Tahoe RSWMP Data Quality Objectives

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I. Background and Purpose for the Tahoe RSWMP

Lake Tahoe has been designated as an Outstanding National Resource Water (ONRW) under the USEPA Water Quality Standards Program and the Clean Water Act. It is also listed as a CWA 303(d) impaired water body by the Nevada Division of Environmental Protection and the California Lahontan Regional Water Quality Control Board. This has triggered development of the Tahoe Environmental Improvement Program (EIP) and a Total Maximum Daily Load (TMDL) pollution control plan, both of which seek to control pollutant loadings to the lake.

Technical documents prepared for the Lake Tahoe TMDL program have concluded that fine sediment particles (FSP <16 µm diameter) and nutrients are causing the decline in clarity of Lake Tahoe. The majority of these fines (72%) and much of the nutrients (phosphorus: 38%, nitrogen 16%) derive from urban land. Therefore, achieving the water quality goals of the TMDL will depend upon source control and loading reductions for these pollutants. It is anticipated that innovative practices and management approaches will be necessary, including a well-designed plan that can be applied within an adaptive management framework for measuring progress and making decisions.

The Tahoe Regional Storm Water Monitoring Program (RSWMP) will be implemented as a stakeholder and agency directed effort designed to collect the information needed for assessing progress toward achieving and maintaining TMDL goals for stormwater quality improvements. As regulatory agencies develop and implement the TMDL there will be specific monitoring needs that reflect the requirements for evaluation and management decisions. The combination of implementing capital projects, monitoring performance, and application of results within the Lake Clarity Crediting Program (as part of the TMDL) is expected to be an iterative process, in which new information informs the specification of subsequent management objectives. In the meantime, it is best to consider the goals and objectives presented below as a set of preliminary suggestions that agencies can draw from as they consider their TMDL urban stormwater monitoring needs in more detail. A periodic programmatic review of RSWMP will be conducted to evaluate monitoring program goals, objectives and products. Recommended adjustments will consider program focus, monitoring design, data development, utility of data/analysis, and product delivery.

Desired outcomes of the Tahoe RSWMP program are based on expressed agency needs and stakeholder input to provide the following:

1) Collection and delivery of reliable information on urban stormwater runoff from an integrated monitoring program linked directly to data needs of the Lake Clarity Crediting Program and TMDL tools. Note that RSWMP is separate from the existing Lake Tahoe Interagency Monitoring Program (LTIMP) in that it focuses on monitoring urban stormwater and evaluation of projects and BMPs designed to reduce pollutant loads. In contrast LTIMP takes a stream monitoring approach that integrates many different upland processes associated with pollutant generation and transport.
2) Implementation of appropriate and consistent methodologies for evaluating load reductions associated with BMPs and stormwater projects intended to achieve TMDL allocation targets.
3) Basin-wide assessment of stormwater pollutant loading patterns designed to give resource managers, decision-makers, and elected officials a periodic report on changes in long-term water quality conditions in response to management actions.

II. Program Goals and Objectives

Based on the desired outcomes a preliminary set of RSWMP goals and corresponding objectives were developed in collaboration with Basin stakeholders and agency representatives during Phase 1 (conceptual development) and Phase 2 (program planning), as summarized below.

RSWMP Monitoring Goal 1. Obtain information to test and improve the performance of TMDL technical tools, including calibration and validation of the Pollutant Load Reduction Model (PLRM) and Rapid Assessment Methodologies (RAMs) that are part of the Lake Clarity Crediting Program (LCCP).

Goal 1 Objectives:

- Refine relationships between land use and pollutant generation.
- Identify significant pollutant source activities and source areas relevant to excessive stormwater concentrations or loads.

- Provide regular updates to characteristic runoff concentrations (CRCs) and characteristic effluent concentrations (CECs) for calibration of models or other tools used to assess load reduction as part of the Lake Clarity Crediting Program.
- Evaluate calibration factors and assumptions used in the TMDL technical tools.
- Monitor selected project areas to validate/test the reliability of existing models at predicting load reductions used in the LCCP.
- Conduct index site sampling to improve our understanding of processes related to the generation, transport and fate of pollutants in urban stormwater runoff.

