FINAL

Ranch Land Rock Pit No. 1 (M-2002-096)
Permit Amendment: Red Creek Quarry Baseline
Surface Water and Groundwater Sampling and Analysis Plan

Prepared for
HolcimUS
Portland, CO
October 2022

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Job: 153625

Brown AND Caldwell

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Table of Contents

1. Introduction....1-1
    1.1 Objectives....1-1
2. Site Description....2-1
    2.1 Site Location and Access....2-1
    2.2 Hydrologic Setting....2-1
    2.3 Geology and Hydrogeology....2-1
    2.4 Mine Plan....2-2
3. Surface Water Monitoring....3-1
    3.1 Surface Water Monitoring Locations....3-1
    3.2 Surface Water Monitoring Schedule....3-1
    3.3 Surface Water Monitoring Procedures....3-1
        3.3.1 Field Methods....3-2
        3.3.2 Laboratory Analysis....3-3
4. Groundwater Monitoring....4-1
    4.1 Groundwater Monitoring Well Network....4-1
    4.2 Groundwater Monitoring Schedule....4-1
    4.3 Groundwater Monitoring Procedures....4-1
        4.3.1 Sampling Methods....4-2
        4.3.2 Laboratory Analysis....4-3
5. Data Validation....5-1
6. Reporting....6-1
7. References....7-1

Figures....1

Appendix A: Analyte Lists....A

Appendix B: QAPP....B

Appendix C: SOPs....C

List of Figures

Figure 1. Site Vicinity Map
Figure 2. Surface Water Categories
Figure 3. Generalized Stratigraphic Column
Figure 4. Groundwater Contours and Well Locations
Figure 5. Surface Water Monitoring and Observation Stations

List of Tables

Table 3-1. Surface Water Sampling Locations....3-1
Table 4-1. RCQ Groundwater Monitoring Well Information....4-1

List of Abbreviations

°C	degree(s) Celsius
BC	Brown and Caldwell
bgs	below ground surface
COC	chain-of-custody
DO	dissolved oxygen
DRMS	Colorado Department of Reclamation and Mine Safety
EPA	U.S. Environmental Protection Agency
ft	foot/feet
Holcim	HolcimUs
HUC	hydrologic unit code
ID	identification number
ORP	oxidation-reduction potential
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
RCQ	Red Creek Quarry
SAP	sampling and analysis plan
SC	specific conductance
SOP	standard operating procedure
TDS	total dissolved solids
μm	micrometer(s)
USEPA	United States Environmental Protection Agency
USGS	U.S. Geological Survey

Section 1

Introduction

This baseline sampling and analysis plan (SAP) provides details on the surface water and groundwater monitoring program that will be conducted at the Red Creek Quarry (RCQ) property under the Ranch Land Rock Pit No. 1 (M-2002-096) permit amendment. It was prepared by Brown and Caldwell (BC) on behalf of HolcimUS (Holcim). The proposed RCQ mine will be an open-pit limestone quarry near Florence, CO. The 3,840-acre RCQ Property will consist of an open-pit limestone quarry to provide raw materials for the Holcim Portland Cement Plant and is located west of Pueblo, Colorado including Sections 24 and 25 in Fremont County and 19, 20, 29, and 30 in Pueblo County, Township 20 South, Range 68 West (Figure 1).

The surface and groundwater baseline monitoring program is part of the Colorado Department of Reclamation and Mine Safety (DRMS) permit application process for RCQ. The analytes and method detection limits selected for the surface water and groundwater baseline evaluation include biological, inorganic, and radiological suites listed in the Colorado Water Quality Control Commission standards for surface and ground waters. This monitoring plan incorporates existing well locations for groundwater quality and establishes surface water monitoring locations for flow and water quality, as well as a Quality Assurance Project Plan (QAPP) and field sampling methodologies.

1.1 Objectives

This SAP is designed to collect data to assess potential water resource impacts from future mining operations conducted at the RCQ. Constituent loading to surface water and groundwater could occur during future operations from stormwater runoff or groundwater seepage into mine pits and therefore baseline data, prior to mining, is needed to evaluate that change.

The goals of the monitoring program include:

- Document the characteristics of surface water and groundwater prior to any mining to assist in evaluation of the RCQ permit applications
- Obtain accurate and defensible data by following the site-specific QAPP (Appendix B) and standard operating procedures (SOPs) (Appendix C)
- Provide accurate and complete reporting of potential future mining-related impacts to appropriate regulatory agencies

This plan covers the monitoring program that will be implemented as part of the mine permitting process.

