WATER QUALITY MONITORING PROTOCOLS AND SAMPLING GUIDELINES

LTIMP

(LAKE TAHOE INTERAGENCY MONITORING PROGRAM)

A SUBCOMMITTEE OF THE WATER QUALITY WORKING GROUP

SEPTEMBER 26, 2002

ACKNOWLEDGMENTS

The *Lake Tahoe Interagency Monitoring Program* (LTIMP) is a subgroup of the Water Quality Working Group and meets the first Wednesday of each month. LTIMP is well attended by a large selection of individuals and agencies, which makes it one of the most successful working groups in the basin. We would like to express gratitude to the group for participation, formal and informal, as technical advisors, commenter, and reviewers. The expanded LTIMP is listed below - without their assistance, preparation of these guidelines would not have been possible.

California State Parks

California Tahoe Conservancy

Caltrans

Camp Dresser and Mckee

City of South Lake Tahoe

Desert Research Institute

EDAW

El Dorado County Department of Transportation

Lahontan Regional Water Quality Control Board

Lake Tahoe Community College

Natural Resources Conservation Service

Nevada Department of Transportation

Nevada Division of Environmental Protection

Nevada Tahoe Resource Team, Nevada Division of State Lands

Placer County Public Works and Engineering Department

Sierra Nevada Community College

South Tahoe Public Utilities District

Tahoe Regional Planning Agency

Tahoe Resource Conservation District

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University of Nevada, Reno

US Army Corp of Engineer

USDA Forest Service, Lake Tahoe Basin Management Unit

US Geological Survey, Water Resource Division, Nevada District

Washoe County Department of Public Works

Washoe Tribe of Nevada & California

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DOCUMENT CREDITS

This document was written by the various members of LTIMP over the past year. Many others have given input and advice through Basin agencies (see listing in the Acknowledgments section).

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9	U. S. Environmental Protection Agency Website

*'LTIMP members' refers to contributions of several members of the group during meetings throughout the year.

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1. PURPOSE AND OBJECTIVES

The purpose of this document is to provide guidelines and recommendations for implemen-ation of water quality monitoring in the Lake Tahoe Basin. It is a cooperative effort from the Lake Tahoe Interagency Monitoring Program (LTIMP). LTIMP was established in 1980 to develop integrated water quality research and monitoring strategies to support regulatory, management, planning, and research activities in the Lake Tahoe Basin. These guidelines are part of an effort to accomplish that mission. Additionally, this protocol and sampling manual is intended to streamline review and approval of monitoring plans that should be implemented in association with key projects, programs and studies. Hopefully the streamlining of these efforts will further close feedback loops that are necessary to advance the use of adaptive management strategies, such as project re-design towards attaining water quality thresholds.

The original key LTIMP members included the Tahoe Research Group-University of California at Davis (TRG), the U.S. Geological Survey (USGS), Lahontan Regional Water Quality Control Board (LRWQCB), Tahoe Regional Planning Agency (TRPA), and the Lake Tahoe Basin Management Unit, U.S.D.A. Forest Service (USDAFS). Since 1999 LTIMP has been operating as a subcommittee of the Water Quality Working Group, with an expanded membership (see inside of front cover).

Water quality monitoring in the Tahoe Basin is expanding through regulatory programs and research projects. There is a need to develop consistent and uniform protocols for unique constituents and monitoring programs in the Tahoe Region. The guidelines proposed in this document are intended to be used by individuals and agencies sampling and monitoring water quality within the Tahoe Region. This manual includes references to more specific protocols such as the U.S.G.S. National Field Manual and Caltrans Stormwater Sampling Protocols.

2. AGENCY MANDATES AND THRESHOLDS

The different agencies throughout the Lake Tahoe Basin established and enforce various mandates and thresholds. These mandates and thresholds have been developed to help protect and maintain the water quality of Lake Tahoe.

The Tahoe Regional Planning Agency Compact was adopted in 1982 and includes the environmental threshold carrying capacities for the Lake Tahoe Region. The Compact defines an environmental threshold as "an environmental standard necessary to maintain a significant scenic, recreational, educational, scientific or natural value…" Threshold standards are the primary guide to much of TRPA's planning and operation. Article V(d) of the TRPA Compact requires the Regional Plan to "provide for attaining and maintaining Federal, State, and local air and water quality standards, whichever are strictest" and identify the means and time schedule for these standards to be attained.

Resolution 82-11 adopted the official Environmental Threshold Carrying Capacities by the Governing Body of the Tahoe Regional Planning Agency. It consists of nine thresholds, one of which is water quality. The water quality threshold is further subdivided into seven indicators for improvements to water quality (Appendix A). These indicators are echoed in the Water Quality Management Plan for the

Lake Tahoe Region, known as the '208 Plan', in reference to the EPA Clean Water Act. The indicators and their standards are the basis for water quality improvements in the Tahoe Basin. As part of the 2001 Threshold Evaluation additional mitigation measures were recently added to focus on implementation of the Environmental Improvement Program (EIP); these are listed in Appendix 1 as EIP Units of Benefit. More information on thresholds and the 2001 Threshold Evaluation can be found on the TRPA website http://www.trpa.org, under Documents and Reports.

A. California Mandates and Thresholds

In California, the State Water Resources Control Board sets statewide policy for implementing state and federal water quality laws and regulations. In the Tahoe region, the Lahontan Regional Water Quality Control Board (LRWQCB) adopts and implements the Water Quality Control Plan (Basin Plan). The Basin Plan establishes water quality standards for surface and ground waters based on designated beneficial uses of water, and identifies narrative and numerical objectives to protect those uses. Water quality problems threatening beneficial uses are identified, along with recommended or required control measures and prohibitions to certain types of discharges. In addition, Lahontan issues National Pollutant Discharge Elimination System (NPDES) permits for a variety of discharges to surface waters, to the three local municipalities and Caltrans.

The Basin Plan includes Water Quality Objectives (Chapter 3), Implementation (Chapter 4), and Water Quality Standards and Control Measures for the Tahoe Basin (Chapter 5). See http://www.swrcb.ca.gov/rwqcb6/ for a copy. Lake Tahoe is one of California's few designated Outstanding National Resource Waters (ONRW) under federal anti-degradation regulations (40 CFR § 131.12 and 48 Fed. Reg. 51402). The ONRW designation does not allow permanent or long-term reduction in water quality.

B. Nevada Mandates and Thresholds

In Nevada, the Nevada Division of Environmental Protection sets statewide policy for implementing state and federal water quality laws and regulations. Two main Bureaus are responsible for the protection of the quality of Nevada's Waters; these are the Bureau of Water Quality Planning (BWQP) and the Bureau of Water Pollution Control (BWPC).

The Bureau of Water Quality Planning (http://ndep.state.nv.us/bwqp/bwqp01.htm) is responsible for several water quality protection functions, which include collecting and analyzing water data, developing standards for surface waters, publishing informational reports, providing water quality education and implementing programs to address surface water quality. The BWQP is divided into three branches: Water Quality Monitoring, Water Quality Standards and Nonpoint Source Program.

The Water Quality Monitoring Branch is responsible for the State of Nevada's water quality monitoring program. This branch maintains and updates water quality data for EPA's national water quality database (STORET), and is responsible for preparation of Nevada's Water Quality Assessment Report, which is required under Section 305(b) of the Clean Water Act (CWA). To ensure federally permitted activities do not cause water quality impairment, this branch issues certifications under Section 401 of the CWA. Additionally, this branch reviews environmental impact statements, environmental assessment documents, clearinghouse documents and permits for the Army Corps of Engineers, the Federal Energy Regulatory Commission and the Nevada Division of State Lands.

The Water Quality Standards branch is responsible for developing and reviewing water quality standards; determining wasteload and load allocations from point and nonpoint sources (respectively); and developing Total Maximum Daily Loads (TMDLs). Water quality management plans and the "impaired waters listing" required under sections 208 and 303(d) of the Clean Water Act, as well as the Continuing Planning Process, are prepared by this branch. Frequent violations of standards for Lake Tahoe and a number of its tributaries will result in their listing on Nevada's 303(d) List for 2002.

The Nonpoint Source (NPS) Program is responsible for all NPS planning, including developing and updating the state management plan, the state assessment report and the Best Management Practices Handbook. Using grant monies available under Section 319(h) of the Clean Water Act, this branch solicits, selects and manages projects that help to control and minimize NPS pollution. A number of these projects feature restoration actions or the implementation of best management practices (BMPs). Other projects focus on public outreach and education that promote environmental stewardship. The NPS staff also coordinates activities with other agencies to minimize pollution derived from land uses that have a high potential for NPS generation.

The Bureau of Water Pollution Control (http://ndep.state.nv.us/bwpc/bwpc01.htm) is responsible for protecting the quality of Nevada waters from the discharge of pollutants. This is accomplished by issuing discharge permits, which define the quality of the discharge necessary to protect the quality of the waters of the State, enforcing the state's water pollution control laws and regulations, and by providing technical and financial assistance to dischargers. The BWPC issues National Pollutant Discharge Elimination System (NPDES) Permits for discharge to surface waters, ground water permits for discharges that may impact subsurface waters, Underground Injection Control (UIC) permits for injection through wells, and Stormwater Permits. Additionally, the BWPC performs engineering reviews of the designs of permitted facilities, inspects permitted facilities and investigates violations of water pollution statutes and regulations.

3. WATER QUALITY ISSUES

In the Watershed Assessment published in May 2000, defined water quality issues in terms of science-based questions that would lead to adaptive management decisions. This process of identifying research needs to provide a roadmap for the funding of monitoring and projects was then used by the Water Quality Working Group and the Science Advisory Group to refine and prioritize these needs into thirteen water quality issues. They generally include such topics as the need for prioritization of restoration projects, the feedback of research and monitoring findings to the design of new projects, the implementation of the Environmental Improvement Program (EIP), and review of water quality standards and thresholds. These issues formed the basis for Budget Proposals to the State of California for funding through Lahontan and TRPA and others. The LTIMP group reviewed the issues and tried to provide specific tasks under the issues to focus research and monitoring efforts.

4. ADAPTIVE MANAGEMENT

Coordinated interagency efforts for natural resource management in the Tahoe Basin have been organized under the adaptive management framework. A detailed application of this approach for the Tahoe Basin has recently been described in the Lake Tahoe Watershed Assessment (January 2000, Vol. 1 Chapter 7). To summarize from this document, the adaptive management approach is designed to speed rates of development and implementation of appropriate resource management strategies through research and monitoring. A critical element of this process is the constant refinement of management strategies through an iterative process of monitoring, data evaluation, decision-making, and management action.

The main objective of an adaptive management approach is to provide timely feedback on the relative effectiveness of management actions, so that modifications in design or approach can be made quickly to achieve stated goals. In the case of Lake Tahoe, research has shown that an immediate reduction of nutrient input into the lake may take up to thirty years to see the resultant clarity changes. So, time is of the essence and management must respond quickly to lessons learned in earlier stages of this process. The cost of reversing this trend may become prohibitive if not accomplished within the next ten years.

The adaptive management framework is designed to achieve this efficiency through an iterative cycle that is graphically demonstrated in Figure 1. The key elements of this cycle are (1) the identification of information needs, (2) acquisition and assessment of that information, (3) an evaluation and decision-making process, followed by (4) management action. This cycle is then repeated with an updated identification of information needs to evaluate the effectiveness of management action. The primary role of science in adaptive management is to provide an integrated approach to research and monitoring that crosses disciplines at appropriate scales and provides new information of relevance to resource managers. It should also assist in the interpretation and application of that information by working with managers to develop adaptive management strategies, experiments and results oriented monitoring. New information through research and monitoring is often critical to making appropriate decisions in resource management.

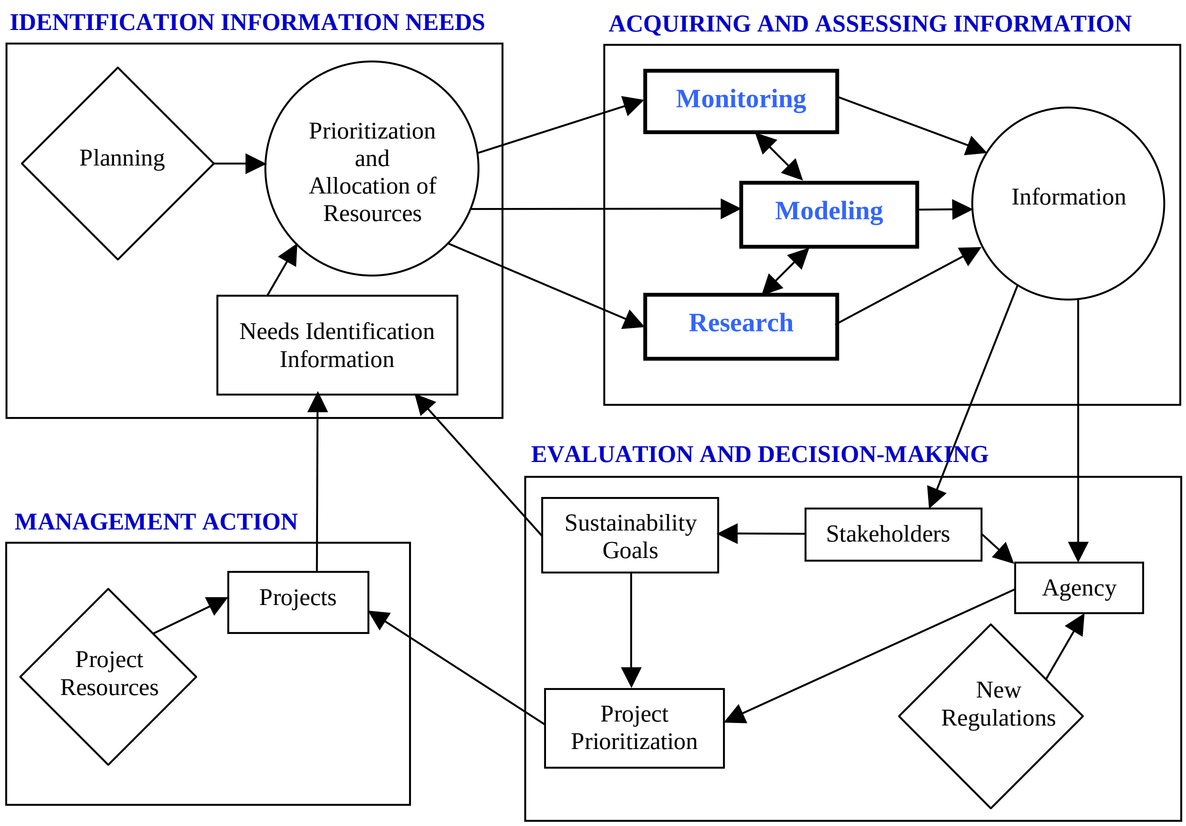

Figure 1: A schematic diagram of an adaptive management planning cycle (Lake Tahoe Watershed Assessment: Volume 1, p. 692 (USDAFS, 2000))

5. PRIORITY CONSTITUENTS AND PARAMETERS

Nutrients, trace elements and suspended sediments are the main constituents of concern in water quality monitoring for the Tahoe Basin. Although other compounds may be important or even regulated in some cases (e.g. MTBE, PCBs or other organic contaminants), they are not routinely monitored at this time and will not be considered in this discussion. Appendix B lists several tables grouped by categories of parameters.

In the compilation of this manual, several LTIMP meetings have centered on the lab constituent list and reporting levels. The appendix cites reporting detection limit as the minimum level for accurate detection of the low nutrient levels often seen in Lake Tahoe. One of the primary goals of these guidelines is to insure consistency and comparability of lab data and methods. The EPA referenced lab method is only an example of a more commonly used method, and does not preclude the use of other methods. Our goal is for the highest accuracy at the lowest reporting limit that can be defensible, repeatable, and comparable to other monitoring.

Nitrogen and phosphorus are the major nutrients that typically limit algal growth in Lake Tahoe. Complex biogeochemical cycles exist for both of these elements and they occur in many different forms, not all of which are clearly identified. For purposes of water quality monitoring, however, scientists typically recognize a few distinct analytic classes and measure the concentrations within these groups.

For nitrogen, the main groups are dissolved ammonium (DNH_4), dissolved nitrate (DNO_3), and total nitrogen (TN). The total nitrogen is typically measured after a Kjeldahl digestion, and thus consists of both the total organic and ammonium nitrogen. It is represented as total Kjeldahl nitrogen (TKN). When this digestion is done on filtered water samples (< 0.45 microns), the analysis represents dissolved Kjeldahl nitrogen (DKN). However, the difference between TKN and DKN is frequently less than analytic variance in their measurements, so TKN is the more commonly measured constituent. It should also be noted that analytic methods for nitrate usually include nitrite. Unless reported differently, therefore, a dissolved nitrate concentration should be considered the sum of nitrate and nitrite concentrations in that sample.

Phosphorus is also reported in several analytically defined groups, with total phosphorus (TP) and soluble reactive phosphorus (SRP) being the most commonly measured. Soluble reactive phosphorus methods measure mostly the dissolved orthophosphate fraction, which is considered the form readily available for algal uptake. Sometimes total dissolved phosphorus concentrations are reported (DP). As with DKN, these are the same as analyses for total concentrations but done on appropriately filtered samples.

Currently, the focus in the Tahoe Basin is on controlling phosphorus inputs to the lake. Bioassays have indicated that Lake Tahoe has shifted to being predominately phosphorus limited for mixed community algal growth thus directing the focus to controlling phosphorus. However, there is still a high occurrence of co-limitation, so control of nitrogen input should not be abandoned.

Recently, it has been recognized that finely divided sediments remain in suspension for long periods of time in Lake Tahoe. This also contributes to a reduction in lake clarity, and may contribute a disproportionate amount of nutrient loading as well (due to surface adsorption). Therefore, monitoring studies have begun to focus on suspended sediment concentrations, turbidity and particle size distributions. In addition to nutrients, it is thought that particle sizes less than 20 microns are particularly important in nutrient loading and clarity loss. So, when practical, particle size classifications should distinguish between size fractions that include between 20 to 63 microns.

Other elements are measured on occasion for specific projects. These include selected metals of interest in storm water such as arsenic, cadmium, chromium, copper, nickel, zinc, lead, and iron. While some of these may have effects on algal growth rates, as micronutrients, others are considered to act as algaecides or may be toxic to higher organisms. Iron is most frequently reported as biologically available iron (BaFe), which includes the dissolved inorganic and some organic iron fractions.

