Lake Tahoe Pollutant Loading Reduction Model (PLRM) Database Refinement
Final Phase II Monitoring Plan

Prepared for: USDA Forest Service Pacific Southwest Research Station

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CHAPTER ONE. INTRODUCTION

PHASE II DATA COLLECTION PURPOSE AND SCHEDULE

The USDA Forest Service Pacific Southwest Research Station awarded 2NDNATURE a grant using SNPLMA Round 9 funding to build upon the data collection strategy and initial data collection efforts funded by the US Army Corps of Engineers (ACOE) during 2009. The ACOE research is Phase I and the SNPLMA research Phase II of the PLRM Database Refinement Study. The 2NDNATURE Team designed the data collection strategy to test and inform a number of assumptions within the current suite of Lake Tahoe urban stormwater management tools, particularly PLRM, but also the BMP RAM and Road RAM.

The Monitoring Plan for the ACOE Lake Tahoe PLRM Database Refinement Study (2NDNATURE 2009a) was submitted to the ACOE in July 2009 following the completion of the Phase I data collection efforts to ensure an accurate summary of the complete data collection strategy. The Phase I Monitoring Plan (2NDNATURE 2009a) includes monitoring goals and objectives, site selection justification, detailed instrumentation and field monitoring protocols, sample QA/QC requirements, and data management specifications. The Phase I data collection effort was limited, extending from December 2008 through July 2009, and the PLRM Technical Advisory Committee (PLRM TAC) is currently reviewing the draft Phase I Technical Report (2NDNATURE 2009c). The greatest value of the ACOE effort was the initiation of a focused and cost-effective data collection, data management and data analysis strategy to begin to directly inform PLRM and the supporting stormwater rapid assessment tools (BMP RAM and Road RAM).

This SNPLMA-funded Phase II Lake Tahoe PLRM Database Refinement Monitoring Plan builds directly upon the Phase I research effort and the monitoring project schedule is provided in Table 1.1. Urban road and SWT monitoring methods and protocols will be implemented through the Spring of 2011 to expand the dataset and continue to improve the science underlying the current versions of the Lake Tahoe urban stormwater management tools. This document provides the rationale and details the data collection protocols that will be implemented by the 2NDNATURE team to achieve the goals of Phase II of the PLRM Database Refinement Study. The final product will be a technical report that synthesizes the data collection, provides analysis of key findings, and presents potential recommendations for refinements to the PLRM algorithms and assumptions, as appropriate.

Table 1.1. Phase II Monitoring Project Schedule.

Task		Begin	End
1	Revise and update Phase I Monitoring Plan.	Complete	
	Conduct and summarize PAC meeting.	Complete	
	Revise and finalize Phase II Monitoring Plan.	Jan 10	July 10
2	Instrument stations.	Complete	
	Maintain stations over course of project.	Sept 09	Jun 11
3	Collect controlled experiment data.	Jan 10	Jun 11
	Collect event-based sampling data.	Jan 10	Jun 11
	Manage data.	Jan 10	Jun 11
	Test, validate and refine PLRM.	Jan 10	Jun 11
	Analyze data.	Jan 10	Jun 11
4	Draft Technical Report.	Jul 11	Nov 11
	Present Technical Report to PAC.	Nov 11	Dec 11
	Produce Final Technical Report.	Dec 11	Feb 12

The 2NDNATURE Team conducted some of the monitoring and site instrumentation for this SNPLMA research in the Fall 2009 and Winter 2010 prior to the release of this Final Monitoring Plan. The research team decided this action was warranted due to the urgency to ensure collection of Winter 2010 data and the identified cost-effectiveness to complete and release the draft of ACOE-funded Phase I data analysis (2NDNATURE 2009c) and technical report prior to finalizing the continued SNPLMA research approach and associated protocols.

BACKGROUND

Northwest Hydraulic Consultants (nhc), 2NDNATURE, and Geosyntec Consultants (nhc et al. 2009a, 2009b) released the initial version of the Pollutant Load Reduction Model (PLRM v1) in October 2009 through grants provided by the US Army Corps of Engineers (ACOE) and the Nevada Division of Environmental Protection (NDEP). The latest versions of the PLRM software and supporting documentation area available for download at: http://www.tiims.org/TIIMS-Sub-Sites/PLRM/docs-downloads.aspx

The PLRM provides Lake Tahoe resource managers with a tool to compare urban stormwater quality improvement alternatives in an urban catchment based on the predicted load reductions of the pollutants of concern. The PLRM estimates pollutant concentrations in urban catchments using two primary water quality algorithms: Characteristic Runoff Concentrations (CRCs) and Characteristic Effluent Concentrations (CECs). These concentrations are multiplied by the predicted runoff volumes at either the catchment outlet using CRCs or the outlet of a stormwater treatment BMP (SWT) using CECs to estimate average annual pollutant loads for each modeled alternative water quality improvement project.

The priority limitation with respect to water quality algorithms in the initial version of the PLRM is minimal fine sediment particle (FSP < 16um) stormwater data available to inform the PLRM CRCs and CECs. The primary data sources used to inform PLRM v1 included previous Lake Tahoe stormwater quality monitoring datasets compiled and integrated from a variety of sources. The available stormwater data was collected to meet a myriad of data collection goals and objectives, and therefore does not perfectly align with the goals and objectives of the PLRM. This research is intended to directly inform the PLRM v1 assumptions and algorithms, particularly with respect to FSP, to continue to improve the predictive power of this model.

LAND USE CRC (CHARACTERISTIC RUNOFF CONCENTRATION)

The PLRM quantifies pollutant generation from an urban land use and associated land use condition. Urban land use types include single family residential, multi-family residential, commercial, primary roads, and secondary roads, etc. Condition is defined as the existing state of a land use relative to the pollutant generation risk during a subsequent storm and is the integration of physiographic characteristics, pollutant source controls, and the effectiveness of pollutant recovery efforts. A wide range of pollutant source controls are implemented on urban land uses with the intention of improving condition and reducing the pollutant generation risk. In the PLRM, the condition of an urban land use is correlated to a characteristic runoff concentration (CRC) for pollutants of concern for lake clarity. A CRC is a representative concentration for a pollutant of concern in stormwater runoff from a specific urban land use and its associated condition. CRCs are combined with continuous runoff hydrology from the PLRM to provide a representative estimate of average annual pollutant loading for specific land use conditions.

PLRM v1 assumes that significant pollutant load reduction opportunities exist as a result of improving urban road management to protect water quality. The PLRM Road Methodology (nhc et al. 2009a) predicts likely road condition and associated CRCs from urban roadways. The SNPLMA monitoring efforts will continue to expand the urban road data collection initiated by the ACOE funded efforts. In addition, the researchers may apply cost-effective sampling techniques to other key urban land use types to improve our understanding of FSP generation and transport on urban lands.

ROAD RAM

The Road Rapid Assessment Methodology (Road RAM) is a tool that is under development for the Lake Tahoe stormwater community to rapidly evaluate the relative condition of an urban roadway using simple, repeatable and cost-effective techniques[1]. The Road RAM will be complementary and consistent with PLRM terminology, road characteristics, pollutant source and sink factors and final road condition evaluation scores. While PLRM provides likely average annual road condition scores, the Road RAM allows discrete temporal and spatial condition evaluations of urban road segments. The urban road monitoring efforts conducted during Phase I data collection (2NDNATURE 2009c) and to be continued under Phase II have been designed to directly inform many aspects of the Road RAM tool as well, including road risk development, RAM observation protocols and RAM scoring calculations.

CEC (CHARACTERISTIC EFFLUENT CONCENTRATIONS)

The PLRM provides a function to estimate the performance of a stormwater treatment BMP (SWT) by assigning a characteristic effluent concentration (CEC) depending on the type of SWT and fundamental design parameters. An SWT is defined as a Treatment BMP that reduces pollutants of concern from a concentrated stormwater flow path. PLRM estimates the CEC from 6 specific SWT types: dry basin, wet basin, infiltration basin, treatment vault, cartridge filter, and bed filter. Based on SWT type, there are specific key design parameters the user inputs into the model and which affect the CEC estimates. These key SWT design parameters include water quality volume (ft^3), footprint (ft^2), infiltration rate (in/hr), draw down time (hr), and minimum hydraulic residence time (hr), among others, and vary with the SWT type (see PLRM User Manual (nhc et al. 2009b) for details). PLRM provides some guidance and suggested ranges for each input parameter; however, the modeler chooses the specific inputs based on the average expected condition over the lifespan of the SWT, based on anticipated maintenance practices. PLRM assumes reasonable maintenance is performed to ensure acceptable water quality treatment function of each SWT. There exists a significant lack of understanding of how SWT condition influences expected water quality treatment performance, but Lake Tahoe resource managers and research personnel agree upon the need for continued and strategic maintenance of the SWT to maintain the expected pollutant load reductions. When combined with continuous runoff hydrology from the PLRM, CECs provide a representative estimate of average annual pollutant loading at the outlet of a SWT.

The ACOE research developed specific data collection and data analysis techniques to test, validate and continue to improve PLRM CEC values based on SWT type and key design parameters. The SNPLMA resources will be used to continue the implementation of these sampling techniques, while expanding the number of SWTs monitored.

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[1] The Road RAM tool is being developed by the 2NDNATURE team, funded by the California Tahoe Conservancy and Nevada Department of Environmental Protection, with the initial version public release expected in the Fall of 2010.

BMP RAM

The 2NDNATURE Team developed the Best Management Practice Maintenance Rapid Assessment Methodology (BMP RAM) to assist Lake Tahoe natural resource managers in determining the relative condition of urban stormwater Treatment BMPs (2NDNATURE 2009b). The primary purpose of the BMP RAM is to inform the user of the relative urgency of water quality maintenance for Treatment BMPs. The BMP RAM provides a practical, consistent and reliable field observation and data management tool to track the condition of a particular Treatment BMP, relative to its observed condition at time of installation or immediately following complete maintenance. Treatment BMP condition is based on the results of rapid field observations that serve as reliable proxies for the treatment processes relied upon by a distinct BMP Type. The treatment processes include infiltration, particle capture, nutrient cycling and/or media filtration. The BMP RAM consists of six distinct STEPs implemented by the user, each of which required data collection, database population and decision making.

Field personnel will perform the BMP RAM tool regularly on each SWT to document the relative condition. The BMP RAM results will begin to inform our understanding of how maintenance urgency may impact CECs and treatment volumes, as well as how condition and the associated treatment performance change over time.

SWT INFILTRATION RATES

PLRMv1 requires the user to input the average annual infiltration rate for the specific SWT types that rely upon infiltration to reduce stormwater loads (i.e., dry basin, infiltration basin and bed filters). The calculation of an average annual infiltration rate for a SWT requires a long-term continuous water budget and is difficult to measure instantaneously in the field. Per the BMP RAM (2NDNATURE 2009b), saturated hydraulic conductivity can be measured during dry conditions using a constant head permeameter (CHP). However, the CHP values are over-estimates of average annual infiltration rates, which include completely saturated conditions of all surrounding soils. Building upon the existing Lake Tahoe SWT data collection strategies employed to improve PLRM CECs, the researchers will expand the monitoring of continuous water budgets of specific SWTs to develop an empirical correlation between average annual infiltration rates and the instantaneous manual CHP measurements obtained within the SWT during dry conditions. The results will provide direction to PLRM users on how to translate measurable CHP values into the PLRM input requirement of an average annual infiltration rate.

Infiltration rates are a key design parameter input into PLRM for dry basins, infiltration basins and bed filters. Infiltration rates will be calculated as part of the continuous surface water hydrology budget throughout the monitoring study and therefore can be directly linked to event-specific treatment performance and existing SWT condition as determined by BMP RAM. The variability in measured infiltration rates will be used to link observed SWT treatment performance with respect to FSP and SRP to the differences in both SWT design and maintenance. This data will be used to improve PLRM CEC loading estimates.

GOALS OF SNPLMA DATA COLLECTION

The urban stormwater data collection effort funded by SNPLMA Round 9 will build upon the initial datasets for urban roadways and SWTs (2NDNATURE 2009c) in order to address the priority data gaps and test key assumptions within the current suite of Lake Tahoe urban stormwater tools. Specifically, SNPLMA data collection will:

1. Expand and apply the urban road monitoring dataset to:
    a. Test and refine the PLRM Road Methodology assumptions regarding the role urban road factors may have on urban roadway water quality condition,
    b. Inform PLRM estimates of the total (TSS) and fine sediment particles (FSP; TSS< 16µm) CRCs from roads varying in condition, with inclusion of soluble reactive phosphorous (SRP) analyses as resources allow,
    c. Improve the breadth and quality of urban stormwater data on the generation, fate and transport of TSS and FSP, as well as SRP where resources allow, and
    d. Collect focused and controlled data from urban roads to inform and improve the Road RAM tool.
2. Apply cost-effective and comparable sampling techniques to increase our understanding of FSP generation from other urban land use types, including commercial and residential surfaces, and their variability of condition.
3. Expand and apply the SWT monitoring dataset to:
    a. Improve the understanding of water quality treatment performance, specifically with respect to primarily FSP, and SRP as resources allow, based on SWT type and key design parameters,
    b. Inform and improve the PLRMv1 CEC estimates based on SWT type and key design parameters, and
    c. Link average annual infiltration rates with measured CHP saturated hydraulic connectivity values to inform PLRM infiltration input requirements.
4. Apply the PLRM to estimate and compare hydraulic capture among SWTs monitored. Hydraulic capture can be estimated in the PLRM using basic design information for each SWT facility and the drainage conditions of the catchment(s) tributary to each SWT. Information on hydraulic capture will allow the research team to estimate the frequency and magnitude of storm events that cause bypass to occur at each SWT, which is a key consideration when developing improved CECs based on the monitoring data collected from this study.
5. Collaborate with academic researchers in data and sample sharing for their development of appropriate numeric conversions from FSP concentrations and loads to # of particles.

CHAPTER TWO. DATA COLLECTION STRATEGY

LAND USE MONITORING

PLRM estimates CRCs for urban land uses defined by the Lake Tahoe TMDL. The Lake Tahoe TMDL and supporting tools have identified urban land uses, and particularly roads, as the main sources of pollutant loads to the Lake (LRWQCB and NDEP 2008, nhc et al. 2009a). 2NDNATURE (2009c) focused only on the collection of water quality data for primary and secondary roads; however, this SNPLMA-funded monitoring effort will expand data collection to include some limited sampling of additional urban land use types included in PLRMv1.

This monitoring plan will remain consistent with the urban road monitoring protocols and data collection strategies developed by the Phase I study (2NDNATURE 2009c). The sampling locations, sample collection protocols, and data analysis will continue as established by 2NDNATURE (2009a). Monitoring on other urban land uses will be phased based on preliminary findings and will use cost-effective techniques conducted in a manner consistent with the established urban road monitoring procedures.

URBAN ROAD MONITORING

The urban road monitoring will continue to evaluate the influence various factors may have urban road condition, improve and validate PLRM CRCs for urban roads and improve the empirical linkage between CRCs and likely road condition. The effort will continue to focus upon FSP and TSS, with a select number of samples (based on available resources) analyzed for SRP as well. The 2NDNATURE research team will combine documentation of key road segment factors as defined in the PLRM and Road RAM, observations of relative roadway condition and cost-effective roadway sampling efforts over a range of urban road conditions that exist in Lake Tahoe Basin. Urban road sampling will consist of controlled experiments and the contributing roadway condition will be evaluated and documented prior to each controlled experiment. The field verification of urban road condition (Road RAM) and subsequent standardized sampling of the associated road water quality will provide valuable qualitative and quantitative data to inform the PLRM Road Methodology and associated CRCs.

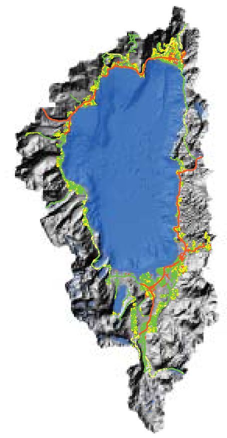
Figure 2.1 provides a visual orientation to summarize the suite of data collected from urban road segments during monitoring as developed by 2NDNATURE (2009a). The field observations and sampling conducted under the SNPLMA Phase II study will improve the correlation between on-the-ground observations (Road RAM) and PLRMv1 predictions of likely average annual condition.

Road Segments and Characterization

Consistent with the sites monitored by 2NDNATURE (2009c), thirty-four (34) road segments, including thirty-two (32) roads and two (2) commercial parking lots (Table 2.1, Figures 2.2-2.3), were selected to represent a range of: road type (primary, secondary), road risk (high, moderate, and low), and jurisdictions in charge of maintenance. The combination of roads selected, based on the above characteristics represent a range of road conditions, is consistent with the PLRM Road Methodology assumptions. Each road segment is standardized to a sampling area of 1,000ft^2 and characterized based on the PLRM Road Methodology (nhc et al. 2009a). The top half of Figure 2.1 presents the spatial distribution of data collected during the road segment characterization.

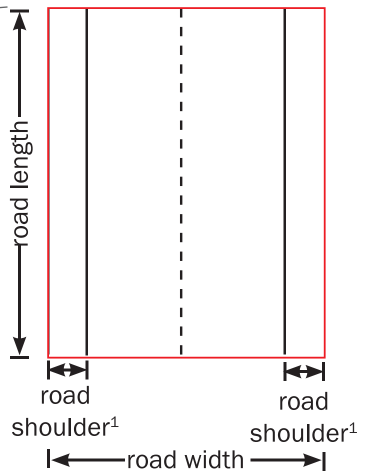
ONCE EVERY 3-5 YEARS

Lake Tahoe Basin



GIS analysis of:
  Road Risk Category
    [PHR, PMR, SHR, PLR, SMR, SLR]
  Jurisdiction

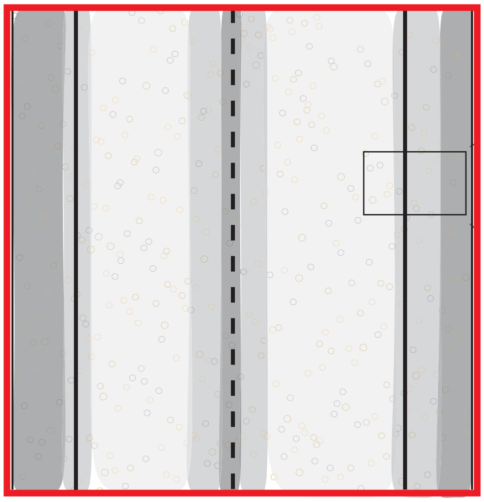
☐ **Road Segment ($10,000ft^2$)**



Characterized by:
  Right and Left Road Shoulder[1] Condition
    [1, 3, 4, 5]
  ▨ Road Surface Integrity
    [H, M, L]

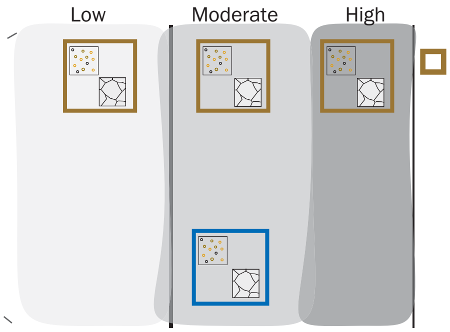
EVENT-BASED

☐ **Road Segment ($10,000ft^2$)**



Visual observations of:
  Material Accumulation Category
    % distribution of:
    ■ High
    ▣ Moderate
    □ Low

1'x1' squares within
Material Accumulation Category



☐ Dry Material Sampling from all 3 categories:
  Volume/Mass [ml, mg]
  Particle Size Distribution
    [% of mass <16µm]
    (limited)
  ▦ Degree of Fines [H, M, L]
  ▨ Road Surface Integrity
    [H, M, L]

☐ Controlled Experiments obtain wet sample from 1 material accumulation category:
  TSS and FSP Concentrations [mg/L]
  Turbidity [ntu]
  Particle Size Distribution [% of TSS]
  ▦ Degree of Fines [H, M, L]
  ▨ Road Surface Integrity [H, M, L]

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[1] PLRM defines the road shoulder to include the pervious area of the right-of-way. For the purposes of this monitoring, only the impervious portion of the road shoulder is considered part of the road segment.

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URBAN ROAD MONITORING DATA COLLECTION SCHEMATIC

FIGURE 2.1

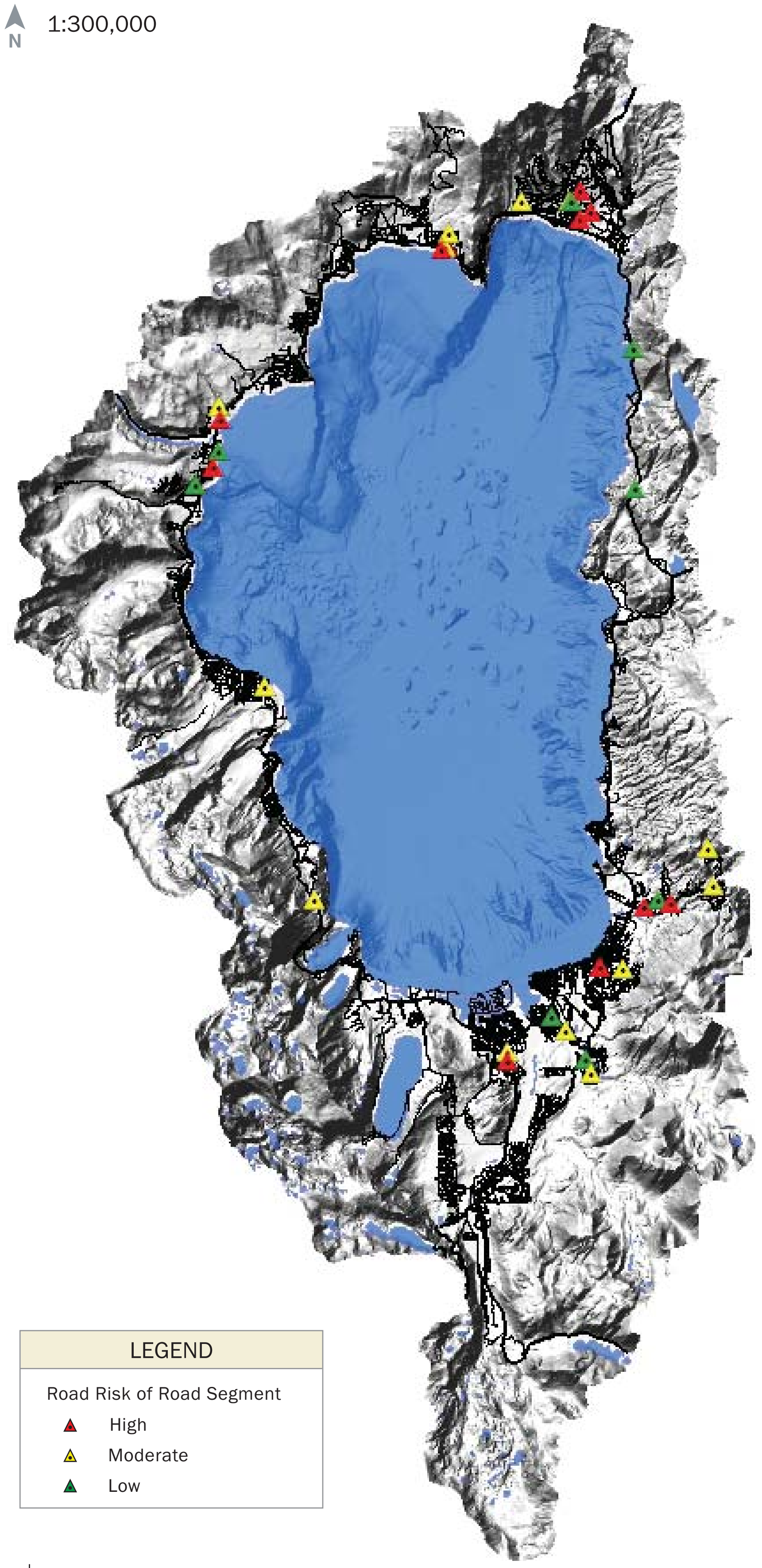
Table 2.1. Urban Road Monitoring Road Segments.

Road Type	Road Segment Code	Street Name	Jurisdiction Responsible for Road Maintenance	Road Risk (estimate September 2009)
Primary	EI	Highway 50	CalTrans	High
	H281	Highway 28	CalTrans	High
	H28TC	Highway 28	CalTrans	High
	H89S	Highway 89	CalTrans	High
	EB1	Highway 89	CalTrans	Moderate
	SPP1	Highway 89	CalTrans	Moderate
	HM2	Pioneer Trail	El Dorado County	Low
	KG1	Kingsbury Grade	NDOT (Douglas County)	High
	KG2	Kingsbury Grade	NDOT (Douglas County)	High
	H28C	Highway 28 (Tahoe Blvd)	NDOT (Washoe County)	High
	H28A	Highway 28	NDOT	Low
	H28B	Highway 28	NDOT	Low
Secondary	SR1	Ski Run Boulevard	CSLT	High
	BO1	Bonanza Avenue	CSLT	Moderate
	KC3	Keller Road	CSLT	High
	EW1	Elwood Drive	CSLT	Low
	KG3	North Benjamin Drive	Douglas County	Moderate
	KG4	Andria Drive	Douglas County	Moderate
	KG5	Juniper Drive	Douglas County	Low
	HM3	High Meadow Trail	El Dorado County	Low
	MA1	Martin Avenue	El Dorado County	High
	TR1	Trout Avenue	Placer County	Moderate
	CO1	Coon Street	Placer County	High
	JP	Red Cedar Street	Placer County	Moderate
	KB1	Cut Throat Avenue	Placer County	Moderate
	PINE	Pine Avenue	Placer County	High
	BURL	Olympic Drive	Placer County	Moderate
	VIL1	Village Boulevard	Washoe County	High
	VIL2	Village Boulevard	Washoe County	High
	DD	Dale Drive	Washoe County	Moderate
	KMAC	McDonald Drive	Washoe County	Moderate
	JEN	Jensen Circle	Washoe County	Low
Commercial	RSLT	Raleys- SLT	Private	High
	RIV	Raley's Incline Village	Private	High

Road Data Collection

Road sampling consists of a collection of visual observations, as well as dry material and wet sediment sampling at each site. The field crew (consisting of 2-3 trained personnel) evaluates the road segment condition during urban road sampling to document road condition. Road condition will be determined by both visual observations and dry material collection and validated by the wet sample results. At road segments characterized with erodible road shoulders, field personnel will collect additional dry material samples from the pervious portion of the road shoulder to evaluate any sampling bias introduced by conducting controlled experiments only on the impervious areas of the road segment.

Field personnel safety is the priority at any road segment site. Hazard cones are placed to surround the sampling location and field personnel. Field personnel must wear hazard vests and be acutely aware of traffic conditions at all times. Sampling locations and visual observations will be dictated by both field personnel safety and minimization of disturbance or distractions to motorists.



Road Segment Sampling Sites by Jurisdiction and Primary and Secondary Road Risk (as calculated September 2009).[1]

Jurisdiction	**# High Risk**		**# Mod Risk**		**# Low Risk**	
Road Type[2]	***P***	***S***	***P***	***S***	***P***	***S***
CalTrans	4		2			
City of South Lake Tahoe		2		1		1
Douglas County				2		1
El Dorado County		1			1	1
NDOT	3				2	
Placer County		2		4		
Washoe County		2		2		1

[1] Table does not include the 2 commercial parking lot sites under private jurisdiction.

[2] P= Primary Road; S = Secondary Road

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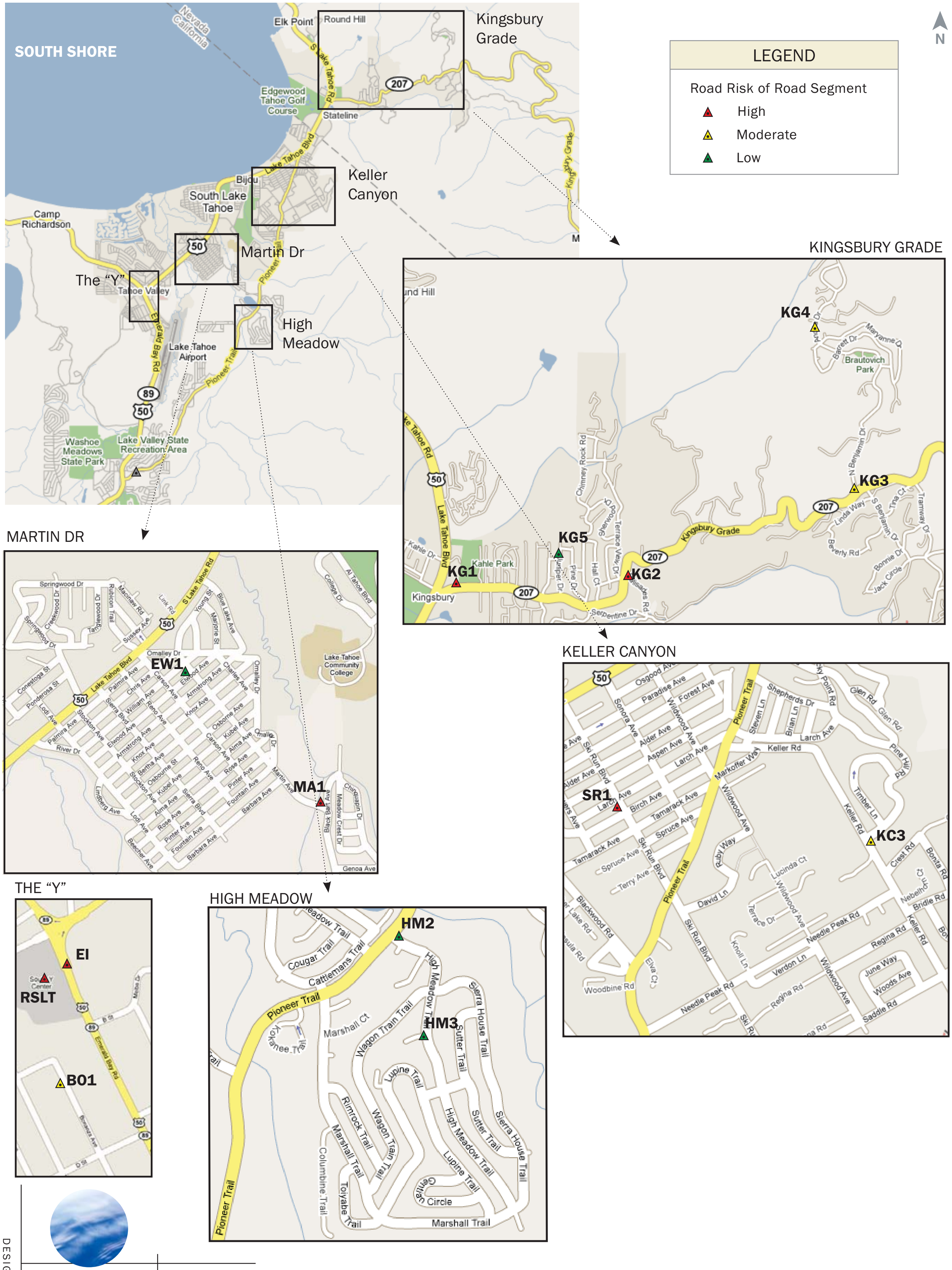
URBAN ROAD MONITORING ROAD SEGMENTS - OVERVIEW

FIGURE 2.2



URBAN ROAD SEGMENTS - SOUTH SHORE

FIGURE 2.3A

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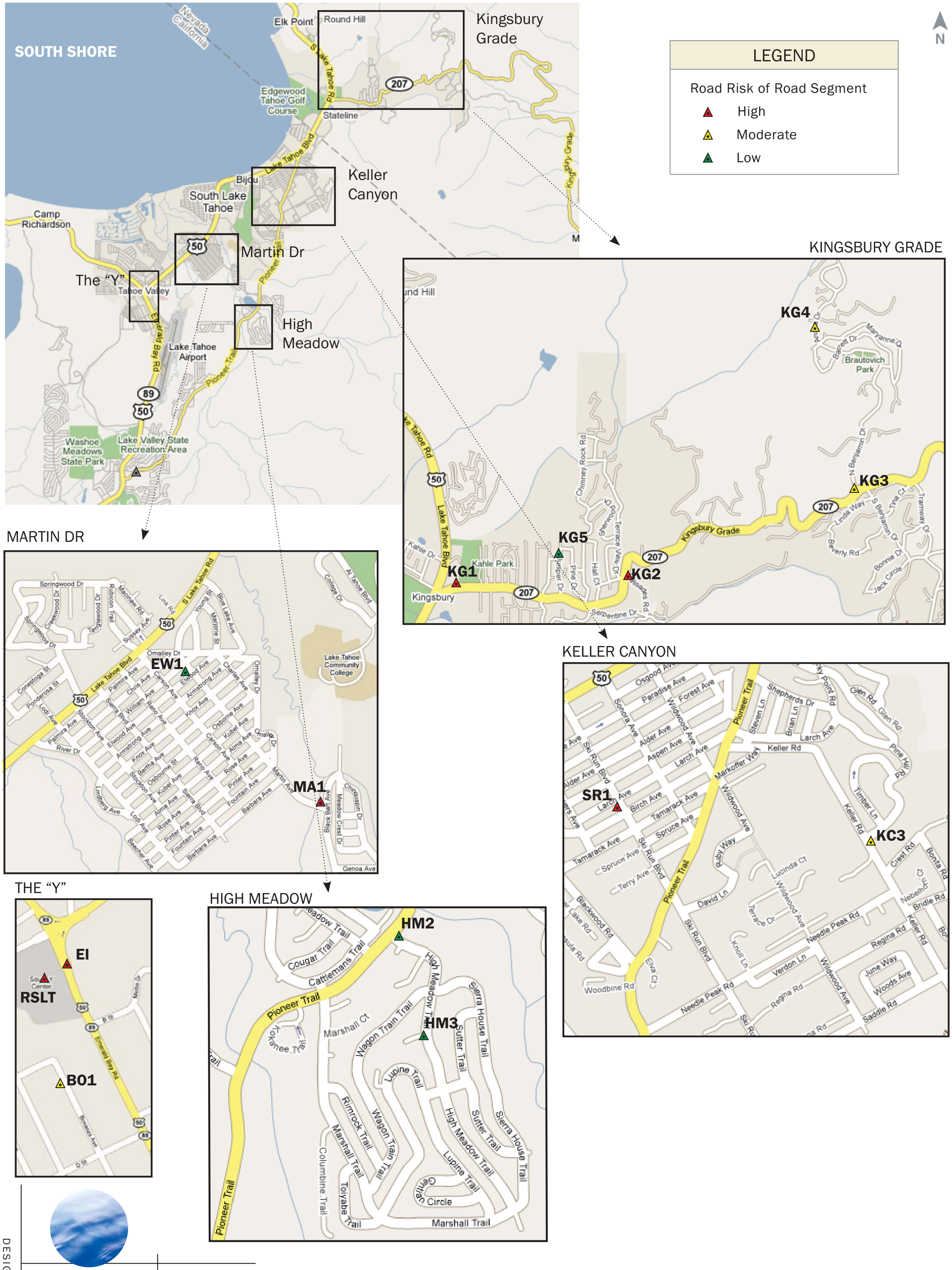

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URBAN ROAD SEGMENTS - SOUTH SHORE

FIGURE 2.3B

LEGEND

Road Risk of Road Segment

- 🔺 High
- ▲ Moderate
- ▲ Low

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URBAN ROAD SEGMENTS - WEST SHORE

FIGURE 2.3C

Visual Observations (See Protocol A)

- Visual observations will be made of the entire 10,000ft^2 road segment:
    - percent distribution of each material accumulation category (heavy, moderate, and light),
    - degree of fine material within each accumulation category, as determined by fines and dust test,
    - evidence of recent road abrasive application (Y/N), and
    - evidence of recent sweeping activity (Y/N).
- Material accumulation categories will be characterized relative to the specific road segment evaluated and not relative to all road segments during the sampling period. The heavy and light accumulation categories of the specific road segment at the time of observation will set the bookend scales of the existing condition for these factors, and then % distribution of each category will be estimated and confirmed by all field personnel.
- To properly QA/QC the data the field observations will be conducted across the entire width of the road segment, including the drive lane, both road shoulders and both flow paths that consist of impervious coverage. Pervious surfaces that extend beyond the concrete will not be included in the observations, but the left and right road shoulder conditions for the complete road segment are documented.
- To account for the potentially mobile unconsolidated material accumulated beyond the impervious edge of the road segment and/or beyond the reach of a road sweeper, visual observations are conducted to determine if a substantial amount of material is present and therefore represents a downslope water quality risk during a subsequent runoff event.

Dry Material Collection – Impervious Surface (See Protocol A)

- Dry material samples will be collected from the heavy, moderate and light material accumulation areas to represent the entire road segment.
    - Dry material samples will be collected using a hand broom and wire brush from a 1ft by 1ft road surface area to measure the volume of material potentially available for subsequent transport.
    - Volume will be measured by immediate transfer into a graduated cylinder and field personnel entered the measurements on field datasheets.
    - Dry material samples will be converted to mass, using an assumed density of 1.7 g/mL for all samples.
    - Most samples will be immediately discarded after measurements are recorded; however a subset will be saved and submitted to Cooper Testing Laboratory following proper handling protocols.

Dry Material Collection – Pervious Surface

- Dry material samples will be collected from the pervious portion of the road shoulder at road segments characterized by an erodible or unstable road shoulder (road shoulder condition score = 1 or 3).
    - Visual observations of the relative degree of disturbance (e.g., soil compaction and human traffic) will be estimated for the length of the road shoulder.
    - Field personnel will scrape the top 1-2” of material from the surface to remove any road generated material blown onto the road to ensure native material is collected.
    - 100mL of dry material samples will be collected for submission to Cooper Testing Laboratory for grain size distribution following proper handling protocols.

Pervious road surface samples will initially be collected one time to ground-truth our current assumptions on the potential FSP generation risk associated with erodible road shoulders. Depending upon results from the initial data collection, additional samples may be collected and/or the technique may be modified.

Controlled Urban Road Experiments (See Protocol B)

2NDNATURE (2009) designed and fabricated a portable simulator that applies a standardized volume of water at a constant intensity over a controlled area of an urban road surface (Figure 2.4). The runoff experiment design meets the following needs:

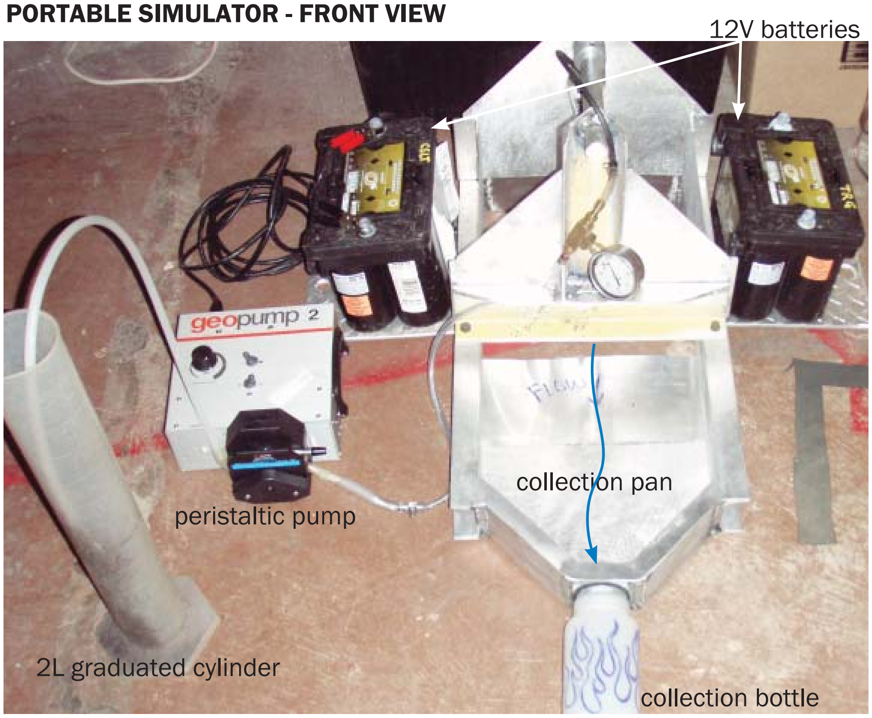
- Ability to sample over 30 Lake Tahoe urban roads using 2 field personnel in 3 days.
- In order to remain cost-effective, the road evaluations, which include the controlled experiments, should take no more than 30 minutes to complete per road segment.
- A minimum of 600 mL of volume must be recovered from the simulation for proper analysis and QA/QC by the analytical laboratory.
- Consistently sample a number of urban roads while keeping water application rate, intensity, contributing area, and water sample collection methods constant. The constraint of these primary hydrologic parameters increase our confidence that computed differences in water quality constituents (TSS, FSP, SRP) are due to differences in roadway condition and not due to natural hydrologic or sampling variability.

The above needs require that the portable simulator be run at an estimated intensity of 5 in/hr. While this intensity is higher than most rain events in Lake Tahoe, this increased rate is necessary to minimize the sampling duration and remain cost-effective. The relatively high intensity of simulated rainfall, to some degree, compensates for the lack of material transport downslope by flowing stormwater over the road surface that occurs during actual stormwater runoff events on impervious surfaces.

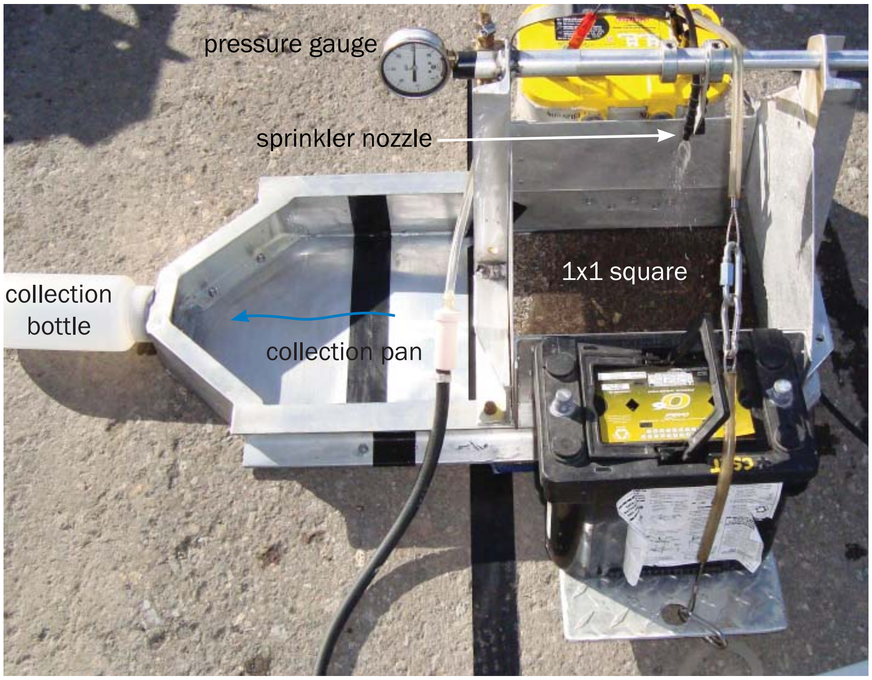
A summary of the portable simulator protocols include:

- Due to field personnel safety and resource limitations, only one wet sample is obtained from each road segment during each sampling period, unless field triplicates are performed for QA/QC procedures. Wet samples are typically collected on the shoulder margin of the drive lane and sites are selected to be visually representative of the condition of that location over the entire road segment. Typically an area of moderate material accumulation is selected to reduce sampling variability across sites and sampling periods. Personal safety and actual road condition occasionally require field personnel to select a location in a different accumulation category.
- To improve the sediment capture efficiency of both the dry material sampling and the controlled experiments, field personnel will conduct dry material collection and controlled experiments on the same 1ft by 1ft square, noting the material accumulation category of the location. The square will first be swept to collect the dry material mass on the road surface following the protocols describe above. Then the controlled experiment will be conducted to collect the smaller-size particles not collected by the hand broom. The double sampling of the road segment will more accurately measure the total sediment and associated pollutant concentration accumulated on the road surface.
- A water volume of 750mL is be applied by the simulator and field personnel will monitor both water pressure and application time to maintain consistency across sampling.