Section 2

Site Description

2.1 Site Location and Access

The mining operation will develop limestone reserves from the Fort Hayes and related formations in portions of U.S. Geological Survey (USGS) Sections 24 and 25, T20S, R68W in Freemont County and Section 19, 20, 29 and 30, T20S, R67W in Pueblo County. The RCQ property (owned by Holcim) encompasses approximately 3,851 acres (Figure 1).

The RCQ property is accessed from Florence by traveling south on State Highway 67 for approximately 11 miles and turning east (i.e., left) onto State Highway 96 to travel to two separate property access points along Highway 96. To access the north end of the RCQ study area, travel approximately 6.5 miles to the access gate. To access the south end of the site, continue along Highway 96 approximately 3 miles to the Holcim access gate (Figure 1).

2.2 Hydrologic Setting

The RCQ property is located within the Upper Arkansas River subbasin, a USGS fourth level hydrologic unit code (HUC) subbasin (HUC 11020002) that drains into the Arkansas River basin. The aquatic resources within the RCQ study area include several ephemeral tributaries to Red Creek and the Arkansas River, an intermittent section of Red Creek, and a perennial section of Red Creek (Figure 2). Observed surface waters supported the delineation wetlands downstream of field recon location 004 and upstream of location 011; surface water within Red Creek was not observed upstream of recon location 004 and downstream of location 011.

2.3 Geology and Hydrogeology

The RCQ property is comprised of Cretaceous age marine sediments of inter-bedded limestones and sandstones including the Fort Hays Limestone and the more argillaceous Smoky Hill Limestone/Shale Members of the Niobrara Formation. Underlying the limestone units is the Codell Sandstone Member and Blue Hill Shale Member of the Carlisle Formation. The primary geologic strata at the site are illustrated in Figure 3.

The Smoky Hill Limestone/Shale overlies the Fort Hays Limestone and consists of up to 125 feet (ft) of dark grey, thin-bedded limestone. The Fort Hays Limestone is the primary limestone resource due its high lime content and consists of approximately 35 ft of medium to light-grey, distinctly bedded limestone with numerous thin clay interbeds. The Codell Sandstone consists of approximately 20 to 30 ft of light grey, fine-grained, massive sandstone. Contact between the Codell Sandstone and the overlying Fort Hays Limestone is denoted by 2 to 3 ft thick transitional zone of dense, arenaceous limestone.

The geology of the RCQ property likely exerts a strong influence on local groundwater conditions. Groundwater was not observed in the limestone units during installation of monitoring wells in November 2021, with the exception of groundwater encountered in Well 2N within a highly fractures/faulted zone at approximately 35 ft below ground surface (bgs). Groundwater levels present in the Codell Sandstone appear to correlate with the dip of the sandstone bed to the southwest (Figure 4). The contact of between the limestone and sandstone was encountered at shallower depths on the north side of Red Creek in Wells 1 and 2S than in Wells 3 and 4. Wells 3 and 4 encountered the Codell sandstone at greater depths resulting in the groundwater table above the contact.

2.4 Mine Plan

The Ranch Land Rock Pit No. 1 located in Section 24 was previously permitted in 2002 under DRMS permit number M-2002-096 as a surface limestone mining operation with no water discharges or material processing. The Ranch Land Rock Pit No. 1 operation is presently inactive. Holcim plans to expand the currently permitted mine to a 3- to 5-million metric ton per year operation mining Fort Hays limestone and related formations. Mining operations at the RCQ property are planned to include quarry operations starting in the northwest corner of the six-section site, construct a crushing plant at the northwest corner, and convey the material via the more than 7-mile corridor to connect the RCQ operation site to the Portland plant.

Section 3

Surface Water Monitoring

Surface water monitoring will be performed by Holcim or its contractor under the direction of Holcim's project manager. Analytical services for the program will be provided by SGS North America, Inc. (a National Environmental Laboratory Accreditation Conference-certified analytical laboratory) or another qualified, certified laboratory. Information regarding the responsibilities of the key personnel for the project is provided in the QAPP (Appendix B).

3.1 Surface Water Monitoring Locations

An investigation to identify wetlands and waters of the United States within the RCQ permit boundaries identified a section of Red Creek as either ephemeral, intermittent or perennial. Only the sections of Red Creek that are perennial will be monitored for water quality.