Physical parameters in water quality monitoring will not be discussed in depth in this manual due to past and other exhaustive information and knowledge regarding them. These parameters are necessary for interpreting the nutrient and chemical loading data. Discharge, gage height, air temperature, precipitation rates and weather conditions influence water runoff volume and its chemical composition. Other factors like pH, dissolved oxygen and water temperature impact the water quality directly. Specific conductance is considered as a monitoring parameter to be a measure of total dissolved ionic concentrations. Turbidity can be used as a surrogate for suspended solids, although it has been shown to be very site specific.

Last of all, standardized and comprehensive field data sheets are essential for reliable water quality sampling. There is no substitute for being in the field and directly observing how various landscape or disturbance factors impact water quality. The field data sheet provides a conduit for this information to enter into the data interpretation process.

6. REFERENCES FOR DESIGNING A SAMPLING PROGRAM

The following is a collection of references and documents related to sampling programs. It is advisable to prepare a 2-5 page sampling plan, whether or not it is required of your agency or funding source. It is also advisable to refer to the plan quarterly to ensure compliance with the plan. Many of these documents are available as PDF files on the Internet.

A. Sampling Manuals

U.S. Geological Survey *Field Methods For Measurement Of Fluvial Sediment* (Edwards and Glysson 1988).

This reference contains two major sections: The "Sediment-Sampling Equipment" section encompasses discussions of characteristics and limitations of various models of depth- and point-integrating samplers, single-stage samplers, bed-material samplers, bed-load samplers, automatic-pumping samplers, and support equipment. The "Sediment-Sampling Techniques" section includes discussions of representative sampling criteria, characteristics of sampling sites, equipment selection relative to the sampling conditions and needs, depth- and point-integration techniques, surface and dip sampling, determination of transit rates, sampling programs and related data, cold-weather sampling, bed-material and bed-load sampling, measuring total sediment discharge, and reservoir sedimentation rates.

U.S. Geological Survey *National Field Manual for the Collection of Water-Quality Data* (USGS, 1998).

This reference includes preparation, equipment, cleaning, collection, processing, measurements for surface and groundwater sampling, biological indicators, and bottom materials.

Caltrans Guidance Manual: Stormwater Monitoring Protocols (Caltrans 2000).

Website: Caltrans - Annual Report and Public Workshops.

This reference contains sections on grab samples and automatic samplers. Section 5 "Selection Of Monitoring Methods and Equipment" contains write-ups on Sample Collection Methods (5-1) and Sample Collection Equipment (5-4). Section 7: "Equipment Installation and Maintenance" contains a section on Automated Samplers (7-6), and Section 10: "Sample Collection" contains a section on Grab Sample Collection (10-4).

U.S. EPA *Compendium Of ERT Surface Water And Sediment Sampling Procedures* (US EPA 1991).

This reference has a section applicable to the collection of representative liquid samples: Section 2.0 Surface Water Sampling: SOP #2013.

U.S. EPA *Nutrient Criteria - Technical Guidance Manual – Rivers and Streams*: U.S. EPA publication EPA-822-B-00-002, p. 152 and p. 88 appendix. (2000). http://www/epa.gov/ost/criteria/nutrient/guidance/rivers/index.html

This reference covers stream system classification, select variables, sampling design for new monitoring programs, building a database, analyze data, criteria development, management programs, monitoring & reassessment of nutrient criteria ranges, case studies, methods of analysis for water quality variables, statistical tests & modeling tools.

B. Setting up Sampling Programs

National Resources Conservation Service *National Handbook of Water Quality Monitoring* (NRCS 1996).

Ground-water Data-collection Protocols and Procedures for the National Water-Quality Assessment Program: Selection, installation, and documentation of wells, and collection of related data. USGS Open-File Report 95-398 (Lapham, W. W. and others, 1995).

This reference covers selection, installation, and documentation of groundwater wells.

U.S. Geological Survey *Quality Control Design for Surface Water Sampling in the National Water Quality Assessment Program* (Mueller et al, 1997).

U.S. Geological Survey *Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Site selection, field operation, calibration, record computation, and reporting* (Wagner and others, 2000).

C. Equipment

U.S.D.A. Forest Service *Field Methods for Measurement of Fluvial Sediment* (Edwards and Glysson, 1988).

This reference contains a section on equipment.

U.S. Geological Survey *National Field Manual for the Collection of Water-Quality Data* (USGS, 1998).

This reference also contains a section on equipment.

D. Sample Collection and Processing

U.S. Geological Survey *National Field Manual for the Collection of Water- Quality Data* (USGS, 1998) and Open-file reports; U. S. Geological Survey.

Protocol for the collection and processing of surface-water samples for the subsequent determination of inorganic constituents in filtered water (Horowitz, A.J. and others, 1994).

Field Guide for collecting samples for analysis of volatile organic compounds in stream water for the National Water-Quality Assessment Program (Shelton, L.R., 1997).

Guidelines for collecting and processing samples for streambed sediment for the analysis of trace elements and organic contaminants for the National Water-Quality Assessment Program (Shelton, L.R., and Capel, P.D., 1994).

E. Collection of Discharge Measurements, Stage Measurement, Gage Operations, and Computation of Continuous Record of Stream flow at Stream Sites

U.S. Geological Survey TWRI Book 3, Chapter A8, *Discharge measurements at gauging stations* (Buchanan, T.J. and Somers W.P., 1976).

U.S. Geological Survey TWRI Book 3, chapter A7, *Stage measurement at gauging stations* (Buchanan, T.J. and Somers, W.P., 1978).

U.S. Geological Survey TWRI book 3, chapter A6; *General Procedure for gauging streams* (Carter, R.W. and Davidian J., 1977)

U.S. Geological Survey TWRI book 3, chapter A13, *Computation of continuous records of streamflow* (Kennedy, E.J., 1983).

F. Sample Collection and Processing of Fluvial and Bed Sediment

U.S. Geological Survey Open-file reports; *Field Methods for Measurement of Fluvial Sediment* (Edwards, T.K. and Glysson, G.D. 1988).

U.S. Geological Survey *National Field Manual for the Collection of Water-Quality Data* (USGS, 1998).

G. Sediment Lab Methods

There have been several discussions in the last year about sediment methods in light of a recent USGS report, "Are Total Suspended Solids and Suspended Sediment Concentrations in Open Channel Flows the Same Data Type," (Glysson, G.D. and Gray, J.R., 2001). Bruce Warden, a chemist from Lahontan RWQCB, wrote a brief comment on this report, and encourages more documentation of methods used. This comment can be found on the last page of Appendix B, Sample Constituents.

The USGS website for recent highway runoff studies at http://ma.water.usgs.gov/FHWA/products/ofr00-491.pdf is also very useful. The LTIMP group has begun an initial comparison of total suspended solids (TSS) and suspended sediment concentrations (SSC) on a few projects, and will be discussing this further in the next year.

U.S. Geological Survey TWRI Book 5, chapter C1, *Laboratory Theory and methods for sediment analysis* (Guy, H.P., 1977).

H. Sample Collection and Processing of Groundwater Samples

U.S. Geological Survey *Ground-water data-collection protocols and procedures for the National Water-Quality Assessment Program: selection, installation, and documentation of wells, and collection of related data* (Lapham, W. W. and others, 1995).

I. Sample Collection with Automatic Samplers

The ability to collect useful information about suspended sediment transport and water discharge is dependent on the timing and frequency of data collection during storms. All river systems, particularly smaller watersheds that respond very quickly to rainfall with peak discharges often occurring shortly after the onset of precipitation, benefit from automated data collection.

Although it is possible to rely solely on manual measurements, important storm flows are infrequent and difficult to predict, and when they do occur, trained personnel may not be available to collect the required information.

Most of the suspended sediment in the Tahoe Basin is transported during storms (approximately 86% of the estimated sediment transport in 1999 occurred during the 8 largest storms). Infrequent, systematic manual sampling will not provide adequate information to make credible suspended sediment load estimates under these conditions. As of yet, there is no reliable method to measure suspended sediment concentrations automatically or continuously in the field.

A common method to estimate suspended sediment loads relies on water discharge to determine the sampling frequency during storms. Usually water discharge is not a good predictor of sediment concentration for rivers and streams that transport the bulk of their sediment load as fines because the delivery of sediment to the channel from hill slopes, roads, and landslides is highly variable. For rivers that transport mostly sand, water discharge and concentration are more closely coupled because the transport of sand particles depends on stream power and the availability of sediment stored in channel bars and flood plains.

A sampling scheme that employs a parameter well correlated to suspended sediment concentration, such as turbidity, can improve sampling efficiency by collecting physical samples that are distributed over a range of rising and falling concentrations (see Lewis and Eads 1996 and 1998). The resulting set of samples can be used to accurately determine suspended sediment loads by establishing a relationship between sediment concentration and turbidity for any sampled period and applying it to the continuous turbidity data (Eads, 2000).

Appendix C is an excerpt from the NRCS Sampling Handbook in relation to sample types. For automatic samplers the choice between time weighted and flow weighted composite sampling are especially important, and is dependent on project objectives. Currently LTIMP is in the process of developing guidelines for the sampling from continuous devices, but there is insufficient data at this time to establish a universal protocol, or if one is even appropriate. The recommendation at this time is to budget for initial sampling screening to characterize the site, with yearly review and adjustments as needed.

Appendix D contains information on the automated samplers installed by El Dorado County Department of Transportation (EDOT) and the City of South Lake Tahoe. These automated samplers were patterned after the installations by Eads and improved upon to meet site conditions on streams and rivers in the Tahoe Basin.

J. Laboratory Sample Analysis Costs

The cost to conduct water quality monitoring for a project varies depending on the type and number of constituents, equipment, and organization administering the work. Appendix E contains cost comparisons of primary constituents for five different labs used by organizations in the Tahoe Basin. The price varies among the different labs, as well as, by the type of constituent. Appendix E also contains examples of costs for several Tahoe Basin projects form the last few years.

7. MONITORING OBJECTIVES

The major objective of monitoring should be to provide data to document existing conditions and evaluate the impacts of proposed management actions, Best Management Practices (BMPs). Due to natural variability it is impossible to collect sufficient data to either establish the true existing conditions or to fully determine the impacts of BMPs. Thus to efficiently and effectively determine both existing conditions and evaluate the impacts of proposed management actions, it is prudent to calibrate models to calculate and forecast events and evaluate the impacts of proposed management actions. The calibration and validation of models is contingent upon monitoring. Hence, the two feed on each other and the result is enhanced monitoring and modeling. This section includes constituents to be monitored, priorities, and sampling regimes for various types of projects.

A. BMP Monitoring

The instrumentation and protocol for monitoring BMPs should reflect the Priority Constituents and Parameters for Lake Tahoe discussed in section 5 of this Guidance document. The primary rational should be developing monitoring protocol that will accurately assess the loadings of nutrients and fine sediments affecting the clarity of Lake Tahoe. Not only should these loadings be quantified by source but the timing of releases should also be documented in order to properly design BMPs to effectively reduce loadings.

B. Water Quality Treatment Basins

Historically, storm water detention ponds and infiltration basins have been utilized as standard BMPs. Management of existing wetlands to trap pollutants and enhance water quality has more recently gained popularity. If sized appropriately detention ponds and infiltration basins allow larger sized sediment and particulate materials to settle out. Additional amounts of nutrients are removed as stormwater percolates through the soil to the subsurface ground water. As long as there is standing water in the basin, a portion of the particulate nutrient load and suspended sediments will settle to the basin floor by gravity. As water is forced through the soil matrix during percolation an additional percentage of the remaining pollutant load will be removed. Sediment and nutrient removal occurs through adsorption, precipitation, trapping, straining, and bacterial degradation or transformation. The wetland cell treats by providing a relatively long residence time for reduction of both particulate and dissolved constituents through physical, chemical, and biological processes.

The benefits of a detention pond/infiltration and wetland two-cell system include the following:

- nitrogen can be biologically converted to nitrate and permanently removed via denitrification (in both basins and in wetlands);
- phosphorus (typically associated with sediment load) can be partially removed by simple sedimentation and soil filtration;
- and suspended sediments and total iron are typically reduced.

To meet local permitting rules basins are typically sized for a one-inch storm from the "project area," the project proponent's (e.g., County, City) paved right-of-way. This sizing assumes other properties in the project area have been BMPed to retain one-inch storms on site, which is recognized is often not the case.

Suggested Monitoring Procedures (from Tahoe City basin monitoring proposal):

The Tahoe City system consists of a detention basin releasing to an artificial wetland.

- Measure runoff inflow of the detention basin (measurements can be made as frequently as once per week and during significant storm events).
- On a regular basis, monitor hydraulic flow through the entire system (including flow to the wetland from the detention basin, outflow from the wetland, outflow from the basin).
- At a minimum, measure nitrogen (nitrate and ammonium), phosphorus (ortho-P [SRP] and TP) and total suspended solids in the inflow water, as well as at the outlet of the detention basin in route to the wetland, a mid-point in the wetland, and at the outlet of the wetland. Since phosphorus has been identified as the most critical limiting nutrient to algal growth in Lake Tahoe, these analyses, along with TSS should be given top priority.
- Additional samples can be taken at each of the sites discussed above for major runoff periods including: rainfall on dry ground (e.g., fall rainstorms and summer thunderstorms), rain-on-snow, and snowmelt.
- Sediment cores and visual observation can determine sediment volume and distribution in the detention basin and wetlands.
- Selected samples from inflow runoff and standing water in the facility can be analyzed for particle size and possibly phosphorus content.
- Water temperature, sediment temperature, and dissolved oxygen can be measured.
- Visual observations should be made in both basins for bank erosion resulting from wind waves or from changes in surface elevations.
- Visual observations should be recorded on a formalized data sheet following each project site visit. Photographs and videotapes can also be taken as appropriate.

Research Questions

The following is a list of topics and questions we hope to address with the proposed monitoring and research program. As the project develops, we may find that some of these issues may be beyond the scope of this contract. At the same time, we may find that the collected data suggests that alternative avenues of inquiry should be followed. The list below is intended to serve as a working guideline for this monitoring effort.

- Quantify hydraulic, nutrient and sediment loading into the wetland basins at various time scales, ranging from annual and monthly estimates to loading rates resulting from specific runoff events.
- Define the relationship between magnitude of runoff, residence time, water depth, and the volume to bottom-area ratio.
- Characterize particle size distribution of sediments entering and leaving system.
- Determine how sediment is transported within the system. What portion settles rapidly near the inflow relative to the portion that remains suspended?

- Investigate the extent to which sediment is resuspended off the bottom (either by wind/ wave action or turbulence at the inflow).
- Determine the efficiency of nutrient and sediment removal in the artificial wetlands basin. This will focus on removal efficiency related to:
  - storm intensity and frequency;
  - various water quality constituents, i.e., nitrogen, phosphorus and sediment;
  - dissolved vs. particulate constituents;
  - season;
  - snow conditions.
- Determine relationship between removal efficiency and [i] temperature, [ii], residence time, [iii] concentration, [iv] bottom contact, and [v] vegetation.
- Determine relationship between hydraulic operation and project maintenance.
- Identify the preferred hydraulic and maintenance plans that will optimize system performance.

C. Best Management Practices for Non-Point Source Discharge Control

EPA's Office of Water has recently added "Best NPS Documents" to its Non-Point Source (NPS) Website. Subject areas include Agriculture, Forestry, Marina, Urban, Stream Restoration, Nonpoint Source Monitoring and Funding. These can be found at:
http://www.epa.gov/owow/nps/bestnpsdocs.html
According to the Tahoe Regional Planning Agency's (TRPA's) Code of Ordinances, property owners are required to infiltrate the volume of a 20 year/1 hour storm that is generated from their property on their property (Subsection 25.5.A). This ordinance includes residential, commercial, and public service properties in the Lake Tahoe Basin. Therefore, new parking lots in the Lake Tahoe Basin need to be designed and built with appropriate and recommended BMPs. Many properties with existing parking lots that have inadequate BMPs will need to be retrofitted under the timeline set forth in Chapter 25 of the Code of Ordinances.

The BMPs will need to be in accordance with TRPA's Handbook of Best Management Practices, which is currently being updated. Recommended BMPs, like any technology, need to be updated as innovations occur and designs are improved. These improvements are reflected in greater pollutant removal efficiencies. Because the handbook has not been updated since 1988, improvements in BMP design need to be relayed through specialists on the Erosion Control Team or the Long Range Planning Division of TRPA. The new handbook will include the best available technology to date, and should be considered a "living document" that will be updated as needed.

A matrix to determine when a parking lot will necessitate an oil/grease separator or interceptors with appropriate pre-treatment systems is also being developed. TRPA and Lahontan Water Quality Control Board are developing these documents collaboratively. In addition, the ordinance passed in 1999 for Source Water protection will require projects that have potential for impact to nearby (600 foot radius) drinking water sources to insure appropriate BMPs, (SWAPP report, TRPA website).

BMPs include more than just structural and non-structural practices implemented on the ground. They also include other non-point source control measures under the Environmental Protection Agency (EPA) such as creating a Formal Storm Water Pollution Prevention Plan and preparing to respond to accidental spills. Therefore, additional non-point source control measures are currently recommended for parking lots:

- Development of a Stormwater Management Plan; complete with a Spill Contingency Plan and BMP Maintenance and Monitoring Plan for commercial and public service parking lots (El Dorado County Environmental Management has one);
- Quarterly sweeping with a high efficiency vacuum street sweeper to clean up potentially contaminated sediments that are then properly disposed of;
- TRPA-Approved BMP Design and Installation; which may include oil/grease separators, pretreatment vaults, curb and gutter or drop inlets, and secondary treatment systems (i.e. retention basins, vegetated swales, etc.) designed to contain at least the 20 year/1 hour storm runoff;

- Maintenance and monitoring of treatment systems based on design;
- Delineation of appropriate uses (i.e. not washing vehicles/equip on parking area unless there is a treatment system to prevent the flush of contaminants from parking surfaces into surface waters);
- Containment of potential contaminants on industrial staging lots with "source separation" (EPA, 1998), which utilize curbing, containment dikes, and other separating devices to prevent staged or stored contaminants from entering treatment systems;
- Property owner education;
- Vehicle and equipment fueling, maintenance, and staging plan to provide the appropriate BMPs for industrial lots with high potential for spills and contamination due to the nature of the use of the lot;
- Snow storage areas and appropriateness for locations.

Note: The appropriate BMPs for a parking lot will depend on many factors. Therefore, the appropriate BMP system will need to be determined by a qualified professional on a case-to-case basis. The forthcoming updated Handbook of Best Management Practices as well as the matrix to determine when certain BMPs will be required on a parking lot will assist project planners in anticipating what will be required.

