Quality Assurance Project Plan (QAPP)

Tahoe Regional Stormwater Monitoring Program

1) Title and Cover Sheet

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The Tahoe Regional Storm Water Monitoring Program (RSWMP) is being developed for implementation as an agency, stakeholder, and science directed effort to collect information and contribute to a larger program—the Lake Tahoe TMDL Management System—that will assess progress toward achieving and maintaining Total Maximum Daily Load (TMDL) goals for urban stormwater quality improvements. It is anticipated that over time the TMDL Management System, or an equivalent TMDL agency directed process, will interact directly with RSWMP in periodic consideration of program objectives and data development.

As part of the RSWMP Phase 2 program design process, the Desert Research Institute (DRI) and University of California, Davis (UCD) have been contracted to develop a preliminary QAPP in advance of the RSWMP Phase 3 implementation. Please note that this document is not intended to serve as the final QAPP in a regulatory context. Rather, it is intended to contain information that will guide initial implementation of RSWMP and to help in the preparation of a regulatory QAPP if and when that document is required.

Participating RSWMP stakeholders and technical advisors (Appendix A) will receive copies of this Quality Assurance (QA) plan, and any approved revisions. Once approved, this QA plan will be available to any interested party by requesting a copy from contact personnel listed on the title page of this document.

4) Problem Definition and Background

Lake Tahoe is world renowned for its natural beauty, water clarity, and cobalt-blue color. However, long-term monitoring shows that (1) Secchi depth transparency has declined by 10 m since 1968, (2) the rate of ^{14}C primary productivity continues to increase at about 5 percent per year, and (3) thick growths of attached algae cover portions of the once-pristine shoreline.

The loss in lake clarity has been driven by increased influx of phosphorus, nitrogen, and fine sediment particles <16 μm in diameter (Jassby et al. 1999; Swift et al. 2006). These pollutants derive largely from land disturbance and urbanization (including roadways) and their transport to the lake is further exacerbated by an accompanying loss of features in the natural landscape capable of treating runoff. To achieve a transparency standard of approximately 30 m (Lahontan and NDEP 2010a), it is estimated that the loading of fine sediment particles, phosphorus and nitrogen must be reduced by 65 percent, 35 percent, and 10 percent, respectively (Lahontan and NDEP 2010a; Sahoo et al. 2010). Achieving these load reductions is expected to take many decades. In the meantime, a 20-year interim transparency goal, known as the Clarity Challenge, requires that basin-wide pollutant load reductions occur, along with monitoring to confirm that the intervening target of 24 meters of Secchi depth transparency is reached. The Clarity Challenge requires that implementation efforts will reduce basin-wide fine sediment particles, phosphorus, and nitrogen loads by 32 percent, 14 percent, and 4 percent, respectively (Lahontan and NDEP 2010b).

The purpose of this document – supported by the Data Quality Objective (DQO) report and Sampling and Analysis Plan (SAP) - is to assist the TMDL regulatory agencies as they work with the jurisdictions and other partners to develop a stormwater monitoring program that serves the needs of the TMDL Management System or its equivalent. As presented below, an important conclusion of TMDL is that urban stormwater represents the best management opportunity for reduced loading of fine sediment particles – the focus of the Clarity Challenge.

4.1 Lake Tahoe EIP and TMDL Programs

Efforts to reduce nutrient and sediment input to Lake Tahoe have been the cornerstone of watershed management for decades. Perhaps the largest and best organized of these efforts has been the Environmental Improvement Program (EIP), developed by the Tahoe Regional Planning Agency (http://www.trpa.org/default.aspx?tabid=227) and highlighted during the 1997 Presidential Summit at Lake Tahoe. It was designed to focus actions related to lake and watershed management and "encompasses hundreds of capital improvement, research, program support, and operation and maintenance projects in the Tahoe Basin, all designed to help restore Lake Tahoe's clarity and environment."

The Lake Tahoe Total Maximum Daily Load Program (TMDL) can be considered a science-based, operational blueprint for implementation of the EIP. The Lake Tahoe TMDL (1) quantifies fine sediment particle and nutrient loading from urban runoff, forested upland flow, atmospheric deposition, stream channel/shoreline erosion and groundwater, (2) uses a customized Lake Clarity Model to link pollutant loading to lake response, and (3) develops the framework for a plan to achieve an annual average Secchi depth of 30 m as required by existing regulations. The *Lake Tahoe Total Maximum Daily Load – Technical Report* (Lahontan and NDEP 2010b) provides the scientific justification for evaluating fine sediment particle and nutrient reduction targets, while the *Final Lake Tahoe Total Maximum Daily Load Report* (Lahontan and NDEP 2010a) provides the administrative framework for the TMDL.

The Lake Tahoe TMDL's *Pollutant Reduction Opportunity Report* (Lahontan and NDEP 2008a) identified options for abating fine sediment particle and nutrient loading from the four largest sources: urban upland runoff, atmospheric deposition, forested upland runoff, and stream channel erosion. The *Integrated Water Quality Management Strategy Report* (Lahontan and NDEP 2008b) effort analyzed pollutant controls to develop several integrated implementation strategies. Stakeholder input helped guide the development of a Recommended Strategy to meet the Clarity Challenge goal.

The Recommended Strategy focuses on reducing basin-wide fine sediment particle loading from urban sources and provides a framework for the TMDL implementation plan. Technical elements of the Recommended Strategy demonstrate that required load reductions are possible, but with an estimated cost of $1.5 billion over a 15 year implementation period. The implementation plan emphasizes ongoing implementation of known technologies while encouraging more advanced and innovative operations, maintenance, and capital improvement efforts to address urban stormwater pollution (Lahontan and NDEP 2008b).

4.2 Lake Clarity Crediting Program

With a science-based target for the amount of pollutant reduction needed to meet the TMDL and a technically-based recommended strategy for implementation, the next element of the Lake Tahoe strategy was the creation of a system to administer and track implementation. Accordingly, the Lake Clarity Crediting Program (LCCP) established a framework that connects on-the-ground restoration and water quality treatment projects to the goal of restoring Lake Tahoe clarity. It defines a comprehensive and consistent accounting system to track pollutant load reductions from urban stormwater using Lake Clarity Credits. According to the *Lake Clarity Crediting Program Handbook* "tracking Lake Clarity Credits (credits) creates a consistent means to quantitatively assess progress toward the Clarity Challenge milestone" (Lahontan and NDEP 2009a).

Credits will be awarded annually for effective, ongoing implementation of pollutant controls and project maintenance in urban catchments. Estimated credits for each restoration water quality treatment project will be applied for each year over the lifetime of the project, unless it is determined that the expected project effectiveness has been lowered as a result of a structural failure, lack of proper maintenance, etc. Theoretically, actual load reduction in a given year is compared to the expected load reduction to determine the appropriate amount of credit to award in that year. In particular, credits are used to determine compliance in National Pollutant Discharge Elimination System (NPDES) permits and Memoranda of Agreement. In this regard, the LCCP links action to expected pollutant load reductions with an Accounting and Tracking Tool to track load reduction progress.

In order for the Lake Clarity Crediting Program to operate as intended it requires two companion tools. The first is a quantitative, science and technology-based methodology for estimating the expected pollutant load reduction from restoration/water quality treatment projects. Without the resources needed to monitor each project/action, it would be economically prohibitive to conform to the innovative framework established by the LCCP. Therefore, as part of the Lake Tahoe Total Maximum Daily Load program, it was considered important to have a tool that would allow the expected pollutant load reduction from a project to be quantified. The *Pollutant Load Reduction Model* or PLRM was initially funded and developed as a project alternative analysis tool (Lahontan and NDEP 2009b), and now provides an example of the approach that can be used to estimate credits. Note that the PLRM is not considered by the TMDL agencies as the only tool for estimating credits; however, it is being considered as perhaps one of a variety of approaches suitable for this purpose. It focuses on urban runoff and has been modified to also include fine sediment particles. The PLRM is a customized interface to the US EPA's Storm Water Management Model version 5 (SWMM5) that includes forms and functionality specific to the Lake Tahoe Basin. The reader is encouraged to consult the *PLRM – Model Development Document* for specific details (http://tiims.org/TIIMS-Sub-Sites/PLRM.aspx).

The approach to be taken for the Lake Tahoe TMDL will center on using the PLRM or an alternative, agency-approved technique to estimate the expected pollutant load reduction values for each project, converting them to Lake Clarity Credits as defined above, and tracking them basin-wide. This approach was selected since it provides an organized, internally consistent and timely approach that would not otherwise be possible based on individual and isolated monitoring efforts.

The second tool created to document progress towards meeting load reduction targets developed by the Lake Tahoe TMDL allows for the rapid assessment on BMP condition with a link to awarded annual credits. The *Best Management Practices Maintenance Rapid Assessment Methodology* (BMP RAM) was recently developed to evaluate the relative condition of urban stormwater treatment BMPs (2NDNATURE 2009a). The BMP RAM tool includes field monitoring, data evaluation and data management sections to track BMP condition with regard to maintenance and efficiency and changes in condition over time, and will help to ensure that treatment BMP performance continues at anticipated or expected levels. The BMP RAM is intended to be a condition assessment used to inspect and report actual conditions in comparison to the expected conditions used in load reduction estimations (Lahontan and NDEP 2009b). Since water quality benefits of treatment BMPs are likely to decline over the years, unless the system is maintained, it is anticipated in the LCCP that the BMP RAM will be used to verify that there is no significant reduction of BMP performance efficiency during its operational lifetime. If such a decline in efficiency does occur the LCCP Handbook provides the protocol for adjusting the award of future credits for a particular BMP.

While the use of the various models and technical tools developed for the Lake Tahoe TMDL represent a sophisticated, state-of-the-art approach for addressing nonpoint source pollutant control, these products are based on the current – and in many cases, limited – local urban runoff data set. It is widely acknowledged that these tools will require more extensive and ongoing calibration and validation. In this regard, calibration refers to a routine update and revision (if necessary) of the functional aspects of these tools based on improved data collection. For example, the PLRM uses values from various sources to define BMP effluent concentrations, estimate flow volumes, and calculate BMP pollutant discharge loads. Monitoring BMP effluent concentrations and loads will help to reduce uncertainty in these estimates. Validation, on the other hand, compares model output (expected load reduction) to field measurements of load reduction. It is key to building confidence that the models and related management tools accurately represent field conditions. Validation will assure stakeholders that the PLRM is producing reliable results, and that the use of this model for determining Lake Clarity Credits is linked to verifiable field measurements.

Because the Lake Clarity Crediting Program provides the framework for administering progress towards meeting the TMDL load reduction targets, and because the TMDL strategy envisions that tools such as the PLRM and BMP RAM will play a significant role in this process, it is imperative there is an directed monitoring effort (on the order of 3-5 years) to calibrate and validate these tools.

4.3 Regional Stormwater Monitoring Program

The Lake Tahoe Watershed Assessment concluded in 2000 that most information then available on BMP effectiveness was of a qualitative nature and was based largely on occasional site inspections and observations (Reuter and Miller 2000). Local knowledge of urban pollutant loading was also meager, based primarily upon infrequent grab samples and shorter duration studies. Since that time, considerable progress has been made, with key summaries on Tahoe stormwater monitoring and BMP effectiveness to be found in Reuter et al. (2001), Geosyntec Consultants (2005), Gunter (2005), 2NDNATURE (2006), Lahontan and NDEP (2008a). Despite the recent progress in stormwater monitoring at Lake Tahoe, there was a general consensus that it lacked coordination—with no comprehensive, standardized or integrative design for data collection and reporting.

Clearly, current and future monitoring efforts must address multiple needs for stormwater monitoring in a manner that is directly applicable to implementation and management of the TMDL and the EIP. Relevant data would significantly increase and the quality would improve if monitoring and data analysis were done in an organized and integrated fashion, based on a unified set of key management questions and program needs, within a science-based adaptive management framework. This approach would combine data from multiple coordinated projects, which is statistically more powerful than attempting to link independent data sets collected for different reasons at different times using different techniques. The old approach is simply too resource intensive and does not readily allow for conclusions to be made outside the confines of each isolated project being monitored. Therefore, stakeholders initiated development of a regional stormwater monitoring program that would bring together project implementers and agencies to create common goals, criteria, implementation strategies, and reporting requirements for Lake Tahoe TMDL allocations and related regional plans.

The Tahoe Regional Stormwater Monitoring program (RSWMP) was originally envisioned as occurring in three different phases, an approach that is still considered appropriate. Phase 1 was focused on collaborative development of a conceptual framework for a comprehensive stormwater monitoring program (Heyvaert et al. 2008). Phase 2 has been focused on design specifications for that framework with specific guidance on stormwater monitoring, analysis, data reporting, and administrative elements (organization), as presented in this document. Phase 3 will represent stakeholder agreements, funding arrangements, and implementation of the monitoring framework developed during Phases 1 and 2, with creation and staffing of program structural elements and full implementation of all monitoring and reporting processes. Over 20 agencies, implementing groups, and research institutions have participated in the RSWMP Phase 1 and Phase 2 process.

5) Program Design and Organization

The TMDL program has made substantial progress in developing a fundamentally new approach to pollutant control in the Lake Tahoe Basin. However, all aspects of this highly innovative and state-of-the-art program are not yet fully developed. The TMDL agencies are currently working on a conceptual framework that begins to address some of these final issues, especially those related to monitoring. That framework will serve as a vehicle for (1) parsing out the different kinds of monitoring that the TMDL agencies believe will be needed to inform implementation of the urban stormwater management program, and (2) assigning responsibility for the different kinds of monitoring associated with TMDL implementation. In the meantime, it is recognized there are three main forms of monitoring

(Manley et al. 2000), each of which can provide information relevant to regional stormwater management and the TMDL program.

Implementation monitoring. Considered to be monitoring of management actions in relation to intended project plans. The purpose of implementation monitoring is to document that projects comply with regulatory conditions and meet mitigation obligations as specified in the construction plans and permit, e.g. was the project built as designed.

Effectiveness monitoring. Monitoring of effectiveness of management practices and actions in achieving desired conditions. Within the TMDL, effectiveness monitoring can occur on a variety of scales, e.g. a single BMP, multiple BMPs that form a water quality improvement project, multiple projects found in the same sub-drainage basin or the same watershed, BMP/improvement efforts within the entire basin). This type of monitoring is an integral part of the capital improvement, regulatory, and incentive programs and allows for the evaluation of individual or combined effects of water quality control actions. Effectiveness monitoring can also be used to help project engineers incorporate those design features that will most successfully remove the pollutants of concern.

Status and trends monitoring. Broadly defined as the monitoring of status and trends of water quality conditions and controlling factors. This is the principal type of monitoring used to gather data that can inform us about long-term changes in water quality conditions relative to established water quality standards and/or goals. Status and trends monitoring is directly linked to effectiveness monitoring in that it evaluates water quality improvement over time at each of the spatial scales listed above (e.g. single and multiple BMPs, watershed, whole-basin).

The Tahoe RSWMP recognizes a fourth monitoring category relevant to development and assessment of management strategies.

Model support monitoring. This is considered monitoring that is directly used to evaluate the basis for numeric assumptions used in models and other assessment tools, and/or to assist in the calibration and validation of these models/tools. Sometimes data from the other three types of monitoring can be used for this purpose, but there are instances when a focused monitoring effort is needed to address specific modeling issues.

Achieving water quality goals of the TMDL will require a well-designed monitoring and assessment plan that can be applied within an adaptive management framework for measuring progress. According to the *Final Lake Tahoe Total Maximum Daily Load Report,* adaptive management, or periodic evaluation and reassessment, is necessary for the long-term success of the Lake Tahoe TMDL. Therefore, a Lake Tahoe TMDL Management

System or equivalent agency-directed process will be developed to provide a framework for adaptively managing implementation of the Lake Tahoe TMDL. This framework will guide a continual improvement cycle to track and evaluate project implementation and load reductions, and will inform milestone assessments by Lahontan and NDEP during the implementation timeframe of the Lake Tahoe TMDL. True adaptive management is best met by having a fully integrated comprehensive monitoring program where the data are centrally managed. The Tahoe RSWMP is expected to serve this purpose for stormwater management, and its efforts will be guided by goals related to the evaluation and documentation of Basin-wide progress toward achieving pollutant reduction targets for the TMDL.

5.1 RSWMP Organizational Framework

The Tahoe RSWMP is expected to be responsive to changing needs and knowledge about stormwater issues and water quality management in the Tahoe Basin. Therefore, a stable and broadly supported adaptive management process will be necessary for its success. There are two main options for RSWMP implementation, as initially developed in the Phase 1 document. The first option is a centralized implementation approach, in which the bulk of all RSWMP activities and monitoring would be conducted directly by a dedicated RSWMP team (consolidated model). The other option is a more decentralized approach, in which a smaller group of dedicated RSWMP staff would provide technical oversight, assistance and core level monitoring, but would work in collaboration with capital program implementation staff who would conduct additional monitoring following RSWMP protocols (interactive model).

Phase 2 recommendations call for initial implementation of RSWMP under the “interactive model” approach, where RSWMP staff develop and administer most of the Program’s core functions, but much of the sampling and analysis is done by jurisdictions or other groups active in stormwater monitoring. This approach allows implementers to choose whether to contract directly with RSWMP for monitoring and associated activities within their jurisdictions, or to conduct the monitoring themselves and through other subcontractors. Core RSWMP functions would be conducted under the guidance of a program manager and team of technical staff (for program coordination, database management, statistical design, data analysis, and synthesis of findings), but other tasks could draw upon available personnel and funding resources of affiliate groups and their subcontractors (e.g. compliance monitoring, laboratory analyses, data reporting, etc).

In either case, the overall structural framework for RSWMP can be defined in terms of assessment teams and process flow, based on the Plan-Do-Check-Act Model created for other programs in the Tahoe basin. In this regard the RSWMP is anticipated to consist of four main groups (Figure 1) that will interact on a regular basis to support and guide a continual improvement process. This process aims to integrate planning, implementation, assessment and decision-making to support effective and efficient implementation of the urban source control strategies identified in the Lake Tahoe TMDL. The four entities described below are considered essential to successful implementation of RSWMP, regardless of which model is chosen, as ultimately this approach will provide the necessary consistency, quality assurance, centralized reporting, and a process for adaptive management.