The surface water monitoring network at the RCQ comprises 3 surface water monitoring locations. The monitoring station identification number (ID), location descriptions, and monitoring frequency are provided in Table 3-1. The surface water monitoring locations are shown on Figure 5.

Table 3-1. Surface Water Sampling Locations

Monitoring Station	Water Body	Description	Northing (meters)	Easting (meters)	Frequency
SW-SEEP	Seep	Surface water seep location	4238095.46	504175.80	Quarterly
SW-RC1	Red Creek	Furthest upstream perennial location on Red Creek	TBD	TBD	Quarterly
SW-RC2	Red Creek	Furthest downstream perennial location on Red Creek	TBD	TBD	Quarterly

Visual observations to document the presence of surface water along the ephemeral portions along Red Creek and tributaries will be conducted by photographing surface water observations stations identified during the wetlands delineation and site reconnaissance conducted in May of 2019. Visual observation locations are shown on Figure 5.

3.2 Surface Water Monitoring Schedule

Surface water will be monitored quarterly for a minimum of five consecutive quarters. The actual dates of the monitoring will depend on weather and sampling location accessibility. Groundwater and surface water monitoring activities are anticipated to be conducted under the same quarterly monitoring event.

3.3 Surface Water Monitoring Procedures

The surface water monitoring program will include the following items:

- Measurement of field parameters:
  - pH
  - Temperature
  - Specific conductance (SC)

  - Oxidation-reduction potential (ORP)
  - Dissolved oxygen (DO)
  - Turbidity
- Collection of water samples for laboratory analysis (see Section 3.3.2 below for further detail)

Water quality samples will be collected prior to any measurement activities in the creek to avoid channel bottom disturbances that could affect the water chemistry. SOPs for surface water quality sampling and stream flow measurement are provided in Appendix C (SOP-7 and SOP-8, respectively) and the general methodology is summarized below.

3.3.1 Field Methods

A general site inspection will be performed upon arrival at the monitoring station and comments regarding site conditions will be recorded in the field sampling record. Field parameters will be measured in the field and recorded on the field sampling record. An example of the field sampling record for surface water is included in Appendix C (SOP-7).

Water Quality Field Instrumentation. The field parameter instruments will be cleaned and calibrated at the beginning of each sampling day according to the manufacturer's specifications using the water quality equipment calibration form located in Appendix C (SOP-2). A drift check on all parameters will be performed at the end of each sampling day. A drift check will be performed mid-day if there are indications that the equipment is not performing normally or is subjected to adverse conditions (e.g., extreme cold); recalibration will be performed for parameter readings that are outside of acceptable performance limits.

If a drift check—either at the end of the sampling day or in response to equipment not performing normally—indicates that the instrument is outside of acceptable performance limits, field staff will qualify the field data collected prior to the drift check. Instrument specifications and calibration procedures for pH, SC, temperature, DO, ORP, and turbidity are included in Appendix C (SOP-2).

Surface Water Sample Collection. Water quality samples will be collected using the preferred direct grab method or other sampling method protocols detailed in SOP-7 (Appendix C). Samples from a flowing stream will be collected using dedicated sampling containers included with each sampling kit supplied by the laboratory, unless the sample bottle contains no preservative, in which case the sample may be collected directly into the sample bottle. Surface water samples will be collected by submerging the dedicated collection container or unpreserved sample bottle in the stream at a point where fresh water is continuously flowing to ensure a representative sample.

Only certified clean bottles that are obtained from the analytical laboratory will be used to store and ship samples to the laboratory. Samples for dissolved constituent analysis will be filtered (0.45 micrometer [μm]) prior to collection in the laboratory-supplied preserved (as appropriate) sample container. All sample containers will be clearly labeled with the station ID, date and time of sample collection, filtered or unfiltered condition, preservatives, and the sampler's initials. Samples will be kept cool in an insulated cooler from the time of collection to receipt by the analytical laboratory as detailed in the QAPP (Appendix B).

Chain-of-custody (COC) forms and custody seals provided by the laboratory will be used for all samples shipped to the laboratory. Sample containers, preservatives, laboratory holding times, analytical methods, and method detection limits for surface water samples are summarized in the QAPP (Appendix B).

Surface water samples will also be collected for quality assurance/quality control (QA/QC) purposes as outlined in the QAPP (Appendix B). For each sampling round, surface water blind duplicate samples will be collected at a frequency of 1 per sampling event.