In the interest of adding more specific information on parking lot treatment systems and their effectiveness, please see the table of excerpted data from the report titled "Investigation of Structural Control Measures for New Development," prepared by Larry Walker Associates in November 1999, and prepared for the Sacramento Stormwater Management Program (Appendix F). Unfortunately, as noted by Walker, BMP effectiveness studies to date have been inconsistent and data reporting has been unreliable. The column "Approval Recommendation" reflects this; if a treatment system has not been tested adequately, Walker and Associates gave it a rating of "not acceptable" until further tests have been completed with correct scientific protocol. Appendix F also shows parking lot monitoring protocols, with the TRPA Discharge Limits for Surface and Groundwater.

Environmental Protection Agency Office of Ground Water and Drinking Water. 1998. *Guidance on Storm Water Drainage Wells, Chapter 7.0 Operational Best Management Practices* http://www.epa.gov/reg5oh20/storm/newchap7.htm)

Strecker, E. and Reininga, K. 1999. *Integrated Urban Stormwater Master Planning.*

Strecker, E., Quigley, M. and Urbonas, B. *Determining Urban Stormwater BMP Effectiveness* http://www.asce.org/peta/tech/nsbd01.html

TRPA. *Handbook of Best Management Practices.* 1988

Walker, Larry and Associates. 1999. *Investigation of Structural Control Measures for New Development*. Prepared for: Sacramento Stormwater Management Program.

D. Golf Courses/Large Turf Areas

Golf courses and other large turf area (schools and ball playing fields, condo complexes, large residential parcels) have the potential to contribute large amounts of fertilizer to both ground water and surface water. At present Lahontan Water Quality Control Board regulates the ten golf courses in California through waste discharge requirements. TRPA requires water quality monitoring at golf courses in Nevada, through conditions of their permits.

The permits written by Lahontan have recently been revised, and reflect changes as a direct result of the monitoring data. For example, the Tahoe City permit requires sampling only once a year due to the results of ten years of data showing a properly managed chemical and irrigation plan that maximizes good turf characteristics while minimizing potential for transport of contaminants to surface and ground waters. Other irrigation plans sampling schedule are far more rigorous.

Many of the new commercial and larger residential developments have fertilizer management plans as a condition of their permits. Monitoring should include groundwater samples and off site runoff as well as surface water sampling of any nearby stream or creek.

Non-commercial turf areas are currently not part of any permitting process and monitoring is voluntary. The Resource Conservation Districts provide assistance and education to private landowners as part of their Backyard Conservation Program. The recent publication *Home Landscaping Guide for Lake Tahoe and Vicinity* includes a chapter on the proper types and amounts of fertilizers. A recommendation of the 2001 Threshold Evaluation is for an increased reduction in fertilizer use and elimination of fertilizer use in SEZ's and the shorezone.

E. Grazing/Confined Animals

The issue of livestock grazing on public or private lands is addressed in Chapter 73 of the TRPA Code of Ordinances, adopted in July 1987, which was drafted from Volume I of the Water Quality Management Plan (208 Plan). The 208 Plan identifies livestock grazing and confinement facilities as potential contributors to water quality degradation. Chapter 73.2 deals with grazing and sets standards for use and streambank protection. A subsection requires a grazing management plan, and that confinement facilities be brought into compliance with BMPs by July 1, 1992.

In both the 1991 and 1996 Threshold Evaluations, the need to revise and implement the ordinance for BMP requirements for both new and existing grazing operations, coordinate implementation efforts with the USDAFS, and expand BMP monitoring. Through the process of the ordinance revision, a Grazing Technical Advisory Committee formed in 1996, and worked to add the Amendment to Chapter 73, adopted by the Governing Board in January 1999. The primary focus was related to livestock facilities, although any pen or confinement of any animals should require similar BMPs.

In terms of water quality monitoring, the primary focus is the installation and subsequent effectiveness of appropriate BMPs. On large-scale operations, such as corrals for concessionaires that rent horses, or cattle grazing operations, monitoring for water quality should include fecal coliform and turbidity, as well as bioassessment surveys to determine riparian habitat health. The bulk of monitoring in the Tahoe Basin has been by the USDAFS through grazing allotments and LWRCB for public health violations.

F. Visual/Photo Monitoring

Visual and other sensory observations and photo monitoring should not be overlooked as cursory and inexpensive methods of monitoring. Many NPDES permits and project funders require a visual monitoring component. The basis for many citizen monitoring groups is the Stream/ Shore Walk Visual Assessment observation sheet (Appendix G: California Stream and Shore Walk Visual Assessment.) Observations should be made, at a minimum, on a monthly basis. Observational data can include color, odor, presence of oil or tar, trash, foam, turbidity, percent snow cover, and many others specific to a monitoring site. Photo monitoring should always be recorded with a photo log with the following information: date, time, person taking picture, general and specific location, (South Lake Tahoe, Angora ECP, culvert at NE corner of Circle View), orientation (N, S, E, W, i.e. looking east), point of reference and permanent landmark or any other info. Ideally, you would want another person to be able to take the same picture based on the information you log.

8. RELATED MONITORING

A. Slope Stabilization and Revegetation

Although this is a guideline primarily for water quality, it is recognized that an integral part of water quality improvements involves revegetation. In a natural, undisturbed watershed, runoff and snowmelt generally infiltrate into the ground, whereas, in a disturbed area, impervious surfaces allow the water to redirect and collect sediment and nutrients. The success or failure of the revegetation effort can mean the success or failure of the entire project.

The importance of revegetation was recognized recently in the adoption of Objectives and Guidelines for Revegetation Success under the Nevada Tahoe Bond Act. This brief document provides a plan for revegetation specifications for any project funded by the Nevada Bond Act. Appendix H includes vegetation monitoring submissions from the following sources, in this order:

Etra and Reynolds. M*onitoring for Revegetation, Erosion Control, Restoration and Water Quality Improvement Projects in the Lake Tahoe Basin*, Oct. 20, 2000.

Hogan, Michael, *Plant Monitoring for Upland Restoration Projects in the Lake Tahoe Basin*, Sept. 17, 2000.

There is increasing interest and attention for the inclusion of detailed revegetation monitoring to be included in the very beginning of project design, and especially post project monitoring for long term sustainability of erosion control. There are a few studies underway to determine what types of protocols are best applied in the Tahoe Basin.

B. Bioassessment

Bioassessment is an evaluation of the condition of a waterbody using biological surveys and other direct measurements of the resident biota in surface waters. This section summarizes LTIMP's recommendations for bioassessment procedures, provides contact information for key bioassessment practitioners, and includes references to current bioassessment guidance documents.

Bioassessment relies on one or more measures of aquatic community assemblages to make inferences about the status or trend in biological integrity. The most common organisms used in bioassessment are benthic macroinvertebrates, periphyton, and fish.

There are several practitioners currently using bioassessment in the Lake Tahoe Basin. The most common methods utilize benthic macro-invertebrates to assess the biological condition of streams. However, standardized protocols are also available from the U.S. Environmental Protection Agency for bioassessments using periphyton and fish (USEPA 1999), for bioassessment in lakes and reservoirs (USEPA 1998a), and for bioassessment in wetlands (USEPA 1996, 1998b).

When conducting bioassessments to evaluate the biological integrity of specific sites, practitioners often rely on comparisons of a "test" site to a nearby "reference site" (or group of reference sites). "Reference sites" are sites with minimal human influences that have similar physical characteristics (i.e., stream size, slope, geology, etc.) to the site being tested. When the goal is to evaluate a specific project (such as a restoration project), baseline or "pre-project" condition can also be compared to post-project condition to measure changes over time. In this situation, it is also necessary to collect bioassessment data at unaffected nearby reference (or "control") sites in order to track natural (i.e., temporal) variability. That is, the practitioner needs to design the study to determine whether any changes detected at the restored site are in fact due to restoration activities (versus natural variability). One common design in such situations is the "BACI" design ("before-after, control-impact").

Protocols

(1) The protocols most commonly used throughout the State of California are the *California Stream Bioassessment Procedures*, or "CSBPs." The California Department of Fish and Game (CDFG), other state and local agencies, citizens' groups, and others use this method widely. **Contact:** Jim Harrington, CDFG, or obtain protocols via the Internet at: http://www.dfg.ca.gov/cabw/protocols.html

(2) Researchers at the University of California's Sierra Nevada Aquatic Research Lab (UC-SNARL) have developed a methodology that is more intensive than the CSBPs, and are using that method throughout the eastern Sierra Nevada, including the Tahoe Basin. This method is currently being used by UC-SNARL, under contract with the Lahontan Regional Water Quality Control Board, to develop reference conditions for streams throughout the eastern

Sierra Nevada.
Contact: Tom Suk, Lahontan RWQCB, or obtain protocols and quality assurance procedures via Internet at:
http://www.swrcb.ca.gov/rwqcb6/files/QAPP/QAPP.htm

(3) The U.S.D.A. Forest Service (USDAFS) has contracted with scientists at Utah State University to develop a bioassessment method for use by the USDAFS. That method is currently being tested by the USDAFS throughout the western United States, including the Lake Tahoe Basin. **Contact:** Joseph Furnish, USDAFS, or obtain more info at: http://www.usu.edu/buglab

(4) A simplified bioassessment method has also been developed for use by citizens' groups, schools, and other educational institutions. The simplified method is titled *The California Streamside Biosurvey*, and copies are available free of charge from: Citizen Monitoring Program, Division of Water Quality, State Water Resources Control Board, P.O. Box 100, Sacramento, CA 95812-0100. **Contact:** David Herbst, UC-SNARL, or obtain a copy via Internet at:
http://www.swrcb.ca.gov/nps/docs/FinRevCAStreamBiosurvey.doc

There are additional practitioners in California who are using other bioassessment methods for special studies or their particular needs. However, the above methods are currently the most commonly used on the California side of the Lake Tahoe Basin.

The State of Nevada, Division of Environmental Protection (NDEP) initiated a statewide Bioassessment Program in 2000. As of the summer of 2002, the State of Nevada will have sampled approximately 100 sites throughout the State on an annual basis. The program has included bioassessment of macroinvertebrates and periphyton; assessment of physical habitat; and evaluation of chemical parameters in the water column for all major water basins in the State. These basins have included the Colorado, Carson, Walker, Truckee, Humboldt, Snake and Tahoe Basins. Tributary monitoring, in addition to the monitoring of the main stems has been included as an additional aspect to the Bioassessment Program. Monitoring sites will be sampled annually for a period of 4 to 5 years to establish baseline conditions and to assess aquatic health.

Eight to ten bioassessment monitoring sites are slated to be monitored by NDEP in the fall of 2002 for the Eastern slopes of the Tahoe Basin. The sites will be monitored annually for a minimum of 4 to 5 years. The selection of those sites will be in coordination with other agencies within the Tahoe Basin but are expected to be based on both upper and lower elevation sites on Nevada's major tributaries to the Lake.

NDEP has adopted the "*California Stream Bioassessment Procedures* " (CSBP) for macroinvertebrate monitoring and physical habitat evaluations. The State has slightly modified the CSBP in that the samples of 3 individual riffles (9 sub-samples) are combined together to represent a composite sample of the reach. The State has also included the measurements of flow, dissolved oxygen saturation, percent riparian vegetation and type, land-use and obvious/potential non-point source pollution within the established reach. NDEP is expected to include more intense quantitative physical habitat parameters as the program advances.

Reference site criteria for conditions and site selection are being conducted by NDEP in coordination with the Nevada Bioassessment Steering Committee. The committee is composed of various other government agencies, tribal representatives, academia, and NPDES dischargers. The goals of the committee are to exchange bioassessment information, promote bioassessment within the state, and to assist the state in the selection of reference sites.

LTIMP Recommendations

LTIMP recognizes that various practitioners may need to utilize different bioassessment methods depending on the specific questions to be answered. However, LTIMP recommends that practitioners conducting bioassessments in the Tahoe Basin consider using, as appropriate, one of the four primary methods currently in use (outlined above), to facilitate the comparability of data between studies. LTIMP also strongly recommends that all bioassessment practitioners implement, as part of their project, the USEPA's Performance-Based Methods System (PBMS), so that the bioassessment data collected by all practitioners can be comparable to the greatest extent possible. The PBMS is described in Chapter 4 of the USEPA's latest bioassessment guidance document (USEPA 1999).

Contacts and References

Following are contacts and references that may be useful for persons planning to conduct bioassessment in the Lake Tahoe Basin:

Contacts:

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References:

U.S. Environmental Protection Agency. 1996. *Wetlands: Biological Assessment Methods and Criteria Development Workshop, Proceedings*, Sept. 18-20, Boulder, CO. Available at USEPA website: http://www.epa.gov/owow/wetlands/wqual/bcproc.html

U.S. Environmental Protection Agency. 1998a. *Lake and Reservoir Bioassessment and Biocriteria*. USEPA Office of Water (4504-F), Washington, DC 20460. EPA 841-B-99-002. (Free copies can be obtained by calling 1-800-490-9198, or via the Internet at: http://www.epa.gov/owow/monitoring/tech/lakes.html

U.S. Environmental Protection Agency. 1998b. *Wetlands Bioassessment Fact Sheets*. USEPA Office of Water (4502-F), Washington, DC 20460. EPA 843-F-98-001. (Free copies can be obtained by calling 1-800-490-9198, or via the Internet at: http://www.epa.gov/owow/wetlands/wqual/bio_fact/

U.S. Environmental Protection Agency. 1999. *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers: Periphyton, Benthic Macroinvertebrates, and Fish*. Second Edition. USEPA Office of Water (4503-F), Washington, DC 20460. EPA 841-B-99-002. (Free copies can be obtained by calling 1-800-490-9198, or via the Internet at: http://www.epa.gov/owow/monitoring/rbp/

U.S. Geological Survey *Methods for sampling fish communities as part of the National Water-Quality Assessment Program* (Meador and others, 1993).

U.S. Geological Survey *Revised methods for characterizing stream habitat as part of National Water-Quality Assessment Program* (Fitzpatrick and others, 1995).

U.S. Geological Survey *Methods for collecting algal samples as part of the National Water-Quality Assessment Program.* (Porter, S. D. and others, 1993).

U.S. Geological Survey *Guidelines for quality assurance and quality control of fish taxonomic data collected as part of the National Water-Quality Assessment Program* (Walsh and others, 2000).

U.S. Geological Survey *Methods for characterizing stream habitat as part of National Water-Quality Assessment Program* (Meador, M. P. and others 1993).

9. QUALITY ASSURANCE/QUALITY CONTROL

The EPA website has a number of publications for quality control documents at (http://www.epa.gov/quality1/qa_docs.html). Some general overview pages are included in Appendix I and a list of additional references. Depending on the size of the project, Quality Assurance (QA) samples can be as little as 1-5 or as many as 20-30. The sample plan should include a section for the QA, and cost for analysis should be included in the budget. When possible, it is recommended that a grab sample be taken at the same time the auto sampler is collecting, in order to verify auto sampler effectiveness and representativeness. In regards to sample analysis and lab procedures, it is recommended that the contract lab be either a state certified lab for California or Nevada, or the lab participate in a blind reference program such as the USGS Standard Reference Program, see website http://bqs.usgs.gov/srs/.

10. REFERENCES

Buchanan, T.J. and Somers, W.P. 1976. *Discharge measurements at gaging stations*: U.S. Geological Survey Techniques of Water-Resources Investigations (TWRI), Book 3, chapter A8, 65p.

Buchanan, T.J. and Somers, W.P. 1978. *Stage measurement at gaging stations:* U.S. Geological Survey TWRI book 3, chapter A7, 28 p.

Caltrans/Larry Walker Associates. 2000. *Guidance Manual: Stormwater Monitoring Protocols (revised).* CTSW-RT-00-005. 5/00, 14 sec.

Develop purpose & objectives, site, constituent, methods & equipment selection, Sampling and Analysis Plan, equipment installation and maintenance, training, prep & logistics, sample collection, QA/QC, lab prep & analytical methods, and data reporting. .

Carter, R.W. and Davidian J., 1977. *General Procedure for gaging streams:* U.S. Geological Survey TWRI book 3, chapter A6, 13p. USGS-Tim Rowe,

Cuffney, T. F. and others. 1993. *Methods for collecting benthic invertebrate samples as part of the National Water-Quality Assessment Program*: U.S. Geological Survey Open-File Report 93-406, 66p.

Sampling design, methods for collecting, maintenance of sampling equipment, sample processing & labeling, field data sheets, safety.

Cuffney, T. F. and others. 1993. *Guidelines for the processing and quality assurance of benthic invertebrate samples collected as part of the National Water-Quality Assessment Program*. U.S. Geological Survey Open-File Report 93-407, 80 p.

Sample processing strategy.

Edwards, T.K. and Glysson, G.D. 1988. *Field Methods For Measurement Of Fluvial Sediment*: U.S. Geological Survey Open-File Report 86-531, 118 p.

Sediment sampling equipment & techniques

Guy, H.P. 1977. *Laboratory Theory and methods for sediment analysis*: U.S. Geological Survey TWRI Book 5, chapter C1, 58 p.

Herbst, D. 1999. *Bioassessment Sampling Procedures*, Sierra Nevada Aquatic Research Laboratory.

Horowitz, A. J. and others. 1994. *U. S. Geological Survey Protocol for the collection and processing of surface-water samples for the subsequent determination of inorganic constituents in filtered water*. U.S. Geological Survey Open-File Report 94-539, 57 p.

Protocol for the collection and processing of surface-water samples for the subsequent determination of inorganic constituents in filtered water.

Hunter, D.A., Reuter, J.E. and Goldman C.R., 1993. *Standard Operating Procedures – LTIMP. Draft. Laboratory analysis of nutrients, iron, TSS, turbidity, conductivity, and pH*. UCD-TRG, 79 p. 2/93.

Kennedy, E.J. 1983. *Computation of continuous records of stream flow*: U.S. Geological Survey TWRI book 3, chapter A13, 53p.

Lapham, W. W. and others. 1995. *Ground-water data-collection protocols and procedures for the National Water-Quality Assessment Program: selection, installation, and documentation of wells, and collection of related data*. U.S. Geological Survey Open-File Report 95-398, 69p.

Selection, installation, and documentation of wells, and collection of related data, and measurement of water levels and collection of additional hydro geologic and geologic data.

