e.g., Chironomids – a.k.a. midges, such as *Chironomus dilutus* (Anderson et al 2015). The toxic soup of multiple biocides has a synergistic effect and different organisms respond in different ways; some are more sensitive than others. In other words, the toxicity testing suite should include new organisms that are most sensitive to the new pesticides in use today. Make sure the lab strain of *H. azteca* (the strain that is still sensitive to pyrethroids) is always used, rather than pyrethroid-insensitive mutants of this organism. Non-responsive toxicity test species (e.g., *Pimephales promelas*) should be excluded to channel resources elsewhere.

e) Add "Integrative" characteristics such as benthic macroinvertebrates (**BMI)**; they are good indicators for episodic toxicity and they yield very useful metrics that indicate how fast conditions change in the waterway.

1.2.4 The Where (monitoring locations)

Comment 18: Apart from requiring selection of "represented locations", the Order does not specify the selection criteria or the need to represent the worse case scenario.
Recommendation:
Sampling locations should be targeted to capture the worst case scenario for any potentially harmful constituent. Language such as "immediately downstream of the mixing zone below the Outfall/confluence/discharge point" or "at each tributary just above confluence" should be included, and directly tied to the monitoring goal.

1.2.5 The When (Monitoring Time)

1.2.5.1 Time of day

Comment 19: The Order and all the Plans associated with it (e.g., MRP, MPU, and SQMP) do not mention the time of day in any context.
For field measurements, selection of monitoring **time** is inseparable from monitoring intent. Measurements done anecdotally - whenever the crew happens to be in the Station – usually do not provide useful DO, pH, Temperature, or turbidity data. Moreover, such data, which usually do not represent the worst case scenarios, <u>cannot be a regulatory tool.</u>

Example: In slow-moving, nutrient-rich waterways the concentrations of dissolved oxygen (DO) can fluctuate daily from 2 mg/L or less at dawn to 15 mg/L or more in the afternoon, after many hours of photosynthesis. DO dips below ~4 mg/l is deadly to most organisms; concentrations must be at least 5 mg/L to protect warm-water aquatic life. The Order does **not** require that DO be measured at dawn to assure that DO problems are detected. In fact, the Order does not mention the time of day at all. Nor does it require that sampling place and time be targeted to capture the worst case scenario for any potentially harmful constituent.
Recommendation:
Use data loggers to collect time-series (continuous) field measurements (see Section 1.2.6e below).

1.2.5.2 Times of specific agricultural activities

Comment 20: The Order does not provide adequate instructions on how to capture discharges related to specific agricultural activities.
Activity-related sample timing is critical, whether it is irrigation, granular chemical application, spraying, dusting, fogging, or basic cultivation practices such as plowing, harvest, or even disposal of pruned branches.
Recommendation:
Sampling should be done when the activity effects reach the waterway.

1.2.5.3 Rain event sampling: time in the storm hydrograph

Comment 21: the Order does not require sampling at a given time during the hydrograph and does not specify the type of Stormwater samples (composites vs grabs).

Studies show that the highest concentrations of storm water constituents are usually detected close to the beginning of the storm flows (i.e., during the rising limb of the storm hydrograph). The Coalition allows for collection of runoff samples up to **three days** from the onset of storm flows (ESJWQC 2017 MPU p.1), but also states that the Region's waterways usually experience "flash" flows that cease immediately after precipitation stops (ESJWQC 2015 SQMP p.51).

Recommendations:

The downstream end of most small drainages, even in low-gradient streams, should be sampled within 24 hrs of rainfall start, **not 3 days.** When sampling runoff, it is best to use triggers of turbidity, water level rise, and altered specific conductance to inform sampling time and to collect samples during the rising limb of the hydrograph. This requires the presence of dedicated crews at each Station. Alternatively, runoff can be captured by deployment of unattended sampling devices (as simple as bottle-traps or as sophisticated as automatic pump samplers) that are triggered when the water level rises.

1.2.5.4 Seasonal patterns

Comment 22: The Order is silent about sampling seasons.

There is ample knowledge about what agricultural activities are best done in which season; a UC Davis guidance document (Prichard 2001) even distinguishes between different parts of the San Joaquin Valley for optimal timing of certain activities such as post-harvest irrigation of almonds. Application of biocides and nutrients also follow seasonal patterns and vary by crop type.

Recommendation: Selection of sample collection seasons should be targeted to agricultural commodities and dominant crop types to maximize the chance of witnessing disturbances and harmful discharges.

1.2.6 The How (Methods)

Comment 23: The Order does not mention entire categories of data collection methods that are needed for compliance and for collection of meaningful data within budget.

The universe of monitoring includes much more than the options required by the Order.