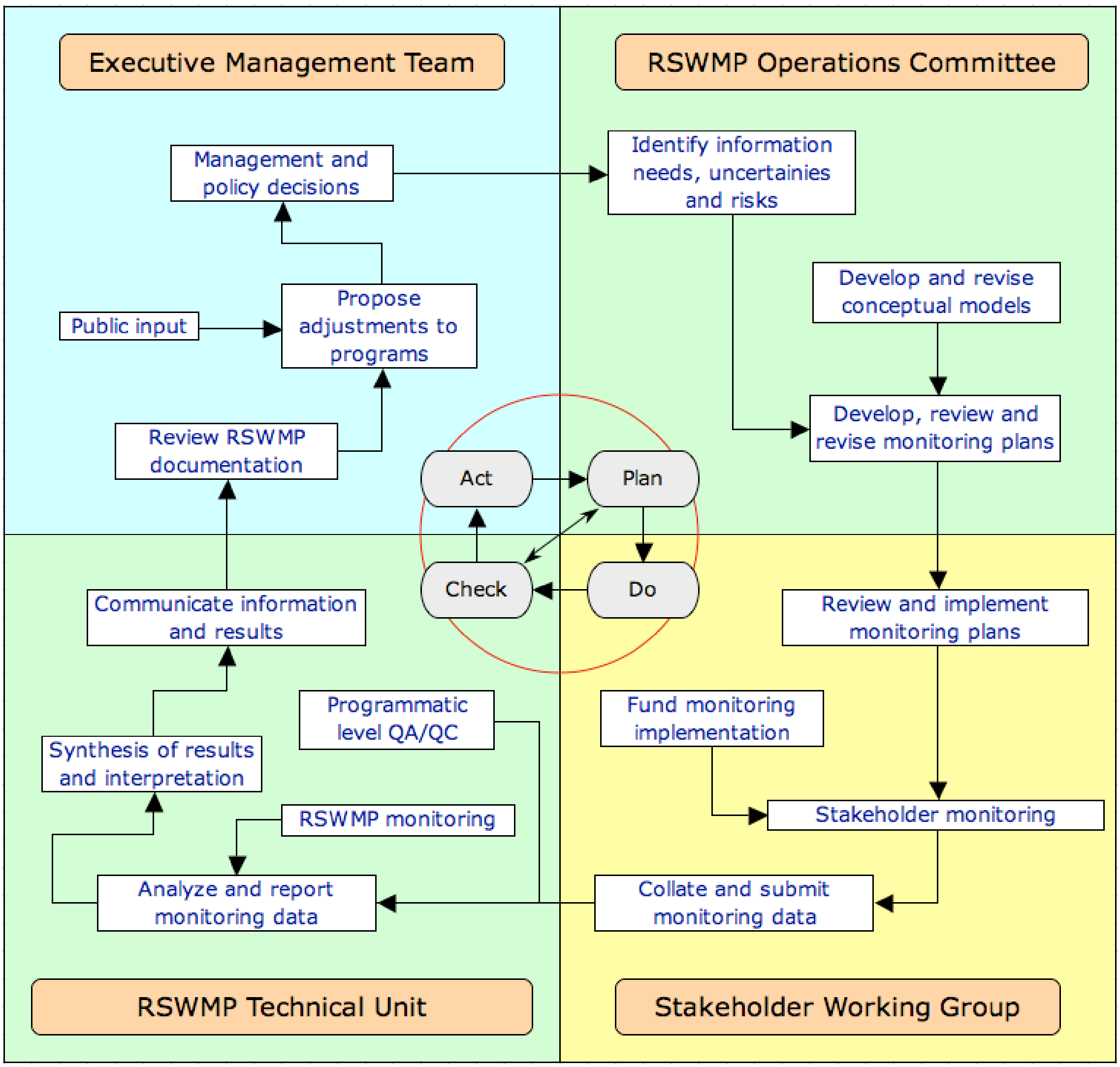

Figure 1. Organizational diagram showing a conceptual relationship between each of the Tahoe RSWMP assessment teams and their respective roles (modified from Tahoe SMIT report and Tahoe RSWMP Phase 1 document). A direct and critical link between the Operations Committee and the Technical Unit is represented by each group having the same box color.

These four groups consist of 1) the RSWMP Development and Operations Committee, responsible for providing ongoing program direction and overseeing implementation of program priorities; 2) the RSWMP Technical Unit, responsible for the day-to-day implementation and function of RSWMP duties; 3) the Stakeholder Working Group, representing the diverse interests and needs of all Tahoe stormwater jurisdictions and agencies; and 4) the TMDL/EIP Executive Management Team, which ultimately makes management decisions, sets program priorities, and develops policy directives based on RSWMP findings and recommendations.

5.2 Program Goals and Objectives

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 on stormwater quality improvements. It is a key component of the overall plan to document progress, and it will supply information needed to help operate the TMDL Management System. However, it should be recognized that RSWMP is not intended to serve as a surrogate, or even a blueprint, for a much larger, Basin-wide stormwater management effort. The development of a TMDL stormwater management program contains a number of items that, while identified as important by the RSWMP Working Group during Phases 1 and 2, are in fact policy issues associated with TMDL implementation and therefore outside jurisdiction of the TSC RSWMP development team and the implementers. Examples include, but are not limited to: specific monitoring requirements for permit compliance, reporting requirements, formal implementation of RSWMP, and a funding strategy.

As regulatory agencies develop their TMDL Management System or an equivalent process, the data provided by RSWMP will be used in concert with other monitoring data to track progress toward achieving TMDL targets. In the meantime, as TMDL agencies continue to develop their TMDL stormwater management program and identify specific monitoring needs, it is best to consider the desired outcomes, goals and objectives presented below as a palate of ideas that agencies can draw from as they consider their TMDL urban stormwater monitoring needs in more detail.

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.

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.

Based on these 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.

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. (A number of these were determined from limited existing data and best professional judgment, suggesting that further confirmation is required.)
- 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.

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 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. Given the "in progress" status of the TMDL Management System or an equivalent agency-directed process, with which RSWMP will interact, the initial plans developed here and in associated documents will focus on aspects of urban stormwater monitoring requirements that were considered relevant by stakeholders.

5.3 RSWMP Key Study Questions

Successful monitoring plans often base their design and implementation on a subset of key study questions. This allows for focused sampling (e.g. location and frequency), selection of appropriate constituents for measurement and laboratory analysis, the identification of suitable field methodologies, and development of a targeted QAPP. 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 continues. 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.

RSWMP 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.)

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

RSWMP 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.)

RSWMP 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 related to TMDL load reduction targets? (This addresses RSWMP Monitoring Goals 2 and 3.)

Background details associated with each of these key study questions are provided in the discussion of monitoring and sampling design (Section 10). Overall, however, it is anticipated that the monitoring design will consist of a nested sampling program that collects data across a series of spatial and temporal scales to evaluate a response for each key question.

6) Project Task Description and Schedule

While it is beyond the scope of this current report to provide all the required details to move directly into implementation of Phase 3, the following tasks were taken into account in this Phase 2 report and should be considered as guidance.

6.1 RSWMP Management and Administration

RSWMP implementation requires the specification of organizational structure and funding sources to sustain the monitoring, data evaluations and reporting requirements of the Lake Tahoe RSWMP. The outline of an organizational framework and list of responsibilities has been developed in consultation with stakeholders and agency staff, as presented in Section 5.1 and explained in Appendix B. Details regarding management and administration of RSWMP related to the TMDL (e.g. data delivery, revision of sampling design) will be identified as part of the process shown in Figure 1. This will also lead to a realistic estimate of staff requirements and operating budget for RSWMP. It is anticipated that funding sources for full implementation and management will be identified and secured by the appropriate agencies. In the meantime, the RSWMP tasks associated with each of the key study questions are summarized below.

6.2 Pollutant Source Monitoring

Pollutant source monitoring will target specific land use types and provide updated information on stormwater runoff and characteristic runoff concentrations (CRCs) as needed to refine/update the calibration of stormwater management models and other TMDL tools. This is considered modeling support monitoring. Key water quality datasets used in the formulation of the PLRM were described as (a) CRCs for sediment and nutrients of concern related to road pollutant potential and (b) CRCs for pollutants for all other land uses not related to roads. As sufficient data are collected, it can also be used to refine relationships between land use and pollutant generation and possibly identify source areas.

6.3 BMP Design, Operation and Maintenance Monitoring

These data will be assembled by RSWMP from BMP monitoring to test performance assumptions and provide information on fine particle and nutrient removals by distinct BMP processes or functions that exist as important elements of TMDL management tools (e.g. Lake Clarity Crediting Program, PLRM, BMP RAM). The monitoring of specific BMPs will help quantify accurate load reduction estimates and the impacts of age and maintenance on performance. This includes both effectiveness monitoring and modeling support monitoring, as described in Section 5. The PLRM currently relies on a limited dataset that defines characteristic effluent concentrations (CECs) for several BMP types. Additional data will be needed to refine/update the calibration of these CECs for pollutant load reduction modeling. This monitoring will also provide implementers with information needed to help design and build more effective BMPs. The monitoring associated with this task will focus on individual BMPs or a selected aggregate of BMPs.

6.4 Pollutant Load Reduction Monitoring

Data from stormwater monitoring are needed to validate the models being used to estimate load reductions from project areas. Therefore, monitoring associated with this task will occur at the sub-watershed scale, and should include runoff from multiple BMPs and restoration efforts as well as from developed lands and any undeveloped areas within the drainage. There must be a direct linkage between model output and stormwater monitoring for accurate testing of parameter calibration and model validation. Therefore, the design of this monitoring will be focused on project locations where the PLRM or equivalent models have provided predictions for pollutant loads in stormwater runoff for the drainage and have projected reductions in pollutant loading associated with project implementation. This includes both effectiveness monitoring and status and trends monitoring, as described in Section 5.

6.5 Stormwater Status and Trends Monitoring

Selection of appropriate index sites for monitoring long-term patterns and trends in urban runoff will provide information needed to evaluate urban catchment loading estimates, and progress toward achieving TMDL targets. Furthermore, these sites will deliver long-term calibration and validation data for model evaluation, in contrast to the shorter-term project scale monitoring sites. Urban outfall sampling conducted on a probabilistic basis will identify spatial patterns in stormwater runoff characteristics and potential outliers in runoff loading characteristics to Lake Tahoe. Together these data will provide a Basin-wide statistical evaluation of changes in pollutant reduction associated with implementation of the TMDL, and will document progress toward regulatory goals. This includes status and trends monitoring, as described in Section 5.

6.6 Data Management, Analysis and Dissemination

The RSWMP Stormwater and BMP Database will provide a repository for the compilation, management, and analysis of Tahoe stormwater data from various sources. This will facilitate RSWMP stakeholder access to resulting data products and tools. Periodic evaluation of the monitoring data will be necessary for QA/QC review, to produce RSWMP reports, and for presentations on findings and recommendations. Specific agency needs, to be defined in the TMDL Management System, will be used as the basis for determining the level of data analysis and the most effective strategy for information dissemination. (Refer to Section 18 for additional discussion)

6.7 Program Assessment and Adjustments

A periodic programmatic review 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. (Refer to Section 19 for additional discussion)

6.8 RSWMP Schedule

The schedule for each task outline above is dependent upon final resolution of RSWMP funding and organization, to be determined by the agency and stakeholder groups. At that time, presumably, the RSWMP Technical Unit will work with the Operations Committee to develop an appropriate implementation schedule and timelines for reporting and programmatic review.

7) Data Quality Objectives and Criteria for Measurement Data

The required number of samples to be collected from each site will vary based on a number of factors, including, but not limited to: observed variability in the annual range of concentration for each constituent; required level of statistical confidence; logistics or sampling and funding availability. Stormwater runoff characteristics vary considerably throughout the year, and previous sampling designs in the Tahoe basin have ranged from approximately 6-40 events or grab samples per year. Selection of an event-integrated sampling approach (e.g. autosampler) reduces uncertainty in characterizing event runoff since it collects water throughout the duration of the event hydrograph.

In this section we provide a statistical evaluation of the number of storm events that should be monitored per year to obtain a reasonable estimate of average runoff concentrations at two representative runoff sampling locations at opposite ends of the Tahoe basin - South “Y” (South Shore) and Speedboat (North Shore). Both of these sites provide a relatively long-term record (WY2003 through WY2008) with a high number of monitored runoff events during that period (Heyvaert et al. 2009), and provide a unique opportunity to test actual field data from the Tahoe basin for analysis of sampling frequency. This work was conducted in collaboration with Geosyntec Consultants as part of a preliminary analysis on data in the Tahoe RSWMP Database.

Monitored runoff event types have been classified for the South Y and Speedboat stations as rain runoff, snowmelt, rain-on-snow, and thunderstorms. Preliminary data analyses have found that thunderstorms tend to have a much higher variability in concentrations than the other event types. Therefore, the water quality data for each station have been divided into two classes: (1) rain runoff / snowmelt / rain-on-snow and (2) thunderstorms. The representative water quality constituents that were analyzed include total nitrogen (TN), nitrate plus nitrite ($[NO_3+NO_2]$-N), total phosphorus (TP), soluble reactive phosphorus (SRP), total suspended solids (TSS), and turbidity.

The method for identifying the number of data points needed is based on the following equation presented by Burton and Pitt (2002):

$$n = [COV*(Z_{1-\alpha} + Z_{1-\beta})/(error)]^2$$

where: n = number of samples needed

α = false positive rate (1-α is the degree of confidence).

β = false negative rate (1-β is the power).

$Z_{1-\alpha}$ = Z score (associated with area under normal curve) corresponding to 1-α.

$Z_{1-\beta}$ = Z score corresponding to 1-β value.

Error = allowable error, as a fraction of the true value of the mean.

COV = coefficient of variation (sometimes notes as CV), the standard deviation divided by the mean.

For this analysis, a value of α of 0.10 was selected, corresponding to a confidence level of 90%, which is generally considered reasonable given the many sources of error associated with stormwater quality data. A commonly used value of β of 0.2, or 80% power, was also selected. The α or alpha statistic is a common metric that is relevant when comparing two sets of data. The coefficients of variation (COV) of the log-transformed data were used in the above formula. An additional statistic was used in this analysis referred to as *acceptable error in estimation of the mean*. This is an important statistic with relevancy to the Lake Tahoe TMDL. As appropriate error limits are yet to be determined for these programs, we have performed the sampling frequency analysis over a range of 'allowable errors' from 5–30 percent. The selection of sample frequency in RSWMP should be guided by this analysis; however, it is premature at this stage to choose a specific value. The final selection will depend on the level of 'allowable error' deemed necessary by the TMDL agencies, based on the specific question the data will address.

However, a few observations can be made based on the plots of 'allowable error' versus sampling frequency (at a fixed α value of 0.10 and β value of 0.20) (Figures 2 through 5): (1) as expected the lower the 'allowable error' value, the more samples are required; (2) concentrations of the dissolved nutrients ([NO_3+NO_2]-N) and SRP) are more variable and thus require a greater sampling frequency than the constituents associated with particulate matter; (3) the relationship between sample frequency and rain runoff/snowmelt versus summer thunderstorms was not always consistent across constituents; and (5) the results from Speedboat and South "Y" were typically similar, with exception of [NO_3+NO_2]-N during the rain runoff/snowmelt events and TN during the thunderstorm season.

As noted above, the final selection of sampling frequency depends on a number of factors, which will be considered as part of the process outlined in Figure 1. An "allowable error" of 0.10 (or 10%) is not unreasonable for a regional stormwater sampling program, which suggests sampling frequency in the range of 10-15 samples per year during the rain runoff/snowmelt season for total or particulate-bound constituents. An equivalent sampling frequency is required for assessing these constituents during thunderstorm periods, but this would be impractical on an annual basis given the relative infrequency of thunderstorms at Tahoe. Thus, the level of confidence associated with data analysis for thunderstorms will be less until sufficient data are assembled over time. Similarly, given the greater variability in runoff concentrations of dissolved constituents, the sampling frequency for dissolved nutrients must be higher than for the particulate constituents to achieve an equivalent "allowable error" of 10 percent.

Finally, when considering event loads, sampling frequency cannot be viewed as independent from flow. In other words, if a sampling frequency of 10 samples per year was deemed adequate to characterize event runoff concentrations (based on agency needs and guidance from the analyses provided here), this does not mean that just any 10 events could be sampled regardless of flow volume. An analysis of the Speedboat and South "Y" data for suspended sediment and fine sediment particles suggest that the majority of the load occurs in 10-15 events (Matt Zelin, UC Davis Masters thesis in progress). Therefore, RSWMP will need to verify that sampling is done for appropriate events, which can be difficult as projected small storms become large storms and large storms sometimes unexpectedly weaken. The RSWMP Technical Unit will need to track sampling efforts in 'real time' to ensure that the best sampling opportunities are targeted.

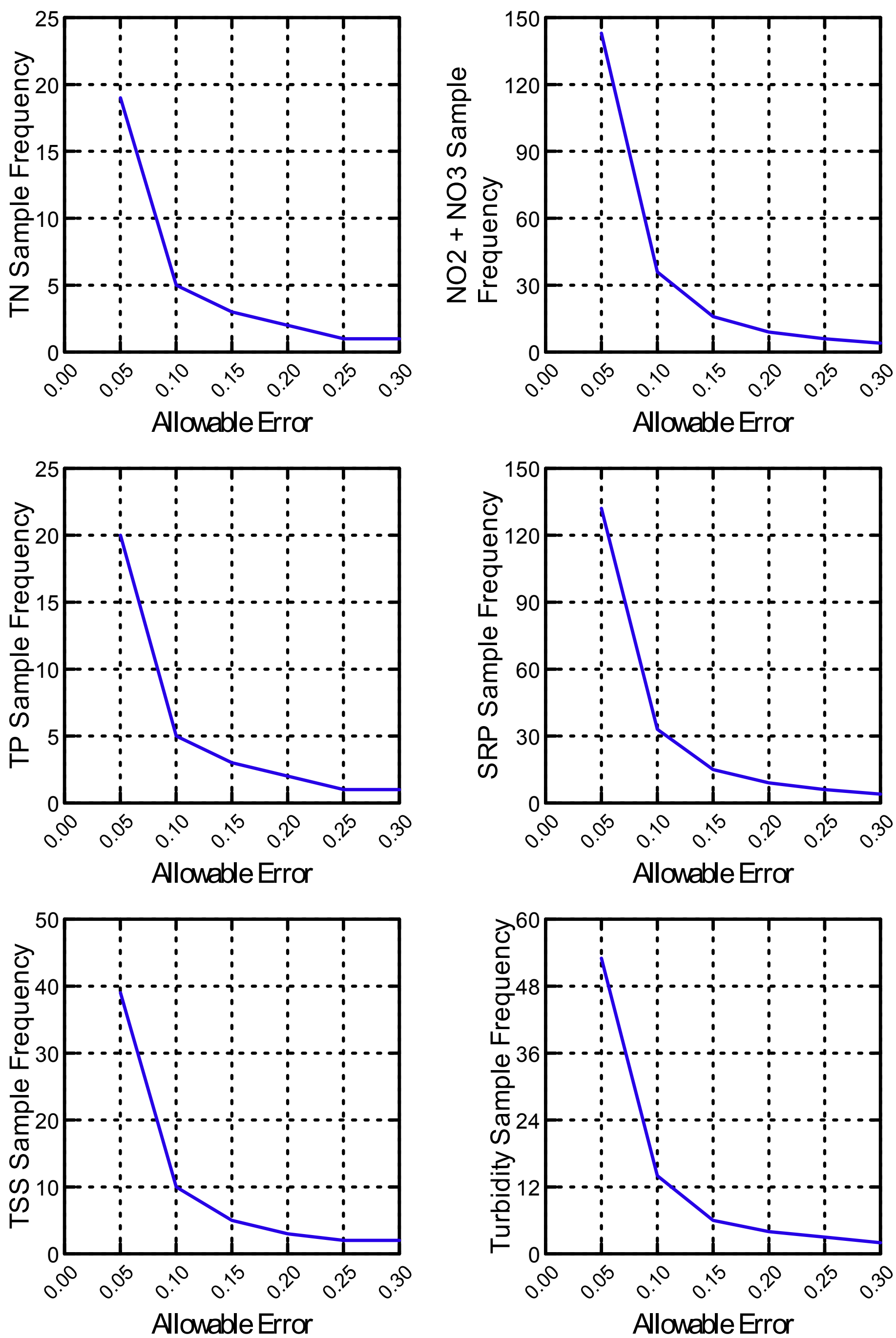

Figure 2. Number of storms needed for various constituents given allowable error for estimate of the mean. Coefficient of variation estimated from **rain runoff/snowmelt** **EMC data collected at Speedboat Avenue** monitoring station.