Meador, M. P. and others. 1993. *Methods for characterizing stream habitat as part of National Water-Quality Assessment Program*. U.S. Geological Survey Open-File Report 93-408, 48 p.

Stream habitat sampling design, methods for characterizing stream habitat.

Porter, S. D. and others. 1993. *Methods for collecting algal samples as part of the National Water-Quality Assessment Program*. U.S. Geological Survey Open-File Report 93-409, 39 p.

Sampling design, methods for collecting, sample processing & labeling.

NRCS/Clausen, J. C, 1996, NRCS *National Handbook of Water Quality Monitoring. Part 600 National Water Quality Handbook.* 13 chap.

Problem & objectives, statistical design, scale, variable selection, sample type, sampling location, sampling frequency & duration, station type, sample collection & analysis, land use & management monitoring, data management.

Shelton, L. R., 1997. *Field Guide for collecting samples for analysis of volatile organic compounds in stream water for the National Water-Quality Assessment Program.* USGS Open-File Report 97-401, 14p.

Preparation, equipment cleaning, sample collection, field measurements, QA/QC, documentation, sample ID, shipping.

Shelton, L. R., and P. D. Capel. 1994. Guidelines for collecting and processing samples for stream bed sediment for the analysis of trace elements and organic contaminants for the National Water-Quality Assessment Program. U.S. Geological Survey Open-File Report 94-458, 20p.

Study design, planning, equipment, cleaning, sample collection, sample processing, field documentation, final cleaning, QA/QC.

Tetra Tech, Inc./U.S. Environmental Protection Agency. 1998. *Techniques for Tracking, Evaluating, and Reporting the Implementation of Nonpoint Source Control Measures – III*. Urban. US EPA Office of Water - US EPA 841-B-97-011, 6 chap.

Methods to inventory BMP implementation, sampling design, methods for evaluating data, conducting evaluation, presentation of evaluation results. US EPA Web page.

U.S. Environmental Protection Agency. 1991. *Compendium of ERT Surface Water And Sediment Sampling Procedures, Sampling Equipment Decontamination, Surface Water Sampling, and Sediment Sampling.* Interim Final, Environmental Response Team, Emergency Response Division, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, DC 20460, pp. 31.

U.S. Environmental Protection Agency. 2000. *Nutrient Criteria - Technical Guidance Manual – Rivers and Streams*. US EPA Office of Water - EPA-822-B-00-002, 9 chap.

Stream system classification, select variables, sampling design for new monitoring programs, building a database, analyze data, criteria development, management programs, monitoring & reassessment of nutrient criteria ranges, case studies, methods of analysis for water quality variables, statistical tests & modeling tools. US EPA Web page.

U.S. Geological Survey. 1998. National *Field Manual for the Collection of Water-Quality Data*. Techniques of Water-Resources Investigations- Handbooks for Water-Resources Investigations, Book 9, A1-A9, 2 volumes, variously paged.

Preparation, equipment, cleaning, collection, processing, measurements for surface and groundwater sampling and biological indicators, bottom materials and safety.

APPENDIX A. TRPA WATER QUALITY THRESHOLDS and EIP UNITS OF BENEFIT

THRESHOLD	DESCRIPTION	PARAMETER	STANDARD	INTERIM TARGETS	UNITS OF BENEFIT
WQ-1	Shallow waters of Lake Tahoe	Turbidity, shallow waters of Lake Tahoe	Decreases sediment load as required to attain turbidity values not to exceed 3 NTU in littoral Lake Tahoe. In addition, turbidity shall not exceed 1 NTU in shallow waters of Lake Tahoe not directly influenced by stream discharges.	NA. Implementation of related research program on turbidity, direct runoff, and shorezone erosion and recommended load reductions.	Reductions in sediment/ nutrient discharge to the lake.
WQ-2	Deep waters of Lake Tahoe	Clarity, winter, pelagic Lake Tahoe	Average secchi depth, December-March, shall not be less than 33.4 meters. (Secchi)	Annual average Secchi depth shall not be less than 22.7 meters in water year 2000.	Reductions in sediment/ nutrient discharge. Watersheds where clarity model applied based on needed load reductions.
WQ-2A	Capital Improvement Program	Deep waters of Lake Tahoe	Clarity, winter, pelagic Lake Tahoe. (CIP; C. Road BMP; D. Trail BMP; E. Slope Stabilization/Revegetation; F. Runoff Treatment)	From January 1, 1997 to December 2001, total expenditures on Capital Improvement Projects. Total phosphorus concentrations shall not exceed established forecast lines. TRPA shall prepare a mitigation plan of urban runoff at the point of discharge.	Acres treated for source control. Miles of roads BMP. Miles of trail BMP. Acres of source control treated. Miles of drainage conveyance treated, should change to load reductions.
WQ-2B	Best Management Practices	Deep waters of Lake Tahoe	Clarity, winter, pelagic Lake Tahoe. (Res. BMP)	By December 31, 2001, 35 percent of the properties shall have BMPs in place, and 30 percent have revegetation of disturbed areas.	% of BMP's installed by jurisdiction
WQ-3	Water quality	Phytoplankton Primary Productivity	Annual mean phytoplankton primary productivity shall not exceed $52gC/m^2/yr$. California: algal productivity shall not be increased beyond levels recorded in 1967-1971, based on a statistical comparison of seasonal and annual mean values.	Annual mean phytoplankton shall not exceed 140 $gmC/m^2/yr$. For water year 2000.	Load reductions for Nitrogen, Phosphorus, and Iron.
WQ-4	Tributaries	Tributary water quality	California: total nitrogen (0.19mg/l), total phosphorus (0.15mg/l) and total iron (0.03mg/l annual average). Nevada: soluble phosphorus not to exceed 0.007mg/l annual average, soluble inorganic nitrogen not to exceed 0.025mg/l annual average. TRPA: attain a 90th percentile value for suspended sediment of 60mg/l.	Total phosphorus concentrations shall not exceed established forecast lines.	% of watershed treated (BMPs, SEZ; water quality; slope stabilization)
WQ-4A	Tributaries	Tributary water quality	Reduce sedimentation	% of 1 inch / hr storm	Volume of runoff treated or reduced
WQ-5	Stormwater runoff quality	Surface discharge to surface water	TRPA threshold-dissolved inorganic nitrogen, 0.5mg/l; dissolved phosphorus, 0.1mg/l; dissolved iron, 0.5mg/l; suspended sediment, 250mg/l; grease and oil, 2 mg/l.	TRPA shall prepare a mitigation plan of urban runoff at the point of discharge.	Miles of roadways treated; acres of intervening areas treated
WQ-6	Stormwater runoff quality	Surface discharge to groundwater	Surface water infiltration into the groundwater shall comply with Uniform Regional Runoff Guidelines. For total nitrogen, 5mg/l; total phosphorus, 1mg/l; total iron, 4mg/l; turbidity, 200 NTU; and grease and oil, 40 mg/l.	TRPA shall prepare a mitigation plan for urban runoff at the point of discharge.	Same as above and: volume of runoff infiltrated, add quality of pretreatment and water quality of infiltrated water (characterization of urban runoff).
WQ-7	Other Lakes	California-Nevada Other Lakes	For other lakes in Nevada, the standards are the same as the tributary standards.	TRPA shall determine the status of developing standards by Sept. 2006.	No degradation from 1991 to 1995 other lake studies

ENVIRONMENTAL IMPROVEMENT PROGRAM UNITS OF BENEFIT

THRESHOLD INDEX	THRESHOLD INDICATOR	THRESHOLD UNIT OF BENEFIT
	Water Quality	
WQ1	Turbidity	* Reduced Sediment /Nutrient Discharge
WQ2	Pelagic Lake Tahoe Winter Clarity (Secchi depth)	* Reduced Sediment/Nutrient Discharge
WQ2-A	Pelagic Lake Tahoe Winter Clarity (CIP)	Acres treated, source control
WQ2-B	Winter Clarity- (% of private properties, BMP's)	Miles of roads BMP
Mitigation –C	Pelagic Lake Tahoe Winter Clarity (Road BMPs)	Miles Improved
Mitigation –D	Pelagic Lake Tahoe Winter Clarity (Trail BMPs)	Miles Improved
Mitigation –E	Pelagic Lake Tahoe Winter Clarity (Slope Stabilize/ Revegetation)	Acres Improved
Mitigation –F	Pelagic Lake Tahoe Winter Clarity (Runoff Treated)	Miles conveyance treated
WQ3	Phytoplankton PPR	* < N, P, Fe discharge
WQ4	Tributary Water	% Watershed treated
Mitigation –A	Runoff Volume	% Runoff Treated
WQ5	Runoff Water	Acres intervening treated
WQ6	Groundwater	Volume runoff infiltrated
WQ7	Other Lakes	Maintain 1991 study level water quality

*NOTE: * These potential benefit units may vary with the specifics of the project.*

APPENDIX B. PRIORITY CONSTITUENTS OR PARAMETERS

a) Nutrients:

CONSTITUENT/ PARAMETER	ABBR.	REPORTED DETECTION LEVEL **	LAB METHOD REFERENCES (EPA METHOD #)	MANDATED OR RECOMMENDED BY	PRIORITY CODE[1]
Total organic+ ammonium nitrogen (Kjeldahl)	TKN	50 ug/l	351.2	LTIMP/USFS	2
Dissolved ammonium nitrogen	DNH_4	5 ug/l	350.1	LTIMP/USFS	2
Dissolved nitrite + nitrate nitrogen	DNO_3	10 ug/l	353.1	LTIMP/USFS	1
Total phosphorus	TP	5 ug/l	365.3	LTIMP/USFS	1
Dissolved orthophosphate phosphorus	SRP/OP	5 ug/l	365.3	LTIMP/USFS	1
Dissolved phosphorus	DP	5 ug/l	365.2	LTIMP/USFS	1

b) Sediment:

CONSTITUENT/ PARAMETER	ABBR.	REPORTING LEVEL	LAB METHOD REFERENCES	MANDATED OR RECOMMENDED BY	PRIORITY CODE
Suspended sediment concentration	SSC	1 mg/l		LTIMP/USFS	1
Total Suspended Solids	TSS	1 mg/l	Dry filter, 160.2	LTIMP/USFS	2
Full Particle size break (2-200 microns)	PS			LTIMP/USFS	2
Turbidity	TURB	.05 NTU	Nephelometric, 180.1	LTIMP/USFS	2

[*] Reported as the lowest quantitative limit for the constituent measured, not a minimum level of statistical calculation or calibration from the laboratory. At a minimum, the quantification limit shall be three times the method detection limit

[1] A code of 1 is highest priority and should be a routine sample; 2 is of lesser priority and may be project specific.

c) **Selected trace metals:**

CONSTITUENT/ PARAMETER	ABBR.	LAB METHOD REFERENCES	REPORTING LEVEL	MANDATED OR RECOMMENDED BY	PRIORITY CODE
Arsenic	As	GF-AA	0.5 ug/L	CALTRANS	2
Cadmium	Cd	GF-AA; ICP-MS	0.2 ug/L	CALTRANS	2
Chromium	Cr	GF-AA; ICP-MS	1.0 ug/L	CALTRANS	2
Copper	Cu	GF-AA; ICP-MS	1.0 ug/L	CALTRANS	2
Iron	Fe	GF-AA; colorimetric	25.0 ug/l	CALTRANS	1
Lead	Pb	GF-AA; ICP-MS	1.0 ug/L	CALTRANS	2
Nickel	Ni	GF-AA; ICP-MS	2.0 ug/L	CALTRANS	2
Zinc	Zn	GF-AA; ICP-MS	5.0 ug/l	CALTRANS	2

d) **Field:**

CONSTITUENT/ PARAMETER	ABBR.	REPORTING LEVEL	MANDATED OR RECOMMENDED BY	PROJECT TYPE	PRIORITY CODE
Water temperature	WT	0.5 deg C	LTIMP/USFS/USGS	LTIMP Mon.	1
Air temperature	AT	0.5 deg C	LTIMP/USFS/USGS	LTIMP Mon.	2
Discharge	Q	0.01 ft^3/s	LTIMP/USFS/USGS	LTIMP Mon.-SW	1
Gage-height	GH	0.01 ft	USGS	LTIMP Mon.-SW	2
Specific conductance	SC	1 uS/cm	LTIMP/USFS/USGS	LTIMP Mon.	1
pH	pH	0.1 units	LTIMP/USFS/USGS	LTIMP Mon.	3
Dissolved oxygen	DO	0.1 mg/L	LTIMP/USFS/USGS	LTIMP Mon.	2
Barometric pressure	BP	1 mm	LTIMP/USFS/USGS	LTIMP Mon.	2
Dissolved oxygen percent saturation	%SAT	1%	LTIMP/USFS/USGS	LTIMP Mon.	2
Precipitation	PRECIP	0.01 in	LTIMP/USFS/USGS	LTIMP Mon.	3
Weather (clear, cloudy, rain, snow, thunderstorm)		N/A	LTIMP/USFS/USGS	LTIMP Mon.	1
Hydrologic event (routine/storm/snowmelt)		N/A	LTIMP/USFS/USGS	LTIMP Mon.	2
Stage Conditions (stable/rise/peak/fall)		N/A	USGS	LTIMP Mon.	2

e) Sample QC:

CONSTITUENT/ PARAMETER	ABBR.	LAB METHOD REFERENCES	REPORTING LEVEL	MANDATED OR RECOMMENDED BY	PROJECT TYPE	PRIORITY CODE
Sample medium (sw, gw, lk)				USGS	LTIMP Mon.	3
Sample method (ewi, edi, dip)				USGS	LTIMP Mon.	3
Sampler type (dh48/81/59,d74,bot, etc)				USGS	LTIMP Mon.	3
Sample purpose (network, bmp)				USGS	LTIMP Mon.	3
Sample collecting agency (USGS, TRG)				USGS	LTIMP Mon.	3
Sample analyzing agency (USGS, TRG)				USGS	LTIMP Mon.	3

From: Bruce Warden [bwarden@rb6s.swrcb.ca.gov]
Sent: Friday, December 14, 2001 16:54
To: Dave Roberts
Cc: Robert Erlich; Mary Fiore-Wagner; Lauri Kemper; Jeremy Sokulsky; rwhitney@trpa.org; acheyvaert@ucdavis.edu; jereuter@ucdavis.edu
Subject: Re: TSS vs. SSC

I've been thinking about this for a while. I wish I could give you a definitive answer. However, I can give you my best guess. You were there at the last LTIMP WQWG where this was discussed and saw that we scientists didn't remotely come to any kind of consensus on TSS vs. SSC. It's still wide open for discussion.

(1) Which of these (SSC Vs. TSS) is better for determining nutrient and fine sediment loading?
SSC is better for total loading in that it is surer to include the sand fraction. However, evidence suggests that most of the Bioavailable nutrients are concentrated with the finer sediment, which both TSS and SSC measure. We don't know which is better for Tahoe conditions, since we haven't done a side-by-side comparison of SSC and TSS data. We do TSS in our lab. The USGS noted significant differences between SSC which measures all the sand, and TSS, which misses some sand, for samples with about 20% or more sand (a lot). There usually isn't a lot of sand in our samples, and even if there where, the question is, so what? Some would argue that the sand is important for beach replenishment, but again as far as fine sediment and nutrient loading is concerned, so what? However, for quality control, we should initially assess the quantity and bioavailability of the nutrients associated with sand particles. If this is significant, we should be sure to include the sand fraction for all analyses (i.e. use SSC method).

(2) Should we require both TSS and SSC in some of the BCP tasks i.e. LTIMP study and analysis?
We should require an initial study to determine if the difference between TSS and SSC is significant enough to warrant requirement of the SSC method. My educated guess is that the differences are not significant, but you never know until you check.

(3) Are there practical limitations to SSC that would make it undesirable i.e. summer vs. winter data collection relative to salt concentrations?
Practical considerations for SSC include salt concentration if the evaporation SSC method is used. The filtration SSC method is limited by plugging of the filter media with high-sediment concentration stormwater samples. USGS uses SSC on all LTIMP samples, but dilution makes road salt insignificant there in stream water. Experience with winter stormwater samples (road runoff) indicates that salt may be very high in these sources.

(4) Which of these methods are better?
My guess on this is that the TSS method is more rugged and will probably give us the kind of results we need in the time we need them. However, for quality control, we must assess SSC vs. TSS differences. And if differences are significant, I would prefer the evaporation SSC method for total quantification, assuming salt concentration is not a major problem. For the filtration method SSC and TSS, the filter used may be important--the methods call for glass fiber filters where nominal pore size may vary from about 0.7 to 1.2 microns, depending on the brand used.

An underlying issue is the particle size distribution, regardless of which method is used--this is most useful for determination of browns and their relative contributions to loss of clarity. Bear in mind that all of this is up for debate. And anything we actually do must be justified by following appropriate quality control.

Other issues are practicality (are there any time/materials/applicability to all sample type issues), representatives (accuracy, precision), and inter-agency data consistency. Generally, the TSS method is more practical (no analytical problems with salt and filter plugging), the SSC method more representative and consistent with other data collected in the Tahoe Basin (i.e. LTIMP data). Some of the practical problems associated with the SSC method may be solved by using the appropriate type of SSC method--for low salt, high sediment samples, use the evaporation or wet sieving method. For high salt, high sediment samples use the wet sieving method.

I've contacted the USGS laboratory in Monterrey that does the LTIMP SSC sample analyses, to get detailed SSC methodology (the original ASTM procedure) and maybe some of our questions will be answered with that further information.

Bruce T. Warden, Ph.D., Environmental Scientist
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Chapter 7 Sample Type

600.0700 Introduction

If water quality did not vary in space or in time, there would be little reason to collect more than one sample to describe the quality of a particular water body. However, water quality does vary spatially and temporally. Both random and deterministic components (fig. 7–1) are found in most water quality data. Variations in water quality data are caused by seasonal differences, trends, and the randomness associated with rainstorms. For example, suspended solids concentrations increase during stormflow, especially during the early part of the storm (Shelly & Kirkpatric 1975). Therefore, because of these temporal and spatial variations, samples must be taken from the entire population of water quality data possible.

