Assessment of Extent and Condition of Depressional Wetlands in southern California

Monitoring Plan

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I. Summary Sheet

Beneficial Uses

This study will be the first-ever systematic condition assessment of southern California depressional wetlands, including an evaluation of indicators that will help assess the condition and stressors associated with the beneficial uses in these areas. In addition, this project will help expand the science of depressional wetland assessment by developing a study design and indicators that could be adopted or modified for other regions of the State. This will allow future management actions to be better targeted toward addressing deficiencies and in improving beneficial uses over the long-term.

Assessment Questions

The depressional wetland assessment will address the following questions of importance to regulatory agencies and regulated communities, and public:

1. What is the extent and distribution of depressional wetlands in Southern California?
2. What is the condition of depressional wetlands in Southern California?
3. What are the major stressors affecting depressional wetland condition in Southern California?

To answer these questions, the following steps will be taken:

1. Map the location and distribution of depressional wetlands.
2. Address the condition of depressional wetlands using an indicator of general wetland condition or health, and a set of more intensive indicators to address the hydrologic, water quality, and habitat conditions within the wetlands.
3. Measure sediment chemistry and toxicity, as well as measurements of potential stressors in the surrounding landscape (e.g. agriculture, flow diversions, industrial activities). Investigate potential stressor-response relationships.

Link to Statewide Monitoring Framework

The statewide SWAMP program assesses the protection of beneficial uses, with a special focus on aquatic ecosystem health. Large monitoring programs funded by SWAMP on a statewide and on a regional basis are conducted to assess the health of the watersheds in California. This proposed monitoring plan focuses a detailed assessment of depressional wetlands in southern California. Data that will be collected through this monitoring program will be SWAMP comparable. The SWAMP QA program and the SWAMP data management program will be included into the proposed program to ensure consistency with the statewide SWAMP program.

Clean Water Act Sections 305(b)/303(d)

The data produced by this monitoring plan will be used in water body assessments required under Clean Water Act (CWA) sections 305(b) and 303(d).

II. Background

California's Surface Water Ambient Monitoring Program (SWAMP) was established to provide a comprehensive, unbiased assessment of all surface waters and to coordinate all water quality monitoring programs and projects conducted by the State Board and the nine Regional Boards. Ambient condition assessment has been a cornerstone of the SWAMP program and serves to provide context for evaluating a range of regulatory and management decisions, including impairment listings under Section 303(d) of the Clean Water Act, permitting, and restoration activities (SWRCB, 2000).

SWAMP has focused mainly on perennial wadeable streams, with limited state or regional assessments completed for large rivers, lakes, estuaries, and nearshore marine environments. This focus is a result of limited funding by the State legislature and limitations on available assessment tools for other waterbody types. To date, the SWAMP program has not focused on freshwater depressional wetlands, despite the fact that they comprise approximately 45% of the State's 3.6 million acres of wetlands (Sutula et al. 2008). Most monitoring and assessment of depressional wetlands is associated with specific impact or mitigation projects. As a result, available information is limited in space and time and there is little knowledge of overall extent and condition of depressional wetlands.

Depressional wetlands (such as vernal pools, freshwater marshes, and wet meadows) occur in topographic depressions that exhibit closed contours on at least three sides. Elevations within the wetland are lower than in the surrounding landscape. The shape of depressional wetlands varies, but in all cases, the movement of surface water and shallow subsurface water is toward the lowest point in the depression. Depressional wetlands may be isolated with no surface water inflow or outflow through defined channels, or they may have near persistent to intermittent surface water flows that connect them to other surface waters or other wetlands. These wetlands may be natural, actively maintained manmade features, or abandoned manmade features. They lose most of their water to evaporation, evapotranspiration, and/or movement into the ground. Surface inundation or saturation may occur perennially, seasonally, or over multi-year cycles depending on the location, climate, size, and substrate type. These wetlands perform then entire suites of functions typically associated with wetlands, but are particularly important as seasonal refugia and breeding areas in dry habitats. Cumulatively, they contribute to groundwater recharge and attenuation of surface runoff, thus reducing the impact of excessive flow to downstream streams, lentic waterbodies and coastal environments, and fostering improved water quality.