Recommendations:

a) frequent field observations: field data sheets should be simple, smart-phone accessible, and standardized for streamlined data management (and possible upload to **CEDEN).** For text categories, useful categorization will make it easy to "calibrate" among observers.

b) field measurement instruments and kits can be used by the growers themselves and/or by the Coalition's mobile tech-support unit personnel. There is a wide selection of wet-chemistry field kits, using a variety of comparators (Lawson and Mistry 2017). This type of field equipment (e.g., pocket Spec. Cond./temperature meter, pH strips, Nitrate ampoules, ammonia reagent kits, or surfactant/detergent kits) is:

- cheap (costs are between a few cents to less than a dollar per test);
- quick (takes less than 5 minutes);
- easy to use by any person who can follow instructions;
- can be augmented by quality checks with Standards to produce data of known and documented accuracy and precision;
- can reduce costs by replacing expensive lab analysis for certain monitoring goals; and
- offer immediate, real time, results that can inform further actions.

c) Reporting by **sending pictures** (e.g., picture of test-tube +comparison chart, with time stamp and lat/long coordinates)

d) Screening methods: Beyond the field kits discussed above, forensic studies such as source identification or evaluation studies for management practice effectiveness should make much wider use of other rapid methods. These screening methods can be used by trained operators, not necessarily in the laboratory, with inexpensive materials and equipment. Examples include ELISA kits (enzyme-linked immunosorbent assay, a.k.a. Immunoassay kits) that are now available for hundreds of organic compounds, Colilert tests for E. coli and other bacterial indicators, or simplified toxicity protocols (e.g., the 2-day adult *Ceriodaphnia dubia* test developed for schools). With appropriate testing of Standards, positive/negative controls, and reference toxicants, these methods can produce data of known and documented quality (as well as suitable for compliance and defensible in court in many cases).

e) Continuous monitoring using data loggers: As mentioned above, the values of dissolved oxygen, pH, and temperature are changing rapidly during the day/night cycle, and single measurements during sampling Station visits (whenever the crew happens to be at the Station) produce data of unknown representativeness and extremely limited use. Because crews visit Stations at times that often do not represent the worst case scenarios, exceedances are often missed. In other words, monitoring of DO, pH and temperature anecdotally ("whenever") cannot be a regulatory tool.

It is recommended to use data loggers to track the changes in these water quality characteristics during the diurnal cycles for several weeks each season. State agencies have been using data loggers to collect time-series field measurements (a.k.a continuous monitoring) for at least 15 years. Compliance is assessed by calculation of meaningful statistics from the data strings (e.g., weekly minimum average of DO) and comparison of these statistics with water quality objectives (Sullivan *et al* 2000)

f) New analytical methods: Measurement systems that can identify new constituents of concern and deliver adequate reporting limits (e.g., for comparison with toxicity-related water quality objectives), or new methods developed per the EPA's Performance-Based Measurement Systems (PBMS) protocols.

g) Use of drones and/or **remote sensing** methods to discover and document overland flow events, algal blooms in receiving waters, etc.

1.3 Programmatic output versus direct evidence

1.3.1 Indirect measures of "success"

Comment 24: The Order places too much emphasis on "bean counting" reports such as Implemented Management Practices, and allows for an "interim compliance" based on meeting management practice implementation requirements, deferring compliance with water quality protection into the far future.
The problem is that – even with all the scientific studies done to evaluate management practices effectiveness -- not all management practices are effective as implemented, and the proof should be on a case by case basis.
Recommendation:
Select appropriate locations and the timing to conduct monitoring (possibly with field instruments and kits) to determine whether the water quality has improved over time.

Comment 25: The Order does not ensure that sampling designs and monitoring results of special studies done by the Coalition are accessible to the public, not even when locations are not disclosed.
When triggered, the Coalition is required to conduct special studies for source identification and effectiveness evaluation (of management practices implemented by ESJ growers). They do not report the individual results and do not provide all supporting documentation (metadata). The entire component of special studies is totally opaque.
Recommendation:
Require reporting of special studies based on **conceptual models** that reflect real geographical layout, sampling design, and analytical results - but with codes for specific locations, dates, or other details that might identify the real Growers. These types of reports will help the Coalition **link** management practice implementation with real improvement in water quality. They will also enable a member of the public to evaluate the efficacy of the study design and the meaning of the results.

1.3.2 Expectations versus real records

Comment 26: The Order does not differentiate between perceived risk and actual risk and does not require reporting of actual risk to waterways.
The Order properly requires that Growers report quite a lot of information via the Farm Evaluation, Irrigation and Nitrogen Management Plan (INMP), and Sediment and Erosion Control Plan. However, high-risk phenomena (such as the possibility of surface flow of water from the field to a receiving water, or the potential for sediment transport) are reported annually as a perceived risk; there is no requirement to collect evidence in real time and estimate the magnitude/duration of these events.
Recommendation:
Involve growers with conducting observations and encourage them to pay attention and report how long the flow event lasted (also see Chapter 2 below).