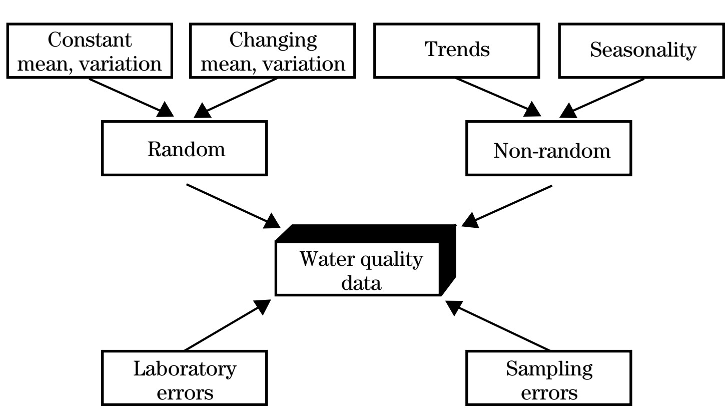
The four types of water quality samples that can be collected are grab, composite, integrated, or continuous. The sample type selected is governed by the study objectives, the variable to sample, and whether concentration or mass is the desired outcome. Composite samples are appropriate for most monitoring study objectives, whereas grab sampling is recommended for a few objectives directed toward reconnaissance sampling (table 7–1). Continuous samples are appropriate only for research and fate and transport studies.

The variable to sample influences the sample type as well. For example, bacteria samples must be taken as grab samples with sterilized bottles and cannot be stored in the field as a composite sample. The concentrations of other variables change dramatically during storage and therefore are inappropriate for compositing. These include all dissolved gases, chlorine, pH, temperature, and sulfide (APHA 1989). Water quality variables that correlate highly with stream velocity, especially those related to suspended sediment concentrations, may need to be sampled with depth integrated samplers. Grab samples may be insufficient to determine mass loading values unless the concentrations are correlated to discharge (Baun 1982).

Table 7–1 Sample type as a function of monitoring study objective

Objective	Grab	Integrated or composite	Continuous
1. Baseline	X	X	
2. Trend	X	X	
3. Fate & transport		X	X
4. Problem definition	X	X	
5. Critical areas	X	X	
6. Compliance	X	X	
7. Conservation practice effectiveness		X	
8. Program effectiveness		X	
9. Wasteload allocations		X	
10. Model evaluation		X	
11. Research		X	X

Figure 7–1 Factors contributing to variability in water quality data



600.0701 Grab samples

A grab sample is a discrete sample that is taken at a specific point and time (APHA 1989; Ponce 1980). Grab samples may not be representative of the water quality of the body of water being sampled. For example, the water quality may vary with depth or distance from the streambank. Samples at a single location in a lake or a single well are really grab samples. For lakes and ground water, variable concentrations may vary with location and depth. For example, nitrate concentrations have been found to be stratified in some water table aquifers in the Midwest. Also, since water quality often varies with time, grab samples may not represent temporal variations.

Grab samples can be collected manually by hand or automatically with a sampler.

600.0702 Composite samples

A series of grab samples, usually collected at different times and lumped together, are considered composite samples. However, composite samples typically are taken only at one point. These samples can be either time-weighted or flow-weighted. The collection of composite samples generally is done with the aid of an automatic sampler, as described in chapter 9, although manual techniques could be used as well. A distinct advantage of the composite sample is that a savings in laboratory and field costs can be realized. Also, compositing will reduce sample-to-sample variability.

(a) Time-weighted composite

Time-weighting is the most common type of water quality compositing. For this type of sample, a fixed volume of sample is collected at prescribed time intervals in either a large composite bottle or separate bottles for compositing later. With automatic samplers, the time interval can range from 1 minute to 100 hours, and the volume collected can range from 10 mL to 990 mL, although larger volumes are possible. Equation 8–1 in chapter 8 can be used to determine the number of samples (n) to take to make up a composite, where n is a function of the variability in the data and the desired precision. For water quality variables where the length of the composite time is greater than the prescribed holding times (USEPA 1983), the collection bottles may be pre-acidified for preservation.

(b) Flow-weighted composite

Time-weighted compositing has been criticized as being inappropriate for mass loading calculations and inaccurate where the discharge and concentrations vary (Baun 1982; Shelly & Kirkpatric 1975). Also, the time interval may miss peak concentrations during peak discharges. Therefore, flow-weighted compositing is an alternative to time-compositing. Where flow-weighted compositing is used, a sample is taken after a specified volume (l^3) of flow has passed the monitoring station. This type of sampling requires automatic equipment that monitors stream stage and calculates discharge. A number of automatic samplers offer this function, or a data logger can be used.

To sample in this manner, the stage-discharge relationship must be known for the monitoring location. Stage-discharge relationships require a great deal of effort to develop unless a calibrated flow devise, such as a weir or a flume, is used.

Flow-weighted compositing also can be achieved using certain types of passive samplers. A passive sampler is one that collects a water quality sample by action of the flow of water itself. A number of these types of devices are described further in chapter 9.

600.0703 Integrated samples

A specific type of grab sample is a depth-integrated sample (USGS 1977). Such a sample may account for velocity or stratification induced changes with depth, but temporal variations would not be integrated.

Multipoint sampling at a station may be necessary because of the horizontal and vertical variations in water quality. The U.S. Geological Survey recommends that streams should be sampled using a depth integrated sampler whenever practical (USGS 1977) except when the stream is too shallow to obtain that type of sample.

For variations across the stream, samples can be collected using either the Equal Width Increment (EWI) method or the Equal Discharge Increment (EDI) method. With the EWI method, depth integrated samples are collected at equally spaced intervals at the cross section. All subsamples are then composited. The EDI method requires knowledge of streamflow discharge by subsection in the cross section. The section is divided into equal discharge subsections, which are then sampled.

Depth-integrated samples may also be appropriate for both lake and ground water systems. In lakes, depth integration can be achieved by sampling each lake strata, by obtaining a sample of the entire water column with a hose, or by automatic devices or pulleys that collect at different depths over time.

Different ground water strata can be sampled with certain types of bailers or with multilevel wells and samplers.

600.0704 Continuous samples

Continuous sampling is rare in nonpoint source pollution studies and is typically used for research purposes (table 7–1). Continuous monitoring can be used for any water quality variable that is measured using electrometric methods (table 7–2). This would exclude analysis of metals and organics.

Several problems are encountered when using continuous sampling. Most electrodes are temperature dependent and have temperature limits beyond which they cease to function. Electrodes normally cannot be placed in areas of rapid water velocity, which influences readings by the probe. However, in-stream stilling wells can be used to reduce this effect.

Several manufacturers produce submersible, multiple recording probes for such variables as pH, dissolved oxygen, conductance, and depth. These probes have been widely used in lake systems.

Table 7–2 The suitability of various water quality variables for continuous monitoring (based on APHA 1989)

Suitable	Not suitable
Ammonia	Metals
Chloride	Organic compounds
Conductivity	Pesticides
Cyanide	
Dissolved oxygen	
Fluoride	
Inorganic nonmetals	
Nitrate	
pH	
Salinity	
Temperature	

600.0705 References

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APPENDIX D. AUTOMATIC SAMPLERS

AUTOMATED SAMPLER WRITE-UP

CREATED BY RUSSELL WIGART, CITY OF SOUTH LAKE TAHOE

Automated Samplers

The use of automated samplers in water quality monitoring is imperative in order to measure flow and attain accurate samples. Flow weighted sampling works best for areas where the flow is easily calculated using an area-velocity meter or ultrasonic level system. For a culvert pipe where the dimensions are known, flow is easily calculated by the sampler because it has the stage information and the pipe configuration, so discharges are an easy pre-programmed calculation. In a situation such as this, using volumetric flow weighted sampling can work best. The sampler is then programmed to sample water based on the amount of volume passing through the pipe (e.g. 200 cubic feet). The sampler will then take a sample every time the specified volume of water passes through the pipe. This is a relatively simple way to draw samples and is easily modified to fit a particular location.

Problems with Flow-weighted Sampling in Channels

For other areas where the flow is not as defined such as a channel, sampling needs to be adjusted so that the samples are triggered during events. In the Trout Creek restoration project, the flow is variable and the difference in the hydrograph between day and night is substantially different. Because the flow is different between day and night volumetric sampling does not work. For example, a stream fluctuates from a level of 5.62 during the day to 5.82 ft. in stage at night, and the water generated in this channel varies from 27,000 cubic feet to 33,000 cubic feet. The sampler will be set to take samples above a given volume, say 33,500 cubic feet of water during events. During the day a storm event occurs and runoff begins. For this storm you just missed the rising limb of the hydrograph because you weren't prepared to sample. Because of this diurnal fluctuation in flow, other ways to sample storm events must be implemented in order to get effective sampling.

Timed Interval Sampling

This is another option that will work for getting samples from areas where a channel is undefined and a rating curve is not established. In this case the user acts like the trigger mechanism in that they have to visually recognize what the stage is and trigger the sampler to sample above a given stage. This is known as setpoint sampling when the sampler is enabled above a given stage. After the sampler is set the user must tell the sampler how often to sample. For example, a storm is expected to come in and drop over a half-inch of rain. The stage is currently at 8.64. For this scenario one might pick an arbitrary number, lets say 8.78 to start the sampler and sample every other hour throughout the duration of the storm event until the stage goes below the setpoint again. This technique allows the user to capture the storm event throughout the duration of the hydrograph and setup time intervals depending on the size of the storm.

For the Trout Creek restoration monitoring this technique was used to gather samples during the preliminary phase. The rating curve developed by the USGS at Martin Bridge was input into the automated sampler and assisted in acquiring flow measurements. The City of South Lake Tahoe and DRI then used those flow measurements and the results form the analysis to figure out total load of sediment and other constituents from summer storm events. Obviously spring runoff will have greater flow rates and higher levels of sediment than summer thunder-bumpers. Capturing this will require other methods of sampling because stage and flow will vary frequently day to day and an increase in flow does not necessarily mean there is a storm event. For situations such as this Turbidity threshold sampling may work best.

Turbidity Controlled Sampling

For estimating suspended sediment concentration (SSC) in rivers, turbidity is potentially a much better predictor than water discharge. Since about 1990, it has been feasible to automatically collect high frequency turbidity data at remote sites using battery-powered turbidity probes that are properly mounted in the river or stream. With sensors calibrated to give a linear response to formazine standards, turbidity and sediment concentration should have a linear correlation close to unity for a given size and composition of suspended particles (Gippel, 1995; Foster et al., 1992). For events of limited duration, the physical properties of the suspended particles probably change very little in most streams. A few (less than 10) data pairs spanning the range of concentrations should be sufficient to reliably establish the relation between

SSC and turbidity during such events (Lewis, 1996). This relationship provides a means for accurately estimating sediment loads during storm runoff events. In addition, the detailed turbidity record often contains the signature of sediment inputs to the channel from erosion and mass wasting (Lewis and Eads, 1996).

For estimating monthly or annual sediment loads, the relation between SSC and turbidity will vary over time with changes in sediment sources, organic loading, or sensor calibration (Gippel, 1995). Thus, the use of a single curve describing the long-term mean relation will yield greater errors than for short-event estimation. Nevertheless, turbidity is probably more useful than water discharge as a long-term predictor of SSC. If the turbidity-SSC relation is roughly linear, load estimates will be nearly unbiased. In contrast, with sediment rating curves (linear in the logarithms), variance estimation is much more complicated (Gilroy et al., 1990) and such models frequently fit the data poorly and are subject to large errors (Walling and Webb, 1988).

Redwood Sciences Laboratory (USDA Forest Service, Pacific Southwest Research Station) has been experimenting with various approaches to estimating suspended sediment loads in small streams. They have developed a prototype system where a data logger program employs nephelometric turbidity to make SSC sampling decisions (i.e., to activate a pumping sampler) in real time (Lewis, 1996; Lewis and Eads, 1996). The algorithm uses a separate rising and falling series of threshold turbidity values. A falling condition is detected when turbidity drops a given percentage below the previous maximum, and a rising condition is detected when turbidity rises a given percentage above the prior minimum. Because the falling condition is usually much longer than the rising condition, the falling series has more thresholds. SSC specimens are collected whenever a threshold for the current condition is crossed. Additional constraints are imposed to limit sampling when turbidity is spiking or fluctuating rapidly.

High frequency noise in the data can be caused by air bubbles or momentary scraps of debris passing in front of the optics. With the probes we are using, these often result in large erroneous readings. Therefore, before recording a value, we first read turbidity at half-second intervals for a half-minute, storing 61 values temporarily in data logger memory. These values are then sorted and the median is recorded. The median is more appropriate than the mean because the mean is sensitive to outliers.

The City of South Lake Tahoe is modeling Jack Lewis and Rand Eads application of this technique and is optimistic in its effectiveness for retrieving good samples and representative data.

Trout Creek Restoration Monitoring

The monitoring for this project is being done to see the background levels of constituents and monitor the changes and hopeful reduction of sediments from the project site downstream to Lake Tahoe. The restoration project is being done to improve natural function of the channel, increase overbank flow and distribute sediment into the floodplain more frequently. The highly incised channel is a mega-sediment transporter especially during storm events. Controlling the flow and allowing the creek to overtop its banks will slow the creek and allow sediment distribution. We can be assured that the project will have an ecological benefit, vegetation benefit, wildlife benefit, fisheries benefit, but showing a water quality benefit for a project of this scale is very difficult because the positive benefits to water quality could take a long time. We would like to determine the benefits to water quality in the 3-year time frame and budget we have to work with. This is a huge task that the City of South Lake Tahoe staff is excited to be a part of.

Trout Creek consists of three monitoring sites, one at Martin Bridge, one on Cold Creek and one on Upper Trout Creek above the restoration. All three sites are self-contained and include the following materials:

Retailer	Price	Quantity	Total Price
Campbell Scientific			
CR 10X Data Logger	$1,265.00	3	$ 3,795.00
Druck 1830 Pessure Transducer	$ 546.00	3	$ 1,638.00
Desicant Case w/pigtail lead	$ 115.00	3	$ 345.00
Druck Polyeurethane cable	$ 1.94	100	$ 194.00
Water Conductivity/temp Probe	$ 295.00	3	$ 885.00
WIR 22 AWG 4 Cond shld/polyeur	$ 0.68	100	$ 68.00
CS 547 Conductivity interface	$ 115.00	3	$ 345.00
Motorola Cell phone package	$ 630.00	3	$ 1,890.00
Yagi Cell phone antenna	$ 157.00	3	$ 471.00
9600 phone modem	$ 429.00	3	$ 1,287.00
20 Watt solar panel w/ mounts	$ 485.00	3	$ 1,455.00
10 Watt (optional, $75 difference)			
Windows Data logger software	$ 300.00	1	$ 300.00
Optically Isolated RS 232 interface	$ 145.00	1	$ 145.00
		sub	$12,938.00
			$13,876.01
Forestry Suppliers			
Staff Gage	$ 35.25	3	**$ 105.75**
Newark Electronics			
D1D07 Relay	$ 43.06	3	$ 129.18
			$ 149.99
Pelican Products			
model 1400 case w/ foam	$ 90.45	3	**$ 271.35**
D&A Instruments			
Turbidity Sensor	$1,550.00	3	$ 4,500.00
Voltage Clamp	$ 75.00	3	$ 225.00
5 meter cable assembly	$ 160.00	3	$ 510.00
			$ 5,265.00
			$ 5,646.71
Jensen Instruments			
VST 5/8" Vaccum pump sampler	$2,200.00	3	$ 6,600.00
24 Bottles for Nontoxic liquid	$ 650.00	3	$ 1,950.00
1 Liter Poly Bottle	$ 100.00	3	$ 300.00
5/8" Hose (25 feet)	$ 60.00	3	$ 180.00
PVC strainer	$ 30.00	3	$ 90.00
		sub	$ 9,120.00
		Total	**$28,573.23**

The Trout Creek restoration-monitoring program will be monitoring the following constituents (TKN (total Kjeldahl Nitrogen), N03 (Nitrate), N02 (Nitrite), TP (Total Phosphorous), OP (Orthophosphate), TSS (Total Suspended Solids), and Turbidity.)

Velocity profiles will be done and rating curves will be established for each site. The rating curves have to be updated frequently to ensure accuracy in flow measurements. At the Martin Bridge location the USGS has an accurate rating curve that is updated frequently, which will be used for the project. Each sampler station will have an OBS-3 turbidimeter. The turbidimeter will give us real time turbidity measurements. (Picture below shows the meter attached to the intake boom.)

The costs for a monitoring project of this magnitude are high. Included in this study will be a turbidity/ suspended solids relationship. Once there is enough data gathered the City of South Lake Tahoe and DRI will correlate the turbidity with the suspended solids. The flow measurements combined with the constant turbidity readings corresponding to the sediment will give us real time loading calculations for sediment and, possibly later, for other constituents. In our initial analysis we found that the turbidity and the hydrograph for the storm parallel each other almost perfectly. This makes us optimistic about correlating the two because the sediment is consistent between storm events. For the August 3rd storm event that dropped nearly 1½ inches of rain, the sediment, turbidity and all of the constituents followed bell shaped curves for the duration of the hydrograph. From this we can draw assumptions that the sediment is related to the turbidity and our correlation will work. After we have determined the relationship of the sediment to the turbidity we will use the turbidity readings to trigger the sampling of the stations. We have to first determine the rising and falling limbs of turbidity as it relates to the hydrograph (see Eads and Lewis abstract above). Logic will later be programmed into the data loggers to let the samplers know when the turbidity is rising and falling and the loggers will trigger the samplers accordingly. This is not a straightforward science and adjustments need to be made frequently in order to have effective sampling.

One problem that may be encountered with this study is that the mica in the water, which is heavily present, may add to higher turbidity readings because of its higher reflectance. Metals such as aluminum silica reflect light at a higher frequency than normal sediments, so the effect of the mica on the outcome of turbidity readings is a factor and is being taken into account. DRI is working closely with the City of South Lake Tahoe to find out the influence of these particles and the implications involved with getting accurate turbidity readings.

Beecher / Lodi ECP
The goal of this project is to find out the efficiency of the Vortechnics stormwater treatment system at removing sediment and nutrients. A Sigma sampler (Model 900 Max) with an area-velocity meter and intake were setup on both the inflow and the outflow. The flow meters were setup right next to one another, so that each would get the same flow measurements and they would be paired.

There are variables in the treatment system that makes it hard to get representative samples. First, there is a detention time for the water based on flow rates. This residence time is what is needed to remove sediments. In order to see how much treatment the water is getting as it passes through the system we had to try and sample the water as it went into the system and as it was leaving the system. Trying to capture the same water on the inflow and the outflow can be estimated by using preprogrammed weir calculations. The weir calculations were programmed into the outflow sampler. As the water level in the box raises, the sampler can calculate the discharge and automatically pair the samples. Having two data sets with paired samples gives us the data that tells us how efficient the box is at removing sediment and nutrients. The results of this study will be given at a later date. (Figure 1 below shows the sampler housing unit and rain gauge; Figure 2 shows the sampler inside the corrugated housing unit.)