Successful assessment of wadeable streams over the past five years combined with the development of new assessment tools, such as the California Rapid Assessment Method (CRAM; Collins et al. 2007) provide an opportunity for Regional Boards to begin focusing on assessment of other water body types. The San Diego, Santa Ana, and Los Angeles Regional Water Quality Control Boards have determined that evaluation of the extent and condition of depressional wetlands will be a priority for the next several years as a new element of the cooperative regional monitoring and assessment in southern California. Depressional wetlands are of particular interest since they are the most abundant wetland type, are subject to ongoing impacts, and are seldom systematically monitored. This study will be the first-ever systematic condition assessment of southern California depressional wetlands, in addition, this project

will help expand the science of depressional wetland assessment by developing a study design and indicators that could be adopted or modified for other regions of the State. This study will be conducted on a region-wide basis for one year, with the anticipation that that the monitoring will be continued if the Water Boards decide to implement this plan over time.

Monitoring Questions

The depressional wetland assessment will address the following questions of importance to regulatory agencies and regulated communities, and public:

1. What is the extent and distribution of depressional wetlands in Southern California?
2. What is the condition of depressional wetlands in Southern California?
3. What are the major stressors affecting depressional wetland condition in Southern California?

The first question involves mapping the location and distribution of depressional wetlands. In addition to providing an initial estimate of extent, the wetland map establishes the sample frame from which to select sampling sites for the condition assessment (question #2) and for future status and trends assessment. The second question addresses the condition of depressional wetlands using an indicator of general wetland condition or health, and a set of more intensive indicators to address the hydrologic, water quality, and habitat conditions within the wetlands. The third question will involve measurements of sediment chemistry and toxicity, as well as measurements of potential stressors in the surrounding landscape (e.g. agriculture, flow diversions, industrial activities). The intensive indicators sampled as part of the condition assessment will be used to investigate potential stressor-response relationships. Where thresholds exist, they can be used to assess the importance of the stressor. Where they don't exist, general distributions of the data can be used to infer relative risk due to individual stressors (Van Sickle et al. 2006). This component requires no additional sampling, but rather a more thorough analysis of the data.

III. Study Methods and Materials

III.a. Monitoring Design

The project has the dual goals of developing and testing new assessment tools for depressional wetlands and implementing an ambient assessment of southern California depressional wetlands. It includes elements of mapping, rapid condition assessment (using CRAM), and intensive assessment using more detailed indicators of wetland condition (e.g. algae, invertebrates) and stressors (e.g. sediment chemistry and toxicity).

Monitoring site selection is an iterative process, where a subset of the sites identified through characterizing the extent and distribution of depressional wetland will be used for the assessment of

wetland condition and stressors. Wetland extent will initially be estimated from the revised wetland maps currently being produced by the southern California wetland mapping project. These maps use a modified National Wetlands Inventory (NWI) protocol and are consistent with Federal and State mapping standards. This comprehensive map will serve as the sample frame for establishment of a series of random sample plots; each plot will be four square miles (2,560 acres) in area. Wetlands within these plots will be mapped with remote sensing data in combination with an adequate degree of ground-truthing. These plots will serve as the sample frame for the wetland condition assessment and as the foundation for future change assessment.

Ambient condition will be assessed using a combination of probabilistic and targeted sampling. Probabilistic sites serve to provide an evaluation of overall regional condition in a statistically meaningful manner; targeted sites serve to provide information about specific areas of interest and can aid in assessment of trends. The four square mile plots established for the evaluation of wetland extent (question #1) will be used as the sample frame for the probabilistic assessment of condition. Using these intensively mapped and ground-truthed plots reduce the occurrence of non-target sample points and increases certainty in area weightings for the condition assessment. The probabilistic survey will utilize the Generalized Random Tessellation Stratified (GRTS) (Stevens and Olsen 2004) technique to ensure spatial balance of the randomly selected plots. Condition will also be evaluated at a series of targeted sampling points consisting of both minimally impacted reference sites and sites of specific management interest. The targeted site locations will be selected in consultation with a project advisory committee consisting of regional board staff and other key stakeholder and technical experts.