1.4 Other data sources, data recipients, and reviewers

1.4.1 Collaboration during the planning and data collection processes

Comment 27: The Order does not require collaboration with other agencies and with potential partners during the development of planning documents for monitoring.
Recommendation: Regional Board staff and Coalition staff should collaborate coordinate and communicate with other federal and state agencies, districts, counties, citizen groups, etc. during the monitoring planning phase and later (CVRWQCB 2007 p. 2).

1.4.2 Comparison of data from various sources

Comment 28: The order does not require comparison of Coalition's data with data generated by others.
The Order properly encourages the use of data collected by others, and provides a list of data repository that Regional Board staff can use for their assessments. However, the Order does not require that Regional Board staff compare independent data with the Coalition's data for the same sites and and/or seasons.
Recommendation:
Support data exploration by Regional Board staff.

1.4.3 Independent technical review

Comment 29: The Order does not require independent technical review of Coalition's submitted documents.

Recommendation: Augment the Coalition's expertise with qualified technical advisors from academia and industry on an ongoing basis, as documents are written and monitoring designs are developed. Technical review will help correct inaccuracies before they are published. The following examples of inaccurate statements are from the Coalition's SQMP discussion (ESJWQC 2015):

- p. 46 *"Although natural processes can convert nitrate or organic nitrogen to ammonium, the concentration of ammonium in these conditions is relatively low."* Nitrate is never converted to ammonia in nature. Ammonia (NH_3) nitrogen can be oxidized to nitrite (NO_2^-) and then to nitrate (NO_3^-) if oxygen is present (i.e., in aerobic conditions), a process called nitrification. Nitrate nitrogen can only be reduced to nitrite and then to molecular nitrogen (N_2) in anaerobic conditions, a process known as denitrification. The molecular nitrogen is released to the atmosphere. However, the SQMP author was indeed correct on this item: Organic nitrogen is readily broken down to ammonia, a process called ammonification.
- p.47 *"A large amount of organic matter can also result in changes in pH as microbial breakdown of dead algae and other organic matter in the water can lead to elevated pH"*; the opposite is usually true: pH values decrease when breakdown of organic matter by microbes is increased.
- p.48 *"E. coli may persist in the presence of oxygen in the environment for periods of time after being voided, and are known to reproduce and proliferate in the environment."* Actually, E. coli bacteria (a) live in anaerobic environments and are not adapted to oxygen, and (b) require stable heat (37^o C) and dense nutrition, which is present only in very special habitats such as muddy lagoons in the sun. Thus, while other coliforms might, E. coli normally does not multiply in the environment.

Chapter 2. Almond Orchard Case Study: NAF Nitrogen Project

Development of this Case Study was informed by reading-material on almond cultivation as presented by the Almonds Board of California (http://www.almonds.com/), as well as from information available at the Integrated Pest Management (IPM) website. The Plan for the case study was adapted from a hypothetical Environmental Monitoring Plan developed by the author for citizen monitoring groups in the past (CWT Toolbox http://www.waterboards.ca.gov/water_issues/programs/swamp/cwt_toolbox.shtml).

Note: *This hypothetical case study features a fictitious almond farm adjacent to imaginary Almond Slough, a tributary of non-existent Sorrel Creek. However, the scenario and associated monitoring plan are as real as it gets.*

Introduction

Sorrel Creek flows east to west from its headwaters in the Snowy Mountains into the Big Valley Wetland Monument, draining an area of 87 square miles. Almond Slough drains an area of eight square miles of the valley floor, and flows from the south into a network of sloughs that drain into Sorrel Creek just before it enters the Big Valley Wetland Monument.

Almond Slough is fringed by a healthy but very narrow riparian corridor, and has very steep banks, 9-15 feet high, with evidence of many landslides. Water is present year-round; however, the water level fluctuates seasonally and in response to flow events (mostly rain runoff or irrigation runoff).

The entire Almond Slough watershed is cultivated, mostly by almond growers. There is one small dairy farm upstream of the orchards.

Natural Almonds Farm (NAF) is located 2 miles upstream of the slough's confluence with another of the network's sloughs, and consists of one large (x-acres) almond orchard situated adjacent to the slough. The almond orchard is irrigated by a permanent array of micro-sprinklers. Water delivery is controlled by automatic valves that open in response to a low-moisture signal from one soil tensiometer located at the south-east corner of the orchard. The trees receive nutrients and biocides on an as-needed basis.

