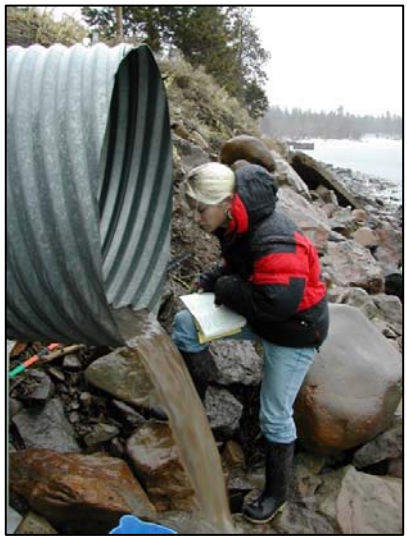
Tahoe Basin Regional Stormwater Monitoring Program

(Tahoe Basin RSWMP Phase 1)

Conceptual Development Plan

March 2008



Tahoe Basin RSWMP
A Cooperative Program of
Tahoe Basin Agencies and the
Tahoe Science Consortium

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TABLE OF CONTENTS **Page**

LIST OF FIGURES

Appendices

Foreword

For the purity and the clarity of its water, Lake Tahoe has long been recognized as one of the outstanding natural features of the world. That renowned clarity has been in decline over the last several decades, however, while millions are spent annually to remove or reduce the environmental stressors causing decline and to restore lost clarity. As with any expensive process in modern business or manufacturing, there must be a system of quality assurance and quality control to ensure that management objectives are adequately addressed with available resources, and that actions are taken proactively when those specified objectives are not achieved. The purpose of the regional monitoring program described herein is to contribute the information needed for that quality management process at Lake Tahoe. At its inception, this program will provide a means by which to collectively assess stormwater monitoring goals and objectives, evaluate the progress toward achieving pollutant reduction targets, and will help adjust actions and funding necessary to best accomplish articulated resource management goals of the present and future.

Within the Tahoe Basin resource management and regulatory communities, as well as at other institutions concerned with controlling pollutant loads to Lake Tahoe, there has developed a strong consensus at all levels for creating a regional stormwater monitoring program. It is significant that both the Storm Water Quality Improvement Committee (SWQIC) and the Tahoe Interagency Executives (TIE) have endorsed the need for, and a conceptual approach toward, implementing the basic goals and objectives that will lead to a regional monitoring program.

This document is intended to serve as a roadmap for the collaborative development and implementation of a Tahoe Basin Regional Stormwater Monitoring Program. It acknowledges the important role of stormwater management in the recovery of Lake Tahoe and its watershed. It also acknowledges the important role of a sound and consistent, science-based program that will deliver cost-effective tools to track cumulative progress and to guide course adjustments going forward with implementation of the unique environmental improvement program that is currently underway at Lake Tahoe.

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Although the conceptual development of the Tahoe Basin Regional Stormwater Monitoring Program (RSWMP) has been led by members of the Tahoe Science Consortium, this document represents the collaborative efforts and contributions of many individuals representing the various jurisdictions, agencies and organizations involved in Tahoe Basin stormwater quality management. In particular, we would like to recognize the cooperative participation of members from the Tahoe Basin RSWMP Core Working Group, who have contributed many hours and creative insights to this process. The names and affiliations of the Core Working Group members are provided in Appendix A.

We also recognize significant contributions from those organizations that have supported the work of their core working group representatives. In addition, we acknowledge the Southern Nevada Public Lands Management Act (SNPLMA) funding provided through the Tahoe Science Consortium and the US Environmental Protection Agency.

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Section 1. Introduction

Background

Resource agencies, local governments, project implementers, the scientific community, environmental groups, decision-makers at the city, county, state and federal levels, and many others have continued to take meaningful steps towards the restoration of Lake Tahoe's waters, its watershed and its air basin. Among these efforts, restoration activities are expanding through (1) continued implementation of erosion control, stormwater management, and riparian restoration projects, (2) an updated Environmental Improvement Program (EIP)(TRPA 2007), (3) development of the Lake Tahoe Total Daily Maximum Load (TMDL) that is providing a quantitative, science-based approach for pollutant reduction, and (4) a strong research/monitoring effort to evaluate key ecological processes and response to water quality improvement projects.

The Lake Tahoe TMDL is organized around a series of critical questions:

- **What pollutants are causing Lake Tahoe's clarity loss?**
- **How much of each pollutant is reaching Lake Tahoe?**
- **How much of each pollutant can Lake Tahoe accept and still achieve the clarity goal?**
- **What are the options for reducing pollutant inputs to Lake Tahoe?**
- **What strategy should we implement to reduce pollutant inputs to Lake Tahoe?**
- **Is the quality of surface runoff and in turn the clarity of Lake Tahoe improving in response to actions to reduce pollutants?**
- **Are the expected reductions of each pollutant to Lake Tahoe being achieved?**
- **Can innovation and new information improve our strategy to reduce pollutants?**

The first five questions are addressed in a series of technical documents that were developed as part of the Lake Tahoe TMDL program (Lahontan and NDEP 2007a, 2007b). Collectively these reports concluded that fine soil particles (<20 µm diameter) are critical to the clarity of Lake Tahoe, that the majority of these fines (70-75%) come from urban land uses, and that achieving water quality goals of the TMDL will depend upon source control and loading reduction of these urban fine particles. Innovative practices and management approaches will be necessary, including a well-designed plan for measuring progress that can be applied within an adaptive management framework. The last three of the questions above will serve to guide efforts to evaluate and document the success of pollutant reduction strategies.

In the 2000 Lake Tahoe Watershed Assessment it was concluded that most of the information on BMP effectiveness had been of a qualitative nature and was based largely on occasional site inspections and observations (Reuter and Miller 2000). At the same time our knowledge of urban pollutant loading was also meager, based primarily on infrequent grab samples. Considerable progress has been made since that admonition in the Watershed Assessment. Recent examples of key summaries for data related to stormwater monitoring and BMP effectiveness can be found in Reuter et al. (2001),

Geosyntec Consultants (2005), Gunter (2005), 2NDNATURE (2006), Lahontan and NDEP (2007b; Chapter 3).

Need for a Comprehensive Stormwater and BMP Effectiveness Monitoring Program

While progress has been made to better manage stormwater and BMP effectiveness monitoring, there is still a general consensus that we have missed critical opportunities to increase our understanding of these topics in the past because of the lack of a coordinated monitoring program. A growing amount of human and financial resources are being used for monitoring and assessment of stormwater runoff quality and effects on pollutant loading to Lake Tahoe. These monitoring efforts need to address multiple issues, including: implementation monitoring, BMP effectiveness (performance) monitoring for evaluation and design purposes, as well as status and trends monitoring. With the advent of the Lake Tahoe TMDL, and a growing commitment to adaptively manage conservation and restoration efforts, it is understood that a well-designed and integrated monitoring plan is needed to meet the needs of all involved parties.

The amount of relevant data and the quality of this data would significantly increase if monitoring and data analysis were done in an organized and integrated fashion, based upon a unified set of key management questions and program needs, within a science-based adaptive management framework. This approach would allow us to design a monitoring plan that could be applied to multiple projects and would produce a far more comprehensive and integrated database than is possible from the haphazard single-project monitoring approach we currently operate under. Combined data from multiple coordinated projects collected through standardized techniques is much more statistically powerful than trying to link independent data sets that were collected in different manners, at different times, and using different techniques. This latter approach is simply too resource intensive and does not readily allow for conclusions to be made outside the confines of the isolated project examined.

We are now at a point in the Tahoe Basin where a well-designed and regionally integrated monitoring program would satisfy the diverse needs of a sustainable cost-effective program that identifies and addresses the mutual goals of regulatory agencies, funding programs, implementers and other stakeholders. The multi-agency development of a regional stormwater monitoring program (RSWMP) will provide an opportunity for agencies, stakeholders, and the scientific community to work together toward developing common goals, criteria, implementation strategies and data reporting needs for the Lake Tahoe TMDL and related regional plans. In particular, a comprehensive regional stormwater monitoring program for the Tahoe Basin will be an invaluable tool that can be used in concert with the final crediting system developed for the Lake Tahoe TMDL.

RSWMP Timeline and Phased Approach

In recognition of the need for a formalized Regional Stormwater Monitoring Program for the Tahoe Basin, in March 2007 the Tahoe Science Consortium (TSC) secured limited SNPLMA funding to pursue science planning for regional monitoring. A series of

discussions were conducted during April and May 2007 during which was determined that regional monitoring for urban stormwater was needed to support water quality planning and the TMDL. Agency and TSC representatives met and formed an RSWMP Core Working Group[1] to develop a conceptual framework for RSWMP. These meetings began in July 2007 and are continuing. An Agency-TSC workshop to discuss regional monitoring concepts and secure agency executive support to initiate RSWMP was held in June 2007. Presentations were made to both the Tahoe Interagency Executives (TIE) and the Storm Water Quality Improvement Committee (SWQIC) in winter 2007–08.

The Lake Tahoe Regional Stormwater Monitoring program (RSWMP) was originally envisioned as three phases – this approach is still considered appropriate. Phase 1, described above, is now complete and has focused on the collaborative development of a conceptual framework for a comprehensive stormwater monitoring program. This framework includes relevant agency, implementer and science considerations, as well as specification of required elements for a monitoring program, the design for structural (administrative) elements, and funding arrangements for a sustainable program. The main deliverables from Phase 1 include: (1) a synthesized set of RSWMP goals and objectives that represent the mutual needs of regulatory, funding, and implementing agencies and (2) this document, which provides guidance on what to consider in the development of the detailed RSWMP technical and organizational plan. Phase 1 also included the production of an initial annotated bibliography for Tahoe Basin stormwater literature (Appendix B).

Phase 2 will build on this conceptual framework by designing a specific monitoring program for the Tahoe Basin that meets agency and implementer priority needs (see, for example, the preliminary data objectives in Section 2). A summary of key items to be developed in Phase 2 include, for example: detailed specification of monitoring design, operating costs, resource and personnel requirements; database management, reporting requirements, and QA/QC procedures; RSWMP organizational structure, funding arrangements, agency roles and responsibilities, internal and external peer-review. Refer to the sections below for more details on these items.

Finally, Phase 3 is the funding and implementation of a fully operational regional stormwater monitoring program, with funding allocations, creation and staffing of program structural elements and complete implementation of all monitoring and reporting processes.

These three phases of RSWMP can be generally compared to the course of a typical erosion control project in the Tahoe Basin, where: Phase 1 equates to conceptual development of a project, complete with stakeholder input and discussion; Phase 2 is comparable to completing the environmental design plans, with engineering specifications, and obtaining project approval/permits; while Phase 3 corresponds to the construction or implementation phase, where the project comes to fruition.

[1] Includes representation of 20 agency, implementing and research entities. See Appendix A for names and affiliations.

RSWMP Fits within an Adaptive Management Framework

Adaptive management is a topic that is discussed often in the Tahoe Basin, but in most cases it has not moved very far from its conceptual basis. The Tahoe Basin RSWMP will tie into implementation (compliance) monitoring, BMP effectiveness evaluation, as well as status and trends monitoring of stormwater runoff and pollution levels. So it will provide a robust information delivery platform, which is critical for an effective adaptive management program in water quality.

Examples where adaptive management is needed in stormwater monitoring include, but are not limited to: (1) implementation monitoring, or the equivalent, to evaluate minimization of adverse impacts during project execution and to document as-built conditions; (2) effectiveness monitoring to help improve future project designs and to inform/verify the TMDL crediting process; (3) targeted monitoring to improve our process-based understanding of BMP functions and performance over the long-term and in response to maintenance activities; and (4) stormwater status and trends monitoring, which combined with information from the LTIMP and Lake Tahoe clarity monitoring will provide a regional picture of conditions and changes in Tahoe Basin water quality.

This adaptive management approach is best supported through a fully integrated and comprehensive monitoring program that produces the high-quality data and associated data analyses required for sustaining a continual improvement cycle implicit to adaptive management (see Section 7).