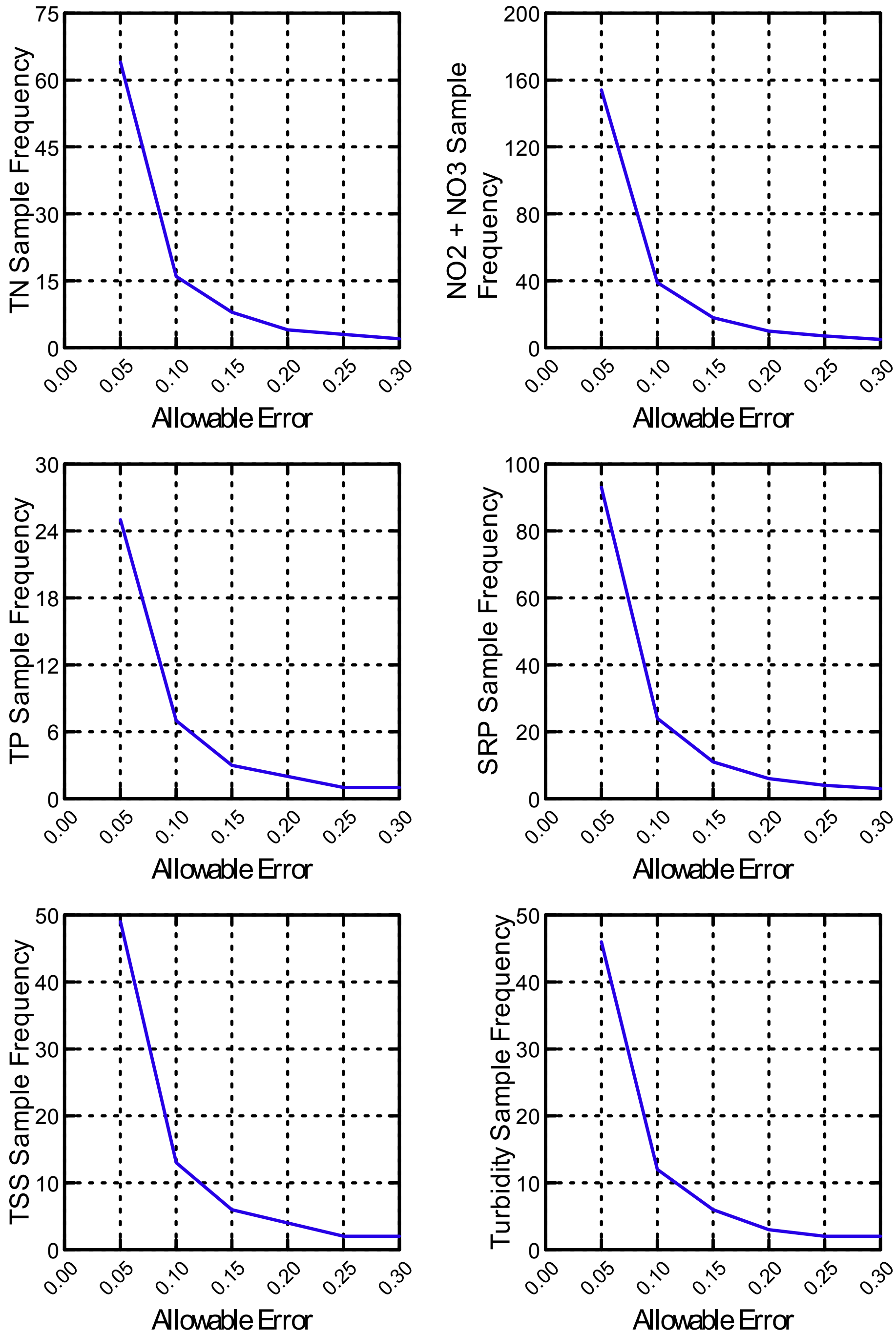

Figure 3. Number of storms needed for various constituents given allowable error for estimate of the mean. Coefficient of variation estimated from **thunderstorm EMC data collected at Speedboat Avenue** monitoring station.

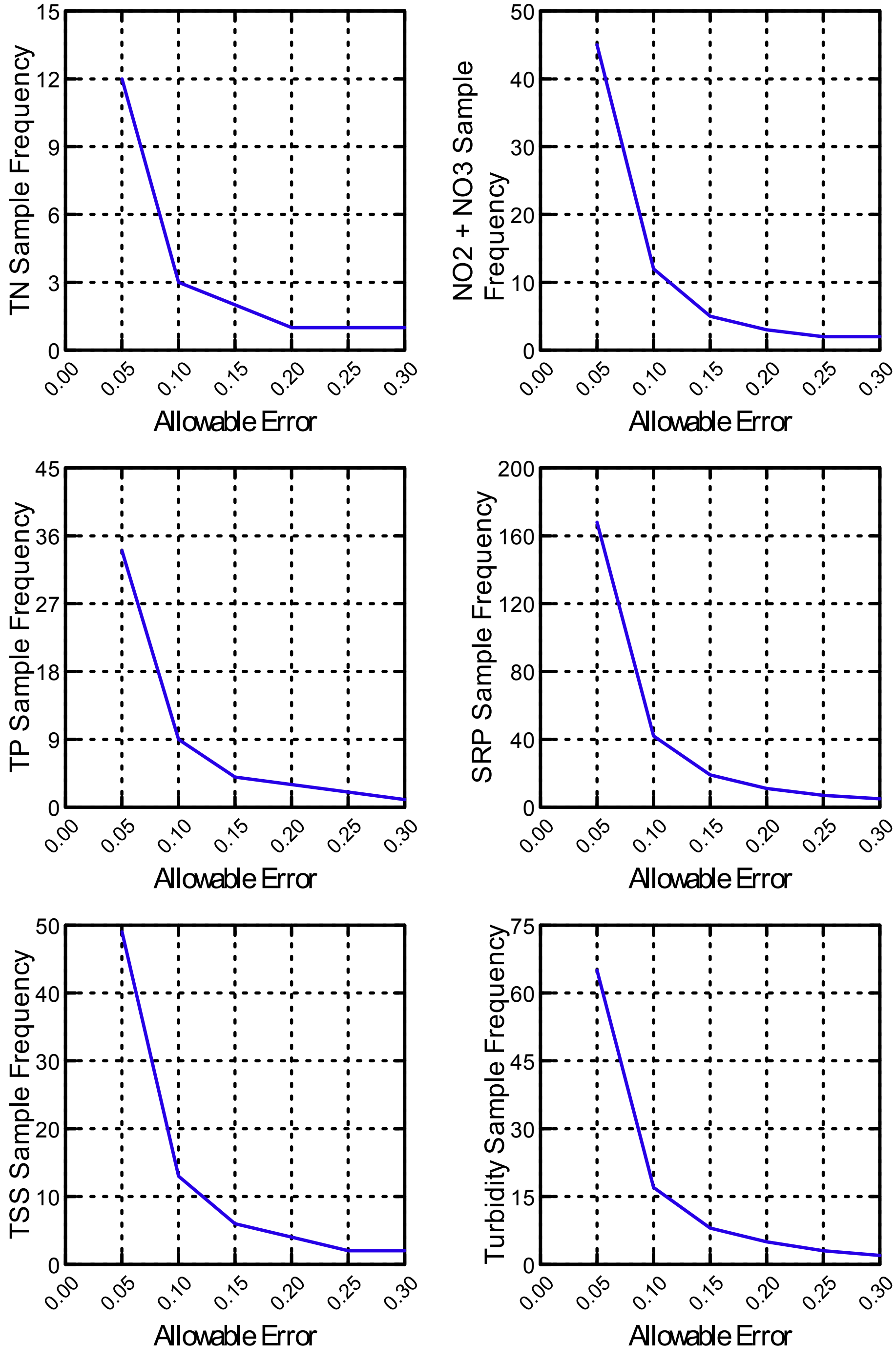

Figure 4. Number of storms needed for various constituents given allowable error on estimate of the mean. Coefficient of variation estimated from **rain runoff/snowmelt EMC data collected at South Y** monitoring station.

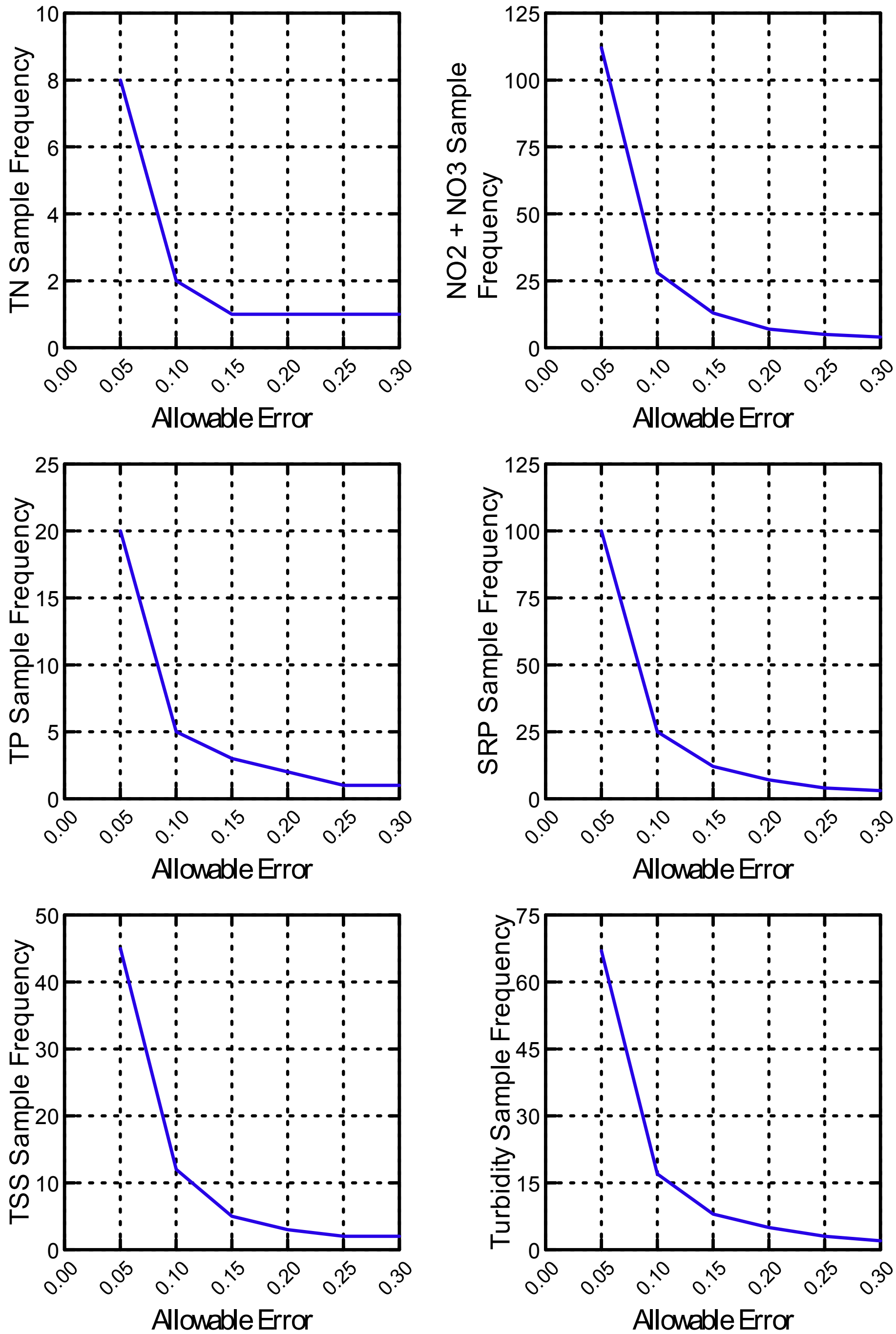

Figure 5. Number of storms needed for various constituents given allowable error for estimate of the mean. Coefficient of variation estimated from **<u>thunderstorm</u> EMC data collected at <u>South Y</u>** monitoring station.

In addition to meeting the frequency of sample collection for event types, it is essential that subsequent sample analyses meet specific criteria. These analytic objectives for the Tahoe RSMWP samples are shown in Table 1. 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. It is assumed that these data will be collected using RSWMP protocols and following the analytic recommendations with reporting limits shown in Section 13.

Table 1. Data quality objectives. Note that laboratory expectations for accuracy, precision, recovery and completeness are identical for the various forms of nitrogen and phosphorus. Recommended analytic methods and reporting limits differ between forms as shown in Table 3. Forms of nitrogen include nitrate (plus nitrite), ammonium, total Kjeldahl-N, soluble reactive-P, total dissolved-P, and total-P.

Parameter	Accuracy	Precision	Recovery	Completeness
Nutrients (N and P)	SRM or QCS within ±10% of true value	Field and laboratory duplicates with <25% RPD	Matrix spikes within 80 to 120%	>90%
Total Suspended Solids (TSS) and Suspended Sediment Concentration (SSC)	NA	Field duplicates with <10% RPD	NA	>90%
Turbidity	±10% or 0.1 NTU, whichever is greater	Field and laboratory duplicates with <10% RPD or 0.1 NTU, whichever is greater	NA	>90%
Conductivity (EC)	±5%	±5%	NA	>90%
pH	±0.5 units	RPD <5% or ±0.5 units, whichever is greater	NA	>90%
Particle Size Distribution (PSD)	NA	Mode of duplicates within 10% of phi value	NA	>90%

8) Special Training Requirements and Certifications

All entities involved with either the collection of field samples or the chemical analysis of stormwater in a laboratory need to follow the established protocols for training requirements, field sampling safety, laboratory health and safety and related topics as required by that institution. RSWMP will not have the authority to oversee this training; however, those labs and sampling units involved with RSWMP work should have this documentation on file.

Generally, field personnel responsible for any site maintenance, sampling, site data collection, sample processing and delivery will review the RSWMP Sampling and Analysis Plan prior to involvement in any field or sampling processing activities. It is anticipated that the RSWMP Technical Unit will conduct periodic orientation workshops during which field personnel will conduct dry runs at designated stations under their management and conduct simulated monitoring, sample collection, documentation, etc.

Furthermore, training representatives from the Technical Unit may conduct a program of site visits during sampling events to verify that correct procedures are applied at RSWMP affiliated sampling sites and that those sites are maintained and operated correctly. These assessments of site conditions and sampling procedures will be documented, along with any notes on any deficiencies or improvements, and distributed to corresponding supervisors.

Laboratories engaged in analysis of sample analysis from RSWMP designated sites are expected to follow the protocols designated for sample analysis in Section 13 and the laboratory QA/QC requirements listed in Section 14, including the RSWMP Inter-laboratory Quality Control Program.

9) Programmatic Documentation and Records

The RSWMP Technical Unit will maintain records of management directives and decisions developed by the Operations Committee. These will form the basis for any changes or adjustments in RSWMP monitoring and sampling design, to be reflected in the annual updates of this QAPP and the corresponding Sampling and Analysis Plan.

All certifications from field training workshops, site inspections, laboratory evaluations and similar materials will be maintained in both hardcopy and electronic versions by the Technical Unit. The RSWMP quarterly data reports and annual assessments will be developed and distributed as outlined in Section 20.

The Technical Unit also will be responsible for maintaining the RSWMP Stormwater and BMP Performance Database. This includes development and delivery of periodic report forms summarizing the data currently available, as well as regular data QA/QC review of all new information entered by participating RSWMP affiliate groups prior to release and distribution.

A wide array of information should be collected and stored that deals with field sampling and laboratory analysis. While the intent of this section of the QAPP was to highlight some of the larger programmatic needs for records and documentation, the reader should refer to the RSWMP Sampling and Analysis Plan (SAP) for further details. Information can include, but is not limited to raw data, data summaries, related data from other sources, field notes, sample preparation and analysis logs, data flags, instrument printouts, model input, and QA/QC checks.

10) Monitoring and Sampling Design

These following sections (10-18) represent general information on the sampling and analysis plan (SAP) for initial RSWMP implementation (Heyvaert, Reuter et al. 2010). A more detailed SAP will be developed as the agency and stakeholder groups determine specific monitoring directions and sites. The organization of RSWMP, discussed in section 5.1, represents an adaptive management process that is expected to produce adjustments in program goals, methods, and sampling design over time. These changes will be reflected in periodic updates to the RSWMP SAP and to this document (QAPP) as necessary.

The diverse Tahoe RSWMP goals have led to recommendation of a blended monitoring design, including a nested approach across both temporal and spatial scales. Given that regional agencies are in the process of determining the level of monitoring that will be needed to inform the urban stormwater portion of the TMDL, a fully developed and specific monitoring design (e.g. final site location) for RSWMP is not yet feasible. Indeed, on April 30, 2010 the Tahoe Stormwater Executives instructed the RSWMP Phase 2 design team to postpone identification of monitoring types and sites, pending further discussion between the regulatory agencies and the urban stormwater jurisdictions. However, once these matters are ultimately addressed as part of the TMDL (for issues such as permit compliance, assessing progress towards the TMDL loading target, etc.), we recommend the monitoring design to be implemented in support of the urban stormwater management program be based on sampling at micro-, meso- and macro-scales.

Micro-scale monitoring, for example, would focus on PLRM-RAM calibrations and is represented by BMP effectiveness monitoring. These are typically shorter-term monitoring efforts on individual BMPs or other specific actions. In contrast, meso-scale monitoring would evaluate pollutant runoff characteristics and loads at the project or catchment scale, primarily for validation of the PRLM (or equivalent models in testing pollutant loading predictions). Macro-scale monitoring at longer-term Stormwater Index Stations would provide information on cumulative effects from a series of water quality improvement projects installed over time within a localized drainage area. With time we expect these data to provide time-series analyses and graphs of the status and trends in changes for urban stormwater quality and loading, in a manner similar to that done for the historic Secchi depth or transparency trend in Lake Tahoe and the long-term LTIMP stream loading data. Additionally, macro-scale monitoring would include outfall monitoring taken with a probabilistic approach in the selection of short-term stormwater outfall monitoring sites around the Tahoe Basin. This constant rotation in outfall monitoring would provide a comprehensive long-term basin-wide data set that allows us to extrapolate beyond the limited scope of Index Station monitoring (vis-à-vis, effects from local geology, urban land-use characteristics, regional meteorological patterns, etc.). Taken together, this monitoring across spatio-temporal scales will allow for scientific-based evaluations of changes in pollutant loading to Lake Tahoe.

10.1 Pollutant Source Monitoring

As stated in Section 6.2, characteristic runoff concentration (CRC) data were used in the formulation of the PLRM. This dataset includes values for both road runoff and for other land uses not related to roads.

A prominent feature of the PLRM Road Methodology is that "the relative condition of an urban road can be correlated to predictable characteristic runoff concentrations" (Lahontan and NDEP 2009b). The PLRM has developed relationships between road pollutant potential scores and available data for CRCs (e.g. Figure A-5 in Lahontan and NDEP 2009b). By necessity there were numerous assumptions used in the development of the Road Methodology. Some of these assumptions will require a dedicated research program to address (e.g. influence of source controls such as road abrasive application, road shoulder protection or stabilization, and street sweeping programs on road pollutant potential scores). Others can be either addressed directly or supported by monitoring data. A key need within the PLRM that must be informed by the RSMWP monitoring program is an *update to the relationships between road pollutant potential scores and pollutant potential CRCs*.