Dale Fields is the owner and operator of NAF. Committed to protect the streams and rivers of Big Valley, Dale has been involved with "Needs Assessment Monitoring" for many years. Soil-moisture measurements inform how much water is needed. Availability of nutrients informs how much fertilizer needs to be added (Nitrogen, phosphorus, and potassium concentrations in soil, foliage, and wood are measured every 3 years at NAF, by independent consultants, per well-established protocols). In addition, since the implementation of the Integrated Pest Management (IPM) protocols, the NAF has reduced biocide use by 60% or more (because the trees are treated only if pests have been found, rather than on a prescribed seasonal schedule).

Natural Almonds Farm (NAF) is a member of the Big Valley Farms Coalition ("the Coalition") which represents this farm and several hundred other growers in all their dealings with the Regional Water Quality Control Board ("Waterboard"). The Coalition is in charge of helping the growers comply with the Waterboard's Waste Discharge Requirements (WDR) Order, and is responsible for collecting and analyzing water samples from receiving waters at representative locations. One of these sampling stations is located at the bottom end of Sorrel Creek just before it enters the wetland area.

A Problem description

A1 Geographical setting and relevant cultivation methods

The edge of the NAF orchard is very close to Almond Slough. Nitrogen fertilizer is added - when needed - as a granular formula of a urea salt, which releases ammonia into the irrigation water applied by the micro-sprinkler array. When the soil is saturated, excess irrigation water flows overland across the dirt road into the riparian corridor (and sometimes into the slough, where a turbid plume can be seen). Overland flow (runoff) from the orchard to the slough also occurs very often during rain events.

A2 Problem statement

Results from the Coalition's sampling at the bottom of Sorrel Creek in previous years revealed elevated concentrations of ammonia and nitrate on several occasions, indicating exceedances of water quality objectives and possible toxicity to aquatic life. The sources of these nitrogen compounds are not known, and the Coalition does not have the funding to conduct a source identification study in the watershed. Based on existing anecdotal evidence, the NAF (and other farms like it) may be contributing to the nitrogen loads on Almond Slough and Sorrel Creek.

A3 Monitoring objective and specific study question

NAF, with the help of the Coalition, intends to embark on a low-tech, low cost monitoring effort that will encourage the grower (and possibly the other farm hands) to pay more attention to water exiting the orchard, and try to estimate the amounts of nitrogen released from the Farm during one water-year. This effort will also include evaluation of the amounts coming from upstream of NAF (i.e., from other sources). The Project will attempt to answer the three specific questions shown in box 3-1:

Box 3-1: Monitoring Questions

(1) What is the frequency of nitrogen release from NAF into Almond Slough in Water-Year 2016-2017?

(2) What is the estimated NAF's contribution of nitrogen to Almond Slough in Water-Year 2016-2017?

(3) Are there other sources, located upstream of NAF, that contribute nitrogen to Almond Slough at the same time?

B Project personnel, roles, and responsibilities

Dale Fields, the grower, is present at the orchard several times a week when performing the necessary farming activities. Paying attention is already an important aspect of farming, and the addition of documentation and sharing is another aspect of stewardship. Chris Tech, a trained member of the

Coalition Mobile Tech Support Unit, will be responsible for field measurements and data management for the Project. Pat Quaile, the Coalition's technical leader, will review the data every eight weeks and provide oversight and support as needed. Robin Knowles, Ph.D serves as an outside advisor to the Coalition.

C Project Activities and Schedule

The major activities planned for this Project can be grouped into three aspects of "monitoring":
C.1 **"Needs Assessments"** has already been conducted for a number of years by Dale Fields, and is an ongoing effort (see Introduction above).
C.2 **Observations, photo-documentation, and field measurements** will be initiated in 2016 and continue into the future.
C.3 **Sampling and laboratory analysis** will be conducted in support of field activities, commencing in 2016.

D Monitoring Strategy and Design

D.1 Sampling design principles used to select locations and timing.

Selection of points in space and time (i.e., location and timing) for observations, field measurements, or sample collection can be done according to a number of **Sampling design principles.** These principles embody three major approaches:

a) **"directed"** (also known as "targeted" or "knowledge-based") - points are selected deliberately based on our knowledge of what they represent, or systematically in space/time. Monitoring locations for the NAF Nitrogen Project will be selected using this design principle, and the timing for routine observations will be selected systematically (e.g., once a week).
b) **"random"** - points are selected at random from a population of "eligible" points that share a specific attribute of interest. This design principle will not be used in the Project.
c**) "responsive"** - points are selected based on given constraints or in response to certain events or conditions. The timing of many monitoring activities planned for this Project will be related to events (irrigation, rain) or observations of unusual changes in water level in the Slough.