Stream Flow Measurements. Stream flow rates will be measured at an established location where a water measuring device, such as a flume, will be installed at a semi-permanent location. The SOP for flow measurement is described in SOP-8 (Appendix B).

Collecting stream flow data will be subject to weather and accessibility. Because the field crew must wade into the flowing water to collect the flow measurements, the health and safety of field personnel will be given priority over data collection during hazardous conditions.

3.3.2 Laboratory Analysis

Surface water samples will be analyzed for the same broad range of constituents to establish baseline conditions and perform direct comparisons to groundwater data. The analyte list includes regulated surface and groundwater constituents and cation/anion data to compare water sources. The constituents to be analyzed during surface water sampling events under this plan are provided in Appendix A. Appendix A also provides the analytical methods, analytical limits, and water quality standards for reference. Additional details, including holding times, container types, and preservatives, are provided in the QAPP (Appendix B) and SOPs 4 and 7 (Appendix C).

Section 4

Groundwater Monitoring

Groundwater monitoring will be performed by Holcim or its selected contractor under the direction of Agrium's project manager. Analytical services for the program will be provided by SGS North America, Inc, or another qualified, certified laboratory. Information regarding the responsibilities of the key personnel for the project is provided in the QAPP (Appendix B).

4.1 Groundwater Monitoring Well Network

The proposed groundwater monitoring network includes 5 groundwater wells (Table 4-1 and Figure 4). Four of the groundwater wells are screened in the Codell sandstone and one well is screened in the Fort Hayes limestone. Water level data has been collected in the RCQ groundwater wells using pressure transducers since Q4 2021 and water levels will continue to be monitored.

Table 4-1. RCQ Groundwater Monitoring Well Information

Well ID	Lithology	Northing (meters)	Easting (meters)	Depth (ft bgs)
Well 1	Codell Sandstone	4238022.76	503777.96	65
Well 2N	Fort Hayes Limestone	4238547.13	504359.11	34
Well 2S	Codell Sandstone	4238544.72	504358.98	58
Well 3	Codell Sandstone	4237724.36	504413.34	92
Well 4	Codell Sandstone	4238015.5	504450.16	70

4.2 Groundwater Monitoring Schedule

Groundwater quality will be monitored quarterly for a minimum of five consecutive quarters. The actual dates of the monitoring will depend on weather and sampling location accessibility. Groundwater and surface water monitoring activities are anticipated to be conducted under the same quarterly monitoring event.

4.3 Groundwater Monitoring Procedures

The groundwater monitoring activities at each well will include:

- Measuring the water level in the well
- Measuring field parameters in groundwater from each well, including:
  - pH
  - Temperature
  - SC
  - ORP
  - DO
  - Turbidity

- Collecting samples for laboratory analysis (see Section 4.3.2 below for further detail)

4.3.1 Sampling Methods

A general site inspection will be performed upon arrival at each monitoring well and comments regarding site conditions will be recorded on the field sampling record. An example field sampling record for groundwater is included in SOP-6 (Appendix C).

Field Instrument Calibration. The field parameter instruments will be cleaned and calibrated at the beginning of each sampling day according to the manufacturer's specifications using the water quality equipment calibration form located in Appendix C (SOP-2). A drift check on all parameters will be performed at the end of each sampling day. A drift check will be performed mid-day if there are indications that the equipment is not performing normally or is subjected to adverse conditions (e.g., extreme cold); recalibration will be performed for parameters with readings that are outside of acceptable performance limits. If a drift check, either at the end of the sampling day or in response to equipment not performing normally, indicates that the instrument is outside of acceptable performance limits, field staff will qualify the field data collected prior to the drift check. Instrument specifications and calibration procedures for pH, SC, temperature, DO, ORP, and turbidity are included in Appendix C (SOP-2).

Water Level Measurements. Depth to water will be measured to the nearest 0.01 ft from the top of the well casing using an electrical water level sounder before sampling the well. The water level sounder will be cleaned with an environmental-grade detergent (Alconox or Liquinox) at the beginning or end of each sampling day. All parts of the sounder that will contact groundwater will be rinsed with distilled water before placement in each well.

Monitoring Well Purge Methods. All monitoring wells will be purged and sampled using standard purging methods or micro-purge (i.e., low-flow) sampling methods. Consistency in the sampling method and operating procedures conducted for each individual well are key components for collecting representative samples that are comparable between sampling events. If possible, once a sampling method has been established for a well, it will not be changed.