Section 2. Goals and Objectives

The programmatic directives, monitoring goals, and monitoring objectives for the Regional Stormwater Monitoring Program were developed collaboratively by the RSWMP Core Working Group of agency (management, funding, implementing and regulatory) representatives and research scientists. These directives, goals, and objectives were developed to integrate ongoing and planned tracking, monitoring, and crediting of stormwater runoff in the Lake Tahoe Basin under one umbrella. RSWMP will regularly perform an objective and unbiased analysis of stormwater monitoring data for the Lake Tahoe Basin to best provide information that implementing agencies need to meet their permit requirements and to assist the regulatory agencies in their evaluation and crediting of pollutant reduction from stormwater runoff. During Phase 1, the RSWMP Core Working Group developed specific programmatic directives, monitoring goals, and data objectives to meet the collective needs of a diverse constituency of agency, stakeholder and science community representatives.

Programmatic Directives

Programmatic directives for the Tahoe Basin RSWMP are those essential features needed in a robust urban stormwater monitoring program, with strong emphasis on developing consistency in how the data are collected, analyzed and reported. It is anticipated also that this Tahoe Basin RSWMP, predicated on collaboration among a wide range of participants, will have a positive influence on the consistency with which data are interpreted and applied in water quality management decisions at the project, watershed and basin-wide scales.

The programmatic directives of a Tahoe Basin Regional Stormwater Monitoring Program are as follows:

A. Develop a stormwater monitoring program that is directly responsive to the needs of all agencies and affiliated partners.

B. Provide program-wide consistency in sampling design, data reporting and quality assurance.

C. Develop data management and communication tools for efficient and effective reporting of current conditions and trends.

D. Assure cost-effective significant benefit from stormwater monitoring through a coordinated regional program that informs relevant management strategies and decisions.

E. Implement a sustainable RSWMP organizational structure with stable funding, dedicated personnel and adequate resources.

Consolidated Monitoring Goals

The consolidated monitoring goals were developed to meet collective needs of all interested parties in Tahoe Basin stormwater, as expressed by the agency, implementer and science representatives on the RSWMP Core Working Group. Refer to Appendix C for more details on the specific monitoring goals that were set forth by the Core Working Group. There was considerable agreement among the various groups, and overall the needs that were expressed fit readily into four consolidated monitoring goals that are listed below, in no particular order of priority.

1. Pollutant Source Monitoring:
   Identify specific sources of urban stormwater pollutants.

2. Pollutant Reduction Monitoring:
   Quantify progress in pollutant reduction and restoration efforts.

3. BMP Design, Operation and Maintenance Monitoring:
   Develop information for improvements in BMP design, operation and maintenance.

4. Data Management, Analysis and Dissemination:
   Provide data reporting, analysis and access for better project design, prioritization and long-term performance.

Preliminary Data Objectives

A preliminary set of data objectives were prioritized by the Core Working Group and represent the highest stormwater monitoring priorities as expressed by the agencies in the Tahoe Basin. Currently, it is considered that these objectives are needed to fulfill the monitoring goals of RSWMP (see Appendix C for memorandum on specific stormwater monitoring objectives from the various agency representatives on the Core Working Group). The Phase 2 document on monitoring design and RSWMP programmatic structure will further specify these objectives in light of data needs and funding availability.

1. For Pollutant Source Monitoring:
   - Identify significant pollutant source activities and source areas relevant to excessive stormwater concentrations or loads.
   - Refine relationships between land use and pollutant generation.
   - Provide regular updates to event mean concentrations (EMC) for basin-scale modeling within an adaptive management framework.

2. For Pollutant Reduction Monitoring:
   - Determine existing concentrations and loads to support pollutant reduction crediting.

- Develop stormwater information needed for evaluating progress toward TMDL and other regulatory goals.
- Provide data required to fulfill permit reporting.
- Update data for project-scale modeling (e.g., Pollutant Load Reduction Model) and for linking to basin-scale models (e.g., USEPA's Stormwater Management Model, or the Loading Simulation Program in C++).
- Provide data to evaluate and update discharge standards and thresholds.
- Distinguish restoration effects from inter-annual variability and climate trends.

3. For BMP Design, Operation and Maintenance Monitoring:
   - Field evaluations on the effectiveness of individual BMPs and projects to lower pollutant loads over time.
   - Develop effectiveness matrix for BMP design variables.

   - Develop information for evaluating BMP physical and biogeochemical conditions as it relates to pollutant removal efficiencies.
   - Determine maximum practical effectiveness (concentrations and loads).
   - Evaluate BMP maintenance strategies and track maintenance data.
   - Verify correct project construction according to engineering specifications.
   - Provide data for pre- and post-project assessments.

4. For Data Management, Analysis and Dissemination:
   - Provide data repository for compilation and management.
   - Evaluate monitoring data regularly to provide quarterly reports and annual data analysis, synthesis of findings and recommendations.
   - Confirm that relevant monitoring needs, goals and objectives are being addressed appropriately and fulfill agency requirements.
   - Provide participant access to data, products and tools after QA/QC review.
   - Include any new or existing data that meet standard protocol requirements.
   - Conduct biennial programmatic review to evaluate monitoring program goals, objectives and products.

Section 3. Conceptual Monitoring Design

The diverse monitoring goals represented in this document (Section 2) have led to the development of a blended approach in our conceptual monitoring design, in which both targeted and probabilistic sampling strategies have been incorporated to conduct monitoring of regional stormwater at various spatial and temporal scales.

Based on previous discussions we will begin to develop the Tahoe Basin RSWMP monitoring design with the assumption that simultaneous monitoring will be needed at three spatiotemporal scales (micro-, meso- and macro-scales) to achieve the stated goals and to meet agency, implementer and scientific needs in a credible and cost effective manner.

The micro-scale is discussed further below, under the heading of targeted monitoring, and focuses primarily on individual BMPs and localized projects at the spatial scale. In the temporal field, this micro-scale monitoring would focus primarily on event sampling (or finer) to discern characteristics associated with short-term processes, e.g., first flush concentrations.

The meso-scale monitoring will focus on the evaluation of pollutant loads that are likely to enter Lake Tahoe from the urbanized watershed. LTIMP currently does an excellent job of monitoring inflow and loading from the major natural tributaries; however, a comparable program for evaluating urban stormwater pollutant loading does not exist, despite its overwhelming importance to the pollutant load budget. Meso-scale RSWMP monitoring will be conducted at the sub-watershed scale in order to better understand the cumulative impacts of a series of water quality improvement projects within a localized drainage basin. Meso-scale monitoring will allow us to evaluate changes in pollutant loading to Lake Tahoe through the combination of data and information from LTIMP and RSWMP efforts, providing for the first time a comprehensive coverage of all contributors to surface discharge. In the temporal field, this meso-scale monitoring is focused mainly on issues like seasonal and annual characterization of stormwater events.

Macro-scale monitoring will take a probabilistic approach in selection of monitoring sites around the Tahoe Basin to develop a comprehensive long-term data set that satisfies statistical requirement for a stratified random sampling approach and allows estimation of statistical characteristics such as statistical distributions, centrality, confidence intervals and error analysis. In the temporal field, this macro-scale monitoring is focused on developing data for trends analysis from both probabilistic sampling and from long-term index station monitoring.

This macro-scale stormwater monitoring, in conjunction with existing lake and stream monitoring programs, will provide the data and information needed to gain a clear regional understanding of status and trends in surface water quality conditions of the Tahoe Basin Given the significant time lag inherent in Lake Tahoe's response to onshore management practices, however, as well as the variability of other factors that influence lake clarity (e.g., wind-driven lake mixing, annual precipitation patterns, seasonal runoff

volumes) it is clear that RSWMP monitoring data from all three scales will be used, in conjunction with lake and watershed modeling, to facilitate integrated lake-level response assessments that evaluate the efficacy of restoration activities and support future adaptive management decisions.

Targeted Monitoring

One of the principal monitoring goals identified for RSWMP is to provide high quality information on BMP performance and design alternatives. This will be achieved most efficiently within a program of targeted monitoring, where selected BMPs and basin projects are chosen for assessment. We will evaluate this approach and make recommendations through a variety of implementations, including paired project studies, specific BMP evaluations, project design evaluations, innovative treatment testing, etc. An important consideration to be included in our Phase 2 RSWMP design recommendations will be to determine the most effective approach for determining which BMPs are monitored and the level of effort required. It is widely agreed in the water quality community at Lake Tahoe that each BMP can not be comprehensively monitored for effectiveness – this is simply too labor intensive and financially burdensome. The Phase 2 document will include specific recommendations on how to prioritize the limited pool of resources available for targeted BMP monitoring. Factors that will contribute to this prioritization include, but are not limited to: BMP classification/type, confidence in existing data, key management questions, and utility for adaptive management assessment.

Examples of issues that can be addressed through targeted BMP monitoring are given below. The Phase 2 Framework document will consider these and other issues in designing the Tahoe Basin RSWMP program.

- Is a particular project design optimal for reduction of key water quality pollutants, especially fine sediments?
- Is a new treatment technology performing as expected, and does it persist over the operational lifetime specified?
- To what extent is the data and knowledge gained from one study applicable or transferable to similar projects?
- How effective is a specific BMP or a set of BMPs in meeting pollutant load reductions as targeted by the TMDL?
- To what extent do model estimates of pollutant reductions for specific BMPs or project designs match the real-world measurements?
- Verification of model estimates for pollutant load reduction crediting and guidance for assuring proper credit application.
- Which are the most effective types of BMPs or projects, and does that assessment change over time?
- What are the quantifiable performance effectiveness and cost-effectiveness benefits of different approaches for project maintenance?

Probabilistic Monitoring

Another of the principal monitoring goals, ultimately, will be to provide information suitable for meeting regulatory discharge requirements. Given the cost constraints noted above, all discharge points (to receiving waters) cannot be sampled. Therefore, we anticipate this monitoring goal will be achieved most effectively by taking a statistical sampling of selected discharge points within regulated jurisdictions. As part of ongoing jurisdictional stormwater mapping, discharge points in the Lake Tahoe Basin are in the process of being located and mapped. These will be incorporated during RSWMP Phase 2 into a basin-wide GIS, and then reviewed for sampling suitability by individual site visits and evaluation. From this population of available discharge points the RSWMP team shall develop a stratified approach for sampling within selected features to assure distributed representation in a probabilistic (statistical) sampling of discharge sites. In addition, statistical sampling of treatment effectiveness data can contribute to the evaluation of discharge requirements and standards, thereby increasing efficiency of the RSWMP monitoring program.

Examples of issues that can be addressed through probabilistic monitoring are given below. The Phase 2 document will consider these and other issues in designing the RSWMP program.

- What is the actual discharge of pollutants from urban stormwater runoff to the Lake;
- What are current estimates of basin-wide stormwater loading from urban sources, based on all available data with appropriate error specification?
- To what extent can data from one monitoring location be used to characterize other discharge points?
- How representative/useful are selected monitoring locations to estimate regional and basin-wide urban stormwater pollutant loading, as targeted in the Lake Tahoe TMDL?
- Are discharge standards useful on a seasonal or annual basis as a surrogate for meeting pollutant load reduction targets?

Status and Trends Monitoring

The third strategy in the blended monitoring design is to develop long-term sites for trends analysis and model calibration purposes; these could be referred to as Stormwater Index Sites. While the Basin has similar index sites for lake clarity and stream discharge (LTIMP), long-term monitoring for stormwater has never been part of any monitoring program. Consequently, it is not possible to evaluate BMP effectiveness at the watershed level. This has been a key information gap and will be an important cornerstone of the Tahoe Basin RSWMP. In this case, we anticipate that various sites around the Tahoe Basin will be monitored in a manner that allow us to evaluate the long-term performance of BMPs and restoration at the watershed and sub-basin drainage scale.

The Tahoe Basin RSWMP status and trends monitoring will enhance information gained from effectiveness monitoring by evaluating changes in pollutant loading from areas of high pollutant loading in drainages where water quality improvement projects are implemented. We envision this monitoring to include geographic regions such as neighborhoods, sub-watersheds and other areas where multiple BMP projects are installed. A key component will be to monitor stormwater drainage areas that can be quantified and mapped (with GIS) to land-use type. The resulting data then can be presented on a single graph in terms of water quality trends, level of effort for water quality improvement projects, and the amount of flow treated within a specified stormwater drainage. Ideally, in a project study area all the drainage runoff would flow to a single outlet point where it can be collected, measured and analyzed. This approach was used successfully during the 2002-03 stormwater monitoring program under the TMDL. While the goal of that monitoring was to define event mean concentrations (EMCs) associated with various land-uses, the Tahoe Basin RSWMP will use these types of sites to monitor stormwater quality and loads, and to relate the water quality to restoration projects installed within those drainages.