D.2 Observation and sampling locations

Fig D-1 shows a schematic depiction of NAF property and the adjacent Almond Slough. The arrows show flow direction, from south to north. Potential observation and sampling points are also shown, as red circles with numbers (each point shown has been assigned an ID, unique to the Region). The gray square is a concrete structure that was used as a pump well in the 1950s. Station #1 is a good observation point from which the staff gage, mounted on the southern side of the concrete structure, can be easily seen/read/photographed. Station #2 enables sampling of the water coming from upstream of NAF. There are several access points further upstream (not shown) that enable sampling to detect spatial differences in various characteristics. Station #3 represents the lowest part of the little earth berm that surrounds the orchard boundary; this is where overland flow occurs.

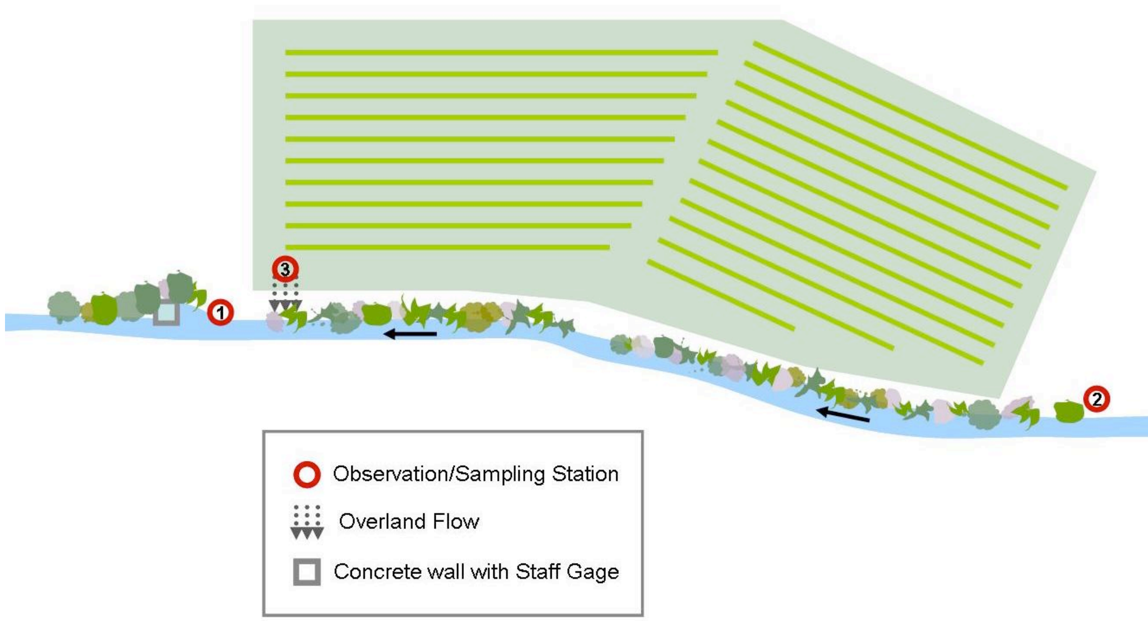

Figure D-1: Observation and sampling locations at NAF and along Almond Slough

D.3 Water quality characteristics for Almond Slough monitoring

D.3.1 Visual observation

Observation characteristics and associated verbal categories will be done weekly and include (but will not be limited to) the following:
-- SKY CODE: Clear; Partly Cloudy; Overcast; Fog; Smoky; Hazy
-- SITE ODOR: None; Sulfides; Sewage; Smoke; Rotting Vegetation; Solvents; Other____
-- OBSERVED FLOW: No Observed Flow; Trickle (<0.1cfs); 0.1-1cfs; 1-5cfs; 5-20cfs; 20-50cfs; 50-200cfs; >200cfs
-- WATER CLARITY: Clear (see bottom); Cloudy (>4" vis); Murky (<4" vis)
-- OTHER PRESENCE: Oily Sheen; Foam; Trash; Other_____
(These are real characteristic names and text categories from the SWAMP data sheet)

D.3.2 Staff gage reading

The staff gage will be attached to the abandoned concrete structure on the south wall. It will be visible from the NAF bank at Station #1 and accessible for periodic cleaning. Staff Gage reading will be recorded on every visit to Station #1.

D.3.3 Photo-documentation

The permanent photo-documentation "frame" of Almond Slough will be established in Station #1 at the Project's onset, and all subsequent pictures will be taken from the same location in the same direction at the same zoom each time. Photo-documentation will be done on every visit to Station #1.