The low-flow sampling method relies on low pumping rates (typically 0.1 to 0.5 liter per minute) from a sampling pump located near the middle of the well screen interval to draw a representative sample of formation water into the pump intake with minimal disturbance of water in the well casing. The protocol for this method requires that water levels in the well be monitored during sampling with the goal of inducing less than 0.3 ft of drawdown.

Water quality parameters for pH, SC, DO, ORP, temperature, and turbidity will be monitored during purging using a flow-through cell. Purging will be considered complete when turbidity is less than 10 nephelometric turbidity units and three successive readings for pH, SC, ORP, and DO are within 0.1 standard unit, 3 percent, 10 millivolts, and 10 percent, respectively. Stabilization of all parameters may not be achievable in some wells; protocols for this occurrence are outlined in SOP-6 (Appendix C).

Sampling flow rate should not exceed the purge flow rate at which water quality indicator parameters stabilized. However, for samples needing to be filtered prior to collection in the sample bottle, a higher pressure may be required to push the sample water through the filter to maintain the same flow rate. Sampling equipment must be the same equipment that was used for purging, and should not be moved between purging and sampling activities. SOPs for low flow (i.e., micro-purge) sampling are described in SOP-6 (Appendix C).

Groundwater Sample Collection. Certified-clean bottles obtained from the analytical laboratory or commercial bottle supplier will be used to collect samples. Samples for dissolved constituents will be filtered (0.45 µm) prior to collection in the preserved sample bottles provided by the analytical laboratory. All sample containers will be clearly labeled with the well ID, date and time of sample collection, filtered or unfiltered condition, preservatives, and the sampler's initials. Samples will be kept cool (less than or equal to 6 degrees Celsius [°C]) from the time of collection to receipt by the analytical laboratory. COC forms and custody seals provided by the laboratory will be used for all samples shipped to the laboratory. The analytical suite for groundwater samples are summarized in Appendix A. SOPs for sample collection and handling are provided in Appendix C (SOP-4 and SOP-6).

Groundwater samples will also be collected for QA/QC purposes, as outlined in the QAPP (Appendix B). For each sampling round, groundwater blind duplicate samples will be collected at a frequency 1 duplicate sample per event.

4.3.2 Laboratory Analysis

Groundwater samples will be analyzed for the same broad range of constituents to establish baseline conditions and perform direct comparisons to surface water data. The analyte list includes regulated surface and groundwater constituents and cation/anion data to compare water sources. The constituents to be analyzed during groundwater water sampling events under this plan are provided in Appendix A. Additional details, including method detection limits, hold times, container types, and preservatives are provided in the QAPP (Appendix B) and in SOP-4 and SOP-6 (Appendix C).

Section 5

Data Validation

Water quality monitoring results will be reviewed as they are received from the laboratory, and a QC evaluation with data validation will be completed within 4 weeks of receipt of the data. Information generated by the monitoring program will be compiled in an updated Access-compatible database. The data will be validated in general accordance with United States Environmental Protection Agency (USEPA) *Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review* and protocols described in Appendix B (USEPA 2010). All data from the investigation will be subjected to a QC analysis, including the following components:

- A review to verify that laboratory sample IDs match sample IDs on the COC forms. Discrepancies will be noted and corrected.
- A review to verify that receiving temperatures are in accordance with preservation requirements specified in the QAPP (Appendix B).
- A review to verify that holding times are in accordance with the analytical methods specified in the QAPP.
- An evaluation of the sample cation-anion balance, measured total dissolved solids (TDS) to calculated TDS, and TDS to SC as described in the QAPP.
- A comparison of field duplicate samples with real samples as described in the QAPP.
- An evaluation of field blanks and equipment blanks (if any) as described in the QAPP.
- An evaluation of laboratory QC procedures and samples.

The goal of the QC review will be to provide valid data of known and documented quality that can be used to document water quality conditions for the project and identify constituent trends in surface water, groundwater, and stock ponds. When possible, laboratory-determined QC acceptance ranges will be used to evaluate data quality. In the absence of laboratory-determined acceptance limits, the general inorganic acceptance limits provided in the USEPA *Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review* will be used (USEPA 2010). Detailed data validation procedures for the RVM are presented in the QAPP (Appendix B).