At the same time, status and trending monitoring will also consider pre-project design needs, post-project assessments, maintenance evaluations, and site testing. All of this data can be made more useful to projects when it is calibrated to longer-term hydrologic data and event records from neighboring sites. This will be achieved by maintaining a dispersed network of long-term sites around the Tahoe Basin. Also, results from the probabilistic monitoring network will be used to support the data collected from the Stormwater Index Sites when conducting a basin-wide evaluation of pollutant load reduction.

Examples of issues that can be addressed through status and trends monitoring are given below. The Phase 2 document will consider these and other issues in designing the RSWMP program.

- How many Stormwater Index Sites are needed to represent the Lake Tahoe Basin, considering variation in land use, precipitation, drainage size, etc.
- Location of these Stormwater Index Sites will consider, drainage characteristics, opportunity for sampling, current placement of water quality improvement projects within the drainage, representation of land uses, plans for pollution reduction projects, etc.
- Based on available data from previous studies the RSWMP Phase 2 document will analyze the number of samples needed each year, the number of sites basin-wide and the expected number of years of sampling needed to show statistical significance.

Pollutant Source Monitoring

The blending of these three approaches is where RSWMP will provide programmatic efficiencies through integrated efforts and economies of scale, since individual sites will serve more than one purpose. Probabilistic sampling data, for example, can be used to help identify pollutant source areas, while also contributing to better assessment of

overall watershed loading characteristics. Reconnaissance sampling would be another strategy that could contribute to both status and trends assessment (probabilistic sampling) as well as to identification of source hot spots.

When short-term site data is aggregated with the data from longer-term sites and calibrated, it expands the available data record. At present, site data are extremely difficult to aggregate because they typically represent widely divergent hydrologic regimes (inter-annual variability) and data quality, besides a difference in application of sampling techniques, analytic methods, and reporting protocols. By standardizing these elements across the Tahoe Basin and by providing nearest neighbor opportunities for site calibration, RSWMP will assure an efficient acquisition and use of stormwater monitoring data.

Examples of issues that can be addressed through pollutant source monitoring are given below. The Phase 2 document will consider these and other issues in designing the RSWMP program.

- The TMDL Draft Technical Report (Lahontan and NDEP 2007a) used basin-wide averages for event mean concentrations (EMCs) of pollutants of concern. This was due to the inherent time and financial constraints that existed during the pilot TMDL stormwater monitoring program. The Tahoe Basin RSWMP pollutant source monitoring, however, would provide a much more localized analysis of pollutant concentrations for the purpose of updating specific pollutant loads and to provide guidance for crediting.
- Monitoring will be designed to identify pollutant loading hot spots that might be considered for locating future projects, with recommendations based on RSWMP evaluations of contributing site characteristics and measured or estimated pollutant concentrations and loads.

Implementation Monitoring, Tracking and Crediting

Implementation monitoring will be necessary to meet the permit requirements or other regulatory obligations almost always associated with project installation. In its most basic form, this includes assurance that the project was done according to specification as detailed in the project design plans. Implementation monitoring could also be conducted in the form of long-term, visual monitoring to insure that the project has not suffered from design, performance or operational failure since it was completed. These different time scales will be taken into account during the design of implementation monitoring for RSWMP. Numerous agencies in the Tahoe Basin require implementation monitoring to comply with regulations and permit conditions. RSWMP will use their project requirements as the starting point for our recommendations.

Tracking and crediting will likely be key aspects of a water quality management system that could develop to oversee progress on reaching TMDL targets for pollutant load reduction. During development of the Tahoe Basin RSWMP monitoring design during Phase 2, every effort will be made to link RSWMP to plans for a crediting system. It is

likely that crediting will be based on pollutant reduction models and/or other standard engineering practices (e.g., Lake Tahoe Pollutant Load Reduction Estimator [PLRE], under development as part of the TMDL program). Again, all projects can not be individually monitored and there is likely to be a significant lag between project completion and the time needed to collected sufficient field monitoring data to make a statistically valid evaluation of project benefits. However, models or other techniques will require comprehensive, yet targeted monitoring in order to validate crediting tools. Additionally, models (such as the PLRE) and most other engineering approaches for estimating pollutant load reductions depend on realistic model parameters (e.g., rates of infiltration, geology-dependent erosion rates, sediment wash-on/wash-off coefficients, constituent-based removal characteristics, etc.) as well as on regional-based input data (e.g., precipitation, land-use, soil characteristics, etc.). The RWSMP Phase 2 document will consider how this monitoring program can contribute to these data needs, how to establish a consistent database that can be accessed by model users, and approaches for updating model parameters and input data based on new information. During Phase 2, we will work with the water quality agencies to help develop this linkage between RSWMP and crediting.

In the Phase 2 Framework document, RSWMP will also make specific recommendations on how to unite the Tahoe Basin RSWMP with a viable tracking system. Project meta-data that can be collected as part of implementation monitoring (location, land use characteristics, project specifics, estimates of pollutant reduction, etc.) and monitoring data should form the basis for an effective tracking system. A quantitative comparison between anticipated pollutant reduction (as estimated by modeling or other engineering methods) and actual monitoring effectiveness data would provide the objective data needed for evaluations to improve future project design in the continuous improvement cycle of adaptive management.

Ultimately, the results from RSWMP implementation monitoring would be aggregated with the data from status and trends monitoring, from LTIMP stream monitoring, and from Lake water quality monitoring to provide a basin-wide picture of progress toward meeting the TMDL clarity goals.

Section 4. Sampling and Analysis

Consistent protocols for the sampling and analysis of stormwater will be essential for developing the efficiencies of scale and the quality of data that are needed to justify this comprehensive regional approach to monitoring. It is likely that much of the monitoring will be conducted over time by various entities and for various purposes. A dynamic process for periodically evaluating the monitoring goals, objectives, design and protocols will maintain a continuity of purpose and consistency in application. Specified as one of the RSWMP programmatic directives, this process will be conducted within an adaptive management framework to be developed during RSWMP Phase 2. It is through this iterative progression of program refinement that the benefits of a regional monitoring program will best be realized.

To start, RSWMP in Phase 2 would need to specify practical and cost-effective methods for obtaining the data and information that is needed immediately. This will guide current monitoring projects until full RSWMP implementation during Phase 3. Several organizations (Caltrans 2000, CDM 2006, Heyvaert et al. 2007a) already have produced some form of sampling and analysis plan (SAP) or recommended operating protocols for stormwater studies in the Tahoe Basin. Therefore, one of the initial products during Phase 2 will be issuance of draft Tahoe Basin RSWMP sampling and analysis guidance based on the preceding three documents. The intent of the Tahoe Basin RSWMP is not to supplant monitoring by various groups in the Tahoe Basin for specific purposes, rather to provide a uniform context within which it operates so as to improve the relevance and applicability of most stormwater data collection efforts.

Typically, the necessary elements for a sampling and analysis plan include the statement of goals and data quality objectives, followed by determination of resources and constraints, then specification of performance and acceptance criteria, with a subsequent section detailing the protocols for collecting and documenting information on relevant site characteristics, and recommendations for monitoring equipment installations, monitoring methods and sampling protocols for the constituents of concern, as well as the laboratory protocols, analytic procedures and QA/QC requirements.

The goals and preliminary objectives have been developed as part of Phase 1. Further specification of the data quality objectives (DQOs) would be conducted as part of Phase 2. Standard operating procedures (SOPs) for field and laboratory methods should be developed according to published guidelines (EPA 2007).

Site Selection

Initially, as part of the Tahoe Basin RSWMP a subset of sites for priority monitoring will be selected from the network of existing available sites maintained by various jurisdictions and organizational entities within the Tahoe Basin. The RSWMP Phase 2 technical team will then work with each group to assure that standard methods are applied, as specified in the draft RSWMP SAP. This initial site selection will consider the requirements of land use and BMP evaluations for the PLRE, the requirements for

jurisdictional monitoring, and the requirements for long-term status and trends analysis. Thereafter, as the DQOs and associated monitoring design are refined, site selection will reflect these adjustments. In collaboration with jurisdictional personnel and their representatives, the Tahoe Basin RSWMP technical team including a stormwater statistician, will contribute to the evaluation of site characteristics for appropriate equipment installation.

GIS and Site Information

Metadata and site characteristic information are essential for subsequent data evaluation and analysis. A typical set of metadata requirements include (FHWA, 2003):

- Parameter, property, constituent, or identifier evaluated;
- Sample matrix (the water column, suspended solids, sediment, atmospheric deposition, or biota);
- Methods for collection, handling, processing, compositing, analysis, and interpretation;
- Type of data measured (concentration, population variable, or ratio);
- Location (latitude and longitude) of sampling point;
- Date and time of day samples were collected;
- Data collection and analyzing entities (who actually made the measurements);
- Data source (whose monitoring program); and
- Indication of data quality (including precision, bias, detection limits, and a defined QA/QC system).

Geographic Information Systems (GIS) are an effective tool for organizing and analyzing spatially-based information. Land use water quality relationships are much easier to discern within a GIS environment. Typical GIS information varies considerably with project type, but examples include:

- Drainage areas
- Slope and aspect characteristics
- Soil type distributions
- Vegetation types and coverage
- Drainage and conveyance and treatment features
- Land use distributions and impervious connectivity
- Stormwater BMP implementations and design characteristics

The draft RSWMP SAP will include standardized data reporting sheets for all of these characteristics and for other characteristics deemed appropriate for different types of RSWMP sites. Ultimately, these data will be entered into a GIS database to be developed for Phase 3 implementation, which will incorporate existing geo-referenced site information and current GIS data layers when available. Taken together, the application of site-specific information with conceptual or process-based models and appropriate statistical tools will drive continual improvement in RSWMP monitoring design and analysis.

Constituents of Concern

Physical and chemical water quality variables are the essential data elements of this Tahoe Basin regional monitoring program. At present the Tahoe TMDL stormwater monitoring program has collected data on a variety of constituents, including: TN, TKN, NO3-N, NH3-N, TP, TDP, SRP, TSS (or SSC), PSD, turbidity, pH, and electrical conductivity. In some cases, screening additional constituents may be important, such as grease and oil, alkalinity, dissolved oxygen, metals and pesticides.

Despite the importance of fine soil particles <20 µm in diameter, very few stormwater monitoring programs have included them. These fine soil constituents are of paramount importance to Lake clarity and are a focus of the TMDL (Swift et al. 2006; Lahontan and NDEP 2007a). Future stormwater monitoring programs must shift to include these in a consistent manner. However, progress has been slow due to a lack of coordinated sampling, suitable analytic protocols and funding programs. New methods for sampling, analysis and reporting need to be developed. Fortunately, a recent SNPLMA grant is addressing this issue directly (Heyvaert et al. 2007b). It is this blend of research and monitoring data that will allow us to best understand the source, transport and fate of these all-important fine sediment particles. The Tahoe Basin RSWMP provides the best opportunity for developing a reliable database on fine particles in stormwater runoff.

The analytic costs associated with collecting these data can be excessive. Therefore, one of the important roles for RSWMP will be to continually evaluate data needs in order to best determine when and where it is appropriate and cost-effective to collect the data. We believe this will improve the responsiveness of RSWMP and the stormwater management community to emerging issues of concern at Tahoe over time.

One of the first actions of RSWMP in Phase 2 will be develop a list of priority analytic constituents and physical variables, with recommendations on which analytes should be reported, at what frequency and at which sites. These recommendations will be evaluated and updated on a periodic basis within the adaptive management framework. In some cases, surrogate variables may be identified that could substitute for more costly sample analyses.

Monitoring Methods and Sampling Protocols

In addressing these topics, existing Sampling and Analysis Plans will be used, with modifications as necessary to address the specific and unique requirements of a Tahoe Basin RSWMP. In particular, methods will be described for the different types of monitoring to be conducted under auspices of the Tahoe Basin RSWMP (implementation, probabilistic, and status and trends monitoring). These methods will ensure consistent practice in the evaluation of BMP performance, or post-project assessment, as well as provide legally defensible data for permit reporting and TMDL tracking. Some of these methods likely will be developed and published as part of a Tahoe SNPLMA project currently in progress (Heyvaert et al., 2007c). Others will be developed specifically by the Tahoe Basin RSWMP staff in collaboration with core group representatives.