PORTABLE SIMULATOR - FRONT VIEW



PORTABLE SIMULATOR - TOP VIEW



SIMULATOR IN ACTION IN THE FIELD

site set-up

simulation

sample collection

transfer to collection bottle

collection pan rinse

PORTABLE SIMULATOR USED IN CONTROLLED URBAN ROAD EXPERIMENTS

FIGURE 2.4

- Following completion of the simulation, which takes approximately 2.5 minutes, an additional 250mL of water is applied using a squirt bottle to rinse the collection pan and capture all material transported from the road to the collection pan into the sample.
- For each sample, turbidity is measured in the field using a Hach 2100P or LaMotte 2020 portable turbidimeter.
- Collected water samples are then submitted to WETLAB for analysis following proper handling protocols.
- Field triplicates and a field blank are collected and submitted to WETLAB at least once during a sampling period to QA/QC field techniques.

Road Shoulder Infiltration

Infiltration and compaction measurements will be collected across a range of Lake Tahoe Basin road shoulder conditions to evaluate how well current PLRM algorithms predict average saturated hydraulic conductivity (Ksat) on road shoulders and whether Ksat is a reliable indicator of surface infiltration capacity. The following protocols will be implemented:

- Select 15 road shoulders to perform infiltration and compaction tests. For the same soil map unit or structural fill, road shoulders will be selected to measure a range of compaction levels that will be categorized based on visual inspection as: (None, Moderate, and Severe).
  - A total of 6 measurements will be made for primary roads (3 compaction levels times 2 soil map units or structural fill)
  - A total of 9 measurements will be made for secondary roads (3 compaction levels times 3 soil map units or structural fill)
- Surface infiltration will be measured using a double-ring infiltrometer and compared to Ksat measurements using the Constant Head Permeameter (CHP) designed by NRCS. Compaction and soil resistance will be measured using a cone penetrometer.
- Ksat will be predicted for each road shoulder using PLRM and compared to field measured Ksat and surface infiltration rates.

Assuming the research confirms that current PLRM road shoulder algorithms are in need of improvement, a second stage of research will be conducted to determine the key factors contributing to variability in road shoulder infiltration. The results of the second stage of research will be used to develop guidelines for others to use when estimating road shoulder infiltration for input into PLRM. Additionally, the technical framework for incorporating improved road shoulder infiltration algorithms into the PLRM will be developed. The second stage protocols include:

- The probable factors contributing to variable Ksat will be identified based on insight gained from Task 1.2 (e.g. sandy vs. clayey soils, volcanic vs. granitic soils, presence or absence of road structural fill, primary vs. secondary roads, vegetation, degree of compaction, plugging of surface soils by fine sediments, etc.).
- Up to 35 additional road shoulders will be selected and tested to constrain the probable factors contributing to Ksat variability.
- The total data set (50 total samples) will be used to identify the primary factors causing variability in measured Ksat.

Road Maintenance Practice Documentation

Accurate documentation by jurisdictions of road maintenance practices was identified as a significant data gap by 2NDNATURE (2009c). The research team has identified road maintenance personnel contacts for 6 of the 7 jurisdictions and provided each with a simple data log to track their road maintenance practices at each of the urban road sampling locations. The log includes both road abrasive application data (frequency and amount applied per unit area) and sweeping data (frequency and sweeper type). 2NDNATURE personnel plan to communicate biweekly to monthly with the identified personnel at each jurisdiction throughout the winter months to encourage accurate and standardized data collection and management.

Improved record-keeping of road maintenance actions will greatly improve our understanding of the water quality benefits of pollutant recovery actions. However, identifying the appropriate personnel within each jurisdiction that has (1) the knowledge of existing road maintenance practices and (2) the inclination and time to discuss those practices and complete the weekly log has been challenging. Requests to complete the log have been met with some resistance and will require persistent communication from 2NDNATURE staff.

ADDITIONAL LAND USE MONITORING

Objectives

The Parcel Methodology is used to estimate the CRCs generated from urban parcels such as single family and multi-family residential, and commercial land uses. The Parcel Methodology defines land use condition based on the presence/absence of private party pollutant source control and/or hydrologic source control implementation. The research team will conduct initial dry material collection and controlled experiments on a collection of land uses (commercial, multi-family residential, single-family residential, etc.) throughout the Lake Tahoe Basin to ground truth the current PLRMv1 assumptions on particle grain size distribution and potential pollutant generation risk of the associated land uses.

Draft Protocols

Similar to the development strategy for the Phase I protocols (2NDNATURE 2009a), the 2NDNATURE team anticipates the full development of the Land Use Monitoring protocols to be an iterative process. The draft protocols are presented below; however, we expect to modify and refine these protocols as new information is gained. Final protocols will be produced with the Draft Technical Report.

2NDNATURE will select monitoring sites based on the following criteria:

- Typify the range of urban land uses (commercial, multi-family residential, single-family residential) to address the land uses represented in PLRMv1;
- Include both pervious and impervious surfaces to allow dry material sampling and controlled experiments consistent with the urban road monitoring, and
- Represent typical Lake Tahoe Basin native soils of both granitic and volcanic origin to evaluate the potential fine sediment particle distribution differences generated from land uses.

The total number of sites selected will depend upon a balance between cost-effectiveness and the likely value of the data collection results. The research team will characterize each site, including sampling area, native soil type based on existing USGS soil mapping, and presence/absence of private party pollutant source control and/or hydrologic source control implementation. Field personnel will conduct monitoring on both the impervious and pervious surfaces at each site.

For the impervious surfaces, visual observations, dry sampling, and controlled experiment protocols at each monitoring site will remain consistent with those performed on the urban roads. Phase I data collection efforts (2NDNATURE 2009c) included 2 impervious commercial sites (RSLT and RIV in Table 2.1) and provided comparable results across urban land use types. Impervious land use monitoring will include:

- Visual observations consistent with urban road protocols will include degree of sediment accumulation, percent distribution of sediment accumulation categories, and degree of fines, of the sites.
- Dry material samples will be collected from a 1ft x 1ft square using a hand broom and a comparison of total and fine sediment will be made relative to land use type, native soil type, and sediment accumulation category.
- Controlled experiments (wet sediment sampling) using the portable simulator will be conducted on impervious surface to generate standardized TSS and FSP water quality concentrations (with SRP as resources allow) to compare relative risk to downslope water quality from the range of land uses.

For pervious surfaces, visual observations and dry material sampling will be consistent with the draft protocols developed for the pervious road shoulder monitoring. Pervious land use monitoring will include:

- Visual comparisons of the degree of disturbance (e.g., soil compaction and human traffic) will be estimated for the entire sampling segment, similar to the percentages of high, moderate and low sediment accumulation on urban road segments.
- Dry sediment sampling of 100 mL of material will be collected within each disturbance category, similar to the urban road protocols on the pervious road shoulder. The sampling will standardize sample collection techniques from site to site. Samples will be submitted for grain size distribution analysis during preliminary evaluations to determine if analyses yield any valuable information concerning FSP generation based on land use and native soil types.

SWT MONITORING

SWT monitoring protocols and data collection strategy will build upon sites and protocols developed by 2NDNATURE (2009a) and expand monitoring spatially, temporally, and in terms of data collected for analysis. Spatially, SWT monitoring will include the four SWTs evaluated under 2NDNATURE (2009c), as well as an additional 5 SWTs. The research team will conduct monitoring from Fall 2009 through Summer 2011 to add 2 complete years to the Winter 2009 (Phase I) dataset. Expanded data collection will include: SRP analysis of selected samples as resources allow; the implementation of the BMP RAMv1 tool (2NDNATURE 2009b) repeatedly on each of the selected SWTs to track condition; and frequent CHP measurements and soil samples for comparison to the average annual infiltration rates observed from the continuous water budgets at each SWT as appropriate. Collectively these data will directly inform the PLRM v1 CEC values, improve our ability to link CHP measured values with PLRM infiltration rate inputs, and increase our understanding of design parameters as well as SWT condition on SWT treatment performance for the pollutants of concern.

The approach to SWT monitoring includes:

1. Continuously monitor **surface water hydrology** to develop a detailed surface water budget for at least 9SWTs. The surface water budget will allow us to:
    a. Calculate event inlet, treated, and bypass volumes, which when combined with sample concentrations to calculate event inflow, treated and bypass outflow pollutant loads and SWT treatment performance (i.e., load reduction).
    b. Inform our understanding of the SWT hydrologic function with respect to key fundamental design parameters for each SWT, including infiltration rates, water quality volume, bypass volume, draw down time, and hydraulic residence times and how these parameters relate to catchment size , land use distribution, and land use condition.
    c. Where applicable, calculate average annual infiltration rates and correlate to manual BMP RAM CHP measurements and inform PLRM v1 user infiltration rate input requirements.
2. Collect **event-based surface water samples** at the inlet and outlet of at least 8 SWTs to evaluate treatment performance based on SWT type.
    a. Samples are collected from passive samplers installed at fixed basin water surface elevations to characterize both treated and bypass volumes, as defined by PLRM (nhc et al. 2009b). Concentrations will be multiplied by event volumes to calculate treated and bypass pollutant loads and evaluate SWT treatment performance, particularly with respect to FSP (and SRP as resources allow).
    b. Field personnel will collect grab samples from the treatment outlet if outflow is occurring to compare water quality results to passive sample collection and address any bias introduced from the passive sample data collection approach. Date and time of sample collection will be compared to the basin stage time series to determine the position on the hydrograph when the sample was collected and the associated outflow volume.
    c. Inform our understanding of the SWT water quality performance with respect to key fundamental design parameters for each SWT, including infiltration rates, water quality volume, bypass volume, draw down time, and hydraulic residence times and how these parameters relate to catchment size, land use distribution, and land use condition.
    d. Outlet water quality data that represents the treated volume fraction of the SWT will be evaluated to directly inform PLRMv1 CEC estimates by SWT type and design parameters.

3. Evaluate **SWT condition** using BMP RAM to:
    a. Inform our understanding of how maintenance urgency may impact CECs and treatment volumes, as well as how condition, and the associated treatment performance, changes over time.

SELECTED SWT SITES

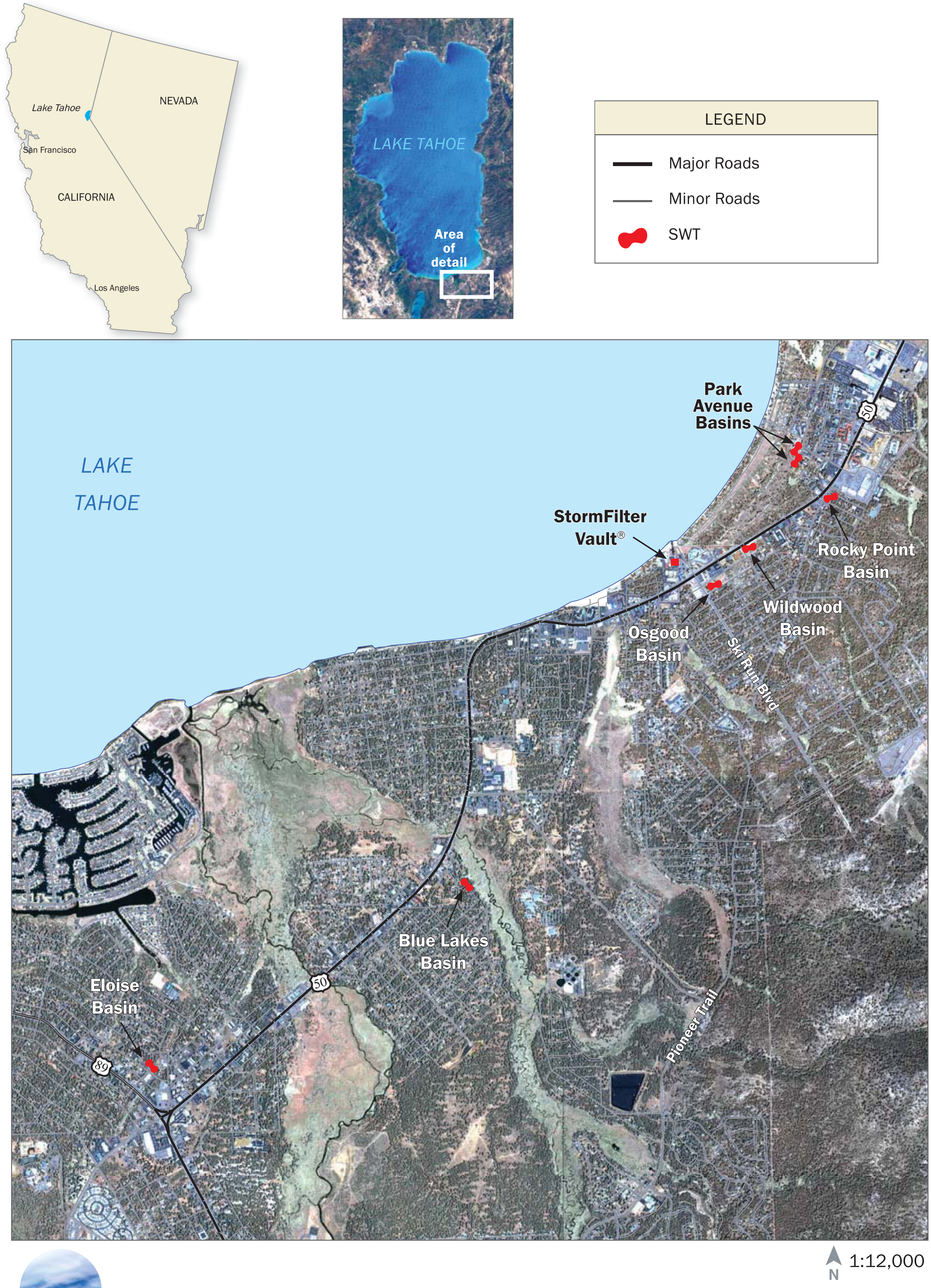
Four Lake Tahoe SWTs were monitored during the Winter 2009 (2NDNATURE 2009b): Osgood Basin, Park Avenue Upper and Lower Basins, and the Stormfilter Vault®. The 2 wet basins, 1 dry basin, and 1 cartridge filter had been previously instrumented and monitored by the 2NDNATURE team, which limited the need for extensive site reconnaissance prior to instrumentation, improved data collection and analysis efficiency by building upon previous knowledge, and provided cost sharing opportunities with other monitoring agencies.

The SNPLMA funding will allow for the continuation of monitoring at the existing 4 SWTs, plus the expansion of monitoring efforts to include an additional 5 SWTs. Detailed surface water hydrology monitoring and water quality sample collection will be conducted at 4 additional SWTs. To date, 2 dry basins, Blue Lakes Basin and Rocky Point South Basin, have been selected and are currently instrumented. Surface water hydrology monitoring only will be conducted at 3 SWTs: Eloise Basin, Wildwood North Basin, and Coon Basin. The concentration of sites in South Lake Tahoe will drastically reduce field personnel travel time during stormwater runoff events (Figure 2.5).

Osgood Basin (Wet Basin) [Figure 2.6]

Monitoring at Osgood Basin will build upon the 2NDNATURE (2009b) monitoring and include event-based surface water sample collection, surface water hydrology monitoring and SWT condition evaluations. Osgood Basin was selected by the research team for SWT monitoring because it is currently being monitored by the City of South Lake Tahoe (CSLT) and significant cost-sharing opportunities exist to improve data collection and analysis efficiency. CSLT agreed to share instrumentation and monitoring resources with the 2NDNATURE research team.

Osgood Basin currently accepts runoff from the Keller Canyon (a natural drainage with sparse residential neighborhoods and densely wooded areas) and Bijou Park Creek (highly urbanized catchment) Watersheds. In November 2007, CSLT instrumented 3 locations (Keller Canyon drainage outlet [KC1], Osgood Basin inlet [KC2 or OSGIN], Osgood Basin outlet [KC3 or OSGOUT]) with Sigma flow meters and automated samplers. Continuous flow (cfs) measurements are recorded by Sigma 950 data loggers on 10-minute intervals to create annual hydrographs. Sigma 900 series automated samplers are equipped with 24 1-liter bottles and are programmed to collect flow-weighted samples throughout a storm event. CSLT continues to monitor in accordance with the approved monitoring plan (CSLT 2007). However, in those cases when CSLT would not collect samples from the inlet (KC2 or OSGIN) and outlet (KC3 or OSGOUT) of Osgood Basin due to insufficient flow in the Keller Canyon watershed (monitoring site KC1), the 2NDNATURE research team bears the costs to monitor and sample the storm event. Results from all submitted samples will be shared between the parties.



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SWT MONITORING SITE LOCATION MAP

FIGURE 2.5

Height	OSG_IN	OSG_B	OSG_OUT
Top	**#2** 103.30	**#3** 102.02	**#2** 102.05
Middle	**#1** 103	**#2** 101.30	**#1** 101.33
Grade	None	**#1** 100.9	**#3** 100.93

Shaded topographic contours of Osgood Basin plotted over a 2001 IKONOS image. Elevations values are in feet, with a contour interval of 0.5 feet. Elevation is relative to 0ft on staff plate where: 0ft staff = 100ft elevation

FIGURE 2.6

Park Avenue Basins [Upper (Wet Basin) and Lower (Dry Basin) Basins] [Figure 2.7]

Monitoring at both Park Avenue Basins will extend 2NDNATURE (2009b) data collection and include event-based surface water sample collection, surface water hydrology monitoring and SWT condition evaluations. The Park Avenue Basins were selected for sampling due to the research team's familiarity with the site, existing infrastructure to house instrumentation, and the close proximity to Osgood Basin (see Figure 2.5).

Park Avenue Basins were the site for event-based and seasonal hydrologic and water quality monitoring from November 2005 to December 2007 by 2NDNATURE under contract with CSLT. Flow meters and automated samplers were installed at both inlets to the Upper Basin to monitor inflow hydrology and water quality and pressure transducers were installed within both the Upper and Lower Basins to develop basin volume time series and determine outflow frequency, duration and volumes. Although all instrumentation was removed in January 2008, the housing remains. Given the research team's knowledge of the site and the existing infrastructure, instrumenting the Park Avenue Basins for monitoring has been relatively efficient.

Stormfilter Vault® (Cartridge Filter)

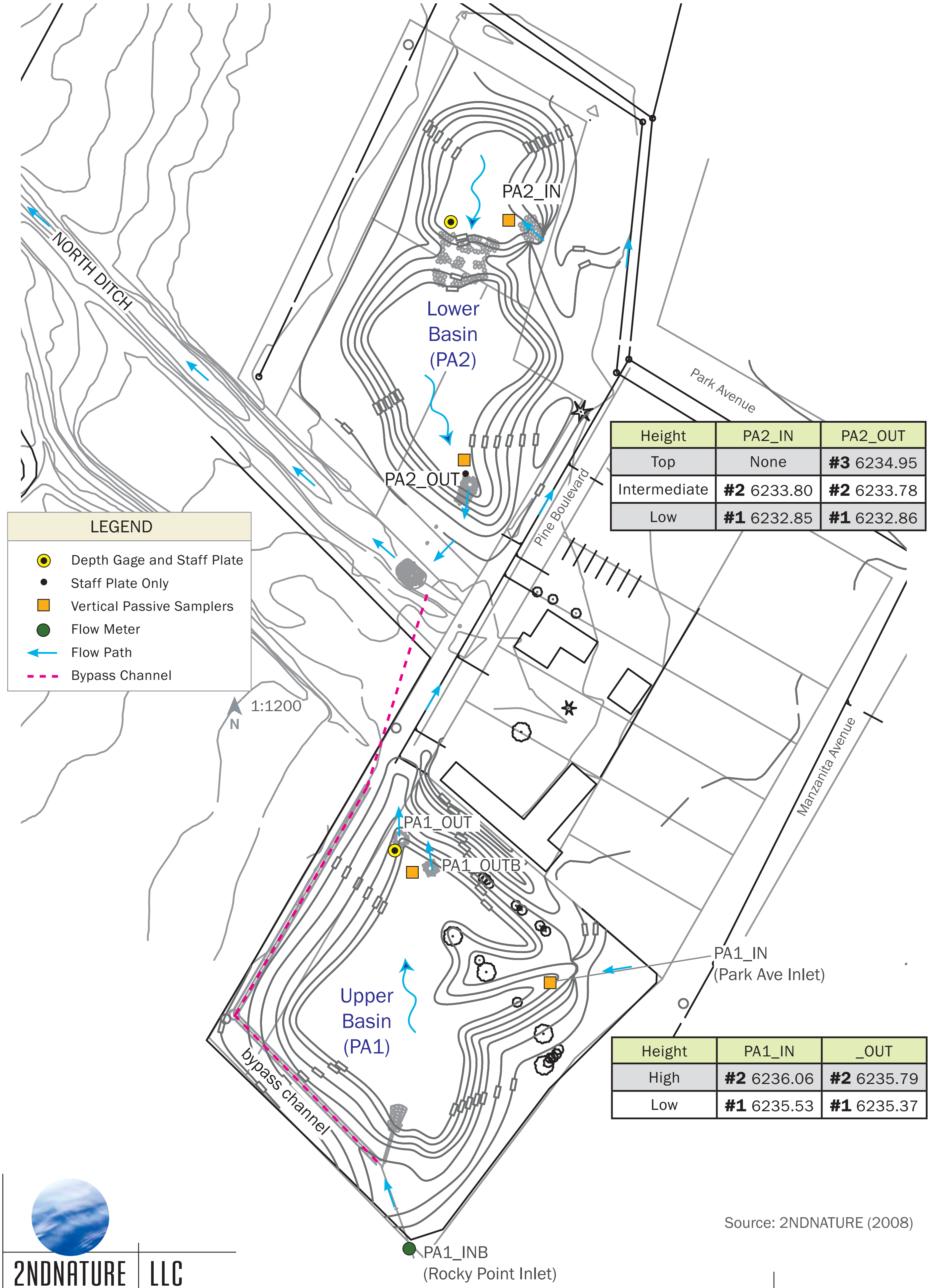
The 2NDNATURE (2009b) monitoring efforts will be continued at the Stormfilter® Vault and include event-based surface water sample collection, surface water hydrology monitoring and SWT condition evaluations. The Stormfilter Vault® was selected for sampling due to the team's familiarity with the site, existing infrastructure to house instrumentation, and the close proximity to Osgood and Park Avenue Basins (see Figure 2.5).

The Stormfilter Vault® was installed in the Ski Run Marina parking lot in 2001 as a passive, flow-through stormwater filtration system containing rechargeable cartridges designed to reduce effluent particulate and dissolved pollutant loads. CSLT instrumented the inlet and outlet of the treatment vault with flow meters and automated samplers to quantify the nutrient, fine sediment and iron retention capability of the proprietary SWT from November 2001 to January 2004. The research team has determined the original cartridges in the Stormfilter were replaced in Summer 2008 (CSLT pers. comm. 2009).

Rocky Point South Basin (Dry Basin) [Figure 2.8]

Rocky Point South Basin monitoring will include event-based surface water sample collection, surface water hydrology monitoring and SWT condition evaluations. The Rocky Point South Basin was selected because it has a classic design that allows for easy instrumentation and monitoring, is unlikely to have significant groundwater impacts on infiltration, and is in close proximity to the basins already instrumented for 2NDNATURE (2009b) monitoring (see Figure 2.5).

The Rocky Point Basin watershed is a relatively small area, dominated by urban land use. As part of the Monitoring Study, the contributing catchment will be characterized in GIS and include area, land use characterization, and % impervious. Additionally, 2NDNATURE will research the design, construction, and monitoring history of the site, and determine the key design parameters of the basin.



Height	PA2_IN	PA2_OUT
Top	None	**#3** 6234.95
Intermediate	**#2** 6233.80	**#2** 6233.78
Low	**#1** 6232.85	**#1** 6232.86

Height	PA1_IN	_OUT
High	**#2** 6236.06	**#2** 6235.79
Low	**#1** 6235.53	**#1** 6235.37

Source: 2NDNATURE (2008)

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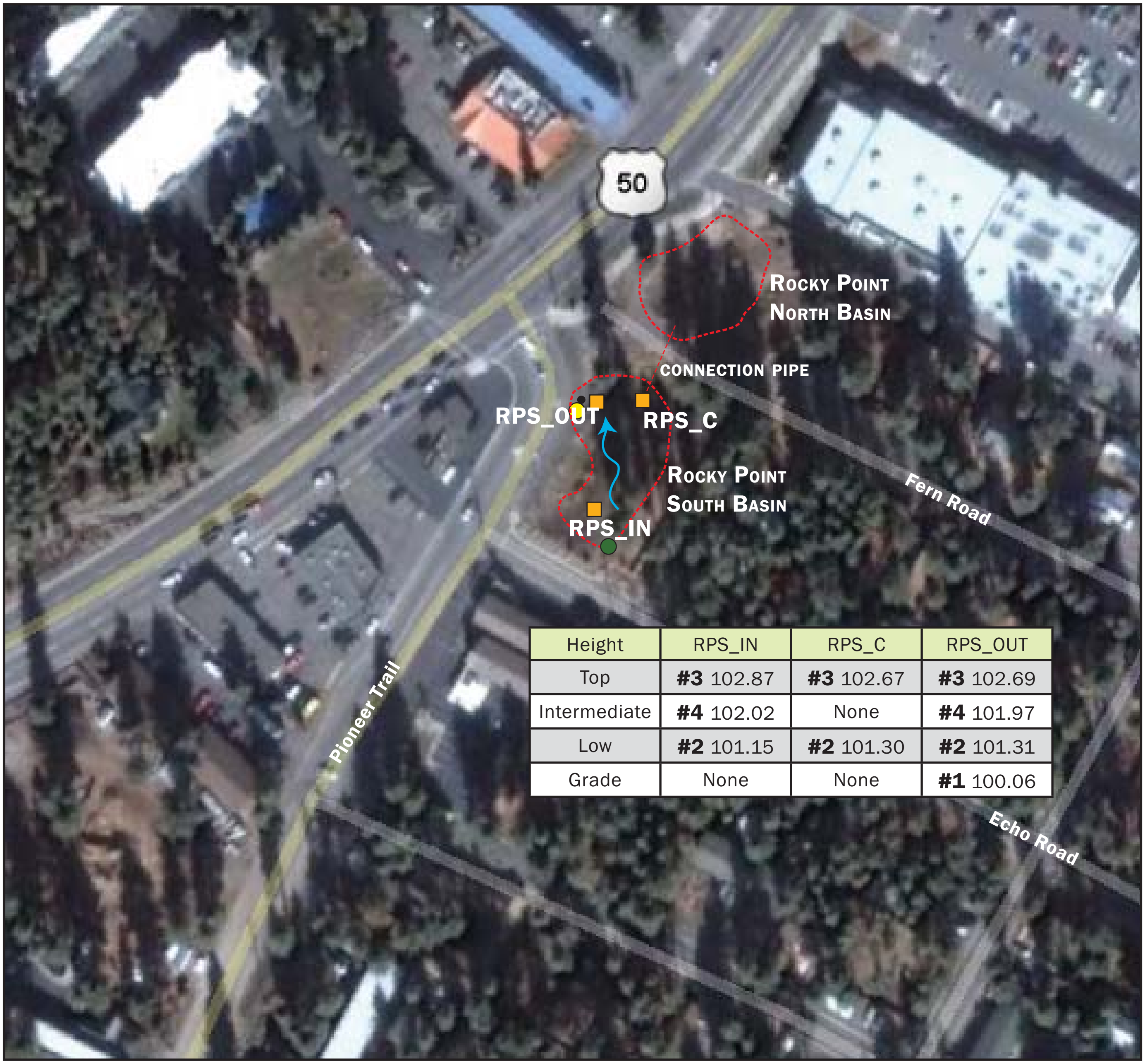
PARK AVENUE BASINS MONITORING LOCATIONS

FIGURE 2.7



Height	RPS_IN	RPS_C	RPS_OUT
Top	**#3** 102.87	**#3** 102.67	**#3** 102.69
Intermediate	**#4** 102.02	None	**#4** 101.97
Low	**#2** 101.15	**#2** 101.30	**#2** 101.31
Grade	None	None	**#1** 100.06

Photo Source: Google Earth
Note: Photos are provided for orientation purposes only. Following in-depth site surveys, improved graphics will be provided in the technical report.

LEGEND

- ◉ Depth Gage and Staff Plate
- 🟧 Vertical Passive Samplers
- ● Flow Meter
- ← Flow Path
- ------- Estimated SWT Boundary

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ROCKY POINT SOUTH BASIN MONITORING LOCATIONS

FIGURE 2.8

Blue Lakes Basin (Dry Basin) [Figure 2.9]

Blue Lakes Basin monitoring will include event-based surface water sample collection, surface water hydrology monitoring and SWT condition evaluations. The Blue Lakes Basin was selected because it has a classic design that allows for easy instrumentation and monitoring, is unlikely to have significant groundwater impacts on infiltration, and is in close proximity to the basins already instrumented for 2NDNATURE (2009b) monitoring (see Figure 2.5).

The Blue Lakes Basin watershed will be characterized as part of this Monitoring Study and include area, land use characterization, and % impervious. The Blue Lakes Basin was constructed in 2005 as part of the Sierra Tract Phase 2 Erosion Control Project. The key design parameters of the dry basin will be derived using Sierra Tract Phase 2 construction documents and a reconnaissance survey of the dry basin.

Eloise Basin (Dry Basin) [Figure 2.10]

Eloise Basin monitoring will include surface water hydrology monitoring and SWT condition evaluations. Eloise Basin was selected for sampling due to the research team's familiarity with the site, existing infrastructure to house instrumentation, and the close proximity to 2NDNATURE (2009b) monitoring locations (see Figure 2.5).

Eloise Basin was the monitored from November 2001 to December 2005 as part of two sequential event-based and seasonal hydrologic and water quality monitoring studies conducted by 2NDNATURE personnel for Tahoe Regional Planning Agency (TRPA) and South Tahoe Public Utility District (STPUD). Flow meters and automated samplers were installed at the inlet and outlet from 2001 to 2003; however, backwatering conditions at the inlet made the instrument of limited benefit. Pressure transducers were installed intermittently from 2001 through 2005 to develop basin volume time series and determine outflow frequency, duration and volumes. All instrumentation was removed in December 2005. Given the research team's knowledge of the site and the existing infrastructure, instrumenting and monitoring Eloise Basin will be relatively efficient.

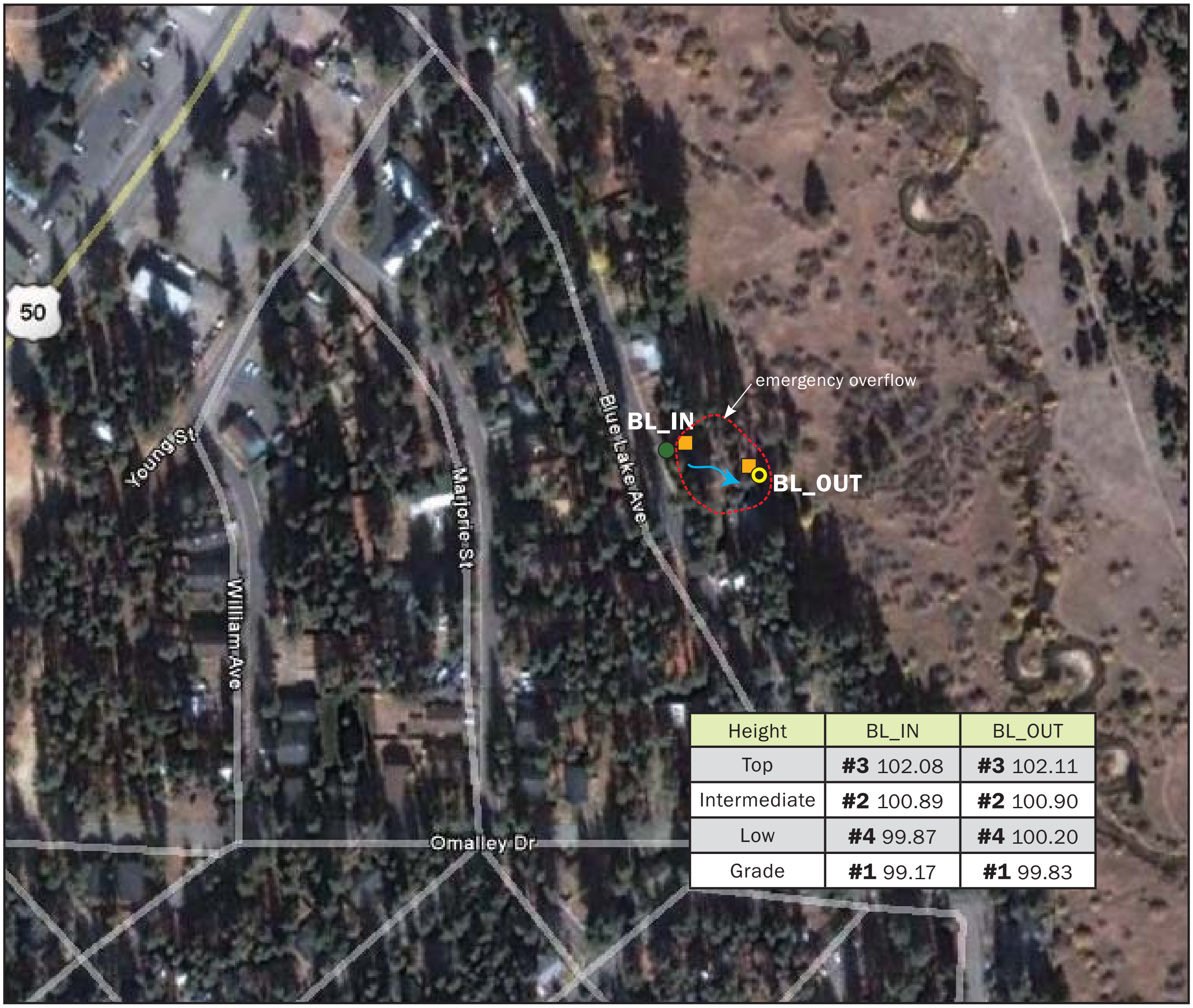
Wildwood North Basin (Dry Basin) [Figure 2.11]

Wildwood North Basin monitoring will include surface water hydrology monitoring and SWT condition evaluations. The Wildwood North Basin was selected for monitoring due to the significant volume of runoff routed to it, the relative unlikelihood that local groundwater will significantly impact the basin's infiltration capability, and its proximity to the previously instrumented 2NDNATURE (2009b) SWTs (see Figure 2.5).

Wildwood Basin has been previously monitored by CSLT and receives runoff from at least 3 separate catchments, including one inlet that receives runoff directly from Highway 50, a primary high risk road (PHR) maintained by Caltrans.

Coon Basin (Dry Basin) [Figure 2.12]

Coon Basin monitoring will include surface water hydrology monitoring and SWT condition evaluations. Coon Basin has been previously surveyed by DRI and the research team will use this existing data to develop the stage to storage volume rating curve for the dry basin SWT. Additionally, Coon Basin can provide information concerning treatment performance factors outside of the south shore of Lake Tahoe.



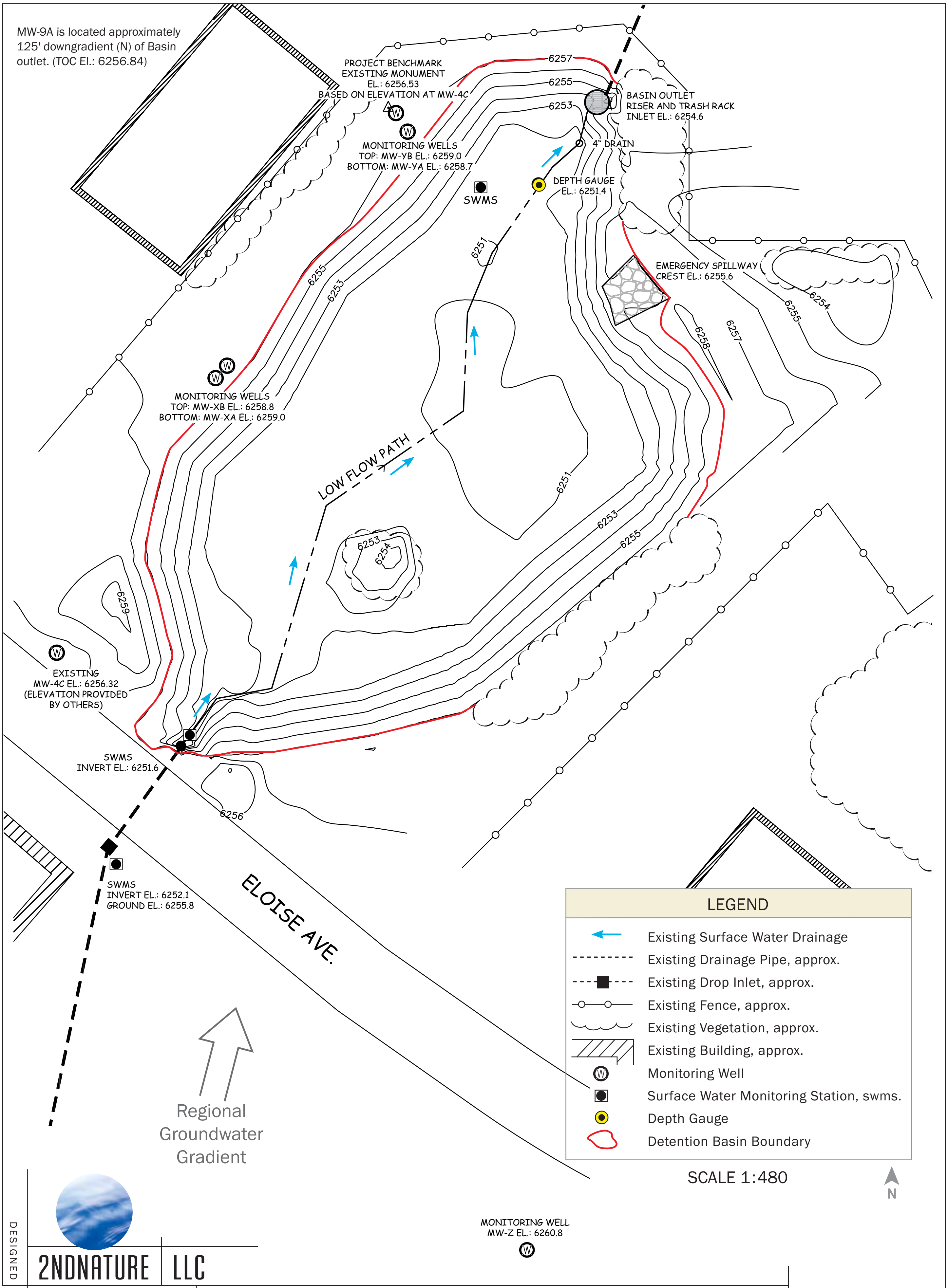
Height	BL_IN	BL_OUT
Top	**#3** 102.08	**#3** 102.11
Intermediate	**#2** 100.89	**#2** 100.90
Low	**#4** 99.87	**#4** 100.20
Grade	**#1** 99.17	**#1** 99.83

LEGEND	
◉	Depth Gage and Staff Plate
🟧	Vertical Passive Samplers
●	Flow Meter
←	Flow Path
-------	Estimated SWT Boundary

Photo Source: Google Earth
Note: Photos are provided for orientation purposes only. Following in-depth site surveys, improved graphics will be provided in the technical report.

BLUE LAKES BASIN MONITORING LOCATIONS

FIGURE 2.9



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ELOISE BASIN MONITORING LOCATIONS

FIGURE 2.10

LEGEND	
◉	Depth Gage and Staff Plate
←	Flow Path
- - - -	Estimated SWT Boundary

Photo Source: Google Earth
Note: Photos are provided for orientation purposes only. Following in-depth site surveys, improved graphics will be provided in the technical report.

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WILDWOOD BASIN MONITORING LOCATIONS

FIGURE 2.11

Photo Source: Google Earth
Note: Photos are provided for orientation purposes only. Following in-depth site surveys, improved graphics will be provided in the technical report.

LEGEND	
◉	Depth Gage and Staff Plate
←	Flow Path
-------	Estimated SWT Boundary

COON STREET BASIN MONITORING LOCATIONS

FIGURE 2.12

Additional SWTs

The 2NDNATURE team is investigating the inclusion of two additional SWTs into the Phase II monitoring and analysis. Caltrans has been monitoring the stormwater treatment capability of the bed filters installed on Highway 50 between Meyers and South Lake Tahoe for several years. The 2NDNATURE Team will coordinate with Caltrans and the contracted monitoring consultants to determine the applicability of the current monitoring dataset to the analysis of the Phase II monitoring data. Additionally, 2NDNATURE field personnel are coordinating with Vail Resorts to obtain permission to monitor the treatment vault located in the Heavenly Ski Resort parking lot. Once permission is obtained, 2NDNATURE monitoring will include event-based surface water sample collection, surface water hydrology monitoring and SWT condition evaluations.

SWT INSTRUMENTATION AND SAMPLE COLLECTION APPROACH

The instrumentation and sample collection approaches vary by SWT type (dry basin, wet basin, cartridge filter). Table 2.2 summarizes the instrumentation for each site. Eight SWTs (Osgood Basin, Park Avenue Upper and Lower Basins, Stormfilter® Vault, Rocky Point South Basin, Blue Lakes Basin, and 2 as-of-yet unselected SWTs) have been/will be instrumented for both detailed hydrologic monitoring and influent/effluent sampling (Figure 2.5). An additional 3 SWTs (Eloise Basin, Wildwood North Basin, and Coon Basin) have been instrumented for surface water hydrology monitoring only. The specific instrumentation and sampling approach is discussed below by SWT type. In addition to instrumentation at each site, a topographic survey is necessary for all sites to obtain critical instrumentation and SWT elevations as well as to create a stage-storage rating curve for each SWT where continuous water budgets will be created.