In addition, a relationship between parcel land-use condition and CRC has yet to be developed in the same manner as was done for the PLRM Road Methodology.

A monitoring program designed to contribute to the updating of pollutant source control issues includes the following.

- Additional monitoring sites are needed to allow for replication at various road pollutant potential scores. Currently, there are six locations used in the existing PLRM Road Methodology. Selection of additional sampling sites to provide an update on the relationship between road pollutant potential score and pollutant potential CRCs, independently for primary and secondary roadways, is desirable to update the PLRM calibration. Locations of particular interest are those roadways that receive minimal drainage from adjacent, non-roadway, land-uses.

- Additional monitoring sites are needed for evaluating CRCs from non-road parcels.
- Water quality monitoring is required for describing runoff characteristics of suspended sediment, fine sediment particles (an estimate of number/mL), total P, dissolved P, total N and dissolved inorganic N, using the autosampler and flow monitoring techniques described in Section 11. Analysis should include turbidity. Conductivity and pH can be added as practical or when specified for a particular site.
- The dataset should include both low, normal and high runoff years to avoid bias.
- Sample frequency must be sufficient to meet agency needs for confidence (see Section 7).
- Field observation data will be needed to calculate the road pollutant potential scores for each monitoring site (refer to Lahontan and NDEP 2009b – Appendix B for details). These include confirmation of road condition, road risk designation, level of road shoulder stabilization and protection, road abrasive application strategy, and pollutant recovery effectiveness.
- The final sampling design should include sampling from impervious and pervious landscapes.

10.2 Load Reduction Capability of Specific BMPs

With few exceptions, the Basin does not have either (1) long-term BMP monitoring sites or (2) much useful data on the ability of specific BMPs to remove fine sediment particles from urban stormwater. These data are vital to test some of the BMP performance assumptions used in the PLRM and the BMP RAM. In particular these focus on the characteristic effluent concentrations (CECs) used by PLRM to calculate load reduction. If sampled with sufficient frequency the CEC measurements can be used to represent treatment effectiveness when compared with CRC or inflow concentrations. This provides an estimate of treatment efficiency (taken by themselves CECs represent levels of pollutants transported downstream). Within the PLRM this information is combined with data on hydrologic flow to estimate the load reduction within a stormwater treatment facility (Lahontan and NDEP 2009b).

In addition, more data on BMP CECs and effectiveness are required to update the calibration of the BMP RAM.

An investigation of potential pollutant control options for use in urbanized drainages at Lake Tahoe fall into one of three broad categories (1) hydrologic source control, (2) pollutant source control and (3) stormwater treatment (Lahontan and NDEP 2008a), where,

- Pollutant Source Controls (PSC) reduce the potential for pollutants of concern to be mobilized and transported.
- Hydrologic Source Controls (HSC) reduce runoff by retaining or providing/amending for the processes of runoff interception, infiltration, and evapotranspiration.
- Stormwater Treatment (SWT) removes pollutants after they have entered concentrated storm water runoff flow paths.

The PLRM includes recommended CECs for the stormwater treatment facilities (SWT). Currently, the recommended CEC values presented in Table 7.3 of the PLRM report came from a variety of sources including Reuter et al. (2001), Geosyntec (2005), 2NDNATURE (2006), nhc and Geosyntec Consultants (2006), Geosyntec Consultants and Wright Water Engineers (2006) and Lahontan and NDEP (2008a). According to the *PLRM – Model Development Document*, the overall confidence in the initial CEC values was moderate; however, "the refinement of CECs will benefit from future testing in the PLRM to improve understanding of the relationship between CECs and average annual load reductions that can be reasonably achieved by a stormwater treatment facility." This will be addressed by RSWMP directed monitoring on selected BMPs.

A monitoring program designed to contribute to the updating of BMP Load Reduction issues include the following.

- Update the CECs currently in the PLRM for stormwater treatment facilities, and include other BMPs that fall under the categories of pollutant source control and hydrologic source control.
- Given the importance of street sweeping to calculations in the PLRM, an updated and more informed dataset on street sweeper efficiency is required.
- Water quality monitoring is required for describing stormwater treatment of suspended sediment, fine sediment particles (an estimate of number/mL), total P, dissolved P, total N and dissolved inorganic N, using the autosampler and flow monitoring techniques described in Section 11. Analysis should include turbidity. Conductivity and pH can be added as practical or when specified for a particular site.

- The dataset should include both low, normal and high runoff years to avoid bias. However, the BMP condition may change as a result of poor maintenance, age or other factors. Since BMP monitoring is needed to support BMP RAM observations, and since the life-time of a BMP could be on the order of 20 or more years, a long-term RSWMP BMP monitoring program will be required.
- Sample frequency must be sufficient to meet agency needs for confidence (see Section 7).
- Field observation data on condition will be needed to calculate BMP RAM scores for each monitoring site (2NDNATURE 2009a,b). These include constant head parameter readings to measure the saturated hydraulic conductivity (K_{sat}), material accumulation, visual observations of BMP structure, type and density of vegetation, visual inspection of inflow and outflow structures. Water quality sampling and observations of condition need to be done simultaneously.

10.3 Pollutant Load Reduction Monitoring

The PLRM tool is intended to operate on a project scale of roughly 10-100 acres. As discussed previously, PLRM is a modeling tool that uses our current understanding of urban hydrology, BMP effectiveness, geology, etc. to simulate sediment and nutrient load reductions as urban stormwater passes through a project area. While a few initial attempts have been made to field test the PLRM (Lahontan and NDEP 2009b), a much more extensive monitoring program is required to validate the PLRM for use in the Lake Clarity Crediting Program and for the TMDL Management System. Similarly, the Road RAM and BMP RAM also require more extensive validation. Recently, 2NDNATURE released a report entitled, *Focused Stormwater Monitoring to Validate Water Quality Source Control and Treatment Assumptions* (2NDNATURE 2009b). That document reports on field work to evaluate the Road RAM and the BMP RAM. Please note that the use of the term PLRM in this section does not imply that it is or will be the only tool for calculating clarity credits. There are other methods and tools that may be technically appropriate for this purpose. Ultimately, we expect that RSWMP field data will be able to provide a side-by-side comparison between these various approaches. The decision to accept various and specific tools for load reduction calculation falls under the purview of the TMDL agencies. The goal of RSWMP is to provide the monitoring data that will support these evaluations and decisions.

The advantage of a long-term RSWMP monitoring program is that a multiple-year strategy can be developed in which PLRM validation monitoring would be performed at project sites over time. A key goal of this monitoring will be to compare the observed pollutant load from a project area with that predicted or expected based on PLRM output. As discussions related to PLRM validation monitoring for urban stormwater continue, the following topics will need to be considered:

- PLRM-RAM validation monitoring is not applied to each load reduction project. It is recommended that validation monitoring focus on projects that include multiple BMPs and pollutant reduction activities. A project with a single BMP would most likely fall under the category of BMP effectiveness monitoring.
- Initiate PLRM-RAM validation monitoring at no less that two locations each year representing different load reduction activities.
- The outlet site for the entire project boundary will require the full, event-based monitoring design using autosamplers, as discussed in Section 11.
- Mapping and condition assessment for urban drainage area and the treatment BMPs is required for both the PLRM and the RAMs. It is important to evaluate urban hydrology (including, pervious-impervious connectivity, surface flow, infiltration, etc.) to the extent possible. All loads reduction actions, including BMP maintenance, street sweeping and abrasive applications, etc. require careful documentation.
- PLRM model simulations will be required for the monitored projects.
- A technique for comparing the annual observed pollutant loads (based on field data) to PLRM output (modeled over appropriate time periods) will need to be developed, based on initial findings of the monitoring program. The TMDL Management System should develop a statistically-based set of guidelines to determine if the PLRM and monitoring data are in agreement. Without sufficient data at this time, it is very difficult to predict how many years a validation experiment will need to run in order to develop statistically robust conclusions. Given the highly variable nature of precipitation and runoff on a variety of time scales (individual storm events, seasonally and annually), even a few years of monitoring data may not be sufficient to adjust the continuous simulation PLRM model, which uses an extended (15-20 year) meteorological data set; i.e., the likelihood that any given year of observed data matching the predicted model output is not high. During the next phase of RSWMP we recommend a pilot study be initiated to compare predicted versus observed data, and for assessing the uncertainty related to the meteorologic structure used in the PLRM. Again, it is important for RSWMP stakeholders understand that these modifications to stormwater models and tools should be based on data developed for this purpose.

- An active research program needs to provide companion information on topics such as the relative importance of seasonal versus average annual results for PLRM-RAM validation.
- There must be a continued focus on the processes relevant to generation, transport and treatment of fine sediment particles.

10.4 Stormwater Status and Trends Monitoring

The TMDL source analysis studies show the importance of urban runoff in affecting lake clarity. While there are existing long-term monitoring programs with established sites to evaluate the status and trends of lake clarity, stream loading and nutrient deposition from the atmosphere, there are no comparable sites for urban runoff. By carefully selecting monitoring sites for urban runoff and operating these into the future, entities in the Tahoe Basin will be able to analyze the long-term trends in urban loading. This will be especially useful for water quality planning and TMDL implementation (evaluating progress towards TMDL targets) when accompanied by information on watershed condition and associated BMP actions within the watershed to reduce runoff loads. This differs from specific BMP monitoring in that it recognizes a larger and longer-term perspective, and that what leaves a single BMP is often modified as it flows towards a receiving water body. Data from this monitoring will inform stakeholders about load reductions on the larger drainage/catchment scale, and the extent to which it is working as projected with implementation of water quality improvement projects. This is the type of information being requested by state and federal funders of the EIP.

Establishing a program of monitoring at long-term stormwater index sites and stormwater outfall sites will allow for the assessment of load reduction at the watershed and sub-basin drainage scale, comparable to the LTIMP stream, lake and atmospheric deposition programs. RSWMP will implement effectiveness monitoring by evaluating changes in the trends of pollutant loading from drainage and watershed areas with high pollutant loads where water quality improvement projects are implemented over time.

Monitoring designed to evaluate changes in the status and trends of stormwater runoff resulting from project implementation should address the following.

- Monitoring should include geographic regions such as neighborhoods, sub-watersheds and other areas where multiple BMP projects are installed. Until the monitoring needs of the urban stormwater management program are fully developed as part of the TMDL Management System or its equivalent, the specific sites for sampling cannot be finalized.

- Monitoring of stormwater index sites needs to be operated over a decadal time scale (at least 10 years).
- Probabilistic monitoring of urban outflows (either to the lake or to main tributaries) will allow agencies, implementers and scientists to extrapolate beyond findings from the location-specific stormwater index sites. This outflow monitoring is also an indicator of the extent to which selected index stations are representative of basin-wide conditions.
- As part of the final selection of the stormwater index sites and outfall site locations, a range of conditions should be considered, e.g. geology, slope, hydraulic connectivity within the catchment, urban land uses, new or proposed BMP/restoration actions anticipated, etc.
- Sample frequency must be sufficient to meet agency needs for confidence (see Section 7).
- Field observation data on watershed condition, BMP implementation, and other load reduction actions need to be documented.
- Water quality monitoring is required for describing suspended sediment, fine sediment particles (an estimate of number/mL), total P, dissolved P, total N and dissolved inorganic N, using the autosampler and flow monitoring techniques described in Section 11. Analysis should include turbidity. Conductivity and pH can be added as practical or when specified for a particular site.

10.5 Selection of Monitoring Locations

On April 30, 2010 the Tahoe Stormwater Executives issued a memo to the RSWMP development team requesting that identification of specific monitoring sites be postponed, pending further discussion between the regulatory agencies and the urban stormwater jurisdictions. They anticipated a negotiated process to determine the type, number and location of RSWMP affiliated BMP and stormwater monitoring sites. Therefore, this aspect of the QAPP awaits future direction and needs to be part of the TMDL-directed process.

RSWMP Phase 2, however, developed several components of a strategy for identification of potential monitoring targets. This included the review of existing BMP types and nomenclature, with the goal of producing a key to BMP listings that would be consistent with varied terminology used by the PLRM, the jurisdictional Municipal Annual Reports, the TRPA BMP Handbook update, and the BMP RAM technical document. An accounting of existing capital projects by the different jurisdictions for each BMP type was then assembled based on information provided in Municipal Annual Reports and from the Nevada Tahoe Conservation District (NTCD). This accounting indicates the relative amount and cost of BMP implementation by types across the Tahoe Basin. A summary of existing and proposed EIP projects was then assembled and distributed for jurisdictional feedback. Finally, a compilation of outfall sites was developed, based on existing GIS information from various sources. Taken together these tools will aid in selection of optimal locations for implementation of the monitoring approach described above, once that decision process has been completed by the TMDL agencies as part of the TMDL Management System. A summary of this supporting material for the site selection process is provided in Appendix C.

11) Monitoring and Sampling Methods

Once sites have been selected as described above, this portion of the document will be prepared in greater detail. Based on the type of monitoring identified, the intended use of that information, and the duration of monitoring anticipated, this section will provide a set of protocols for site management and sampling requirements. Note that general recommendations related to site selection, sampling frequency, constituents and recommended statistical approaches for data analysis will be included in this document, whereas technical specifications for each site installation, field procedures, data collection, sample processing, and sample analysis will be developed in the Sampling and Analysis Plan (SAP) or provided as addendum materials. Below is a short summary of several critical steps for stormwater monitoring and sampling, as taken from the RSWMP SAP.

11.1 Equipment Installation and Maintenance

Personnel responsible for affiliated sampling stations should be previously trained in appropriate RSWMP methods for collecting stormwater data and samples. Sampling sites should be visited as needed, primarily dependent on frequency of flow events, to ensure that equipment will operate during events, that probes are operational and calibrated, and that the flume and culverts are free of any debris. Routine calibration should be performed at each site on an annual to biannual basis. Calibration results and changes to equipment should be recorded in a field logbook for that site and communicated on standard form to the RSWMP Technical Unit.

Make sure that exact times and parameters are properly maintained on autosamplers, data loggers, precipitation gauges and other equipment. Even slight errors in time will confound later data analyses. Do not adjust for daylight savings time, leave samplers and other equipment on Pacific Standard Time.

Verify proper function of all equipment. Check batteries for proper charging. If battery voltage is 12.4 volts or lower, batteries must be charged. If the site is equipped with solar panels, ensure all connections are properly attached and panels are free of all snow, ice or debris. Make sure that all sensors, intake tubes, rain gauges, and strainers are in good working order, and clear of debris, ice, and sediment. Check internal and external desiccant condition in electronic components and replace before expired. Check sampler tubing for wear or breaks. Note any changes in the field log at each site.

Flow monitoring equipment should be calibrated seasonally. This calibration is to assure that coefficients for calculations (manual or automated Manning's equation) are accurate. Also verify sampling and purging volumes. Ensure stage readings are correct by removing bubbler/AV sensors and placing them in a container with known water depth.

Keep a small watertight container in the housing at each site. This should contain a write-in-the-rain field pad, pencils or waterproof pen (to record any maintenance work, problems, changes), Sharpie^{TM} or indelible pen for labeling bottles, tools to effect repairs and adjust the distributor arm on autosamplers, fuses, etc.

Perform seasonal site inspection and maintenance. Perform biannual or quarterly maintenance, as appropriate for each site.

Remove snow and ice from around equipment and flumes to ensure accurate measurements. Snow, especially plowed snow, can inhibit flow readings in primary flow devises (flumes, weirs, etc.) by damming or diverting the flows. This task is tedious but a very important step that ensures unrestricted flow of water through the primary measuring device.

11.2 Event Preparation

Weather monitoring is critical for preparation of sampling equipment and crews. In most cases, monitoring local weather forecasts provides several days of advance notice on event type and approximate size. Unfortunately, a disproportionate number of these events seem to occur at night, on weekends, and during the holidays. Field crews must adequately prepare in advance for these events by checking and programming equipment at each site, having clean sample bottles on hand and establishing logistical plans to visit each site during the event in order to verify proper function.

Have all sampling bottles and lids clean and ready to go before each storm. Be sure all bottles are in good condition to avoid leakage or contamination of all or part of a sample. All bottles should be soap scrubbed, hot water rinsed, acid washed, then rinsed three times with lab-certified deionized water before use. Store bottles with caps on after washing to prevent contamination.

Check for adequate inventory of bottles, filters and other consumable items. Anything used for sample collection and processing should be available before each storm event arrives. Samples should be processed and filtered within 48 hours of collection for subsequent chemical analyses. That is not usually enough time to get new materials ordered and delivered.

Verify placement and labeling of bottles. When exchanging bottles or sampler bases; make sure that the correct bottles were indeed filled as reported by the equipment. Note any exceptions or errors in the field log. Label caps with site ID, date and bottle number. Use indelible marker. Verify labels are correct before removing bottles from the site.

Estimate storm duration and intensity. Use the estimate to calculate a reasonable flow volume or time interval for sampler programming at each site in anticipation of runoff patterns. This will usually be based upon site specific experience, so results should be recorded in the field log for future reference. It is recommended that you visit each site regularly during an event to ensure that the equipment is working properly and that the sampling interval is set to collect representative samples.

Check equipment and site condition. Verify that batteries are fully charged by checking voltages with a VOM-multimeter. Make sure that all sensors, intake tubes, strainers, flumes and culverts are clear of debris and sediment.

Take baseline samples prior to storm arrival. It is generally recommended that a sample be collected within a 24 hour period before an event to assess existing flow conditions at each site.

Set autosamplers to start at the beginning of runoff event. It is important to capture the entire event hydrograph whenever possible. So flow monitoring should always commence before the storm begins. The autosampler program should be set to start running at a certain trigger (change in flow or level, a specific time, etc.) Alternatively, start the autosampler manually just prior to runoff or as soon as possible after the storm begins.

11.3 Event Monitoring and Sampling

Managing site installations for flow measurement and sampling requires a considerable investment of personnel time for quality data collection. The equipment itself must be closely monitored during the course of an event to assure appropriate function. Many events within the Tahoe Basin produce runoff over extended periods, such that field crews must alternate to maintain proper function of equipment, interval timing, debris removal and bottle exchange.

Safety should always be paramount in the installation and the operation of sampling equipment, during site access, and while traveling between sites in the midst of summer and winter storms. Always wear protective gear and carry emergency supplies. Verify that vaccinations against tetanus and hepatitis are current. Avoid flooding channels whenever rising waters are hazardous. Always park vehicles in a safe location.

Reliable flow measurements should always accompany sample collection. Samples taken without corresponding flow measurements are not generally analyzed. Therefore, field crews must verify that equipment is operational before an event begins, and then return shortly after runoff starts to verify that samplers were triggered correctly and are logging the flow data. Over extended runoff periods at automated sampler sites, crews will generally return at least every 6 hours, and frequently as often as every 2 hours to change out bottles and check for problems.

Constant volume interval sampling is preferred. This requires continuous flow measurements and electronic equipment that calculates the volume of flow that has passed a sensor. At each instance of a preset discharge volume (typically cubic feet) the sampler is triggered to take another sample. However, this approach is not always practical, especially when a new site is brought online and the runoff characteristics for its drainage basin are unknown or poorly defined.