In addition, standardized procedures will be described for collecting important ancillary information such as flow data, precipitation and meteorological data, maintenance activities, soil moisture conditions, snow storage and other land use activities. Procedures will be described for determining the number of event samples to be collected, sample pacing, compositing schedules, and sample handling. Standardized protocols will be provided for recording types of precipitation events, start and end times for events, runoff volumes, peak intensities, recurrence intervals, etc.

After field methods have been detailed in the draft SAP, technical staff will conduct site visits where appropriate to work collaboratively with RSWMP affiliated personnel or their representatives to assure consistency in methods and data quality.

Lab Protocols and Analytic Procedures

A number of research laboratories and commercial labs have performed analytical chemistry for various Tahoe projects over the years. Fortunately, most of these analyses were usually conducted according to procedures published by the EPA, USGS, ASTM or APWA as standard methods. However, even these differences in laboratory methods can introduce substantial variance and uncertainty to stormwater data sets. Therefore, it will be imperative that specific analytic methods are applied to Tahoe Basin RSWMP stormwater samples to meet specific standards. In particular, to be accepted into the Tahoe Basin Stormwater Database for legal or permitting purposes we must be able to substantiate competence for admissibility. This means we must determine specific methods and laboratory protocols for sample handling and analysis. Furthermore, these methods must suit a variety of sample matrices (stormwater, lake water, stream and ground waters) for assembled data analysis on lake loading estimates and for modeling purposes.

The RSWMP staff will work directly with designated laboratories (as recommended by RSWMP affiliates) to review analytic methods, determine differences, assess appropriateness and ultimately to make recommendations that will meet analytic needs for the RSWMP goals and data quality objectives. To the extent practical these methods will also be selected to meet requirements for admissibility to other data compilation efforts, such as EPA's STORET, the International Stormwater BMP Database, and the California Surface Water Ambient Monitoring Program. However, analytic needs specific to the Tahoe Basin will take precedence where necessary. This would be the case, for example, with analysis of particle size distribution (PSD), which is a uniquely Tahoe issue in terms of concern for particle distributions <20 microns.

QA/QC

Quality assurance and quality control (QA/QC) procedures will be specified in the Quality Assurance Project Plan (QAPP) and the draft SAP so that field personnel, laboratory technicians and data analysts know their requirements. Programmatic quality assurance is expected to be an iterative process, implemented as part of the QAPP cycle

as RSWMP matures (Figure 1). This process will follow the guidelines developed as part of the EPA Quality System Series and their requirements for Quality Management Plans (EPA, 2001), which will help direct overall development and implementation of the Tahoe Basin RSWMP. Other quality assurance specifications will define roles and responsibilities, interagency and affiliate activities, sample handling and chain-of-custody requirements, data review, validation and verification requirements, as well as assessment and response actions.

Consistent quality control procedures will be implemented as part of RSWMP sample collection and analysis. This generally includes blanks, spikes, replicates, splits and standard reference materials. The percentage of samples that should be devoted to QC will be determined as appropriate and necessary to meet the DQOs or RSWMP programmatic objectives. However, we anticipate between 10–20% of analytic costs will be associated with quality control samples. Recommended response actions will be provided when QC conditions are not met.

Furthermore, RSWMP technical staff will begin to conduct site inspection and training programs to assure full implementation of appropriate techniques and QA/QC. Ultimately, event visits will be conducted on a random basis to confirm that appropriate methods and quality control procedures are consistently applied.

Finally, an inter-laboratory sample analysis program will be implemented as part of the Tahoe Basin RSWMP. Historical results from inter-laboratory comparisons have shown that analytical uncertainties in data sets can be much larger than the published values for accuracy of standard methods (FHWA, 2003). Therefore, only those laboratories that have been certified as participating in the RSWMP inter-laboratory blind sample comparative analysis program will be allowed to provide accredited data for legal and permitting purposes.

Section 5. Data Management and Analysis

With standardization of stormwater data collection and monitoring procedures (Section 4), it will become much easier to compile the information from various sites and different projects. The development of a shared and broadly accessible stormwater database would further enhance this compilation effort and would improve the consistency, reliability, completeness and credibility of data, particularly when accompanied by clear and detailed written procedures for data management and reporting.

Stormwater Quality Database

The Regional Stormwater Monitoring Program would work to facilitate adopting and augmenting the Tahoe BMP Database currently under development to collect, store and distribute the stormwater data provided by various BMP monitoring projects in the Tahoe Basin. Geosyntec Consultants (Portland, OR) has been contracted with funding from a recent SNPLMA grant to develop the Tahoe BMP Database. They are one of the key developers of the International BMP Performance Database (http://www.bmpdatabase.org), and will implement many of the same features for data collection, delivery and analysis in the Tahoe BMP Database. The next logical step would be to take that database and extend its utility to include all stormwater sampling associated with the Tahoe Basin RSWMP.

The cost and infrastructure requirements for extending development of the Tahoe BMP Database to a full Tahoe Basin Stormwater Database would need to be determined by RSWMP in Phase 2 consultation with Geosyntec and their associates. Ultimately, the objective is to host this extended stormwater database on the existing Tahoe Integrated Information System (TIIMS) for community access to all stormwater data and analysis products. The addition of a GIS interface would further enhance the utility of this database, and those costs could be estimated in consultation with TIIMS staff at the TRPA. These feature specifications and cost estimates for the full development and maintenance of a TIIMS-hosted Tahoe Basin Stormwater Database will provide the basis for subsequent funding requests by affiliated agencies to support implementation. That implementation would be expected to provide GIS mapping linked to the stormwater database.

In the meantime, the RSWMP Phase 2 team could provide two interim products that would serve to compile the available stormwater data and GIS information. A simplified stormwater database should be constructed in Access and distributed to RSWMP partners. A separate GIS database also should be constructed in ArcGIS and distributed to RSWMP partners. This should build on the existing GIS data sets (TMDL, TetraTech, TIIMS), rather than starting from scratch. Outfall information, site characteristics, drainage areas and land use distributions would then be developed for existing and potential monitoring sites.

Data Management QA/QC

The two interim RSWMP database products should include procedures for documenting electronic file locations, instructions for data screening, importing and archiving instructions, as well as mandatory quality assurance checks and metadata requirements. They would also include procedures for dealing with data that are below the detection limits or are considered not to be of high quality. Protocols would need to be developed to regularly review quality assurance results and to quickly identify and rectify problems.

As discussed for analytic methods, the Tahoe Basin RSWMP data standards should attempt to conform to EPA's STORET, the International Stormwater BMP Database, and the California Surface Water Ambient Monitoring Program.

Standard procedures will need to be adopted and documented for all data entry, verification, calculations, and reporting. Subsequent statistical analyses should be detailed, including methods and software. Protocols would be developed for periodic data quality assessment (accuracy, precision, completeness, representativeness, comparability) relevant to data quality objectives.

Data templates would be developed in consultation with RSWMP Core Working Group members or representatives. These will form the basis for data reporting by RSWMP affiliates, and will provide efficient data collection and entry routines into the interim databases and, ultimately, into the full Tahoe Basin Stormwater Database.

Data Analysis and Reporting

Data analysis and reporting protocols should be developed to address priority data objectives and monitoring goals (Section 2), based principally on further discussion with the RSWMP Core Working Group, Geosyntec and RSWMP stormwater statisticians. These features should be integrated into the Tahoe Basin Stormwater Database, and would support detailed queries, data export and some statistical functions. Examples of available data on query would include:

- monitoring site locations
- drainage boundaries and area
- topography: slope and aspect distributions, flowpath lengths
- average runoff coefficients
- average annual number of storms
- storm size / frequency distributions
- annual precipitation: isohyetal estimates and gauged measurements
- soil type distributions
- depth to seasonal high groundwater
- land use distributions
- impervious coverage and connectedness
- conveyance features and discharge points
- water quality data at sampling locations
- hydrologic data at sampling points

Data analyses are more complex than site characterization, and much of the data analysis will be done as part of the periodic reporting cycle. However, these data should be made available for query and download (after QA/QC) so that subsequent data exploration and analysis would be available to the Tahoe stormwater community. Furthermore, some standard data analytic routines would be built into the database, including:

- sample means
- sample medians
- geometric means
- sample standard deviations
- interquartile ranges
- percentiles
- extreme values
- time series plots
- boxplots
- confidence intervals
- Kruskal-Wallis tests
- storm event summary routines

A standardized, web-based quarterly reporting of summary results could be provided to all RSWMP affiliates. This would be based on standardized reporting routines (e.g., graphs showing loading trends) that can be put on the web and which anyone can download. Data would be made available for download after completing all QA/QC requirements.

An annual "Lake Tahoe Basin Stormwater Quality Report" would be the compilation of these web-based routines and data, along with a summary data analysis section and any recommendations for mid-course adjustments (i.e., simple adaptive management). This report would include a description of any program changes that have been developed in consultation with the RSWMP Core Working Group, along with appropriate contacts or instructions for implementation. It would provide updated results from the stormwater monitoring and projects or studies conducted during the year with relevance to modeling, management or regulatory decisions.

The Tahoe Basin RSWMP should also conduct a more comprehensive reporting every 5-years (immediately preceding the threshold status review). This report would provide the more substantive status and trends analyses and adaptive management recommendations.

Section 6. Reporting Cycles and Products

The potential exists for the Tahoe Basin RSWMP to take on a key role in a water quality management system that is currently being developed to support achieving the water quality improvement targets expected from the Lake Tahoe TMDL. The RSWMP Phase 2 Framework document will focus extensively on establishing specific products and reporting cycles that meet the needs of regulatory/permitting agencies, project implementers and water quality scientists. Below we discuss a number of possible products that can be delivered by a functioning and fully supported RSWMP; others will be identified during Phase 2 discussions. The Phase 2 Framework document will provide specific recommendations on how to integrate each ancillary product into the Tahoe Basin Regional Stormwater Monitoring Program, with consideration that reporting cycles vary between federal, state and local funding programs.

Conceptual Model Defining RSWMP Role in Lake Tahoe TMDL Management System

The Lake Tahoe TMDL Water Quality Management System, currently under development, is in part dependent on the BMP effectiveness and urban stormwater status and trends data that will be developed by RSWMP. As part of the Phase 2 document we will assist the TMDL agencies in developing a working conceptual model that defines the specific role(s) of RSWMP in the Management System.

Consistency in Sampling, Analysis and Data Evaluation

At least two approaches are necessary to address the issue of consistency. First, as part of the Phase 2 document we will create a series of documents, including but not limited to a Tahoe Basin RSWMP Quality Assurance Project Plan (see Section 9, Task 2), a Data Quality Objectives analysis (see Section 9, Task 3), and a Sampling and Analysis Plan (see Section 9, Task 5). These products will establish the criteria for sampling, analysis and data evaluation. Second, the Phase 2 Framework document will consider how RSWMP staff will oversee conformity by the various parties involved with data collection and management once RSWMP is operational.

Data Repository and Tracking

The RSWMP Core Working Group has identified the need to establish a repository for stormwater data and consider its possible links to a system for tracking pollutant reduction at the BMP, localized drainage, and basin-wide scales. As discussed in Section 5 (*Stormwater Quality Database*), it is envisioned that the Tahoe BMP Database (current development being funded by a SNPLMA science grant) will be extended into a full Tahoe Basin Stormwater Database, and that ultimately this will be hosted on TIIMS (Tahoe Integrated Information Management System). The Phase 2 document will identify data management needs, coordinate with the Tahoe BMP Database project, investigate the needs for expanding into the Tahoe Basin Stormwater Database, and consider various options (and readiness) for using TIIMS as a platform for data and report dissemination.

In addition, the Phase 2 document will discuss the financial and staffing needs to maintain a Tahoe Basin Stormwater Database, linked to TIIMS.