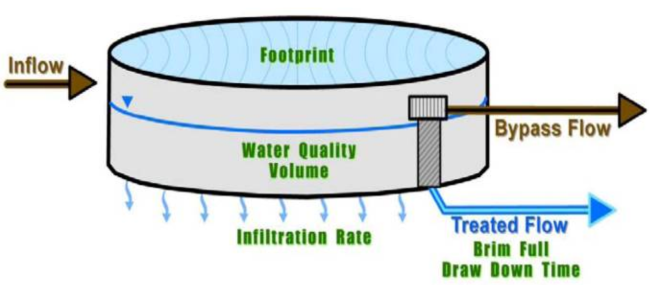
Table 2.2. SWT Monitoring Site Instrumentation. See Figures 2.6 through 2.12 for site-specific instrumentation locations. Instrumentation in grey was previously installed under a separate monitoring contract. Descriptions indicate the following instrumentation: Flow = Sigma 950 Flow Meter; Stage = InSitu LevelTroll 500; Auto: Sigma 900 Series Automated Sampler; PS = Passive Sampler.

SWT	SWT Type	Instrumentation		SWT Topographic Survey Completion Date
		Event-Based Surface Water Sample Collection (Site ID)	Surface Hydrology (Site ID)	
Osgood Basin	Wet Basin	Inlet Auto (OGIN_ASC) Outlet Auto (OGOUT_ASC) Inlet PS1-2 (OGIN_PS) Basin PS1-3 (OGB_PS) Outlet PS1-3 (OGOUT_PS)	Inlet Flow (OGIN) Outlet Flow (OGOUT) Basin Stage (OG_LT)	Summer 2009
Park Avenue Upper Basin (PA1)	Wet Basin	Inlet PS1-2 (PA1IN_PS) Outlet PS1-2 (PA1OUT_PS)	Inlet Flow (PA1INB) Basin Stage (PA1_LT)	Summer 2007
Park Avenue Lower Basin (PA2)	Dry Basin	Inlet PS1-2 (PA2IN_PS) Outlet PS1-3 (PA2OUT_PS)	Basin Stage (PA2_LT)	Summer 2007
Rocky Point South Basin	Dry Basin	Inlet PS2-4 (RPSIN_PS) Outlet PS1-4 (RPSOUT_PS) Connection PS2-3 (RPSC_PS)	Inlet Flow (RPSIN) Basin Stage (RPS_LT)	Summer 2010
Blue Lakes Basin	Dry Basin	Inlet PS1-4 (BLIN_PS) Outlet PS1-4 (BLOUT_PS)	Inlet Flow (BLIN) Basin Stage (BL_LT)	Fall 2009
Eloise Basin	Dry Basin	n/a	Basin Stage (EL_LT)	Summer 2003
Wildwood North Basin	Dry Basin	n/a	Basin Stage (WWN_LT)	Summer 2010
Coon Basin	Dry Basin	n/a	Basin Stage (Coon_LT)	Summer 2010
Stormfilter Vault®	Cartridge Filter	In Auto (SFIN_ASC) Outlet Auto (SFOUT_ASC)	Inlet Flow (SFIN) Outlet Flow (SFOUT) SWT Stage (SF_LT)	Summer 2010

Significant cost-sharing for this monitoring study has been achieved through collaboration with both CSLT and TRPA. To date, CSLT has provided 8 In-Situ LevelTrolls, 1 In-Situ BaroTroll, 2 Sigma 950 Flow Meters, and 2 Sigma Automated Samplers, and may be providing an additional 1-3 Sigma Flow Meters and Automated Samplers. TRPA has contributed 5 Sigma Flow Meters and 2 Sigma Automated Samplers to the monitoring efforts. Site instrumentation will continue through January 2010 as instrumentation becomes available from our partners.

Wet Basin/Dry Basin Monitoring (Protocols C-E)

PLRM modeling of Wet and Dry Basins



PLRM Dry Basin schematic illustrating water quality volume, bypass flow through the bypass outlet structure, and treated flow through the treatment outlet. Wet Basin requirements include wet pool volume (not water quality volume) and hydraulic residence time (not brim full draw down time). See PLRM (nhc et al 2009b) for complete discussion and definition of terms.

PLRM v1 is designed to assign a static characteristic effluent concentration (CEC) for each pollutant of concern to the volume of the effluent water from a specific SWT has been "treated". When the SWT treated flow capacity is exceeded, PLRM assumes the excess volume is bypass and the bypass CEC = the inflow CEC. PLRM v1 requirements for wet and dry basins are different, yet share similar concepts for calculating treated and bypass flows. The wet pool volume (wet basin) and water quality volume (dry basin) is defined by the storage capacity of the SWT below the bypass outlet structure designed for water quality treatment. The treated water quality volume is assigned a static CEC that assumes proper treatment within the SWT and improved water quality. The CEC assigned in PLRM varies by SWT type and pollutant of concern. One of the primary challenges of this SWT research is to identify appropriate field sampling protocols, as well as data analysis techniques of SWT-specific and temporally-specific data, to inform PLRM CEC values for water quality volumes by SWT type.

Surface Water Hydrology

A continuous water budget is created at each dry and wet basin using a stage recorder (In-Situ LevelTroll 500) and detailed topographic elevation data. The stage recorders are installed within the SWT to record water depth on 15-minute intervals (see Protocol C). In conjunction with the recorder, staff plates are installed and used to manually verify and QA/QC stage recorder data. Topographic surveys will be completed by Summer 2010 for all SWTs, including specific elevation of all critical basin features (inlet(s), outlet(s), stage recorder, staff plate, etc.). Basin topographic data will be tied to continuous stage data to create a depth to volume rating curve and continuous basin storage volume time series. The basin volume(s) at outflow will be determined using the depth to volume rating curve and surveyed outlet elevations. The basin volume time series will be compared to outflow volume(s) and change in basin water storage will be used to create a detailed surface water budget and determine event, seasonal and annual inflow and outflow volumes using the following equation:

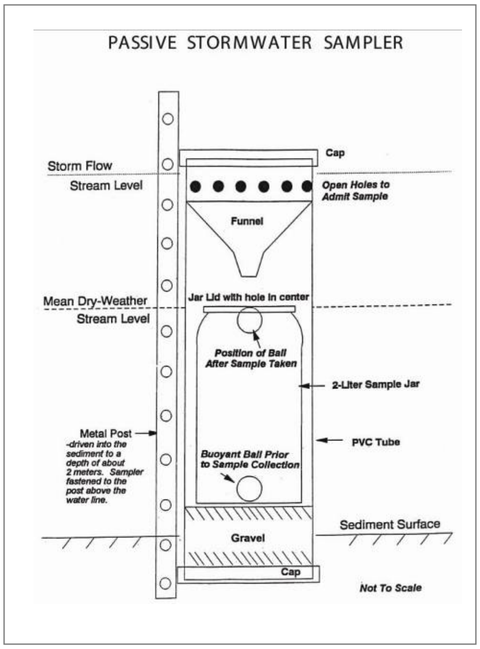
Change in Storage (volume) = Water Inputs (volume) – Water Losses (volume) [EQ1],

where change in basin water storage at any one time is the net balance of inputs minus losses over the same duration. Water inputs include all surface water runoff entering the SWT through constructed inlets and direct precipitation. Water losses include water exiting the SWT through infiltration, outflow through one or more of the SWT outlet features, and/or evapotranspiration.

Only Osgood Basin has been instrumented with Sigma 950 Flow Meters at both the inlet and outlet due to on-going CSLT monitoring at the SWT. Flow meters were installed in the Fall 2009 at the inlets of Park Avenue Upper Basin, Rocky Point South Basin and Blue Lakes Basin. An additional 1-3 flow meters may be available from CSLT. If these flow meters are provided, selection of the monitoring locations will be determined with input from the TAC. The flow meter continuous inflow hydrographs will be used to QA/QC the surface water budget calculations and inform our estimates of contributing catchment volumes and treated versus bypassed volumes.

Event-Based Surface Water Sample Collection

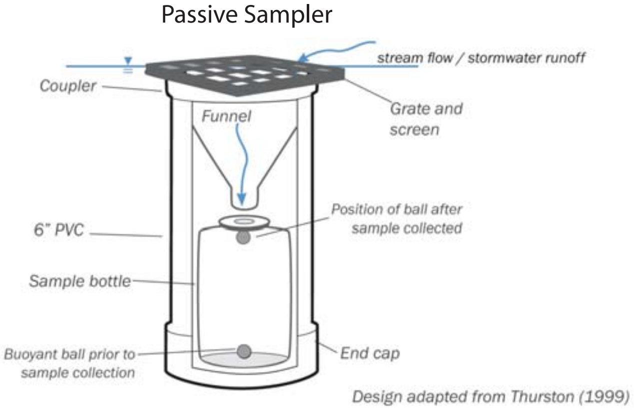
Passive samplers are the primary sampling technique to sample the influent and effluent water quality of selected SWTs (see Table 2.2). Passive samplers are designed as a low-cost method to simultaneously collect water samples associated with a specific basin water surface elevation at both the SWT inlet and outlet. Bottles can be installed weeks prior to the targeted sampling events and collect a water sample on the rising limb of the hydrograph (standardizing sample collection across all sites) without the need for field personnel to be on-site during the storm event. Passive samplers are self-sealing to preserve the sample until field personnel can safely retrieve the sample for laboratory analysis.



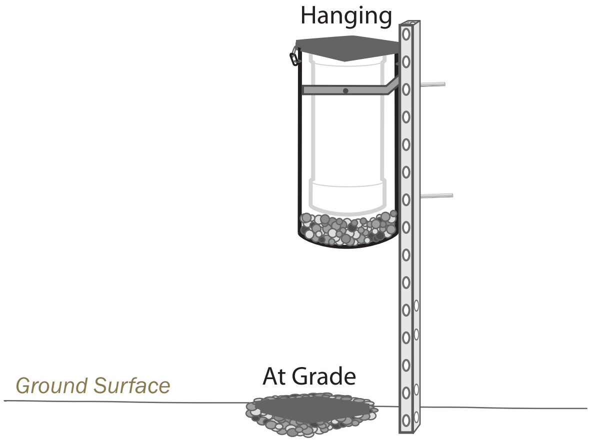
At each selected SWT, a number of passive samplers are installed at the inlet and outlet, placed vertically at distinct water surface elevations to collect a number of water samples at different stages of the SWT inundation hydrograph. Figure 2.13 provides a general schematic illustrating the sample collection approach. Sample collection is standardized based on relative SWT stage and the event volume during collection can be estimated using the surface water budgets for each SWT. Prior to installation, the elevations of all SWT outlet features were determined using topographic survey techniques. Passive samplers are installed at both the inlet and outlet to capture each of the following elevations: (1) at grade with the base of the SWT, (2) at the elevation of the treatment outlet, (3) halfway between the treatment and bypass outlet elevations, and (4) at the bypass outlet elevation. In some instances, the number of passive samplers may be less if elevation differences between the treatment and bypass outlet elevations are relatively small. Figures 2.14A-E illustrates the relative elevations and locations of the passive samplers specific to each of the 5 SWTs currently instrumented for passive water sample collection.

Field personnel will periodically collect grab samples from the SWT treatment outlet when outflow occurs, noting the date and time of sample collection (see Field Protocol I). These water quality results will be compared to the passive sampler results to address any bias introduced by the passive sampler monitoring technique. Passive samplers collect water at a fixed water surface elevation during the rising limb of the hydrograph. The grab sample timing will be compared to the SWT stage time series to determine the hydrograph position. These samples will provide a more complete picture of the SWT treated pollutant loads.

BASIN SWT PASSIVE SAMPLER DESIGN

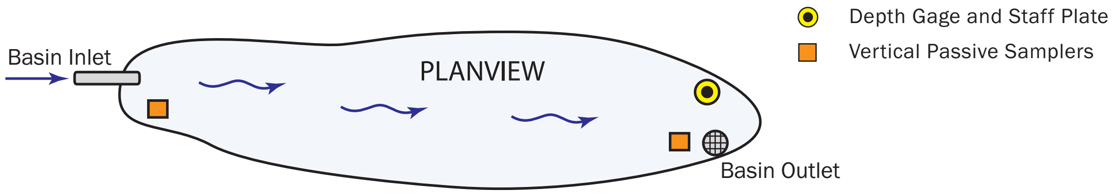


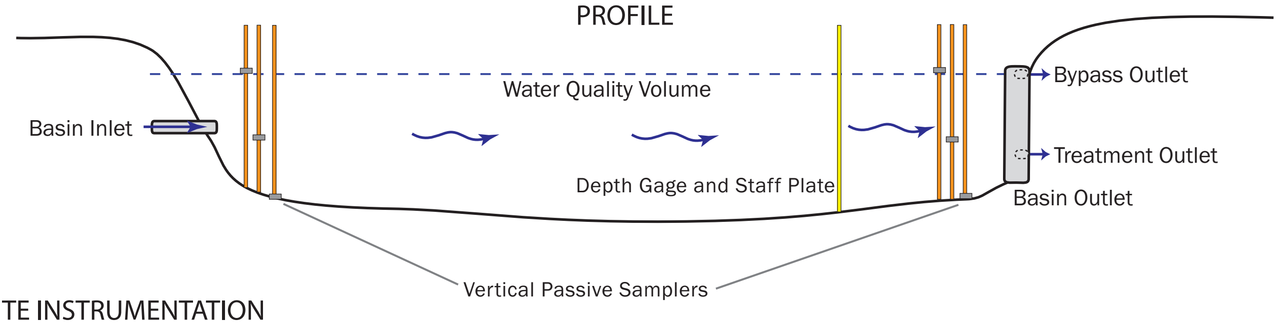
Design adapted from Thurston (1999)



- Passive samplers can be custom fabricated to meet site-specific needs, but typically are Nalgene Stormwater Samplers®.
- Passive samplers can be (1) buried in the flow path to collect sample at grade or (2) secured to vertical sign post to collect a sample at a targeted stage elevation (i.e., hanging).
- Sample is collected when water surface exceeds elevation of top of sampler. Sample flows over grate, through funnel and into bottle. As bottle fills with water during the event, the ping pong ball floats to the top and plugs the hole in the lid and seals the sample until it is collected by field personnel.

BASIN SWT





SITE INSTRUMENTATION

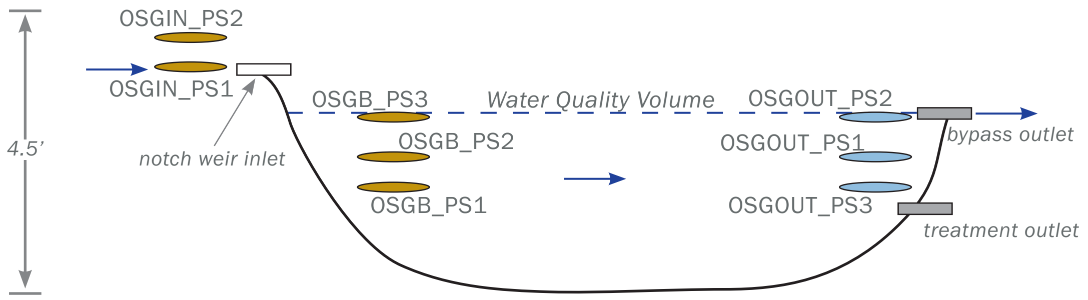
- Depth Gage installed in basin to record water depth continuously on 15-minute intervals and create surface water hydrology time series.
- Staff Plate is installed to QA/QC depth data.
- 4 - 8 Basin Passive Samplers are installed within basin (2-4 at inlet and 2-4 at outlet, depending on basin depth at invert of bypass outlet).
  - Samplers are installed to collect samples at various water surface elevations to standardize sampling based on relative basin stage.
  - Inlet and outlet sampler elevations are matched as closely as possible to create inlet/outlet sample pairs. This technique assumes that at the same basin stage, the inlet/outlet sampler pairs are collecting samples at a similar location on the storm hydrograph and observed water quality differences between the samples is the result of flow through and interaction with the SWT.

SWT SAMPLING SCHEMATIC

FIGURE 2.13

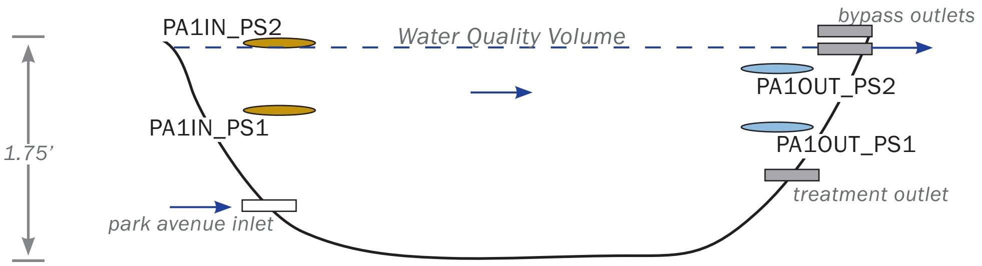
A.

Osgood Basin



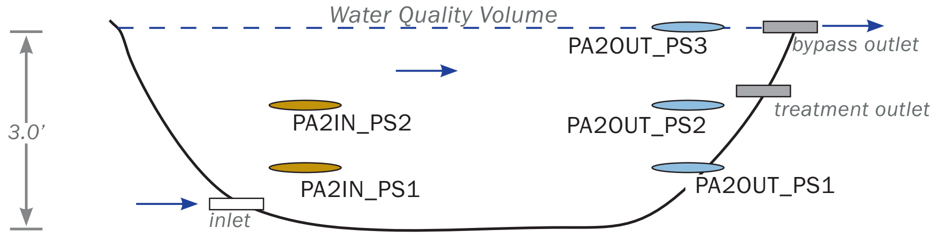
B.

Park Avenue Upper Basin (PA1)



C.

Park Avenue Lower Basin (PA2)



LEGEND

▭ Conveyance Structure
⬭ Passive Sampler

Note: Schematics drawn to show relative elevation within each SWT. Horizontal dimension is not drawn to scale.

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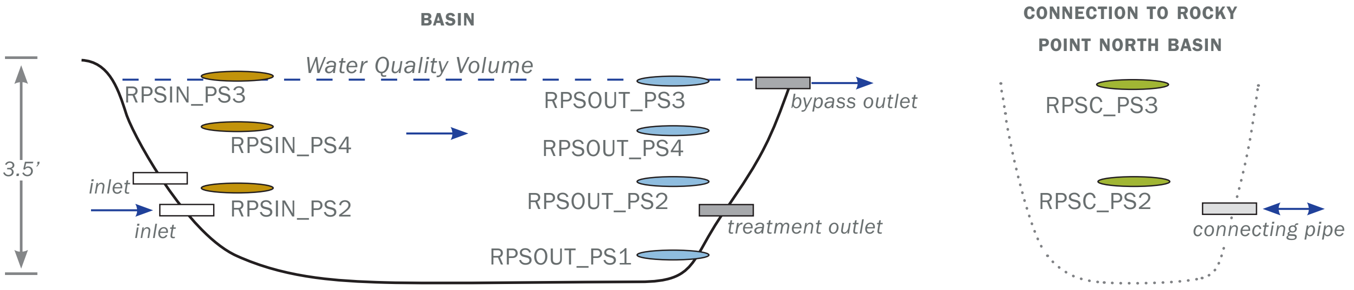
CROSS SECTION SCHEMATICS OF SWT SAMPLE COLLECTION
WINTER 2010

FIGURE 2.14

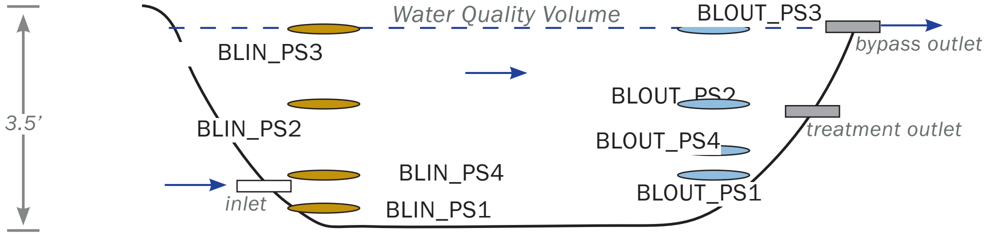
D.

ROCKY POINT SOUTH BASIN



E.

BLUE LAKES BASIN



LEGEND

▭ Conveyance Structure
⬭ Passive Sampler

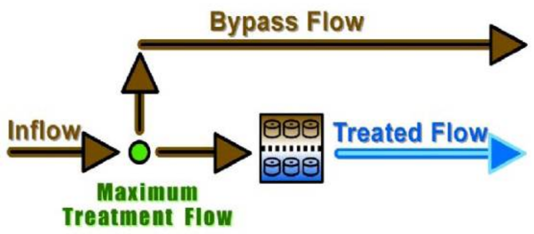
Note: Schematics drawn to show relative elevation within each SWT. Horizontal dimension is not drawn to scale.

Due to resource limitations, not all SWTs can be simultaneously instrumented with Sigma Automated Samplers at the inlet and outlet. Currently, Osgood Basin is the only SWT with automated samplers at both the inlet and outlet. This equipment has been installed by CSLT and will be used to compare and correlate the data collected by the passive samplers. Due to cost restrictions, automated samplers are currently not installed at any of the other SWTs; however, 1-3 samplers may be available from CSLT. If these instruments are provided, selection of the appropriate monitoring locations will be determined with input from the TAC.

Cartridge Filter

PLRM Modeling of Cartridge Filter

PLRM v1 requires the user to input the maximum treated flow for a cartridge filter SWT. Maximum treatment flow is defined as "the maximum flow rate through the cartridge filter that provides effective treatment" (nhc et al. 2009b). In proprietary filters, this is typically estimated as unit rate per cartridge * number of cartridges. Stormwater runoff that flows through the cartridges is considered treated flow, while all flows which exceed the maximum treatment flow are considered bypass flow. The treated flow is assigned a static CEC that assumes proper treatment within the SWT and improved water quality.



PLRM Cartridge Filter schematic illustrating bypass flow when the maximum treatment flow is exceeded, and treated flow through the SWT See PLRM (nhc et al 2009b) for complete discussion and definition of terms.

Surface Water Hydrology

A Sigma 950 flow meter was installed at the inlet and outlet of the Stormfilter Vault® in March 2009 to monitor the hydrology associated with this SWT (see Protocol D). To supplement this data, a LevelTroll 500 pressure transducer was installed within the outlet in July 2009 to continuously monitoring outflow water depths. Pipe dimensions have been measured, and outflow volumes will be calculated on event, seasonal, and annual time scales.

Water Quality Sample Collection

Automated samplers (Sigma 900 series) were installed by March 2009 within the inlet and outlet of the Stormfilter® Vault to collect flow-weighted samples throughout targeted sampling events (see Protocol D).

SWT Condition Assessments (BMP RAM)

Field personnel will conduct condition evaluations for each SWT in accordance with the protocols developed for BMP RAM (2NDNATURE 2009b). SWT condition will be evaluated for each relevant treatment process (conveyance, infiltration, particle capture, nutrient cycling, media filtration) associated with the SWT type. In order to calculate BMP RAM scores (BMP RAM STEP 5), SWT type must be properly identified (BMP RAM STEP 2) and benchmark and threshold values (BMP RAM STEP 3) must be set for each SWT. 2NDNATURE personnel will work with the responsible jurisdictions to properly conduct these steps at each SWT. 2NDNATURE will conduct discussions with jurisdictions to perform maintenance at SWT where potentially required. This information would greatly improve our ability to evaluate the effects of maintenance on SWT water quality treatment performance.

INFILTRATION RATES

PLRM v1 requires the user to input an average annual infiltration rate for each SWT; however, infiltration rates vary both temporally based on soil saturation conditions and spatially based on frequency of soil inundation within the SWT. Data collection to inform the PLRM user input requirements will include:

- Hydraulic conductivity analyses of discrete sediment samples collected from the base and sides of dry and wet basins,
- CHP measurements conducted according to the BMP RAM protocols described above, and
- Solving EQ1 for event, seasonal and annual infiltration volumes based on the detailed SWT hydrology monitoring.

To improve our spatial understanding, at least once per year during dry conditions, discrete soil samples collection and simultaneous CHP measurements will be conducted from various locations within each basin that represent assumed differences in annual inundation characteristics. The soil samples will be submitted to the Cooper Laboratory for particle grain size distribution analysis to improve the technical basis of PLRM and BMP RAM with respect to annual basin infiltration volumes, basin soil properties, and discrete spatial CHP measurements.

To improve our temporal understanding of infiltration rate variability between dry and saturated soil conditions, the SWT surface water elevation and volume time series and the water budget mass balance equation (EQ1) will be used to determine event, seasonal and annual infiltration volumes and derive a continuous infiltration volume time series. This continuous infiltration volume time series will improve estimates of average annual infiltration rates in SWTs by including times of both saturated and unsaturated soil conditions. Additionally, if resources permit, discrete soil samples and CHP measurements will be conducted during more frequently than annually to develop and improve the relationship between what can be measured rapidly and cost-effectively (CHP measurements) and the PLRM user input requirements.

PLRM MODEL DEVELOPMENT

PLRM models will be developed to estimate performance among the SWTs being monitored for water quality by 2NDNATURE. Modeled performance estimates will be compared and evaluated against monitored performance estimates to allow for better interpretation of monitoring data to validate and/or modify PLRM CECs. Modeled estimates of key performance metrics, such as hydraulic capture, will allow the 2NDNATURE team to estimate the frequency and magnitude of storm events that cause bypass to occur at each SWT, which is a key consideration when developing improved CECs based on the monitoring data collected from this study. This task involves developing 5 PLRM models, one for each SWT facility monitored for water quality, which includes: 1) Osgood Basin; 2) Upper and Lower Park Avenue Basins; 3) Rocky Point South Basin; 4) Blue Lakes Basin; and 5) Ski Run StormFilter Vault. PLRM model development as part of this study will include the following tasks:

1. Derive design parameters necessary to simulate each SWT facility in the PLRM from field surveys completed by 2NDNATURE and reconnaissance-level field investigations.
2. Develop input data on the drainage conditions for the catchment(s) draining to each SWT to simulate runoff in the PLRM. Input data will be derived from planning documents, construction plan sets, GIS resources, Google street view, and reconnaissance-level field investigations.
3. Using PLRM, generate and evaluate information on the performance of each SWT. In particular, interpret the hydraulic capture of each SWT facility to improve understanding regarding the function of the SWT. Assess the function of each SWT relative to the methods, locations, and timing of water quality monitoring data collection efforts.

4. Using PLRM models and collected monitoring data, complete a preliminary assessment of the potential effects that variable hydrology and SWT hydraulics have on CECs. Develop approaches that can be used in a subsequent effort (potential USACE funded effort) to directly predict water quality treatment performance of individual storm water runoff events at each SWT.

Note that PLRM models will not be used in this study to directly predict water quality treatment performance of individual storm water runoff events at each SWT. This type of analysis would require significantly more work than proposed to estimate antecedent conditions in the drainage catchment(s) and SWT facilities.

CHAPTER THREE. SAMPLE DELIVERY AND ANALYSES

WATER QUALITY SAMPLES

All samples collected in the field will be submitted to WETLab for TSS (mg/L) and Particle Size Distribution [PSD] (% by mass for the following particle sizes: <1µm, <10 µm, <16 µm, <20 µm, <63 µm, <100 µm and <1000 µm) analysis. As resources allow, samples will be submitted for SRP (mg/L) as well. TSS and SRP analyses are performed by WETLab (see Appendix B for WETLab standard operating procedures); PSD analysis is subcontracted to Desert Research Institute (DRI) and conducted using the laser optical backscatter (Saturn Digisizer 5200). Thus DRI researchers will have access to all stormwater samples collected for this research effort. Coordination and data sharing of necessary sample information will be provided to the DRI researchers if they choose to conduct any additional particle count analysis of any of the stormwater samples provided.

All samples will be properly labeled (see Protocol F) and submitted with the proper chain of custody forms (see Protocol G) to WETLab by field personnel within the proper holding times (Table 3.1). Field quality control samples will include field blanks and composite replicate samples (described above). Lab quality control samples will include method blanks, matrix spikes, laboratory duplicates and external standards (Table 3.2).

URBAN ROAD CONTROLLED EXPERIMENT SAMPLES

For samples collected during the controlled experiments, field personnel will submit the 1L samples (see Protocols B, F and G) directly to WETLab for analysis. Once per sampling period a field triplicate and a field blank will be submitted and analyzed by the laboratory.

ADDITIONAL LAND USE CONTROLLED EXPERIMENT SAMPLES

For samples collected during the controlled experiments on impervious surfaces, field personnel will submit the 1L samples (see Protocols B, F and G) directly to WETLab for analysis. Once per sampling period a field triplicate and a field blank will be submitted and analyzed by the laboratory.

SWT PASSIVE SAMPLER SAMPLES

For SWT samples collected from the passive samplers, field personnel will submit the 1L sample (see Protocols E, F and G) directly to WETLab for analysis. Once per event a field replicate will be analyzed by the laboratory by splitting a passive sampler sample into two equal sample volumes.

SWT GRAB SAMPLES

For SWT grab samples collected from outflow from the treatment outlet, field personnel will submit the 1L sample (see Protocols F G, and I) directly to WETLab for analysis. Once per sampling event a field replicate will be submitted and analyzed by the laboratory.

SWT AUTOMATED SAMPLER SAMPLES

For samples collected by the automated sampler, samples will be composited as follows (see Protocols D, F and G):

- All samples collected at the inlets will be composited.
- For short-duration storms and/or when the full hydrograph is not captured, outflow samples will composited by lab into 1 sample.
- For long-duration storms when the full hydrograph is captured, outflow samples will be lab-composited into 3 samples based on storm duration and flow intensity.
- Analytical replicates will be conducted regularly to document analytical precision.

SOIL SAMPLES

All soil samples collected in the field will be submitted to Cooper Testing Laboratory for particle grain size distribution analysis. Samples are submitted with the proper chain of custody forms (see Protocols F and G). A minimum mass of 50 grams (approximately 30 mL) is required for proper analysis. The particle-size analysis of soils (ASTM D 422-63) includes a combination of sieves (for particles >75µm) and a hydrometer (particles <75µm). The resulting data is presented as the sample % finer than the following approximate particle sizes: 9.5mm (3/8in sieve), 4.76mm (sieve #4), 1.00mm, 50µm, 35µm, 23µm, 13µm, 9µm, and 6µm.

URBAN ROAD DRY SEDIMENT SAMPLES

A fraction of the dry material samples collected from the urban road segments are kept and submitted for PSD analysis to refine the Road RAM and validate the degree of fine material visual observation protocols.

ADDITIONAL LAND USE DRY SEDIMENT SAMPLES

A fraction of the dry material samples collected from the impervious and pervious land use surfaces are kept and submitted for PSD analysis to refine the visual observation protocols.

SWT SOIL SAMPLES

Soil samples collected from within the SWTs will be submitted for PSD analysis to improve our technical understanding of infiltration volumes, CHP measurements, and SWT treatment performance over time.

Table 3.1. Analytical Laboratory Sample Requirements per Analysis Yype.

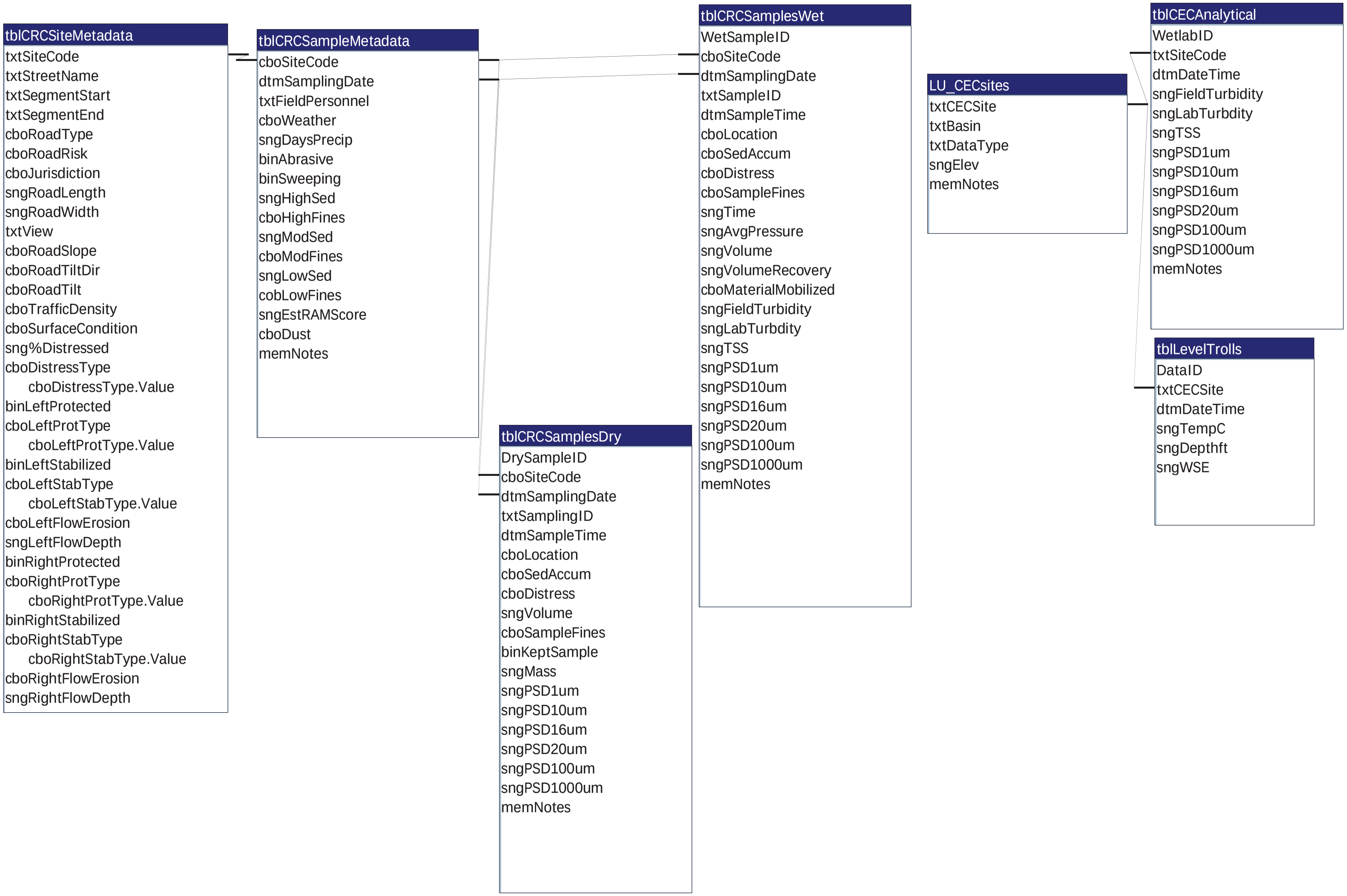
Analysis	Analysis Method	Detection Limit	Sample Volume (mL)	Sample Bottle Type	Holding Time	Preservation Method
Total Suspended Sediment (TSS)	EPA 160.2	1 mg/L	300mL	HDPE	7 days	On ice (4^{o}C)
Particle Size Distribution (PSD) – Water Samples	Saturn Digisizer 5200	n/a	<600mL	HDPE	28 days	On ice (4^{o}C)
Soluble Reactive Phosphorous (SRP)	SM 4500-PE	1 µg/L	300mL	HDPE	2 days	On ice (4^{o}C)
Particle Size Distribution (PSD) – Soil Samples	ASTM D 422-63	~6.6 µm	~30mL (50g)	Ziploc	N/A	N/A

Table 3.2. Type and Frequency of QA/QC Samples.

Sample Type	Sample Frequency
Field Blank	One per event – hold for analysis pending analytical results
Composite Replicate	One per event per 3 sites – rotate sampling site
Method Blank	One per event – rotate sampling site
Matrix Spike	One per run for each analyte
Analytic Duplicate	One per run for each analyte
Analytic Blank	One per run for each analyte
External Standard	One per run for each analyte

CHAPTER FOUR. DATA MANAGEMENT

All data collected under this Monitoring Plan will be managed in a digital Microsoft (MS) Access relational database (PLRMDatabaseRefinement.accdb; Figure 4.1). Field site observations will be recorded entered into Palm Pilots during all sampling and instrument maintenance activities. Upon return to the office, all data will be QA/QC'd for accuracy and completeness and then integrated into the MS Access database. Instrument downloads will be corrected for barometric pressure as necessary, checked for inaccuracies, and calibrated to the relevant spot measurements prior to database entry (see Protocol C). Results of lab analyses will be submitted electronically by the laboratory, checked for data quality and completeness, verified against the chain of custody record, and then entered into the database.



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STUDY DATABASE STRUCTURE

FIGURE 4.1

CHAPTER FIVE. FIELD PROTOCOLS

Keys to good field work:

- *Be safe. Event sampling is by nature hazardous due to storm conditions. Field personnel should always wear proper protective clothing when outside during a storm. Personnel safety always comes first. Use best professional judgment. If conditions do not allow safe access to the sampler, personnel should wait until safe conditions exist.*
- *Be safer. Road sampling is dangerous and some sites are in heavily trafficked areas. Use traffic cones to alert/divert traffic as necessary. All field personnel should wear orange safety vests when conducting CRC evaluations.*
- *Follow the protocols closely and review prior to each field mobilization. Use the provided data sheets.*
- *Take detailed field notes in a field notebook. At the end of the field day, spend several minutes reviewing notes and adding any additional information, observations, problems encountered, suggestions, etc.*
- *Take photos detailing station condition, discharge events. Establish photo points (location, camera orientation) and repeat every field visit to document changes over time. Detail the locations of each photo on field datasheet or in field notebook.*
- *All field work is referenced by view/context looking downstream/downslope (e.g., right road shoulder is defined as the road shoulder on right when looking downslope).*
- *Take all precautions to avoid sample contamination.*
- *Be aware of the pollutant of concern and take all precautions to avoid contamination. Sources of contamination vary with different pollutants.*
- *Clean sample bottles, field equipment, etc. with distilled, de-ionized (DI) water.*
- *Properly label samples according to protocols and accurately complete chain of custody forms.*

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- *WETLAB, Office: (775)355-0202*
- *Raph Townsend, Field Sampling: (530) 386-2454, raph_townsend@yahoo.com*
- *Cory Hunt, Field Sampling: (530) 541-2980 or (775) 530-7319, chunt@enviroincentives.com*

ATTACHED PROTOCOLS

Protocol A: Road Condition Evaluations (Visual Observations and Dry Material Sampling)

Protocol B: Controlled Urban Road Experiments (Wet Sediment Sampling)

Protocol C: InSitu Installation and Maintenance

Protocol D: Sigma Installation, Maintenance and Sample Collection

Protocol E: Passive Sampler Installation, Maintenance and Sample Collection

Protocol F: Sample Labeling

Protocol G: Chain of Custody

ATTACHED DATASHEETS

Road Condition Evaluation Datasheets

Instrument Logs (Sigma, InSitu)

Chain of Custody

Labels

CHAPTER SIX. REFERENCES

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Lake Tahoe Pollutant Loading Reduction Model (PLRM) Database Refinement
Final Phase II Monitoring Plan: Protocols, Field Datasheets & Appendices

Prepared for: USDA Forest Service Pacific Southwest Research Station

July 2010

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http://www.fs.fed.us/psw/partnerships/tahoescience/
The views in this report are those of the authors and do not necessary reflect those of the USDA Forest Service Pacific Southwest

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PROTOCOLS

Protocol A: Road Condition Evaluations (Visual Observations and Dry Material Sampling)

Protocol B: Controlled Urban Road Experiments (Wet Sediment Sampling)

Protocol C: InSitu Installation and Maintenance

Protocol D: Sigma Installation, Maintenance and Sample Collection

Protocol E: Passive Sampler Installation, Maintenance and Sample Collection

Protocol F: Sample Labeling

Protocol G: Chain of Custody

Urban Road Condition Evaluations

Overview

Road condition evaluations include visual assessment and dry material sampling methodologies. Below the protocols are provided for all data collection techniques, as well as General Safety and Site Set-up Protocols.

Personnel Needed: 2 field personnel 30 minutes per road segment for Road Condition Evaluation

General Equipment Needed:

- Large Traffic Cones (6-10)
- Orange Safety Vests
- Camera
- Sharpies
- Field Datasheets/Palm Pilots
- Field Notebooks
- Field Maps
- Tahoe Street Map
- Pens/Pencils
- Tool Box

General Road Segment Site Set-up/Safety/Field Protocols:

NOTE: Field personnel safety is of utmost importance. Use extreme caution when working on side of road.

1. SAFETY
    a. Field truck should be parked completely on road shoulder, out of drive lane. Park in area of high visibility – avoid curves in road, etc. When parked put on 4-way flashers.
    b. All field personnel should wear brightly colored safety vests.
    c. Place traffic cones on side of road. Cones should provide adequate warning to traffic – up to 200 yards away in both directions for high speed roads. Cones should be placed every 50-100 yards and extend a few feet into drive lane to create buffer for field personnel, while minimizing motorist disturbance and without forcing cars into oncoming traffic lane.
    d. The orange cones create the 'safety zone'.
        i. Never stand outside of safety zone.
        ii. Set up all equipment several feet within safety zone.
        iii. Unless absolutely necessary, do not stand between equipment and edge of safety zone.
        iv. Unless absolutely necessary, do not stand/kneel with back to oncoming traffic.
    e. **Look out for one another.** If someone has his/her head down sweeping the road, someone else should be looking out for traffic and providing warnings. If someone yells "Move!", don't think, just move.
    f. Check weather and highway conditions prior to starting the day to ensure access to road sites.
        i. NDOT: http://www.nevadadot.com/traveler/roads/
        ii. Caltrans: http://www.dot.ca.gov/cgi-bin/roads.cgi
        iii. Weather: http://www.weather.gov/
2. FIELD NOTES
    a. **Field notes can never be too detailed.**
    b. Follow the protocols and complete field datasheets completely. Field personnel must ensure all critical information is recorded during observations.
    c. Each field personnel should carry a field notebook to document any additional, observations, problems encountered, equipment needs, etc. Make it standard practice before leaving road segment to take time to write down and detail any of these notes.
    d. Take lots of photos.
3. CONTAMINATION
    a. **Always be aware of potential contamination and continually take actions to avoid contamination.** The pollutant of concern with this project is sediment, dirt and dust. Manage

equipment, samples and sample containers to minimize contamination. The quality of the research is dependent upon the quality of the observations and samples collected.

b. Take efforts to minimize contamination of inadvertent dirt in all sample bottles, equipment, etc.
c. Wipe down all dry material sampling equipment between samples and especially between road segments.
d. Rinse and dry all wet sampling equipment. Be sure the water supply, squirt bottle, and graduated cylinder remain dirt-free.
e. Place all bottle caps with open side **down** whenever they are removed from the bottle.

Road Condition Visual Assessment

An initial characterization is required at the time of the very first visit to the road segment and includes a general inventory of road segment characteristics and road factors. The quicker road condition assessment is performed during every road segment visit.

Personnel Needed: Initially – 1 field personnel 15 minutes per road segment; Subsequent Observations – 1 field personnel 5 minutes per road segment

Equipment Needed:

- Survey Tape
- Stadia Rod
- Pavement Distress Identification Guide
- Field Datasheet
- Pen

Initial Road Segment Characterization:

Note: Initial assessment is performed once, the first time the road segment is monitored, and includes collection of metadata which will be field-verified during subsequent road segment visits.