Constant time interval sampling should be used when constant volume intervals are not possible or practical. This method still requires that flow is measured continuously, but sampling occurs at a fixed time interval considered appropriate for the site. Typical intervals may range from 30 minutes to 2 hours, although shorter intervals may be required for intense, short duration events.

Grab sampling at regular time intervals is recommended as a last resort. Grab sampling is recommended if automated sampling is not performing reliably or is not available at a target site. Flow measurements are required as each sample is taken. These may be taken with automated flow monitoring equipment or by manual methods when necessary.

Sampling density should be sufficient to capture a range of representative points in the hydrograph. This decision is usually dependent upon the type and duration of the storm anticipated and the experience of field crews in assessing prior runoff volumes. For an event to be classified as good, we recommend a minimum target of 10 or more samples from each site during an event of 24 hours or less and a hydrograph showing the entire event from start to finish. More samples would be better, but there are practical limitations.

When removing bottles immediately cap, check labels, fill out field logs, download data and transport to the lab for processing. Take extreme caution to avoid any potential for sample misidentification or contamination. Note any unusual conditions or circumstances in the field logs. Use indelible pens to mark labels or bottles. Mark and number bottle caps sequentially and verify identification before removing from the sampler site. Samples are transported in coolers at constant temperature (near 4°C). Make sure bottles caps are tight, and try to keep bottle upright. Take care not to contaminate the sample with rain drops, vehicle exhaust, dirty hands, etc.

Download flow sensor data when removing samples. Download the flow and sampling data from each site onto Sigma Data Transfer Units (DTUs), Isco Rapid Transfer Devices (RTDs), or onto laptop computers. This should be done each time the bottles are removed. When sampling events are infrequent, data should be offloaded on a bi-monthly basis. Repeat a data download if there is any question about the integrity of data transfer.

12) Sample Handling and Custody Procedures

Identification information for each sample is recorded on bottle labels or on a standardized field data sheet when the sample is collected. This information should include the sample location, sample number, date and time of collection, sampler's name, and method used to preserve sample (if any). Samples are placed in coolers on ice and processed in the field laboratory.

Samples delivered to the field processing facility will typically not require specific custody procedures, because in most cases they will be delivered immediately to the field facility of the organization for which the person works. If required or as necessary, however, samples collected in the field will be recorded on a standard chain of custody form for delivery to outside laboratories.

Table 2 describes the appropriate type container bottle for collecting and transporting samples and maximum holding times. Samples must be placed on ice in coolers and sent immediately for analysis of nutrients and particle size distribution in order to be analyzed within the desired holding times.

Table 2. Sample bottles and holding times.

Analyte	ID	Sample Container	Preferred Holding Conditions
Soluble Reactive Phosphorus (orthophosphate)	SRP	Polyethylene sampling bottle	Filtered sample in the dark at 4°C, up to 7 days or freeze
Total Dissolved Phosphorus	TDP	Polyethylene sampling bottle	Filtered sample in the dark at 4°C, up to 28 days or freeze
Total Phosphorus	TP	Polyethylene sampling bottle	In the dark at 4°C, up to 28 days or freeze
Nitrate + Nitrite	$[NO_3+NO_2]$-N	Polyethylene sampling bottle	In the dark at 4°C, up to 7 days or freeze
Ammonia	NH_3-N	Polyethylene sampling bottle	Filtered sample in the dark at 4°C, up to 7 days or freeze
Total Kjeldahl Nitrogen	TKN	Polyethylene sampling bottle	In the dark at 4°C, up to 28 days or freeze
Total Suspended Solids	TSS	Polyethylene sampling bottle	In the dark at 4°C, up to 7 days
Suspended Sediment Concentration	SSC	Polyethylene sampling bottle	In the dark at 4°C, up to 7 days
Turbidity	Turbidity	Polyethylene sampling bottle	In the dark at 4°C, up to 7 days
Electrical Conductivity	EC	Polyethylene sampling bottle	In the dark at 4°C, up to 28 days
pH	pH	Polyethylene sampling bottle	In the dark at 4°C, up to 7 days
Particle Size Distribution	PSD	Polyethylene sampling bottle	In the dark at 4°C, up to 7 days

Chemical preservatives are often added to water samples to prolong the stability of specific constituents during storage. The laboratory will first divide the submitted sample into appropriate bottles for each analysis and then add a specific chemical preservative appropriate for each analysis. The use of preservatives is best left to analytical laboratory staff, as the use of bottles pre-filled with preservatives increases logistical problems for the field crew. Ideally, samples for analysis of dissolved nutrients should filtered with 48 hours through clean 0.45 µm membrane filters.

Chain of custody (COC) forms must be filled out for all samples submitted to the laboratory. At a minimum, these forms must contain a sample date, sample location, and analyses requested. An example COC is provided in Appendix D. Place COC forms in a watertight plastic bag and place in the cooler with the samples. Keep a hardcopy of all COC forms in a binder for reference. When shipping samples, it is good practice to also include the shipper's initials, date/time shipped, and the shipping service's parcel tracking number on the COC.

Be sure to verify that deliveries (usually overnight shipping) will be received at the appropriate time. Some labs are closed over the weekends and holidays, so samples would potentially sit undelivered and unrefrigerated. Verify that the shipment has been received either: (a) with the shipper using the parcel tracking number; (b) with a phone call to the lab, or (c) by other method pre-arranged with the analytical laboratory.

12.1 Field Requirements

Once samples are collected they must be delivered to the lab for immediate processing and analytic preparation. There are certain data that must accompany this delivery, including a list of sample dates and times, sampling errors, and discharge logs. Sample processing personnel may also need to be notified of samples in storage for processing or analysis. There are specific holding times within which runoff samples should to be processed and specific analyses should be performed, as listed in Table 2.

Samples should be transported and stored at low temperatures. Keep samples at about 4°C. Higher temperatures stimulate bacteria and algal growth, as well as other chemical reactions. Use coolers with frozen gel packs or water bottles. Standard ice works also, but the melt water can dissolve labels. Use clear, wide packing tape to secure labels if there is any danger they may fall off in transport. This is true for the transport of both sample bottles and analysis bottles. Keep samples in the dark as much as practical.

A sample log should be created when samples are delivered to their processing site. Upload the flow and sampling data from each site onto a designated computer. This information is then compiled at the laboratory into a sample log data sheet that indicates which samples should be processed or composited. A compositing schedule would be included on this sheet as necessary.

12.2 Sample Processing

Decide whether to create flow-weighted composite samples or analyze as individual samples. This will depend upon a number of factors. Most important is the current sample backlog. All analyses have a maximum holding period (see Table 2 for recommendations). If the chemists or contract laboratory already have a backlog of analyses to be completed within the recommended holding times, consider creating composites for the event. These composites may be created at the field processing facility, or alternatively sent to the analytic laboratory with specific instructions for compositing the individual samples. Details on sample compositing are provided in the SAP.

Optional field laboratory analysis. If a field laboratory is available, it may be preferred to immediately conduct some analyses in the process of sample processing, such as TSS, turbidity, pH (and filtrations for soluble fractions). In this case, be sure to reference the SAP for recommended procedures.

Bottle washing. If clean bottles are not provided by the analytic laboratory, then the field facility may prepare clean bottles by using a Liquinox wash and scrub, followed by a rinse with hot tap water, a thorough rinse with a 0.1N HCL solution, and finally three laboratory-grade deionized water rinses.

13) Analytical Methods Requirements

It is important to select one or more analytical laboratories that are capable of conducting the desired analyses. Selection criteria include location, performance, ability to meet analytical reporting limits (RLs), and past experience with both the sample types and the expected concentration ranges that will be collected by the monitoring program. A local laboratory can provide logistical support by providing sample bottles, supplies, and other equipment on short notice, as well as provide sample preservation and analysis services. The analytical laboratory should also contribute to the development of sampling.

Each laboratory that performs water quality analyses will require certification. Typically most laboratories have such certification coming from such sources as a state run program, the USEPA, USGS or others. Prior to being accepted as an RSWMP lab this documentation needs to be reviewed by the RSWMP Technical Unit and the RSWMP Operations Committee (see Figure 1). It is acknowledged that there are numerous analytic methodologies that can adequately measure the constituents of concern for RSWMP. While it is not necessary to restrict participants to a single analytical method, unpublished methods should not be accepted and all QA/QC requirements as defined in Tables 1 through 4 have to be met.

Analytes monitored in Lake Tahoe basin stormwater are shown in Table 3, along with preferred analytic methods (Standard Methods, USGS, ASTM) and reporting limits. These are the methods that have been routinely used by laboratories for analysis of LTIMP and TMDL samples. While some laboratories may sometimes report at higher levels than the targeted limits shown in Table 3, they should be as close as practical or better. Note that method detection limits (MDLs) are lab specific, can change over time, and will always be less than the reporting limits. The determination of MDL is required for nutrients but typically not available for pH, conductivity, turbidity, suspended solids, suspended sediment, or particle size distribution. 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 3. 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

Further information on laboratory methods can be obtained from the respective DRI and UC Davis laboratory manuals (Thomas et al., 2008; Goldman et al. 2002), as well as from other laboratory manuals, e.g. Standard Methods (APHA, 1992), the USGS (1985), and the EPA (1994).

14) Quality Control Requirements

Quality control samples will be taken following the schedule shown in Table 4 to ensure that valid data are collected. Depending on the constituent, quality control samples will consist of at least one equipment or field blank and a duplicate sample taken during each sampling event. These will be submitted with a frequency of at least 5% of samples submitted for analysis, or at minimum of one per sampling event, whichever is greater.

Table 4. Recommended QA/QC 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).

In addition, samples will be periodically split and analyzed as part of an RSWMP inter-laboratory quality control program. When analytical results for split samples analyzed by affiliate laboratories differ by greater than 20%, laboratory methods will be compared and modified as needed (unless concentrations are near the detection limit) to ensure that comparable data are obtained from each laboratory conducting RSWMP analyses.

Laboratory blanks, spikes, replicates, and standards will be prepared during analyses to provide adequate laboratory QA/QC. These QC samples are routinely run in the laboratories as part of their Standard Operating Procedures, which will be reviewed annually by RSWMP Technical Unit personnel.

14.1 Field Quality Control

Field blanks are prepared in the field by pouring deionized (DI) analytic lab water into sample bottles that are then exposed to equivalent conditions as the standard sample bottles. It is best when these are labeled in a manner that will be blind to the processing lab and analytic laboratory. Try to collect one of these every event at alternating sites. If problems are detected by analysis of these field blanks, it may become necessary to introduce additional blanks at various field and processing steps to determine where the contamination is occurring. The different types of blanks typically used in assessment of contamination sources are shown below (adapted from Geosyntec et al., 2009).

- **Method (Processing) Blanks** are prepared during sample processing by passing clean laboratory-grade deionized water through the same processing steps. They are used to determine the level of contamination introduced by laboratory sample processing (different from analytic blank).
- **Source Solution Blanks** are determined by analysis of the deionized water used to prepare the other blanks. The source solution blank is used to account for contamination introduced by the deionized water when evaluating the other blanks.
- **Bottle Blanks** are prepared by filling a clean bottle with source solution water and measuring the solution concentration. Bottle blanks include contamination introduced by the source solution water and sample containers. By subtracting the source solution blank result, the amount of contamination introduced by the sample containers can be determined.
- **Travel Blanks** are prepared by filling a sample container in the laboratory with laboratory grade deionized water and shipping the filled water along with the empty sample containers to the site. The travel blank is shipped back with the samples and analyzed like a sample. The bottle blank result can be subtracted from the travel blank to account for contamination introduced during transport from the laboratory to the field and back to the laboratory.
- **Equipment Blanks** are usually prepared in the laboratory after cleaning the sampling equipment. These blanks can be used to account for sample contamination introduced by the sampling equipment, if the bottle blank results are first subtracted.
- **Field Blanks** account for all of the above sources of contamination. Field blanks are prepared in the field after cleaning the equipment and sampling laboratory-grade deionized water with the equipment. They include sources of contamination introduced by reagent water, sampling equipment, containers, handling, preservation, and analysis. Because the field blank is an overall measure of all sources of contamination, it is used to determine if there are any blank problems.

Field replicates are useful for detecting problems in sample collection, handling, transport, and processing. With automated equipment it is not strictly practical to collect true replicate samples, unless one triggers the sampler manually. In this case, manually triggered samples should be accompanied by a manual sample replicate. Another option is to take a manually triggered sample that is accompanied by a grab sample. It is recommended that this procedure should be performed at alternating sites about once per event. Again, the sample should be submitted blind.

14.2 Laboratory Quality Control

Lab duplicates are created at the processing stage. They are useful for identifying problems due to sample processing and analysis. We recommend that one or two of these should be run with each sampling event. Employ the same processing conditions as used with standard samples. Label these as laboratory duplicates, with the same identification as their source sample. Additional laboratory QC samples are to be included as shown in Table 4.

- **Analytic Blanks** are run by the laboratory with each batch of samples to determine the level of contamination associated with laboratory reagents and glassware. These results are different from the analysis of method blanks, which represent contamination introduced by sample processing, when necessary (e.g., sample filtration or digestion).
- **Laboratory Duplicates** where one sample is split into two portions and analyzed twice. The purpose of the laboratory duplicate analysis is to assess the reproducibility of the analysis methods. Results of the laboratory duplicate analysis should be reported with the sample results. Be aware that sample splitting methods such as churn and cone splitters may result in higher error for TSS duplicates.
- **Matrix Spikes** are used to assess analyte recovery and data quality. Matrix spike and spike duplicate samples are prepared by adding a known amount of target compound to the sample. The spiked sample is analyzed to determine the percent recovery of the target compound in the sample matrix. Results of the spike and spike duplicate percent recovery are compared to determine the precision of the analysis. Results of the matrix spike and spike duplicate samples should be reported with the sample results. If the spike is significantly more or significantly less than the concentration of analyte in the sample, it may not yield useful information. A blank spike should also be analyzed with each run to measure the ability of the laboratory and the method to recover that analyte in the absence of sample matrix. If recovery is good (within the designated recovery range for the analyte and method) for the blank spike, but poor (outside the recovery range) for the matrix spike, possible matrix interference in the sample should be reported.
- **Standard Reference Material (SRM) or Quality Control Sample (QCS)** are prepared by an external agency or derived from material different than used for

calibration standards. The concentrations of analytes in the standards are certified within a given range of concentrations. These are used as an external check on laboratory accuracy. One external reference standard appropriate to the sample matrix should be analyzed and reported at least quarterly by the laboratory. If possible, one reference standard should be analyzed with each batch of samples.

- **Audit Samples** are blind submissions prepared by a third party to contain the pollutants of concern. Putative concentrations are known only to the organization preparing the sample, and each analytic lab sends their results back to the issuing entity. For example, both the US EPA and the US Geological Survey have this type of analytic audit program. Refer to Section 14.3 regarding the internal audit samples that are included as part of the RSWMP inter-laboratory QC program.

Accuracy will be determined by measuring performance testing samples or standard solutions from sources other than those used for calibration. Precision measurements will be determined periodically on both field and laboratory replicates. The number of replicates for precision estimates of field measurements should be three or more. The number of replicates for precision estimates of laboratory analyses should be at least five. Recovery measurements will be determined by laboratory spiking of a replicate sample with a known concentration of the analyte. The target level of addition should be similar to the original sample concentration. Completeness is the number of analyses generating useable data for each analysis divided by the number of samples submitted for that analysis.

14.3 RSWMP Inter-Laboratory Quality Control Program

The goal of the Tahoe RSWMP is to generate representative, consistent results for stormwater monitoring across the Tahoe Basin. Several regional analytic laboratories have experience in the analysis of Tahoe stormwater samples, which can at times produce very low concentrations requiring optimized methods. Therefore, an inter-laboratory QC program will be established as part of RSWMP to assure that analytic results are relatively consistent, whichever laboratory is conducting the analyses.

A preliminary program was started as part of the Stormwater TMDL Monitoring Program, and will be continued for all laboratories that seek RSWMP endorsement. A minimum of six samples per year will be sent in duplicate to each participating laboratory for specified analyses. The results will be collated quarterly in blind representation, and individual results shared with the corresponding laboratory as follow up on any corrective action that may be necessary. Results from the inter-laboratory QC program will be presented annually in the RSWMP data summary and interpretive reports.

An example of previous comparative inter-laboratory analytic results is shown in Appendix E.

15) Equipment Inspection, Calibration and Maintenance Requirements

Automated samplers, flow meters, and water quality probes require periodic calibration to ensure reliable operation and accurate results. The user is expected to be familiar with the manufacturer's instructions for maintenance and calibration of all equipment used at monitoring locations for measurements and sampling.

Autosamplers need to be calibrated after installation to verify the correct purge and sample volumes are applied. This is especially important when there is evidence of inconsistent sample volumes, or missed sample bottles. The cause can be worn intake tubing, clogged intake strainers, obstructions in the line including ice, or malfunctioning components.

Flow meters are calibrated to stage height in fixed installations, and kept clear of debris, flow obstructions, ice and snow. Data from fixed meter installations should be compared seasonally to manual flow measurements under different flow conditions. Manual flow meters should be compared annually to alternate equipment or flow measurement methods. If data are not consistent the meter should be factory calibrated to correct for measurement error.

Total event volumes recorded by precipitation meters should be compared to bulk measurement methods. This is accomplished by establishing a standard bulk rain gage at the same site as the continuously recording precipitation meter, and comparing results on a seasonal basis. If they do not agree within 10% of total volume, inspect the precipitation meter for damage or return to the factory for repair.

16) Inspection and Acceptance of Supplies and Consumables

This section is not highly applicable to the Lake Tahoe RSWMP. Field sampling does not typically require the use of consumable materials. However, there are two topics that are relevant: (1) each analytical laboratory is required to follow their procedures for inspection and acceptance of supplies and consumables required for the operation of their facilities, with procedures for insuring proper disposal of chemical waste documented in each laboratory's general operating QAPP; and (2) proper operation of the autosamplers requires the use of a chemical desiccant to maintain instrument operation – procedures for the use and disposal of this or any other consumable materials used in the field (such as acid washes or calibration solutions) should be included as appropriate in the field protocols developed by each sampling entity or field facility.

17) Non-Direct Measurements

The Rapid Assessment Methodologies (Road and BMP) that the Lake Tahoe RSWMP will help to calibrate and validate, depend on field observations and measurements that define the relative condition of BMPs and road surfaces. Indeed, the conceptual nature of the RAMs is to be able to establish a quantitative relationship between simple field observations/measurement and more quantitative assessment of water quality. For the purpose of this QAPP, the observations/measurement required to support RAM condition scores are considered non-direct measurements. The field observations required for RAM were developed by 2NDNATURE for use within the Lake Tahoe TMDL (Lahontan and NDEP 2009b; 2NDNATURE 2009a).

Examples of the types of observations required for condition assessment for the BMP RAM include constant head permeameter to measure the saturated hydraulic conductivity (K_{sat}), material accumulation, visual observations of BMP structure, type and density of vegetation, visual inspection of inflow and outflow structures. These observations/ measurements are recorded on field data sheets by the user. The RAM database empirically integrates the field observations with established benchmark and threshold values to generate a BMP RAM score for each treatment BMP (2NDNATURE 2009a).