Meeting Permit Requirements for Reporting

The Core Working Group has discussed the possibility that Tahoe Basin RSWMP staff could assist in preparing the water quality monitoring reports for implementers as required under their permits with regulatory agencies. For example, the Lahontan Water Board has an NPDES permit with El Dorado County, Placer County and the City of South Lake Tahoe for storm water/urban runoff discharges that requires monitoring and reporting under the California Water Code including a Storm Water Management Plan with an effectiveness assessment component. The specific role that RSWMP could play in helping permitees to meet their monitoring and reporting requirements will be an important topic of discussion in Phase 2, along with funding arrangements. If achieved, this would insure a common reporting format and, when done in close cooperation with the agencies, could provide guidance in determining what types of data and data analysis are required. Not only would this greatly enhance consistency between permit reports, it also provides a uniform database so that RSWMP scientists and others could conduct statistically-based meta-analysis of multiple projects; i.e., monitoring data from all RSWMP projects could be used in a larger, over-arching statistical evaluation of BMP effectiveness and status and trends (see following topic). Finally, the products would be designed to meet the regulatory reporting requirements of all participating implementing agencies relieving them of individually meeting this obligation.

Analysis of Localized Pollutant Sources, BMP Effectiveness and Progress Towards Pollutant Load Reduction

Each year the Tahoe Basin RSWMP will obtain data on EMCs from localized pollutant sources, BMP effectiveness, and cumulative pollutant load reduction. This analysis will look at results on multiple scales of space (site, project, drainage, Tahoe Basin) and time (event, annual, and multiannual trends). As part of the Phase 2 document, we will (1) determine the level of statistical analysis needed for these data, (2) determine the most appropriate approach for tracking BMP effectiveness within a time-series format, (3) work with agencies, implementers and scientists to determine the most useful types of analyses for inclusion in an annual report, and (4) work with regulatory agencies to determine how the RSWMP data can be used to measure progress towards meeting TMDL targets.

Identification of Knowledge Gaps and Key Management Questions

As data from the Tahoe Basin RSWMP program becomes available it will be important that it be used to assess knowledge gaps, develop key management questions, and form the basis for directing and prioritizing science research in the area of stormwater management. The Phase 2 Framework document will establish a format for the integration of RSWMP monitoring data and research within an adaptive management framework.

Information Update for Incorporation into Permits and Other Policy/Planning Documents

Using an adaptive management framework, we anticipate that Tahoe Basin RSWMP data will be used to update NPDES stormwater permits as they are renewed every five years. As part of the Phase 2 we will address the needs that agencies such as Lahontan and NDEP will have for re-issuing permits and what RSWMP can do to contribute to this process.

Dissemination of Data and Findings

In Phase 2 RSWMP will consider how to disseminate data and findings. As noted above, the Tahoe Basin RSWMP data may be hosted on TIIMS or a similar website for public use. The specific approaches to dissemination of findings are dependent on staff and financial resources; the various strategies include an annual report, regular meetings with the Core Working Group, in-basin presentations, publications in peer-reviewed journals, a newsletter, fact sheets. Web-based distribution of RSWMP data, reports and tools will be necessary to support a consistent basin-wide approach to stormwater monitoring and management.

Section 7. Organizational Development

A stable and broadly supported organizational structure will be important to the successful implementation of a Tahoe Basin Regional Stormwater Monitoring Program. Whatever form it takes, the organization must be responsive and have the ability to respond to changing needs and knowledge about stormwater issues and water quality management in the Tahoe Basin. Considerable progress has been made over the last year to better define the processes and structural elements that contribute to an adaptive program for the Lake Tahoe Basin that integrates well with broader issues and management requirements (Sokulsky and Beierle, 2007; Huffman and Carpenter, 2007). The exact form of the Tahoe Basin RSWMP organizational structure will be determine during Phase 2, and will draw on available expertise, as represented by the cited documents and their authors, in discussion with Tahoe Basin RSWMP staff and agencies during Phase 2.

Integrated Assessment and Continual Improvement

The efficiencies of scale at programmatic and jurisdictional levels, upon which this regional stormwater monitoring program are predicated, will be best achieved within an adaptive management framework. The adaptive management process incorporates research into an integration of design, management, and monitoring that systematically tests assumptions in order to adapt and learn. (Salfasky et al., 2001). It is a procedure for dealing with and reducing uncertainty in resource management decisions. However, this is difficult to achieve in complex resource management programs, especially where environmental regulations necessarily constrain management experiments. Instead, most of these programs have turned to a continual improvement cycle, where monitoring fills the role of research experiments and indicates the progress toward management goals.

A fully realized adaptive management framework for the Tahoe Basin would integrate assessment, evaluation and decisions about many relevant factors beyond stormwater issues. However, the Tahoe Basin RSWMP will be a vitally important component of this framework, and would operate under adaptive management principles itself. It is expected to contribute to a broader program of basin-scale integrated assessment that would facilitate evidence-based decision-making at executive levels (Huffman and Carpenter, 2007). Integrated assessment and planning within an adaptive management framework leads to the process of continual improvement and allows policy to be revised, based on improved knowledge. Taken together, adaptive management and continual improvement facilitate coordination and resource management decisions across agencies to ensure that past performance informs future actions (Sokulsky and Beirle, 2007).

Operational Models

We believe there are two basic models that would be appropriate for developing a functional Tahoe Basin Regional Stormwater Monitoring Program. For lack of better terminology we will call these the “in-house” model and the “contract” model.

With the in-house model, nearly all functions of the program are developed, administered and completed by a fully-staffed third party program that exists separately from the agencies and entities that have a direct stake in those projects that RSWMP monitors. In this case, there is a fairly large payroll and operating budget that is assigned directly to the Tahoe Basin RSWMP organization. The advantage of this approach is a seamless integration of all task elements and products. Also, quality control and program modifications would be easier to implement, and the program may be more responsive overall. Furthermore, with RSWMP as an independent third party, there would be less potential for conflict of interest in the outcome (findings) of projects monitored by RSWMP, which would enhance the credibility of results. The disadvantages of this approach include developing and maintaining larger allocations from funding sources, along with increased staffing responsibility and management overhead. Also, it would most likely result in less direct interaction between Tahoe Basin RSWMP personnel and agency staff, leading to inefficiencies in feedback between stakeholders and RSWMP about on-the-ground issues important to end users of the RSWMP data products. In addition, too large of an RSWMP staff could take attention away from technical issues as personnel management will inevitably become a larger issue requiring more executive staff time.

The alternative approach, at least for the initial implementation of the Tahoe Basin RSWMP, would be the contract model, where a smaller RSWMP staff develop and administer most of the RSWMP functions, but much of the work is done in collaboration with other groups. These external tasks would still be accomplished under the guidance of an RSWMP director and staff, but would draw on the available personnel and funding resources of affiliate groups or would fund subcontractors directly (e.g., to accomplish aspects of station/equipment installation and operation, monitoring and laboratory analyses, etc.) In this case, there are more groups involved with greater potential for miscommunication and diluted end products that do not meet the precise needs of the Tahoe Basin RSWMP and their stakeholders. There would also be increased administrative overhead for developing and executing the necessary contracts and interagency agreements. On the other hand, overall, it could be a less expensive implementation of the Tahoe RSWMP, especially during initial development before RSWMP becomes a well established, mature program at Tahoe that is recognized for long-term contributions to better stormwater data and management needs.

In part, much of this discussion about which model is best suited to the Tahoe Basin RSWMP must happen in the context of funding mechanisms (see Section 8). In either case, however, we believe that there will be certain structural elements in common to both models. These are discussed below, from the perspective of an adaptive management process for the Tahoe Basin RSWMP.

Organizational Structure

A team approach has been recommended for development and implementation of an Integrated Assessment for the Tahoe Basin (Huffman and Carpenter, 2007). This is also appropriate for the Tahoe Basin RSWMP, where a coordinated program would be built

with extensive stakeholder and decision-maker involvement. That has been the process used during Phase 1, where the Tahoe Basin RSWMP Core Working Group consisted of at least one representative from most of the regional stormwater stakeholder groups. It is important to keep in mind that the discussion below is just one example of the many approaches available, and it is not to be taken as a final recommendation at this time. However, it will serve as a basis for the start of discussion during Phase 2.

An integrated assessment team approach for the Tahoe Basin RSWMP would consist of an Executive Team, a Design Team and a Technical Team, as well as data collectors, stakeholders and resource managers. Although the steps and linkages may differ somewhat, one overall approach is shown in Figure 2, as adapted from Huffman and Carpenter (2007).

Executive engagement is essential for annual reviews of conceptual models, strategic and annual plans, synthesis of findings, and communicating RSWMP information that could inform adaptive management decisions. An Executive Steering Committee is seen as filling this role, and would link to the Tahoe Interagency Executive (TIE) group.

Given the success of the RSWMP Core Working Group, it is expected that they will continue to exist actively as the Design Team; working on a regular basis to represent the needs of implementers and resource managers, working with the Technical Team to develop or revise the framework (building on this document), and providing regular feedback to the TIE. The Design Team is made up of agency representatives, as well as scientific representatives from the Technical Team.

The Technical Team operates to accomplish goals identified by the Design Team. It includes research experts with specialization in the necessary fields, as well as the RSWMP technical staff and administrative personnel. This team also serves as a technical advisory group to ensure that the Design Team receives useful, high-quality data and reporting products as well as appropriate recommendations for continual improvement in the framework of the Tahoe Basin Regional Stormwater Monitoring Program.

External programmatic review will be an important part of this process. It is likely to occur initially as an annual occurrence, perhaps with representatives from other successful regional stormwater programs (such as the San Francisco Estuary Institute, California Stormwater Monitoring Coalition, or California Surface Water Ambient Monitoring Program).

Section 8. Funding Mechanisms and Operating Budget

Identifying funding mechanisms and developing an operating budget will be a significant task, critical to the successful implementation of RSWMP. The RSWMP Core Working Group has long recognized the fact that all parties involved, and especially the traditional funding agencies, must play an active and even a lead role in these discussions – it is unrealistic to expect that those preparing the Phase 2 Framework document can lead or control these discussions in the sense of final decision-making about funding. This is an agency issue, but the Tahoe Basin RSWMP team will be a key participant to these discussions. It is also recognized that there are real financial constraints on the technical and administrative operation of RSWMP. At the same time, there is a consensus that RSWMP needs a defined organizational structure (see Section 7) and a reasonable operating budget for it to meet the expressed goals and objectives.

The Tahoe Basin RSWMP operating budget must be sufficient to support an organizational structure that conducts stormwater monitoring, BMP effectiveness evaluation, and documentation towards water quality improvement, in order to become unified within the Tahoe Basin as a clearly identified organization, with a staff that can serve as a focal point and information source for the many discussions related to stormwater management that transcend the basic monitoring requirements of individual BMPs/water quality projects. Finally, the Core Working Group has also recognized that within an uncertain funding environment, the Tahoe Basin RSWMP will need flexibility to expand as resources allow. With this in mind, the Phase 2 Framework document will consider multiple funding scenarios for a Tahoe Basin RSWMP technical and administrative design, based on different levels of effort.

The Phase 2 document will consider the following, larger areas of concern, in its evaluation of funding mechanisms and operating budget. As noted above, while those preparing the Phase 2 document are not directly responsible for the procurement of funding per se, this aspect of the work needs to be initiated early in the process so as to optimize the likelihood that transition between Tahoe Basin RWSWP specification and planning (Phase 2) and the RSWMP implementation (Phase 3) can be as seamless as possible without major delays due to funding.

Estimation of Technical and Administrative Costs

Based on the stated goals/objectives and the resulting design of a monitoring plan to meet these needs, the project team will develop budgets including costs for sampling, sample analysis (laboratory costs), transportation expenses, data management (including QA/QC), equipment, data analysis, report preparation (including those required for permits and those that will fill key knowledge gaps in an integrative fashion), data dissemination, website maintenance, education and outreach, and numerous other areas. A series of 5-year budgets will be developed, based on level of effort. As an example, these levels of effort could include a budget based on (a) the current, basin-wide level of funding for stormwater monitoring, (b) or one meeting just the most important goals/objectives, or (c) another that outlines an innovative approach that would serve as a

model for stormwater monitoring nation-wide. This specific task is best done as an initial draft, followed by discussions with representatives of the funding groups and the Core Working Group, followed by the development of a recommended product. As noted above, early development of an initial budget is critical. The development of this recommended budget must recognize trade-offs between increased knowledge, expense, and what decision-makers will need to create sound policy informed by science.