1. Determine location and assign road segment site code.
   a. Record name of road. Note cross-streets.
   b. Identify and record start (upslope) and end (downslope) boundaries of road segment using conspicuous, permanent landmarks (street signs, fire hydrants, fencing, drop inlets, etc.).
   c. Mark location on a map (street map, field map, etc.).
   d. Assign unique site code using name of road and letter, as necessary. Example: DD is on Dale Drive; H89A is one of many road segments on Highway 89.
2. Record segment metadata, estimating as necessary. This information will be verified with phone calls and GIS data.
   - Jurisdiction in charge of road segment maintenance
   - Road segment type (primary or secondary)
   - Road segment risk (high, moderate, low)
   - Road segment width
3. Record segment measurements and characteristics.
   a. Depending on site safety concerns, use visual estimates to determine:
      i. Road segment length (parallel to flow of traffic) in feet.
      ii. Average road segment width (perpendicular to flow of traffic) in feet. Road segment width extends from far (left-most) edge of left road shoulder across drive lane to far (right-most) edge of right road shoulder. If road shoulder is not stabilized, edge of shoulder is determined by flow path, edge of pavement, etc. Width is verified in the office using GIS tools.
   b. Note direction of observations. The default is downslope; however if that is not readily determined, note direction of observations (to determine rights and lefts) using obvious landmarks (other streets, the lake, etc.).
   c. Determine road segment slope (high, low). Slope is the longitudinal slope (axis parallel with the flow of traffic, along the length of the segment). Slope is verified in the office using GIS tools.
      i. High: Greater than 5%.
      ii. Low: Less than 5%.

d. Determine direction (right, left, center crown) and degree (high, moderate, low) of road segment tilt. Tilt is the cross section slope (axis perpendicular to the flow of traffic, along the width of the segment) and describes the routing of stormwater from the drive lane to the road shoulder.
  i. Direction is the dominant side to which stormwater flows from the drive lane.
    1. Left, Right: looking downslope, or the view described in step 3b above.
    2. Center Crown: water is routed equally to both road shoulders.
    3. Possible field indicators include:
       - Relative size of flow paths (dominant side is larger)
       - Presence/absence of stabilization features (e.g., curb and gutter) (dominant side more likely stabilized)
       - Evidence of flow (dominant side more likely to have flow)
  ii. Degree describes the percentage of flow routed to the dominant side.
    1. High: 95-100% of runoff is directed to one side.
    2. Moderate: 75-95% of runoff is directed to one side.
    3. Low: Runoff is evenly distributed (50%) or up to 75% of runoff is directed to one side.

e. Determine road surface integrity (high, moderate, low). Observe overall integrity of road segment surface pavement, observing distribution and intensity of cracks, pocks, etc.
  i. High: Less than 10% of surface shows signs of deterioration.
  ii. Moderate: 10-25% of surface shows signs of deterioration.
  iii. Low: Greater than 25% of surface shows signs of physical deterioration.

f. Visually assess the percent of the road segment area that is distressed and note dominant distress type.
  i. Block: Cracking pattern that divides asphalt into rectangular pieces
  ii. Crack: Long, narrow deteriorations in asphalt, can be longitudinal or transverse
  iii. Pock: Circular depressions in pavement surface (e.g., potholes)

g. Determine relative traffic density (high, moderate, low).
  i. High: Very busy road; cars passed every 1-2 minutes.
  ii. Moderate: Busy road; cars passed every 4-5 minutes.
  iii. Low: Quiet road; cars passed every 5-10 minutes.

4. Record road shoulder observations for both left and right road shoulders.

a. Record presence/absence of road shoulder protection and type of protection. Road shoulder protection includes any structural improvements made to minimize human and/or automobile disturbance of native soils and subsequent erosion along the side of the road. Types include:
   - Boulders
   - Fencing
   - Paving
   - Slope (dropoff)
   - Slope (hill)

b. Record presence/absence of road shoulder stabilization and type of stabilization. Road shoulder stabilization includes any improvements made to minimize erosion on road shoulder within dominant flow path along road shoulder. Types include:
   - AC Dike
   - Curb and Gutter
   - Rock-lined Channel

c. Record degree (high, moderate, low) of erosion in road shoulder flow path and average depth (ft) of channel.
  i. Degree of erosion.
    1. High: Deep channel (>6”) and/or active signs of erosion (gullying, bank cuts, etc.).
    2. Moderate: Shallow channel (<6”) and few signs of active erosion.
    3. Low: No channel development and no signs of erosion.
  ii. Use stadia rod to determine average channel depth of road shoulder flow path.

Road Condition Visual Observations:

Note: Road condition observations and assessment is performed during every road segment visit.

1. Identify side code. Verify road segment metadata collected during initial road segment characterization and note any changes on field datasheet.

2. Record date, field personnel (initials), weather (cloudy, rainy, sunny) and estimate number of days since last precipitation event.
3. Note any evidence of recent road abrasive application and/or road sweeping.
    a. Potential signs of road abrasive application:
        - Presence of rounded (non-native) particles and/or abrasives in road shoulder/flow path.
    b. Potential signs of road sweeping:
        - Sweeper (broom) marks on road surface.
        - Observe active sweeping in neighborhood during sampling
4. Record degree (high, moderate, low) of dustiness at road segment.
    a. High: Visible thick dust in air, especially obvious with passing traffic. Vision is obviously impaired. Lots of sneezing and eye irritation.
    b. Moderate: Visible dust in air with traffic. Vision slightly impaired. Some sneezing and eye irritation.
    c. Low: No visible dust in air with traffic.
5. Estimate % of road segment per material accumulation category and determine level of fines per category.
    a. Determine locations and percent of each material accumulation category. High, moderate and low accumulation is determined specific to the road segment and is not relative to observations made elsewhere. Every road segment will have some percentage of each of the 3 categories. Relative percentage is based on the entire area of the road segment. Observe percentages across both the entire length and width of the road segment to determine overall road segment percentages.
    b. Within each accumulation category, determine the degree (high, moderate, low) of fine sediment using the finger test. Lick finger and wipe road surface.
        i. High: Finger is black and sediment feels clayey/silty. There is little to no grit in teeth.
        ii. Moderate: Finger is grey to light brown; feels slightly clayey, with some grit.
        iii. Low: Little to no sediment on finger and any sediment adhered to finger is very gritty.
6. Follow additional draft Road RAM protocols and complete Road RAM datasheet as necessary.

    PRIMARY FLOW PATH (Road RAM Datasheet Row #3)

    a. Identify primary flow path (East or North/ West or South / Equal) based field indicators (relative size, road tilt, etc.). Record answers (Yes/No) to following questions concerning primary flow path on field datasheet.
    b. Is the road shoulder flow path accessible by a passing road sweeper? If flow paths are equal and the answer for either flow path is no, record “NO”.
    c. If answer to above is YES, move to Datasheet Row #4. If answer to above is NO, is there non-native material (i.e., road abrasives) accumulation in the flow path? If flow paths are equal and the answer for either flow path is yes, record “YES”.
    d. If answer to above is NO, move to Datasheet Row #4. If answer to above is YES, can a handful or more of material be easily grabbed from a 1 sq-ft area? If flow paths are equal and the answer for either flow path is yes, record “YES”.

    BEYOND PRIMARY FLOW PATH (Road RAM Datasheet Row #4)

    a. Examine area beyond primary flow path. Record answers (Yes/No) to following questions concerning primary flow path on field datasheet.
    b. Are there impervious surfaces (e.g., sidewalks, bike paths) beyond the primary flow paths? If flow paths are equal and the answer for either side of road is yes, record “YES”.
    c. If answer to above is NO, move to Datasheet Row #5. If answer to above is YES, are these areas accessible by a road sweeper? If flow paths are equal and the answer for either side of road is no, record “NO”.
    d. If answer to above is YES, move to Datasheet Row #5. If answer to above is NO, is there non-native material (i.e., road abrasives) accumulation in these areas? If flow paths are equal and the answer for either side of road is yes, record “YES”.
    e. If answer to above is NO, move to Datasheet Row #5. If answer to above is YES, can a handful or more of material be collected in a 1 sq-ft area? If flow paths are equal and the answer for either side of road is yes, record “YES”.

Dry Material Sampling

Personnel Needed: 1 field personnel 10-15 minutes per road segment

Equipment Needed:

- 1’x’1 Square with Plastic Sheet
- Dust Pan
- Hand Broom
- Graduated Cylinders (10ml, 100ml, 1000ml)
- Wire Brush
- Hard Edge
- Spray Bottle
- Camera
- Funnel
- Bucket
- Ziplocs
- Paper Towels/Rags
- Chain of Custody
- Field Datasheet
- Pen

Data Collection:

1. Ensure all equipment is clean and ideally store equipment together in bucket to avoid confusion with wet sampling equipment. Avoid use of water, but wipe down all equipment using paper towels/rags. If equipment is rinsed, dry completely prior to collecting samples.
2. Dry material sampling is conducted in each of the three material accumulation categories (high, moderate, low) as designated by road condition visual observations. Select locations that are at a minimum 1’x1’.
   a. Prepare location by sweeping dust and debris in a 1-2ft line.
   b. Place 1’x1’ square on road surface with plastic sheet on the downslope/downtilt side.
   c. Using tape, secure inside edge of square to road surface to hold square in place and allow for easy removal of road sediment. Ensure that tape does not reduce sampling area below 1 ft^2.
   d. Using hand broom, sweep all material from inside square on to plastic sheet. Hold down edges of square as necessary to prevent movement.
   e. Gather all material into center of plastic and carefully transfer volume to graduated cylinder.
3. Record data on field datasheet.
   a. Sample ID. Format is Site Code_AccumulationCategory&Replicate Number
      i. For example DD_H1 is the first sample taken in the high material accumulation area from Dale Drive
   b. Time of sample collection in 24-hour format.
   c. Location on road (flow path, road shoulder, drive lane).
   d. Material accumulation category (high, moderate, low) as designated in road condition visual observations.
   e. Road surface integrity (high, moderate, low) at sampling location.
      i. High: Less than 5% of square shows signs of road surface distress.
      ii. Moderate: 5-25% of square shows signs of road surface distress.
      iii. Low: More than 25% of square shows signs of road surface distress (pocks, cracks, etc).
   f. Perform Fines Test.
      i. Locate appropriate site within material accumulation area 1. It should not be the same area where dry sample was collected.
      ii. Scrape road surface with a hard edge sweep using moderate amount of pressure to remove top layer of coarser material from surface.
      iii. Wet finger using spray bottle. (Note: Ensure finger is clean prior to performing test.)
      iv. Using two fingers and with a moderate amount of pressure, rub the pad of the fingers back and forth along 6” (approximately the length of a hand) of the road surface twice (e.g., cover 24” of road surface.

    - v. Look at finger surface. Are fingerprints visible through the material on finger? Record answer (Yes/No) on field datasheet.
    - vi. Wet finger with spray bottle and rub fingers together. Do fingers feel slimy or gritty or both or neither? Record answer on field datasheet.
  - g. Perform Dust Test.
    - i. Within unswept 1x1 foot square within material accumulation area 1, sweep road surface vigorously (5 sweeps in 3 seconds)
    - ii. Within 2 seconds of sweeping, estimate the height of the resulting dust cloud. Height is estimated based on the body parts of the sweeper. It is easiest if one person sweeps, and the other field personnel records observations. Record height (ankles/knee/waist) on field datasheet.
    - iii. Estimate duration of time (in seconds) the dust cloud is visible. Record # of seconds on field datasheet.
  - h. Volume of material (ml) collected from 1’x1’ square to nearest ml.
    - i. If value was less than 3 ml, record as 3ml.

4. At least one dry material sample is kept per road segment for laboratory analysis. All other samples are disposed on-site. Typically moderate accumulation sample is kept, or whichever accumulation category represents where the wet sediment sample is collected. If sample is kept:
  - a. Transfer sample from graduated cylinder to Ziploc bag and securely close bag.
  - b. Label bag with Sample ID, Date, Time, and Volume.
  - c. Place in larger Ziploc with other dry samples.
  - d. Complete chain of custody. Samples are submitted for the following analyses.
    - i. Mass (mg)
    - ii. Particle Grain Size Distribution (as % of mass)
      1. <1 µm
      2. <10 µm
      3. <16 µm
      4. <20 µm
      5. <63 µm
      6. <100 µm
      7. <1000 µm

Controlled Urban Road Experiment (Wet Sediment Sampling)

Overview

Controlled urban road experiments are always conducted in conjunction with a Road Condition Evaluation. Please review the Road Segment Site Set-up and Safety Protocols within the Road Condition Evaluation protocols to ensure data collection is conducted safely, accurately and completely.

Personnel Needed: 2 field personnel 10-20 minutes per road segment

Equipment Needed:

- Rainfall Simulator Sampler (includes metal frame, tubing, sprinkler nozzle, 2L graduated cylinder)
- 2 Charged 12V Batteries
- GeoTech Geopump 2 peristaltic pump
- Extra Pump Tubing
- Hach 2100P Portable Turbidimeter (including clean vials, wipe cloth, cleaning drops, calibration solutions, manual)
- Chem Wipes
- Rags/Paper Towels
- Duct Tape/Gorilla Tape/Concrete Tape
- Silica Gel and Caulking Gun
- Plumber’s Putty
- Leatherman/Straight Edge
- Wire Brush
- 1’x1’ inside square
- Stopwatch
- 5-gallon buckets of water
- Cooler with ice
- Chain of Custodies
- Sample Bottles (1L wide-mouth Nalgene HDPE)
- Pipettes and Pipette Bulbs
- Propane Torch and Extra Propane
- Squirt Bottle marked at 250ml volume
- Bungees/Carabiners
- Towel
- Allen Wrench

Data Collection:

1. Handle rainfall simulator sampler with care. (See Figure 2 in Sampling Plan as reference.)
    a. Sampler can be rested on bottom or back edge (so bottle end is up in air).
    b. Carry sampler by top bar or edge near bottle. Avoid grabbing by sprinkler nozzle or pressure gage.
    c. DO NOT grab sampler by the flexible metal edge of collection pan. It is important that this is kept as smooth as possible, with no kinks, to ensure a good fit with the road surface.
    d. Be very careful with the bottle lid fitting. DO NOT unscrew lid from sampler.
    e. Before beginning sample operation for the day, check tubing, nozzle, etc. for leaks and adjust as necessary.
2. Create a clean environment while sampling. We are analyzing samples for sediment and therefore everything must be kept as dirt-free as possible.
    a. Rinse and dry all equipment between sampling and especially between road segments. Ensure sampler, water supply, squirt bottle, graduated cylinder, etc are kept dirt-free.
    b. Always place bottle lids with the bottom down when not being used.
    c. Always cap bottles when not being immediately used. Even if it is just going to be for a second, screw the lid back on the bottle.
3. Set up sampler. (See Figure 2 as reference.)

   a. Select location on road surface in area of moderate material accumulation. Note that sampler (with bottle attached) extends approximately 18” downslope. Be sure there is enough room for sampler to rest evenly and completely on road surface.
   b. In close proximity to selected sampling location (but not upslope), pour water on road surface to determine direction of runoff.
   c. Attach sample bottle to sampler. Screw bottle to lid tightly but avoid twisting lid fitting independently of sampler.
   d. Prepare sampling location.
      i. Place the 1’x1’ inside square down in selected sampling location so orientation is perpendicular to the runoff direction.
      ii. Using hand broom and/or wire brush, sweep all four sides to create a 1” clean border around the square. This will ensure a good seal for the sampler and prevent leaks.
      iii. On downslope side, extend line 6” on each side. This will be the downslope edge of the 1’x1’ rainfall area square and where the edge of the collection pan will be taped to the road surface. Clean road surface as completely as possible to ensure tape will stick to road.
      iv. Tape is extended 18-20” along downslope edge of sampling area, as well as a 3-4” strip along either side to ensure the downslope corners of the sample area are fully protected. Depending on road conditions, there are 3 strategies to prepare sample location:
         1. Silicone.
            - Apply silicone 12-15” along center of the downslope swept line, as well as 3-4” along sides to protect corners from leaking. Silicone is used to create waterproof seal under tape and to fill in any road surface cracks.
            - Place gorilla tape over silica. Wipe any excess silica that oozes out from tape edge.
         2. Propane Torch
            - In areas where road surface is mostly smooth, tape can be used without silicone. In these cases, use propane torch to heat road surface and tape to mildly melt tape into road. ***Do not use propane torch in combination with silicone, as silicone is highly flammable.***
         3. Plumber’s Putty
            - In areas where road surface is moderate in fines and dust, plumber’s putty can be used in place of silicone (road sites high in fines and dust cannot form a solid seal between the putty and the road). Apply a generous amount of putty along downslope swept line, as well as 3-4” along sides to protect corners from leaking. No tape is used in this step – sampler is placed directly on to plumber’s putty.
   e. Place sampler over selected location with collection pan on the downslope end. Looking down on sampler, line front edge of rainfall area square with upslope edge of tape/putty to standardize the rainfall area to 1’x1’. When done correctly approximately ¼” of tape/putty will be exposed along edge of collection pan.
   f. Place batteries on each sampler wing. Using rope and carabiners, distribute weight of batteries on sampler edges. Make sure rope goes over top of sampler bar and will not disturb water application on rainfall square.
   g. Tape collection pan to road surface.
      i. If using plumber’s putty, push the excess putty over the collection pan edge, forming a barrier and seal between the ground and sampler.
      ii. Use gorilla tape to secure collection pan edge to tape on road surface. Use a straight edge to smooth the tape at the corners of the sampler to prevent leaks out the side and corners of the sampler. It may be helpful to angle the tape towards the inside of the rainfall square to create seal. To prevent pooling in the collection pan near the tape, cut tape on downslope corners and smooth to sides of collection pan.

4. Attach pump and prepare for sampling.
   a. Fill graduated sampler to 750 ml. Ensure intake pipe inside cylinder is downslope.
   b. Attach tubing to pump.
   c. Attach pump to battery. Red is positive; black is negative.
   d. Ensure pump direction is the same as from the pump to the sampler.
5. Run rainfall simulation.
   a. One person stands on edges of collection pan to weight edges and improve sampler’s seal to road surface.

- b. Turn on pump.
- c. Begin timer when water starts coming out of sprinkler nozzle.
- d. Monitor pressure to maintain 25 psi. Adjust pump speed as necessary.
- e. Watch water flow. Using clean straight edge, encourage water to flow into collection pan instead of pooling around tape. With clean fingers, press down on collection pan edge as necessary.
- f. Stop timer when no more water comes out of sprinkler nozzle. (Duration should be around 2min 50sec.)

6. Collect sample.
    - a. Scrape any sediment on tape into collection pan using clean straight edge.
    - b. If water is pooling around tape or in rainfall square, use pipette to transfer water to bottle. Person standing on sampler may have to stay in place to prevent seepage out the sides of sampler.
    - c. Two people are needed to lift sampler and transfer sample to bottle. Field personnel safety is very important. As personnel lift sampler they should move away from drive lane, maintaining a safe distance from traffic as sample is recovered.
        - i. Person 1 lifts sampler from back and holds vertically to transfer sample from collection pan to bottle. Be careful not to tilt sampler too quickly and lose water from the collection pan. DO NOT rest sampler on bottle as this may damage the bottle lid fitting.
        - ii. Person 2 grabs edges of road tape extending beyond sampler and helps lift sampler off road, loosening tape where stuck to road. While Person 1 holds sampler, Person 2 uses squirt bottle filled with 250ml to rinse sampler and transfer all sediment into bottle. This is all the water you get, so use judiciously.
    - d. If necessary, transfer sample to a sample analysis bottle. Swirl sample to mobilize sediment. Carefully transfer to other bottle, to avoid losing sample volume. It will be necessary to transfer water back and forth a few times to get all sediment from collection bottle to analysis bottle.
7. Measure sample turbidity following instructions in turbidimeter user manual. A couple of notes:
    - a. Always run 2-3 validation tests with provided gels with known turbidity prior to testing any sample. Record validation results.
    - b. Never touch the outside of the glass vial with fingers. Use the black cloth provided.
    - c. Have at least 2 vials for samples – one for cleaner samplers, one for dirtier samples. Rinse with sample prior to analysis to condition the vial.
    - d. Pour sample back into analysis bottle following measurement.
    - e. Throw out vials at the end of the sampling period.
    - f. Record ‘out of range’ samples as >1000NTU and ensure lab completes turbidity analysis for these select samples.
8. Record data on field datasheet.
    - a. Sample ID. Format is Site Code_AccumulationCategory&Replicate Number.
        - i. For example DD_H1 is the first sample taken in the high material accumulation area from Dale Drive.
    - b. Time of sample collection in 24-hour format.
    - c. Location on road (flow path, road shoulder, drive lane).
    - d. Material accumulation category (high, moderate, low) as designated in road condition visual observations. Wet samples are usually collected in areas of moderate accumulation.
    - e. Road surface integrity (high, moderate, low) at sampling location.
        - i. High: Less than 5% of square shows signs of road surface distress.
        - ii. Moderate: 5-25% of square shows signs of road surface distress.
        - iii. Low: More than 25% of square shows signs of road surface distress (pocks, cracks, etc).
    - f. Amount of fines within sample (high, moderate, low).
        - i. High: A significant amount of fines are present in sample. When sweeping, a lot of dust is generated and may cause field personnel to cough, sneeze, or blink a lot.
        - ii. Moderate: Some fines are present in sample. When sweeping, a little bit of dust is generated into air.
        - iii. Low: Very few fines are present in sample. Little to no dust is generated while sweeping the sample.
    - g. Time (min) of rainfall simulation.
    - h. Average pressure (psi) during simulation.
    - i. Volume (ml) applied for sample collection. Default is 1000ml (750ml through pump + 250 ml in squirt bottle).

    j. Approximate volume (ml) recovered in sample analysis bottle.
    k. Degree of material on road surface mobilized during rainfall simulation (high, moderate, low). Look at square where rainfall simulation occurred and compare to adjacent road surface.
        i. High: Most to all sediment was removed during sample collection.
        ii. Moderate: 75-90% of the sediment was mobilized during sample collection.
        iii. Low: Less than 75% of sediment was mobilized during sample collection.
    l. Results of field turbidity test (ntu).

9. All wet samples are submitted to laboratory for analysis.
    a. Label bottles in sharpie with Sample ID, Date and Time.
    b. Place **upright** in cooler on ice. Never store or freeze water samples on side.
    c. Complete chain of custody. Samples are submitted for the following analyses.
        i. TSS (mg/L)
        ii. Particle Grain Size Distribution (as % of mass)
            1. <1µm
            2. <10 µm
            3. <16 µm
            4. <20 µm
            5. <63 µm
            6. <100 µm
            7. <1000 µm
        ii. Turbidity >1000ntu for those samples that were ‘out of range’ on field turbidity test.
    d. QA/QC Requirements
        i. Field triplicates should be collected and submitted to the laboratory at a minimum of one site per sampling period. Ideally triplicates are performed at two sites: one relatively dirty and one relatively clean road segment.
        ii. One field blank should be submitted to laboratory per sampling period.
            1. Use same water source used for controlled experiments.
            2. Transfer water to sample collection bottle and then sample analysis bottle.
            3. Label sample analysis bottle as BLK1 with date and time collected.
    e. Deliver samples and completed chain of custody to appropriate laboratory within stated holding times (7 days). Keep a copy of chain of custody for records.

Optional Spot Turbidity Measurements

Personnel Needed: 1 field personnel 5-10 minutes per road segment

Equipment Needed:

- Hach 2100P Portable Turbidimeter (including clean vials, wipe cloth, cleaning drops, calibration solutions, manual)
- Chem Wipes
- Rags/Paper Towels
- Pipettes and Pipette Bulbs

Data Collection:

1. If there is runoff at the road segment, spot turbidity measurements should be collected from the primary flow paths – and from both road shoulders if there is runoff in each.
2. Using pipette, collect at least 100ml of volume from primary flow path.
3. Measure sample turbidity following instructions in turbidimeter user manual. A couple of notes:
    a. Always run 2-3 calibration tests prior to testing sample and record values.
    b. Never touch the outside of the glass vial with fingers. Use the black cloth provided.
    c. Have at least 2 vials for samples – one for cleaner samplers, one for dirtier samples. Rinse with sample prior to analysis to condition the vial.
    d. Discard sample.
    e. Throw out vials at the end of the sampling trip.
    f. Record ‘out of range’ samples as >1000NTU and submit those samples to lab for turbidity analysis.

4. Record data on field datasheet.
    a. Sample ID. Format is Site Code_Location.
        i. For example DD_LRS is the left road shoulder from Dale Drive.
    b. Time of sample collection in 24-hour format.
    c. Location on road (flow path, road shoulder, drive lane). Default is the flow path.
    d. Results of field turbidity test (ntu).

IN-SITU LEVELTROLL & BAROTROLL

Installation

Personnel Needed: 1-2 experienced field personnel 2-4 hours per station to install.

Equipment Needed:

- InSitu LevelTroll (BaroTroll as needed)
- digging bar
- vertical steel sign/fence post or rebar
- side braces
- BaroTroll housing (3ft long 8” PVC, top, lock)
- wire/cable
- perforated PVC
- PVC end cap
- lock
- post driver
- level
- radiator clamps
- tools
- drill

Installation:

Note: The most effective installation materials, housing and configuration for each station will depend upon site conditions and limitations. Trained and experienced field personnel should be used to ensure proper and safe installation of expensive equipment in stream.

1. Calibrate and setup instruments (In-Situ LevelTroll 500, In-Situ BaroTroll if necessary) in office.
    a. Follow software instructions provided in user manuals.
    b. Check that date and time are accurate.
    c. Set to record data on 15 minute intervals.
        - Water depth as feet. Calibrated and corrected for elevation (barometric pressure differences).
        - Pressure in psi. Calibrated and corrected for elevation.
        - If an un-vented instrument is to be installed, access to vented barometric pressure data is required. A vented instrument can be set to record on same 15 minute interval and installed on-site, in the office, or at another nearby station. One BaroTroll instrument can be used to correct multiple unvented gages. The In-Situ software can link unvented instrument data and vented data to correct the water depth time series automatically. The barometric corrections can also be conducted manually.

2A. Install un-vented pressure transducers.
    a. Secure vertical sign post/rebar in streambed, buried 1-2ft in channel substrate. If possible, use a sign post already installed for passive samplers. Place side braces into the stream bank to further secure housing, if necessary.
    b. Attach PVC (with perforations along bottom 1-2ft) to post/rebar using radiator clamps. Radiator clamps should be spaced evenly along the length of PVC to properly secure it to the post/rebar.
    c. Install pressure transducer within PVC. Attach sufficient length of stainless cable to instrument to ensure placement at the bottom of PVC.
    d. Loop cable through PVC cap and lock cap to PVC to prevent theft or vandalism.
    e. One vented pressure transducer (In-Situ BaroTroll) will need to be installed somewhere in the project area to record and allow correction for barometric pressure differences. It is not necessary to install one at every station. One vented transducer can be used for the entire project area, as long as data is recorded on 15-minute intervals and widely

available to all agencies operating instruments. To install a programmed In-Situ BaroTroll on-site:

- Choose location above the high flow line to ensure instrument cannot be inundated.
- Bury a 3ft long 8" PVC piece in ground. Place BaroTroll in PVC.
- Lock top in place to prevent theft and/or vandalism.

OR:

3B. Install vented pressure transducer.
  a. Secure vertical steel sign post/rebar in streambed, buried 1-2ft in channel substrate. If possible, use a sign post already installed for passive samplers. Place side braces into the stream bank to further secure housing, if necessary.
  b. Attach PVC (with perforations along bottom 1-2ft) to post/rebar using radiator clamps. Radiator clamps should be spaced evenly along the length of PVC to properly secure it to the post/rebar.
  c. Install pressure transducer within PVC. Run instrument cable with PC attachment to bank.
    - Ensure vented LevelTroll is purchased with sufficient length of cable to extend instrument to desired location in stream.
    - Special care should be taken to ensure cable does not kink or bend.
    - End of cable should be installed in location above the high flow line to ensure cable top is not inundated.
  d. Cable should be locked to prevent theft or vandalism of instrument.
  e. No BaroTroll is needed if all Level Trolls used are vented.

Download Procedure

1. Be sure you have:
    a. Charged computer plus extra battery
    b. Extra adaptor port for computer, with 9-pin serial port
    c. Instrument cable
    d. A/C adapter to run computer off car, if necessary.
    e. Wrench/tool to open PVC housing, and during the winter season warm water to unfreeze/open PVC housing.
2. Tasks to do:
    a. Download data
        i. Clean off instrument. Remove debris, organisms from around the probes.
        ii. Connect instrument to cable to computer.
        iii. Open Win-Situ 5 Software – if no response, check cables assuring there is a tight connection with the computer.
        iv. If device is still not connecting click on "Preferences" on the top toolbar and select "Comm Settings." Select 9600 Baud rate and then click ok. The instrument should connect at this Baud Rate. Once the connection between the computer and instrument is made change the Baud rate back to 57600.
        iv. Instrument should appear under connection. In bottom right corner the two plugs inserted into each other indicates a connection.
        v. Click on Logging icon, second from left. Window will show active log indicated by an icon of a man jogging. You must stop the active log in order to download the data. Right click and select "Stop." Right click again and select "Download," choose to download all data.
        vi. View data to assure that instrument was working correctly and collected data for the full duration and collected all the required parameters during the deployment.
        vi. Downloaded data will be saved to "My Data." To access data, click on View and select "My Data." Right click the recently downloaded file, and

        select “Export to Csv.” Select the file under the “Exported Data” File and in the window to the right the location of the file on the C drive will be indicated.
    vi. Check details on Instrument – Battery Capacity and Storage Capacity in the upper right corner. Record these values in the field log. If battery capacity is low, the instrument will need to be sent back to In-situ.

b. Start new test.
    i. To start new test, old test must be deleted. Right-click old test and choose Delete. This is why it is imperative that you check that gage has downloaded correctly and data is saved!! Deleting this should also clear out the data storage capacity.
    ii. Right-click Tests and choose “New”. Wizard will take you through the set-up. If you are unsure of any of the settings, go to the data file just downloaded. Beginning lines give description of setup, including mode, reference depths, and sampling intervals. When setting up both Level and BaroTrolls, it is best to have them recording at same interval with same start times.
    iii. When finished, double check details to make sure test will begin. If you chose a manual start, do not forget to start test before disconnecting.
    iv. Once you’ve convinced yourself that recording will happen, click on the icon in the right corner to disconnect the instrument and exit Win-Situ software.

SIGMA FLOW METERS AND AUTOMATED SAMPLERS

Installation

Personnel Needed: 1-2 field personnel 20 hours to install equipment

Equipment Needed:

- Sigma 950 Flow Meter (including submerged area/velocity sensor, sensor cable, power cable, computer cable, battery pack)
- optional flow meter mounting kits (wall mounting, suspension harness, or manhole rung hanger)
- Sigma 900 Max Portable Sampler (including pump tubing, intake line, tubing connectors, intake strainer, bottles, battery pack)
- 36" CMP housing
- lock
- drill
- computer
- instrument maintenance log

Instrument Installation:

Note: The most effective installation materials, housing and configuration for each station will depend upon site conditions and limitations. Trained and experienced field personnel should be used to ensure proper and safe installation of expensive equipment in stream.

1. Install sampler per instructions provided in instrument manual.
    a. Install 36" CMP housing on level ground above and adjacent to sampling source. Choose location where inside of CMP housing will remain dry.
    b. Connect pump tube to body. Consider the following issues when installing the intake tube:
        - Tube should be as short in length as possible and free of kinks.
        - Tube should slope downward from sampler to allow complete drainage between sampling.
        - Tube should be placed in area of well-mixed flow.
        - Tube should be well placed vertically in water column to ensure sample collected is representative of entire water column.
    c. Set up bottles.
    d. Install and align distributor arm.
    e. Install full bottle shutoff device.
    f. Connect to power source
2. Install area/velocity sensor per instructions provided in instrument manual.
    a. Mount device. Consider the following:
        - Sensor should be installed in area of uniform flow with minimal turbidity.
        - Sensor should be installed where channel area can be confined.
        - Sensor and sampler must be in close proximity for proper connection.
    b. Connect to power source.
    c. Connect to sampler.
3. Program and calibrate area/velocity meter per instructions provided in instrument manual.
    - Level in feet.
    - Velocity in feet per second
    - Flow as liters per second
    - 15 minute intervals
    - Submerged area/velocity
    - Enter appropriate channel criteria to calculate flow
4. Secure housing with lock.

Monthly Maintenance

Personnel Needed: 1 field personnel 1-2 hours to download data, calibrate and maintain instruments

Equipment Needed:

- charged computer
- appropriate instrument cables
- extra computer battery
- calibration materials
- camera
- field notebook
- pens/pencils
- instrument logs
- instrument batteries (if replaceable)

Monthly Maintenance

1. Connect flow meter to field computer per instrument operations manual.
    a. Download data to computer. Check data to ensure there are no data gaps and the data seems accurate. Recalibrate sensor as necessary.
    b. Check date and time.
    c. Check battery level.
    d. Set up instrument to start recording again on 15-minute intervals.
    e. Fill out instrument maintenance log (see Figure 6.11 attached at the end of this section). Take photos.
2. Clean sensor of any debris.
3. Check and maintain desiccants. Replace as necessary.
4. Place instrument back into housing and lock in place.

Sample Collection

Personnel Needed: 1 field personnel 1-2 hours per targeted event for pre-event preparation of instrument; 1 field personnel 1-2 hours per targeted event to collect samples following event

Equipment Needed:

- sample analysis bottle
- computer
- cable
- sample analysis bottles
- distilled, de-ionized water
- ice
- cooler
- pens/pencils
- field notebook
- camera
- sample labels
- chain of custody
- station monitoring log
- instrument logs

Sample Collection

1. Pre-event
    a. Arrive at the station 24 hours prior to the targeted runoff event. In the case of summer thunderstorms that come with little warning, there may be insufficient time to deploy the samplers prior to the beginning of the event. While not a preferred method, sample bottles can be deployed

and remain in the field in preparation for summer thunderstorm sampling. However, if this technique is used, the sample bottles in the field must be checked and cleaned twice weekly to minimize the potential for contamination of material on the bottle prior to the occurrence of a runoff event.

   b. Connect computer to instruments. Verify that both flow meter and automated sampler are working properly. Check date/time, battery level, desiccants, probe conditions, etc.
   c. Based on anticipated event volume and duration, program sampler to collect samples on specific volume intervals.
   d. As necessary, change interval of flow meter data collection.
   e. Ensure bottles in sampler are clean and empty.
   f. Verify that sampler is properly connected and will collect runoff from proper location. Check intake tubing for kinks and dirt and distributor arm for proper alignment.
   g. Complete instrument maintenance log. Take photos.

2. Post-event
   a. Arrive at site within 12 hours after the event has ended.
   b. Download sample history data.
      i. Connect sampler to computer and following instrument manual, download the sampling history for the event.
      ii. Verify that number of samples collected by sampler match number reported by the instrument.
      iii. Check date and time of each collected sample.
      iv. Complete instrument maintenance log.
   c. Collect samples.
      i. Composite samples according to project specifications.
      ii. If analyses require chemical preservation transfer sample to appropriate sample analysis bottle.
      iii. Complete label for each bottle and firmly secure to bottle. Label should include, at minimum, project and station name, date, time, and field personnel.
      iv. Place all bottles in Ziploc in cooler with ice and complete chain of custody.
      v. Take photos. Record staff plate measurement. Complete necessary information in station visit monitoring log (.
      vi. Deliver samples and completed chain of custody to appropriate laboratory within stated holding times. Keep a copy of chain of custody for records.

NALGENE STORM WATER SAMPLERS

Installation – Single Unit Within Flow Path

Personnel Needed: 1-2 field personnel 4-6 hours to install 3 samplers

Equipment Needed (assumes use of Nalgene units):

- three (3) Nalgene Storm Water Samplers [Cat. No. 1100-1000 (HDPE) and/or 1120-1000 (Glass) depending on targeted pollutants of concern]
- three (3) Nalgene Storm Water Mounting Kits (includes mounting tube, clamp, wire hanger, cable tie, and mounting stake)
- slot-headed screwdriver
- flagging
- shovel
- digging bar
- Nalgene Installation Guide
- lock

Installation:
Note: The most effective installation materials, housing and configuration for each station will depend upon site conditions and limitations. Trained and experienced field personnel should be used to ensure proper and safe installation of equipment.
Note: The Storm Water Sampler should be used during installation of the Storm Water Mounting Kit to ensure the setup will properly collect a sample. To avoid contamination the sampler should not be left on-site. It should be installed in the mounting tube just prior to an anticipated runoff event.

1. Follow the instructions provided in the Nalgene Installation Guide, briefly summarized below.
    a. Grate mounting
        i. Hang mounting tube from stormwater grate near the edge of the storm drain chamber using wire hanger (provided in mounting kit), cable, or string.
    b. Ditch mounting
        i. Dig a hole deep enough to set the sampler at grade. Be sure to place dirt at the downstream end of the hole.
        ii. Drive mounting stake into downstream side of hole with open side of V facing upstream.
        iii. Set mounting tube at grade and secure to stake using screwdriver and clamp.
        iv. Backfill the hole, ensuring that water is directed towards the passive sample.
2. If necessary, secure Mounting Kit against vandalism using lock.
3. Test placement of Storm Water Sampler within Mounting Kit. Use level to ensure sampler rests evenly on housing. Make any adjustments necessary.

Installation – Hanging Units with Stream, Detention Basin, etc.

Personnel Needed: 1-2 experienced field personnel 6-8 hours per station to install passive samplers.

Equipment Needed:

- three (3) Nalgene Stormwater Samplers [Cat. No. 1100-1000]
- three (3) Nalgene Stormwater Mounting Kits (includes mounting tube, clamp, wire hanger, cable tie, and mounting stake)
- slot-headed screwdriver
- flagging
- shovel
- digging bar
- Nalgene Installation Guide
- vertical steel sign/fence post or rebar
- side braces

- lock
- post driver
- level
- radiator clamps
- tools
- drill

Installation:

Note: The most effective installation materials, housing and configuration for each station will depend upon site conditions and limitations. Trained and experienced field personnel should be used to ensure proper and safe installation of expensive equipment in stream.

Note: For best results, samplers should be installed during low flow conditions when access to the channel is the greatest. To avoid contamination Storm Water Samplers should not be left at site between sampling events.

1. Installation and housing must be secure and sturdy enough to remain in place during high flow events and potential collisions with debris.
   - Secure vertical steel sign post/rebar in stream bed so it is buried 1-2ft in channel substrate for stabilization.
   - If possible, place side braces into the stream bank to further secure vertical post.
   - Depending on the differences in stage between targeted discharges, it may be possible to secure more than one sampler to a single vertical sign post.
2. Install Nalgene Mounting Kit according to the details in the Nalgene Installation Guide for stream mounting. Install kit on upstream side of sign post to reduce obstruction of sample.
3. Test placement of Storm Water Sampler at station. Use level to ensure that sampler will rest evenly on housing. Make any adjustments necessary.

Sample Collection

Deploy Storm Water Sampler:

1. Arrive at station 24-48 hours prior to anticipated runoff event. In the case of summer thunderstorms that come with little warning, there may be insufficient time to deploy the samplers prior to the beginning of the event. While not a preferred method, sample bottles can be deployed and remain in the field in preparation for summer thunderstorm sampling. However, if this technique is used, the sample bottles in the field must be checked and cleaned twice weekly to minimize the potential contamination of material in the bottle prior to the occurrence of a runoff event.
2. Check condition of each mounting tube to ensure the sampler is properly and securely installed to collect stormwater runoff from catchment. If there are any problems, fix if possible. If it cannot be fixed immediately or prior to runoff event, describe problem on station visit log and report to project manager. Housing should be fixed prior to any subsequent sampling, to ensure the catchment runoff is being sampled properly.
3. Avoid contamination. Place all materials on tarp while prepping station. Rinse materials with distilled, de-ionized water as necessary.
4. Based on targeted pollutants of concerns, install proper sampler type (HDPE or glass) in mounting tube.
5. Depending on volume and field triplicate requirements, more than one Storm Water Sampler may need to be deployed for an event.
6. Ensure stormwater runoff will be routed into the sampler(s). Remove any obstructions in flowpath and adjust installation as necessary.
7. Take photos. Complete necessary information in station visit monitoring log.

Collect Samples:

1. Arrive at the station within 6- 12 hours of the onset of stormwater runoff (and anticipated sample collection).
2. Remove Storm Water Sampler from mounting tube and immediately seal top with lid.
3. Sample must have been properly collected in order to be submitted to lab.

  - If sample has exceeded the proper holding time in the passive sampler, then samples cannot be submitted to lab. Sediment holding times are lengthy. Samples to be submitted for nutrients, hydrocarbons, trace metals, and pesticides can remain at site up to 4 days if water/air temperatures are below 38^{o}C. Evaluations of sample condition must be made in field based on conditions prior to submission to laboratory.
  - If the runoff volume was not great enough to fill the bottle and properly seal the lid, sample in unusable - the exception being that field personnel arrived within an hour of sample collection. In this case, sample can be submitted to lab, but must be flagged as “unsealed”.

4. If analyses require chemical preservation transfer sample to appropriate sample analysis bottle.
5. Complete label for each bottle and firmly secure to bottle. Label should include, at minimum, project name, station name, date, time, and field personnel.
6. For field triplicates, transfer samples into appropriate analysis bottles as necessary and include replicate number on label.
7. Place all bottles in Ziploc in cooler with ice and complete chain of custody.
8. Take photos. Complete necessary information in station visit monitoring log.
9. Deliver samples and completed chain of custody to appropriate laboratory within stated holding times. Keep a copy of chain of custody for records.

Some notes about nutrient sample handling:
Samples become contaminated if they are touched by skin. If you touch the inside of the cap, or the rim of the sample bottle, please dump the sample, rinse the bottle and start over. If you sneeze or cough over the sample, please dump it. Please pay close attention and take care not to compromise sample.

SAMPLE BOTTLE LABELING

All samples must be clearly and consistently labeled to ensure no data loss due to poor sampling handling. All samples collected must be labeled with the following information. The same information must be simultaneously entered onto the chain of custody to ensure reliable sample tracking.

Sample Labeling	Example
Sample Location: **A**	Sample Location: Osgood KC3
Sample Type: **B**	Sample Type: CEC Auto
Bottle #, Composite?: **C**	Bottle or Rep#: 1-4 composite
Replicate #: **D**	Replicate: none
Date: **E**	Date: 052006
Time collected: **F**	Time collected: 1402
Field Personnel: **G**	Field Personnel: MM

Example label indicates surface water outflow sample from outlet to Osgood Basin, composite from bottles #1-4 from autosampler on May 20, 2006 at 14:02 by field personnel with initials MM. No field replicate was submitted.