D.3.4 Field measurements

Measurements of temperature, specific conductance, and pH will be conducted by the Mobile Tech Support Unit person (Chris), when triggered as described in Section D.4 below. Chris will also measure ammonia and nitrate using field kits, and collect water samples for lab analysis of Ammonia, nitrate, and Total Nitrogen only if needed.

D.4 Roles and logistics planned for this Project

Field observations will be conducted by Dale (the Grower) who is already at the site as part of normal business operations. Routine observations will be done very frequently at Stations #1 and #2.

During every Station Visit, Dale will take pictures of the field observations data sheet and the staff gage, and send them in real time, by text or email, to Chris at the Coalition's Mobile Tech Support Unit.

If overland flow is observed in Station #3, Dale will fill out the observations data sheet for Station #3 as well, and take pictures as needed. In addition, Dale will estimate the discharge volume (in Cubic feet/second, or Gallon/sec, or even Quart/sec), try to evaluate the total length of time the flow was happening, and keep records of these estimates (this might require more than one visit).

Dale will alert the Chris (the Mobile Tech Support person) when field measurements are required under the following circumstances:

- when overland flow is observed at NAF during dry weather; or
- when unusual conditions are observed in the Slough (e.g. murky waters, foam, increased water level, etc.); or
- during rain events that produce runoff from NAF.

When informed by other parties about an unusual situation happening downstream of NAF, Dale will conduct observations at NAF as needed and possibly alert Chris for water testing.

The Coalition's Mobile Tech Support Unit is dedicated to responsive monitoring which can be triggered by any unusual situations and they are able to arrive within a very short period of time during dry weather (they are not always available during rain events). Each crew member travels with a variety of sampling devices (e.g., a collection of beakers mounted on a long pole for sampling the center of the slough from a tall, steep bank). They also bring several instruments and kits for field measurements, as well as pre-cleaned sample containers and preservatives for many analytical suites.

Chris (the Mobile Tech Support crew member) will conduct field measurements at the appropriate locations, including both Stations upstream and downstream of NAF property. Samples for laboratory analysis will be collected, according to established Standard Operation Procedures, if ammonia is detected with the field kit (ammonia is a good indicator for fresh input in this case, and will inform sampling for "definitive" laboratory analyses of all nitrogen species). The samples will be delivered to the laboratory under Chain of Custody procedures for analysis of ammonia, nitrate+nitrite, and total nitrogen (see methods in Section 8 below). Samples for analysis of other constituents deemed appropriate and/or requested by the Regional Board may also be collected.

Footnote: The roles above are planned for WY 2016-2017, if the Grower will assist the Mobile Tech Support person with the field measurements. If Dale is interested in performing the field measurements in subsequent years, the Clean Water Team (the Citizen Monitoring Program of the State Water Resources Control Board) will provide training, and the Coalition will provide full technical support, including supply of instruments, kits and Standard solutions for quality checks.

D.5 Other sources of data and information

Constituent concentrations data at the Sorrel Creek downstream station is available from the Coalition and will be used as reference to the overall nitrogen loads. There is little information about water movement within the slough network that includes Almond Slough, but water level data have been gathered infrequently by The Friends of Sorrel Creek (FSC) via staff gage readings in locations where such gages could be permanently installed. FSC volunteers have recently acquired, and been trained in the use of, a dissolved-oxygen data logger. They will be deploying this instrument in various sloughs during the dry weather period, hopefully collecting at least four deployment episodes (one week each) at Almond Slough. The data will be available to NAF Nitrogen Project personnel three days after each retrieval of the instrument.

E Measurement Quality Objectives (MQOs) and choice of measurement methods

Not all monitoring data must be highly accurate and precise; the required level of accuracy and precision depends on the study question. For example, a wide range of error can be tolerated for data collected to answer the question "where is this constituent coming from", if the data is of known and documented quality. The Coalition can reduce monitoring costs by using field methods when they are adequate.

F Quality assurance plan

All instruments will be calibrated often to reduce drift from the calibrated state. All data will be supported with periodic quality checks of all instruments and kits to assess the accuracy and precision of each instrument or kit.

G Data management, interpretation, and reporting

G.1 Electronic reporting of field observations/measurements

This Project makes use of available technological advances. Information is captured electronically via digital pictures on a cell phone and can be sent immediately. There are a number of spreadsheet applications for cell phones, some of which can be programmed with specific placeholders and drop-down menus. Thus, Field Observations (i.e., selected verbal categories) can be entered into a spreadsheet using drop-down menus, and Results of field measurements will be typed in.

Laboratory data have been reported in electronic format for decades, and the Coalition has a streamlined process in place for data transfer.

G.2 Data integration, management, and analysis

Documented, validated and qualified data generated in this Project will be stored in the NAF Project File. Selected information fields will be exported to a Data Exchange Node that will be connected to other data through the California Environmental Data Exchange Network (CEDEN); this will be done by the Coalition.