Evaluation of Funds Currently Expended for Stormwater Monitoring

Working with Basin agencies and other relevant parties, the Phase 2 Framework document will identify the level of funding currently being used to support stormwater monitoring in the Tahoe Basin. Details on what specifically that funding will be used to support (field sampling, analytical costs, reporting, etc.) will be categorized to the extent possible.

Strategies for RSWMP Funding

There are many sources of funding that could be potentially available to help support RSWMP. These include, but are certainly not limited to the Southern Nevada Public Lands Management Act (SNPLMA), federal Clean Water Act funding (e.g., Water Quality and Assessment Planning or EPA Assessment and Watershed Protection Program grants), USFS Water Quality & Erosion Control Grants, state bond acts (e.g. California Proposition 84 grants), other state/local funding sources (e.g., Nevada Lake Tahoe License Plate Program grants), and many others (e.g., Stormwater Utility Districts, in-lieu permit fees, and TRPA Threshold Monitoring, Excess Coverage and Water Quality Mitigation Fees). Many of these potential sources require local, state or federal matches, so one of the advantages of the Tahoe Basin RSWMP would be coordination of various funding sources to leverage existing funds for new funding proposals and programs. The RSWMP project team will work with the agencies, staff of federal, state and local governments, and other stakeholders to identify funding potential opportunities.

Use of Existing and Future Funds for RSWMP

Prior to the implementation of a Tahoe Basin RSWMP in Phase 3, there must be agreement on the part of agencies and those parties currently involved in stormwater monitoring to agree to contribute to RSWMP. Whatever level of funding RSWMP receives, it must be stable and secure to avoid stranded investments in infrastructure and data sources, and to minimize the chance of creating a mismatch between expectations and outcomes. Further, the commitments to funding will need to allow for cost increases due to inflation to avoid the kinds of program erosion that have plagued LTIMP.

Transfer of Funding to RSWMP

Funding for RSWMP is likely to come from a variety of sources and funding periods (e.g., federal, state or local fiscal years). The Phase 2 documents will consider the most effective strategy or strategies for transferring funds to RSWMP. Direct transfers through

contracts or agreements, memoranda of understanding, or other such instruments will all need to be explored.

Operating Budget

The operating budget partially depends on the RSWMP operational structure (see Section 7). The Phase 2 document will consider the following items (as well as others) in developing the Tahoe Basin RSWMP operational budget: identify key personnel needed to meet specific goals/objectives; determine the availability of agency staff and identify their roles in the day-to-day operation of RSWMP; funding of consultants; operational expenses for office spaces and supplies, telephone/IT, supplies, etc.; equipment needs for field sampling (if any); travel; etc.

Financial Accounting

It is likely that funding could come to RSWMP through multiple sources and would be used by RSWMP to support a wide range of activities through multiple parties. During the Phase 2 work, attention must be given to developing a consistent and reliable bookkeeping process.

Section 9. Work Plan and Budget for Tahoe Basin RSWMP Phase 2

Scope and Objectives

This work plan describes the general processes, steps, and products that are necessary to establish a comprehensive Tahoe Basin Regional Stormwater Monitoring Program (RSWMP). The work outlined in this plan represents Phase 2 (design specification phase) in RSWMP development. This phase will continue with the iterative process established during Phase 1 for building a consistent, high-quality, consensus-driven approach toward stormwater monitoring. Phase 2 will fully engage representatives from regulatory agencies, implementing jurisdictions and other groups that are expected to be the end users of data and analytic RSWMP products, with members of the scientific community leading development of Phase 2 Framework documents and products.

The overall goals of the Tahoe Basin RSWMP are to develop a long-term program of stormwater monitoring, assessment and management recommendations to help inform the effective and efficient reduction of pollutant loads required by NPDES permits and TMDL requirements. This will be accomplished through an adaptive system that remains responsive to the needs of both regulated entities and regulators in meeting their load reduction targets, water quality standards and other mandates. In Phase 2, Tahoe Science Consortium (TSC) scientists, along with TSC staff and selected subcontractors will be responsible for the completion of the following tasks to investigate and develop the stormwater monitoring program plan, including:

- establishing an organizational structure for RSWMP, including a Project Advisory Group (RSWMP Core Working Group: aka Design Team), and clear definitions of how RSWMP will work in partnership with agencies and project implementers;
- developing consistent sampling and monitoring protocols and a QA/QC program;
- guiding the development of a stormwater database and reporting products,
- developing a monitoring design that is statistically valid, efficient, effective, reliable and responsive to the expressed goals and objectives;
- establishing clear protocols for data analysis and information transfer; and
- providing guidance for long-term funding.

Work Plan

This work will be accomplished by members of the Tahoe Science Consortium (TSC), its representatives and any subcontractors deemed necessary. It is anticipated that the USDA Forest Service Lake Tahoe Basin Management Unit (LTBMU), based in South Lake Tahoe, California, will administer this agreement, perhaps in concert with funding representation from additional sources. The TSC through its representatives shall be responsible for performance of the work as set forth and specified in this document. A TSC project representative shall notify the LTBMU project manager of any events or proposed changes that would affect the scope, budget or schedule of work to be performed under this agreement.

Based on previous experience, we expect that products from this proposal will produce a significant portion of what is necessarily required to fully implement the Tahoe Basin RSWMP. However, much remains uncertain at this time about how the agencies will decide to use RSWMP in their programs, or how they will fund RSWMP, as well as the specifics involved in crafting those agreements. Additional effort and products may be required. Funding for Phase 2 is limited to the extent that creation of a functioning RSWMP will require more agency and partner interaction than LTIMP development did in 1978. This is largely due to the regulatory ramifications of the RSWMP with regard to meeting permit requirements and providing data to be used directly in TMDL crediting and other regulatory programs. Agreement between parties will be critical, and as we know, these types of negotiations require significant time.

Task 1. Project Management, Administration and Coordination

Continued communication between the TSC team, the LTBMU project representative and RSWMP core working group members (project advisory group) will be critical to the success of this project. Therefore, the TSC representatives will continue to hold monthly meetings of the RSWMP Core Working Group to maintain effective communication with representatives of the designated agencies. These meetings will also provide monthly updates to the LTBMU project administrator.

1.1 Project Oversight: Provide all technical and administrative services as needed for contract completion; monitor, supervise, and review all work performed; and coordinate budgeting and scheduling to assure that the contract is completed within budget, on schedule, and in accordance with approved procedures, applicable laws, and regulations.

1.2 Quarterly Reports and Invoicing: Ensure that the contract requirements are met through completion of written quarterly status reports submitted to the LTBMU project representative by the 10th of the month following each calendar quarter. The progress reports shall describe activities undertaken and accomplishments of each task during the month, milestones achieved, and any problems encountered in the performance of the work under this contract.

1.3 Engage Program Stakeholders: This will involve the collection and application of stakeholder input, presentations on progress and methods, development of outreach materials and presentation summaries to meetings of selected committees in the Lake Tahoe Basin. Examples of these groups include the Stormwater Quality Improvement Committee and the Tahoe Interagency Executives Committee. The TSC RSWMP team will continue to meet regularly (monthly) with the Core Working Group.

1.4 Coordination with Other Programs and Projects: The TSC RSWMP team will coordinate with ongoing programs and projects associated with the TMDL development and EIP implementation. Work products developed under this agreement are expected to be integrated and/or consistent with other TMDL products. This will require coordination with agency and project staff to assure consistency.

Task 1 Products:

- Summary notes from monthly RSWMP Core Working Group meetings.
- Quarterly progress reports linked to invoicing.
- Progress and product presentations.

Estimated Cost: $48,634

Task 2. Quality Assurance Project Plan for the Tahoe Basin RSWMP

The primary purpose of a Quality Assurance Project Plan (QAPP) for the Tahoe Basin RSWMP is to assure that monitoring goals and objectives will be adequately addressed when the program is implemented in Phase 3. The RSWMP QAPP is intended to serve as the technical manual to be used by all participants. This document, in concert with oversight of individual and collective monitoring efforts will insure consistency of data between projects, and will allow data from multiple projects to used as part of an integrated statistical evaluation. The lead personnel on this task will be TSC representatives working in close communication with individuals at the regulatory agencies (LRWQCB and NDEP) and with staff person(s) from other appropriate Tahoe agencies.

2.1 Review Existing Programs: The TSC representatives will collect and review existing QAPPs from any current Tahoe Basin monitoring programs (e.g., TMDL, Caltrans, NDOT).

2.2 Draft QAPP: The TSC representatives and their subcontractors shall produce a draft Quality Assurance Project Plan to guide full implementation of the Tahoe Basin RSWMP. This document will follow EPA guidelines for developing QAPP documents (USEPA, 2002). The draft QAPP will be distributed to RSWMP core group members for review. Comments and suggestions will be addressed and incorporated into the final version where appropriate.

2.3 Final QAPP: The final QAPP document will be posted on the website of the Tahoe Integrated Information System (TIIMS). It is anticipated that this document will be subject to annual review and revision as part of full RSWMP implementation (Phase 3).

Task 2 Products:

- Draft QAPP.
- Final RSWMP QAPP document.

Estimated Cost: $30,368

Task 3. Monitoring Goals and Data Quality Objectives

The primary purpose of the Data Quality Objectives (DQO) Process is to develop performance and acceptance criteria that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions

(USEPA, 2006). The first part of the DQO process involves identification of monitoring goals. This was completed in a collaborative and iterative process during RSWMP Phase I (see Section 2 of this document), along with preliminary specification of data objectives (key questions). However, significant effort is still required to refine and prioritize the data objectives, and to assign statistical boundaries and expectations to those objectives. That will be fully developed as part of the Phase 2 program.

3.1 Define the Boundaries: Prioritize and select key questions (data objectives). Then specify the target populations and characteristics of interest, as well as spatial and temporal limits for those objectives. This begins the process of constraining program focus to specific information needs.

3.2 Review Existing Data: To date several pilot studies have been conducted on stormwater runoff in the Tahoe Basin. These are represented in the attached annotated bibliography (Appendix B). Based on specified acceptance criteria, the available data will be assembled and reviewed for assessment of quality, quantity, reliability and data needs. Consultation with a statistician with expertise in stormwater data will help the TSC RSWMP to further inform the specification of monitoring design and expected costs.

3.3 Develop Performance Criteria: Applying accepted statistical techniques used in stormwater studies elsewhere, develop tolerable decision and estimation uncertainty levels for anticipated uses of stormwater monitoring data (permitting, modeling, design evaluations, BMP performance assessment, etc.) These will be used to guide monitoring design decisions in the next task.

Task 3 Products:

- DQO document that specifies prioritized, bounded data objectives for RSWMP Phase 3.

Estimated Cost: $30,948

Task 4. Monitoring Design Specifications

Since the Tahoe Basin Regional Stormwater Monitoring Program is expected to serve multiple purposes, it will be developed as a nested design across both temporal and spatial scales. The monitoring design will contain both probabilistic elements and targeted sampling. The project team, led by TSC representatives, shall work with the RSWMP Core Working Group to identify appropriate sites for targeted sampling. The statistician will consult with the development team (TSC representatives) in the design of probabilistic features. Technical staff will determine the appropriate sampling locations and equipment for this design.

4.1 Identify Criteria for Targeted Monitoring: Project representatives will work with the core group to identify objective criteria for determining those specific features of interest that would be monitored as part of the initial RSWMP implementation. These representatives will then consult with agency and implementer staff to identify sites that

represent targeted features. Site visits will be conducted to evaluate and document suitability for monitoring.

4.2 Identify Population of Sites for Probabilistic Status and Trends Sampling: Some outfall mapping has been completed already for portions of the Tahoe Basin. Additional mapping is in progress by jurisdictional staff within each district (county, city, GID). These sites will be compiled by project staff into a GIS database to be used for developing sampling strata and associated sites. Site visits will be conducted to collect information on site characteristics, access and suitability for monitoring, which will be entered into the GIS database and will form the basis for randomized selection of sites within each strata to statistically represent that population. Stormwater index sites for trends analysis and for assessment of long-term project effectiveness at subbasin/drainage scales will be selected based on existing data, opportunity for establishing a permanent collection station, land use and activity characteristics, anticipated BMP/implementation or project development within the selected drainage, and other relevant criteria.