A: Sample location (see Figures 1, 3 and 4 for location and IDs):
- PA1_IN: Park Avenue Upper Basin Inflow
- PA1_OUT: Park Avenue Upper Basin Outflow
- PA2_IN: Park Avenue Lower Basin Inflow
- PA2_OUT: Park Avenue Lower Basin Outflow
- KC2: Osgood Basin Inflow
- KC3: Osgood Basin Outflow
- SF_IN: StormFilter Vault Inflow
- SF_OUT: StormFilter Vault Outflow
- RSID: Road Segment ID #
- PS#: CRC Passive Sampler

B: Sample Type
- CEC Auto: SWT autosampler
- CEC Pass: SWT passive sampler
- CRC: Road segment grab sample

C: Bottle #, Composite:
- CEC Auto: Autosampler bottle(s) #
- CEC Pass: Passive sampler bottle # (1-4, 1 is lowest elevation, 4 is highest)
- CRC: Time elapsed since flow started (ex: t=10min)
- If any of the samples are composited, write composite (or comp) on label.

D: Replicate number (if field replicate taken at site)
E: Date of collection
F: Time of collection (if collected from passive sampler enter FF (first flush))
G: Initials of field personnel collecting sample

CHAIN OF CUSTODY

1.0 PURPOSE AND SCOPE

1.1 This Standard Operating Procedure (SOP) describes the procedures to be used for documenting the history and possession of a sample from the time that sample containers are dispatched, through its collection, analysis and data reporting, to its final disposition.

2.0 RESPONSIBILITY

2.1 The principal investigator is responsible for ensuring that all project personnel are aware of this SOP. The project hydrogeologist and/or his/her designee will be responsible for ensuring that all sample custody procedures will be performed in accordance with this SOP and the study protocol.

3.0 FIELD CUSTODY PROCEDURES

3.1 Field documentation will include sample labels, groundwater or surface water sampling information forms, daily field activities logbook and chain-of-custody and analysis request forms. These documents will be filled out in indelible ink. Any corrections to the document will be made by drawing a line through the error and entering the correct value without obliterating the original entry. Persons correcting the original document will be expected to initial any changes made. The documents are described below.

3.2 Sample Labels will be used to identify samples. Labels will be covered with transparent plastic tape to protect the label. The sample label, to be filled out using waterproof ink, will be completed as described in the Bottle Labeling Protocol.

4.0 CHAIN OF CUSTODY

4.1 The chain-of-custody (COC) form is filled out for groups of samples collected at a given location on a given day and is routinely provided by the contract laboratory, which signs the COC first to relinquish the pre-cleaned sample containers. A project COC form will be used for those occasions when the contract laboratory COC form is not available and sample containers are purchased from a commercial vendor.

4.2 The COC will be filled out and signed by the field personnel in order to relinquish every shipment of samples to the respective analytical laboratories.

4.3 One copy is made of the COC prior to shipment and is maintained with the field notes. The COC makes provision for documenting sample integrity and the identity of any persons involved in sample or sample container transfer. Other information entered on the COC includes:

- Project name and number
- Sample field I.D. number and number of samples
- Sampler's/recorder's signature
- Name of person receiving the sample
- Inclusive dates of possession
- Date of sample receipt
- Project & collection location
- Date and time of collection
- Sample type & preservation information.
- Laboratory name, sample number, and analyses requested

4.4 The original COC forms are sealed in the shipping cooler. If samples are shipped by common carrier, the sample custodian is responsible for ensuring the custody is formally transferred.

FIELD DATASHEETS

Road Condition Evaluation Datasheets

Instrument Logs (Sigma, InSitu)

Chain of Custody

Labels

Road Condition Initial Road Segment Characterization Field Datasheet

- Complete only once, at first site visit. Data will generate RS field map and data table.
- ***All field observations are conducted looking downslope along road segment length.***

Road Segment (RS) ID: ____________________ Date: ____________________

Field Personnel: ____________________ Time: ____________________

Metadata

Road Name: ____________________

Segment Boundaries:

Upslope: ____________________

Downslope: ____________________

Road Segment Length: ____________ft

Road Segment Width: ____________ft

Road Segment Slope: H L

Road Segment Tilt:

Dominant Direction: L R

Severity: H M L

Road Surface Integrity: H M L

LEFT ROAD SHOULDER

Protected? Yes No

Type: Fencing Paving Boulders

Other ____________________

% LRS Protected:

0-25% 25-50% 50-75% 75-100%

Stabilized? Yes No

Dominant Type:
Curb and Gutter Rock Lined

Other ____________________

% Distribution:

Curb and Gutter ____________

Rock Lined ____________

Other ____________

Severity of flow path erosion: H M L

RIGHT ROAD SHOULDER

Protected: Yes No

Type: Fencing Paving Boulders

Other ____________________

% RRS Protected:

0-25% 25-50% 50-75% 75-100%

Stabilized? Yes No

Dominant Type:
Curb and Gutter Rock Lined

Other ____________________

% Distribution:

Curb and Gutter ____________

Rock Lined ____________

Other ____________

Severity of flow path erosion: H M L

Notes:

Road Condition Visual Observations, Dry Material Sampling and Wet Sediment Sampling

- Complete every site visit for dry (road material) and wet (simulated runoff) sample collection.
- ***All field observations are conducted looking downslope along road segment length.***

Road Segment (RS) ID: ____________________

Field Personnel: ____________________

Date: ____________________

Weather: ____________________

Days since Precip: ____________________

Evidence of Abrasives: yes no

Evidence of Sweeping: yes no

Site Dustiness: H M L

DRY (Road Material) Sample Collection

High Accumulation

% of RS: ____________

Sample ID: ____________

Sample Time: ____________

Location:

Flow Path Road Shoulder
Drive Lane

Surface Integrity: H M L

Fines: H M L

Sample Volume: ____________

Kept? yes no

Moderate Accumulation

% of RS: ____________

Sample ID: ____________

Sample Time: ____________

Location:

Flow Path Road Shoulder
Drive Lane

Surface Integrity: H M L

Fines: H M L

Sample Volume: ____________

Kept? yes no

Low Accumulation

% of RS: ____________

Sample ID: ____________

Sample Time: ____________

Location:

Flow Path Road Shoulder
Drive Lane

Surface Integrity: H M L

Fines: H M L

Sample Volume: ____________

Kept? yes no

WET (Simulated Runoff) Sample Collection

Sample ID: ____________

Sample Time: ____________

Accumulation: H M L

Location:

Flow Path Road Shoulder
Drive Lane

Surface Integrity: H M L

Fines: H M L

Experiment Time: ____________

Average Pressure: ____________

Volume Applied: ____________

Volume Recovered: ____________

Material Mobilized: H M L

Turbidity: ____________

Spot Turbidity Measurements

Sample ID: ____________________

Sample Time: ____________________

Location:

Flow Path Road Shoulder Drive Lane

Turbidity: ____________

Additional Information

Traffic Density: H M L

Notes:

ROAD RAM STEP 4B FIELD OBSERVATIONS – DRAFT FIELD DATASHEET

Row #	**ROAD RAM STEP 4 Field Observation Datasheet**			
1	RS ID	Field Personnel	Observation Date	Observation Time
	Road Segment (RS)			
2	Estimated Width (ft)	Length (ft) [10,000/Width]	RS Start	RS End
	Primary Flow Path			
3	Dominant Flow	Accessible to Sweeper?	Non-Native Accumulation?	Handful or greater of material easily obtained?
		Yes No	Yes No	Yes No
	Beyond Primary Flow Path			
4	Impervious Surface? (Y/N)	Accessible to Sweeper?	Non-Native Accumulation?	Handful or greater of material easily obtained?
		Yes No	Yes No	Yes No
	Percent Distribution Material Accumulation Area			
5		Area 1	Area 2	Area 3
	% of Road Segment			
	Dry Material Collection			
	MATERIAL ACCUMUNCATION AREA 1			
6	**Volume (ml)**	**Fines Test**	**Dust Test**	
		Finger print visible? Yes No	Height	Ankle Knee Waist
		Slimy / Gritty / Both / Neither	Seconds	
	MATERIAL ACCUMUNCATION AREA 2			
7	**Volume (ml)**	**Fines Test**	**Dust Test**	
		Finger Print Visible? Yes No	Height	Ankle Knee Waist
		Slimy / Gritty / Both / Neither	Seconds	
	MATERIAL ACCUMUNCATION AREA 3			
8	**Volume (ml)**	**Fines Test**	**Dust Test**	
		Finger Print Visible? Yes No	Height	Ankle Knee Waist
		Slimy / Gritty / Both / Neither	Seconds	

SIGMA AUTOMATED SAMPLER AND FLOW METER INSTRUMENT CHECKLIST - PLEASE FILL OUT EVERY TIME INSTRUMENT IS SERVICED / DOWNLOADED / CHECKED / ETC.

Date	Time	Site	Event Type	Personnel	File Downloaded	Samples Collected		Settings					Clean Bottles Installed	Notes
						#Bottles	Sent to Lab, individ or composited?	Event Trigger	Sample Interval	Vol per Sample	Sample per Bottle	Flow Reading Interval		

IN-SITU WATER INSTRUMENT CHECKLIST - PLEASE FILL OUT EVERY TIME INSTRUMENT IS SERVICED / DOWNLOADED / CHECKED / ETC.

Date	Time	Site	Personnel	Gage	File Extracted	Data OK	Battery			New Test				Notes
							Capacity	Changed?	New Capacity	Name	Interval	Mode	Start Time	
				mini / baro / level										
				mini / baro / level										
				mini / baro / level										
				mini / baro / level										
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				mini / baro / level										

2NDNATURE
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www.2ndnaturellc.com

CHAIN OF CUSTODY RECORD

PAGE ____ **OF** ____

PROJECT NAME AND JOB #: ______________________

SEND CERTIFIED RESULTS TO: ______________________

ELECTRONIC DELIVERABLE FORMAT: **YES** **NO**

Sampler: ______________________

Date: ______________________

LABORATORY: ______________________

TURNAROUND TIME: Standard 24hr Rush 48hr Rush 72hr Rush

GLOBAL I.D.: ______________________

Sample Identification	Sample Date	Time Sampled	Sample Filtered?	SAMPLE CONTAINERS					REQUESTED ANALYSIS										
										Nutrients								Additional Analysis	
										Filtered									
				30 mL Poly Bottles	250 mL Poly Bottles	2.5L bottle	Other	Composite Samples?	Chlorophyll	NO_x^-	NO_2^-	NH_4^+	SRP	DP	DKN	TKN	TP	TSS	Grain Size

RELEASED BY:	Date & Time		RECEIVED BY:	Date & Time	SAMPLE CONDITION (circle one)
1.		→			Ambient Refrigerated Ice
2.		→			Ambient Refrigerated Ice
3.		→			Ambient Refrigerated Ice
4.		→			Ambient Refrigerated Ice
5.		→			Ambient Refrigerated Ice

NOTES:

08-570 SNPLMA PLRM SAMPLING
Site Location:
Sample Type:
Bottle #, Composite?:
Rep #:
Date:
Time Collected:
Field Personnel:

08-570 SNPLMA PLRM SAMPLING
Site Location:
Sample Type:
Bottle #, Composite?:
Rep #:
Date:
Time Collected:
Field Personnel:

08-570 SNPLMA PLRM SAMPLING
Site Location:
Sample Type:
Bottle #, Composite?:
Rep #:
Date:
Time Collected:
Field Personnel:

08-570 SNPLMA PLRM SAMPLING
Site Location:
Sample Type:
Bottle #, Composite?:
Rep #:
Date:
Time Collected:
Field Personnel:

08-570 SNPLMA PLRM SAMPLING
Site Location:
Sample Type:
Bottle #, Composite?:
Rep #:
Date:
Time Collected:
Field Personnel:

08-570 SNPLMA PLRM SAMPLING
Site Location:
Sample Type:
Bottle #, Composite?:
Rep #:
Date:
Time Collected:
Field Personnel:

08-570 SNPLMA PLRM SAMPLING
Site Location:
Sample Type:
Bottle #, Composite?:
Rep #:
Date:
Time Collected:
Field Personnel:

08-570 SNPLMA PLRM SAMPLING
Site Location:
Sample Type:
Bottle #, Composite?:
Rep #:
Date:
Time Collected:
Field Personnel:

08-570 SNPLMA PLRM SAMPLING
Site Location:
Sample Type:
Bottle #, Composite?:
Rep #:
Date:
Time Collected:
Field Personnel:

08-570 SNPLMA PLRM SAMPLING
Site Location:
Sample Type:
Bottle #, Composite?:
Rep #:
Date:
Time Collected:
Field Personnel:

APPENDIX A. WETLAB QUALITY ASSURANCE PLAN

WETLAB

Western Environmental Testing Laboratory

QUALITY ASSURANCE PLAN

Prepared by: **Western Environmental Testing Laboratory**
475 E Greg Street #119
Sparks NV 89431

For use by: **Western Environmental Testing Laboratory**
475 E Greg Street #119
Sparks NV 89431

April 2007

WETLAB

Western Environmental Testing Laboratory

LABORATORY QUALITY ASSURANCE PROGRAM
REVISION 4
April 2007

Signature of the authorized individuals below constitutes approval of the general format and composition of this manual. Individual sections are coordinated with the parties responsible for their implementation.

Approved By:

Andrew Smith, Laboratory Director

Date: 4/25/07

Michelle Sherven, President

Date: 4-25-07

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INTRODUCTION

Western Environmental Testing Laboratory (WETLAB) specializes in analytical chemistry and provides a range of services for the environmental industry. These services include chemical analysis for microbiology, inorganics, and metals, from sources such as surface water, groundwater, drinking water, wastewater, soil, sludge, vegetation and hazardous wastes.

The Quality Assurance Plan (QAP) describes the management policy, organizational structure and the specific quality assurance (QA) requirements for inorganic, metal, and microbiological analyses performed at WETLAB. The management at WETLAB advocates the development and use of the best analytical practices as mandated by each testing situation. This QAP adheres to the applicable elements described in ISO/IEC Guide 25-1990, "General Requirements for the Competence of Calibration and Testing Laboratories", and the current revision of the National Environmental Laboratory Accreditation Conference (NELAC) Quality Systems document.

QUALITY POLICY

The objective of WETLAB is to produce the highest quality data which is accurate, precise, legally defensible, and meets our client's data requirements in a timely and cost effective manner. The Quality Assurance program provides guidelines and rules to ensure that all data produced meets or exceeds WETLAB standards. The quality control program of the laboratory ensures the maintenance of the controlled analytical processes. The quality assessment program incorporates all the necessary elements to ensure that the quality control system is functioning effectively. Implementation of the quality assurance program is based on documentation of all aspects of the program, validation and statistical control, and periodic verification and inspection.

WETLAB is committed to continuous improvement and to providing analytical services that are of the highest quality. WETLAB believes that client satisfaction is the most important service our employees can provide.

1.0 LABORATORY ORGANIZATION AND MANAGEMENT

1.1 Organizational Charts

The organization of WETLAB, including QA and reporting functions, is shown in Figure 1-1-1.

1.2 Management Responsibilities

Professional qualifications and experience of the individuals filling these positions are maintained and resumes are kept on file. As pertaining to quality, the specific duties and responsibilities of WETLAB's key personnel, i.e., President, Laboratory Director, Operations Manager and Technical staff are described below.

President:

The President is responsible for the oversight of quality and performance of WETLAB. The Laboratory Director reports directly to the President and the President has responsibility for all laboratory activities including implementation of the QA program. The President is also responsible for:

- Providing technical assistance on quality issues to ensure that WETLAB is in compliance with regulatory programs and with the QA program.
- Providing guidance and approving changes in laboratory quality assurance staff.
- Implementation of the Quality Assurance Manual.
- Company policy and strategy for quality
- Providing necessary leadership to assure that corporate policy is met
- Providing resources to implement the formal Quality Assurance (QA) program
- Assures that all samples are properly labeled, stored, and logged into the sample tracking system

Laboratory Director / QA Manager:

The Laboratory Director / QA Manager is responsible for the implementation of the WETLAB QA program and compliance with standard operating procedures (SOP). The Laboratory Director / QA Manager or an approved designee reviews all analytical data and signs all laboratory reports. The Laboratory Director / QA Manager assures that all laboratory staff has the education, experience, and basic laboratory skills necessary to adequately perform their jobs. The Laboratory Director / QA Manager is responsible for the health and safety aspects of the laboratory operations including administration of the chemical hygiene and safety plans. The Laboratory Director / QA Manager has sufficient authority and organizational freedom to identify quality problems; to initiate, recommend or provide solutions; to verify implementation of solutions; and, if necessary, to stop work until the problem is resolved.

The duties of the Laboratory Director / QA Manager include:

- Overall direction and general administration.

- Review of analytical procedures and practices.
- Training and professional development of staff.
- Technical review of proposals, bids, and quotations.
- Review of reports for compliance with WETLAB quality standards and client requirements.
- Notifying the President of deficiencies in the quality system and monitoring of corrective actions.
- Monitor external audits, write responses and ensure corrective actions.
- Development of QA procedures, instructions and plans.
- Maintain surveillance over all applications of the QA plan, make recommendations for resolution of problems, or further evaluation by management.
- Initiate formal corrective action(s).
- Issue stop-work orders for work which is not in compliance with requirements.
- Direct and maintain records of laboratory certification programs.
- Implementation of the Quality Assurance Manual.

Operations Manager:

The Operations Manager reports directly to the President. The Operations Manager has sufficient authority and organizational freedom to identify efficiency or personnel problems; to initiate, recommend or provide solutions; and to verify implementation of solutions.

The duties and responsibilities of the Operations Manager are as follows:

- Direct and coordinate the overall operation of the laboratory.
- Ensure the effective utilization of staff, adherence to technical requirements, schedules and budgets in order to maximize profits and satisfy clients.
- Responsible for laboratory productivity and turnaround times.
- Supervise group leaders whose responsibilities include assigning laboratory priorities.
- Administer LIMS.
- Ensure the adherence to quality requirements on a daily basis by technical staff.

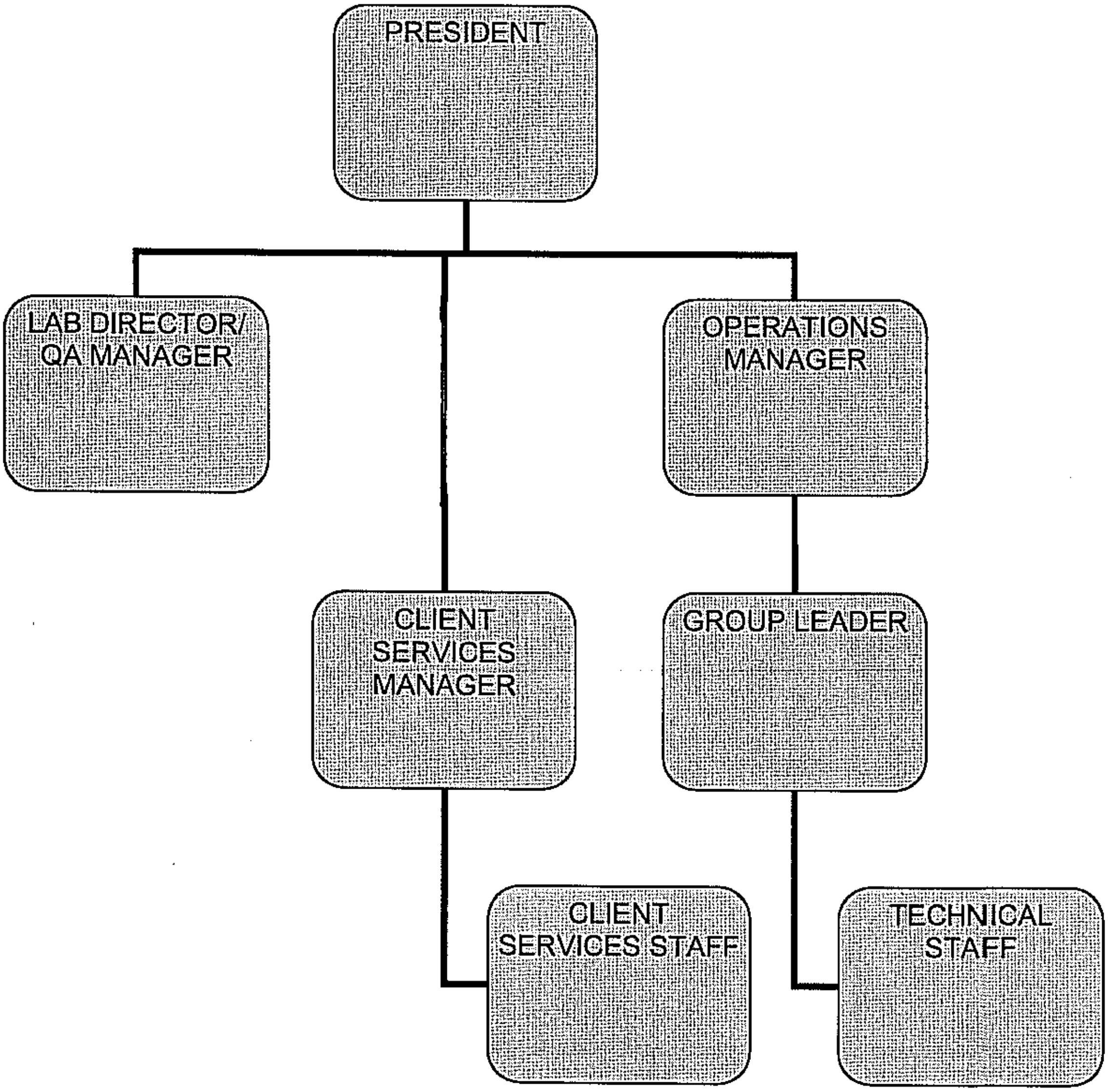
Technical Staff

All WETLAB analysts have the primary responsibility for performing their jobs in accordance with the WETLAB SOP's and QA manual. They work together with their co-workers and supervisor to ensure that the company's high standard for quality is upheld. They perform and document calibration, preventative maintenance, data processing, and data review procedures. Report any nonconformance to their supervisor and QA Manager.

1.3 Ethics Policy

WETLAB utilizes a clearly stated ethics policy which is discussed with all new employees during orientation. The employee is required to understand the high standards of integrity implied in the duties performed and the data reported in connection with their employment at WETLAB. They understand that intentionally reporting data values that are not the actual values obtained; intentionally reporting days and times of analyses that are not the actual dates and times of analyses; and, intentionally representing another individual's work as their own will be cause for dismissal. They are also required to inform WETLAB of any accidental or intentional reporting of falsified data by themselves or other employees.

FIGURE 1-1-1. WETLAB Organizational Chart



2.0 QUALITY SYSTEMS

2.1 Quality Assurance Program

The purpose of this laboratory QA/QC Plan is to provide an overview of the quality systems in effect at WETLAB. The QA program is documented by written policies and procedures. The policies and practices of the quality system presented in this plan are set forth as minimums. Additional quality measures may be required for specific projects.

The principle objective of the QA Program at WETLAB is to provide a product of documented quality which fulfills the requirements of each client's project. The QA program was developed to follow the intent of the ISO/IEC Guide 25-1990, "General Requirements for the Competence of Calibration and Testing Laboratories" and, the National Environmental Laboratory Accreditation Conference (NELAC) Quality Systems manual. Both laboratory management and clientele as means of reviewing analytical results for accuracy and reliability utilize the QA program. The basic philosophy regarding quality as detailed in these documents has been used as a guideline for the development of the QA Program at WETLAB. The Program addresses general activity in the following areas:

1. Laboratory Organization and Management
2. Quality Systems
3. Personnel Training and Certification
4. Laboratory Facilities
5. Instrument Calibration, Verification and Maintenance
6. Reagent, Standard and Procurement Control
7. Test Methods and Standard Operating Procedures
8. Sample Management
9. Data Handling, Reporting and Record Keeping
10. Records
11. Statistical Quality Control
12. Laboratory Health and Safety and Waste Management

Within the first 30 days of employment, all new staff is oriented as to the basic elements of the QA Program. QA Program orientation is documented and records are maintained by the QA Department. As part of the basic orientation, new personnel are required to read and understand the QA/QC Plan. It is also a requisite for all staff to read any new revision of the Plan to keep current with the QA Program.

Orientation as to specific requirements of each department is the responsibility of the department supervisory staff during training of new personnel. The personnel certification procedure describes the specific requirements for obtaining, maintaining and documenting certification of staff.

Analysts are assigned analytical duties commensurate with their education, experience and training. Only those personnel experienced in the use of analytical instrumentation are permitted to operate the equipment. A person with the necessary expertise must supervise inexperienced personnel until the former have attained proficiency in the use of a particular piece of equipment. Following an initial training period, laboratory personnel are evaluated by a certified analyst on all aspects of their position. Each analyst must demonstrate the necessary working knowledge of the technical and theoretical aspects of his specialty and position. An individual is authorized to perform only the functions in which they have demonstrated competence.

All equipment necessary for conducting laboratory analyses is maintained and calibrated prior to use. Trained personnel analyze the samples and data and generate the reports. Within the analysis cycle there are specified inspection points beyond which analysis data do not progress until these data have been reviewed and approved. Therefore, data are continually checked throughout the analysis and report preparation cycle.

The QA program functions to ensure that the clients are provided with a product of documented quality. The program is scrutinized and modified when necessary to fulfill the requirements of the client and to continually improve the program.

2.2 QA Reports to Management

For day-to-day reporting, a Corrective Action Report (CAR) (Appendix F) is initiated for situations requiring immediate attention. Distribution of these documents includes the Laboratory Director and/or Group Leaders who must acknowledge, approve and sign corrective action(s) to remedy out-of-control situations.

Results of both external and internal performance audits are distributed to laboratory management for review and action, as appropriate. After acceptable corrective action responses are received and verified for all noted deficiencies, the audit is closed and management receives a written status report.

2.3 Audits

2.3.1 Internal Audits

Planned and scheduled internal audits are performed to verify compliance with all aspects of the QA program and to determine its effectiveness. It is intended that internal QA audits be utilized as a management tool for enhancement of project operations, functions and quality.

Internal systems audits for each department are performed on years when no external agency is auditing. These audits are performed by QA personnel in accordance with written procedures and checklists. The QA Manager performing these audits has stop-work authority for the activities audited. The scope of these audits include, verification of compliance to the quality systems and technical evaluation in the areas of control of equipment, personnel certification, analytical SOPs, sample ID and storage, standards preparation and tracking and data documentation. Audit results are reported in writing to responsible management for review and corrective action, if necessary. A maximum of 30 days is given to respond to the original report. The original copy of the completed report, with responses, is kept on file by the QA Department. QA personnel follow up by verifying the effectiveness of the implemented corrective action.

Additionally, all laboratory notebooks are routinely reviewed by the analyst and a second reviewer to assure correctness of sample and QC calculations. All active laboratory data books and QC files are subject to periodic audits/surveillances by QA personnel and/or Supervisors.

Raw data evaluations will be based on the following completed information, as applicable:

- Parameter and method
- Instrument ID and settings
- Date and initials of analyst
- Valid standard curve
- Frequency of QC
- QC calculations and recoveries
- Sample calculations
- Neatness and ease of data interpretation

Reviewed data will be documented as "reviewed by" and signed (initials) and dated by the reviewer.

An effective Quality program provides rapid and thorough correction of QC problems. Corrective Actions minimize the questionability of the data.

2.3.2 External Audits

When the results from an external on-site audit or performance evaluation study are received by the QA Department, a summary of the results will be distributed to appropriate laboratory personnel, i.e., the Lab Director and Group Leader(s).

If deficiencies exist, the Lab Director or Group Leader will issue a response addressing the findings and resultant steps to correct the deficiency. Upon receipt of all corrective action responses, a formal corrective action report will be forwarded to the respective outside client or agency.

2.3.3 Management Review

The laboratory management conducts a review of its quality system and its testing and calibration activities to ensure its continuing suitability and effectiveness and to introduce any necessary changes or improvements in the quality system and laboratory operations. The following criteria are reviewed:

- Internal audit results and responses
- External audit results and responses
- Interlaboratory comparison tests
- Client concerns and/or complaints
- Corrective action reports
- EH&S incidents having the potential of affecting client analyses
- Assessment of current certifications

Within 10 working days of performing the review, a copy of the review will be distributed as necessary to departmental staff in order to correct any findings or deficiencies associated with their department. All deficiencies must be responded to within 30 calendar days after receipt. All records are maintained by the QA Department.

2.3.4 Performance Evaluation Audits

As part of an on-going laboratory QA/QC program, WET LAB routinely participates in semi-annual Water Pollution (WP), Water Supply (WS), and Soils Performance Evaluation Studies and in round-robin proficiency testing and laboratory certification programs conducted by the local and state agencies. These studies are procured from a National Institute of Standards and Technology (NIST) accredited laboratory

A list of the current state certifications for the WETLAB facility is given in Appendix C.

2.4 Corrective Actions

In addition to providing acceptance criteria and specific protocols for corrective actions in the SOPs, WETLAB implements general procedures to be followed to determine when departures from documented policies, procedures and quality control have occurred. These procedures identify:

1) Individual(s) responsible for assessing each QC data type;
2) Individual(s) responsible for initiating and/or recommending corrective actions;
3) Define how the analyst should treat a data set if the associated QC measurements are unacceptable;
4) Specify how out-of-control situations and subsequent corrective actions are to be documented; and,
5) Specify procedures for management to review corrective action reports.

To the extent possible, samples shall be reported only if all quality control measures are acceptable. If a quality control measure is found to be out of control, and the data are to be reported, all samples associated with the failed quality control measure shall be reported with data qualifiers, as appropriate, and notations in the accompanying case narratives.

2.4.1 Corrective Actions from Internal Indicators

Monitoring systems in the laboratory are designed to help ensure not only that reported data are of known and documentable quality, but also that the quality reflects the degree of excellence expected and demanded by WETLAB personnel and clients. Quality indicators for the effectiveness of these monitoring systems include both internal and external audits and/or surveillances to measure performance against established criteria for good laboratory practices. When evaluation of these quality indicators shows an unsatisfactory condition affecting the quality of services provided, a Corrective Action Report (CAR) must be initiated.

Immediate corrective action to correct or repair non-conforming equipment and systems is generally initiated as the result of QC procedures. An analyst will know immediately, for example, that an instrument has drifted out of calibration if it does not meet the allowable QC criteria, and can take immediate action to repair the system.

Corrective action may also be initiated due to QA issues. These are most often identified during audits. Corrective action in this case involves an investigation into the root-cause of the non-conformance, and may take much longer to identify and resolve. Staff training, SOP revision, replacement of equipment, and LIMS reprogramming, are among the many types of long-term corrective action that may result from a QA audit.

All corrective actions will comprise the following steps to ensure a closed-loop corrective action system:

- Define the problem
- Assign responsibility for investigating the problem
- Determine a corrective action to eliminate the problem
- Assign and accept responsibility for implementing the corrective action
- Establish effectiveness of the corrective action and implement the correction
- Verify that the corrective action has eliminated the problem

The initial responsibility to monitor the quality of a function or analytical system lies with the individual performing the task or test. Quality indicators are evaluated against laboratory established or client specified QC requirements. If the assessment reveals that any of the QC acceptance criteria are not met, the analyst must immediately assess the analytical system to correct the problem. When an acceptable resolution cannot be met and/or data quality is negatively impacted, the analyst will notify the Group Leader or Laboratory Director.

When the appropriate corrective action measures have been defined and the analytical system is determined to be "in control" or the measures required to put the system "in control" have been identified and scheduled, the problem and resolution or planned action is documented on the appropriate form.

The QA Department has the authority to stop the analysis and to hold all analyses of samples affected by an out-of-control situation. The method cannot be restarted without documentation leading to the QA Department's approval to restart the method. For cases where suspension of the method was imposed by QA, QA sign-off is required prior to reinstatement of the affected method.

The Laboratory Director and Group Leaders are responsible for correcting out-of-control situations, placing highest priority on this endeavor.

2.4.2 Corrective Actions on Analytical Reports

The "product" or "material" that WETLAB provides to its clients are the completed analytical reports. If an out-of-tolerance condition (error) is discovered, the affected areas are identified and segregated when possible. The department must determine the extent to which any analytical data may have been affected by the out-of-tolerance condition. Documentation of this may appear in the case narrative, report cover letter, corrected report, whichever is appropriate. Several key areas within the laboratory may be affected.

If the analytical results are affected, the department group leader issues a corrective report and, if appropriate, a case narrative may be included.

2.4.3 Client Complaints and Concerns

The President and Lab Director are responsible for directly dealing with client complaints about data quality or incompleteness of data reports. The QA Manager or Lab Director is responsible for initiation of any required formal corrective actions.

3.0 PERSONNEL TRAINING AND CERTIFICATION

All personnel meet the educational standard as determined by their job duties. Personnel selected for performing laboratory activities shall have the experience or training commensurate with the scope, complexity, or special nature of the activities.

All new WETLAB personnel must read the current QA documents and any subsequent revisions. Orientation as to the specifics of the QA program at WETLAB is conducted and documented for all new staff within the first few weeks of employment.

3.1 Administrative Procedures

The administrative procedures cover all aspects of sample management operation such as sample receipt, login, reporting, purchasing and client services. These procedures are readily available to all staff.

3.2 Laboratory Quality Assurance Plan

In order to produce quality data, it is essential that each employee be familiar with the quality assurance program. A thorough presentation of the program can be found in the Quality Assurance Plan. Each laboratory employee is issued a copy of the manual.

3.3 Health and Safety Orientation and Training

The health and safety of our employees, clients and the public is our greatest concern. Each employee must comply with the safety requirements, practices and procedures. These criteria are drawn from EPA and OSHA requirements, *Good Laboratory Practices*, and requirements obtained from experience and mandated by management. The Health and Safety manual is designed to be dynamic documents, open to revisions and/or additions as needed. All laboratory personnel undergo a health and safety training class (based on the requirements of 29 CFR 1910.1200 and 29 CFR 1910.1450 as applicable to laboratory operations).

3.4 Procedure Manuals

The quality of the data produced is directly related to the methods employed and the training of the analysts and staff. A vital part of our training program involves the complete familiarization of each analyst and staff member to the methods being performed. Procedure manuals (Standard Operating Procedures (SOPs)) are available in each analytical section of the laboratory and the administrative areas. These procedures are reviewed when necessary at a frequency of at least every three years by the technical staff and Lab Director. Changes are made with the approval of the technical staff, Lab Director and QA.

3.5 Initial Demonstration of Performance/Method Validation

All technical laboratory staff must complete an initial demonstration of method performance in conformance with relevant industry/regulatory guidelines for each method they perform. Acceptance criteria are specified in the standard operating procedures.

3.6 Training/Qualifications Documentation

Training files are maintained for each employee that includes documentation of attendance at training seminars, a listing of method certifications successfully completed, and checklists for method specific training requirements. Documentation of personnel qualifications (resumes) are also maintained on file.

To be certified to perform sample analysis, each analyst must demonstrate a working knowledge of the technical and theoretical aspects of their specialty and position. Each analyst is required to undergo individual training in his or her department prior to unsupervised analysis of any samples.
The training consists of at least the following points:

1) The trainee shall become familiar with the procedures to be performed along with the reagents and equipment used.
2) Successful initial demonstration of method performance is required. Under the direction of a certified analyst, the trainee shall analyze a set of known samples to demonstrate a good working knowledge of the analysis that will be performed. Exceptions to this requirement are microbiology and tests for which spiking solutions are not available, for example, solids analyses, pH, color, or turbidity.
3) Finally, the trainee shall go through all the steps of the analysis, including the preparation of standards and reagents. When the trainee has proven competence of the specific analysis, paperwork is completed documenting the trainee's certification.

The originals of current employee technical certifications are kept on file. Certifications are updated as needed.

4.0 LABORATORY FACILITIES

The physical laboratory facility can adversely affect the quality of results unless it complies with minimum requirements set forth by EPA and OSHA or other legal requirements. WETLAB's facility was constructed in accordance with local and state building and safety codes. All fire extinguishers and hood velocities are monitored to ensure compliance with safety regulations. Due to the fast-paced growth of environmental chemistry and microbiology, our facility plan is evaluated periodically as the demand for analyses increases. Appendix G provides more detailed information about the specific laboratory facilities including a floor plan.

5.0 INSTRUMENT CALIBRATION, VERIFICATION AND MAINTENANCE

5.1 Instrument Calibration

All equipment is maintained in proper working order with a written log for maintenance, repair and calibration. Service is provided for much of the major instrumentation by the manufacturer and required maintenance is performed at regular intervals. Where applicable, reference materials certified by NIST, including thermometers, are used for calibration purposes. WETLAB maintains the operating, service and calibration manuals provided by the manufacturer for all laboratory equipment. Maintenance files and service records are maintained for all instruments.

The laboratory utilizes state-of-the-art instrumentation for multi-matrix chemical analyses. Appendix C provides more detailed information about the specific laboratory equipment.

Instrumentation is controlled, calibrated and maintained according to specified schedules to verify acceptable instrument performance at the time the instrument is used for the generation of analytical data.

All instruments must be calibrated prior to use with known certified traceable reference materials. The manner in which various instruments are calibrated is dependent on the particular type of instrument and its intended use. All sample measurements are made within the calibrated range of the instrument. Preparation of all reference materials used for calibration will be documented in a standards preparation notebook.

Calibration information may be documented in any of several locations. The requirements for calibration vary with each instrument, thus necessitating flexibility in the recording of such information. The calibration data may be documented in an instrument logbook, on the raw data, on equipment specific forms. It is the responsibility of the analyst using the instrument to perform and document the required calibration. Calibration must be done on or before the due date. Calibration records are maintained by the group responsible for the equipment.

If the calibration schedule has not been observed, or the required level of accuracy cannot be attained for a specific instrument, the supervisor is notified and the instrument is placed on "HOLD" and is unavailable for use until the specifications are attained. This is indicated by a "HOLD" sticker placed on the instrument. The instrument logbook shall document the "HOLD" status of the instrument and the effective dates. Should an instrument be found to be out of calibration, all data obtained subsequently to the last successful calibration is evaluated by the Group Leader and appropriate corrective action is taken as deemed necessary.

Instrument calibration typically consists of two types: initial calibration and continuing calibration. Initial calibration procedures establish the calibration range of the instrument and determine instrument response over that range. Typically, three to five analyte concentrations are used to establish instrument response over a concentration range. A blank must be analyzed as well as a calibration check for verification. The calibration curve must meet the linearity requirements of the method, which are listed by method in appendix E and described in the standard operating procedures. If a linear regression is used the coefficient of variation (CV) should be no less than 0.995.

The concentrations of standards used for calibration must be appropriate for the samples to be analyzed. Samples more concentrated than the highest standard are diluted to the working range of the curve. Drinking water analyses must include a low calibration standard at the reporting level concentration.

Continuing calibration usually includes measurement of the instrument response to fewer calibration standards and requires instrument response to compare with certain limits (e.g. ± 10%) of the initial measured instrument response. Continuing calibration may be used within an analytical sequence to verify stable calibration throughout the sequence, and/or to demonstrate that instrument response did not drift during a period of non-use of the instrument.

5.2 Calibration Verification

Required calibration verification frequency and criteria for inorganic and organic analyses are method specific and are delineated within the respective SOP and Appendix E.

No instrument calibration verification is employed in the methods for acidity, alkalinity, BOD, color, corrosivity, DO, gravimetric oil and grease, hardness, ignitability and all of the solids methods.

For microbiology, total coliforms must be accompanied by a blank and for fecal coliforms, a positive and negative control must be run with each new lot of media.

5.3 Instrument Maintenance

Corrective action in the form of maintenance may be required in cases where an instrument either continues to fail initial calibration or drifts out of calibration. Regularly scheduled preventive maintenance may also be used in accordance with the manufacturer's suggested program. Each instrument has its own maintenance log that is used to document all maintenance activities performed on the instrument.

6.0 REAGENT, STANDARD AND PROCUREMENT CONTROL

At the center of all analytical procedures are the reagents, chemicals, stock cultures and other materials. The quality of these items is directly related to the quality of the data produced. To ensure that our analysts are using the most current reagents and chemicals, our laboratory has a cross-check system that begins with purchasing and continues through disposal. This system provides minimum standards to ensure our analytical results are not compromised.

6.1 Purchasing

It is the responsibility of each analyst to ensure that all depleted reagents, chemicals and materials in his/her area are ordered correctly and in a timely manner so there is always a sufficient supply. The request is written on a Purchase Order form (P.O.) and submitted to the Laboratory Director for final written approval. Following final approval, the purchasing agent assigns a sequential purchase order number (from the P.O. log) to the request and places the order. A copy of the purchase order is given to shipping and receiving. The quoted prices from the vendor are verified, then each P.O. is filed in numerical order in the Purchase Order file. When the materials are received, the packing list is compared with the purchase order by the shipping and receiving personnel. If all packing slips, invoices and prices are correct the invoice is submitted for payment. All invoices for each vendor are collected and attached to a voucher apron for approval. In the event an invoiced price does not coincide with the quoted price, the package is returned to the purchasing agent for reconciliation with the vendor. Once the paperwork has been corrected, it is again submitted to the payables section for review and payment.

6.1.1 Laboratory Reagents and Standards

The quality of reagents used depends upon the nature of the analysis. "Analytical Reagent" grade is used when no minimum requirement is stated. When necessary for a particular procedure, a higher grade reagent is obtained. High purity acids and/or solvents are used for digestions or extractions for trace level analyses. Gases utilized for analyses are of several different grades depending on analytical and instrumental requirements. The tanks are labeled according to the grade of gas in the cylinder.

6.2 Receiving

All materials, chemicals, instrument and sample shipping and receiving are handled through the shipping and receiving area. Non-sample materials are distributed from the central storage area to the appropriate departments. Organic solvents, acids and dry chemicals are marked with the received date. Material Safety Data Sheets (MSDS) that may accompany chemicals or standards are filed in binders and are stored on a bookshelf in the main lab as a central reference source, available to all employees. Standard certificates are sequentially numbered, logged into a standard database maintained by the QA department, and retained by the group leaders. Items received broken or missing pieces are noted in the log and then given to the purchasing agent for reconciliation.

6.3 Storage

Proper chemical storage is essential to the quality of the data generated as well as the safety of the analysts and staff. All stock organic solvents and acids are stored in fire-proof, OSHA-approved metal storage cabinets. Dry chemicals in use are stored in a cool, dry area in each laboratory. Chemicals and standards requiring refrigeration are retained in a unit temperature controlled at 4°C± 2°C. Stock cultures are stored in a freezer at -26°C and working cultures are stored at 4°C± 2°C. To prevent cross contamination, refrigerated chemicals and standards must be stored in a separate unit from samples and sample extracts.

6.4 Chemical and Standard Labeling and Tracking

A standard format for labeling of reagents, stock cultures, chemicals and standards is necessary to provide traceability, consistent information, maintenance of current solutions and an orderly appearance. Upon arrival, each solvent, acid, chemical and standard container is labeled with the following information (in plain view without obscuring any information on the original container label). The date received and initials of the receiving party are noted on the label prior to storage. It is the responsibility of the analyst to note the date opened and his/her initials on the label. Each standard is logged into the standard logbook for that department. A unique WETLAB lot # is assigned to each standard prepared. This number is also written on the standard container.

In the case of organic standards, which may arrive several vials to a box, the date received and initials are marked on the outside of the box. As each vial or ampule is used, the analyst notes the date opened and initials the vial or ampule label. If the entire contents are used, the date opened is noted in the organic standards prep log with the lot number and analyst's initials. If a vial or ampule is used as a reagent in an organic extraction and is entirely consumed, the date opened, initials, lot number and manufacturer are noted in the extraction log.