Figure 1

Figure 2

Ski Run ECP

The Ski Run Erosion Control Project consists of four basins that pre-treat stormwater before it outlets into Lake Tahoe. The two upper basins are designed to detain stormwater collected from separate tributary areas. These basins allow settling time before the stormwater outlets through a weir. Given available capacity, the water from the upper basins is polished by two lower wetland basins. Otherwise the flows bypass the wetland basins to avoid flushing sediments through the system. This multistaged treatment system creates more than one treatment to allow sediment and nutrients to be utilized, detained, infiltrated and evaporated. The goal of this project is to calculate the efficiency of the one basin in removing sediment and nutrients.

For this project there are four samplers that are setup on basin #1; one on the outflow and three on the inflows. The sampler on the outflow for this project is a weir and the other three are all in culvert pipes. For anyone thinking of doing water quality-monitoring projects such as this, it is highly recommended to use smoothed wall non-corrugated pipe, so that the instrumentation can be mounted easily on the bottom of the pipe.

Setup for this project included using manhole inserts, pipe inserts and creativeness to mount the equipment into the pipes and weir. The manhole inserts hold the sampler suspended in the manhole, so the instrumentation is non-visible to anyone and easily retrievable and maintained. Manhole inserts can easily be made of steel plating and some chain or can be bought from retailers for around $350-$400. Pipe inserts were made to fit into corrugated pipes to create laminar flow for good flow data and assist in acquiring representative samples. Pipe inserts can be made of rounded sheet metal and locked in place by either using a turnbuckle with some brackets or threaded steel dowels with some brackets. The equipment should first be mounted securely to the sheet metal beforehand to facilitate installation and the cables should be secured to the sheet metal with grommets (see figure 4). The expansion of the turnbuckle or tightening of the screws secures the insert tightly to the sides of the culvert pipe. The sampler can then be placed in the manhole insert and the cables attached (see figure 3).

Figure 3

Figure 4

For a weir, the setup is somewhat different. The sampler can be placed in a manhole or housed in a unit to the side or above the weir. An area-velocity meter was used for this project to figure out flow rates. The meter was mounted level on a concrete block and placed at the bottom of the weir approximately at 4H (see Diagram 1 below). This location keeps the measurements accurate by avoiding the influence of drawdown. The intake line (where the samples are taken from) was mounted to the top of the weir to capture water leaving the basin. The type and size of the weir is then input into the sampler. This particular weir on Ski Run is a double non-contracted rectangular weir (see figure 5).

Diagram 1

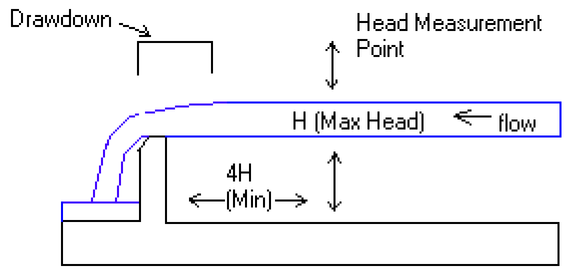

Figure 5

APPENDIX E. LABORATORY SAMPLE ANALYSIS COSTS

The cost to conduct water quality monitoring for a project varies depending on the type and number of constituents, equipment, and organization administering the work. Below is a comparison of lab sample costs of primary constituents for five different labs used by organizations in the Tahoe Basin. As shown in Table 1, the price varies among the different labs, as well as, by the type of constituent.

TABLE 1: Laboratory Sampling Costs (for years 2000-2002)

Constituents	NO3/NO2	NH4	TKN	THP	OP/SRP	TSS
Lahontan	$10.00	$10.00	$16.00	$11.00	$10.00	$8.00
UCD - TRG	$18.00	$16.00	$29.25	$16.00	$16.00	$19.50
DRI - DHS	$15.38	$15.38	$34.55	$23.83	$15.38	$34.65
High Sierra	$15.00	$13.00	$25.00	$12.00	$13.00	$16.00
Sierra Environmental	$32.00	$25.00	$35.00	$25.00	$20.00	$16.00
WET LAB	$20.00	$20.00	$35.00	$18.00	$15.00	$10.00

Total Project Monitoring Costs*

Below are cost comparisons of an El Dorado County Department of Transportation project that has been on-going for the past several years, (1995-2000) and cost estimates of two City of South Lake Tahoe (CSLT) projects to be implemented in the near future.

El Dorado County staff has been conducting water quality sampling through the use of automatic samplers since 1995 at the Angora erosion control project site. The objective of the monitoring is to determine if spreading and infiltrating water across a meadow is as effective as treating water in basins. Samples are being collected for eight constituents (the above plus bioavailable iron and total Nitrogen). As shown in Table 2, the County costs to conduct this monitoring is $150,000 as follows:

TABLE 2: Angora Project Monitoring Costs

Expenditure	Cost	Percent of Total Cost
equipment and access	$37,500	25%
labor (design, install, maintain equipment, data evaluation, and report writing)	$90,000	60%
lab sample analysis	$22,500	15%
TOTAL	**$150,000**	**100%**

CSLT staff will sample water at the basins located at Highway 50 and Wildwood to determine basin water quality treatment effectiveness. Automatic samplers are installed at three inlets and one outlet. CSLT staff estimate water quality sampling for 3 years to cost an estimated $109,000, including 100 samples for eight surface water constituents and 36 ground water samples (sample one time per month over 3 years). The cost breakdown is shown in Table 3.

TABLE 3: Wildwood Basin Monitoring Cost Estimates

Expenditure	Cost	Percent of Total Cost
equipment and access	$23,980	22%
labor (install and maintain equipment)	$23,980	22%
lab sample analysis:	$61,040	56%
surface water (0.47%)		
ground water (0.09%)		
TOTAL	**$109,000**	**100%**

The CSLT will sample ground water near the basins along Pine Boulevard near Stateline Avenue. The objective of the project is to monitor ground water wells due to the basins proximity to potable water sources. The estimated cost of sampling five constituents at three ground wells for three years is $52,130. The cost breakdown is shown in Table 4.

TABLE 4: Stateline Basin Monitoring Cost Estimates

Expenditure	Cost	Percent of Total Cost
equipment and access	$6,260	12%
labor (install and maintain equipment)	$23,980	46%
lab sample analysis	$21,890	42%
TOTAL	**$52,130**	**100%**

As shown above, project monitoring costs vary depending on the organization implementing the work and the intensity of the monitoring plan.

* The Angora project information has been updated as of May 2002, and is available as an excel spreadsheet for those interested. There are also new project costs for the Angora Creek SEZ Restoration Project provided by El Dorado County Erosion Control team. This appendix was intended to provide some examples of ranges of costs, changes in expenditures happen routinely throughout the life of a project.

APPENDIX F. PARKING LOT MONITORING AND RELATED BMP'S

Data excerpted from "Investigation of Structural Control Measures for New Development" prepared by Larry Walker and Associates (1999)

Product	*Company*	*Performance Data (% Removal)*						*Reference*	*Notes*	*Approval Recommendation*	*Follow-up Recommendation*
		TSS	*Cu*	*Pb*	*Zn*	*O&G*	*Other*				
Jensen Interceptor	Jensen Precast	24	12	13	29	38	Diesel (+16) Motor Oil (+33)	Piner, 1994	1 storm w/ in/out grab samples. (+) = increase in concentration	Not Acceptable	Studies at 2 sites w/10 storms each. Follow recommended protocol. Review sizing guidelines
		63/50	33/25	47/33	26/18	ND	TOC (+19/+15)	Kinnetic, 1996	6 storms monitored w/ in/out flow-weighted composite samples. Grab samples for O&G for 2 storms. Removals for intercepted flow/total flow		
Teichert Interceptor	Teichert Precast								No studies	Not Acceptable	Studies at 2 sites w/10 storms each. Follow recommended protocol. Review sizing guidelines
BaySaver	BaySaver, Inc.	80 est.						BaySaver, 1998	Field study of 3 storms w/auto samplers. EMC not computed, Effluent TSS at irreducible levels. Field study planned a U-Maryland	Not Acceptable	Studies at 2 sites w/10 storms each. Follow recommended protocol.
Stormceptor	CSR Hydro Conduit	80					TKN (41)	Service, 1998	4 storms for TSS; 5 storms for TKN. No significant inlet conc. for others	Not Acceptable	Studies at 2 sites w/10 storms each. Follow recommended protocol.
		26			21		PAH (36)	Greb, 1998	45 storm events. Removals based on EMC		
		93					TPH (82)	Environ. Sampling, 1997	3 storm events for TSS; 1 event for TPH. Removals based on EMC		
		53	21	51	39	43		Labatiuk, 1997	4 storm events. Removals based on EMC		
Downstream Defender	H.I.L. Technology, Inc.								Only reliable data are for sediment analysis. 90% removal of particles >150μ. Field study planned	Not Acceptable	Studies at 2 sites w/10 storms each. Follow recommended protocol.
Vortechs	Vortechnics	80						Vortechnics	Lab test at design operation rate of 24 gpm/ft^2	Not Acceptable	Studies at 2 sites w/10 storms each. Follow recommended protocol.
		84						Vortechnics, 1998	7 storm events. Removals based on EMC		
V2B1	Kistner Concrete								Only lab data on sediment removal. Field studies planned.	Not Acceptable	Studies at 2 sites w/10 storms each. Follow recommended protocol.
CDS	CDS Technologies	84						Schwarz, 1999	Lab test. Percent mass capture of sand particles at 125 gpm	Not Acceptable	Studies at 2 sites w/10 storms each. Follow recommended protocol. Use smaller screen size.
		70						Walker, 1999	4700 micron screen not effective for TSS <75 mg/L		
StormFilter	Stormwater Management	92	65	82	83	81	COD (70) TPH (84)	Stomwater, 1994	7 storm events. Removals based on EMC	Conditionally Acceptable	Studies at 1 site w/10 storms each. Follow recommended protocol w/cartridge system.
		43	33	50	29			Lief, 1998	8 storm events		
						74/69		Woodward, 1998	Lab tests with compost and Perlite filter media		

Product	Company	Performance Data (% Removal) TSS	Cu	Pb	Zn	O&G	Other	Reference	Notes	Approval Recommendation	Follow-up Recommendation
Envirodrain	Envirodrain						TRPH (95) at 25 gpm TRPH (82) at 60 gpm		Lab summary sheets only – no report	Not Acceptable	Studies at 2 sites w/10 storms each. Follow recommended protocol.
Fossil Filter	KriStar Enterprises					55	Diesel (98.6) Motor Oil (94.8)	Enetch, 1996	Lab test of absorbent exposure study	Not Acceptable	Studies at 2 sites w/10 storms each. Follow recommended protocol.
								Eagle, 1998 Sandine, 1996	Hydraulic capacity tests confirmed rating of 12 gpm/LF		
						41	N&P increased slightly	Ambient, 1997	1 storm event w/composite samples		
		32/38	18	46	24/26		Diazinon(34/+4) Clorpyrifos (69)	Larry Walker, 1998b	Results from two storm events		
HydroKleen	Weaver Manufacturing LLC								Manufacturers field study indicates non-detect levels – no report. Study in progress by CSUC	Not Acceptable	Studies at 2 sites w/10 storms each. Follow recommended protocol.
Ultra-Urban Filter	Abtech Industries					83		AbTech, Note 1	Lab test with simulated stormwater	Not Acceptable	Studies at 2 sites w/10 storms each. Follow recommended protocol.
						91		AbTech, Note 2	Lab test repeated with unit after 2 months in field		
								AbTech, Note 3	Lab leaching test indicated no sheen in leachate with average concentration of 1.6 mg/L oil		
StormTreat	Storm Treat Systems, Inc.	95		65	90		TRH (90) TP (89) TDN (44) COD (75) FC (83)	Allard, 1999	4 storms sampled. Types of samples or storm characteristics not indicated.	Not Acceptable	Studies at 2 sites w/10 storms each. Follow recommended protocol. Provide sizing procedure.
		99		77	90		TPH (90) TP (89) TDN (44) COD (82) FC (97)	Horsely, 1995	5 storms sampled. Types of samples or storm characteristics not indicated		

KEY:

TSS= total suspended solids
Cu=copper
Pb= lead
Zn=zinc
O&G=oil and grease
TOC=total organic compounds
mg/l=milligrams/liter
gpm=gallons per minute

ND=not detected
TKN=total kjeldahl nitrogen
TN=total nitrogen
PAH=Polycyclic aromatic hydrocarbons
TPH=total petroleum hydrocarbons
COD=Chemical oxygen demand

TRPH=total recoverable petroleum hydrocarbons
N&P=nitrogen and phosphorus
TP=total phosphorus
TDN=total dissolved nitrogen
FC=fecal coliform

*Please note that this table is included for informational purposes only, and does not constitute endorsement of any product or company by TRPA.

PARKING LOT MONITORING PROTOCOLS

Parking lots with treatment systems should be monitored for the first four qualifying storm events per calendar year in addition to one spring runoff event. The spring runoff event sample should be timed to capture the flush of snowmelt from the impervious surfaces, which typically carries the accumulation of pollutants from the winter into the treatment system. The qualifying storm event will be a 2 year/1 hour storm, or 0.55" of water in an hour. However, the qualifying storm may need to be selected for the size of the parking lot treatment system. In some cases, a 2 year/1 hour storm will not have enough volume for discharge from the treatment system. If another qualifying event is not established for a particular parking lot, the 2 year/ 1 hour storm will be sampled. If there are not at least four 2 year/1hour storms to sample, sampling will be done quarterly if there is any discharge from the treatment system.

Sampling should be timed in order to catch the "first flush" of pollutants that enter the treatment system. The "first flush" describes the initial runoff from parking lots that contains the highest concentrations of pollutants, including sediment, oil, and other contaminants. In order for the effectiveness of a parking lot treatment system to be accurately evaluated for removal efficiency, stormwater sampling needs to occur in a way to ensure that this "first flush" is captured.

In order to ensure that the "first flush" is captured, the time of concentration (Tc) for the water to reach the sampling point needs to be determined using the rational runoff calculation (see below) and determining the retention time of the treatment system components.

$$Q_{pk}=CIA$$

where Q_{pk} is peak discharge,
C is the runoff coefficient,
A is area,
and I is runoff in inches/hour

Monitoring plans should be established with reasonable monitoring points at the inflow and outflow of the system, as delineated ahead of time in the "BMP Monitoring Plan" as required by TRPA. Additionally, when feasible, background monitoring should occur for up to one year prior to treatment systems being online and contributing runoff. The parking lots will be monitored at the point of discharge of the system into secondary treatment (i.e. retention basins or ponds), as well as where any discharge potentially meets with surface water. An attempt to quantify sediment and particle removal efficiencies will be incorporated into the monitoring plan.

Table 2 (see below) lists the surface water discharge limits as stated in *Chapter 81: Water Quality Control* of the TRPA Code of Ordinances. USGS Standard Water Quality Sampling Procedures should be utilized in the collection, storage, preservation, and transport of all samples (USGS, 1997-99). Additionally, samples need to be analyzed by a certified lab that can test BELOW the discharge limit for each constituent.

Table 2: Surface Water Discharge Limits per Chapter 81, TRPA Code of Ordinances

Constituent	*Maximum Concentration*
Dissolved Inorganic Nitrogen as N	0.5 mg/l
Dissolved Phosphorus as P	0.1 mg/l
Dissolved Iron as Fe	0.5 mg/l
Grease and Oil	2.0 mg/l
Suspended Sediment	250 mg/l

Discharges to groundwater will also be monitored (i.e. if the treatment system incorporates infiltration to groundwater), and will need to remain within the discharge limitations as delineated in TRPA's Code of Ordinances *Chapter 81: Water Quality Control* (see Table 3). Groundwater recharges will be monitored through the establishment of groundwater monitoring wells at the point of discharge. It is important to incorporate the necessity of monitoring into the design of the system, to ensure that samples are obtained at the point where discharge to groundwater occurs. The constituents that need to be monitored include the following:

Table 3:Groundwater Discharge Limits per Chapter 81, TRPA Code of Ordinances

Constituent	*Maximum Concentration*
Total Nitrogen as N	5 mg/l
Total Phosphate as P	1 mg/l
Iron as Fe	4 mg/l
Turbidity	200 JTU
Grease and Oil	40 mg/l

If constituent levels are higher than that allowed by TRPA's Code of Ordinances, Chapter 81, remediating action will need to occur.

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Strecker, E. and Reininga, K. 1999. Integrated Urban Stormwater Master Planning.

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U.S. Geological Survey. 1997-99. National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations. Book 9, chaps. A1-A9, 2 v., variously paged.

Walker, Larry and Associates. 1999. Investigation of Structural Control Measures for New Development. Prepared for: Sacramento Stormwater Management Program.