4.3 Produce Monitoring Design Document: This document will provide the details about which sites were selected for targeted monitoring and why, as well as the intended use of information and duration of monitoring. It will also provide a set of protocols for the random sampling of outfall sites to be monitored. This will include a statistical strategy for preliminary screening and/or stratified random sampling, specification of monitoring duration, sample and data collection requirements, as well as an explanation of intended purpose of the information. A longer-term strategy based on an adaptive management approach for future site selection and data evaluation will also be included. Specifications related to location, sampling frequency, constituents and recommended statistical approaches for data analysis will be included here, as well as in the Sampling and Analysis Plan.

Task 4 Products:

- Monitoring design document that details design approach, identifies sites and provides site selection procedures.

Estimated Cost: $63,222

Task 5. Sampling and Analysis Plan

Several organizations (Caltrans, NDOT, TERC/DRI) already have produced versions of a Sampling and Analysis Plan (SAP) for stormwater studies in the Tahoe Basin. Therefore, we anticipate working directly with one or more of these groups to modify an existing SAP to reflect the unique requirements of a comprehensive Tahoe Basin RSWMP. The project team will work with an appropriate partner (e.g., CSUS Office of Water Programs) to facilitate the development of a Tahoe Basin Stormwater SAP that meets the needs of all the RSWMP participants. Furthermore, RSWMP technical staff will begin to conduct site inspections to assure full implementation of appropriate techniques and QA/QC.

5.1 Sampling and Analysis Plan: This document will provide detailed protocols for collecting and documenting information on all relevant site characteristics, as well as recommendations for monitoring equipment installations, monitoring methods and sampling protocols for constituents of concern, laboratory protocols and analytic procedures and QA/QC requirements, etc.

5.2 Site Inspection: Project staff will conduct periodic site visits to evaluate the on-the-ground conditions for equipment and installation at the possible monitoring sites.

5.3 Inter-Laboratory Sample Analysis Program: Tahoe Basin RSWMP analyses should be conducted by laboratories that have been certified as participating in an inter-laboratory blind sample comparative analysis program. Some preliminary inter-laboratory analyses have been conducted as part of the Tahoe TMDL/EPA Stormwater Network. That program will be continued as part of Phase 2 to the extent needed to establish guidelines for sample analysis.

Task 5 Products:

- Sampling and Analysis Plan for all aspects of formal monitoring and sampling associated with Tahoe Basin RSWMP implementation.
- Site training and inspection forms filled out for each participating agency or jurisdiction.
- Tahoe Basin RSWMP inter-laboratory QC program.

Estimated Cost: $25,871

Task 6. Stormwater Database Development, Data Management and Analysis

The complete compilation and analysis of stormwater data will be critical to achieving Tahoe Basin RSWMP goals. Given the amount of data that will be assembled over time, this can only be accomplished with a database designed and built toward those objectives. Therefore, RSWMP will consult with appropriate partners to adapt the Tahoe BMP Database that is currently under development by Geosyntec and their collaborators. Ultimately, the objective will be to host this database in a GIS accessible format on the Tahoe Integrated Information System (TIIMS) for community access to data and analysis products.

6.1 Tahoe Stormwater Database: The TSC representatives will consult with RSWMP Core Working Group representatives, with TIIMS staff and with Geosyntec to develop specifications and cost estimates for extending the Tahoe BMP Database to expanded use as the Tahoe Basin Stormwater Database. In the interim, the RSWMP Phase 2 team will implement an Access database to collect stormwater information and an ArcGIS database to track information on existing and potential monitoring sites.

6.2 Data Management QA/QC Protocols: Standard forms and protocols will be developed to manage data collection, delivery, entry, analysis and reporting. Data reporting templates will be provided to all RSWMP affiliates engaged in stormwater monitoring.

6.3 Data Analysis and Reporting: As needed to complete the Phase 2 RSWMP design requirements, data analyses, event summaries and statistical analyses will be provided with the quarterly RSWMP progress reports. Additional reporting on protocols and QA/QC requirements for field, lab and data management activities will be distributed as developed during Phase 2.

Task 6 Products:

- Design specifications and cost estimates for Tahoe Basin Stormwater Database.
- Data reporting templates distributed to RSWMP affiliates.
- Quarterly data reporting and summaries used in Phase 2 RSWMP design.
- Standard protocol documents for field, lab and data tasks.

Estimated Cost: $22,534

Task 7. Organizational Development

The basic elements of organizational structure were presented in Section 7. These include: a Design Team, provisionally represented by the Tahoe Basin RSWMP Core Working Group; an Executive Team, provisionally represented by the Tahoe Interagency Executive Committee; and a Technical Team, provisionally represented by the Tahoe Science Consortium Stormwater Group. Further details for an appropriate organizational structure and required personnel will be developed during Phase 2, in consultation with Tahoe Basin RSWMP affiliate representatives and consultants.

7.1 Organizational Structure: The Tahoe Basin RSWMP Team will initiate stakeholder meetings to determine a viable operational model and organizational structure for the regional stormwater monitoring program. A consultant will be employed to facilitate and document the results of these discussions, as well as to research and report on important factors for implementation of the preferred solutions. These discussions will be conducted in collaboration with development of Task 8 (RSWMP Funding Agreements).

Task 7 Products:

- Documentation (memo format) of key outcomes from facilitated discussions with stakeholders, agency and scientific representatives to determine preferred operational model and organizational structure for Tahoe Basin RSWMP.
- Report contributing to Tahoe Basin RSWMP framework document that specifies duties, responsibilities, products and linkages between all RSWMP teams, personnel, affiliates and funding groups.

Estimated Cost: $23,062

Task 8. Develop Funding Agreements for Regional Program

As discussed elsewhere in this document, it is well beyond the scope of work and official capacity for the TSC RSWMP development team to take on the responsibility of securing funding for Phase 3 implementation of this overall effort. Therefore, it will be, by

necessity, the joint responsibility of the agencies and implementers, in communication with the RSWMP team.

8.1 Funding Discussions: We have budgeted a very limited amount of time to the Principal Investigators and the Facilitator (approximately two weeks in total) to participate in discussions between agency and implementer representatives. The TSC RSWMP team will provide information on the funding needed to implement RSWMP and to help strategize on sources of RSMWP funding, to the extent possible.

8.2 Budget Needs: The TSC RSWMP development team will provide information on the following topics; estimation of technical and administrative costs, evaluation of funding currently spent on stormwater monitoring, identify optional mechanisms for transfer of funds to support RSWMP for Phase 3 activities considering financial accounting and, develop a draft RSWMP operating budget.

Task 8 Products:

- Participation in interagency led discussions on funding strategies.
- Estimation of RSWMP administrative and technical budget, resource and personnel needs.

Estimated Cost: $14,668

Phase 2 Personnel and Budget

Specific personnel that will work on preparation of the Phase 2 document have not yet fully been identified; instead the time and cost estimates are based on position/area of expertise required for each task (see Section 9). Values include benefits (as appropriate) and institutional indirect costs. It is anticipated that this initial budget could be modified based on comments to this scope of work (prior to final contract approval).

We anticipate that the actual level of effort to implement RSWMP will be greater than that set forth in this document; this especially applies to the involvement of agency representatives who will benefit the most from an effective Tahoe Basin RSWMP. As previously discussed, along with LTIMP, RSWMP will be one of the largest monitoring programs in the Tahoe Basin, and surely will be the most comprehensive program developed in the past 30 years. Given its direct applicability to regulatory requirements, the negotiations concerning administrative portions of the RSWMP (including funding) could be very significant. The current budget can not fully account for these issues or for other technical issues that may arise during the course of Phase 2. Also, RSWMP set-up costs will be included under Phase 3 activities. However, we are certain that the work tasks presented in this document will provide us with the basis of technical information needed to proceed into Phase 3 implementation.

Below, we (1) list the areas of required expertise for development of the Phase 2 Framework document and specified products, (2) provide a brief overview of that position's responsibilities and (3) present a justification summarizing the role of each position in the RSWMP Project Team. Please note that we have developed the required

personnel needs with the understanding that both the development of the Phase 2 monitoring and RSWMP organization design, and the actual Phase 3 implementation effort will require participants with a wide range of skills; this is especially true for the issue of funding sources. In this current Phase 2 proposal we have not relied solely on the expertise available at the research institutions, rather, we have looked to the private, public and academic sectors to the best fit for project needs.

• Principle Investigators (PI) - This position will provide scientific and organizational direction to the project, and will be responsible for producing the final document and coordination of Project Team. The PIs will be involved in all aspects of this work and therefore a strong background in water quality, stormwater sampling, data analysis, analytical procedures, design and operation of large monitoring programs, and experience in integrating science with water quality planning is vital. Drs. Alan C. Heyvaert (DRI) and John E. Reuter (UCD) will serve in this role. It is estimated in total, a 60% PY (person year) is needed to successfully deliver the Phase 2 document.

• Administrative Assistant (AA) - It is anticipated that this project will require a level of organization that goes well beyond a typical research grant. Given the wide range of current and expected participants in a fully implemented RSWMP, project coordination, meeting scheduling, preparation of meeting notes and project documents will be essential. At least a 25% PY will be needed for these critical activities. We suggest that the AA be on staff at UCD.

• Field Technicians (Tech) - Selection of meaningful and functional sampling sites lies at the heart of every successful monitoring program. Monitoring will likely been conducted on multiple scales as part of RSWMP, including long-term index stations, stations for the probabilistic sampling (see Section 3), and BMP and project monitoring. Extensive field surveys, along with a practical understanding of the factors involved in establishment and operation of automated stormwater monitoring stations is required. These personnel will also participate in development of an approach toward implementation monitoring as well as in formulating the Sampling and Analysis Plan (see Section 9, Task 5). The combined expertise of agency personnel and research institution staff will best serve this purpose. We suggest that a combination of staff from the Basin's two Conservation Districts (NTCD and TRCD) as well as from DRI and TERC to perform this work at a combined level of 50% PY.

• Stormwater Statistician - A statistically valid monitoring design is central to any monitoring program. Stormwater monitoring in particular poses some unique issues that are not applicable in conventional stream and lake monitoring. It is essential that we bring in the expertise of a bona fide stormwater statistician to provide assistance on specific issues such as number, type and location of sites, sampling frequency, methods for analysis and presentation of results, and to participate in discussions of level of sampling required to make sound management decisions in the Lake Tahoe Basin (Data Quality Objectives Process; see Section 9, Task 3). In addition, the statistician will help perform analyses using the existing TMDL Stormwater Monitoring database to determine number of locations, sampling frequency and expected level of confidence so that these

determinations can be made using Tahoe- specific data. We anticipate that an outside consultant will serve as the stormwater statistician at a cost of approximately $30,000.

• Quality Assurance/Quality Control Programmatic Advisor (QA/QC Advisor) - QA/QC is fundamental to meet the programmatic directive of assuring consistency in stormwater monitoring (see Section 2). Analytical labs have documented QA/QC plans specifically for sample holding time, chemical analysis and data reporting; the QA/QC Advisor will set out guidelines for what RSWMP would require from a participating lab. In addition, there are aspects related to QA/QC that apply to the entire RSWMP program, therefore, the QA/QC Advisor will also prepare guidelines for QA/QC at this programmatic level. As with the statistician, it will be critical to obtain the services of someone with experience in all aspects of QA/QC related specifically to stormwater monitoring and program development. We will likely need to bring in an outside consultant at, at least a cost of $15,000.

• Data Manager/GIS - Data management is another key component of all monitoring programs. In preparing the Phase 2 document the expertise of a data manager will be needed to (1) provide recommendations for the establishment of a working Lake Tahoe RSWMP and (2) preparation of data for use by the stormwater statistician. The UCD/DRI stormwater team (under the direction of Alan Heyvaert) currently has expertise in this area, as well as in the use if GIS for selecting and characterizing drainage features. We anticipate a need of 25% PY for this activity.

• Facilitator - The creation of a working RSWMP will require a high degree of cooperation, agreement and trust between its many partners and participants. Based on our positive experience during the creation of the Tahoe Science Consortium, the use of a qualified facilitator provides a productive level of discussion that a facilitator who is not a direct stakeholder can supply. We anticipate that a consultant will be hired at a level of $10,000.