Dilution's made from commercially prepared standards or reagents and solutions prepared from dry chemicals are placed in containers consistent with the type of solution (i.e. organics-glass with Teflon-lined lid or crimp top; inorganics/metals-white Nalgene or glass bottle with a cap). The required label information is as follows: Date prepared, initials, unique standard ID, chemical name, concentration, and expiration date.

Other information such as exact preparation instructions, lot number, and solvent used can be cross-referenced in the solutions/standards prep logs by name and date prepared.

6.5 Disposal

Proper disposal of expired standards, chemicals, biological materials, reagents and solutions is imperative. Most standards, reagents, solutions and chemicals are deemed expired by the manufacturers' supplied expiration date. If no date is available, a laboratory-determined date is given by the user, based on the known stability of the chemical.

These wastes, and their containers if required, are deposited in appropriately labeled satellite receptacles (in accordance with 29 CFR, Part 1910). As these satellites become full, they are transferred to permanent disposal containers as liquid waste by type or lab packed solid wastes or biological materials ("sharps"). (Refer to WETLAB Chemical Hygiene Plan for methods of transfer, personal protection required and documentation and to SOP 11.02 "Sample Disposal and Waste Management.")

Wastes are removed from the laboratory facility on a regular basis Copies of all manifests and analytical results are retained by the Laboratory Director.

Liquid biological wastes, such as total coliform samples, are sterilized by contact with bleach for a minimum of 10 minutes and then disposed of as ordinary liquid waste. Solid biological waste, such as fecal coliform plates or Quantitray trays, are sterilized by either contact with bleach in the same way liquids are or placed in the UV sterilization box for a minimum of 10 minutes and then disposed of as an ordinary solid waste.

7.0 ANALYTICAL METHODS AND STANDARD OPERATING PROCEDURES

7.1 Analytical Methods

Whenever possible, the analytical methods used by WETLAB have been approved and published by State or Federal agencies, such as the U.S. Environmental Protection Agency (USEPA), Department of Energy (DOE), American Public Health Association (APHA), American Society for Testing and Materials (ASTM), or the National Institute for Occupational Safety and Health (NIOSH) as described in WETLAB's SOPs. A list of selected, but not exhaustive, reference documents supported and used by WETLAB. is as follows:

U. S. Environmental Protection Agency, <u>Methods for Chemical Analysis of Water and Wastes</u>, EPA 600/4-79-020, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, revised March 1983.

ibid. <u>Methods for the Determination of Metals in Environmental Samples-Supplement</u>, EPA-600/R-94-111, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, May 1994.

ibid. <u>Methods for the Determination of Inorganic Substances in Environmental Samples</u>, EPA-600/2-93-100, August 1993.

ibid. Prescribed Procedures for Measurement of Radioactivity in Drinking Water, EPA 600/4-80-032, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, August 1980.

ibid. Methods for the Determination of Organic Compounds in Drinking Water, EPA/600/4-88/039, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, July 1991.

ibid. Methods for the Determination of Organic Compounds in Drinking Water, Supplement I, EPA/600/4-90 Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, August 1992.

ibid. Methods for the Determination of Organic Compounds in Drinking Water, Supplement II, EPA/600/R-92/129, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, April 1990, and updated September 1992 and March 1997.

ibid. Manual for the Certification of Laboratories Analyzing Drinking Water, 4th Edition, EPA/57/9-90/008, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio, April 1990, and updated September 1992 and March 1997.

ibid. Test Methods for Evaluating Solid Waste, SW-846, 3rd Edition, Office of Solid Waste and Emergency Response, Washington, DC, September 1986, and updated September 1994.

Standard Methods for the Examination of Water and Wastewater, 19th Edition, APHA-AWWA-WPCF, Washington, DC, 1995.

Hach Chemical Company, Hach Handbook of Water Analysis, Loveland, Colorado, 1979.

Code of Federal Regulations, Appendix A to Part 136-Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, 40 CFR Part 136, 1996.

Prior to implementing new procedures, analyses are conducted using standards, spikes, and duplicate samples as controls. A SOP is also prepared which documents and describes the analytical method. Once the procedure is properly understood by the analyst and acceptable quality control data (detection limits, precision and accuracy) is achieved, the method is placed in the laboratory for use. Quality Control requirements are within individual analytical procedures.

7.2 Standard Operating Procedures

WETLAB maintains several types of procedures: general laboratory practice procedures; program specific procedures; data tracking and reporting procedures; laboratory equipment control procedures; analytical procedures; and, personnel certification and training procedures. All analytical SOPs are reviewed every three years; lab equipment and administrative SOPs are reviewed as needed. All personnel are responsible for conducting quality related activities in compliance with these documents. All forms utilized for recording analytical records are controlled by the program. The references used for developing the analytical methods are acknowledged in the written SOP. All procedures and forms require review and approval by supervisory staff as well as the QA Department prior to implementation. Procedures are prepared, approved and reviewed in accordance with procedure 9.05, Standard Operating Procedures.

The procedures are written according to established format guidelines. The following outline is observed to incorporate all relevant information in the procedure:

1. Scope and Application
2. Summary of Method
3. Safety
4. Sample Handling and Preservation
5. Interferences
6. Apparatus
7. Reagents
8. Procedure
9. Quality Control
10. Calculations
11. Reporting Format
12. References

Appendix C contains a list of analytical procedures with the associated reference method.

7.3 Analytical Quality Control (QC)

In order to assess the validity of a reported result, QC indicators are placed in the measurement system to provide a tool for evaluating how well the method worked. There are QC indicators to evaluate the method performance at both the preparation and the measurement steps, and QC indicators to evaluate matrix effects.

Most samples to be analyzed in the laboratory require some pre-treatment before a measurement can be made. This may include extraction, digestion, distillation, etc. During the pre-treatment step, samples are arranged into discreet, manageable batches, to facilitate and control uniform treatment for all samples. Each batch will have a maximum of 20 investigative samples of the same matrix (e.g., soil or water). In addition, QC indicators such as blanks, spikes, and duplicates are added to each prep batch to monitor the performance of the system. All QC associated with a batch will be carried through the entire analytical procedure from preparation to final analysis. A blank or reagent blank is used to monitor potential contamination from the sample preparation process. The reagent blank volume or weight must be approximately equal to the sample volumes or sample weights being processed. In the absence of a suitable solid matrix for soil blanks, reagents will be added to an empty flask and carried through the entire analytical scheme. Results will be calculated based on starting with a "blank" soil approximately equal to the weight of the samples.

Specific QC guidelines are given in departmental analytical procedures. Appendix E contains QC criteria by method for inorganics and organics.

Occasionally problems are encountered in meeting the QC requirements. In some cases data may be outside the criteria and still be reported (e.g., when insufficient volume remains to reanalyze). In these cases, a Nonconformance corrective Action Report must be generated by the analyst, and approved by the Laboratory Director or QA Manager. Additionally, client contact may be necessary to explain the QC problem. If acceptance criteria are still not met after corrective actions have been taken, and no further corrective actions are indicated, the data is reported with a qualifier or flag. Any data qualifiers used will appear on the applicable data report form and will be discussed in the report cover letter or case narrative. Examples of data qualifiers that may be used are shown below.

B	Blank contamination; Analyte detected above the method reporting limit in an associated method blank.
HT	Sample held beyond accepted holding time.
M	Reported value is estimated; the sample matrix interfered with the analysis.
N	There was insufficient sample available to perform a spike and/or duplicate on this analytical batch.
NC	Not calculated due to matrix interference.
Q	Reported value is estimated; the value failed to meet QC criteria for either precision or accuracy.
SA	Reported value was calculated using the method of standard additions.

8.0 SAMPLE MANAGEMENT

8.1 Sample Receiving

Appropriate measures are taken in the handling, storage and shipping of samples and other chemical material to assure compliance with all regulatory requirements.

Samples for analysis may be delivered by the client, picked up by a WETLAB employee, or shipped to the laboratory in coolers with appropriate coolant via a commercial carrier such as UPS, Federal Express, or California Overnight. If a common carrier is used the way bill number and the shipping documents will become part of the permanent project file. Appropriate safety precautions are taken in the laboratory with samples which are classified as hazardous due to a variety of circumstances and/or contaminants. For samples of known hazard, bottles are labeled identifying the hazard. Special care is taken in the handling, storage and disposal of these samples.

The login staff (laboratory personnel properly trained to handle samples of evidentiary nature)are responsible for maintaining custody of the samples during the login and distribution processes and for assuring that all records documenting that possession are properly completed. Samples that require refrigeration will not be allowed to warm to room temperature during the login and distribution processes. The date, time, and sample integrity upon receipt is documented by the login staff. After verification that all samples listed on the COC form are in possession, the "Received By Laboratory" space on the COC is signed. The samples are then placed in the secure sample storage area. Standard Operating Procedure No. 11.01 provides additional information regarding sample log in procedures.

There are three major types of samples the laboratory accepts. The procedure and required paperwork for each type are as follows:

8.1.1 Analysis required for compliance with SDWA - each sample must be submitted with a Chain of Custody (COC). The client must provide address, system name, PWS (Public Water System) ID, sample date, sample time, collection point, sample collector's name, collection source type and sample type. The sample collector should be the first person to relinquish the samples. Lab personnel should sign and date each COC form. A unique Laboratory ID is assigned and affixed to each container. This number must also be written on the COC that corresponds to each sample.

8.1.2 Bacteriological Analysis - Microbiological samples must be submitted is sterilized containers. These are provided to the client upon request. The client must complete a Microbiological form for each sample. This form should include client address, system name, system location, PWS ID, sample date, sample time, collection point, sample collector's name, source type, and sample type. The sample collector should be the first person to relinquish the samples. Lab personnel should date and time each Bac T form. The samples are assigned unique Laboratory ID numbers and the ID number is affixed to the sample container. The samples are taken directly to the microbiologist for analysis.

8.1.3 All Other Analyses - each client should complete a COC form for each set of samples. If a client sends samples by delivery/mail, and neglects to include a completed COC, one should be faxed to the client to fill out and sign, then it should be faxed back for login. Before signing the COC, lab personnel should insure the COC contains clients mailing and billing address, phone number, required analysis, sample collector's name, client's sample ID's, sample dates and locations. The sample collector should be the first person to relinquish the samples. In some cases, an analysis must be submitted to another laboratory.

8.2 Sample Login

The Sample Custodian will unpack the samples and check sample preservation (pH, temperature, etc.) in accordance with WETLAB's sample receipt and log-in procedures. The custodian will record any problems encountered, and contact the Lab Director for instructions.

A written job file is kept which includes copies of the COCs with cross-referencing information for all samples received and distributed. Any sample projects that have special handling or rush turnaround time requirements are rapidly identified and the information is communicated immediately to the appropriate lab personnel. Custody seal(s) on shipping container(s) are inspected for evidence of tampering and noted. The sample bottles are counted and verified against the client COC record. Discrepancies in receipt are documented. The COC is signed and dated by the sample custodian.

A unique Laboratory ID Number is assigned in order to group samples that were received together as a set, example: 903-001. The WETLAB ID number is recorded in the Sample Log-In Book along with the client's name, date, sample type, and project name/number. For WETLAB's purposes, the number designations delineate the year (first digit), the month (second & third digits), and the lab number for this project (last three digits). If there is more than one sample in a project, a two-digit extension is added to the Lab Number, example: 903-001-01.

All samples are labeled with the sample number. The information on the clients sample bottle label is checked for consistency with the chain of custody form. Any inconsistencies are corrected by the client.

8.3 Sample Management and Tracking

The WETLAB Laboratory ID Numbers are assigned in order to group samples which were received together as a set.

When all samples are logged-in, the samples are placed in the appropriate refrigerator and the proper lab is notified of any RUSH samples or any short holding times.

Because the facility is secured and the entrance by the clientele and general public is very restricted, it is not necessary to have an internal Chain of Custody procedure unless requested by the client.

Any sample projects which have special handling or rush turnaround time requirements are rapidly identified and the information is communicated immediately to the appropriate lab personnel. The status of all projects are reviewed daily by technical staff and customer service representatives to assure that all projects get handled as requested by the client or as required by the circumstances.

8.4 Sample Containers and Preservation

After consultation with the client, a sample bottle request is initiated. The type of sample container, volume and required preservatives are indicated on the bottle request form, which is then submitted to Client Services, where the necessary containers are prepared.

The quality and type of containers used for sampling can significantly impact the quality of the analytical results. Sampling containers are purchased pre-cleaned and certified by the manufacturer to ensure there is no induced contamination for metals, volatile organics, and semivolatile organics testing. If a bottle is purchased that is not certified, the appropriate laboratory analyses will be performed to ensure cleanliness.

The size of the sample bottle and the required preservative is mandated by EPA. All sample bottles are prepared in the laboratory according to these instructions. (See Appendix B for listing of containers per analysis type.)

A color coded label indicating the type of analysis is affixed to the bottle, and the appropriate volume of preservative is added. A Chain-of-Custody (COC) form and instruction for sampling are included with the shipment.

Clients are responsible for proper sampling, field filtration, preservation, hazardous sample notations, temperature control and shipments of samples to WETLAB in a proper manner to meet the required holding times.

The pH should be tested on a representative preserved sample from each batch received by the lab, with the exception of volatile organics and TOX. This is done using narrow range pH test strips in a portion of sample that is disposed of after it is checked. If the pH does not meet preservation requirements, it is adjusted as per the method requirement. The pH of all volatile samples is taken by the analyst immediately prior to analysis. Water samples for cyanide analyses are also checked for residual chlorine prior to analysis by the analyst. All exceptions are noted on a Corrective Action Report.

For samples that require thermal preservation the shipping chest is checked to verify that the sample containers are in adequate contact with wet or blue ice.

If a sample is received at the laboratory without preservatives the client is notified and a new sample is requested, if the client requests that sample is to be analyzed, preservatives are added in the prep lab. If it is determined by laboratory personnel that the wrong preservative has been added, the client should be advised and asked to resample.

A listing of the sample preservation requirements for each method is in appendix B.

8.5 Holding Times

Once a sample has been taken, it must reach the laboratory as soon as possible. The time lapse between sample acquisition and analysis must not exceed the EPA required holding times for compliance samples. Appendix B contains a list of sample preservation and holding time requirements for each method. Samples beyond the holding time, which are not for compliance use, may be analyzed at the discretion of the client. A disclaimer is placed on the final report to this effect.

Holding time is defined as the time from sample collection until initiation of analysis. The chain of custody form must include the date and time sampled. For analyses that have the maximum allowable holding time expressed as days, the holding time is expressed in calendar days measured from the date sampled. Analyses with short holding times expressed in hours have the holding time measured in hours from the date and time collected.

Short hold time parameters such as nitrate/nitrite, pH, hexavalent chromium, turbidity, orthophosphate and bacteriological samples are logged in promptly upon arrival. The technical staff are advised immediately by the login staff.

If a required hold time is missed due to negligence on the part of the laboratory, the client is apprised of the situation. Resampling and reanalysis expenses may be negotiated and borne by the laboratory with approval of the Laboratory Director.

8.6 Packing and Shipping

The integrity of a sample is only as reliable as the means used to obtain it. At the center of any sampling procedure is the sample container and packaging. Sampling containers are requested by the client through Client Services. A sample bottle request form is completed by the Client Services Representative and forwarded to the responsible party in the laboratory for same day shipment. Sample bottles requested for pickup from the laboratory or delivery to a client or site contain the necessary preservatives, noted on the labels. These containers are packaged to prevent shifting during transport. It is suggested that clients pack ice chests with sufficient wet ice to ensure that all sample containers stay in contact with ice in the ice chest.

8.7 Chain of Custody Procedures

In order that an analytical process is legally defensible, it must follow a chain of custody procedure. When sample containers are supplied by the laboratory, a COC form accompanies each set to begin the tracking process. Samples seals and tags are available on request. Upon return to the laboratory, the form is checked for completion and cross-checked against the samples submitted. Any discrepancies are immediately resolved with the client. The COC form is signed, dated and time noted by the party relinquishing the samples. The form is signed and dated by laboratory sample receiving personnel to complete the transfer. The original is retained in the client file until released with the final report. The form also includes the following information: identification of tests to be performed on each sample, sample matrix, and laboratory sample identification numbers.

The samples are now in the custody of the laboratory, where they are stored in a controlled storage area until disposal occurs. Access to the storage area is limited to laboratory personnel. All samples remain in the storage area when not in use. Any aliquots of the original samples that are digested or extracted are retained in the designated prep areas for analysis.

Samples transferred to another laboratory are transferred under chain of custody. A copy of the completed chain of custody form is maintained in the laboratory project file. Samples are not subcontracted to another laboratory without client approval.

8.8 Sample Disposal

It is necessary for the safety of all individuals in the laboratory and compliance with DOT and NRC regulations, that all laboratory waste be handled appropriately. In an effort to minimize exposure of laboratory personnel to extremely hazardous materials, hazardous samples are returned to the client for disposal.

The sample storage area(s) is routinely purged of expired samples. Expiration is determined by holding time or a laboratory-imposed date of thirty days following release of the final report, unless otherwise directed by the client. Samples are segregated by matrix type and placed in the appropriate disposal container for transport. All "clean" water samples are flushed to the sewer with abundant quantities of water.

The final disposal site of hazardous materials is determined by the contracted waste disposal company. All containers transported are manifested in accordance with DOT regulations. A copy of the manifest, analytical results and destruction notifications are retained by the Safety Officer or Laboratory Director.
See the WETLAB. Chemical Hygiene Plan and standard operating procedure for sample disposal and waste management (11.02) for details regarding handling and storage of waste products.

8.9 Subcontracting of Analysis

Subcontracting laboratories will be reviewed with an emphasis on their overall quality control practices and compliance with the quality assurance requirements of ISO/IEC Guide 25-1990. Any laboratory used for subcontracting shall be approved by the QA Department or Laboratory Director. The subcontracting lab should be asked to submit a copy of their Quality Assurance Manual, certification list and relevant proficiency study results. If testing is subcontracted to another laboratory, the client's documented, verbal authorization is required prior to shipping.

9.0 DATA HANDLING, REPORTING AND RECORD KEEPING

The analytical laboratory business is by nature service-oriented, striving to provide a quality product (analytical data), on time and at a reasonable cost. Important to our business and clients is the systematic approach used in handling the large amount of data that are generated. This system must allow for rapid information access and retrieval, maintenance and storage.

9.1 Laboratory Reporting and Paper Flow

An organized system of workflow through the laboratory is essential to satisfying analytical criteria and laboratory reporting policies. The paperwork process may begin as a price quote. This information is kept as part of the client file. Many samples arrive in the laboratory without notice and are handled by the sample login section. Analyses are completed as described in the sample tracking system. All analytical and quality control data are reviewed by the Laboratory Manger or designee prior to report generation. Once all data have been approved and released for printing, the client file information is assembled and a final report is prepared. The complete package is submitted to the Laboratory Director for final review and approval.

Invoicing occurs as a function of report generation. Prices are determined based on laboratory list prices or a prearranged discount schedule, quote or contract.

Approved methodologies and reporting formats are specified by the appropriate agency for all certified laboratories.

Drinking water parameters, reported to the state, are processed on a form approved by the EPA or applicable state agency. The form lists the maximum contaminant levels (MCL) for those parameters that are regulated.

The standard analytical report will in general contain the following:

- Cover letter with information on method references, client information, sample order ID, and Lab Director signature.
- A secondary page with pertinent report comments including general comments, specific comments and a data qualifier legend.
- Analytical results reported by sample and by test with appropriate significant figures, and appropriate report limits that have been adjusted for dilution, if necessary. Appropriate information such as dates of analysis, date sampled, analysis method, date received, and date reported.
- If requested by the client, quality control information including laboratory performance checks (LCS and method blanks), and matrix specific QC (matrix spike/matrix spike duplicate) may be included in the report as requested by the client.

- A copy of the COC form.

Other deliverables may also be included such as raw data packages, electronic data transfer or disk deliverables.

9.2 Data Validation, Reduction and Reporting

Data reduction is performed by the WETLAB analysts and consists of calculating concentrations in samples from the raw data obtained from the measuring instruments. The complexity of the data reduction will be dependent on the specific analytical method and the number of discrete operations (e.g., extractions, dilutions, or concentrations) involved in obtaining a sample that can be measured. The analyst will reduce or calculate all raw data into the final reportable values. Copies of all raw data and the laboratory notebooks, strip-charts, chromatograms, spreadsheets and record files will be retained to allow reconstruction of the data reduction process at a later date if necessary.

System reviews are performed at all levels. The individual analyst constantly reviews the quality of data through calibration checks, QC sample results, and performance evaluation samples. The analyst is provided with set acceptance/rejection criteria for the performance of each analytical method. A listing of data acceptance criteria and corrective action procedures can be found in Appendix E. Data that fails to meet the criteria specified is brought to the attention of the supervisor or Laboratory Director. Reanalysis or "flagging" the data may be necessary. If reanalysis is not possible due to insufficient sample or loss of holding time, the client is notified. If the client elects to have the data reported, it will be "flagged" with a data qualifier that will appear on the final report describing the problem with the quality control. These reviews are performed prior to submission to the supervisor, laboratory director, or another qualified analyst for a second level of review. The supervisor and/or the Laboratory Director review the data to ensure consistency with laboratory QC requirements, to verify reasonableness with other generated data, and to determine if program requirements have been satisfied. A selected amount of the hard copy output of the data will be reviewed to ensure that results are interpreted correctly. The reviewer checks the following items:

- Data calculations and quantitation of compounds including any dilution factors
- Sample holding times
- Calibration and Quality control acceptability
- Interpretation of chromatograms, identification of compounds

Unusual or unexpected results will be reviewed, and a resolution will be made as to whether the analysis should be repeated.

Prior to final review and sign-off by the Laboratory Director or a designee, a third level administrative review is performed for compliance to the laboratory and client QC requirements, and to ensure that the case narrative covers any noted deficiencies. An invoice, any necessary QC reports, data packages or EDDs are generated at this time. The Laboratory Director performs the final review prior to reporting the results to the client.

Data audits are also performed by regulatory agencies, client representatives, or third party data validators. The frequency, level of detail, and the areas of concern during these reviews are dependent on the specific program requirements. Third party data validation done by or at the request of a regulatory agency or client will generally be conducted according to specific technical review protocols, such as EPA's Laboratory Data Validation Functional Guidelines.

Reports will contain final results, units, date/time collected, and analysis date. In addition, special analytical problems, and/or any modifications of referenced methods will be noted. Additional information may be included in reports upon request. The number of significant figures reported will be consistent with the limits of uncertainty inherent in the analytical method. Consequently, most analytical results will be reported to no more than two or three significant figures.

9.2.1 Electronic Data Deliverables (EDD) File Verification

EDD verification ensures that measures are taken to provide clients with error free electronic data files. There are two methods for generating the EDD. Both methods required a 2nd person review to verify the EDD is consistent with the raw data and hard copy report.

9.2.1.1 Electronic Transfer

Transferring information directly from calculation software to electronic data transfer (EDT) file is ideal due to elimination of transcription errors.

9.2.1.2 Manual Transfer

Data entered into EDT file manually requires the person to verify that the information was transferred accurately.

The 2nd person verifying the electronic data file may do so by computer screen or hard copy.

9.3 Storage

An appropriate data storage facility is essential in maintaining the integrity of data generated for future use. Each final report and associated data package are retained within the laboratory for five years.

9.4 Data Retrieval

The retrieval of previous data is often requested for legal purposes and is required immediately. Our retrieval policy has been instituted to facilitate this process and to provide compensation for laboratory personnel removed from their current workload. A request by the client for retrieval of past data is charged at a rate commensurate with the age of the report. For data older than two years, the retrieval is charged at the current secretarial rate per hour. This rate is applied from the time physical removal from storage begins until the complete package is assembled and ready for pickup or delivery. Should an analyst or group leader become involved in a retrieval project, the charges increase to the billable chemist rate per hour. The client is invoiced for all charges incurred with the data package.

10.0 RECORDS

Quality Assurance records are documents generated in support of quality related activities.
All original issues of controlled documents such as standard operating procedures and Quality

Assurance manuals are lifetime records and are archived indefinitely. Completed analytical records documented on controlled forms are non-permanent and are archived for a minimum of five years prior to disposal. The documents, as well as data packages, are organized by the appropriate department in uniquely numbered file boxes.

The distribution of controlled documents is monitored internally to the affected staff and externally to individuals requiring the information. Changes to controlled documents are subject to approval of the QA Department.

10.1 Laboratory Data Control

Raw data are retained for a minimum of five years and disposed of thereafter. Exceptions are clients who specify in the contract document that raw data is to be transferred to their custody at the end of the five year period. Each analytical section of the laboratory is issued laboratory notebooks specific to an instrument and/or method. The following information must be included for each analysis:

- Analysts signature (once per page and day)
- The instrument used in the analysis. If a laboratory has more than one instrument of a particular model, a unique designation must be given to each.
- Calibration curve correlation coefficient (if applicable)
- Calibration and Spiking Standards Identification
- Analytical procedure used
- Date and time
- WETLAB laboratory sample number
- Any deviations from standard analysis procedures such as dilutions.

Any blank sections left open on a page will be crossed out. All entries will be in dark colored ink that can be easily photocopied. To ensure that all raw data is documented completely, a notebook audit is performed by the QA department or Laboratory Director a minimum of once per quarter. This audit encompasses a check for all required quality control and documentation procedures outlined in the SOPs.

A unique control number is issued for all laboratory logbooks, including instrument run logs, maintenance logs, calibration logs, extraction logs, and standard preparation logs. The logbooks are bound, labeled with the logbook number, and have each page numbered. A record is maintained of all logbooks, including the control number, date issued, date completed. Completed logbooks are archived in a central storage location.

Organic chromatograms and inorganic integrator printouts are maintained in files clearly labeled with the date, instrument number, and method. The complete data folder is submitted with the sample data report forms to the QA Manager or designated technical staff for review. After review the data folders are filed by instrument and by date.

11.0 STATISTICAL QUALITY CONTROL

WETLAB's overall QA objectives are to meet the analytical needs of the client with respect to accuracy, precision, completeness, representativeness, comparability, legal defensibility and timeliness. EPA precision and accuracy criteria are used as method specific criteria to accept or reject analytical data. When these criteria are either not available or not applicable, WETLAB will base the accept/reject criteria on the performance of similar methods and the historical performance at WETLAB. WETLAB meets the needs of the client for precise, accurate data by adhering to these criteria or other appropriate criteria as required.

11.1 Precision

Precision and accuracy are determined from the results of the routine batch quality control (QC) samples. The samples are duplicates or matrix spike duplicates and matrix spikes.

Precision is defined as the measure of the mutual agreement among individual measurements of the same chemical constituent in a sample (duplicates) secured under the same analytical protocols.

Laboratory precision will be expressed as relative percent difference (RPD) of the duplicate sample values.

$$RPD = \frac{|A-B|(2)}{A+B} \times 100$$

a = First sample value of duplicate analysis
b = Second sample value of duplicate analysis

The acceptance limits are set based on the nature of the material being analyzed (sample or standard) and are found in each SOP. Samples that fall outside the respective limits are reanalyzed at the advisement of the section supervisor and QA Manger.

11.2 Accuracy

Accuracy is defined as the degree of agreement of a measured value with the true value of the quantity of concern. Accuracy will be measured as percent recovery for lab control samples or matrix spikes as the primary criteria and percent recovery of the surrogate spikes as a secondary QC criteria for applicable analyses.

$$\text{Percent Recovery} = \frac{SSR - SR}{SA} \times 100$$

Where:

SSR = Spike sample result
SR = Sample result
SA = Spike added from spiking standard

11.3 Control Charts

The use of control charts for statistical monitoring provides a visual interpretation of the precision and/or accuracy of an analytical method. Control charts enable the analyst to detect a trend or bias in a procedure at the time the analysis is performed. The ability to identify a deviation in the performance of a method may prevent the need for reanalysis later or be an indication of impending instrument malfunction. When used correctly and consistently, control charts provide a means of validating analytical methods.

The applicability of control chart techniques is based on the assumption that the laboratory data approximates a normal distribution.

The chart for standards is constructed from the target and standard deviation of a standard. It includes upper and lower warning levels (WL) and upper and lower control levels (CL). Common practice is to use ± 2s and ± 3s limits for the WL and CL, respectively, where s represents standard deviation. The chart can be set up by using either the calculated values or by using percentages. Percentage is necessary if the concentration varies.

Control charting is performed using appropriate software. The monthly values are entered for a standard or calibration check and are used by the system to generate the limits and mean of the control chart. Each subsequent value emerged is plotted on the chart. Values exceeding the control limits are unacceptable. These standards are rerun or remade as necessary. Values showing a trend over time may be an indication of a deteriorating standard or instrument malfunction. A method exhibiting a bias of seven consecutive points above or below the mean is considered out of control and corrective action must be taken.

Any out of control situation should be brought to the attention of the group leader and/or the QA Manager. New cumulative control limits are generated and maintained in each department on an annual basis.

11.4 Expression of Results

An integral part of producing quality data is reporting the data in the units applicable to the method used and the matrix analyzed. It is imperative that the correct units and/or conversion factors be used to ensure that the final result is not misleading. Units versus method and matrix should be checked at each step of the review process. Any errors detected should be reviewed with the group leader or analyst to determine the correct result and units.

11.5 Significant Figures

A primary objective in reporting analytical data is to present the data so it may be interpreted properly with reference to the accuracy of the analytical method used. To avoid ambiguity in reporting results or in presenting directions for a procedure, it is necessary to use "significant figures".

All the digits in a reported result are expected to be known definitely except the last digit, which may be in doubt. Such a number is said to contain only significant figures. If more than a single doubtful digit is carried, the extra digit or digits are not significant. If an analytical result is reported as "75.6 mg/L", the analyst should be quite certain of the "75", but may be uncertain as to whether the ".6" should be .5 or .7, or even .4 or .8, because of unavoidable uncertainty in the analytical procedure. If the standard deviation is known from previous work to be $\pm$ 2 mg/L, the analyst should round off the result to "76 mg/L" before reporting it. Alternately, if the method is so efficient that a result of "75.61 mg/L" can be conscientiously reported, then the analyst should not round it off to 75.6.

Any digit that is necessary to define the specific value or quantity is said to be significant. When measured to the nearest 1 m, a distance may be recorded as 157 m; this number has three significant figures. If the measurement had been made to the nearest 0.1 m, the distance may have been 157.4 m; this number has four significant figures.

11.5.1 Zeros are significant when they occur in the middle of a number or at the end of a number on the right-hand side of the decimal point. For example, the following significant zeros are underlined: 106, 0.0106, 0.106, 0.1060.

11.5.2 If a series of operations is to be performed (addition, subtraction, multiplication, division), all figures are carried through the calculations, then the final answer is rounded to the proper number of significant figures. The final result is expressed in terms of the number that has the least significant figures. For example, 39.3 x 3.5 = 137.55, but since 3.5 has only two significant figures, the final result should be expressed at 140.

11.5.3 Unless otherwise specified in the contract, WETLAB routinely reports two significant figures for analytical results, and three significant figures for quality control samples.

11.6 Rounding

Rounding off of digits is a necessary operation in all analytical areas. However, when it is applied in calculations incorrectly or prematurely, it can adversely affect the final results. Rounding off is done only as described in the following:

11.6.1 When the first digit discarded is less than five, the last digit retained should not be changed. For example, 3.46325, if rounded to four significant figures, would be 3.463; if rounded to three significant figures, 3.46.

11.6.2 When the first digit discarded is greater than five, or if it is a five followed by at least one digit other than zero, the last digit retained should be increased by one unit. For example, 8.37652, if rounded to three significant figures would be 8.38; if rounded to four digits would be 8.377.

11.6.3 When the first digit discarded is exactly five, followed only by zeros, the last digit retained should be rounded upward if it is an odd number, but no adjustment should be made if it is an even number. For example, 4.365, when rounded to three significant figures, becomes 4.36. The number 4.355 would also round to the same value, 4.36, if rounded to three significant figures.

11.7 Linear Regression

Conversion of raw data into analytical results can be achieved by a variety of methods. One of the more common means is linear regression (also known as the method of least squares), the process of forecasting future performance or relations based on past performance or relations. WETLAB incorporates this method in the majority of its data conversion processes.

The execution of a linear regression calculation is normally performed using a scientific calculator preprogrammed for this function. In linear regression, data are usually expressed as pairs of variables that can be plotted on a graph. The points are usually labeled as "x" and "y". The objective is to determine the value of "y" based on the known value of "x". If sufficient points are available and the functional relationship between the two variables is well defined, a smooth curve can be drawn through the points. If the function is not well defined, linear regression will affix a straight line to the pattern. The correlation coefficient should be calculated for each linear regression line. An acceptable coefficient should be ≥0.995. A coefficient <0.995 requires re-evaluation or reanalysis of the calibration curve. Manual computation of a linear regression equations is rarely required, but may be accomplished using any comprehensive statistical reference.

11.8 Method of Standard Addition

Occasionally, the determination of analytical data becomes a difficult task due to the nature of a sample matrix and its inherent interferences. The true concentration of the compounds of interest are masked to a point where an alternate analytical procedure must be employed, i.e., the method of standard addition.

For example, a particular sample is believed to contain about 10 ppm of copper. An aliquot of the sample is taken and diluted 10 fold with water. This would make the final concentration of copper 1 ppm. A second aliquot of the sample is taken and copper standard added so the final diluted sample will contain copper at the unknown level plus 0.5 ppm. A third aliquot of the sample is taken and copper standard added so that after dilution the sample will contain the unknown level of copper plus 1.0 ppm.

The signals from the three samples are now measured under the same conditions. A graph is made of the signal obtained versus the concentration of copper added. The three points must lie on the same straight line. The line is now extended to the left of the signal axis into the region of the negative concentration. The concentration of the unknown is read at the point where the calibration line intersects the negative concentration axis. Instrument manuals and SOPs provide the analysts with instructions on how to perform the method of standard addition.

11.9 Development of Detection Limits

The method detection limit (MDL) is defined as the point at which the observed signal can reliably be considered to be caused by the analyte being measured.

WETLAB follows the specification in 40 CFR Part 136, Appendix B to determine method detection limits (MDL). The procedure is further described in W.E.T. LAB. SOP 9.10. MDL determinations shall be performed annually using standard solutions at approximately 3-5 times the published IDL or MDL for each method, or the concentration value that corresponds to known instrumental limitations. Preparation of the standard solutions shall include all preparation steps (digestion, filtration, extraction, distillation, etc.) that would be used in the preparation of environmental samples. MDLs shall be determined by running the standard solutions seven to ten times, determining the standard deviation of the results, and multiplying the standard deviation by the appropriate "t statistic" from the chart below (taken from Chapter 1, Section 5 of SW-846).

STUDENTS' t VALUES AT THE 99 PERCENT CONFIDENCE LEVEL

Number of Replicates	Degrees of Freedom (n-1)	t(n-1, 0.99)
7	6	3.143
8	7	2.998
9	8	2.896
10	9	2.821

MDL is calculated as follows:

MDL = t x S

Where: t = student's t values at the 99% confidence level (see table)
S = Standard deviation

Soil sample MDL determinations for organics may be performed using muffled sand, an appropriate salt or other soil matrix substitute.

The instrument detection limit (IDL) is defined to be three times the average of the standard deviations obtained on three nonconsecutive days from the analysis of a standard solution, with seven consecutive measurements of that solution per day. The standard solutions analyzed shall be prepared at a concentration of 3 to 5 times instrument manufacturer's estimated IDL. Where no such estimated IDL exists, the procedure-specific method detection limit may be used.

MDL studies are not required for acidity, alkalinity, BOD, color, corrosivity, DO, gravimetric oil and grease, hardness, ignitability, pH, titrimetric sulfide, conductivity, any of the solids methods, or turbidity.

12.0 CONTRACT REVIEW

Prior to accepting a contract or order for work, the contractual materials are reviewed to ensure that the clients project requirements are adequately defined and understood, and that the laboratory can meet those requirements. The review process is defined in the procedure for Contract Review, 09.12.

APPENDICES

Appendix A.	Quality Assurance Glossary
Appendix B.	Containers, Preservatives & Holding Times
Appendix C.	Site Specific Information for W.E.T. LAB. Facility
Appendix D.	Example of an Internal Audit Checklist
Appendix E.	Method-Specific Calibration and QC Criteria
Appendix F.	Corrective Action Report

APPENDIX A

QUALITY ASSURANCE GLOSSARY

Quality Assurance Glossary

Accreditation - A formal process by which a laboratory is evaluated for its competence to perform a specified kind(s) of measurement. Also, the decision based upon such a process. When a certificate is issued, the process is often called certification.

Accuracy - The degree of agreement of a measured quality of concern.

Aliquot - A part which is a definite fraction of a whole; as, aliquot samples for testing or analysis .

Analvte - The specific component measured in a chemical analysis.

Blank - The measured value obtained when a specified component of a sample is not present during the measurement. In such a case, the measured value/signal for the component is believed to be due to artifacts; hence, it should be deducted from a measured value to give a net value due to the component contained in a sample. The blank measurement must be made so that the correction process is valid.

Blind Sample - A sample submitted for analysis whose composition is known to the submitter but unknown to the analyst. A blind sample is one way to test proficiency.

Calibration - Comparison of a measurement standard or instrument with another standard or instrument to report or eliminate by adjustment any variation (deviation) in the accuracy of the item being compared.

Certification - See Accreditation.

Check Standard - A standard originating from a separate source than the calibration standard. This standard is analyzed at a minimum of every ten samples. The results are generally plotted on a control chart to evaluate the measurement process.

Control Chart - A graphical plot of test results with respect to time or sequence of measurement, together with limits within which they are expected to lie when the system is in a state of statistical control.

Control Limit - The limits shown on a control chart beyond which it is highly improbably that a point could lie while the system remains in a state of statistical control.

Detection Limit - The smallest concentration/amount of some component of interest that can be measured by a single measurement with a stated level of confidence.

Duplicate Sample - A second sample randomly selected from a population of interest to assist in the evaluation of sample variance.

Equipment Blank - Reagent water that is used to rinse sampling equipment. The results are used to verify the decontamination process between samples.

Error - Difference between the true or expected value and the measured value of a quantity or parameter.

Internal Standard - A standard added to each sample at the sample concentration. response of the unknown is compared to the response of the standard.

Laboratory sample - A sample intended for testing or analysis prepared from a gross sample or otherwise obtained. The laboratory sample must retain the composition of the gross sample. Often, reduction in particle size is necessary in the course of reducing the quantity.

Limit of Quantitation (LOQ) - The lower limit of concentration or amount of substance that must be present before a method is considered to provide quantitative results. By convention. LOQ = $10s_0$, where s_0 is the estimate of the standard deviation at the lowest level of measurement.

Matrix Spike - A known concentration of standard is added to a sample of known quantity and analyzed. The purpose is to determine whether the sample matrix contributes bias to the results.

Matrix Spike Duplicate - A second matrix spike analyzed on between the two results is calculated to measure precision.

Method - An assemblage of measurement techniques and the order in which they are used.

Method Blank - An aliquot of reagent water is treated exactly as the sample and analyzed. the results must fall below the MDL.

Performance Audit - A process to evaluate the proficiency of an analyst or laboratory by evaluation of the results obtained on a known test material.

Precision - The degree of mutual agreement characteristic of independent measurements as the result of repeated application of the process under specified conditions. It is concerned with the closeness of results.

Primary Standard - A substance or artifact, the value of which can be accepted (within specific limits) without question when used to establish the value of the same or related property of another material. Note that the primary standard for one user may have been a secondary standard of another.

Procedure - A set of systematic instructions for using a method of measurement or the steps or operations associated with them.

Quality - An estimation of acceptability or suitability for a given purpose of an object. item, or tangible or intangible thing.

Quality Assessment - The overall system of activities whose purpose is to provide assurance that the quality control activities are done effectively. It involves a continuing evaluation of performance of the production system and the quality of the product produced.

Quality Assurance - A system of activities to provide to the producer/user of a product/service the assurance that it meets defined standards of quality, utilizing quality control and quality assessment.

Quality Control - The overall system to control the quality of a product or service so that it meets the needs of users. The aim is to provide quality that is satisfactory, adequate, dependable and economic.

Relative Standard Deviation - The coefficient of variation expressed as a percentage.

Replicate - A counterpart of another, usually referring to an analytical sample or measurement, for which duplicate is the special case consisting of two samples or measurements.

Sample - A portion of a population or lot. It may consist of an individual or groups of individuals. It may refer to objects, materials or measurements, conceivable as part of a larger group.

Sensitivity - Capability of methodology or instrumentation to discriminate between samples with differing concentrations or containing differing amounts of an analyte.

Significant Figure - A figure(s) that remains to a number or decimal after the ciphers to the right or left are canceled.

Standard - A substance or material with properties believed to be known with sufficient accuracy to permit its use to evaluate the same property of another. In chemical measurements, it often describes a solution or substance commonly prepared by the analyst to establish a calibration curve or the analytical response of an instrument.

Standardization - The process whereby the value of a potential standard is fixed by measurement with respect to a standard(s) of known value.

Standard Addition - A method in which small increments of a substance under measurement are added to a sample under test to establish a response function, or to determine by extrapolation the amount of a constituent originally present in the test sample.

Standard Method - A method (or procedure) of test developed by a standards-writing organization, based on a consensus opinion or other criteria by a collaborative testing procedure.

Standard Operating Procedure (SOP) - A procedure adopted for repetitive use when performing a specific measurement or sampling operation.
Surrogate - A compound that is added to each sample to monitor extraction and purge efficiency.

Travel Blank - Reagent water that is placed in a sample container and treated like samples in terms of exposure to site conditions, storage, etc. Generally analyzed for VOCs only.

Traceability - The ability to trace the source of uncertainty of a measurement or a measured value .

Warning Limits - The limits shown on a control chart within which most of the test results are expected to lie (within a 95% probability) while the system remains in a state of statistical control.