Similarly, examples of the types of observations required for condition assessment of roads in the PLRM include, road slope, traffic conditions, application frequency of road abrasives (sand), level of road shoulder protection and stabilization and road sweeping effectiveness. These observations are used to calculate a road condition score within the PLRM which in turn is related back to an existing relationship between road pollutant potential score and pollutant potential CRC (characteristic runoff concentration)(Lahontan and NDEP 2009b).

The responsibility for establishing and revising the benchmarks and thresholds, as well as the technical operation of the RAM databases will be defined as part of the TMDL Management System or its equivalent.

18) Documentation and Data Management

All field measurements and observations will be recorded at the time of sampling. Samples collected in the field will be recorded on a standard chain of custody form for delivery to laboratories, as required. A post-event summary report will be generated for each RSWMP sampling site to describe the specific event conditions encountered and to review the flow and sampling data, along with a discussion of any issues encountered during the event or in subsequent sample processing and delivery. All monitoring and analytic data will be entered into Excel spreadsheets, developed for the Tahoe RSWMP Stormwater and BMP Performance Database.

Field and sampling personnel will be responsible for recording and entering all data for this project into the Database. These data and laboratory results will be reviewed by the RSWMP Technical Unit to ensure accuracy and correctness. Outliers and anomalies will be identified using protocols described in the RSWMP SAP for detecting and correcting data entry and analysis errors.

Records generated by this project will be stored on servers hosting the RSWMP data collection. These data will be backed up on CD-RW as acquired and all calculated data will be backed up to off-site servers weekly. Laboratory records pertinent to this project will be maintained at the respective laboratory offices. Each sampling group is responsible for maintaining hardcopy documentation of sampling and analyses, accompanied by electronic copies sent to the RSWMP Technical unit.

Copies of this QAPP and the RSWMP SAP will be distributed to all parties involved with the project. Any future amended QAPPs and SAPs will be held and distributed in the same fashion.

All records will be passed to the Program Manager for review and forwarding as appropriate. The data and analyses generated by this program will be used to create quarterly data reports and annual analysis summaries that address the directives and goals developed by the Operations Committee. Corresponding analysis of QA/QC performance should be done in support of the data reports and annual summaries. A typical site data reporting form is shown in Appendix F. This will include a summary of work accomplished during the reporting period, a summary of findings, changes in project equipment or monitoring approach, and projected work for the next reporting period. These materials will be kept indefinitely in both hardcopy and electronic versions at the office of the Program Manager and with the executive staff of participating RSWMP agencies.

19) Assessment and Response Actions

This section focuses on the assessment of the RSWMP process as presented in Figure 1. That framework defines two avenues that require RSWMP assessment. The first is at a broad scale where the RSWMP Technical Unit interacts with the Executive Management Team, the RSWMP Operations Committee and the Stakeholder Working Group. At this scale, the RSWMP program manager will work with these other groups to insure that (a) the information collected and analyzed by RSWMP is incorporated into the TMDL Management System, (b) the communication of information and results to the public and decision-makers is timely and understandable, (c) the transfer of data to RSWMP is timely and efficient, (d) each year the results are evaluated in order to revise the sampling program as needed and (e) RSWMP results are incorporated back into the load reduction models in an adaptive management framework. The RSWMP program manager and the TMDL agency staff person overseeing the TMDL Management System need to be sure that these issues are addressed. Required response actions should be defined by the TMDL Management System as part of its adaptive management framework.

The second aspect of RSWMP requiring assessment and possible response actions falls under the purview of the RSWMP Technical Unit ("Check" quadrant in Figure 1). This relates to analysis and reporting of data, as well as oversight of field and laboratory activities that produce data. All collected data shall be immediately reviewed by the RSWMP Technical Unit for completeness and accuracy. Errors shall be documented and corrected where feasible, and the team shall generate appropriate corrective action as necessary to improve data quality. The corrected data shall be input to master flow files for each site. RSWMP program staff will further evaluate monitoring results and data on a quarterly basis to verify that data as provided are of appropriate quality and usefulness.

Any recommended modifications to changing the sample design, schedule, or protocols on the basis of the periodic data evaluations, shall be directed through the program manager. Significant modifications to the program should be requested by the RSWMP Management Committee.

20) Programmatic Reporting

As shown in Figure 1, information and results from the RSWMP program is directly relayed to the Executive Management Team. As the TMDL Management System or an equivalent process is developed, it will need to address a number of issues regarding programmatic reporting. The RSWMP program manager should be involved in these discussions. Items to be considered include, but are not limited to (a) specific format of data analysis and presentation style required by the TMDL agencies, (b) scope of evaluation of data to meet TMDL needs (required products from RSWMP), (c) strategy for incorporating new data into revision of model calibration, (d) length of monitoring required to validate load reduction models for specific BMPs/projects, (e) format for presentation of status and trends monitoring results, (f) required documentation for update of RSWMP protocol, and (g) operation of the load reduction models within the TMDL Management System. Once these issues have be discussed and resolved, they should be specified as part of the programmatic reporting by RSWMP. It will also be important to establish a clear definition on the role expected of RSWMP in interacting with other stakeholders.

RSWMP should be expected to produce quarterly data reports for delivery to the Executive Management Team and the RSWMP Operations Committee. RSWMP will produce an annual technical report along with a summary brochure appropriate for the public and other stakeholders. The RSWMP program manager will need to make periodic presentations to stormwater managers and executives. It is envisioned that as RSWMP matures and becomes fully operational, the Technical Unit will have the resources to be able to produce interpretive reports, along with periodic programmatic reviews based on adaptive management and evaluation milestones established within the TMDL Management System.

21) Data Review, Verification and Validation

As the data become available in the RSWMP Database, a periodic review to determine quality and appropriateness will be performed by Technical Unit personnel. Issues will be noted and when necessary, reconciliation and correction will be done by a committee composed of the Data Manager, Field Staff, Analyst, Project Manager and appropriate Laboratory Director. Any corrections require a unanimous agreement that the correction is appropriate

Data outliers will be flagged for verification. The data outliers will then be verified (data entry checked for correctness) and laboratory analysis will be re-checked. If laboratory QA/QC is found to be OK, then the data outlier will be accepted as a real value.

Data will be separated into three categories: data meeting all data quality objectives, data meeting failing precision or recovery criteria, and data failing to meet accuracy criteria. The responsibility for this action will be assumed by the RSWMP Technical Unit. Data meeting all data quality objectives, but with failures of quality assurance/quality control practices will be set aside until the impact of the failure on data quality is determined. Once determined, the data will be moved into either the first category or the last category.

Data falling in the first category is considered usable by the project. Data falling in the last category is considered not usable. Data falling in the second category will have all aspects assessed. If sufficient evidence is found supporting data quality for use in this project, the data will be moved to the first category, but will be flagged with a "J" as per EPA specifications.

Adjustments in sampling location, techniques and analyses will be recommended, as appropriate, as the monitoring program develops. This will involve discussion among team members, including the Technical staff and Operations Committee, and will be done on a quarterly basis.

22) Programmatic Verification and Validation Methods

There are two scales to consider in verification and validation. The first is related to the data gathering process itself. This has either been previously discussed in this report of the Sampling and Analysis Plan (SAP). This includes topics such as collection of field blanks and field replicate samples to insure proper field techniques, and the requirements for analytical accuracy, precision, recovery shown in Table 1. The use of laboratory audit samples and SRMs is also a technique to verify analytical methods. In addition, all measured data is informally compared to the existing database to identify possible outliers.

After the data have been approved, the second scale of verification and validation required for the Lake Tahoe RSWMP involves validation of the modeled (e.g PLRM) versus the measured pollutant load reduction values collected at the project level. As discussed in Section 10, a technique for comparing the annual observed pollutant loads (based on field data) to PLRM output (modeled over a 15 to 20 year period) needs to be developed based on the initial findings of the monitoring program. The TMDL Management System or its equivalent, working in concert with the RSWMP Technical Unit should develop a statistically-based set of guidelines to determine if the PLRM and monitoring data are in agreement.

As recommendations for changes in monitoring approach or sampling design are developed, all four of the groups involved in the RSWMP organizational chart will be involved in decisions about what and how to adjust the monitoring program, based on periodic review of data delivery in relation to priority monitoring goals and objectives.

23) Reconciliation with Data Quality Objectives

The project needs a sufficient numbers of data points, as represented by the completeness data quality objective in order to do trend analyses and determine effects from pollutant load reduction strategies. A failure to achieve the numbers of data points cited could mean an inability to provide these assessments. Guidance on sampling frequency, based on a statistical analysis of the available dataset for two urban stormwater locations is provided in Section 7. Final determination of sample frequency depends on the specific needs of the TMDL agencies and should be developed as part of a jurisdiction and agency-directed process.

The project team will review data quarterly to determine whether the data quality objectives (DQOs) are being adequately met. They will suggest corrective action if necessary.

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Appendix A. RSWMP Stakeholder Participation and Contact List

RSWMP Contact List

Name	**Affiliation**	**Email**	**Contact**
Mahmood Azad	Douglas County	mazad@co.douglas.nv.us	Primary
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Appendix B. RSWMP Group Functions and Responsibilities

Active participation by each of the four RSWMP groups shown in Figure 1 of the QAPP (Section 5.1) will be necessary for development of a fully functional and sustainable RSWMP that operates within an adaptive management framework. The anticipated functional roles for each of these four groups are described in greater detail below.

1) RSWMP Development and Operations Committee. This committee will be composed of a representative from each of the three TMDL agencies – Lahontan Water Board (Lahontan), Nevada Division of Environmental Protection (NDEP) and the Tahoe Regional Planning Agency (TRPA). At least one representative from the RSWMP technical unit will serve on this committee, as well as one representative from the project implementers community, who will act as a working member and as liaison to the Stakeholder Working Group (perhaps through SWQIC). The primary duties are to:

- Receive Executive Management Team input related to program priorities and policy directives and translate this input into programmatic actions and information needs.
- Identify and prioritize critical information needs and data gaps.
- Develop comments and identify information needs that could affect the overall monitoring design.
- Review and approve the monitoring design prepared by the Technical Unit annually (e.g. adequacy of site location, data acquisition [frequency and parameters], etc.) as required by the TMDL Management System, results from RSWMP analysis, and/or dictated by new science based on monitoring, research or modeling both internal and external to the Lake Tahoe Basin.
- Discuss how RSWMP data are being used in support of the TMDL implementation, including the EIP stormwater program, and determine if RSWMP objectives are being achieved.
- Review funding needs and available resources.
- Provide an annual programmatic report to relevant Basin executives, appropriate board members and decision makers, and other stakeholders.
- Develop, review and manage a strategy for public education and outreach.

- Identify and prioritize key management questions related to stormwater issues that could be addressed through research.
- Maintain a relationship with other large stormwater monitoring programs nationally to keep track of their advances.
- Meet on a quarterly basis to discuss the operational condition of field monitoring, monitoring status, status of data delivery, data analysis to date, QA/QC, etc.

2) Stakeholder Working Group. A working group has been active throughout the development of RSWMP during Phase 1 and Phase 2. This group has included a representative from each of the regional stormwater stakeholder groups consisting of jurisdictions, implementers, resource management groups, and regulatory agencies. The organizational structure provided here recommends that SWQIC assume the important responsibilities of the stakeholder working group. Specifically, SWQIC would review products of the Development and Operations Committee and provide comments.

- Oversee and assume responsibility for implementation of stakeholder monitoring and transfer of data to the RSWMP Technical Unit.
- Receive and discuss preliminary data assessments from RSWMP.
- Maintain existing funding sources and work with other groups to seek new sources as needed.
- Evaluate the effectiveness of RSWMP in helping project implementers to meet their regulatory monitoring requirements that are within the domain of RSWMP.
- Provide technical specifications on projects and other treatment actions that are needed for annual assessment of monitoring results by RSWMP.
- Delivery of jurisdictional documents for regulatory purposes (e.g. municipal annual reports) with RSWMP data reports used to meet the water quality monitoring elements of this obligation.
- Meet on a biannual basis with the Operations Committee and RSWMP Technical Unit members to discuss RSWMP activities.

3) RSWMP Technical Unit. This is the group that is directly responsible for operation of RSWMP on a daily basis to accomplish specified RSWMP tasks in terms of developing monitoring practices, sampling and analysis, overseeing external RSWMP-certified monitoring, RSWMP database management and data analysis, producing technical documents and reports, providing information transfer and serving in a technical advisory capacity to the TMDL Executive Management Team. The RSWMP Technical Unit will need a program manager along with a small number of dedicated staff in order to accomplish all the activities outlined below. This Unit is not envisioned as simply a 'monitoring management' entity. While this is part of the overall activities of the RSWMP Unit, expertise in large-scale monitoring design, experimental design and implementation, modeling and model parameters, advanced statistics, database management, and especially evaluation and understanding of water quality data will be critical. The RSWMP Technical Unit must have a sound, comprehensive understanding of stormwater that is science-based.

- Assist stakeholder monitoring groups with site set-up and the ongoing operation of sample collection (includes periodic site visitation).
- Oversee programmatic QA/QC actions (field and laboratory).
- Oversee data management functions.
- Conduct field monitoring and sample analysis as required (e.g. Index Sites).
- Develop and operate the Stormwater and BMP Database and enter all monitoring data into this system.
- Conduct data analysis, synthesize results, and prepare interpretation appropriate for personnel within the regulatory and implementing agencies, and the interested public.
- Quarterly reporting of new data that has passed QA/QC screening.
- Production of annual RSWMP report to Executive Team and Stakeholder Group. Provide data, assessment and interpretation, with insights as to how these results can be used to inform TMDL urban source control program implementation and crediting, EIP stormwater program implementation, and overall priorities.
    - Assessment of site locations and data acquisition (which parameters, frequency, quality of data).
    - Recommendations for changes in monitoring design and objectives.
    - Statistical assessment of data
    - Address specific data objectives
- Deliver data and analysis in a format needed for regulatory requirements and for direct use into the TMDL/EIP Management System.

- Work with TMDL/EIP Management Team to integrate RSWMP data/findings with TMDL management tools.
    - Field validation of PLRM, BMP RAM, Road Ram, etc. for use in lake clarity and crediting and tracking programs
    - Test model/tool assumptions
    - Data for model calibration and improvement
    - Understanding BMP functional processes for use in project design (interaction with Project Implementers Working Group)
    - Inform adaptive management decisions

4) TMDL/EIP Executive Management Team. This team will consist of an executive level representative from each of the Tahoe Basin agencies that have direct responsibility for water quality regulation through the TMDL and/or implementation of the Regional Plan (i.e., TRPA, Lahontan and NDEP). This executive level engagement is essential for RSWMP linkage to the TMDL Management System and other programs, as well as for executive review of conceptual models, strategic and annual plans, synthesis of findings, and use of RSWMP information in the context of management decisions.

- Provide executive level direction for the incorporation of information products from the RSWMP Technical Unit into management programs and policy decisions, including any changes pertaining to:
    - PLRM, BMP RAM, Road RAM and crediting program
    - TMDL Management System
    - Municipal annual reporting requirements and NPDES program
    - Approval of BMP functional assessments for the BMP handbook and database
- Review information and activities pertaining to load reduction progress.
- Evaluate performance milestones.
- Develop TMDL/EIP programmatic recommendations and TMDL priorities.
- Adaptively manage the urban stormwater program within the context of the TMDL Management System.
- Make decisions about program funding, resource allocation, adjustments to TMDL goals, allocations, and program priorities.

Appendix C. Background Information on Monitoring Site Selection

The RSWMP Phase 2 monitoring design has identified the following as relevant to evaluation of existing conditions and potential changes in stormwater pollutant loads and reductions with implementation of the Tahoe TMDL and the EIP:

- Pollutant Source Monitoring
- BMP Performance Assessment Monitoring
- Pollutant Load Reduction Monitoring, and
- Status and Trends Monitoring

Descriptions and information about stormwater structures and facilities in the Tahoe Basin were collected from jurisdictions to facilitate the site selection process for stormwater monitoring. This process, as described below, resulted in the compilation of BMP and outfall inventories, as well as several "feedback forms," which were circulated for collecting additional information.

Tahoe Basin BMP Inventory

Evaluation of pollutant load reductions by stormwater BMPs is one of the main goals for RSWMP targeted monitoring. Obviously, however, not all BMPs can be monitored by RSWMP. Therefore, an effort was initiated with the Stakeholder Working Group to prioritize the BMP types for monitoring. A handout was prepared for discussion in July 2009, based on PLRM documentation for BMPs under the categories of Pollutant Source Control, Hydrologic Source Control, and Stormwater Treatment. It became clear during this discussion that different names were used interchangeably, e.g., "treatment basin" and "wet basin" both of which appeared to refer to the same feature. This led to confusion and contradictory statements about BMP types under discussion. Therefore, an RSWMP key to BMP nomenclature was developed in spreadsheet form (Table C1) to provide a consistent terminology for discussion, and ultimately for compilation of information on existing and proposed BMP projects across different jurisdictions in the Tahoe Basin. Every attempt was made to keep the RSWMP BMP Key consistent with existing PLRM terminology and categories, while also representing the terminology and categories presented in Municipal Annual Reports and the TRPA BMP Handbook update (in progress).

Table C1. RSWMP key to BMP nomenclature.

RSWMP BMP Key	RSWMP synonyms	BMP RAM list synonyms	TRPA list synonyms	PLRM list
Source	Municipal Annual Reports and all other sources listed here.	BMP RAM Technical Document (Final version, September 2009)	TRPA BMP Handbook (Draft version, September 2009)	PLRM (March 2006)
Pollutant Source Control				**Pollutant Source Control**
Curb and gutter	Curb and gutter			Curb and gutter
Revegetation and bare soil cover	Revegetation, bare soil cover, mulch, wood chip mulch, pine needle mulch, soil restoration			Revegetation, soil restoration
Road shoulder stabilization	Road shoulder, road shoulder stabilization			
Slope stabilization	Slope stabilization, riprap, rock slope protection			Rock slope protection
Street sweeping	Street sweeping		Street sweeping	Street sweeping
Hydrologic Source Control				**Hydrologic Source Control**
Flow spreading	Flow spreading, water spreading, grading for sheet flow, sheet flow infiltration			
Impervious area reduction	Impervious area reduction, disconnecting impervious coverage			Remove or disconnect impervious area
Infiltration feature	Infiltration feature, dry well, infiltration trench, roof drip-line, rock-lined channel, infiltration well, soak away pit, infiltration tube, soak hole, sump, sub-surface infiltration system, subsurface drain, slotted pipe, perforated pipe, slotted channel drain, rock-lined swale, rock-lined ditch, percolation trench	Infiltration feature, dry well, infiltration trench, roof drip-line, rock-lined channel	Infiltration trench, infiltration well, soak away pit, infiltration tube, soak hole, sump, drywell, sub-surface infiltration system	Rock-lined ditch
Porous pavement	Porous pavement, porous asphalt, pervious concrete, porous aggregate, grinding shoulders, modular block, pervious pavement, permeable pavement, infiltration parking area, permeable pavers, porous paving	Porous pavement, porous asphalt, pervious concrete, porous aggregate, grinding shoulders, modular block	Pervious pavement, permeable pavement, infiltration parking area, permeable paving, porous paving	Pervious pavement

Table C1. RSWMP key to BMP nomenclature (continued).