Based on the tasks presented in Section 9, a $259,308 budget was developed. The following is a task-by-task summary. It does not show any costs incurred by the organization that administers this contract, since that remains unknown.

Task 1. Project Management	*$48,634*
Task 2. Quality Assurance Project Plan	*$30,368*
Task 3. Monitoring Goals and DQO	*$30,948*
Task 4. Monitoring Design Specifications	*$63,222*
Task 5. Sampling and Analysis Plan[†]	*$25,872*
Task 6. Database Development and Management	*$22,534*
Task 7. Organizational Development	*$23,062*
Task 8. Funding Agreements	*$14,668*
Total (includes travel, operational costs, institutional ICR)	*$259,307*

[†]Production of a complete and final Sampling and Analysis Plan could require a large part of the total budget, if done for the purpose of regulatory requirements. Ideally, others who have already developed

formal SAPs for their specific purposes (e.g., Caltrans and NDOT) will lend their assistance to the TSC RSWMP team for this task. Otherwise, our budget does not cover the anticipated actual cost of this complete task.

Schedule

Scheduling for the Tahoe Basin RSWMP Phase 2 has yet to be determined, and will depend upon discussion with funding partners and their requirements. However, it is anticipated that the Phase 2 process will take place over at least one full annual period, with a desire to have most of the steps shown below completed by July 2009.

1	*Project Management, Administration and Coordination*
	1.1 Project Oversight
	1.2 Quarterly Reports and Invoicing
	1.3 Engage Program Stakeholders
	1.4 Coordination with Other Programs and Projects
2	*Quality Assurance Project Plan for the Tahoe Basin RSWMP*
	2.1 Review Existing Programs
	2.2 Draft QAPP
	2.3 Final QAPP
3	*Monitoring Goals and Data Quality Objectives*
	3.1 Define the Boundaries
	3.2 Review Existing Data
	3.3 Develop Performance Criteria
4	*Monitoring Design Specifications*
	4.1 Identify Criteria for Targeted Monitoring
	4.2 Identify Population of Sites for Probabilistic Status and Trends Sampling
	4.3 Produce Monitoring Design Document
5	*Sampling and Analysis Plan*
	5.1 Sampling and Analysis Plan
	5.2 Site Inspection
	5.3 Inter-Laboratory Sample Analysis Program
6	*Stormwater Database Development, Data Management and Analysis*
	6.1 Tahoe Stormwater Database
	6.2 Data Management QA/QC Protocols
	6.3 Data Analysis and Reporting
7	*Organizational Development*
	7.1 Organizational Structure
8	*Develop Funding Agreements for Regional Program*
	8.1 Funding Discussions
	8.2 Budget Needs

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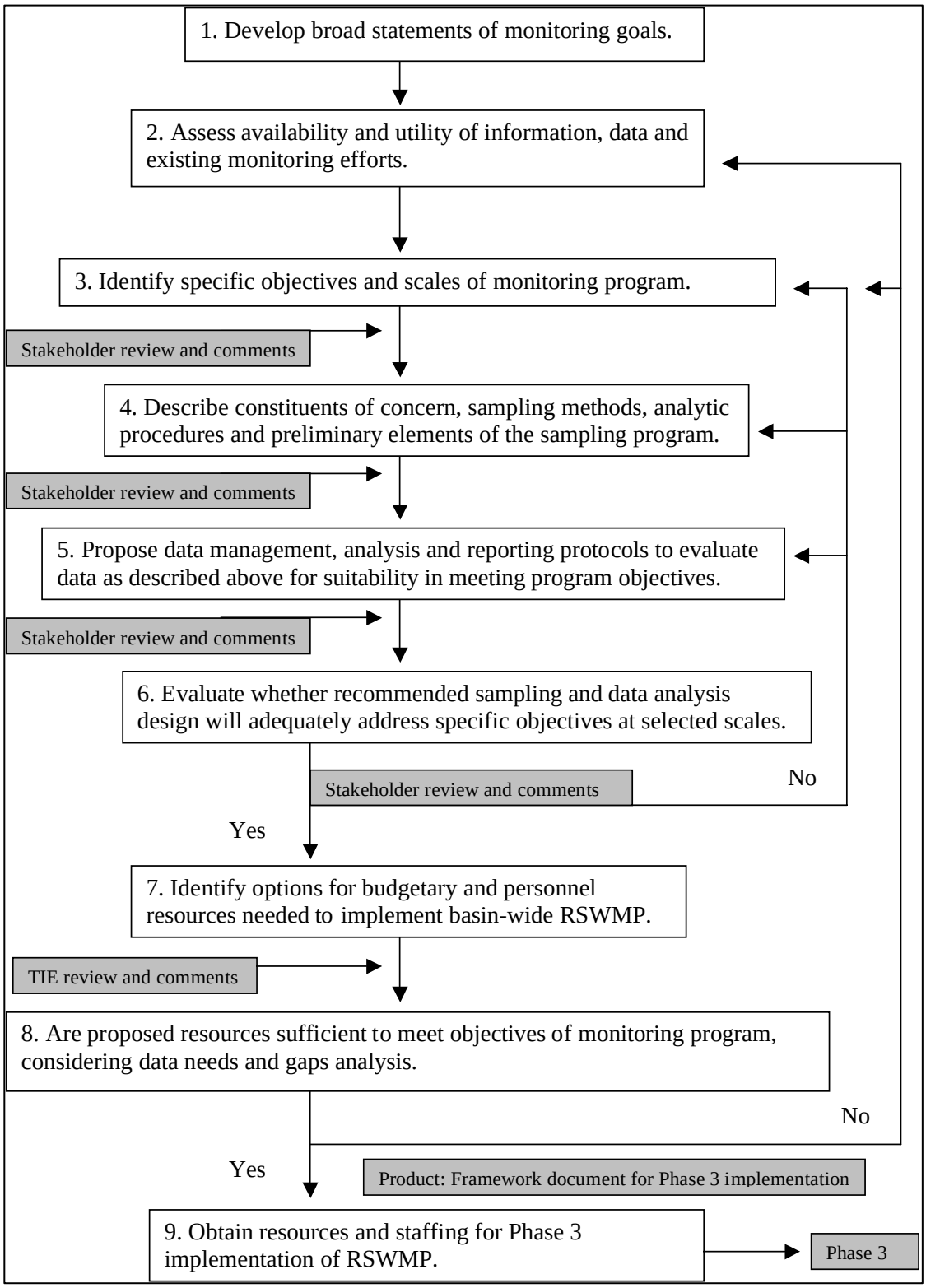

Figure 1. Process for developing framework document for Tahoe Basin Regional Stormwater Monitoring Program (Phase 2).

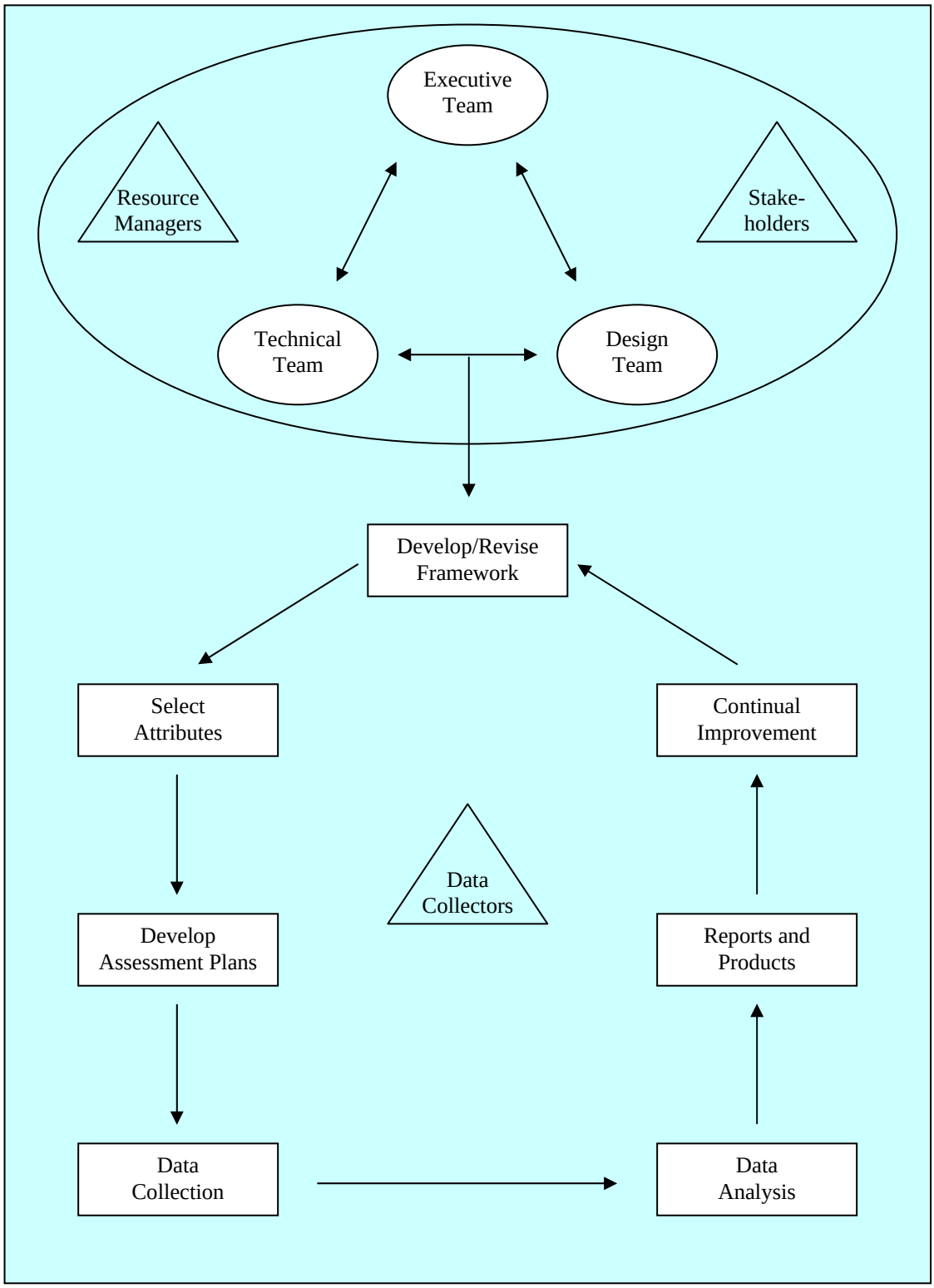

Figure 2. Tahoe Basin RSWMP assessment teams and process flow (adapted from Huffman and Carpenter, 2007).

Appendix A.

Members of the Core Working Group have been meeting monthly to assist in development of the Tahoe Basin RSWMP. These members are representatives from the regulatory agencies, funding groups, the science community, planning agencies, local jurisdictions and implementers at Lake Tahoe.

Therefore, we recognize the cooperative participation of these individuals who have been the Tahoe Basin RSWMP representatives:

Larry Benoit (Tahoe Regional Planning Agency)
Joyce Brenner (California Department of Transportation)
Kim Gorman (Nevada Tahoe Conservation District and NV GIDs)
Steve Cooke (Nevada Department of Transportation)
Robert Erlich (City of South Lake Tahoe)
Elizabeth Harrison (Nevada Division of State Lands)
Alan Heyvaert (Desert Research Group)
Zach Hymanson (Tahoe Science Consortium)
Peter Kraatz (Placer County)
Jason Kuchnicki (Nevada Department of Environmental Protection)
Jacques Landy (US Environmental Protection Agency)
Wally Miller (University of Nevada, Reno)
John Reuter (University of California, Davis)
Dave Roberts (Tahoe Resource Conservation District)
Hannah Schembri (Lahontan Regional Water Quality Control Board)
Barbara Shanley (USDA Forest Service, LTBMU)
Russ Wigart (El Dorado County)
Tricia York (California Tahoe Conservancy)

Appendix B.

Annotated Bibliography of Tahoe Basin Stormwater Literature.

(Available at the TSC web site: www.tahoescience.org.)

Appendix C.

Monitoring Goals and Objectives Response Compilation.

(Available at the TSC web site: www.tahoescience.org.)