APPENDIX B

CONTAINERS, PRESERVATIVES & HOLDING TIMES

SAMPLE PRESERVATIVES AND HOLD TIMES

DRINKING WATER

Method	Parameter	Amount	Container	Preservative	Hold Time
310, 305, SM2320	Alkalinity, Acidity	100 ml	1-500ml P	2-6° C	14 days
TEM	Asbestos	1000ml	1-1L P	2-6° C	48 hours
300.0, 375, 325	Chloride, Sulfate, Bromide	500 ml	1-500ml P	2-6° C	28 days
300.0, 353, SM4500	Nitrate, nitrite	100 ml	1-250 ml P	2-6° C	48 hours
353, SM4500	Nitrate+nitrite	100 ml	1-500 ml P	2-6° C, H_2SO_4, pH <2	28 days
335, SM4500	Cyanide	500 ml	1-500 ml P	2-6° C, ascorbic acid (if chlorinated), NaOH, pH>12	14 days
300.0, 340, SM4500	Fluoride	300 ml	1-250ml P	None	28 days
200.8	Lead and Copper	1000 ml	1-1L P	None, preserved at laboratory with HNO_3, pH<2	6 months
SM 2330B	Corrosivity	500 ml	1-250ml P	None	None
SM 9223	Total Coliform	100 ml	100ml P (sterile)	2-6°C, $Na_2S_2O_3$	30 hours
524.2	THMs	120 ml	2-40ml VOA vials	2-6° C, ascorbic acid, HCl in field	14 days
504.1	EDB/DBCP	80 ml	2-40ml VOA vials	2-6° C, $Na_2S_2O_3$	14 days
508	Pesticides	1000 ml	11L amber G	2-6° C, $Na_2S_2O_3$	7,14 days
515.1	Herbicides	1000 ml	1-1L amber G	2-6° C, $Na_2S_2O_3$	14,28 days
524.2	Volatiles	120 ml	2-40mL VOA vials	2-6° C, ascorbic acid, HCl in field	14 days
525.2	Semi-volatiles	2000 ml	2-1L amber G	2-6° C, Sodium sulfite, HCl in field	14 ,30 days
531.1	Carbamates	40 ml	1-40ml VOA vial	2-6° C, $Na_2S_2O_3$, MCA in field	28 days
547	Glyphosate	125 ml	1-125ml amber G	2-6° C, $Na_2S_2O_3$	14 days
548.1	Endothall	250 ml	2-250ml amber G	2-6° C, $Na_2S_2O_3$	7,14 days
549.1	Diquat/Paraquat	1000 ml	1-1L amber P	2-6 °C, $Na_2S_2O_3$	7,21 days
550	PAHs (PNAs)	2000 ml	2-1L amber G	2-6°C, $Na_2S_2O_3$, HCl	7days
551	D/DBP	80 ml	2-40mL G vials	2-6°C, Ammonium chloride, pH 4.5-5	14 days
552.1	Haloacetic Acids	150 ml	1-125ml amber G	2-6°C, Ammonium chloride	28 days

Notes: For holding time 7,30 (or X,Y) means 7 (X) days for extraction, plus 30 (Y) additional days for analysis.
P=Plastic, G=Glass AQ = aqueous
Na2S2O3 = Sodium thiosulfate H2SO4 = Sulfuric acid HCL = Hydorchloric acid MCA = Monochloroacetic acid

SAMPLE PRESERVATIVES AND HOLD TIMES INORGANICS Waste Water/ Surface Water/ Soils/ Oils/ Aqueous

Method	Parameter	Amount	Container	Preservative	Hold Time
2320, 310	Alkalinity	200 ml	1-500ml P	2-6°C	14 days
350, 351, 353, 365	Ammonia, TKN, total Phosphorus	500 ml AQ 50 g solid	1-500 ml P	2-6°C, H_2SO_4, pH<2 2-6°C	28 days
405.1	BOD	1000 ml	1-1 L P	2-6°C	24 hours
410.	COD	50 ml	1-500 ml P	2-6°C, H_2SO_4, pH<2	28 days
300.0, 325, 375, 340	Chloride, Sulfate, Bromide, Fluoride	50 ml AQ 20 g solid	1-500ml P 125 mL G	2-6°C	28 days
SM 9221	Coliform, fecal	100 ml	125ml P-sterile	2-6°C, $Na_2S_2O_3$	6 hours
110.2	Color	50 ml	1-500ml P	2-6°C	48 hours
120.1	Conductivity	500 ml	1-500ml P	2-6°C	28 days
335,4500	Cyanide, amenable	500mL AQ 20g	1- 500 ml P 125 ml G	2-6°C, NaOH pH>12, 2-6°C	14 days
335,4500 9010	Cyanide, total	500mL, 20g	1- 500ml P 125 ml G	2-6°C, NaOH pH>12, 2-6°C	14 days
1010	Flashpoint	100mL, 50g	1 L G 125 ml G	2-6°C	7 days
425.1	MBAS (surfactants)	1000 mL	1-1L P	2-6°C	48 hours
300.0, 4500	Nitrate, nitrite	100mL AQ 20g solid	1-250 ml P 125 ml G	2-6°C	48 hours
353, 4500	Nitrate + Nitrite	100 mL	1- 250ml P	2-6°C, H_2SO_4, pH<2	28 days
140.1	Odor	500mL	1-500ml G	2-6°C	24 hours
413.1	Oil & grease	1000 mL	1-1 L G	2-6°C,H_2SO_4, pH<2	28 days
150.1	pH (water)	50 mL	1-250ml P	None	Immediately
9045	pH (soil)	50 mL	P,G	None	Immediately
420.1 9065	Phenol	500mL AQ 100g solid	1 L G 125 ml G	2-6°C, H_2SO_4, pH<2 2-6°C	28 days
365	Phosphorus, ortho.	100mL AQ 50g solid	1-500ml P 125 ml G	Filter on site, 2-6°C 2-6°C	48 hours
2540C	Solids, dissolved	100ml	1-500mlL P	2-6°C	7 days
160.5	Solids, settleable	1000 mL	1 L P	2-6°C	48 hours
160.2	Solids, suspended	1000 mL	1 L P	2-6°C	7 days
160.3	Solids, total	500mL,50g	1 L P	2-6°C	7 days
160.4	Solids, volatile	500 mL	1 L P	2-6°C	7 days
376.	Sulfide	500 mL AQ 50g solid	1 L P 125 ml G	2-6°C NaOH pH>9, ZnAC 2-6°C	7 days
415.1 9060	TOC	100mL AQ 50g Solid	250 ml G amb 125 ml G jar	2-6°C, H_2SO_4, pH<2 2-6°C	28 days
9020	TOX	500mL AQ 50g Solid	1 L G amb 125 mL G jar	2-6°C ,H_2SO_4 ,no head space 2-6°C	28 days
180.1	Turbidity	100 mL	1-500ml P	2-6°C	48 hours

P=Plastic, G=Glass AQ = aqueous

TABLE 1 SAMPLE PRESERVATIVES AND HOLD TIMES
METALS

Method	Parameter	Amount	Container	Preservative	Hold Time
200, 6010, 6020, 7000	All metals except Cr(VI) and Hg	200 ml 20 g Solid	1-500ml P 250ml G	HNO_3,pH<2	6 months
245, 7470, 7471	Mercury	200 ml, 20 g Solid	1-500ml P 250ml G	HNO_3,pH<2	28 days
218, 3500 7196, 7197	Chromium hex.	200 ml 20 g Solid	1 L P 250mL G	2-6°C	24 hours

Organics

Method	Parameter	Amount	Container	Preservative	Hold Time
8015A W	Non-halogenated Volatiles	80mL	2-40mL G vials	2-6°C, 1:1 HCl	14 days
8015A S	Non-halogenated Volatiles	100g	1-4oz jar	2-6°C	14 days
8041 W	Phenols	1000mL	1-1L G amber	2-6°C	7,40 days
8041 S	Phenols	100g	1-8 oz G jar	2-6° C	14 days
8061A W	Phthalate esters	1000mL	1-1L G amber	2-6°C	7,40 days
8061A S	Phthalate esters	100g	1-8oz G jar	2-6°C	14 days
608,8081W	Pesticides	1000 mL	2-1L G amber	2-6° C, $Na_2S_2O_3$, if chlorinated, pH: 5-9	7,40 days
8081A (oil)	Pesticides	80mL	2-40mL G vials	2-6°C	7,40 days
8081A S	Pesticides	100g	1-8oz G jar	2-6°C	14 days
8082 W	PCB's	1000 mL	2-1L G amber	2-6° C, pH: 5-9	7,40 days
8082 (oil)	PCB's	80mL	2-40mL G vials	2-6°C	7,40 days
8082 S	PCB's	100g	1-8oz G jar	2-6°C	14 days
8091 W	Nitroaromatics & Ketones	1000mL	1-1L G amber	2-6°C	7,40 days
8100 S	PNA's	100g	1-8oz G jar	2-6°C	7,40 days
8100 S	PNA's	1000mL	1-1L G amber	2-6°C	14 days
614,8141W	Organophosphorus pesticides	1000mL	2-1L G amber	2-6°C	7,40 days
8141A S	Organophosphorus pesticides	100g	1-8oz G amber	2-6°C	14,40 days
615, 8151A W	Chlorinated herbicides	1000 mL	2-1L G amber	2-6°C	7,30 days
8151A S	Chlorinated herbicides	100g	1-8oz G jar	2-6°C	14 days
624, 8260B W	Volatile Organics (GC/MS)	80mL	2-40mL G vials	2-6°C, $Na_2S_2O_3$, if chlorinated, 1:1 HCl	14 days
8260B S	Volatile Organics (GC/MS)	100g	1-8oz G jar	2-6°C	14 days
625, 8270C W	Semi-volatiles	1000 mL	2-1L G amber	2-6°C, $Na_2S_2O_3$ if chlorinated	7,40 days
8270C S	Semi-volatiles	100g	1-8oz G jar	2-6°C	14,40 days
418.1 W	TPH in water	1000mL	1-1L G amber	2-6°C, 1:1 H_2SO_4	14 days
418.1AZ S	TPH	100g	1-8oz G jar	2-6°C	14 days

Notes: For holding time 7,30 (or X,Y) means 7 (X) days for extraction, plus 30 (Y) additional days for analysis.
P=Plastic, G=Glass
$Na_2S_2O_3$ = Sodium thiosulfate H_2SO_4 = Sulfuric acid HCL = Hydorchloric acid MCA = Monochloroacetic acid

TABLE 1 SAMPLE PRESERVATIVES AND HOLD TIMES RADIONUCLIDES

Method	Parameter	Amount	Container	Preservative	Hold Time
900	Radiological, all except Rn222 and Tritium	1 Gallon 50 g solid	2-1/2 Gallon P 250 mL G jar	None None	6 months 6 months
RN-222	Radon 222	80 ml	2x40 mL amber G	None	72 hours
906.0	Tritium (H_3)	250 ml AQ 300 g (Sample size varies with solid moisture content)	1-250 mL G 2 - 250 mL G jar	None None	6 months 6 months

P=Plastic, G=Glass AQ = aqueous

Appendix C

Site Specific Information

WETLAB

Western Environmental Testing Laboratory

QUALITY ASSURANCE PLAN

This document contains information specific to the WETLAB. facility and is organized in the following format:

5.0 WETLAB Standard Operating Procedures

6.0 Facility Floor Plan

7.0 Instrumentation List

8.0 List of Certifications

9.0 Performance Evaluation Studies

Western Environmental Testing Lab
LIST OF STANDARD OPERATING PROCEDURES

METALS

SOP NO.	REV. NO.	DATE	TITLE
7.03	REV. 2	01/07/04	INDUCTIVELY COUPLED PLASMA-ATOMIC EMISSION SPECTROMETRY BY EPA 6010B
7.04	REV. 6	1/27/06	INDUCTIVELY COUPLED PLASMA-ATOMIC EMISSION SPECTROMETRY BY EPA 200.7
7.07	REV. 2	01/07/04	MERCURY DETERMINATION BY EPA 245.1 AND 7470A
7.08	REV. 2	01/07/04	DETERMINATION OF TRACE ELEMENTS BY STABILIZED TEMPERATURE GRAPHITE FURNACE ATOMIC ABSORPTION- EPA 200.9/279.2/3113B
7.09	REV. 2	01/07/04	MERCURY DETERMINATION BY EPA 7471A
7.10	REV. 2	01/07/04	DIGESTION OF AQUEOUS SAMPLES BY EPA METHOD 3010A
7.11	REV. 1	05/13/02	DIGESTION OF SOLID, SLUDGE SAMPLES BY EPA METHOD 3050A
7.12	REV.4	01/27/06	TOXICITY CHARACTERISTIC LEACHING PROCEDURE FOR METALS AND SEMI-VOLATILES BY EPA METHOD 1311
7.13	REV. 1	05/13/02	ACID DIGESTION OF OILS FOR METALS ANALYSIS BY EPA METHOD 3031
7.14	REV. 1	01/27/06	INDUCTIVELY COUPLED PLASMA-MASS SPECTROMETRY BY EPA 200.8

GENERAL CHEMISTRY

SOP NO.	REV. NO.	DATE	TITLE
8.01	REV. 4	04/23/07	ANALYSIS OF LIQUIDS FOR PH BYSM 4500-H^+ B /EPA150.1
8.02	REV. 2	11/03/03	ANALYSIS OF SOLIDS FOR PH BY EPA 9045B
8.03	REV. 1	05/14/02	IGNITIBILITY (FLASHPOINT) OF LIQUIDS (USEPA 1010) AND SOLIDS
8.04	REV. 4	04/18/07	BIOCHEMICAL OXYGEN DEMAND – SM 5210 B / EPA 405.1

Western Environmental Testing Lab
LIST OF STANDARD OPERATING PROCEDURES (Continued)

GENERAL CHEMISTRY (Continued)

SOP NO.	REV. NO.	DATE	TITLE
8.05	REV. 1	05/15/02	COLOR – SM 2120B
8.06	REV. 2	01/22/04	THRESHOLD ODOR TEST – EPA 140.1
8.07	REV. 3	04/20/07	ELECTRICAL CONDUCTIVITY – SM 2510B
8.08	REV. 2	06/28/05	FLUORIDE – SM 4500-FL C
8.09	REV. 0	02/02/07	METEORIC WATER MOBILTY PROCEDURE (MWMP) – ASTM E2242-02
8.10	REV. 0	02/06/07	PERCENT MOISTUR/SOLIDS IN SOILS – EPA160.3
8.12	REV. 6	03/01/06	TOTAL DISSOLVED SOLIDS – SM 2540C
8.13	REV. 5	04/23/07	TOTAL SUSPENDED SOLIDS – SM 2540 D / EPA 160.2
8.15	REV. 1	06/03/02	TURBIDITY – EPA 180.1
8.16	REV. 2	11/10/04	ALKALINITY - SM 2320B
8.22	REV. 5	01/27/06	ANIONS - ION CHROMATOGRAPHY 300.0
8.23	REV. 4	12/15/03	TOTAL & ORTHO PHOSPHOROUS - EPA 365.3/4500P E
8.24	REV. 1	06/10/02	PREPARATION OF SATURATED SOIL PASTE
8.29	REV. 1	06/13/02	NITRITE – SM 4500 NO2 B
8.30	REV. 1	06/25/02	ACIDITY – SM 2310B
8.31	REV. 2	04/18/07	AMMONIA NITROGEN – SM 4500-NH3 D / EPA 350.3
8.32	REV. 3	08/26/04	TOTAL KJELDAHL NITROGEN – EPA 351.3
8.33	REV. 1	07/01/02	TOTAL VOLATILE SOLIDS – EPA 160.4
8.34	REV. 1	07/01/02	CYANATE – SM 4500-CN L.
8.35	REV. 2	11/11/04	CYANIDE, WEAK ACID-DISSOCIABLE- SM 4500- CN I
8.36	REV. 3	11/22/04	CYANIDE, TOTAL- SM 4500- CN C
8.37	REV.1	07/09/02	CYANIDE, AMENABLE BY ISE–SM 4500-CN F/SW846 9213

Western Environmental Testing Lab
LIST OF STANDARD OPERATING PROCEDURES (Continued)

GENERAL CHEMISTRY (Continued)

SOP NO.	REV. NO.	DATE	TITLE
8.38	REV. 5	01/25/06	OIL AND GREASE - EPA 1664
8.39	REV. 0	08/08/03	CHEMICAL OXYGEN DEMAND – SM 5220D
8.40	REV. 0	09/29/03	RESIDUAL CHLORINE – SM 4500 CL F
8.41	REV. 0	09/30/03	ALKALINITY AND ACIDITY – SM 2320B / 2310B
8.43	REV. 0	05/03/04	ACID GENERATING/NUETRALIZING POTENTIAL
8.42	REV. 0	06/16/06	QUALITATIVE SULFIDES
8.44	REV. 3	04/18/07	TKN/T-P BY FLOW INJECTION ANALYSIS - EPA 351.2/365.4

QUALITY ASSURANCE

SOP NO.	REV. NO.	DATE	TITLE
9.01	REV. 0	09/26/03	DAILY LAB QC & PIPETTE CALIBRATION
9.04	REV. 1	02/17/04	GLASSWARE CLEANING
9.05	REV. 0	02/18/04	PREPARATION OF STANDARD OPERATING PROCEDURES
9.06	REV.1	05/17/03	CORRECTIVE ACTION AND DOCUMENTATION
9.07	REV. 0	11/07/03	INTEGRATION OF CHROMATOGRAPHY PEAKS
9.09	REV. 1	05/16/03	REVIEW OF DATA, LAB RECORDS AND REPORTS.
9.11	REV. 0	02/12/04	MANAGEMENT ASSESSMENT PROGRAM
9.12	REV. 0	02/18/04	CONTRACT REVIEW
9.13	REV. 0	04/30/04	PERFORMANCE EVALUATION PROGRAM

Western Environmental Testing Lab
LIST OF STANDARD OPERATING PROCEDURES (Continued)

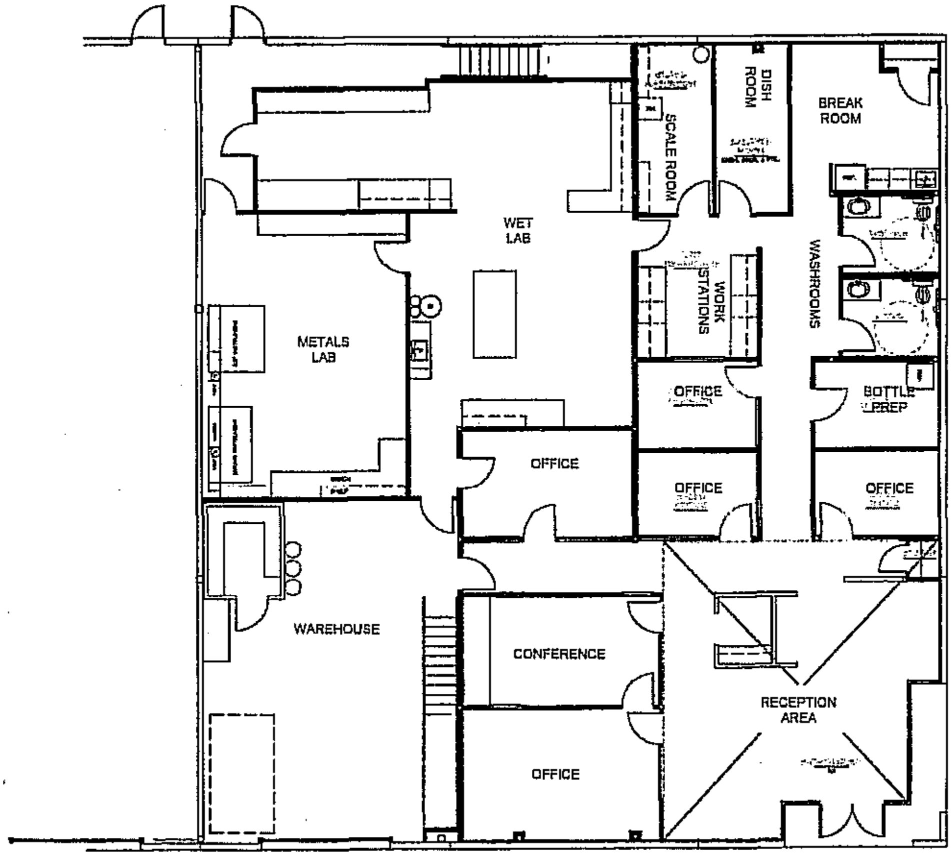
SOP NO.	REV. NO.	DATE	TITLE
9.14	REV. 0	04/01/04	PERSONNELTRAINING AND CERTIFICATION
9.16	REV. 1	05/16/03	REVIEWING AND DOCUMENTING CHANGES MADE TO DATA AFTER REPORT PREPARATION
9.17	REV. 1	01/30/04	VALIDATION OF NON-STANDARD OR LAB DEVELOPED METHODS
MICROBIOLOGY			
10.02	REV. 2	10/27/04	FECAL COLIFORM BY MEMBRANE FILTRATION
10.03	REV. 2	03/30/06	TOTAL COLIFORMS AND E.COLI BY COLILERT / QUANTITRAY – SM 9223 B
SAMPLE MANAGEMENT			
11.01	REV. 5	04/13/07	SAMPLE LOG IN
11.02	REV. 1	05/16/03	WASTE DISPOSAL
11.03	REV. 0	06/17/02	WASTEWATER SLUG DISCHARGE CONTROL PLAN
11.04	REV. 0	09/30/03	SAMPLE BOTTLE AND EQUIPMENT CLEANING PROCEDURE FOR ELDORADO COUNTY
11.05	REV.0	01/23/06	ABBREVIATED CLEANING PROCEDURE FOR COMPOSITE SAMPLING EQUIPMENT USED FOR CALTRANS

6.0 WETLAB FACILITY

The WETLAB facility located at 475 E. Greg St, Sparks Nevada is a 7,500 square foot building with individual laboratories for analyses in metals, and wet chemistry. A floor plan is shown in the following figure:

FIGURE 3-1
WETLAB FACILITY FLOOR PLAN

1st Floor



2nd Floor

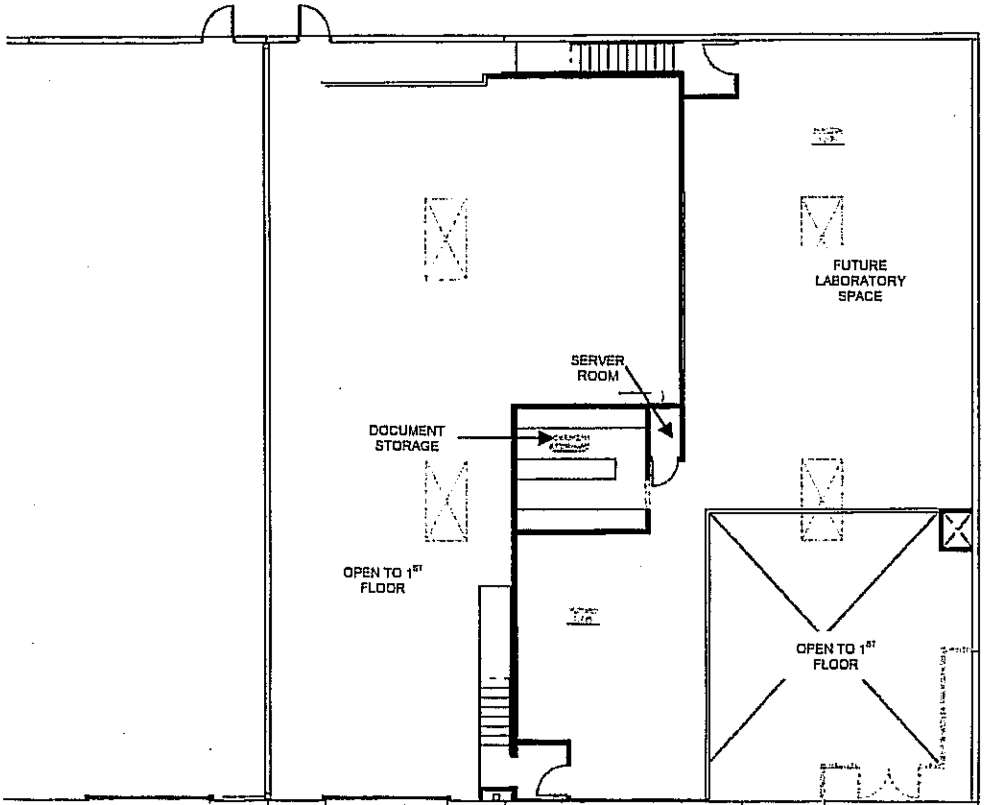


TABLE 4-1
WETLAB INSTRUMENTATION LIST

Major Analytical Equipment
Miscellaneous wet chemistry glassware, block digesters, balances, ovens Dionex DX120 Ion Chromatograph Perkin Elmer UV/VIS Lambda 2 Spectrophotometer
Lachat Quickchem 8000 Flow Injection Analyzer
Hach 2100 Turbidimeter
Midivap Cyanide Distillation Unit
Oil & Grease Solid Phase Extraction System
WESTCO Ammonia Distillation Unit
Perkin Elmer Optima 4300 DV ICP Perkin Elmer Elan DRC-e ICP/MS
CETAC M-6000A Mercury Analyzer

8.0 STATE CERTIFICATIONS

WETLAB holds certifications in Nevada and California. Following is a list of certifications which are current at the time of issuance of this document.

Agency	Analytes
Nevada	Microbiology, SDWA inorganics, CWA inorganics. RCRA inorganics
California	Microbiology, SDWA inorganics, CWA inorganics, RCRA inorganics

9.0 PERFORMANCE EVALUATION STUDIES

As part of an on-going laboratory QA/QC program, WETLAB routinely participates in semi-annual Water Pollution (WP) and Water Supply (WS) Performance Evaluation Studies and in round-robin proficiency testing and laboratory certification programs conducted by the local and state agencies. These studies are procured from a National Institute of Standards and Technology (NIST) accredited laboratory.

Performance Evaluation Study	Analyses Performed	Frequency
Water Supply (WS) PE Study	Inorganics, Alkalinity, pH, Phosphate, Turbidity, Nitrite, Metals, Coliform Bacteria	Semi-annually
Water Pollution (WP) PE Study	Nutrients, Demand, Minerals, Inorganics, Nitrite. Metals, Bacteria	Semi-annually
SOIL PE Study	Ignitability, Corrosivity, Metals, Cyanide	Semi-annually

APPENDIX D

EXAMPLE OF AN INTERNAL AUDIT CHECKLIST

INTERNAL AUDIT CHECKLIST

Date of Audit:_____________ Department:______________ Audited by:______________

QA/ QC Procedures	YES	NO	N/A	Comments
Are analysts following procedures outlined in SOPs and methods?				
Are standard curves prepared to adequately cover the expected concentration ranges of the sample?				
Are standard curves prepared daily or verified daily?				
Are new curves generated whenever out-of-control conditions are indicated or new reagents are prepared?				
Is control chart data maintained and updated regularly?				
Have method detection limits been determined for each matrix type and documented?				
Have method detection limits been updated regularly according to method guidelines?				
1. Are the following run at a frequency consistent with the method and **WETLAB** standard operating procedures?				
1.1 Laboratory Control Samples				
1.2 Method Blank				
1.3 Calibration Blank				
1.4 Spikes				
1.5 Spiked Duplicates				
1.6 Duplicates				
Are trip and field blanks analyzed as needed?				
Is the data reviewed by a supervisor/peer and signed off before it leaves the department?				
Are records kept of all lab observations and calculations and signed off by analyst or supervisor?				
Are data review checklists used by all analyst?				
Have contamination problems been encountered? Were they documented and corrected?				
Have any out-of-control situations been encountered? Was the corrective action plan documented?				
Are SOPs and other reference materials up-to-date?				
Is lab equipment properly maintained and maintenance documented?				
Are preventative maintenance procedures documented?				
Are instrument run logs maintained and signed off by the supervisor?				
Are instrument operating manuals available to the analyst?				
Are calibration records kept for equipment?				
Are standards traceable to NIST or EPA standards?				
Are fresh standards prepared at a frequency consistent with good QC?				
Are standard preparation logs maintained?				

QA/ QC Procedures	YES	NO	N/A	Comments
Are instrumentation gas logs maintained?				
Are standards properly labeled with concentrations, date of preparation, expiration date and person who prepared the reagent?				
Are all hoods functional; hood flow monitored and documented?				
Is the pH meter calibrated daily with two buffers in the range of interest? Is fresh buffer used daily?				
Are the conductivity meters calibrated with 0.01M KCl before each use?				
Is the analytical balance calibrated with a set of class "S" or "S1" weights quarterly?				
Have the "S" class weights been calibrated within the past three years?				
Are refrigerator temperatures monitored daily with an accurate thermometer?				
Are incubator temperatures monitored daily with an accurate thermometer?				
Are the water bath temperatures monitored and recorded when in use?				
Are sample containers properly stored and routinely checked for contamination?				

Comments:

APPENDIX E

METHOD SPECIFIC CALIBRATION, QC CRITERIA AND CORRECTIVE ACTIONS

Appendix E. Method-Specific Calibration and QC Criteria

ANALYSIS	METHOD	CONTROL ITEM	ACCEPTANCE CRITERIA	CORRECTIVE ACTION
TKN by FIA	**351.2**	Initial calibration (4 std, 1 blank)	r≥0.995	Recalibrate
		Continuing calibration (1 daily or every 10 samples)	±10%	Recalibrate; reanalyze previous 20 samples
		Matrix Spike per 10 samples	See SOP	
		Calibration blank (after each calibration check and end of run	<Report Limit	
NO3+NO2, NO2, NO3(calc)	**353.2**	Initial calibration (5 std, 1 blank)	r≥0.995	Recalibrate
		Continuing calibration (1 daily or every 10 samples)	±10%	Recalibrate; reanalyze previous 10 samples
		Matrix Spike per 10 samples	±20%	Reanalyze
		QC Check Standard After ICAL	±10%	Recalibrate
		Calibration blank (after each calibration check and end of run	<Report Limit	Recalibrate and reanalyze all samples > RL

Appendix E. Method-Specific Calibration and QC Criteria (cont.)

ANALYSIS	METHOD	CONTROL ITEM	ACCEPTANCE CRITERIA	CORRECTIVE ACTION
ICP Metals	**200.7**	Initial Calibration Minimum of a blank and one standard	r≥0.995	Rerun calibration standards
		Continuing calibration Instrument Performance Check (IPC)	After initial cal; ±5% after subsequent cal; ±10%	Reanalyze standard; if second analysis out, recalibrate, rerun all samples since last compliant IPC.
		Lab Fortified Blank	±15%	Rerun batch
		Calibration blank (after each IPC solution)	<IDL	Rerun blank, if second CCB analysis out, recalibrate and reanalyze all samples since last compliant CCB
		Laboratory Reagent Blank/ Method blank (1 per 20 or batch)	<2.2*the analyte MDL	Determine cause of problem, redigest set if necessary and reanalyze
		Laboratory Fortified Blank (LFB) (1 per 20 or batch)	±15%	Recalibrate
		Laboratory Duplicates	See SOP	
		Spiked Samples (Lab Fortified Sample Matrix) one per 10 samples	±30%	Redigest, or if LFB OK flag data as suspect due to matrix interference

Appendix E. Method-Specific Calibration and QC Criteria (cont.)

ANALYSIS	METHOD	CONTROL ITEM	ACCEPTANCE CRITERIA	CORRECTIVE ACTION
ICP Metals	**200.8**	Initial Calibration (ICAL) Minimum of a blank and one standard	r≥0.995	Rerun calibration standards
		Continuing calibration After ICAL, after every 10 samples and at end of run	±10%	If >±10%, recalibrate and continue analysis. If >±15%, recalibrate and reanalyze all samples since last compliant continuing cal standard.
		Calibration blank (after each continuing calibration standard)	<IDL	Rerun blank or recalibrate and rerun all samples since last compliant calibration blank.
		Laboratory Reagent Blank (LRB) (1 per 20 or batch)	<2.2*the analyte MDL or <10% sample analyte level, whichever is greater	Determine cause of problem, redigest set if necessary and reanalyze
		Spiked Samples (Lab Fortified Sample Matrix) one per 10 samples	±30% (%Recovery not calculated if spike added is <30% of sample conc.)	Redigest, or if LFB OK flag data as suspect due to matrix interference

Appendix E. Method-Specific Calibration and QC Criteria (cont.)

ANALYSIS	METHOD	CONTROL ITEM	ACCEPTANCE CRITERIA	CORRECTIVE ACTION
Mercury	**245.1**	Initial Calibration (5 std, 1 blank)	r≥0.995	Recalibrate
		Continuing calibration Instrument Performance Check (IPC) (after ICAL, every 10 samples, and end of run	Initial, ±5%; subsequent, ±10%	Recalibrate, reanalyze all samples since last compliant IPC.
		Matrix spike (1 per 10)	±30%	If LFB OK, then flag sample result as suspect due to matrix interference.
		Duplicates	See SOP	
		Laboratory Reagent Blank (LRB) (1 per 20 or batch)	<2.2*MDL or <10% of sample concentration	Reprocess samples
		Continuing Calibration Blank (CCB) (after ICAL, every 10 samples, and end of run	<MDL	Correct problem and all samples since last compliant CCB
		QC Check Standard (QCS)	±10%	Recalibrate
		Lab Fortified Blank (1 per batch)	±15%	Recalibrate

Appendix E. Method-Specific Calibration and QC Criteria (cont.)

ANALYSIS	METHOD	CONTROL ITEM	ACCEPTANCE CRITERIA	CORRECTIVE ACTION
Anions by IC Chloride, Nitrate/Nitrite Sulfate	**300.0**	Initial calibration curve	r≥0.995	Rerun calibration standards
		Instrument Performance Check Sample (IPC) analyze after ICAL, every 10 samples and end of run	±10%	Reanalyze IPC; if second analysis still out, recalibrate and reanalyze all samples since last compliant IPC
		Calibration Blank Analyze with each IPC	<MDL	Determine cause of blank problem, reanalyze all samples since last compliant calibration blank
		Lab Fortified Blank (one per batch)	±10%	Correct problem and reanalyze batch
		Spiked Samples	±20%	If LFB OK flag sample suspect due to matrix
		Duplicates	25% RPD	Reprep dups and reanalyze
TDS, TSS, Total Solids, T. Vol. Solids Settleable Solids, O&G COD	**2540C** **2540D** **2540B** **160.5** **410.4** **1664**	Method Blank	<Reporting Limit	Determine cause of blank problem, reanalyze set if necessary
		Lab Control samples	±20%	Reprep batch and reanalyze
		Duplicates	25% RPD	Reprep batch and reanalyze

Appendix E. Method-Specific Calibration and QC Criteria (cont.)

ANALYSIS	METHOD	CONTROL ITEM	ACCEPTANCE CRITERIA	CORRECTIVE ACTION
Alkalinity Fluoride Turbidity	**2320B** **4500FC** **180.1**	Method Blank	<Report limit	Determine cause of blank problem, Reanalyze set if necessary
		Lab Control Samples	±10%	Reprep batch and reanalyze
		Duplicates	20%RPD	Reprep batch and reanalyze
pH	**4500H-B/9045**	3 Buffers	Within 0.05 pH unit of true value	Recalibrate
		Lab Control sample	±0.1 pH unit	Recalibrate and reanalyze
		Duplicate 1 per 20 or per batch, whichever is greater	±0.1 pH unit	Reanalyze; flag data if still outside limits
Conductivity	**2510B**	Method Blank	N/A	
		Lab Control Samples	±20%	Reanalyze batch
		Duplicates	15% RPD	Reanalyze; flag data is still outside limits

Appendix E. Method-Specific Calibration and QC Criteria (cont.)

ANALYSIS	METHOD	CONTROL ITEM	ACCEPTANCE CRITERIA	CORRECTIVE ACTION
Coliform Bacteria	**9223B**	Method Blank	No growth	Determine cause of blank problem, Reanalyze set if necessary
		Control Organism Check:	Pseudomonas aeruginosa: 0 / 0 Klebsiella pneumoniae: 1 / 0 E. Coli: 1 / 1	If any of these results do not occur, replace media
		Autofluorescence	Must not occur	Replace media
		Sterility Check	No growth accepted	Replace containers
		Accuracy Check	± 2.5%	Replace containers

ANALYSIS	METHOD	CONTROL ITEM	ACCEPTANCE CRITERIA	CORRECTIVE ACTION
Fecal Coliform	**9222D**	Method Blank	No growth	Determine cause of blank problem, Reanalyze set if necessary
		Control Organism Check:	Pseudomonas aeruginosa: 0 / 0 Klebsiella pneumoniae: 1 / 0 E. Coli: 1 / 1	If any of these results do not occur, replace media
		pH Check	7.4 ± 0.2 SU	Replace Media
		Autofluorescence	Must not occur	Replace media
		Sterility Check	No growth accepted	Replace containers
		Accuracy Check	± 2.5%	Replace containers, filter funnels, graduated cylinders

Appendix E. Method-Specific Calibration and QC Criteria (cont.)

ANALYSIS	METHOD	CONTROL ITEM	ACCEPTANCE CRITERIA	CORRECTIVE ACTION
ICP Metals	**6010B**	Initial Calibration Minimum of a blank and one standard		
		Initial Calibration Verification (ICV)	±10%	Recalibrate
		Continuing Calibration Verification (CCV)	±10%	Recalibrate, verify calibration, rerun all samples since last compliant CCV
		Calibration Blank (after each ICV and CCV)	<±3 x IDL	Recalibrate and reanalyze all samples since last compliant calibration blank
		Method blank (1 per 20 or batch)	Not >MDL	Determine cause of problem, redigest set if necessary
		Spiked Samples (MS) one per 20 samples or each batch if <20 samples.	±25%	Flag data as suspect due to matrix interference
		Matrix duplicates	20% RPD if sample value > 10 x IDL	Re-prep samples and reanalyze
		Interference Check Sample (ICS)	Beginning & every 8 hours %R=80-120	Recalibrate & rerun all samples since last compliant check sample
		LCS every 20 samples	See Method	

Appendix E. Method-Specific Calibration and QC Criteria (cont.)

ANALYSIS	METHOD	CONTROL ITEM	ACCEPTANCE CRITERIA	CORRECTIVE ACTION
Mercury	**7470/7471A**	Initial Calibration (5 std, 1 blank)	r≥0.995	Recalibrate
		Continuing calibration (after every 10 samples, and end of run)	±20%	Recalibrate, reanalyze previous 10 samples
		Matrix spike (1 per batch)	±15%	Reanalyze batch or run by MSA.
		Matrix Spike Duplicates	See SOP	
		Method Blank (1 per 20 or batch)	<2.2*MDL	Reprocess samples
		Continuing Calibration Blank (CCB) (after Ical, every 10 samples, and end of run	<MDL	
		QC Check Standard (after each calibration)	±10%	Recalibrate
		LCS(1 per batch)	±10%	Reprep batch and reanalyze

APPENDIX F

CORRECTIVE ACTION REPORT

WETLAB

CAR Number:

NONCONFORMANCE CORRECTIVE ACTION REPORT

QC Batch ID:	Today's Date:
Analysis Date:	Originator:
Affected Sample #:	Test/Method:

Sample Analysis:	**External Origin:**
Duplicate Precision	Client Issue / Request
Holding Time Expiration	Agency Requirement
LCS Recovery	PE Results
Blank Contamination	Other
Calibration	
SOP / Method Deviation	
MS/MSD Recovery	
Other	

Y / N Comment on report? Y / N Contact client? Y / N Reissue report?

Problem: ______________________________

Corrective Action: ______________________________

Preventative Action: ______________________________

______________________ Responsible Individual (sign/date)

______________________ QA (sign/date)

Report Comments

Please circle letter for all that apply

B – Blank Contamination; Analyte detected above the method reporting limit in an associated blank. Sample #________/ Analyte________

HT – Sample held beyond the accepted holding time. Sample #________/ Analyte________

M – Reported value is estimated; The sample matrix interfered with the analysis. Sample #________/ Analyte________

N – There was insufficient sample available to perform a spike and/or duplicate on this analytical batch. Sample #________/ Analyte________

NC – Not calculated due to matrix interference. Sample #________/ Analyte________

Q – Reported value is estimated; The value failed to meet QC criteria for either precision or accuracy. Sample #________/ Analyte________

SA – Reported value was calculated using the method of Standard Additions. Sample #________/ Analyte________

STANDARD OPERATING PROCEDURE

TITLE: Oil and Grease

METHOD NUMBER: EPA 1664

MATRIX: WASTE WATER AND OTHER LIQUID MATRICES

APPROVAL

DATE ISSUED: May 30, 2007

PREPARED BY: Andrew Smith

TECHNICAL APPROVAL J. Freeman

LAB DIRECTOR APPROVAL A Smith

1.0 SCOPE AND APPLICATION

This method is used to determine n-hexane extractable materials (HEM) in surface waters and industrial aqueous wastes. Extractable materials that can be determined are vegetable oils, animal fats, waxes, soaps, greases and other related materials.

2.0 SUMMARY OF METHOD

An acidified 1 liter sample is passed through an activated solid phase extraction (SPE) disk. The activated disk is able to bind up and hold any extractable material. The extractable materials will be released from the disk upon the rinsing with n-hexane. The n-hexane, along with extracted materials, is retrieved in a pre-weighed collection vessel. The n-hexane is evaporated while extracted materials remain in the vessel. The amount of extracted materials, "oil and grease", are determined gravimetrically.

3.0 SAFETY

Use proper precautions when handling unknown samples. Wear appropriate protective equipment, including lab coat, gloves, and safety glasses.

4.0 SAMPLE HANDLING AND PRESERVATION

HOLD TIME:	28 days
PRESERVATIVE:	HCl to pH<2, chill to 4°C
CONTAINER:	Glass only

5.0 INTERFERENCES

5.1 Solvents, reagents, glassware, and other sample-processing hardware may yield artifacts that affect results. Specific selection of reagents and purification of solvents may be required.

5.2 Interferences extracted from samples will vary considerably from source to source, depending upon the diversity of the site being sampled. For those instances in which samples are thought to consist of complex matrices containing substances (such as particulates or detergents) that may interfere with the extraction procedure, a smaller sample may need to be collected for analysis.

6.0 APPARATUS AND EQUIPMENT

6.1 Vacuum pump
6.2 Filtration apparatus: SPE manifold-Accuprep 7000
6.3 SPE disks-Nu•Phase, or equivalent.
6.4 Glass screw-top collection vials.
6.5 Dessicator.
6.6 Laboratory balance.
6.7 1000mL graduated cylinder.
6.8 Pre-weighed aluminum evaporating tins. Dry tins at 105° C, and store in a dessicator until use.
6.9 Sodium Sulfate drying cartridges.

7.0 REAGENTS

7.1 n-Hexane, 85% purity, 99.0% min. saturated C6 isomers, residue <1 mg/L
7.2 Acetone, ACS reagent
7.3 N-Hexadacane/Stearic Acid standard, 2 mg/mL each; purchased commercially from CPI Intl. or equivalent vendor source.
7.4 Methanol, 85% purity

8.0 METHOD-OIL AND GREASE

8.1 Assemble SPE manifold with filter disks "ripple" or "fuzzy" side up.

8.2 Extraction Disk Conditioning

8.2.1 Wash reservoir and disk with 10ml of n-hexane. Apply light vacuum
to waste side and pull about 1ml through the disk. Vent the vacuum and allow disk to soak for 2 minutes. Apply light vacuum

to pull remaining solvent through the disk and allow to dry. Repeat this step once more.

8.2.2 Add 10mls methanol to the reservoir. Pull 1 ml through disk then allow to soak as above. Apply vacuum to waste side and pull methanol through until it is 1-2 mm above the surface of the disk. ****Do not let the disk dry out.****

8.2.3 Add 10mls of reagent grade water to the reservoir. Apply vacuum to waste side and pull the water through disk until the surface of disk is covered by 1-2mm of water. Repeat once more. ****Never let disk dry out before introducing the sample.****

8.3 Sample Extraction

8.3.1 With a marker, mark sample bottle at volume level for subsequent true volume determination. Check the pH of each sample using the following procedure: Dip a minimal portion of glass stirring rod into the well mixed sample. Withdraw the stirring rod and touch it to the "narrow range" pH test strips. Retain the glass rod until until the end of the extraction period and the rinse the stirring rod with a small portion of n-hexane to ensure no extractable material is lost on the stirring rod. Collect the rinsate in the extraction funnel. If the pH is not <2, add HCL until the pH is <2.