III.b. Indicators

Evaluation of Wetland Condition and Stress

Indicators will be selected to 1) relate to priority beneficial uses identified by the regional boards and 2) be consistent with indicators being used by USEPA's National Wetland Condition Assessment (http://water.epa.gov/type/wetlands/assessment/survey/index.cfm).

Two broad categories of indicators will be collected at each site: indicators of condition and indicators of stress. There are three types of indicators that will be used to assess wetland condition. The first is the California Rapid Assessment Method (CRAM). CRAM is a cost effective diagnostic tool that is part of a comprehensive statewide program to monitor the health of wetlands and riparian habitats throughout California (Collins et al., 2007). CRAM assessments are based on four attributes of wetland condition; landscape context, hydrology, physical structure, and biotic structure. Attributes are evaluated based a set of metrics, or readily observable field indicators. The second indicator of condition is community-level characteristics of aquatic macroinvertebrates. Aquatic macroinvertebrate communities found in depressional wetlands have been found to be sensitive to a variety of physical and chemical factors (K. Lunde, pers. comm.). The third indicator of condition is algae. Algae can be used to assess primary productivity as well as general condition of a wetland. The most comprehensive approach would be to

sample both benthic and planktonic community composition for diatoms, soft-bodied algae, and cyanobacteria, including microalgae and macroalgae, and sample for biomass and algal toxins.

There are four types of indicators that will be used to assess stress. The first of these is sediment toxicity. The 10-day chronic test (EPA 2000) with the epifaunal amphipod *Hyalella azteca* will be used to assess the toxicity of the wetland sediments. The second indicator of stress is sediment chemistry. Measures of sediment chemistry will include metals, nutrients, total organic carbon, and pesticides. The samples for chemistry will be held for analysis, pending the outcome of the sediment toxicity test results. The third set of stress indicators are hydrology (water inputs and outputs) and hydroperiod (magnitude, duration, and extent of inundation or saturation). Evaluation of hydrology and hydroperiod can provide insight to wetland health/condition. These factors will affect the wetland's plant and animal community structure and growth and thus can be used to both explain and potentially predict wetland condition scores. The fourth set of stress indicators are landscape-scale stressors. Factors such as surrounding land use and land cover, proximity to other wetlands, and alterations in overland flow pathways can affect the ability of a wetland to support characteristic flora and fauna. Features of the surrounding landscape may alternatively serve to explain or predict wetland condition.

III.c. Data Analysis and Assessment

Each of the indicators has a set of thresholds to evaluate the collected data, in order to characterize the level of disturbance at a given wetland. Each indicator also has a set of quality assurance (QA) procedures which must be met in order for the data to be acceptable. These procedures may exist as a set of standardized benchmarks for laboratory performance (e.g., for sediment chemistry and toxicity analysis), as periodic field audits (e.g., for CRAM), or as required demonstration of competence as part of a training course (e.g., for landscape-scale stressors).

CRAM attributes are evaluated based a set of metrics, or readily observable field indicators. Each metric is evaluated based on a standardized set of mutually exclusive descriptions representing a full range of possible condition. Metrics are scored based on narrative descriptions, quantitative measures, or diagrams (depending on the metric). Scores range from 3 to 12 for each metric; metric scores can be aggregated to overall attribute scores and attribute scores aggregated to an overall index score based on simple combination rules. Attribute and index scores are expressed as percent possible, ranging from 25 (lowest possible) to a maximum of 100. Details of CRAM assessments can be found in the CRAM User's Manual (Collins et al. 2008) or on the CRAM web site at www.cramwetlands.org.