RSWMP Monitoring Goal 2. Evaluate the effectiveness of current or improved treatment practices and innovative strategies for reducing pollutant generation and transport in stormwater runoff.

Goal 2 Objectives:

- Conduct field evaluations on the effectiveness of individual BMPs and projects to lower pollutant loads over time, including pre- and post-project assessments when practical.
- Develop information for evaluating BMP physical/biogeochemical conditions and BMP design/performance conditions as they relate to pollutant removal efficiencies.
- Determine maximum practical effectiveness (concentrations and loads).
- Develop effectiveness matrix for BMP design variables.
- Evaluate BMP maintenance strategies and track maintenance data.
- Verify correct project construction according to engineering specifications (implementation monitoring).

Monitoring Goal 3. Determine whether the quality of surface runoff is improving in response to stormwater management actions, and if the expected long-term reductions in pollutant loading are being achieved.

Goal 3 Objectives:

- Determine the status of existing concentrations and loads to support the credit scheduling feature of the LCCP.
- Develop stormwater information needed for evaluating progress toward TMDL and other regulatory goals.

- Conduct probabilistic outfall sampling to document basin-wide loading patterns and changes in response to EIP restoration activities at an environmentally relevant time scale.
- Provide data required to fulfill permit reporting.
- Provide data to evaluate and update benchmarks for stormwater quality.
- Distinguish restoration effects from inter-annual variability and climate trends.

It is important to note that collectively these program goals and objectives represent the potential products from a "mature" and fully implemented stormwater monitoring program, which is well beyond the scope of this initial RSWMP implementation. The initial plans developed here and in associated documents will focus on aspects of urban stormwater monitoring requirements that are selected as relevant at this time. At the request of the TMDL agencies this does not include details for objectives related to compliance monitoring, BMP RAM or Road RAM monitoring, or for approval and tracking of Lake Clarity Credits.

RSWMP Study Questions

Given the broad scope and extended nature of anticipated RSWMP operation, the primary goals and objectives presented above will be reformulated on a periodic basis in the adaptive management cycle (planning, implementation, assessment, decision) and then information needs related to those goals and objectives will be further developed as the regional stormwater monitoring program matures. During the interim, initial implementation of RSWMP will focus on evaluating a subset of runoff conditions and stormwater management practices represented by the key study questions listed below.

Study Question 1. Are the stormwater Characteristic Runoff Concentrations (CRCs) developed for identified land use types in the Tahoe Basin suitable for use in deriving model estimates of pollutant loading? (This is related to RSWMP Monitoring Goal 1.)

Study Question 2. Are the stormwater Characteristic Effluent Concentrations (CECs) developed for different treatment and source control practices appropriate estimates of load reductions for these BMPs? (This addresses RSWMP Monitoring Goals 1 and 2.)

Study Question 3. Are drainage area load reduction estimates from PLRM (or other model) projections verified by field data collected from the projects under consideration? (This is related to RSWMP Monitoring Goals 1, 2 and 3.)

Study Question 4. Are pollutant loads from urban stormwater runoff in the Tahoe Basin decreasing in response to EIP and TMDL implementation, and what are the long-term trends, vis-à-vis, TMDL load reduction targets? (This addresses RSWMP Monitoring Goals 2 and 3.)

III. Information Inputs and Data Needs

This program will collect new data and assemble existing information that meet the data quality requirements in Section V. Monitoring and sampling efforts will consist of both field and laboratory measurements, including meteorological monitoring, flow monitoring, and in-situ turbidity monitoring. The primary focus of laboratory measurements will be on fine suspended sediment concentrations (<16 µm) and the secondary focus will be on analyses of soluble and total nutrient concentrations (phosphorus and nitrogen).