All data collected for the NAF Nitrogen Project, as well as the water level and dissolved oxygen data collected by the Friends of Sorrel Creek and all current and historic data collected by the Coalition at the mouth of Sorrel Creek, will be reviewed by Dr. Robin Knowles, who will provide input on the potential conclusions from the data and suggest design modifications for future monitoring.

Chapter 3 A Vision of a Monitoring Framework for Eastern San Joaquin

A monitoring program is created to accomplish specific goals. Within the context of nonpoint source agricultural discharges, the ILRP monitoring goals include the following:

Goal One: Compliance
Goal Two: Source identification
Goal Three: Management practice effectiveness evaluation
Goal Four: Long term trends

The current ESJ monitoring Program, as noted by both the State Board and numerous environmental advocates, is inadequate. Existing data collected over the past 12 years indicate that compliance (goal 1) has not been achieved and there is no way of predicting whether the Program will achieve compliance within the current Order's schedule. The long term regional trends (goal 4), as observed from existing data, do not show dramatic decreases in concentrations over time, and show slight increases for some constituents. As for the remaining two goals, namely source identification (Goal 3) and management practice effectiveness evaluation (Goal 3), the Program is totally **opaque**; the monitoring design, spatial layout, and analytical results of these "special studies" have not been released to the public. At this time, there is no way of knowing if these goals are archived, when, or where.

As mentioned in the Introduction above, water quality monitoring is not limited to sample collection and laboratory analysis; there are many aspects of monitoring that are not "rocket science" and are not prohibitively expensive. However, these options require all parties, including the growers, to be involved, attentive, and responsive. The "traditional" sampling and analysis aspect, as conducted by the current Program, will not accomplish all goals. It would benefit the ILRP monitoring program if other modes of data collection - and information collection – are introduced.

This chapter lists some old and new ideas that help focus monitoring resources to collect data that are more likely to achieve the program's goals. It also describes data collection tools that have not been widely used in the ILRP Program and can expand existing resources to collect much more information and data. The list includes the following:

- Targeting water and soil movement events to address **episodic discharges** rather than conducting routine monitoring;
- Looking for particulate-bound pollutants in the **sediment rather than in the water**;
- Selecting study watersheds to address each of the major **agricultural commodities;**
- Using inexpensive field-based analytical tools such as test strips, wet chemistry kits, and immunoassay (ELISA) kits to identify constituent **sources** and evaluate the **effectiveness** of management practices**;**
- Creating a mobile technical support unit with crews that are familiar with the Region, well trained in sampling and in the use of the field kits described above, and available "on call" to respond to water quality problems in real time;
- Involving the Growers and other citizens in **paying attention and alerting** a mobile technical support unit as needed, thus spreading the ability/potential to capture problematic discharge throughout the Region.

3.1 Framework components

These ideas can easily be applied to an ESJ Regional monitoring framework that incorporates the following component:

3.1.1 Component1: fixed stations at integrative sites

A small number (3-4) of "long term" monitoring Stations at the bottom of perennial stream drainages that had a history of exceedances will be selected where deposition occurs. Water and sediment samples will be collected 4 times a year during dry weather and analyzed for a wide range of constituents including toxicity.

3.1.2 Component 2: commodity-based Stations

Twelve monitoring Stations located at the bottom of small, uniform watersheds, each one draining predominantly one type of crop/commodity, will be selected. Two Stations will represent each of the top 6 commodities. One Station for each commodity will be fixed over time. Stream water quality (temperature, dissolved oxygen, etc.) will be tracked with automatic data loggers for 20 weeks each year. Water samples will be collected during 4 rain events (during fall and spring) and during 4 irrigation runoff events. Sediments will be collected 4 times a year. Analytes will include commodity-specific materials to reduce cost.

3.1.3 Component 3: Routine observations and reporting

Growers will make weekly and anecdotal observations (per the standard SWAMP protocol), read the local staff gage, and report to the Coalition instantaneously using cell phones. When they observe storm runoff or unusual dry-weather flows into receiving water (irrigation runoff, overland flow, pumping) they will alert the Coalition's Technical Support Team.

3.1.4 Component 4: Responsive monitoring when alerted by observations

When alerted, Technical Support Team members go to the site, conduct basic field measurements using field kits, and collect water samples for ELISA and/or laboratory analyses if necessary. Samples collected this way, throughout the Region, will greatly increase the ability of the Program to identify water quality problems where they happen, not only where we are looking for them.

3.1.5 Component 5: Special studies for source identifications and management practice effectiveness

When water quality problems are identified, the Coalitions' technical team can track the problem's source by moving up the watershed and measuring constituents of interest and other relevant characteristics with field equipment and/or ELISA kits.