Section 6

Reporting

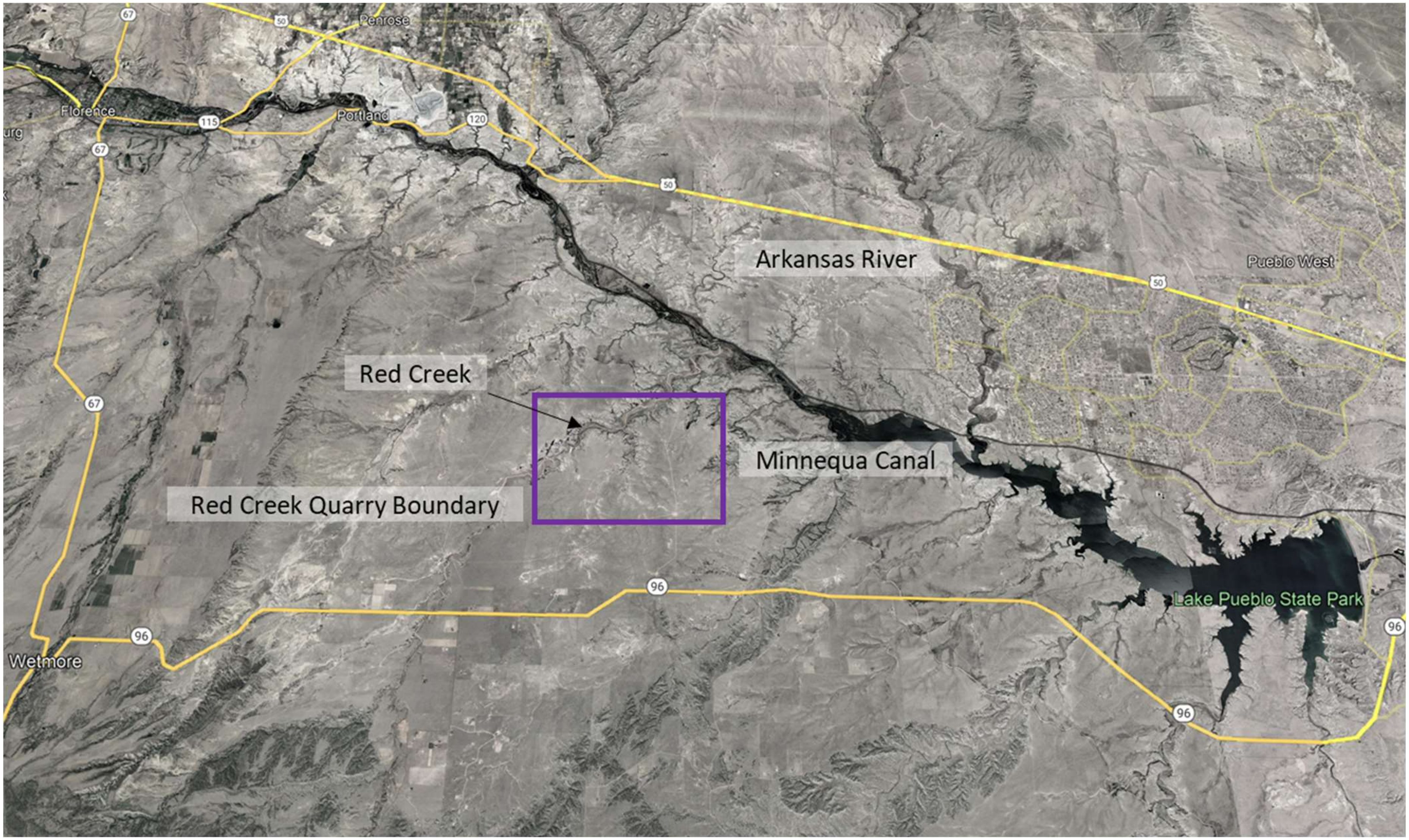
Background conditions for surface and groundwater quality un-impacted by mining are required for the DRMS permit. Reports documenting activities performed under this plan will be prepared and submitted to the Holcim for review and approval. Monitoring reports will be prepared after each sampling event to summarize baseline water resources data collection. The Monitoring Event Summary Report will include sections describing: the methodology used to collect the data, water quality monitoring results, and water quality data validation. Possible data gaps, anomalous or unexpected data, and unexpected changes in site conditions for groundwater and/or surface water will also be discussed.