The RSWMP team will obtain the data described above at selected field sites identified in the Sampling and Analysis Plan, with annual assessment of runoff volumes, sampled volumes, runoff concentrations, pollutant loads, and assessment of variability with different flow rates and seasons. Available existing data from previous monitoring will be evaluated and included as relevant to the annual assessments.

IV. Targeted Monitoring Populations

Question 1 Targets. Nine categories of urban upland land use are recognized by the TMDL. Collection of stormwater CRC data will be focused on a subset of these, selected from the following urban land uses represented as discrete impervious categories in the PLRM: primary roads, secondary roads, single family residential, multi-family residential, commercial-industrial-communications-utilities (CICU).

Question 2 Targets. Eighteen categories of pollutant treatment and source control practices were identified in the RSWMP BMP collation. Collection of stormwater CEC data will be focused on a subset of these, represented in the PLRM as stormwater treatment practices: dry basin, wet basin, infiltration basin, treatment vault, cartridge filter, bed filter.

Question 3 Targets. Over two hundred erosion control, restoration, and water quality improvement projects have been identified by RSWMP as having been implemented since 1983 or currently planned for the Tahoe Basin. A subset of these will be selected for drainage scale monitoring to evaluate against corresponding and contemporaneous pollutant loading predictions from the PLRM.

Question 4 Targets. The RSWMP has assembled locations for all known stormwater outfall sites to Lake Tahoe. A subset of these will be classified as accessible to monitoring, and selected for sampling to evaluate basin-wide runoff pollutant characteristics and changes in loading rates over time.

V. Analytical Approach

The following table shows recommended analytic methods and reporting limits for analytes of concern. Note that lab-specific method detection limits can change over time, and must always be less than the reporting limits. Laboratory methods will be those that have been routinely used by Tahoe laboratories for the analysis of LTIMP and TMDL, with desired reporting limits equivalent to or better than the values shown in Table 1.

Table 1. Recommended analytic methods and reporting limits.

Analyte	Methods	Description	Target Reporting Limit
Orthophosphate as P (i.e. Soluble Reactive Phosphorus)	EPA 365.1; or EPA 365.2; or EPA 365.3; or SM 4500-P-E	Colorimetric, phosphomolybdate	10 µg/L
Total Dissolved Phosphorus as P	EPA 365.1 w/ USGS I-4600-85; or EPA 365.2; or EPA 365.3; or SM 4500-P-F	Colorimetric, persulfate digestion, phosphomolybdate	10 µg/L
Total Phosphorus as P	EPA 365.1 w/ USGS I-4600-85; or EPA 365.2; or EPA 365.3; or SM 4500-P-F	Colorimetric, persulfate digestion, phosphomolybdate	10 µg/L
Nitrate + Nitrite as N	EPA 353.1; or EPA 353.2; or SM 4500-NO3-F	Colorimetric, cadmium reduction	10 µg/L
Dissolved Ammonia as N	EPA 350.1; or SM 4500-NH3-G; or SM 4500-NH3-H	Colorimetric, phenate	10 µg/L
Total Kjeldahl Nitrogen	EPA 351.1; or EPA 351.2	Colorimetric, block digestion, phenate	50 µg/L
Total Suspended Solids	EPA 160.2; or SM 2540-D	Gravimetric	1 mg/L
Suspended Sediment Concentration	ASTM D3977	Gravimetric	1 mg/L
Turbidity	EPA 180.1; or SM 2130-B	Nephelometric	0.1 NTU
Electrical Conductivity	EPA 120.1; or SM 2510-B	Probe and sensor	1 µS/cm
pH	EPA 150.1; or SM 4500-H-B	Probe and sensor	0.01 SU
Particle Size Distribution	SM 2560; or RSWMP addendum SOP	Laser backscattering	NA

Phosphorus and nitrogen are important limiting factors for the growth of algae in Lake Tahoe and other waterbodies. Each has been shown to stimulate growth either singularly or in combination, depending on the time of year, and each (as both dissolved and total constituents) are considered in the Lake Tahoe TMDL (Total Kjeldahl-N is operationally defined as total organic-N plus ammonium). Total suspended solids, suspend sediment concentration, turbidity and particle size distribution provide data on total and fine sediment. These are important as (1) indicators of erosion and (2) because fine sediment particles contribute directly to the loss of lake transparency. Electrical conductivity can be an indicator of urban runoff, and pH is used to partition geochemical phases of certain pollutants because it can have a toxic affect if too low or too high.