Part of this study will be used to help create biological metrics or indices for macroinvertebrates and algae in depressional wetlands, similar to those developed for streams [e.g. macroinvertebrate and periphyton Indices of Biological Integrity (IBI)]. Quality assurance procedures for macroinvertebrates and algae include re-analysis on a subset of samples in order to evaluate precision in identification and enumeration, and creating sample vouchers in order to conduct sorting and identification audits.

Toxicity will be assessed with unpaired one-way Student t-test. Samples will be considered toxic if they are significantly different and <80% of the control value. Sediment collected with the test organisms will be used as a negative control. A water-only Cu reference toxicant test will be conducted as a positive control.

Sediment chemistry measurements will be assessed by comparing the values to freshwater Probable Effects Concentrations (MacDonald et al. 2000), or published LC50 values (concentrations that cause a 50% reduction in survival) for pyrethroid pesticides (Amweg et al. 2005).

The range in hydrologic alterations will be assessed by comparing data distributions at the probabilistic sampling sites to the reference sites. Hydrologic alteration measures will be compared to the habitat condition measures as part of the stressor-response investigation.

Lansdcape-scale stressors will be assessed by applying the approach used by SWAMP's Reference Condition Monitoring Program (Ode and Schiff 2009), modified for depressional wetlands. This approach was designed to characterize natural and stressor gradients relating to biological condition in streams, at both local and watershed scales. Spatial data layers will be analyzed to look for gradients and will be compared to measures of wetland function/condition.

III.d. Data Collection and Frequency of Sampling:

The 2011 field season will be used to test protocols and conduct a pilot assessment on a small number of sites in order to determine efficacy of various indicators. Some sites will be sampled repeatedly in 2011, in order to determine the most appropriate index period for both macroinvertebrates and algae.

Results of the pilot assessment will be used to design the full ambient assessment program, which will begin in 2012. Elements of the ambient assessment, including method refinement, index period, sample size, and stratification will be determined in coordination with the technical workgroup following the 2011 pilot phase. The work plan will be updated to reflect the second phase of the project once it is developed. .

CRAM

General condition of the vegetated depressional wetland area will be evaluated using the depressional module of the California Rapid Assessment Method (CRAM; Collins et al. 2008) as modified based on investigations during the 2011 pilot phase. CRAM assessments are based on four attributes of wetland condition; landscape context, hydrology, physical structure, and biotic structure. Attributes are evaluated based a set of metrics, or readily observable field indicators. CRAM assessment areas (AAs) will be established at each study site according to the guidance provided in the CRAM User's Manual (Collins *et al.* 2008). Some sites may require multiple CRAM AAs depending on the size of the wetland. Each metric will be evaluated for each AA based on a standardized set of mutually exclusive descriptions representing a full range of possible condition. Metrics are scored based on narrative descriptions, quantitative measures, or diagrams (depending on the metric).

MACROINVERTEBRATES

The SWAMP program currently has accepted sampling protocols for streams, but not depressional wetlands. The stream protocols can be used to inform decisions regarding sampling in wetlands. However, because there are no standard SWAMP protocols for sampling macroinvertebrates in depressional wetlands, these details will be determined by the technical workgroup. Our preliminary recommendation for a sampling approach includes a multi-habitat design, including an emergent vegetation zone, an open (no vegetation) emergent zone, a surface vegetation zone, and a surface vegetation zone. All of these zones will be restricted to the 1.5 m depth nearshore area. Sampling will be conducted using dip (sweep) nets with a standardized and repeatable protocol based on the urban IBI (K. Lunde, pers. comm.)