8.3.2 Pour the 1 liter sample into the reservoir and apply minimum vacuum to the waste side. **** This sample extraction should take at least 10 minutes to achieve best results.**** Once extraction is finished allow vacuum to dry disk for 10 minutes.

8.3.3 While vacuum is open to waste add 4mls of acetone to the reservoir and disk, or attach sodium sulfate drying cartridges to the SPE manifold, to remove any remaining water. Apply max vacuum for 5 minutes.

8.4 Sample Elution

8.4.1 Add 10mls of n-hexane to sample container to rinse remaining sample and add to reservoir. This n-hexane is added in order to elute residue from disk. When adding the solvent, rinse down the sides of the reservoir. Carefully apply vacuum to the elute side and pull a few drops of solvent through and release the vacuum. Allow the disk to soak for 2 minutes before collecting the solvent. Repeat this step once more.

8.4.2 Remove the collection vessels from the manifold, transfer solvent to the pre-weighed aluminum evaporating tins, and place them in a laboratory hood to slowly evaporate the solvent. When all apparent traces of the solvent has been evaporated, and only that residue which is present is observable, allow the evaporating tins to stand in the laboratory hood for an additional 30 minutes.

8.4.3 Place samples in a dessicator and obtain gross weight to the nearest 0.1 mg. Repeat the cycle of desiccating and weighing until the weight loss is less than 4% of the previous weight or less than 0.5 mg, whichever is less. Record weight in log book.

8.5 Determine true sample volume by filling sample container to previous volume mark with water. Pour water into 1000mL graduated cylinder and record volume in log book.

9.0 QUALITY CONTROL

9.1.1 Set one blank per run. Blank consists of 1000mL of DI water acidified with 2 mls of 1:1 HCl. The Blank recovery must be lower than the reporting limit, or the source of contamination must be eliminated before continuing.

9.2 Analyze a Matrix Spike (MS) with each batch of 10 or fewer samples. The spike is a standard purchased commercially at a concentration of 2 mg/mL each. 5mL of the standard is added to 1 liter of client sample for a final concentration of 20 mg/mL total. Recovery should be 79 - 114%, or corrective action must be taken.

9.3 Analyze a Laboratory Control Sample (LCS) with each batch of 20 or fewer samples. The control is a standard purchased commercially at a concentration of 2 mg/mL each. 5mL of the standard is added to 1 liter of reagent grade water acidified with 1:1 HCl for a final concentration of 20 mg/mL total. Recovery should be 78 - 114%, or corrective action must be taken.

9.4 Due to the quality control requirements of EPA 1664 the analyst shall confirm the accuracy of the analytical balance before pre-weighing the aluminum evaporating tin and after the final weighing. This is done by measuring the weight of certified 2.00g and 0.002g (2mg) weights. The weights should be accurate to ± 0.01g for the 2.00g weight and ± 0.0002g (0.2mg) or corrective action must be taken.

10.0 CALCULATIONS

$$\text{Oil and Grease, mg/L} = \frac{(\text{Flask final, g} - \text{Flask initial, g}) \times 1{,}000{,}000}{\text{Sample volume, mL}}$$

11.0 REPORTING FORMAT

Report results as mg/L.

12.0 REFERENCES

12.1 EPA Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, U. S. Environmental Protection Agency, EMSL, Cincinnati, Ohio 45268, March 1983, Method 160.3.

12.2 Improved Procedure with Optimized Prefilter in the Determination of n-Hexane extractable Materials(Oil and Grease) for EPA Method 1664 Revision A, CPI International, Santa Rosa, CA. 95403.

APPENDIX B. COOPER LABORATORY DOCUMENTATION

COOPER TESTING LABS

STATEMENT OF QUALIFICATIONS

ACCREDITATION

Cooper Testing Labs has been inspected and accredited by AASHTO (American Association of State Highway & Transportation Officials), The US Army Corps of Engineers and Caltrans for Geotechnical Laboratory testing.

TESTING PROCEDURES

All testing at CTL is conducted in accordance with the specifications of the American Society for Testing Materials (ASTM), U.S. Army Corps of Engineers, Caltrans and other pertinent entities.

QUALITY CONTROL

Quality control is of the utmost importance at CTL. The laboratory managers continually monitor testing activities in the lab in order to assure that testing is proceeding in accordance with the appropriate standards. Any discrepancies are reviewed and the test is rerun if appropriate. A laboratory manager reviews all test results before they are released to the client. If test result accuracy is suspect, the entire test is reviewed and rerun if appropriate.

GEOTECHNICAL TESTING EXPERIENCE

The staff at CTL has over 100 combined years of experience in the lab and in the field doing geotechnical testing. All testing is performed by, or under the direct supervision of, an experienced geotechnical laboratory technician.

OUTSIDE AUDITS

It is the policy of CTL to participate in testing audit activity, i.e., Caltrans Reference Sample Program, AASHTO Materials Reference Program etc. Programs such as these allow us to see how our results compare with those from labs around the state and around the country.

SAMPLE CUSTODY PROCEDURES

Samples are logged in on arrival. At that time they are assigned a job number and start date and are cross checked with the request sheet or chain of custody to make sure all the samples are accounted for. They are then inspected for proper containment; i.e., sample bags are sealed and have no holes; shelby tube end-caps are taped to prevent moisture loss. If there is a chance of significant moisture loss prior to testing, samples will be stored in a wet room that is kept at over 90% relative humidity. After testing is complete the samples are logged into the sample storage room and assigned a shelf number and date. The samples are stored for a minimum of 30 days after the report goes out. After 30 days the samples are returned to the sender for proper disposal if they are contaminated, or discarded if they are not contaminated.

DATA FILING SYSTEM

Separate files are maintained by client and project. All original worksheets, purchase orders, test requests and/or chain of custody documentation are kept in the client/project file for a period of 7 years. Additional copies of any test results can be provided upon request.

EQUIPMENT BACKUP SYSTEMS

It is the policy at CTL to maintain redundant testing systems wherever possible. This redundancy is designed to minimize the impacts on testing of events such as power outages or equipment failure. It also allows us to run comparison testing as a check of the proper functioning of our equipment. For example, the majority of the equipment in the lab is run on compressed air. Many of the tests such as permeability and consolidation are long duration tests taking up to two weeks to complete. If the compressed air system goes down, many tests can be ruined. We have set up our system with a backup compressor on line, set to come on when the pressure drops below a predesignated pressure level.

EQUIPMENT MAINTENANCE AND CALIBRATION

Equipment maintenance and calibration are an integral part of the testing process at CTL. All applicable equipment (scales, load cells LVDTs, etc.) is calibrated at least once every year by a senior CTL technician. An independent calibration company with equipment traceable to NBS standards calibrates our calibration equipment annually. Each piece of equipment is inspected when it is used for testing. All testing equipment and instrumentation at CTL are regularly checked for signs of damage, wear, or being out of calibration. Part of the job at CTL is to check the instrument each time it is used. If the equipment is found to need service it is tagged out of service and reported to the laboratory manager. The laboratory manager will assure the prompt repair of the equipment. It is then recalibrated before being put back in service. All equipment manuals, schematics and calibration reports are maintained in the laboratory manager's files.

SELECTED LIST OF PROJECTS

The following is a partial list of projects for which we have provided geotechnical laboratory services:

Dams

Uvas Dam

Calaveras Dam

Bear Gulch Dam

Mt. Spring Reservoir

Danville Reservoir

Leland Reservoir

Willow Lake Dam

Vikery Reservoir

Sunset Reservoir

Tongue River Dam

Lenihan Dam

Landfills

Altamont, Alameda County

Scotia, Scotia

Casper, Mendocino

Fairhaven, Fairhaven

Eastlake, Clear Lake

Maui, Confidential

Hillside, Colma

Sacramento Landfill

King City Landfill

Sunnyvale Landfill

Koppers, Oroville (Superfund)

Mesquite Landfill

Tunnels

Caldecott Tunnel

Polhemus Tunnel

Lenihan Dam

Crystal Springs Lake Tap Shaft Tunnel & Pipeline

Nuclear Power Plants

Diablo Canyon

Humbolt

Other Geotechnical Projects

Modesto Reservoir Outlet Works

Gilroy/Morgan Hill Wastewater Treatment Facility

Los Vaqueros Water Conveyance Project

Travis AFB

Black Butte Hydroelectric Project

Stanford Linear Accelerator

Altamont Pipeline & Water Treatment Plant

Designation: D 422 – 63 (Reapproved 2002)

Standard Test Method for Particle-Size Analysis of Soils[1]

This standard is issued under the fixed designation D 422; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the quantitative determination of the distribution of particle sizes in soils. The distribution of particle sizes larger than 75 µm (retained on the No. 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 75 µm is determined by a sedimentation process, using a hydrometer to secure the necessary data (Note 1 and Note 2).

NOTE 1—Separation may be made on the No. 4 (4.75-mm), No. 40 (425-µm), or No. 200 (75-µm) sieve instead of the No. 10. For whatever sieve used, the size shall be indicated in the report.

NOTE 2—Two types of dispersion devices are provided: (*1*) a high-speed mechanical stirrer, and (*2*) air dispersion. Extensive investigations indicate that air-dispersion devices produce a more positive dispersion of plastic soils below the 20-µm size and appreciably less degradation on all sizes when used with sandy soils. Because of the definite advantages favoring air dispersion, its use is recommended. The results from the two types of devices differ in magnitude, depending upon soil type, leading to marked differences in particle size distribution, especially for sizes finer than 20 µm.

2. Referenced Documents

2.1 *ASTM Standards:*

D 421 Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[2]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[3]

E 100 Specification for ASTM Hydrometers[4]

3. Apparatus

3.1 *Balances*—A balance sensitive to 0.01 g for weighing the material passing a No. 10 (2.00-mm) sieve, and a balance sensitive to 0.1 % of the mass of the sample to be weighed for weighing the material retained on a No. 10 sieve.

3.2 *Stirring Apparatus*—Either apparatus A or B may be used.

3.2.1 Apparatus A shall consist of a mechanically operated stirring device in which a suitably mounted electric motor turns a vertical shaft at a speed of not less than 10 000 rpm without load. The shaft shall be equipped with a replaceable stirring paddle made of metal, plastic, or hard rubber, as shown in Fig. 1. The shaft shall be of such length that the stirring paddle will operate not less than ¾ in. (19.0 mm) nor more than 1½ in. (38.1 mm) above the bottom of the dispersion cup. A special dispersion cup conforming to either of the designs shown in Fig. 2 shall be provided to hold the sample while it is being dispersed.

3.2.2 Apparatus B shall consist of an air-jet dispersion cup[5] (Note 3) conforming to the general details shown in Fig. 3 (Note 4 and Note 5).

NOTE 3—The amount of air required by an air-jet dispersion cup is of the order of 2 ft^3/min; some small air compressors are not capable of supplying sufficient air to operate a cup.

NOTE 4—Another air-type dispersion device, known as a dispersion tube, developed by Chu and Davidson at Iowa State College, has been shown to give results equivalent to those secured by the air-jet dispersion cups. When it is used, soaking of the sample can be done in the sedimentation cylinder, thus eliminating the need for transferring the slurry. When the air-dispersion tube is used, it shall be so indicated in the report.

NOTE 5—Water may condense in air lines when not in use. This water must be removed, either by using a water trap on the air line, or by blowing the water out of the line before using any of the air for dispersion purposes.

3.3 *Hydrometer*—An ASTM hydrometer, graduated to read in either specific gravity of the suspension or grams per litre of suspension, and conforming to the requirements for hydrometers 151H or 152H in Specifications E 100. Dimensions of both hydrometers are the same, the scale being the only item of difference.

3.4 *Sedimentation Cylinder*—A glass cylinder essentially 18 in. (457 mm) in height and 2½ in. (63.5 mm) in diameter, and

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[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.03 on Texture, Plasticity, and Density Characteristics of Soils.

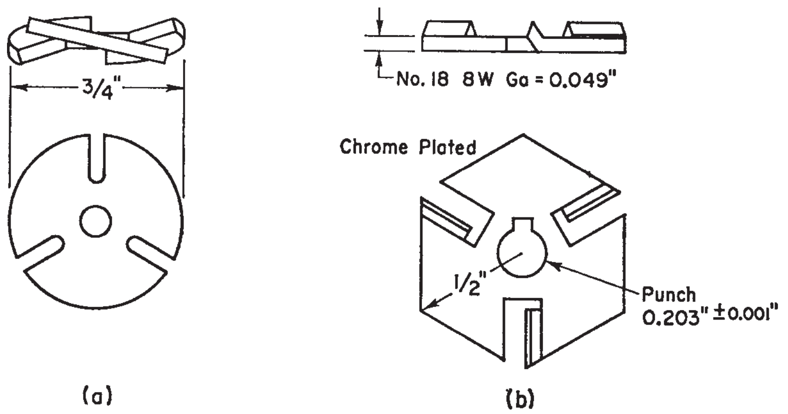
Current edition approved Nov. 10, 2002. Published March 2003Originally published in 1935. Last previous edition approved in 1998 as D 422 – 63 (1998).

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] *Annual Book of ASTM Standards*, Vol 14.03.

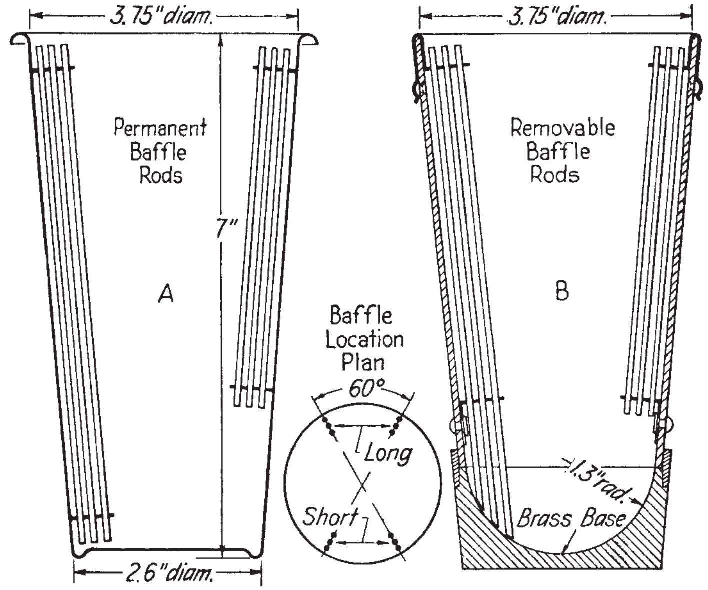
[5] Detailed working drawings for this cup are available at a nominal cost from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428. Order Adjunct No. ADJD0422.



Metric Equivalents

in.	0.001	0.049	0.203	½	¾
mm	0.03	1.24	5.16	12.7	19.0

FIG. 1 Detail of Stirring Paddles



Metric Equivalents

in.	1.3	2.6	3.75
mm	33	66	95.2

FIG. 2 Dispersion Cups of Apparatus

marked for a volume of 1000 mL. The inside diameter shall be such that the 1000-mL mark is 36 ± 2 cm from the bottom on the inside.

3.5 *Thermometer*—A thermometer accurate to 1°F (0.5°C).

3.6 *Sieves*—A series of sieves, of square-mesh woven-wire cloth, conforming to the requirements of Specification E 11. A full set of sieves includes the following (Note 6):

3-in. (75-mm)
2-in. (50-mm)
1½-in. (37.5-mm)
1-in. (25.0-mm)
¾-in. (19.0-mm)
⅜-in. (9.5-mm)
No. 4 (4.75-mm)
No. 10 (2.00-mm)
No. 20 (850-µm)
No. 40 (425-µm)
No. 60 (250-µm)
No. 140 (106-µm)
No. 200 (75-µm)

NOTE 6—A set of sieves giving uniform spacing of points for the graph, as required in Section 17, may be used if desired. This set consists of the following sieves:

3-in. (75-mm)
1½-in. (37.5-mm)
¾-in. (19.0-mm)
⅜-in. (9.5-mm)
No. 4 (4.75-mm)
No. 8 (2.36-mm)
No. 16 (1.18-mm)
No. 30 (600-µm)
No. 50 (300-µm)
No. 100 (150-µm)
No. 200 (75-µm)

3.7 *Water Bath or Constant-Temperature Room*—A water bath or constant-temperature room for maintaining the soil suspension at a constant temperature during the hydrometer analysis. A satisfactory water tank is an insulated tank that maintains the temperature of the suspension at a convenient constant temperature at or near 68°F (20°C). Such a device is illustrated in Fig. 4. In cases where the work is performed in a room at an automatically controlled constant temperature, the water bath is not necessary.

3.8 *Beaker*—A beaker of 250-mL capacity.

3.9 *Timing Device*—A watch or clock with a second hand.

4. Dispersing Agent

4.1 A solution of sodium hexametaphosphate (sometimes called sodium metaphosphate) shall be used in distilled or demineralized water, at the rate of 40 g of sodium hexametaphosphate/litre of solution (Note 7).

NOTE 7—Solutions of this salt, if acidic, slowly revert or hydrolyze back to the orthophosphate form with a resultant decrease in dispersive action. Solutions should be prepared frequently (at least once a month) or adjusted to pH of 8 or 9 by means of sodium carbonate. Bottles containing solutions should have the date of preparation marked on them.

4.2 All water used shall be either distilled or demineralized water. The water for a hydrometer test shall be brought to the temperature that is expected to prevail during the hydrometer test. For example, if the sedimentation cylinder is to be placed in the water bath, the distilled or demineralized water to be used shall be brought to the temperature of the controlled water bath; or, if the sedimentation cylinder is used in a room with controlled temperature, the water for the test shall be at the temperature of the room. The basic temperature for the

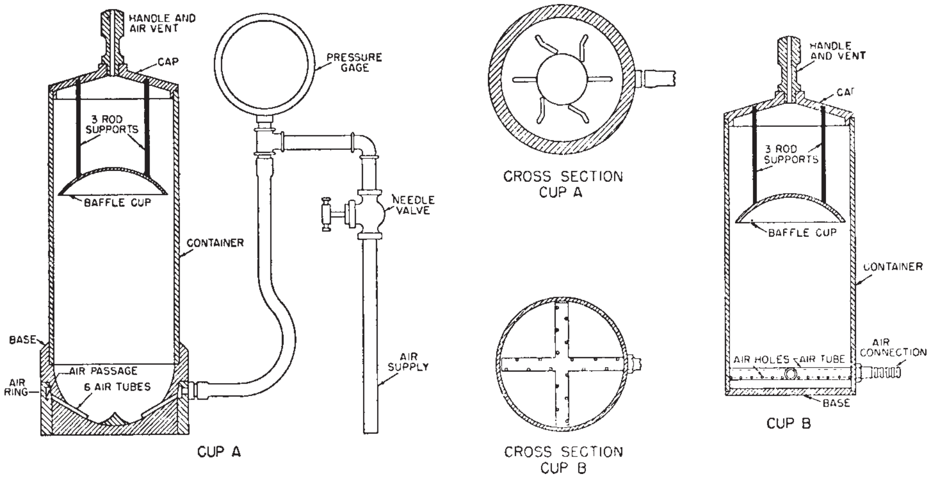
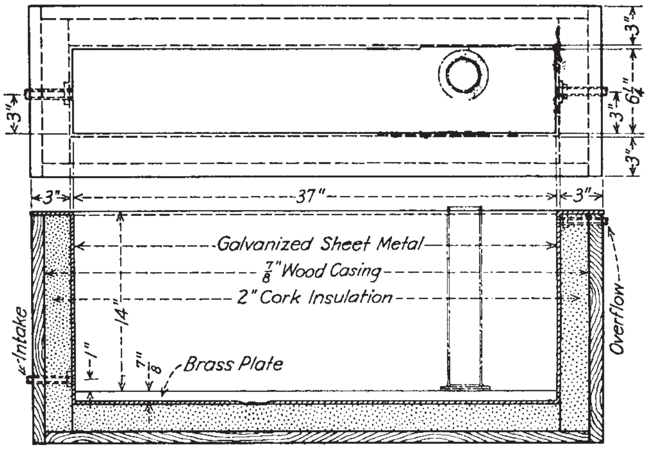


FIG. 3 Air-Jet Dispersion Cups of Apparatus B



Metric Equivalents

in.	⅞	1	3	6¼	14	37
mm	22.2	25.4	76.2	158.2	356	940

FIG. 4 Insulated Water Bath

hydrometer test is 68°F (20°C). Small variations of temperature do not introduce differences that are of practical significance and do not prevent the use of corrections derived as prescribed.

5. Test Sample

5.1 Prepare the test sample for mechanical analysis as outlined in Practice D 421. During the preparation procedure the sample is divided into two portions. One portion contains only particles retained on the No. 10 (2.00-mm) sieve while the other portion contains only particles passing the No. 10 sieve. The mass of air-dried soil selected for purpose of tests, as prescribed in Practice D 421, shall be sufficient to yield quantities for mechanical analysis as follows:

5.1.1 The size of the portion retained on the No. 10 sieve shall depend on the maximum size of particle, according to the following schedule:

Nominal Diameter of Largest Particles, in. (mm)	Approximate Minimum Mass of Portion, g
⅜ (9.5)	500
¾ (19.0)	1000
1 (25.4)	2000
1½ (38.1)	3000
2 (50.8)	4000
3 (76.2)	5000

5.1.2 The size of the portion passing the No. 10 sieve shall be approximately 115 g for sandy soils and approximately 65 g for silt and clay soils.

5.2 Provision is made in Section 5 of Practice D 421 for weighing of the air-dry soil selected for purpose of tests, the separation of the soil on the No. 10 sieve by dry-sieving and washing, and the weighing of the washed and dried fraction retained on the No. 10 sieve. From these two masses the percentages retained and passing the No. 10 sieve can be calculated in accordance with 12.1.

NOTE 8—A check on the mass values and the thoroughness of pulverization of the clods may be secured by weighing the portion passing the No. 10 sieve and adding this value to the mass of the washed and oven-dried portion retained on the No. 10 sieve.

SIEVE ANALYSIS OF PORTION RETAINED ON NO. 10 (2.00-mm) SIEVE

6. Procedure

6.1 Separate the portion retained on the No. 10 (2.00-mm) sieve into a series of fractions using the 3-in. (75-mm), 2-in. (50-mm), 1½-in. (37.5-mm), 1-in. (25.0-mm), ¾-in. (19.0-mm), ⅜-in. (9.5-mm), No. 4 (4.75-mm), and No. 10 sieves, or as many as may be needed depending on the sample, or upon the specifications for the material under test.

6.2 Conduct the sieving operation by means of a lateral and vertical motion of the sieve, accompanied by a jarring action in order to keep the sample moving continuously over the surface of the sieve. In no case turn or manipulate fragments in the sample through the sieve by hand. Continue sieving until not more than 1 mass % of the residue on a sieve passes that sieve during 1 min of sieving. When mechanical sieving is used, test the thoroughness of sieving by using the hand method of sieving as described above.

6.3 Determine the mass of each fraction on a balance conforming to the requirements of 3.1. At the end of weighing, the sum of the masses retained on all the sieves used should equal closely the original mass of the quantity sieved.

HYDROMETER AND SIEVE ANALYSIS OF PORTION PASSING THE NO. 10 (2.00-mm) SIEVE

7. Determination of Composite Correction for Hydrometer Reading

7.1 Equations for percentages of soil remaining in suspension, as given in 14.3, are based on the use of distilled or demineralized water. A dispersing agent is used in the water, however, and the specific gravity of the resulting liquid is appreciably greater than that of distilled or demineralized water.

7.1.1 Both soil hydrometers are calibrated at 68°F (20°C), and variations in temperature from this standard temperature produce inaccuracies in the actual hydrometer readings. The amount of the inaccuracy increases as the variation from the standard temperature increases.

7.1.2 Hydrometers are graduated by the manufacturer to be read at the bottom of the meniscus formed by the liquid on the stem. Since it is not possible to secure readings of soil suspensions at the bottom of the meniscus, readings must be taken at the top and a correction applied.

7.1.3 The net amount of the corrections for the three items enumerated is designated as the composite correction, and may be determined experimentally.

7.2 For convenience, a graph or table of composite corrections for a series of 1° temperature differences for the range of expected test temperatures may be prepared and used as needed. Measurement of the composite corrections may be made at two temperatures spanning the range of expected test temperatures, and corrections for the intermediate temperatures calculated assuming a straight-line relationship between the two observed values.

7.3 Prepare 1000 mL of liquid composed of distilled or demineralized water and dispersing agent in the same proportion as will prevail in the sedimentation (hydrometer) test. Place the liquid in a sedimentation cylinder and the cylinder in the constant-temperature water bath, set for one of the two temperatures to be used. When the temperature of the liquid becomes constant, insert the hydrometer, and, after a short interval to permit the hydrometer to come to the temperature of the liquid, read the hydrometer at the top of the meniscus formed on the stem. For hydrometer 151H the composite correction is the difference between this reading and one; for hydrometer 152H it is the difference between the reading and zero. Bring the liquid and the hydrometer to the other temperature to be used, and secure the composite correction as before.

8. Hygroscopic Moisture

8.1 When the sample is weighed for the hydrometer test, weigh out an auxiliary portion of from 10 to 15 g in a small metal or glass container, dry the sample to a constant mass in an oven at 230 ± 9°F (110 ± 5°C), and weigh again. Record the masses.

9. Dispersion of Soil Sample

9.1 When the soil is mostly of the clay and silt sizes, weigh out a sample of air-dry soil of approximately 50 g. When the soil is mostly sand the sample should be approximately 100 g.

9.2 Place the sample in the 250-mL beaker and cover with 125 mL of sodium hexametaphosphate solution (40 g/L). Stir until the soil is thoroughly wetted. Allow to soak for at least 16 h.

9.3 At the end of the soaking period, disperse the sample further, using either stirring apparatus A or B. If stirring apparatus A is used, transfer the soil-water slurry from the beaker into the special dispersion cup shown in Fig. 2, washing any residue from the beaker into the cup with distilled or demineralized water (Note 9). Add distilled or demineralized water, if necessary, so that the cup is more than half full. Stir for a period of 1 min.

NOTE 9—A large size syringe is a convenient device for handling the water in the washing operation. Other devices include the wash-water bottle and a hose with nozzle connected to a pressurized distilled water tank.

9.4 If stirring apparatus B (Fig. 3) is used, remove the cover cap and connect the cup to a compressed air supply by means of a rubber hose. A air gage must be on the line between the cup and the control valve. Open the control valve so that the gage indicates 1 psi (7 kPa) pressure (Note 10). Transfer the soil-water slurry from the beaker to the air-jet dispersion cup by washing with distilled or demineralized water. Add distilled or demineralized water, if necessary, so that the total volume in the cup is 250 mL, but no more.

NOTE 10—The initial air pressure of 1 psi is required to prevent the soil-water mixture from entering the air-jet chamber when the mixture is transferred to the dispersion cup.

9.5 Place the cover cap on the cup and open the air control valve until the gage pressure is 20 psi (140 kPa). Disperse the soil according to the following schedule:

Plasticity Index	Dispersion Period, min
Under 5	5
6 to 20	10
Over 20	15

Soils containing large percentages of mica need be dispersed for only 1 min. After the dispersion period, reduce the gage pressure to 1 psi preparatory to transfer of soil-water slurry to the sedimentation cylinder.

10. Hydrometer Test

10.1 Immediately after dispersion, transfer the soil-water slurry to the glass sedimentation cylinder, and add distilled or demineralized water until the total volume is 1000 mL.

10.2 Using the palm of the hand over the open end of the cylinder (or a rubber stopper in the open end), turn the cylinder upside down and back for a period of 1 min to complete the agitation of the slurry (Note 11). At the end of 1 min set the cylinder in a convenient location and take hydrometer readings at the following intervals of time (measured from the beginning of sedimentation), or as many as may be needed, depending on the sample or the specification for the material under test: 2, 5, 15, 30, 60, 250, and 1440 min. If the controlled water bath is used, the sedimentation cylinder should be placed in the bath between the 2- and 5-min readings.

NOTE 11—The number of turns during this minute should be approximately 60, counting the turn upside down and back as two turns. Any soil remaining in the bottom of the cylinder during the first few turns should be loosened by vigorous shaking of the cylinder while it is in the inverted position.

10.3 When it is desired to take a hydrometer reading, carefully insert the hydrometer about 20 to 25 s before the reading is due to approximately the depth it will have when the reading is taken. As soon as the reading is taken, carefully remove the hydrometer and place it with a spinning motion in a graduate of clean distilled or demineralized water.

NOTE 12—It is important to remove the hydrometer immediately after each reading. Readings shall be taken at the top of the meniscus formed by the suspension around the stem, since it is not possible to secure readings at the bottom of the meniscus.

10.4 After each reading, take the temperature of the suspension by inserting the thermometer into the suspension.

11. Sieve Analysis

11.1 After taking the final hydrometer reading, transfer the suspension to a No. 200 (75-µm) sieve and wash with tap water until the wash water is clear. Transfer the material on the No. 200 sieve to a suitable container, dry in an oven at 230 ± 9°F (110 ± 5°C) and make a sieve analysis of the portion retained, using as many sieves as desired, or required for the material, or upon the specification of the material under test.

CALCULATIONS AND REPORT

12. Sieve Analysis Values for the Portion Coarser than the No. 10 (2.00-mm) Sieve

12.1 Calculate the percentage passing the No. 10 sieve by dividing the mass passing the No. 10 sieve by the mass of soil originally split on the No. 10 sieve, and multiplying the result by 100. To obtain the mass passing the No. 10 sieve, subtract the mass retained on the No. 10 sieve from the original mass.

12.2 To secure the total mass of soil passing the No. 4 (4.75-mm) sieve, add to the mass of the material passing the No. 10 sieve the mass of the fraction passing the No. 4 sieve and retained on the No. 10 sieve. To secure the total mass of soil passing the ⅜-in. (9.5-mm) sieve, add to the total mass of soil passing the No. 4 sieve, the mass of the fraction passing the ⅜-in. sieve and retained on the No. 4 sieve. For the remaining sieves, continue the calculations in the same manner.

12.3 To determine the total percentage passing for each sieve, divide the total mass passing (see 12.2) by the total mass of sample and multiply the result by 100.

13. Hygroscopic Moisture Correction Factor

13.1 The hydroscopic moisture correction factor is the ratio between the mass of the oven-dried sample and the air-dry mass before drying. It is a number less than one, except when there is no hygroscopic moisture.

14. Percentages of Soil in Suspension

14.1 Calculate the oven-dry mass of soil used in the hydrometer analysis by multiplying the air-dry mass by the hygroscopic moisture correction factor.

14.2 Calculate the mass of a total sample represented by the mass of soil used in the hydrometer test, by dividing the oven-dry mass used by the percentage passing the No. 10 (2.00-mm) sieve, and multiplying the result by 100. This value is the weight W in the equation for percentage remaining in suspension.

14.3 The percentage of soil remaining in suspension at the level at which the hydrometer is measuring the density of the suspension may be calculated as follows (Note 13): For hydrometer 151H:

$$P = [(100\,000/W) \times G/(G - G_1)](R - G_1) \quad (1)$$

NOTE 13—The bracketed portion of the equation for hydrometer 151H is constant for a series of readings and may be calculated first and then multiplied by the portion in the parentheses.

For hydrometer 152H:

$$P = (Ra/W) \times 100 \quad (2)$$

where:

a = correction faction to be applied to the reading of hydrometer 152H. (Values shown on the scale are computed using a specific gravity of 2.65. Correction factors are given in Table 1),

P = percentage of soil remaining in suspension at the level at which the hydrometer measures the density of the suspension,

R = hydrometer reading with composite correction applied (Section 7),

W = oven-dry mass of soil in a total test sample represented by mass of soil dispersed (see 14.2), g,
G = specific gravity of the soil particles, and
G_1 = specific gravity of the liquid in which soil particles are suspended. Use numerical value of one in both instances in the equation. In the first instance any possible variation produces no significant effect, and in the second instance, the composite correction for R is based on a value of one for G_1.

15. Diameter of Soil Particles

15.1 The diameter of a particle corresponding to the percentage indicated by a given hydrometer reading shall be calculated according to Stokes' law (Note 14), on the basis that a particle of this diameter was at the surface of the suspension at the beginning of sedimentation and had settled to the level at which the hydrometer is measuring the density of the suspension. According to Stokes' law: see Table 2

$$D = \sqrt{[30n/980(G - G_1)] \times L/T} \tag{3}$$

where:
D = diameter of particle, mm,
n = coefficient of viscosity of the suspending medium (in this case water) in poises (varies with changes in temperature of the suspending medium),
L = distance from the surface of the suspension to the level at which the density of the suspension is being measured, cm. (For a given hydrometer and sedimentation cylinder, values vary according to the hydrometer readings. This distance is known as effective depth (see Table 2)),
T = interval of time from beginning of sedimentation to the taking of the reading, min,
G = specific gravity of soil particles, and
G_1 = specific gravity (relative density) of suspending medium (value may be used as 1.000 for all practical purposes).

NOTE 14—Since Stokes' law considers the terminal velocity of a single sphere falling in an infinity of liquid, the sizes calculated represent the diameter of spheres that would fall at the same rate as the soil particles.

15.2 For convenience in calculations the above equation may be written as follows: see Table 3

TABLE 1 Values of Correction Factor, α, for Different Specific Gravities of Soil Particles[A]

Specific Gravity	Correction Factor[A]
2.95	0.94
2.90	0.95
2.85	0.96
2.80	0.97
2.75	0.98
2.70	0.99
2.65	1.00
2.60	1.01
2.55	1.02
2.50	1.03
2.45	1.05

[A] For use in equation for percentage of soil remaining in suspension when using Hydrometer 152H.

TABLE 2 Values of Effective Depth Based on Hydrometer and Sedimentation Cylinder of Specified Sizes[A]

Hydrometer 151H		Hydrometer 152H			
Actual Hydrometer Reading	Effective Depth, L, cm	Actual Hydrometer Reading	Effective Depth, L, cm	Actual Hydrometer Reading	Effective Depth, L, cm
1.000	16.3	0	16.3	31	11.2
1.001	16.0	1	16.1	32	11.1
1.002	15.8	2	16.0	33	10.9
1.003	15.5	3	15.8	34	10.7
1.004	15.2	4	15.6	35	10.6
1.005	15.0	5	15.5		
1.006	14.7	6	15.3	36	10.4
1.007	14.4	7	15.2	37	10.2
1.008	14.2	8	15.0	38	10.1
1.009	13.9	9	14.8	39	9.9
1.010	13.7	10	14.7	40	9.7
1.011	13.4	11	14.5	41	9.6
1.012	13.1	12	14.3	42	9.4
1.013	12.9	13	14.2	43	9.2
1.014	12.6	14	14.0	44	9.1
1.015	12.3	15	13.8	45	8.9
1.016	12.1	16	13.7	46	8.8
1.017	11.8	17	13.5	47	8.6
1.018	11.5	18	13.3	48	8.4
1.019	11.3	19	13.2	49	8.3
1.020	11.0	20	13.0	50	8.1
1.021	10.7	21	12.9	51	7.9
1.022	10.5	22	12.7	52	7.8
1.023	10.2	23	12.5	53	7.6
1.024	10.0	24	12.4	54	7.4
1.025	9.7	25	12.2	55	7.3
1.026	9.4	26	12.0	56	7.1
1.027	9.2	27	11.9	57	7.0
1.028	8.9	28	11.7	58	6.8
1.029	8.6	29	11.5	59	6.6
1.030	8.4	30	11.4	60	6.5
1.031	8.1				
1.032	7.8				
1.033	7.6				
1.034	7.3				
1.035	7.0				
1.036	6.8				
1.037	6.5				
1.038	6.2				

[A] Values of effective depth are calculated from the equation:

$$L = L_1 + 1/2\,[L_2 - (V_B/A)] \tag{5}$$

where:
L = effective depth, cm,
L_1 = distance along the stem of the hydrometer from the top of the bulb to the mark for a hydrometer reading, cm,
L_2 = overall length of the hydrometer bulb, cm,
V_B = volume of hydrometer bulb, cm^3, and
A = cross-sectional area of sedimentation cylinder, cm^2

Values used in calculating the values in Table 2 are as follows:
For both hydrometers, 151H and 152H:
L_2 = 14.0 cm
V_B = 67.0 cm^3
A = 27.8 cm^2

For hydrometer 151H:
L_1 = 10.5 cm for a reading of 1.000
= 2.3 cm for a reading of 1.031

For hydrometer 152H:
L_1 = 10.5 cm for a reading of 0 g/litre
= 2.3 cm for a reading of 50 g/litre

$$D = K\sqrt{L/T} \tag{4}$$

TABLE 3 Values of K for Use in Equation for Computing Diameter of Particle in Hydrometer Analysis

Temperature, °C	Specific Gravity of Soil Particles								
	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
16	0.01510	0.01505	0.01481	0.01457	0.01435	0.01414	0.01394	0.01374	0.01356
17	0.01511	0.01486	0.01462	0.01439	0.01417	0.01396	0.01376	0.01356	0.01338
18	0.01492	0.01467	0.01443	0.01421	0.01399	0.01378	0.01359	0.01339	0.01321
19	0.01474	0.01449	0.01425	0.01403	0.01382	0.01361	0.01342	0.1323	0.01305
20	0.01456	0.01431	0.01408	0.01386	0.01365	0.01344	0.01325	0.01307	0.01289
21	0.01438	0.01414	0.01391	0.01369	0.01348	0.01328	0.01309	0.01291	0.01273
22	0.01421	0.01397	0.01374	0.01353	0.01332	0.01312	0.01294	0.01276	0.01258
23	0.01404	0.01381	0.01358	0.01337	0.01317	0.01297	0.01279	0.01261	0.01243
24	0.01388	0.01365	0.01342	0.01321	0.01301	0.01282	0.01264	0.01246	0.01229
25	0.01372	0.01349	0.01327	0.01306	0.01286	0.01267	0.01249	0.01232	0.01215
26	0.01357	0.01334	0.01312	0.01291	0.01272	0.01253	0.01235	0.01218	0.01201
27	0.01342	0.01319	0.01297	0.01277	0.01258	0.01239	0.01221	0.01204	0.01188
28	0.01327	0.01304	0.01283	0.01264	0.01244	0.01255	0.01208	0.01191	0.01175
29	0.01312	0.01290	0.01269	0.01249	0.01230	0.01212	0.01195	0.01178	0.01162
30	0.01298	0.01276	0.01256	0.01236	0.01217	0.01199	0.01182	0.01165	0.01149

where:

K = constant depending on the temperature of the suspension and the specific gravity of the soil particles. Values of K for a range of temperatures and specific gravities are given in Table 3. The value of K does not change for a series of readings constituting a test, while values of L and T do vary.

15.3 Values of D may be computed with sufficient accuracy, using an ordinary 10-in. slide rule.

NOTE 15—The value of L is divided by T using the *A*- and *B*-scales, the square root being indicated on the *D*-scale. Without ascertaining the value of the square root it may be multiplied by K, using either the *C*- or *CI*-scale.

16. Sieve Analysis Values for Portion Finer than No. 10 (2.00-mm) Sieve

16.1 Calculation of percentages passing the various sieves used in sieving the portion of the sample from the hydrometer test involves several steps. The first step is to calculate the mass of the fraction that would have been retained on the No. 10 sieve had it not been removed. This mass is equal to the total percentage retained on the No. 10 sieve (100 minus total percentage passing) times the mass of the total sample represented by the mass of soil used (as calculated in 14.2), and the result divided by 100.

16.2 Calculate next the total mass passing the No. 200 sieve. Add together the fractional masses retained on all the sieves, including the No. 10 sieve, and subtract this sum from the mass of the total sample (as calculated in 14.2).

16.3 Calculate next the total masses passing each of the other sieves, in a manner similar to that given in 12.2.

16.4 Calculate last the total percentages passing by dividing the total mass passing (as calculated in 16.3) by the total mass of sample (as calculated in 14.2), and multiply the result by 100.

17. Graph

17.1 When the hydrometer analysis is performed, a graph of the test results shall be made, plotting the diameters of the particles on a logarithmic scale as the abscissa and the percentages smaller than the corresponding diameters to an arithmetic scale as the ordinate. When the hydrometer analysis is not made on a portion of the soil, the preparation of the graph is optional, since values may be secured directly from tabulated data.

18. Report

18.1 The report shall include the following:

18.1.1 Maximum size of particles,

18.1.2 Percentage passing (or retained on) each sieve, which may be tabulated or presented by plotting on a graph (Note 16),

18.1.3 Description of sand and gravel particles:

18.1.3.1 Shape—rounded or angular,

18.1.3.2 Hardness—hard and durable, soft, or weathered and friable,

18.1.4 Specific gravity, if unusually high or low,

18.1.5 Any difficulty in dispersing the fraction passing the No. 10 (2.00-mm) sieve, indicating any change in type and amount of dispersing agent, and

18.1.6 The dispersion device used and the length of the dispersion period.

NOTE 16—This tabulation of graph represents the gradation of the sample tested. If particles larger than those contained in the sample were removed before testing, the report shall so state giving the amount and maximum size.

18.2 For materials tested for compliance with definite specifications, the fractions called for in such specifications shall be reported. The fractions smaller than the No. 10 sieve shall be read from the graph.

18.3 For materials for which compliance with definite specifications is not indicated and when the soil is composed almost entirely of particles passing the No. 4 (4.75-mm) sieve, the results read from the graph may be reported as follows:

(*1*) Gravel, passing 3-in. and retained on No. 4 sieve . . . . . %
(*2*) Sand, passing No. 4 sieve and retained on No. 200 sieve . . . . . %
    (*a*) Coarse sand, passing No. 4 sieve and retained on No. 10 sieve . . . . . %
    (*b*) Medium sand, passing No. 10 sieve and retained on No. 40 sieve . . . . . %
    (*c*) Fine sand, passing No. 40 sieve and retained on No. 200 sieve . . . . . %
(*3*) Silt size, 0.074 to 0.005 mm . . . . . %
(*4*) Clay size, smaller than 0.005 mm . . . . . %
    Colloids, smaller than 0.001 mm . . . . . %

18.4 For materials for which compliance with definite specifications is not indicated and when the soil contains material retained on the No. 4 sieve sufficient to require a sieve analysis on that portion, the results may be reported as follows (Note 17):

SIEVE ANALYSIS

Sieve Size	Percentage Passing
3-in.	. . . .
2-in.	. . . .
1½-in.	. . . .
1-in.	. . . .
¾-in.	. . . .
⅜-in.	. . . .
No. 4 (4.75-mm)	. . . .
No. 10 (2.00-mm)	. . . .
No. 40 (425-µm)	. . . .
No. 200 (75-µm)	. . . .

HYDROMETER ANALYSIS

0.074 mm	. . . .
0.005 mm	. . . .
0.001 mm	. . . .

NOTE 17—No. 8 (2.36-mm) and No. 50 (300-µm) sieves may be substituted for No. 10 and No. 40 sieves.

19. Keywords

19.1 grain-size; hydrometer analysis; hygroscopic moisture; particle-size; sieve analysis

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