3.1.6 Component 6: Follow-up studies for existing regulatory processes

Monitoring resources may be allocated to continuation of management plans and other regulatory processes in drainages with known water quality problems.

3.2 How the Framework can help achieve the Program's goals

Implementation of commodity-focused monitoring, utilization of a vast selection of inexpensive tools, and involvement of the Growers can increase the likelihood that the monitoring goals will be achieved in time.

3.2.1 Goal 1: Compliance

The major reason for monitoring in the Region is to assure compliance of agricultural discharges with water quality objectives (WQOs). Laboratory measurements data collected via Components 1, 2, 3 and 4 will be used to compare detected concentrations of potentially harmful constituents to WQOs for water and sediments for all the beneficial uses that are relevant to each waterway.

3.2.2 Goal 2: Source identification

Components 3, 4 and 5 may be very useful in achieving this goal, often in real time (while the discharge is happening) and at a fraction of the cost needed for laboratory analyses.

3.2.3 Goal 3: Management practices effectiveness evaluations

This group of special studies require spatial and temporal flexibility and sample density that are easier to accomplish by inexpensive analyses suggested in components 3, 4 and 5. Grower observations can help inform these studies.

3.2.4 Goal 4: Long term trends

Components 1 and 2 will provide a robust dataset that will enable the detection of change over time with a high level of confidence. The overall condition of the Region will be depicted by component 1, while long-term trends in specific sectors of irrigated agriculture can be detected from component 2 data, grouped by commodity type.

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Appendix A to this **"2017 proposed Order"** which includes Order No. R5-2012-0116-R4 plus three attachments (Information Sheet, Monitoring and Reporting Program (MRP), and CEQA Mitigation Measures) – is at:

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Revital Katznelson, Ph.D.

Revital Katznelson received her B. Sc. in biology, M.Sc. in microbial ecology, and Ph.D. in biochemistry from the Hebrew University of Jerusalem, Israel. She has over 30 years of experience in performing, interpreting, and assuring quality of field and laboratory analyses of chemical, biological and bacteriological water quality characteristics. She also has hands-on experience in toxicity testing using a variety of test organisms. Beyond the laboratory, Dr. Katznelson has decades of experience using a wide array of field instrument and kits, and she is proficient with the use of enzyme-linked immunosorbent assay (ELISA) kits and the sealed-well technology (e.g., Colilert) used to count indicator bacteria.

Dr. Katznelson has led numerous ecological studies in a variety of aquatic systems including creeks, ponds, lakes, marshes, lagoons, and reservoirs, and has developed innovative methods to assess - and to increase - the representativeness of samples collected in these types of waterbodies.

In the National arena, Dr. Katznelson has been part of the Water Quality Data Elements Workgroup and the Aquatic Sensors Workgroup of the Methods and Data Comparability Board (affiliated with the National Water Quality Monitoring Council) for several years, and was the lead person in the development of quality assurance guidance for field measurements and telemetry using various water quality sensors.

As a technical liaison at the California State Water Resources Control Board, and a member of the Clean Water Team affiliated with the Surface Water Ambient Monitoring Program (SWAMP), Dr. Katznelson has introduced an array of concepts and tools for training, guidance, data management, documentation, and quality assurance to the realm of water quality monitoring in California. She has successfully applied elaborate instructional design principles, and her unique ability to teach basic scientific concepts, to the construction of her citizen monitoring workshops, her national presentations, and her quality assurance workshops for SWAMP. She also was the co-developer of the SWAMP Advisor, a web-based expert system for compilation of a SWAMP-comparable Quality Assurance Project Plan. Dr. Katznelson was the lead, and primary author, of the SWAMP Field Methods Distance Learning Course Part 1, which was delivered on CDs and on-line in 2005. In the late 2000s, Dr. Katznelson was deeply involved in implementing, troubleshooting, and interpreting the SWAMP physical habitat assessments and algae protocols as they were developing, and she eventually created all contents of the SWAMP Field Methods Distance Learning Course Part 2 (physical and biological assessment) published in 2012. She is currently writing interpretive monitoring reports, providing technical support services, and assisting citizen groups with their environmental monitoring as a volunteer.

Since the late 1970s, Dr. Katznelson has taught in many environments including undergraduate classrooms/labs/field activities at the university, specialized methodology courses and training workshops, and individual mentoring. She uses the current Water Quality Monitoring Design course, provided by UC Berkeley Extension twice a year, to share her decades of experience with her students.

Dr. Katznelson's latest publications and a link her resume (with full publication list), are available on her website at:
http://www.water-science-etc.net/PRODUCTS-pubs.htm