The analytic data objectives for Tahoe RSMWP samples are shown in Table 2. Accuracy will be determined by measuring performance testing samples, standard reference material (SRM), Quality Control Samples (QCS), or standard solutions from sources other than those used for calibration. Precision will be determined from measurements of relative percent difference (RPD) on both field and laboratory replicates. Nutrient recovery measurements will be determined by laboratory spiking of replicate samples with a known concentration of analyte. Completeness will be represented by the number of analyses generating useable data for each analysis divided by the number of samples submitted for that analysis. Error (uncertainty) associated with analytical measurement is generally small (less than 20%), but this error becomes greater as measured concentrations approach the detection limits.

Table 2. Analytic data quality objectives.

Parameter	Accuracy[1]	Precision[2]	Recovery[3]	Completeness[4]
Nutrients (N and P)	SRM[5] within ±10% of true value	Field and laboratory duplicates with <25% RPD	Matrix spikes within 80 to 120%	>90%
Total Suspended Solids	NA	Field duplicates with <10% RPD[6]	NA	>90%
Turbidity	±10% or 0.1 NTU, whichever is greater	Field and laboratory duplicates with <10% RPD[7] or 0.1 NTU, whichever is greater	NA	>90%
Conductivity	±5%	±5%	NA	>90%
pH	±0.5 units	RPD <5% or ±0.5 units, whichever is greater	NA	>90%
Particle Size Distribution	NA	Mode of duplicates within 10% of phi value	NA	>90%

1 Refers to the ability to measure the actual value of an analyte.
2 Refers to the variability in measured values from replicate analytic tests of the same water sample.
3 Refers to the ability to add a know amount of analyte to a sample and quantitatively retrieve it in the chemical test, which serves to indicate interference during analysis from other chemicals in the sample matrix.
4 Describes whether valid data is produced for all the submitted samples, or just some fraction thereof.
5 SRM is a standard reference material with a known concentration of the analyte in question.
6 RPD is the relative percent difference in analysis of replicate samples.

It is assumed that much of the data collected by RSWMP is likely to demonstrate lognormal or alternate probability distributions, in which case the appropriate transformations will be applied prior to analysis and tested for goodness-of-fit. The RSWMP development team has specified that, at a minimum, the following information will be provided for each study question.

Question 1 estimation procedures will include the estimated mean CRC (derived from event mean concentrations), standard error of the estimated mean, 90% confidence limits for the mean, coefficient of skewness, and probability plots for monitoring of selected land uses. Equivalent non-parametric statistics will include the estimated median CRC (derived from event mean concentrations), median absolute deviation, interquartile range, and quartile skew coefficient.

Question 2 estimation procedures will include the estimated mean CEC (derived from event meant concentrations) and mean volume reduction, standard error of the estimated means, 90% confidence limits for the means, coefficient of skewness, and probability plots for monitoring of selected treatment practices. Equivalent non-parametric statistics will include the estimated median CEC (and volume reduction), median absolute deviations, interquartile ranges, and quartile skew coefficients. Differences between influent and effluent median event mean concentrations (EMCs) will be tested with non-parametric rank-sum analysis, and if significant the differences will be evaluated in parallel probability plots.

Question 3 estimation procedures will include estimated annual loading yields for monitored catchments, along with probability plots of event loading estimates and specification of relevant characteristics for the catchment. These results will be compared to PLRM predictions for these drainages by jackknife testing to assess standard error of the estimate, correlation coefficient and bias.