APPENDIX G. CALIFORNIA STREAM AND SHORE WALK VISUAL ASSESSMENT

Body of water:

Watershed name:

County:

Start Time:

Volunteers:

Date:

End Time:

REACH LENGTH (Write approx. length of reach surveyed):

WEATHER (please write all weather codes that apply):

Past 24 hours:	**Precipitation in past 24 hours:**	**inches:**	**Current conditions:**
	yes		
	no		

STARTING POINT (Describe):

Station ID: **Latitude:** **Longitude:**

STARTING POINT OBSERVATIONS (Write the code for each parameter in the box below. Codes provided on right margin of this sheet):

Odor:	Algae:	Foam:	Turbidity:	Flow:	Oil:	Litter:	Color:

LAND USES WITHIN REACH (List land use and activity codes, in order of importance, within 1/4 mile of stream reach):

1) 2) 3) 4)

DISCHARGES (Use the codes provided on the right margin or at the bottom of this sheet):

Point	Type	Location	Odor	Algae	Foam	Turbidity	Flow	Oil	Litter	Color

DOMINANT STREAM- or SHORESIDE VEGETATION:

% Native
(briefly describe):

Natural vegetative zone width:

% Non-native
(briefly describe):

ENDING POINT (Describe):

Station ID: **Latitude:** **Longitude:**

ENDING POINT OBSERVATIONS (Write the code for each parameter in the box below. Codes provided on right margin of this sheet):

Odor:	Algae:	Foam:	Turbidity:	Flow:	Oil:	Litter:	Color:

Notes, special problems, comments:

Photos taken: (please attach photo log)

Photo #	**Brief description**
1)	
2)	
3)	
4)	

OBSERVATION CODES:

Weather:
0. Clear/sunny
1. Calm
2. Lt. Breeze
3. Windy
4. Very windy
5. Overcast/cloudy
6. Partly cloudy
7. Foggy
8. Drizzle
9. Rain
10. Snow
11. Hail
12. Other

Odor:
0. None
1. Feces
2. Fishy
3. Musty
4. Decay
5. Ammonia
6. Petroleum
7. Sulfide
8. Chlorine
9. Other

Algae:
0. None
1. Light (<5%)
2. Mod. (5-25%)
3. High (26-50%)
4. Dense (>50%)

Foam:
0. None
1. Separated bubbles
2. Moderate (<1/2 in high)
3. High (>1/2 in high)

Turbidity:
0. Clear
1. Cloudy
2. Murky

Flow:
0. None
1. Low
2. Med.
3. High
4. Flood

Oil:
0. None
1. Light sheen
2. Slick
3. Tar on banks/be

Litter:
0. None
1. Light (< 5 pcs)
2. Mod. (6-10 pcs)
3. High (11-25 pcs)
4. Dense (> 50 pcs)

Color:
0. None
1. Blue
2. Brown
3. Olive brown
4. Green
5. Red
6. Yellow
7. Other

Land Uses
0. undeveloped
1. residential
2. rural residential
3. commercial/offices
4. auto repair/gas station
5. industrial
6. sewage treatment
7. institution/school
8. landfill
9. agriculture
10. grazing
11. animal feedlot/dairy
12. fish hatchery
13. construction
14. logging
15. mining
16. golf course
17. park/recreation facilities
18. timberland
19. open space (describe)
20. other (describe in comme

Discharge Points:
0. none
1. pipes
2. concrete drain channel
3. earth drainage ditches
4. other (describe)

Types of Discharges:
0. none (no flow)
1. seep/spring
2. pond drainage
3. industrial
4. sewage discharge
5. storm water runoff
6. agricultural
7. feedlot/dairy/grazing
8. leaking pipeline
9. illegal dump site
10. other (describe)

APPENDIX H. REVEGETATION

MONITORING FOR REVEGETATION, EROSION CONTROL, RESTORATION AND WATER QUALITY IMPROVEMENT PROJECTS IN THE LAKE TAHOE BASIN FOR LTIMP MONITORING MANUAL

JULIE ETRA AND JOAN REYNOLDS
OCTOBER 30, 2000

SUMMARY

Site stabilization of disturbed slopes through the establishment of a persistent plant community has been implemented throughout the Lake Tahoe Basin for several decades. The success of the treatments utilized to stabilize slopes, to revegetate disturbed soils, and to restore areas to healthy functioning systems needs to be monitored. The following types of projects should be included in a comprehensive program: erosion control, revegetation, restoration, and water quality improvement projects.

The **primary** objectives of project monitoring are to determine whether or not design objectives were met, and to evaluate success of design treatments and their implementation over time. An additional objective is to produce standardized and valid monitoring methodologies appropriate for evaluating project success/failure according to project and monitoring objectives.

This proposed monitoring scheme address three different types of projects: 1) erosion control and revegetation, 2) creek and wetland restoration, and 3) water quality improvement projects. All of these projects can be monitored either on a 1) reconnaissance level, or 2) intensive level.
Slopes treated for erosion control should be monitored at the reconnaissance level. Data sheets have been developed in an effort to standardize monitoring. Reconnaissance level surveys also may be appropriate for water quality and restoration projects although intensive sampling may be desired, especially to establish baseline conditions.

Reconnaissance level sampling methodology can be designed to include a large array of site specific components, including but not limited to 1) site conditions, such as: slope (length, degree); aspect; soil type; adjacent native plant community type; and 2) treatment types and performance such as: contractor; structural components; drainage systems; revegetation health, vigor and mortality; disturbances (natural and man-caused); predation; evidence of erosion (type); vegetation cover; total cover (rock, mulch, blankets, etc); runoff sources; hazards; areas in need of re-treatment; etc. (WBS Inc., 2000 Field Data Sheet). This method is cost-effective and less intrusive to the resource but conclusions based on statistics alone cannot be drawn.

Intensive sampling for erosion control and revegetation, restoration, and water quality improvement projects, may include vegetation cover (basal or foliar), composition, frequency, density and diversity; and soil sampling (microbial activity, texture, percent organic matter). Revegetation monitoring may be limited to measures of plant cover, abundance and distribution. Erosion control monitoring may include methodologies that measure soil movement i.e. pins or sediments troughs. Restoration monitoring can include measurements of ecosystem functioning (e.g. nutrient cycling, biotic interactions, invasibility, reproduction, resilience). Typical methodologies for measurement of vegetation on this level include line intercept, point intercept, cover frames, permanently located plots (shrubs survival, vigor, and vitality), belt transects, and a combination of lines and cover plots (i.e. nested frequency). Point intercept has been recognized as one of the most repeatable, non-subjective methods of intensive sampling (Buckner, D.L. 1985. *Point-intercept Sampling in Revegetation: Maximizing Objectivity and Repeatability*. American Society Surface Mining & Reclamation, 1985 Annual Mtg., Denver, CO.)

Monitoring for erosion control and revegetation should become standard protocol for all restoration-related projects in the Lake Tahoe Basin.

MONITORING FOR REVEGETATION, EROSION CONTROL, RESTORATION AND WATER QUALITY IMPROVEMENT PROJECTS IN THE LAKE TAHOE BASIN

JULIE ETRA AND JOAN REYNOLDS

OCTOBER 2, 2000

INTRODUCTION

Site stabilization of disturbed slopes through the establishment of a persistent plant community has been implemented throughout the Lake Tahoe Basin for several decades. The success of the treatments utilized to stabilize slopes, to revegetate disturbed soils, and to restore areas to healthy functioning systems needs to be monitored. Experienced professionals working in the field of revegetation and erosion control in the Lake Tahoe Area offer an incredible, but as yet untapped resource of information for site-specific project implementation and monitoring.

Frequently vegetation monitoring is overlooked in the development of future projects, resulting in a lack of planning and budget. Monitoring should be identified in the initial project development to ensure project objectives and performance standards are achieved. The development of an effective monitoring program will provide useful information concerning project success, and help to determine the best treatments for future projects.

Most vegetation monitoring methodologies have been developed for rangeland, agriculture, mining, and forestry applications (Bonham, 1989; Rangeland Monitoring Utilization Studies 1995; Rangeland Monitoring Analysis, Interpretation and Evaluation, 1995). The incentive for monitoring these projects has been typically performance based. Therefore, many of these projects, particularly mining, are bonded (insurance policies developed in order that mandated performance standards be met). The literature is almost non-existent or very weak for specific methodologies that address aspects of cut and fill slope stabilization or water quality improvement projects from a biological perspective.

DEFINITIONS

The following definitions describe the various types of projects that utilize revegetation treatments throughout the Lake Tahoe Basin

Erosion Control: Primary objective is to stop soil particle movement downslope e.g. soil/slope stabilization. Many types of erosion control treatments, such as structural engineering, (retaining walls, rip-rap, rockery walls) erosion control blankets, wattles, mulches, bonded fiber matrices, soil amendments, tackifiers, seed, and plants, are utilized for slope stabilization.

Revegtation: Primary objective is to re-establish vegetation cover in an area that has been previously disturbed. Vegetation cover may be composed of native and/or non-native species dependent upon the project objectives.

Restoration: Primary objective is to return an area to a pre-disturbed condition, typically with native species. In the Lake Tahoe Basin, restoration of wetlands, Stream Environment Zones (SEZ's) and meadows are usually designed to mimic or improve the natural condition and functioning of a site.

Water Quality Improvement Projects: Primary objective is to trap sediments and nutrients.

OBJECTIVES

The **primary** objectives of project monitoring, as described above, are to determine whether or not design objectives were met, and to evaluate success of design treatments and their implementation over time. This information should be made available and applied to project designs, thereby enhancing the success of future projects.

Additional objectives are as follows:

- Produce standardized and valid monitoring methodologies appropriate for evaluating project success/failure according to project and monitoring objectives.

- Develop methodologies that can be taught to other professionals and replicated over time.

- Develop performance standards and success criteria that can be used Basin-wide and elsewhere.

METHODOLOGIES

This proposed monitoring scheme address three different types of projects: 1) erosion control and revegetation, 2) creek and wetland restoration, and 3) water quality improvement projects. All of these projects can be monitored either on a 1) reconnaissance level, or 2) intensive level.

‘ The choice of sampling is dictated in part, by the objectives, the vegetation type, the vegetation characteristics to be measured, and the availability of financial and technical resources’ (Bonham, 1989). This also applies to monitoring of non-vegetative components of projects.

Monitoring objectives need to be stated in the initial project development. The objectives will help to determine the intensity of the site specific monitoring. Slopes treated for erosion control cannot usually tolerate intensive ground sampling due to the instability of the site and fragile nature of the vegetation. For these areas, reconnaissance level monitoring e.g. photo points and ocular assessments by experienced professionals may be most appropriate. For areas where sampling techniques will not impact the project site, more intensive monitoring may be appropriate. Intensive monitoring typically includes statistical analysis (determined by the sampling objective) with greater sampling precision, accuracy, and repeatability. Reconnaissance level surveys also may be appropriate for water quality and restoration projects. However, topography and resilience of the vegetation, as well as limited opportunities for erosion, may provide opportunities for more intensive field sampling. Objectives need to include the duration of time to monitor (years) in order to evaluate project success criteria.

A literature review should be conducted prior to implementing monitoring, regardless of the type of project or intensity of surveying. This should include an evaluation of designed as well as as-built plans. This provides the surveyor with the type of treatment, date of treatment, performance standards, watering regime, source of planting materials, seed and seeding rates, replacement plantings or additional treatments, maintenance, and additional information about a site prior to site sampling. This information is critical in determining the success criteria of a project.

Reconnaissance level. This sampling methodology can be designed to include a large array of site specific components, including but not limited to 1) site conditions, such as: slope (length, degree); aspect; soil type; adjacent native plant community type; and 2) treatment types and performance such as: contractor; structural components; drainage systems; revegetation health, vigor and mortality; disturbances (natural and man-caused); predation; evidence of erosion (type); vegetation cover; total cover (rock, mulch, blankets, etc); runoff sources; hazards; areas in need of re-treatment; etc. (WBS Inc., 2000). This method is cost-effective and less intrusive to the resource but conclusions based on statistics alone cannot be drawn.

Intensive level. Intensive sampling for erosion control and revegetation, restoration, and water quality improvement projects, may include vegetation cover (basal or foliar), composition, frequency, density and diversity; and soil sampling (microbial activity, texture, percent organic matter). Revegetation monitoring may be limited to measures of plant cover, abundance and distribution. Erosion control monitoring may include methodologies that measure soil movement i.e. pins or sediments troughs. Restoration monitoring can include measurements of ecosystem functioning (e.g. nutrient cycling, biotic interactions, invasibility, reproduction, resilience).

Typical methodologies for measurement of vegetation on this level include line intercept, point intercept, cover frames, permanently located plots (shrubs survival, vigor, and vitality), belt transects, and a combination of lines and cover plots (i.e nested frequency). Point intercept has been recognized as one of the most repeatable, non-subjective methods (Buckner, 1985) of intensive sampling.

Monitoring plans need to address the timing of sampling, sample size and budget. Results should illustrate the relationship of performance standards to monitoring methods in order to evaluate success criteria and/or the need for remediation.

REPORTING

Results from the monitoring project would be based on the objectives and requirements of the funding agency. The minimum report may include photographs taken at photo points as well as a write-up of ocular assessments. A more in depth analysis may be written with statistical data and lead to a journal article or monitoring field guide for future project development. Regardless of the report format, analysis should be produced and provided to all collaborators in a timely fashion.

FIELD DATA SHEET FOR MONITORING REVEGETATION AND EROSION CONTROL PROJECTS
(RECONNAISSANCE LEVEL)

Project/Location: ______________________________

Date: __________ Surveyors: ______________________________

Treatment Type(s): ______________________________

Performed by: ______________________________

Date of Treatment/ Age of Project: ______________________________

Slope: ______________________________

Aspect: ______________________________

Soil Type: ______________________________

Performance Standards: yes( ) no( ) Were Performance Standards Met? yes( ) no( )

Site Re-treated After Initial Treatment? yes( ) no( )

Engineering (walls, curb, etc..): ______________________________

Condition of Drainage Improvements: ______________________________

Infiltration trenches: ______________________________

Drop Inlets: ______________________________

Collection Systems: ______________________________

Runoff Source (onsite or offsite): ______________ **Discharge: Concentrated( ) Dispersed( )**

Seed Mix and Seeding Rate: **PLS: yes ( ) no ( )**

Seeded Plant Species	lbs/ac	Source	% Cover	Non-seeded or Planted Species	% Cover

Container Plantings
(% Survival, Species): ______________________________

Soil Surface Status: ______________________________

____

Disturbances (i.e. foot traffic, rodents, neighboring uses, etc.): ______________________________

____

____

Total Plant Cover %: ______________________________

Bare: ______________________________

Rock: ______________________________

Litter: ______________________________

Notes: ______________________________

____

____

____

Preliminary Summary of Erosion Control Monitoring

In The Lake Tahoe Basin

Components of Two Projects Implemented in 1999:

1. Kingsbury – Linda Way and Tina
2. Incline One – Geraldine, Jeffrey Ct., and Ida Ct.

Objectives: To evaluate the field forms developed for erosion control site monitoring (e.g. to see how the data sheet works in gathering information for evaluating erosion control projects); and to begin monitoring erosion control projects to evaluate treatment types and success/failure based on site characteristics. A secondary objective included determining whether or not the two projects met the current *Objectives and Guidelines for Revegetation Success Under the Nevada Tahoe Bond Act.*

Methods: We have developed two methods of monitoring – reconnaissance and intensive. To date, the reconnaissance level approach has been employed. Reconnaissance level monitoring is qualitative and not replicable. (Ocular measurements of plant cover need to be performed by professionals in vegetation and/or botanical consulting, with experience in determining cover values).

Preliminary Results:

1) Kingsbury:

   a) The treated slope on Linda Way is approx. 2:1 and steeper, on a NW aspect, the top of the slope is vertical and unraveling. It was seeded in 1999 with a commercial seed mix (local and non-local seed sources) that included colonizing species of grasses, forbs and shrubs/trees. The slope was treated with Bonded Fiber Matrix (BFM), Kiwi Power and Fertile fibers. Foliar cover values were estimated at about 5%, with lots of seedling establishment, primarily by grasses and sagebrush. Plant cover varies throughout the slope. Total cover by vegetation and litter was estimated at about 80%. The treatment also appeared to enhance the existing native plant vegetation on the slope. Vegetation has become well established behind the asphalt curb, despite road cast and degradation of the curb itself. Disturbances included rodent activity, and one set of human footprints that crossed the treated slope. Erosion is slight, due primarily to the unstable top of slope, and the rodent activity. Soil surface status was determined to be a Class 4 with some movement of soil particles (BLM, 1973). Overall, the treatment for this site is considered successful and productive.

   b) The treated slope on Tina is approx. 2:1 and steeper, on a west aspect. It was treated in 1999 with the same commercial mix as Linda Way. The slope was treated with layering Hydropost compost, BFM, and pine needles, seeded and amended with Kiwi Power and Fertile fibers. The addition of compost did not appear to be an effective treatment. Plant cover was less than 1%, and total cover 25-30%. Disturbances included an abundance of foot traffic. Garbage was found behind the wall. The treatment for this site was not considered successful, and a second treatment pass is recommended (performance standards were developed for this project allowing for a second treatment).

2) Incline One:

   a) The treated slope on Geraldine is about 3:1 on a northeast aspect. It was seeded in 1999 with a commercial seed mix (local and non-local sources) that included species of grasses, forbs and shrubs; and planted with native species of shrub tublings. The slope was treated with Biosol and pine needle compost. Foliar cover values

FIELD DATA SHEET FOR MONITORING CREEK AND WETLAND RESTORATION AND WATER QUALITY IMPROVEMENT PROJECTS
(RECONNAISSANCE LEVEL)

Project/Location: ______________________________

Date: __________ Surveyors:

Treatment Type(s) (Plant salvage, top soil application, amendments, erosion control fabrics, biotechnical, etc.): ______________________________

____

Performed by: ______________________________

Date of Treatment/ Age of Project: ______________________________

Slope: ______________ Aspect: ______________

Performance Standards: yes( ) no( ) Were Performance Standards Met? yes( ) no( )

Site Re-treated After Initial Treatment? yes( ) no( )

Engineering (walls, curb, etc..): ______________________________

____

Condition of Drainage Improvements: ______________________________

Infiltration trenches: ______________________________

Drop Inlets: ______________________________

Collection Systems: ______________________________

Seed Mix and Seeding Rate: **PLS: yes ( ) no ( )**

Seeded Plant Species	lbs/ac	Source	% Cover	Non-seeded or Planted Species	% Cover

Container Plantings (% Survival, Species): ______________________________

Soil Surface Status: ______________________________

____

Disturbances (i.e. foot traffic, rodents, neighboring uses, etc.): ______________________________

____

____

Total Plant Cover %: ______________________________

Bare: ______________________________

Rock: ______________________________

Litter: ______________________________

Notes: ______________________________

____

____

____

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PLANT MONITORING FOR UPLAND RESTORATION PROJECTS IN THE LAKE TAHOE BASIN

PREPARED BY MICHAEL HOGAN

SEPTEMBER 17, 200

INTRODUCTION

Revegetation has historically been considered a useful treatment for eroding slopes in the Lake Tahoe Basin and elsewhere. Natural high elevation ecosystems employ vegetation and vegetation byproducts such as mulch to maintain a robust and productive soil cover on hill slopes, meadows and wetlands. More recently, the importance of rebuilding soil on disturbed sites has been recognized as the foundation for developing sustainable revegetation plantings (Whitford and Elkins 1986),(Bradshaw 1992) (Bradshaw and Chadwick 1980) (Munshower 1994). We have not, however, measured the effectiveness of these treatments in any sort of systematic manner in the Lake Tahoe Basin. Effective and well designed monitoring of these treatments will allow us to determine planting effectiveness as well as help us to develop better methods to treat eroding slopes, thereby reducing sediment, mobile nitrogen and phosphorus delivery into watercourses and ultimately into Lake Tahoe. A well-developed monitoring program, while adding some additional time investment to erosion control projects, can pay healthy dividends in useful information. Without this information, we may not know whether these projects are helping to solve the problems for which they were designed.