ALGAE

This study will be used to help create biological metrics or indices for algae in depressional wetlands, similar to the SWAMP-approved periphyton IBI developed for streams. GIS will be used to delineate the perimeter of each wetland and to draw, starting at a random spot, 10 points equidistant from one another, along the wetland perimeter. In the field, the 10 points will be identified and a transect starting at the wetland edge will be placed perpendicularly to the edge associated with each point. The transects will extend from each point into the wetland, up to a depth of 1m, or halfway across the wetland, for shallow water bodies. For sampling the soft sediment benthic substrate, a clear 1" diameter acrylic tube with a sharpened edge will be used as a corer to obtain a series of 20-mm cores, off of which the top 5mm will be used for isolating benthic algal specimens. One "representative" sampling spot will be identified along each of the transects, that falls within a depth range of 0.25 to 0.75 meters deep. All 10 samples will be combined into a "composite", which will then be subsampled for taxonomic identification of both the diatom and soft-bodied/cyano assemblages, as well as for a benthic algae toxin assay.

Phytoplankton will be sampled by immersing a 200 mL sampler attached to a pole into the water in the center of each of the 10 transects, at a fixed depth, for a total of at least 1.5 L of composite sample. Final volume of the composite will be measured with a graduated cylinder in order to derive quantitative information about phytoplankton abundance. Aliquots of known volume will be removed from the composite for sampling of suspended biomass and presence of algae toxins in the water column. The remaining composite will be concentrated by filtration or settling (e.g., Wetzel and Likens 1991, APHA 1998) to facilitate determination of taxonomic composition.

An estimation of macroalgal percent cover will be carried out via point-intercept assessment of presence/absence of macroalgae at objectively determined locations within each wetland. Floating mats, filaments and masses suspended in the water column, and algal mats on the wetland bottom (both true algae and cyanobacteria) will all be included as "macroalgae" for assessment purposes. Along each of the transects, at 50-cm intervals starting from the point on the wetland edge, the presence or absence of macroalgae will be scored. The number of sampled points will be tallied as will the number of points at which macroalgae was intercepted (i.e., was present). The percent cover will be calculated

as the percent of assessed points that had macroalgae present. In addition to this, a visual estimate of floating macroalgae (on the water's surface) for the wetland at large will be made.

The purpose of the qualitative macroalgae sample (i.e., floating mats, filaments and masses suspended in the water column, and algal mats on the wetland bottom (both true algae and cyanobacteria)) is to capture the taxonomic diversity of this assemblage. This will facilitate taxonomic determination of the species in the quantitative sample, as well as help establish the presence of indicator and toxin-producing taxa in the wetland. Specimens from each visually distinct taxon observed in the wetland will be collected and composited into a large Whirlpak bag for subsequent identification by a taxonomist. An attempt will be made to be as exhaustive as possible in sampling the various taxa present.

SEDIMENT CHEMISTRY & TOXICITY

One composite sediment sample will be collected from each site at the hydrologic point of entry into the wetland. This will be identified based on best professional judgment of where fine-grained sediments will most likely first settle upon entry. At this location, water column characteristics will be measured before sediment collection, and will include water column depth, physiochemical parameters (dissolved oxygen, pH, temperature, conductivity).

Sediment samples will be collected with a Ponar grab sampler or shovel, depending on water depth. The top 8 cm of sediment will be collected from each grab using a plastic scoop. The sediment from multiple grabs will be homogenized before being distributed to containers for sediment chemistry or toxicity analysis.

Samples for trace metals will be analyzed by Inductively Coupled Plasma Mass Spectrometry (ICPMS) using EPA Method 6020m. Samples for organic constituents will be analyzed by Gas Chromatography/Mass Spectrometry (GC/MS) using EPA Method 8270c. Total organic carbon concentrations will be determined by EPA Method 415.1. Quality assurance procedures will include analysis of field replicates, equipment blanks, method blanks, matrix spikes, and reference materials, per SWAMP QAPP protocols.

Toxicity testing will be conducted using the *Hyalella azteca* 10-day survival test following procedures outlined in USEPA 2000.