RSWMP BMP Key	RSWMP synonyms	BMP RAM list synonyms	TRPA list synonyms	PLRM list
Source	Municipal Annual Reports and all other sources listed here.	BMP RAM Technical Document (Final version, September 2009)	TRPA BMP Handbook (Draft version, September 2009)	PLRM (March 2006)
Hydrologic Source Control				**Hydrologic Source Control**
Biofilter	Biofilter, vegetated swale, vegetated ditch, grass swale, grass filter strip, vegetated buffer strip, bioslopes, vegetated filter strip, grassed buffer strip, filter strip, grassed filter, vegetated buffer, vegetated bio-swale, bioinfiltration swale, grass percolation area, infiltration channel, infiltration swale, infiltration strip	Biofilter, grass swale, grass filter strip, vegetated buffer strip, bioslopes	Vegetated filter strip, grassed buffer strip, filter strip, grassed filter, biofilter, vegetated buffer [TRPA shows vegetated bio-swale, bioinfiltration swale, grass percolation area, infiltration channel as separate category; also in water spreading category]	Vegetated ditch, infiltration swale or strip
Stormwater Treatment				**Stormwater Treatment**
Bed filter	Bed filter, surface sand filter, underground sand filter, perimeter sand filter, sand filter	Bed filter, surface sand filter, underground sand filter, perimeter sand filter, organic media filter	Bed filter, surface sand filter, underground sand filter, perimeter sand filter	Bed filter
Cartridge filter	Cartridge filter, media filter, proprietary media filter, media filtration unit, organic media filter	Cartridge filter, proprietary media filter	Media filtration unit, organic media filter, proprietary media filter [TRPA combine these with bed filters]	Media filter
Dry basin	Dry basin, detention basin, extended detention basin, dry pond, detention pond, hydraulic settling basin, extended detention pond, dry detention basin	Dry basin, extended detention basin, dry pond, detention pond	Dry basin, hydraulic settling basin, dry pond, extended detention pond/basin, dry detention basin	Detention basin
Infiltration basin	Infiltration basin, large-scale infiltration feature, infiltration gallery, infiltration field	Infiltration basin, large-scale infiltration feature	Infiltration basin, infiltration feature	
Sediment trap	Sediment trap, vertical CMP, catch basin, sand can, double sand can, pre-cast concrete box, sediment can, sediment collection device	Sediment trap, vertical CMP, catch basin	Sediment trap, sand can, double sand can, pre-cast concrete box	Sediment trap
Settling basin	Settling basin, concrete forebay	Settling basin, concrete forebay		
Treatment vault	Treatment vault, hydrodynamic device, flow separation vault, hydrodynamic separator, vortex separator, swirl concentrator, oil/grit separator, MCTT, settling chamber, baffle box, vault	Treatment vault, flow separation vault, hydrodynamic separator	[TRPA lists hydrodynamic separator, vortex separator, and swirl concentrator in separate category; and also lists oil/grit separator, and water quality inlet as separate category]	Hydrodynamic device

Table C1. RSWMP key to BMP nomenclature (continued).

RSWMP BMP Key	RSWMP synonyms	BMP RAM list synonyms	TRPA list synonyms	PLRM list
Source	Municipal Annual Reports and all other sources listed here.	BMP RAM Technical Document (Final version, September 2009)	TRPA BMP Handbook (Draft version, September 2009)	PLRM (March 2006)
Stormwater Treatment				**Stormwater Treatment**
Wet basin	Wet basin, wet pond, retention pond, wetland basin, wetland channel, wetland swale, wet extended retention pond, stormwater wetland, constructed wetland, stormwater basin, retention basin, wet extended detention basin, constructed wetland, stormwater wetland	Wet basin, wet pond, retention pond, wetland swale, wet extended retention pond, stormwater wetland, constructed wetland	Wet basin, stormwater basin, retention basin, wet extended detention basin, wet pond [TRPA shows constructed wetland and stormwater wetland as separate category]	Wet pond, wetland basin or channel
Other TRPA Types				
Abrasives and road salt management	Abrasive management, road salt management, road sanding		Abrasive management, road salt management, road sanding	
Cultured periphyton	Cultured periphyton, periphyton biofilm treatment system		Cultured periphyton	
Drop inlet	Drop inlet, DI, drainage inlet, storm drain inlet, drop inlet insert, water quality inlet insert	Drop inlet, DI, storm drain, culvert		
Electro-floculation	Electro-coagulation		Electro-coagulation	
Rain garden	Rain garden, recharge gargen, small vegetated basin, infiltration garden, bio-retention garden, rainwater garden, on-lot infiltration system		Rain garden, recharge gargen, small vegetated basin, infiltration garden, bio-retention garden, rainwater garden, on-lot infiltration system	
Snow storage	Snow storage, snow removal, snow plowing		Snow storage, snow removal, snow plowing	
Tree and planter boxes	Tree and planter boxes, tree box, planter box, tree pit, tree box filter, street tree well		Tree and planter boxes, tree box, planter box, tree pit, tree box filter, street tree well	
Miscellaneous				
AC pavement/overlay	AC pavement/overlay			
AC swale/conveyance swale	AC swale, conveyance swale, asphalt dike, AC dike, berm, water bar			
Check dam	Check dam			
Conveyance pipe	Conveyance pipe, storm drain pipe, storm drain, pipe			Storm drain

Table C1. RSWMP key to BMP nomenclature (continued).

RSWMP BMP Key	RSWMP synonyms	BMP RAM list synonyms	TRPA list synonyms	PLRM list
Source	Municipal Annual Reports and all other sources listed here.	BMP RAM Technical Document (Final version, September 2009)	TRPA BMP Handbook (Draft version, September 2009)	PLRM (March 2006)
Miscellaneous				
Culvert	Culvert			
Drainage channels	Drainage channel, channel			
Energy dissipater	Energy dissipater, outlet protection			
Flow splitter	Flow splitter			
Interceptor box	Interceptor box			
Land use change	Land use change			Land use change
Outfall	Outfall, discharge point			
Private parcel BMPs	Private parcel BMPs			Private parcel BMPs
Rain barrel	Rain barrel, cistern			
Retaining wall	Retaining wall, retaining structure, gabion basket, terracing			Retaining structure
Road surface treatment	Road surface treatment, paving practices			
Silt fence	Silt fence, erosion control fence			
Trash rack	Trash rack, inclined scree			
Stream Environment Zone (SEZ)	Natural Stream Environment Zone for stormwater treatment			
Residential BMPs	Residential BMP program, private BMP implementation, backyard conservation program			Private BMP implementation

The PLRM list of BMP types (nhc et al. March 2006, Lahontan and NDEP 2009b) formed the basis for initial organization and categories in the RSWMP key. This was supplemented by additional BMP types and synonyms listed in the BMP RAM Technical Document (September 2009) and the TRPA BMP Handbook draft update (September 2009). Finally, all BMP names listed in the various Tahoe jurisdictional Municipal Annual Reports were also included, categorized according to the best fit with existing names. This resulted in an RSWMP BMP Key that listed the principal BMP types and synonyms for equivalent BMP names, which was initially distributed in September 2009. This is not meant to be the final iteration of this document, but it provided a needed consistency so additional information could be gathered.

Based on the RSWMP BMP Key, available information on existing BMP applications was assembled from Municipal Annual Reports and from the Nevada Tahoe Conservation District preliminary database for water quality assets. This was used to create an accounting worksheet that shows the distribution of different BMP types by each jurisdiction and the relative scale of application across the Tahoe Basin (Table C2). This BMP accounting worksheet was distributed to the Stakeholder Working Group in December 2009, along with an RSWMP memo suggesting a list of priority BMP types for further discussion on targeted monitoring, considering how many jurisdictions cited them in their Annual Reports, how actively they had been the subject of discussion in Working Group meetings, the level of knowledge or data available on each type, and the anticipated level of implementation in the future. Some of the priority BMPs were flagged as being actively investigated by other programs and projects. The Working Group was asked for examples of sites where BMP types have been monitored in the past or are being monitored now, and where monitoring is anticipated. These could become candidate sites for RSWMP targeted BMP monitoring implementation in Phase 3.

It is notable that the GIS approach used by NTCD represents a good model for what is ultimately needed by RSWMP. Based on project area polygons (mostly EIP-related), the NTCD has conducted a basin-wide inventory of BMPs, including results from importing CAD files that have been georeferenced and where water quality assets are linked to available metadata.

Although incomplete at this time, as data were not available from all jurisdictions and existed in several different formats, it is expected that the example provided by Table C2 can be used by the TMDL agencies to develop a consistent reporting format that helps refine selection of monitoring priorities and opportunities based on needs of the TMDL Management System (see Section 10.5).

Table C2. Accounting of BMP applications by jurisdictions across the Tahoe Basin.

BMP Type	Units	City of South Lake Tahoe	Carson City County	Douglas County	El Dorado County	Placer County	Washoe County	Caltrans	NDOT	Total Reported
Pollutant Source Control										
Curb and gutter	linear feet	1,040		149,685			71,240		151,009	372,974
Revegetation and bare soil cover	square feet			1,133,535			1,374,674		2,574,502	5,082,711
Road shoulder stabilization	linear feet	1,264								1,264
Slope stabilization	square feet			292,436			100,085		1,050,708	1,443,229
Street sweeping										
Hydrologic Source Control										
Flow spreading										
Impervious area reduction	square feet			985						985
Infiltration feature	linear feet			15,645			11,536		483	27,664
Porous pavement										
Biofilter	linear feet			3,631			1,830			5,461
Stormwater Treatment										
Bed filter										
Cartridge filter										
Dry basin	cubic feet			43,455			94,828		42,050	180,333
Infiltration basin	each			2						2
Sediment trap	each			296	159	159	195		10	819
Settling basin										
Treatment vault	each			40			8		19	67
Wet basin	cubic feet	94		1,861,720			39,838			1,901,652
Other TRPA Types										
Abrasives and road salt management										
Cultured periphyton										
Drop inlet	each	1,191		337			55		355	1,938
Electro-floculation										
Rain garden										
Snow storage										
Tree and planter box										
Miscellaneous										
AC pavement / overlay										
AC swale / conveyance swale	each						1			1
Check dam										
Conveyance pipe	linear feet			26,501			30,010		30,101	86,612
Culvert										
Drainage channels	linear feet	148								148
Energy dissipater										
Flow splitter										
Interceptor box										
Outfall *	each	271			273	402	410			1,356
Rain barrel										
Retaining wall	linear feet			28,463			41,978		7,874	78,315
Road surface treatment	square feet						78,280		495	78,775
Silt fence										
Trash rack										
Stream Environment Zone (SEZ)	linear feet			3,030			55,900			58,930
Residential BMP program										

* Derived from RSWMP stormwater outfalls inventory

Environmental Improvement Program (EIP) Project Areas

RSWMP will monitor selected drainage areas and index sites for assessing changes in the stormwater runoff characteristics associated with multiple patterns of land use and EIP implementation as they are integrated on the urban landscape. Monitoring EIP project areas will likely form an important part of the status and trends monitoring for RSWMP. So information about past, ongoing and future activity was solicited from jurisdictions in order to prepare for site selection.

A preliminary spreadsheet was developed based on suggestions and information provided by jurisdictions and the TRPA. After several iterations, this workbook was divided by jurisdiction into separate worksheets (a total of nine worksheets, with an example shown in Table C3) and distributed accordingly. Each jurisdiction in the Working Group was then asked to enter available information in the empty cells, including whether they would recommend particular projects for monitoring, or to be reviewed for potential future monitoring, and the reason for this recommendation. This process was demonstrated in April, 2009, when Working Group participants interactively worked through examples of jurisdiction-specific spreadsheets and discussed the site nomination procedure.

Stormwater Outfall Inventory

The RSWMP probabilistic outfall sampling will be stratified into separate tiers, with direct outfalls to the lake identified as a first tier group, with those to tributaries and other surface waters as a second tier, and all other outfalls (including BMPs) as a third tier group. The lake outfalls are probably the easiest to work with and most important, so some preliminary work was conducted by RSWMP technical staff in site visits to evaluate characteristics for stormwater runoff and monitoring. Probabilistic monitoring of outfall sites will be based on a stratified random selection of rotating sites, tied to long-term calibration (status and trends) sites. Results will be used to establish status of stormwater runoff conditions around the Tahoe Basin, to identify outliers, and to provide a measure of watershed restoration efficiency - and/or problems. A GIS-based statistical approach will be the appropriate method for site selection as monitoring will be organized on a spatial basis.

The need for information on existing outfall sites was explained at Working Group meetings, and then jurisdictions provided available data in varying formats and at differing levels of detail. The information from these sources were integrated using GIS and has resulted the RSWMP outfall map shown in Figure C1, which will be used in site selection for the probabilistic outfall monitoring.

Table C3. Example template of worksheet for reviewing EIP project information relevant to RSWMP for site selection.

Project Number	Project Name	Project Lead	Implementer's Project Number	EIP #	EIP Name	Thresholds Addressed	Total Funding:	Comments:	Date Project Completed (or anticipated)	Monitoring Plan Available (Y/N)	Maintenance Plan Available (Y/N)	Primary Data Source	Recommend for RSWMP Review (Y/N)	Recommend for RSWMP Monitoring (Y/N)	Reason Selected
1	Rocky Point ECP Phase I & II	CSLT	PWC 1998-03	695	Rocky Point Erosion Control Project	WQ	$8,398,250	Funding #s due fall 04 Funding may include part of phases 3 & 4	1/2/2002	Quantitative	No Plan	City SLT			
2	Beecher-Lodi	CSLT	PWC 1995-02	n/a	Pre-EIP		$1,145,990	Vortechnics 4000 Need EIP information	8/1/1997	No Plan	No Plan	City SLT			
3	Gardner Mountain ECP	CSLT	PWC 1986-15	n/a	Pre-EIP		$ 546,750	Funding-steve, 220 tons of riprap- what for?	7/1/1992			City SLT			
4	Regina Road ECP	CSLT	PWC 2000-03	10075	Regina Road Erosion Control Project	WQ	$ 8,858	No CTC record ?	9/1/2000	No Plan	No Plan	City SLT			
5	Stateline ECP	CSLT	PWC 1987-10	n/a	Pre-EIP		$4,581,689	EIP?? Stormwater interceptors used 17 SDMH not included on DI total. $760K CTC funds for land acquisition	12/1/1997	No Plan	No Plan	City SLT			
6	Al Tahoe / Pioneer Trail ECP	CSLT	PWC 1990-04	n/a	Pre-EIP		$2,360,400	Need Actual EIP name, # Need Map copy.	11/20/1992	No Plan	No Plan	City SLT			
7	12th - 13th Street ECP	CSLT	PWC 1993-02	n/a	Pre-EIP		$1,243,900	18 SDMH not included in Distilling Basins and Sed Traps combined into one total. 12th & 13th Streets	10/1/1994	Quantitative		City SLT			
8	Al Tahoe / Pioneer Trail / Bijou Creek ECP	CSLT	CWP 1993-14	n/a	Pre-EIP		$1,392,329	Assume Vegetated Swall 3ft wide to change SF to LF for BMPs	9/1/1999	No Plan	No Plan	City SLT			
9	Lakeview Avenue	CSLT	PWC 1993-04	n/a	Pre-EIP		$ 14,708	no CTC record Lakeview Ave GIS map polygon location- best guess	9/1/1993	No Plan	No Plan	City SLT			
10	Clement Street ECP	CSLT	PWC 1995-03	n/a	Pre-EIP		$ 243,030	What is correct funding for this project CTC funds $1M, council proposal $240k?	9/1/1996	Photo	No Plan	City SLT			
11	Gardner Mountain ECP Phase II	CSLT	PWC 1993-08	n/a	Pre-EIP		$ -	Funding? See project ID#003 no CTC record of this project	11/1/1993	No Plan	No Plan	City SLT			

Table C3. Example template of worksheet for reviewing EIP project information relevant to RSWMP for site selection (continued).

Project Number	Project Name	Project Lead	Implementer's Project Number	EIP #	EIP Name	Thresholds Addressed	Total Funding:	Comments:	Date Project Completed (or anticipated)	Monitoring Plan Available (Y/N)	Maintenance Plan Available (Y/N)	Primary Data Source	Recommend for RSWMP Review (Y/N)	Recommend for RSWMP Monitoring (Y/N)	Reason Selected
25	Ski Run Water Quality Improvement Facilities Phase I	CSLT	PWC 1998-13	n/a	Pre-EIP		$4,084,050	Wildwood Basins Ph. 1 appears to have installed 2 basins Phase 2 appears to have installed wetland basins north of Hwy50 along w/conveyance.	1/1/1992			City SLT			
26	Tahoe Valley ECP	CSLT	PWC 1986-06	n/a	Pre-EIP		$ 654,400	Riprap listed in tons Reveg listed as lump sum	5/22/1992			City SLT			
27	Ski Run Water Quality Improvement Facilities Phase II	CSLT	PWC 1997-02	n/a	Pre-EIP		$ -	needs check with CSLT see proj #025	6/29/1999			City SLT			
28	Bijou / Wildwood ECP Phase I	CSLT	PWC 1983-02	n/a	Pre-EIP		$ 588,700	BIJOU AREA WATER QUALITY EIP # 172?? Riprap area estimated from 499 tons at 1.5 tons/CY and 1" thick	1/1/1989			City SLT			
29	Saddle / Sterling ECP	CSLT	PWC 1992-06	n/a	Pre-EIP		$ 113,000	GIS map polygon location- best guess	8/1/1993			City SLT			
63	Ski Run Blvd Stream Zone Restoration Project Phase II		PWC 1995-06	934	Ski Run Blvd. SEZ Restoration- Phase II		$ 345,750	EIP data from implementer records Catchment area = 287 acres Unverified CTC funding figure from implementer records	12/1/1997			City SLT			
64	West Sierra Tract ECP	CSLT	PWC 1986-04	n/a	Pre-EIP		$ 352,300	Detention basin volume based on excavation quantity estimate Project description includes rock energy dissipators and reconstruction of open channel - but neither shown on contractor invoice.	12/1/1989			City SLT			
66	Industrial Tract SEZ Restoration	CSLT	PWC 2000-04	13	South Y Industrial Tract Erosion Control Project/SEZ	WQ	$ -	Included removal of 400 ft of Industrial Ave. No CTC project record GIS map polygon location- best guess	10/1/2002			City SLT			
149	Bijou Creek Meadow	CSLT	PWC 2005-04				$ -	Bijou Crk- project still in planning as of 8/19/09 dkf				CTC			

Table C3. Example template of worksheet for reviewing EIP project information relevant to RSWMP for site selection (continued).