Section 7

References

United States Environmental Protection Agency. 2010. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review. EPA 540-R-10-011.

Figures



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Red Creek Quarry
Sampling and Analysis Plan

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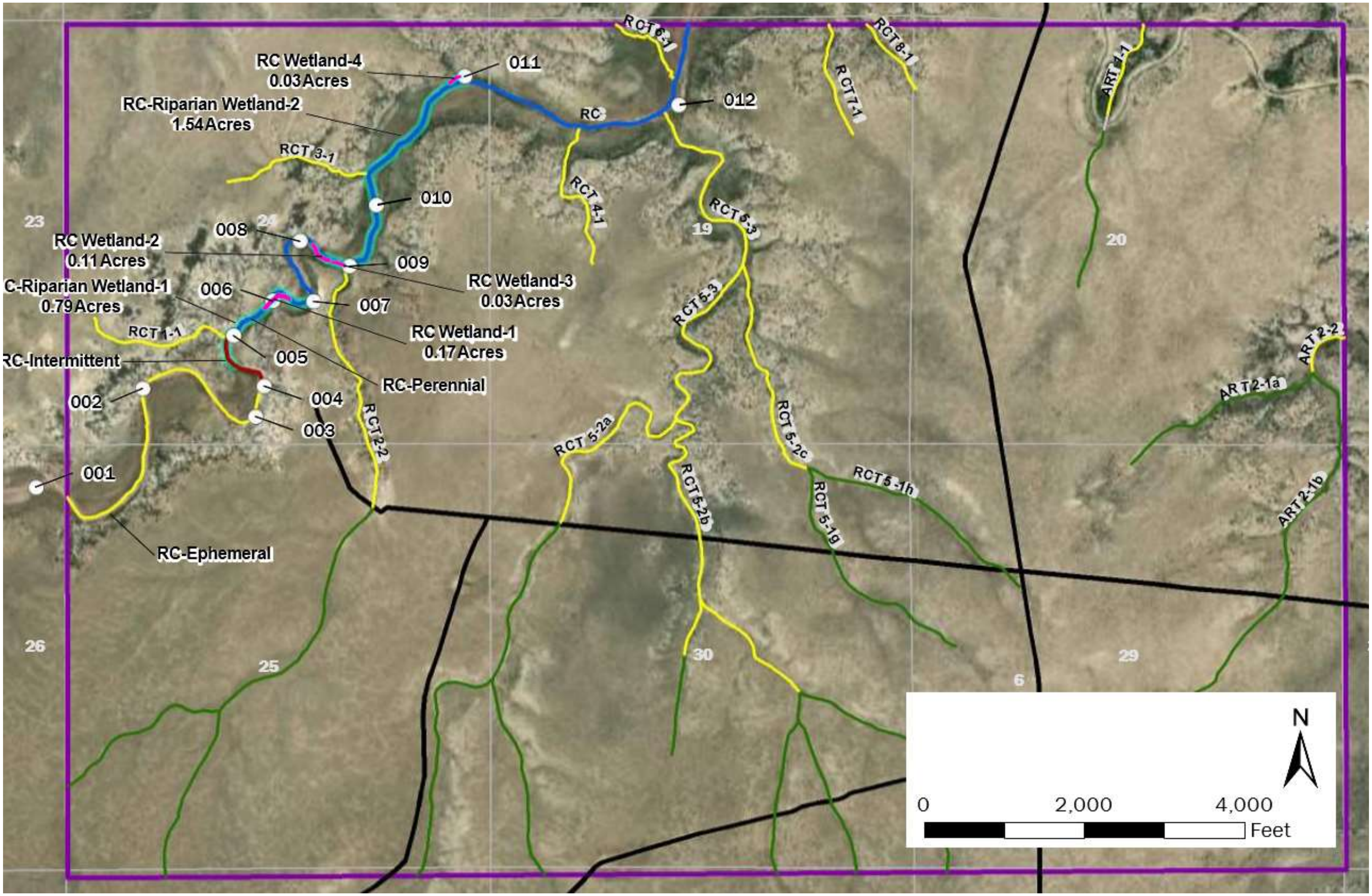
Figure 1
Site Vicinity Map