HYDROLOGY / HYDROPERIOD

Two types of hydrology measurements will be taken. One set of hydrology measurements are made as part of the CRAM assessment, including determining water source, entrenchment (hydrologic connectivity) and channel stability. The source of the water entering the wetlands will be investigated through consulting maps, wetland managers, and websites (including the County of San Diego's Watershed Protection Program site, and the Project Clean Water site). Hydrologic connectivity and channel stability will be measured on site using the methods specified in the CRAM Field Book.

The second set of hydrology measures will be will be assessed through both direct and indirect measures. Indirect measures include catchment imperviousness and presences and height of inlet and

outlets to the wetland, which can affect the frequency, extent, and duration of inundation. A subset of wetlands will be directly monitored. Direct monitoring will consist of installing a rebar stake in the center of the wetland and attaching a pressure transducer or multi-probe data sonde. Weekly measures will be conducted during key index periods to quantify water depth, extent of inundation (areal coverage), salinity, specific conductance, pH, temperature, DO, and turbidity. Data distributions at the probabilistic sampling sites will be compared to the reference sites to estimate the ranges of hydrologic alteration. Hydrologic alteration measures will be compared to the habitat condition measures as part of the stressor-response investigation.

LANDSCAPE STRESSORS

Local and large-scale landscape units are identified for each wetland, at multiple spatial scales. For each unit, a large number of metrics are calculated to characterize the natural gradients and anthropogenic stressors affecting the wetland. These metrics are based on several sources of spatial data, including: geology (type and mineral content), ecoregion, climate, land cover, timber harvesting, wildfires, population density, mining activity, grazing, pesticide use, invasive species, and road or railroad density.

III.e. Spatial and Temporal Scale

This study will provide a statistically valid representation of the overall regional condition based on probabilistically selected sites. This study will also include targeted locations, consisting of reference sites (which represent the least impacted sites in the region and will provide a benchmark against which the condition at other sites can be gauged) and sites of specific management interest (selected in coordination with the project's technical advisory committee; these sites may be restoration sites, sites subject to specific stressors or interest, or regionally significant sites). The ability of this program to answer questions regarding trends in wetland condition will depend on the availability of funding for continued sampling beyond 2012.

III.f. Data Management

Data generated from this project will reside on SCCWRP's data exchange servers, in a SWAMP-compatible database for available data fields. The data on these servers are backed up twice per day. Access to the database will be available via the Wetlands Portal of the State Water Resources Control Boards My Water Quality Web site. Data may also be submitted to CEDEN if the system is modified to be able to accept the type of data compiled by this study.

IV. Coordination and Review Strategy

SCCWRP scientists will serve as the project manager, and will be responsible for producing the study work plan, coordinating field collection and laboratory analysis activities, data management, and report preparation. The project's technical advisory committee (TAC) will assist in the production of the work plan, and will be responsible for data review and final report review. The TAC is currently made up of members from the State Water Resources Control Board, the San Diego, Los Angeles and Santa Ana Regional Water Quality Control Boards, California Department of Fish and Game, US Army Corps of Engineers, US Fish and Wildlife Service, US Forest Service, and UC Berkeley.

V. Quality Assurance

This document should serve as a general framework for project development and implementation. More detailed Standard Operating Procedures, Quality Assurance Project Plans, and Data Management Plans will be developed as companion documents. SWAMP quality assurance practices will be followed if possible.

VI. Reporting

SCCWRP staff will be responsible for producing the final study reports. A technical report will be produced and submitted to all funding agencies, and a manuscript will be produced for submission to a scientific journal (e.g., Journal of American Water Resources Association). Sampling for the project is expected to be conducted in spring/summer 2012, followed by laboratory analysis, quality assurance screening, and data interpretation. A first draft of the report will be produced in summer 2013, and a final report in fall 2013. Data for the project will be made available to the public through the Wetlands Portal, following quality assurance screening.