Question 4 estimation procedures will include both graphical and statistical tests of spatial distribution and nonhomogeneity in the long-term data sets. Multivariarate plots, rank plots, and kriged maps will be constructed for normalized event concentrations and pollutant loadings around the Tahoe Basin representing long-term data patterns. Serial correlation or independence will be evaluated by the Pearson test or equivalent. Trends over time will be evaluated with nonparametric methods, including the Kendall, the Spearman, and the Cox-Stuart tests.

VI. Performance and Acceptance Criteria

The RSWMP development team recognizes the high variability inherent to Tahoe Basin stormwater runoff and effluent data. Therefore, estimating characteristic values will at times require balancing the reliability of estimates against costs associated with increasing the number of monitoring locations and sampling frequency. It is anticipated that in most cases an alpha (α) of 0.10, corresponding to a confidence level of 90%, will generally be reasonable for estimation purposes, given the many sources of error associated with stormwater quality data, with a beta (β) of 0.2, corresponding to 80% power. An additional statistic is the *acceptable error in estimation of the mean,* which will be particularly relevant to the Lake Tahoe TMDL. Allowable error in estimation will determine the number of sites and sampling frequency required. It is premature to choose specific values for allowable error at this time, as it will depend on the level of allowable error deemed acceptable by the TMDL. However, the corresponding requirements will be added to this document as that information becomes available.

The stormwater sampling program will need to adhere to specific QC procedures to ensure proper design, implementation, and analysis. These QC procedures will include field blanks and duplicates as well as laboratory quality control samples and standards as outlined in Table 3. QC results must remain within the limits presented in Table 2 for analytic data to be accepted.

Table 3. Recommended quality control samples and frequency.

Sample Type	Sample Frequency	Description
Field duplicate	One per 5% of samples analyzed, or at least one per event, rotate sites	Collected as a manually triggered or grab sample immediately following a normal sample
Field blank	One per event per 10 sites, rotate sites	DI water deployed in standard field sample container during event or pre-event
Composite replicate	One per event per 10 sites, rotate sites	Processing and creation of a replicate composite sample at the laboratory
Method blank	One per 20 samples processed for each analyte, or one per run	DI water passed through standard laboratory sample processing procedure
Analytic replicate	At least one per run for each analyte, or 10% of samples	Split from sample added to analytic run
Analytic blank	One per run for each analyte	DI water passed through analytic procedure with samples
Matrix spikes	At least one per run for each analyte, or 10% of samples	Percentage recovery from spiked sample during analytic run
SRM or QCS	One per run for each analyte	Standard material from different source than calibration standards, analyzed with samples during analytic run
External audit samples	Once per year	These samples are obtained from the US EPA or other agencies with a QA/QC audit sample program
Internal audit samples (RSWMP)	Six samples per year (minimum)	These samples are prepared and distributed by the RSWMP Technical Unit (See Section 14.3).

VII. Monitoring and Sampling Design

The monitoring and sampling program will consist of a distributed network of sites selected for targeted and probabilistic monitoring approaches. These will employ both grab and automated water sampling techniques to represent site runoff characteristics. *In-situ* monitoring will be conducted to provide precipitation data for each site as well as continuous flow and turbidity measurements.

All of this design information including the number of sites and frequency of sampling will be determined and documented within the Tahoe RSWMP QA Project Plan (QAPP). Details on monitoring, sampling and analytic methods will be provided in the RSWMP Sampling and Analysis Plan (SAP). The QAPP and SAP will then be properly implemented, with all QA-related procedures properly monitored by the RSWMP QA manager in order to provide an appropriate level of confidence that results are credible, unbiased, and meaningful. These results will be documented in annual assessment reports that include information on estimation procedures and any caveats that are observed in interpreting the data.

Development of subsequent versions of the RSWMP DQO, QAPP, and SAP documents is expected to be an iterative process that will continue to refine the specification of RSWMP goals, objectives and study questions within the context of for both TMDL and EIP implementation and assessment. Iterative development of these documents and recurring assessment is standard procedure in life cycle management for large programs.