Plant and soil monitoring is not trivial and is often poorly planned and implemented. Inadequately planned and implemented monitoring may provide useless or misleading information and may even damage the project itself. The following report outlines some of the basic concepts that should be included or considered in a defensible, useful monitoring program. These concepts can be applied to most of the plant monitoring in the Lake Tahoe Basin, whether upland, riparian or wetland.

BASIC CONCEPTS

Plant and soil monitoring, in order to be useful, should contain certain elements. The primary elements are:

Definition of success or desired state: This basic foundation of a monitoring program is often overlooked or assumed. Articulating this element will allow the rest of the monitoring program to be clearly defined. This definition should be tied to project goals. In the case of erosion control, **cover**[1] is likely to be the key attribute measured.

Precision and accuracy levels: These elements are the framework for developing statistical analysis. More important, they will define how ‘good’ the information is. Without measures of precision and accuracy, monitoring data may be useless, inaccurate or misleading. It is quite easy to imagine the large amount of potential bias that might be present in sampling if precision and accuracy were not included in a sampling protocol and analysis. (Turner) suggests that estimates of plant attributes without measures of precision are unacceptable and are of little use. Other legal mandates for accuracy and precision require at least an 80% confidence level for shrub lands and 90% or pasture or grassland [ref]. The actual number of samples required will depend on measurement types and goals of the monitoring program. For instance, if a point in time measurement is used, the number of samples required for statistical sufficiency is likely to be different than if samples are compared over a number of years.

Reproducibility-defensibility: Monitoring protocol and data should be reproducible in order to be valuable and legally defensible. Monitoring results that are based on ‘expert opinion’ is very vulnerable to differences in opinion. This sort of approach ultimately may lead to arguments and litigation, especially when a costly management response is as stake. A well-planned monitoring program with appropriate statistical accuracy will produce meaningful data that is not susceptible to multiple and conflicting interpretation.

[1] Cover measurements for erosion control should include at least plant and mulch cover.

Monitoring objectives: In order for monitoring activities and data to be meaningful, a clearly defined monitoring objective must be stated. That is to say, why is monitoring being done? This objective should be closely linked to the success definition stated earlier. For upland plant monitoring in the Tahoe Basin, monitoring will usually be related to erosion control projects. These projects will usually have cover as the key element since the cover or 'C' factor is of primary importance in erosion control. Therefore, cover will usually be the plant component being measured. Any number of cover measurement techniques may be used (Bonham 1989).

Sampling objective: The sampling objective refers to the level of statistical precision that will be achieved by the monitoring. A clearly stated sampling objective will help define how many samples will be needed in order to provide data that is representative of the real population of interest. Without a clearly stated sampling objective, statistical accuracy may not be achieved and ultimately, monitoring data may be either useless or indefensible.

Sample size: When the management and sampling objectives have been stated, sufficient sample size needs to be determined in order to reach statistical adequacy. Several publications include sample size formulas including (Elzinga, Salzer, and Willoughby 1998) and (Fischer 1986). Initial pilot monitoring is usually required to establish the necessary number of total samples required. Pilot sampling provides estimates of the population mean and standard deviation from which variability and ultimately sample size is usually determined.

Potential for management: In order for monitoring to be useful in an adaptive management context, some sort of potential for a management response should exist. Monitoring data should be used to determine if management objectives have been met and if not, imply management or practice improvements or produce a management response. In cases of built projects in the Lake Tahoe Basin, this management response may include: 1) retreatment of project area and , 2) to feed monitoring results into future projects in order to improve those projects. Information about what has worked well and what could be done better in the future are crucial pieces of information that have not been effectively shared in the Lake Tahoe Basin. This will require management and exchange of data and findings between project practitioners and proponents.

The use of monitoring data to help improve future projects is likely to be the most useful application of monitoring data. The infrastructure and data exchange required for this project improvement program will require a concerted effort by entities and individuals involved in restoration-based erosion control work.

Disturbance potential of monitoring activity: A key consideration for monitoring of upland revegetation projects is the potential for disturbance of the area being monitored by the monitoring personnel. If disturbance is not minimized, the monitoring data will most likely reflect monitoring disturbance rather than actual plant response to management. An adequate monitoring plan should reflect careful consideration of this situation and provide for minimizing or eliminating disturbance.

CONCLUSION

Plant monitoring is the most likely avenue to increasing plant-based erosion-control success rates. It is essential to know whether our projects are working and if they are not meeting success criteria, how to improve them. Plant monitoring is not trivial. A well-developed monitoring program will provide useful information while a poorly developed or over-simplified program may actually be detrimental to overall success of project goals. The elements described in this report are relatively generic. Each management objective requires careful consideration of goals and monitoring potential. However, the elements described above should be part of most monitoring programs so that useful information can be developed and applied to adaptive management-based programs and regulatory plant monitoring.

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APPENDIX I

Sampling and Analysis Plan

(Field Sampling Plan and Quality Assurance Project Plan)

with Guidance

Prepared by: Quality Assurance Program

United States Environmental Protection Agency

Region IX

75 Hawthorne Street

San Francisco, CA 94105

March 1997

This Sampling and Analysis Plan (SAP) was prepared to assist in the preparation of a combined Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) for one-time and short-term field sampling events. It was prepared using the guidance document EPA Requirement for Quality Assurance Project Plans for Environmental Data Operations (QA/R-5), August 1994; Guidance for the Data Quality Objectives Process (QA/G-4), September 1994; and FSPs for previous sampling events sponsored by the Site Evaluation and Grants Section, EPA Region IX. This SAP includes sampling of surface and subsurface soil, sediment, surface and ground water, and other matrices. Exceptions to the procedures contained herein will occur, and generic sections may need to be modified or new project-specific sections may need to be written. For ease in developing a project-specific SAP, an electronic template (in WordPerfect 6.0) is available upon request. The electronic template includes the SAP and the accompanying guidance for completing each section.

The Sampling and Analysis Plan (SAP) documents the procedural and analytical requirements for a one--time or time--limited project involving the collection of water, soil, sediment or other samples to characterize areas of potential environmental contamination. It contains all the elements of a Quality Assurance Project Plan (QAPP) and a Field Sampling Plan (FSP) that must be included in order to meet the requirements for any U.S. Environmental Protection Agency (EPA) funded project in which environmental measurements are to be taken. ***The format is designed for projects of limited scope that may also need to be developed on short notice. It should be used for no more than 20 samples or for samples collected over a period of not more than 14 days. It is assumed that the requested analyses will be performed by the EPA Region IX Laboratory****.*

This guide provides item--by--item instructions for filling out the SAP form. More complete information is provided for completing Sections 6.0 through 9.0 (sampling procedures). If these sections are appropriate for the project, they may be used verbatim or with project-- and site--specific modifications. An electronic version (WordPerfect 5.2 or 6.0 format) of the guide is available upon request to be used for this purpose.

U.S. EPA Region IX Quality Assurance (QA) Program staff is available to provide assistance to complete the SAP. Please call 415--744--1636, Monday through Friday, 7:30 a.m. to 5:00 p.m.

9.0 QUALITY CONTROL

9.1 FIELD QUALITY CONTROL SAMPLES

This subsection describes equipment rinsate, field, and/or trip blanks to be collected during the sampling event. In general equipment, rinsate blanks will be collected when reusable, non--disposable sampling equipment (e.g., trowels, hand augers, and groundwater sampling bailers) are being used for the sampling event. Only one blank sample per matrix per day should be collected. If equipment rinsate blanks are collected, field blanks and trip blanks are not required under normal circumstances. Equipment rinsate blanks can be collected for soil, sediment, and ground water samples. A minimum of one equipment rinsate blank is prepared each day for each matrix when equipment is decontaminated in the field. Field blanks are collected when sampling water or air and equipment decontamination is not necessary or a sample collection vessel is not used (e.g., there are dedicated pumps). A minimum of one field blank is prepared each day sampling occurs in the field but equipment is not decontaminated. Trip blanks are required only if no other type of blank will be collected for VOC analysis and when water samples are being collected. If trip blanks are required, one is submitted to the laboratory for analysis with every shipment of samples for VOC analysis. These blanks are submitted "blind" to the laboratory, i.e., packaged like other samples and each with its own unique identification number.

9.1.1 Equipment Blanks

Include this subsection if equipment rinsate blanks will be collected. This is generally the case for FSPs. Only one blank sample per matrix per day, not to exceed the ratio of one blank for every 10 samples, should be collected. If equipment rinsate blanks are collected, field blanks and trip blanks are not usually required.

Include this paragraph if blanks will be analyzed for both metals <u>and</u> organic compounds:

Equipment rinsate blanks will be collected to evaluate field sampling and decontamination procedures by pouring HPLC organic--free (for organics) or deionized water (for inorganics) over the decontaminated sampling equipment. One equipment rinsate blank will be collected per matrix each day that sampling equipment is decontaminated in the field. Equipment rinsate blanks will be obtained by passing water through or over the decontaminated sampling devices used that day. The rinsate blanks that are collected will be analyzed for ________[*include types of target analytes, e.g., "metals", "TPHs" or "VOCs"*].

Include this paragraph if blanks will be analyzed <u>only</u> for organic compounds:

Equipment rinsate blanks will be collected to evaluate field sampling and decontamination procedures by pouring HPLC organic--free water over the decontaminated sampling equipment. One equipment rinsate blank will be collected per matrix each day that sampling equipment is decontaminated in the field. Equipment rinsate blanks will be obtained by passing water through or over the decontaminated sampling devices used that day. The rinsate blanks that are collected will be analyzed for _________[*include types of target analytes, e.g., VOCs" or "TPHs"*].

Include this paragraph if blanks will be analyzed <u>only</u> for metals:

Equipment rinsate blanks will be collected to evaluate field sampling and decontamination procedures by pouring deionized water over the decontaminated sampling equipment. One equipment rinsate blank will be collected per matrix each day that sampling equipment is decontaminated in the field. Equipment rinsate blanks will be obtained by passing water through or over the decontaminated sampling devices used that day. The rinsate blanks that are collected will be analyzed for metals.

Always include this paragraph:

The equipment rinsate blanks will be preserved, packaged, and sealed in the manner described. A separate sample number and station number will be assigned to each sample, and it will be submitted blind to the laboratory.

9.1.2 Field Blanks

Include this subsection if field blanks will be collected. Only one blank sample per matrix per day should be collected, but not to exceed the ratio of one blank for every 10 samples. Equipment blanks may be substituted for field blanks. If field blanks are prepared, equipment rinsate blanks and trip blanks are not required under normal circumstances.

Include this paragraph if blanks will be analyzed for both metals <u>and</u> organic compounds:

Field blanks will be collected to evaluate whether contaminants have been introduced into the samples during the sampling procedures. Field blank samples will be obtained by pouring HPLC organic--free water (for organics) and/or deionized water (for inorganics) into a sampling container at the sampling point.. The field blanks that are collected will be analyzed for _________[*include types of target analytes, e.g., "metals" or " VOCs"*].

Include this paragraph if blanks will be analyzed <u>only</u> for organic compounds:

Field blanks will be collected to evaluate whether contaminants have been introduced into the samples during the sampling procedures. Field blank samples will be obtained by pouring HPLC organic--free water into a sampling container at the sampling location. The field blanks that are collected will be analyzed for _________[*include types of target analytes, e.g., "VOCs" or "TPHs"*].

Include this paragraph if blanks will be analyzed <u>only</u> for metals:

Field blanks will be collected to evaluate whether contaminants have been introduced into the samples during the sampling procedures. Field blank samples will be obtained by pouring deionized water into a sampling container at the sampling point. The field blanks that are collected will be analyzed for metals.

Always include this paragraph:

The field blanks will be preserved, packaged, and sealed in the manner described. A separate sample number and station number will be assigned to each sample, and it will be submitted blind to the laboratory.

9.1.3 Trip Blanks

Include this subsection if trip blanks will be collected. Only one blank sample per matrix per day should be collected. If equipment rinsate blanks or field blanks are prepared, trip blanks may not be required under normal circumstances.

If trip blanks are to be collected, include this paragraph:

Trip blanks will be prepared to evaluate if the shipping and handling procedures are introducing contaminants into the samples, and if cross contamination in the form of VOC migration has occurred between the collected samples. Trip blanks will be prepared and analyzed for ____ [*Include list of requested analyses*]. A minimum of one trip blank will be submitted to the laboratory for analysis with every shipment of samples for VOC analysis. Trip blanks are 40mL vials that have been filled with HPLC--grade water and shipped with the empty sampling containers to the site prior to sampling. The sealed trip blanks are not opened in the field and are shipped to the laboratory in the same cooler with the samples collected for volatile analyses.

Always include this paragraph:

The trip blanks will be preserved, packaged, and sealed in the manner described. A separate sample number and station number will be assigned to each trip sample and it will be submitted blind to the laboratory.

9.1.4 Field Duplicate Samples

Duplicate samples are collected simultaneously with a sample from the same source under identical conditions into separate sample containers. A duplicate sample is treated independently of its counterpart in order to assess laboratory performance through comparison of the results. At least 10% of samples collected per event will be duplicates. At least one duplicate will be collected for each sample matrix. Every analytical group for which a standard sample is analyzed will also be tested for in one or more duplicate samples. Duplicate samples should be collected from areas of known or suspected contamination.

Include this paragraph if collecting soil, sediment or other matrix samples:

Duplicate samples will be collected at sample locations _______________[*sample locations which will be split for duplicate analysis*]. Duplicate samples will be collected from these locations because ________________*[add sentence(s) here explaining the rationale for collecting duplicate samples from these locations; i.e., samples from these locations are suspected to exhibit the highest concentrations of contaminants, or previous sampling events have detected the highest levels of contamination at the site at these locations.]*

Include this paragraph if collecting samples and analyzing for VOCs and other compounds:

Samples to be analyzed for __________________[*list all analytical methods for this sample event except for volatiles*] will be homogenized with a trowel in a sample--dedicated 1--gallon disposable pail. Homogenized from the bucket will then be transferred to the appropriate wide--mouth glass jars for both the regular and duplicate samples. All jars designated for a particular analysis (e.g., SVOCs) will be filled sequentially before jars designated for another analysis are filled (e.g., metals). Soil samples to be analyzed for volatile organic compounds will not be homogenized. When collecting duplicate soil samples to be analyzed for volatile organic compounds, equivalent portions of sample collected from the same boring will be transferred to both regular and duplicate sample containers.

Include this paragraph if collecting samples and not analyzing for VOCs:

Samples will be homogenized with a trowel in a sample--dedicated 1--gallon disposable pail. Homogenized material from the bucket will then be transferred to the appropriate wide--mouth glass jars for both the regular and duplicate samples. All jars designated for a particular analysis (e.g.,SVOCs) will be filled sequentially before jars designated for another analysis are filled (e.g., metals).

Include this paragraph if collecting samples and analyzing only for VOCs:

Samples will not be homogenized. When collecting duplicate samples to be analyzed for VOCs, equivalent portions of sample collected from the same boring will be transferred to both regular and duplicate sample containers.

Include this paragraph if collecting water samples:

Duplicate water samples will be collected for water sample numbers _____________ *[water sample numbers which will be split for duplicate analysis*]. Duplicate samples will be collected from these locations because ________________[*add sentence(s) here explaining the rationale for collecting duplicate samples from these locations; i.e. samples from these locations are suspected to exhibit the highest concentrations of contaminants or previous sampling events have detected the highest levels of contamination at the site at these locations.*] When collecting duplicate water samples, bottles with the two different sample identification numbers will alternate in the filling sequence (e.g., a typical filling sequence might be, VOCs designation GW--2, VOCs designation GW--4 (duplicate of GW--2); metals, designation GW--2, metals, designation GW--4, (duplicate of GW--2) etc.). Bottles for one type of analysis will be filled before bottles for the next analysis are filled. VOCs bottles will always be filled first.

Always include this paragraph:

Duplicate samples will be preserved, packaged, and sealed in the same manner as other samples of the same matrix. A separate sample number and station number will be assigned to each duplicate, and it will be submitted blind to the laboratory.

9.2 LABORATORY QUALITY CONTROL SAMPLES

Laboratory QC samples are analyzed by the Region IX Laboratory as part of the standard laboratory QC protocols. The laboratory monitors the precision and accuracy of the results of its analytical procedures through analysis of QC samples. In part, laboratory QC samples consist of matrix spike samples and matrix spike duplicates for organic analysis and a duplicate and matrix spike samples for inorganic analyses. Laboratory QC samples are an aliquot (subset) of the field sample. They are not separate samples, but a special designation of an existing sample. A routinely collected soil sample (a full 8oz sample jar or two 120mL sample vials) contains sufficient volume for both routine sample analysis and additional laboratory QC analyses. However, for water samples, double volumes of samples are supplied to the laboratory for its use. Two sets of water sample containers are filled and all containers are labeled with a single sample number. The laboratory is should be alerted as to which sample is to be used for QC analysis by the notation on the sample container label and the traffic report and chain--of--custody record or packing list.

At a minimum, one laboratory QC sample is required per week or one per 20 samples (including blanks and duplicates), whichever is greater. If the sample event lasts longer than 1 week or involves collection of more than 20 samples per matrix, additional QC samples will be designated. For this sampling event, samples collected at the following locations will be the designated laboratory QC samples:

If a matrix is not being sampled, delete the reference to that matrix:

For soil, samples ____________[*soil sample numbers designated for QC*]

For sediments, samples ____________[*sediment sample numbers designated for QC*]

For water, samples ____________[*water sample numbers designated for QC*]

For other matrices, samples _______________ [*sample numbers designated for QC*]

Add a paragraph explaining why these sample numbers were chosen to be QC samples. QC samples should be the samples from each matrix expected or known to contain a moderate level of contamination. The rationale *should justify the selection of QA/QC samples based on previously--detected contamination at the site, historic site operations, expected contaminant deposition/ migration, etc.*

9.3 FIELD VARIANCES

It is not uncommon to find that, on the actual sampling date, conditions are different from expectations such that changes must be made to the SAP once the samplers are in the field. The following paragraph provides a means for documenting those deviations, or variances. Adopt the paragraph as is, or modify it to project--specific conditions.

As conditions in the field may vary, it may become necessary to implement minor modifications to sampling as presented in this plan. When appropriate, the QA Program will be notified

and a verbal approval will be obtained before implementing the changes. Modifications to the approved plan will be documented in sampling project report.

United States Environmental Protection Agency	Office of Research and Development Washington, D.C. 20460	EPA/600/R-98/018 February 1998

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