VII. Project Schedule

Initial implementation of this program will be a two year process. Preliminary work to refine indicators will occur in spring 2011. Sample draw and preparation of the final methodology will be conducted in winter 2011/2012. This will provide sufficient time to use what lessons were learned during the preliminary sampling and improve the full-scale sampling. The full-scale sampling will occur in spring/summer 2012. Laboratory analysis should take approximately 6 months. Compiling data, examining results, and making our assessments should require approximately three months (spring 2013). A written first draft report should be completed by summer 2013. Additional sampling/implementation will be contingent on ongoing funding.

The schedule for the proposed project is as follows:

	2011										2012												2013								
	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9
Convene meetings of technical advisory committee	■									■	■	■												■	■	■	■				
Complete plan for preliminary sampling	■																														
Preliminary sampling to refine indicators		■	■	■	■																										
Analysis of preliminary sampling						■	■	■	■																						
Sample draw and method refinement										■	■	■	■	■																	
Final sampling														■	■	■															
Laboratory analysis															■	■	■	■	■	■	■	■									
Data compilation and analysis																							■	■	■	■					
First draft																											■	■	■		
Final draft																														■	

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Appendix A – Potential Analytes and Analytic Methods for Sediment Chemistry Analysis

Type	Analyte	Laboratory	Project Quantitation Limit (units, wet or dry weight, ng/g unless otherwise stated)	Analytical Method and Achievable Laboratory Limits (units, wet or dry weight, ng/g unless otherwise stated)	
Physio-chemical	pH	Field	NA	SM4500H+B	NA
	Conductance	Same	10 mhos	SM2510B	NA
	DO	Same	0.1 mg/L	SM4500OG	0.1 mg/L
	Temperature	Same	-5 ^{o} C	SM2550B	-5 ^{o} C
Bulk Sediment Characteristics	Ammonia	CRG Lab	0.01 mg/kg	SM 4500-NH3F	0.01 mg/kg
	Sediment grain size	CRG Lab	0.1%	Plumb 1981	0.1 %
	Total organic carbon	CRG Lab	0.01 mg/kg	EPA 9060	0.01 mg/kg
Trace Metals	Antimony	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Arsenic	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Barium	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Beryllium	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Bismuth	CRG Lab	0.5 mg/kg	EPA 6020	0.5 mg/kg
	Boron	CRG Lab	0.025 mg/k	EPA 6020	0.025 mg/k
	Cadmium	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Calcium	CRG Lab	1 mg/kg	EPA 6020	1 mg/kg
	Cesium	CRG Lab	0.05 mg/kg	EPA 6020	0.05 mg/kg
	Chromium	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Cobalt	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Copper	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Iodine	CRG Lab	0.05 mg/kg	EPA 6020	0.05 mg/kg
	Iron	CRG Lab	1 mg/kg	EPA 6020	1 mg/kg
	Lead	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Lithium	CRG Lab	0.05 mg/kg	EPA 6020	0.05 mg/kg
	Magnesium	CRG Lab	1 mg/kg	EPA 6020	1 mg/kg

Type	Analyte	Laboratory	Project Quantitation Limit (units, wet or dry weight, ng/g unless otherwise stated)	Analytical Method and Achievable Laboratory Limits (units, wet or dry weight, ng/g unless otherwise stated)	
	Manganese	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Mercury	CRG Lab	0.005 mg/kg	EPA 6020	0.005 mg/kg
	Molybdenum	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Nickel	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Phosphorus	CRG Lab	0.5 mg/kg	EPA 6020	0.5 mg/kg
	Potassium	CRG Lab	1 mg/kg	EPA 6020	1 mg/kg
	Selenium	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Silicon	CRG Lab	0.1 1 mg/kg	EPA 6020	0.1 1 mg/kg
	Silver	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Sodium	CRG Lab	1 mg/kg	EPA 6020	1 mg/kg
	Strontium	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Thallium	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Tin	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Titanium	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Vanadium	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
	Zinc	CRG Lab	0.025 mg/kg	EPA 6020	0.025 mg/kg
Polyaromatic hydrocarbons	1-Methylphenanthrene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	2,3,5-Trimethylnaphthalene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	2,6-Dimethylnaphthalene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	2-Methylnaphthalene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Acenaphthene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Acenaphthylene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Anthracene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Benz[a]anthracene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Benzo[a]pyrene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Benzo[b]fluoranthene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Benzo[e]pyrene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg

Type	Analyte	Laboratory	Project Quantitation Limit (units, wet or dry weight, ng/g unless otherwise stated)	Analytical Method and Achievable Laboratory Limits (units, wet or dry weight, ng/g unless otherwise stated)	
	Benzo[g,h,i]perylene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Benzo[k]fluoranthene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Biphenyl	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Chrysene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Dibenz[a,h]anthracene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Fluoranthene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Fluorene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Indeno[1,2,3-c,d]pyrene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Naphthalene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Perylene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Phenanthrene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
	Pyrene	CRG Lab	1 µg/kg	EPA8270	1 µg/kg
Organochlorine Pesticides	Aldrin	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	a-Chlordane	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	trans-Chlordane	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	Dacthal	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	2,4-DDD	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	4,4-DDD	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	2,4-DDE	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	4,4-DDE	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	2,4-DDT	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	4,4-DDT	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	Dieldrin	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	Endosulfan sulfate	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	Endosulfan I	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	Endosulfan II	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	Endrin	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg

Type	Analyte	Laboratory	Project Quantitation Limit (units, wet or dry weight, ng/g unless otherwise stated)	Analytical Method and Achievable Laboratory Limits (units, wet or dry weight, ng/g unless otherwise stated)	
	Heptachlor	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	Heptachlor Epoxide	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	Methoxychlor	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	Mirex	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	Oxychlordane	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
	Toxaphene	CRG Lab	1 µg/kg	EPA 8270	1 µg/kg
Organophosphorus Pesticides	Azinphos-methyl	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Bolstar	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Chlorpyrifos	CRG Lab	5 µg/kg	EPA 8270	5 µg/kg
	Demeton	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Diazinon	CRG Lab	5 µg/kg	EPA 8270	5 µg/kg
	Dichlorvos	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Dimethoate	CRG Lab	5 µg/kg	EPA 8270	5 µg/kg
	Disulfoton	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Ethoprop	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Ethyl	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Fencholorphos	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Fensulfothion	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Fenthion	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Malathion	CRG Lab	5 µg/kg	EPA 8270	5 µg/kg
	Merphos	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Methamidophos	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Methidathion	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Methyl	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Mevinphos	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Phorate	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Phosmet	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg

Type	Analyte	Laboratory	Project Quantitation Limit (units, wet or dry weight, ng/g unless otherwise stated)	Analytical Method and Achievable Laboratory Limits (units, wet or dry weight, ng/g unless otherwise stated)	
	Methyl	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Tetrachlorvinphos	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Tokuthion	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
	Trichloronate	CRG Lab	10 µg/kg	EPA 8270	10 µg/kg
Pyrethroids	Allethrin	CRG Lab	10 µg/kg	EPA 625	10 µg/kg
	Bifenthrin	CRG Lab	10 µg/kg	EPA 625	10 µg/kg
	Cyfluthrin	CRG Lab	10 µg/kg	EPA 625	10 µg/kg
	Cypermethrin	CRG Lab	10 µg/kg	EPA 625	10 µg/kg
	Danitol	CRG Lab	10 µg/kg	EPA 625	10 µg/kg
	Deltamethrin	CRG Lab	10 µg/kg	EPA 625	10 µg/kg
	L-Cyhalothrin	CRG Lab	10 µg/kg	EPA 625	10 µg/kg
	Permethrin	CRG Lab	10 µg/kg	EPA 625	10 µg/kg
	Prallethrin	CRG Lab	10 µg/kg	EPA 625	10 µg/kg

*EPA, Method for Chemical Analysis of Water and Waste Water

** SM, Standard Methods for the Examination of Water and Waste Water