Project Number	Project Name	Project Lead	Implementer's Project Number	EIP #	EIP Name	Thresholds Addressed	Total Funding:	Comments:	Date Project Completed (or anticipated)	Monitoring Plan Available (Y/N)	Maintenance Plan Available (Y/N)	Primary Data Source	Recommend for RSWMP Review (Y/N)	Recommend for RSWMP Monitoring (Y/N)	Reason Selected
152	D Street Phase II	CSLT	PWC 1985-04	n/a	Pre-EIP		$ 407,841	Totals from CSLT drawings (not sure if as-built) Two basins of unknown size CSLT did land acquisition for this project, so some funding from South Tahoe Redevelopment	8/6/1995			CSLT			
164	Regan Beach	CSLT	PWC 1984-08	n/a	Pre-EIP		$ 512,941		8/1/1986			CTC			
195	Glorene / 8th Street ECP	CSLT	PWC 1999-15	699	Glorene/Eigth Erosion Control Project	WQ	$3,912,980	have electronic plans and record hard copies CTC funding includes $515K of land acquisition	10/1/2005			City SLT			
196	Park Avenue Drainage Basins	CSLT	PWC 2001-08	n/a	Pre-EIP		$ 132,382	Assume AC pavement is 3ft wide to change SF to LF for BMPs	9/1/2002			City SLT			
197	Sierra Tract ECP Phase II	CSLT	PWC 2004-07	693	Sierra Tract Erosion Control Project	WQ	$ 873,436		10/1/2005			City SLT			
199	Ski Run Water Quality Phase II Int	CSLT	PWC 1997-06	994?	US 50 Highway Improvements from South 'Y' to Ski Run Blvd		$ -	paper plans only	2/1/1998			City SLT			
200	Ski Run Water Quality Improvement Facilities	CSLT	PWC 1988-13	n/a	Pre-EIP		$5,941,350	paper plans only includes $3,252,250 in land acquisition	11/1/1991			City SLT			
201	Ski Run Improvements	CSLT	PWC 1999-02	994?	US 50 Highway Improvements from South 'Y' to Ski Run Blvd		$ -	Hard copy plans Business Improvement District money? Assume AC pavement is 3ft wide to change SF to LF for BMPs	7/1/2000			City SLT			
202	Ski Run Marina Drainage Retrofit	CSLT	PWC 2001-07	n/a	Pre-EIP		$ 384,000	Installed the Filter System north of US 50 $38K USFS funding for CURTEM monitoring	2/1/2003			City SLT			

Table C3. Example template of worksheet for reviewing EIP project information relevant to RSWMP for site selection (continued).

Project Number	Project Name	Project Lead	Implementer's Project Number	EIP #	EIP Name	Thresholds Addressed	Total Funding:	Comments:	Date Project Completed (or anticipated)	Monitoring Plan Available (Y/N)	Maintenance Plan Available (Y/N)	Primary Data Source	Recommend for RSWMP Review (Y/N)	Recommend for RSWMP Monitoring (Y/N)	Reason Selected
203	Pioneer Trail Retaining Wall	CSLT	PWC 2001-15	10070 ?	Pioneer Trail III ECP		$ 562,500	CAD drawings are of an erosion control blanket	1/1/2003			City SLT			
		CSLT		172	Bijou Area Erosion Control Project (Planning and Design)	WQ	$ -								
		CSLT		691	East Pioneer Erosion Control Porject/Keller Cnayon (Planning and Design)	WQ	$ -								
		CSLT		696	Al Tahoe Erosion Control Project (Planning and Design)	WQ	$ -								
		CSLT		714	Lake Tahoe Water Quality Improvements at Tahoe Meadows	WQ	$ -								
		CSLT		767	15th Street Bike Trail	WQ	$ -								

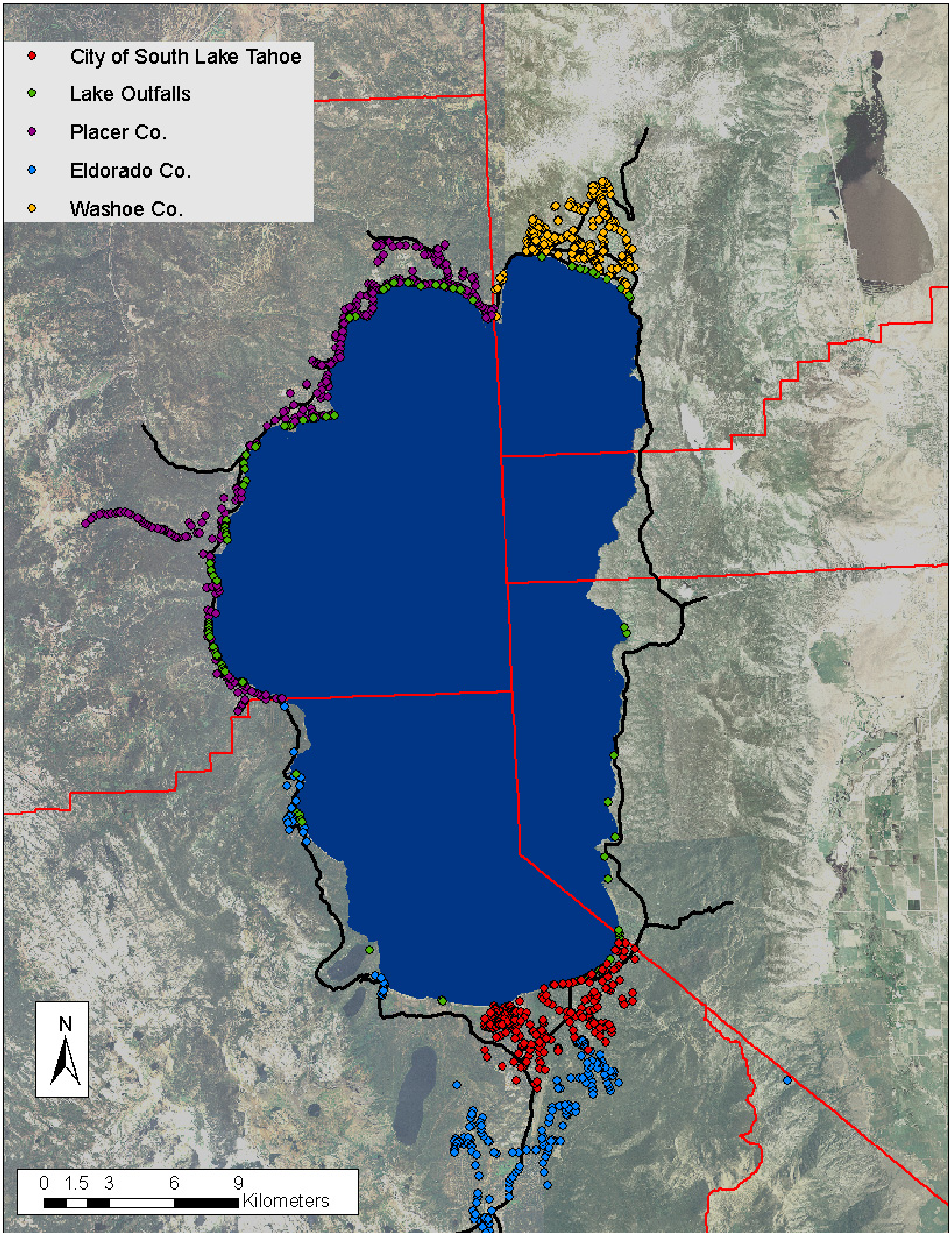


Figure C1. Distribution of Stormwater Outfall sites by jurisdictions around the Tahoe Basin. TRPA lake outfalls represent point previously identified by the Tahoe Regional Planning Agency as part of a lakeshore survey.

Stormwater BMP Monitoring Site Selection

Preliminary worksheets were developed for collecting information on existing or planned BMP installations to be used for evaluating their potential selection as monitoring sites. These spreadsheets were sent to implementing agency representatives for their suggestions and comments. Each sheet contained the following column headings: Project ID, Project Name, EIP Number, EIP Name, Implementer ID, Implementer Project Number, Date Project Completed, Total Funding Amount, BMP Type Implemented, Location Description, Short Description of BMP, Annual Average Volume of Stormwater treated by BMP, Catchment Area Contributing to and Treated by the BMP, Footprint of BMP, Treatment Capacity of BMP, Installation Date, Status (ongoing or planned – add dates if possible), Hydrologic Data Availability (Y/N), Water Quality Data Availability (Y/N). As decisions are made later in the selection of specific BMP types for prioritized RSWMP monitoring, these and similar worksheets should be useful in collecting information on potential target monitoring sites.

Summary

A compilation of BMP, EIP and outfall information was needed to support a future site selection process for RSWMP monitoring. This was accomplished to the extent possible with existing information, and in the process it generated useful discussion about monitoring priorities. It is clear, however, that jurisdictions are operating at different stages in their assembly of information on water quality assets and infrastructure. Working with other groups in the Tahoe Basin, RSWMP will continue to identify critical gaps in the information needed for monitoring site selection, as well as to provide improved consistency in terminology and data formats.

In the meantime, the Tahoe Stormwater Executives have issued instructions that further identification of specific monitoring sites is postponed, pending further discussion between the regulatory agencies and the urban stormwater jurisdictions. They anticipate a negotiated process to determine the type, number and location of RSWMP affiliated BMP and stormwater monitoring sites, after which the information provided will facilitate the selection of appropriate candidate sites for monitoring.

Appendix D. Example of Typical Chain of Custody (COC) Form

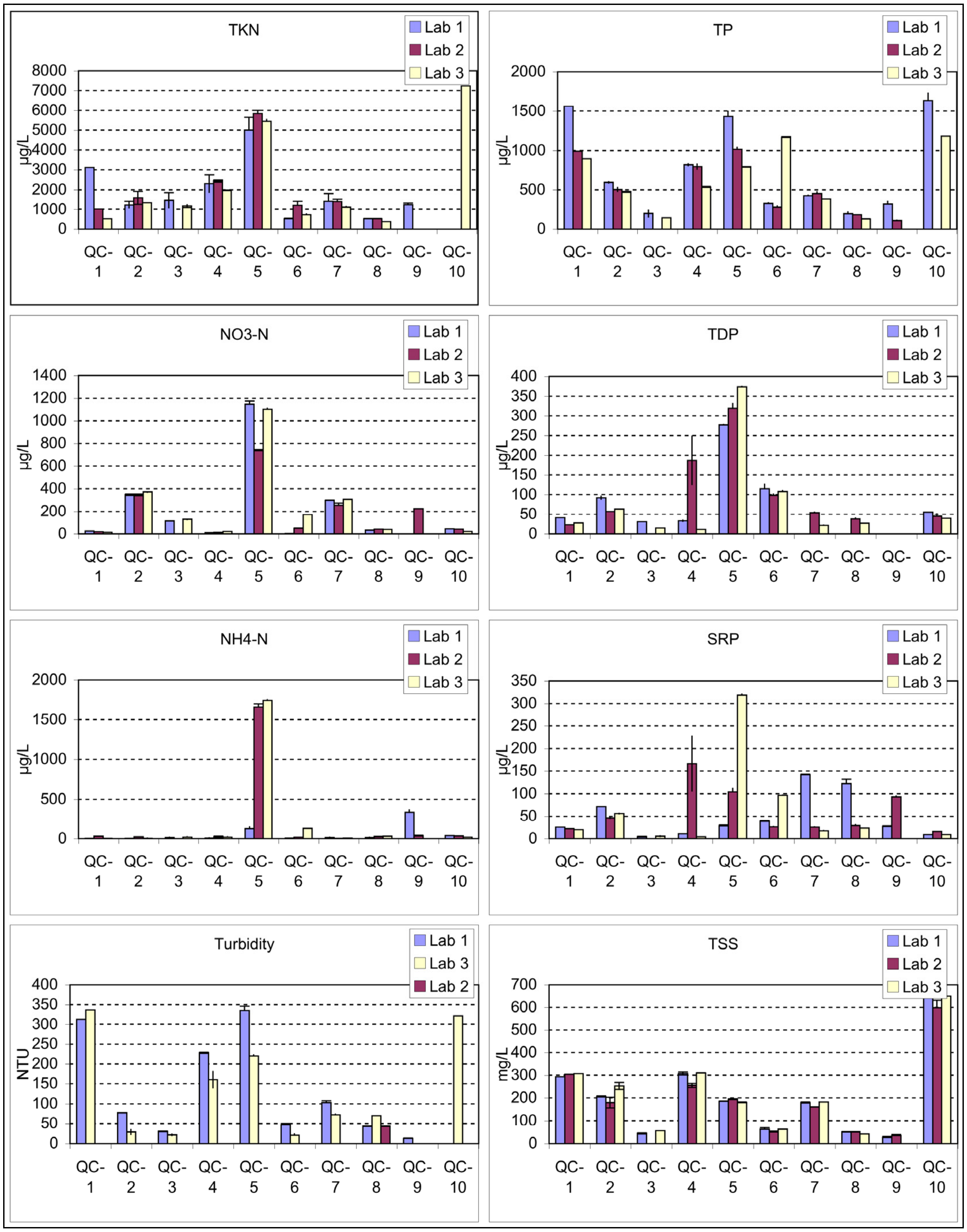
Water Analysis Laboratory
Desert Research Institute
2215 Raggio Parkway, Reno NV 89512
775-673-7380

CHAIN-OF-CUSTODY FORM

Project:		Analysis Requested						
Sample ID	Date Sampled							Comments

Relinquished by	Date and Time	Received by	Relinquished by	Date and Time	Received by
Relinquished by	Date and Time	Received by	Relinquished by	Date and Time	Received by

Appendix E. Example of Comparative Inter-Laboratory Analytic Results



Blind sample splits were sent to participating laboratories in duplicate. The results show within laboratory and inter-laboratory variability for analytic results. It is evident that some analyses (e.g. TSS) are more robust across laboratories than others. Areas were problems are evident (as in SRP) can be addressed to resolve inter-lab discrepancies.

Appendix F. Example of Information for Quarterly Site Data Reporting Generated from RSWMP Database (additional constituents, data, and metrics can be included).

1 Introduction

Table 1: General site and location information

Site name	South Y
Site Type	Stormwater
Location Type	inlet
Monitoring Location Type	Culvert
BMP Type	n/a
Date Installed	2003-01-22
Lat/Lon	(38.9131, -120.0018)
Elevation	unknown

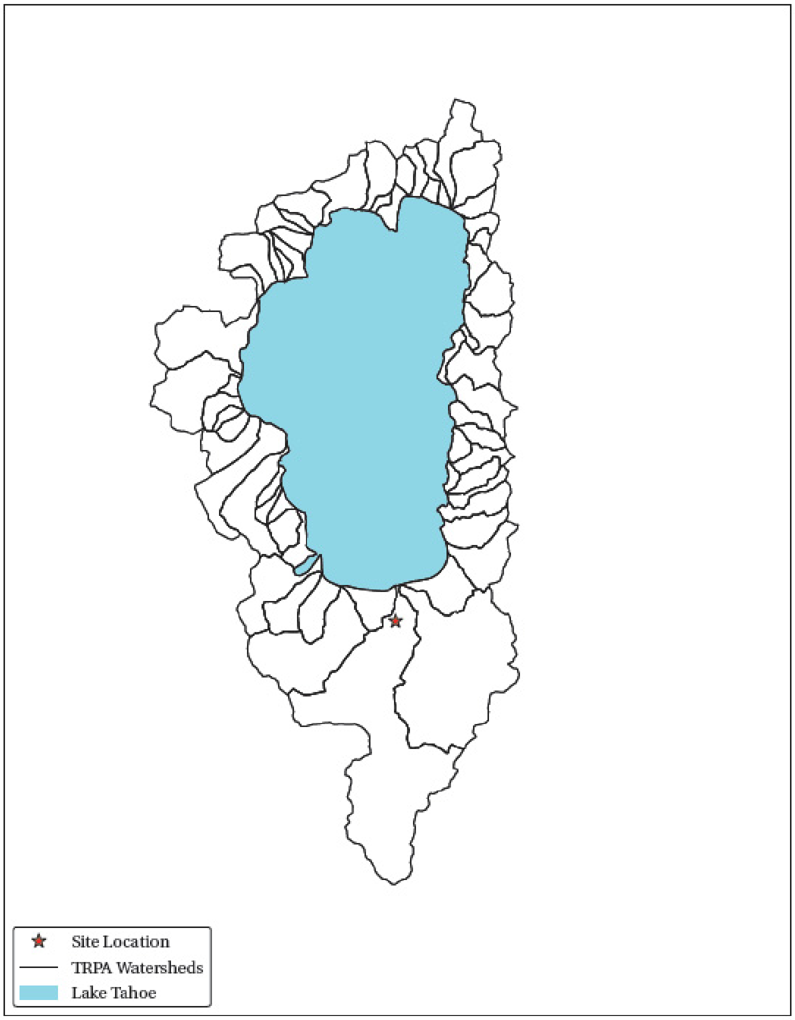


Figure 1: General location map

2 Turbidity

Table 2: Summary of Turbidity concentration at the Culvert of the South Y inlet

Statistic	Value
Count	82
Number of Non-detects	0
Min, Max	18.500, 2211.639
Mean (95% conf. interval)	307.536 (234.850, 397.481)
Std. Dev.	367.404
Skewness	2.731
Median (95% conf. interval)	181.945 (128.359, 253.337)
25^{th}, 75^{th} percentiles	96.922, 395.345
p-value, detects (normal, log-transform)	0.684, 0.990

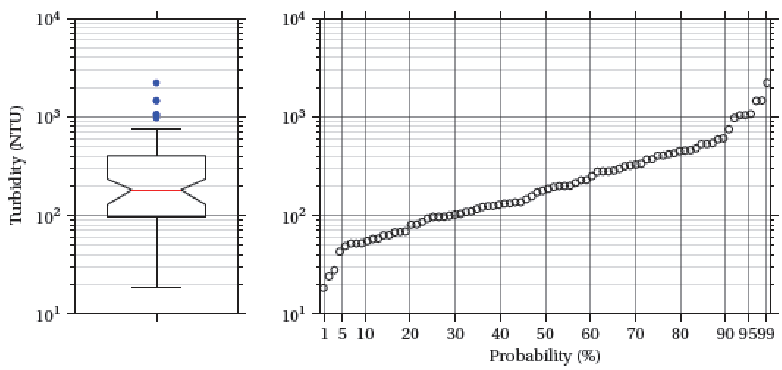


Figure 2: Box and probability plots of Turbidity concentration at the South Y inlet

3 Soluble Reactive Phosphorus

Table 3: Summary of Soluble Reactive Phosphorus concentration at the Culvert of the South Y inlet

Statistic	Value
Count	80
Number of Non-detects	0
Min, Max	0.002, 0.117
Mean (95% conf. interval)	0.026 (0.021, 0.031)
Std. Dev.	0.022
Skewness	1.873
Median (95% conf. interval)	0.020 (0.015, 0.024)
25th, 75th percentiles	0.012, 0.034
p-value, detects (normal, log-transform)	0.818, 0.986

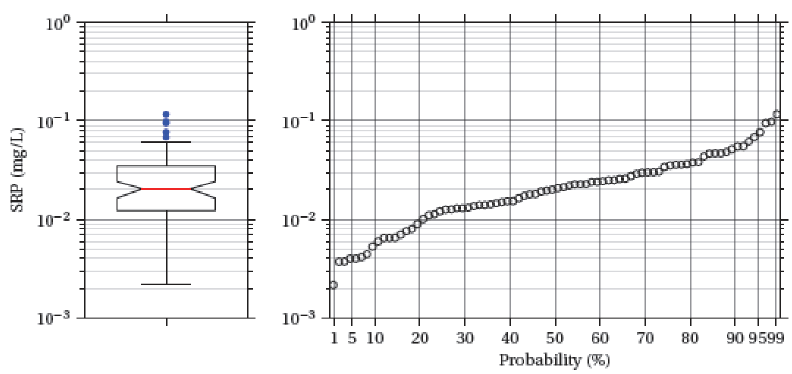


Figure 3: Box and probability plots of Soluble Reactive Phosphorus concentration at the South Y inlet