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Legend

○ Field Recon Locations

Stream Category

Ephemeral

Intermittent

Perennial

Pipeline

Upland / Not Jurisdictional

Clevenger Parcel Boundary

PLSS Section Line

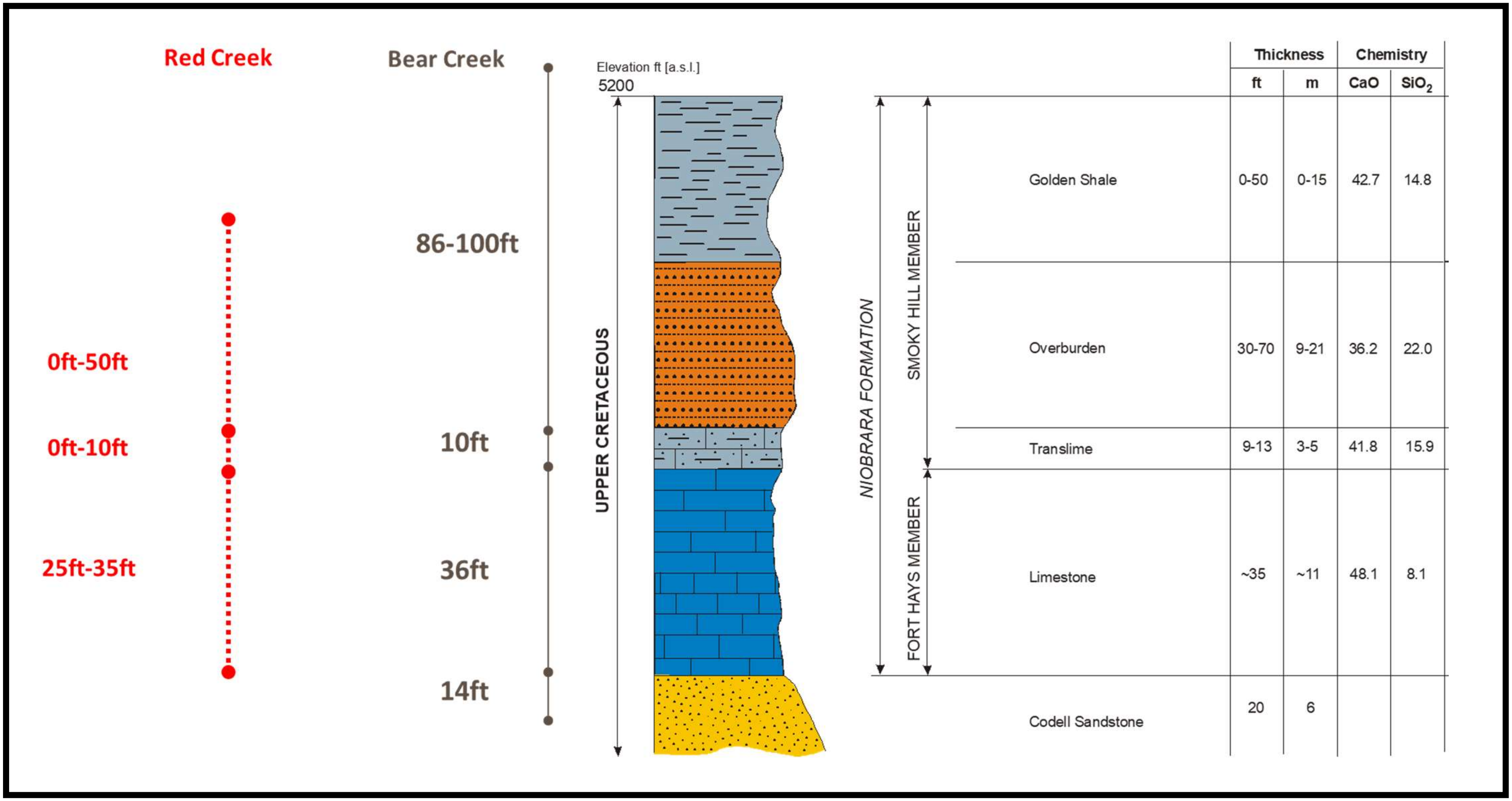
Wetlands

Riparian Wetlands

Road *

** Road is the approximate location of breakpoint between Ephemeral and Upland areas*

Figure 2
Surface Water Categories



	Thickness		Chemistry	
	ft	m	CaO	SiO_2
Golden Shale	0-50	0-15	42.7	14.8
Overburden	30-70	9-21	36.2	22.0
Translime	9-13	3-5	41.8	15.9
Limestone	~35	~11	48.1	8.1
Codell Sandstone	20	6		

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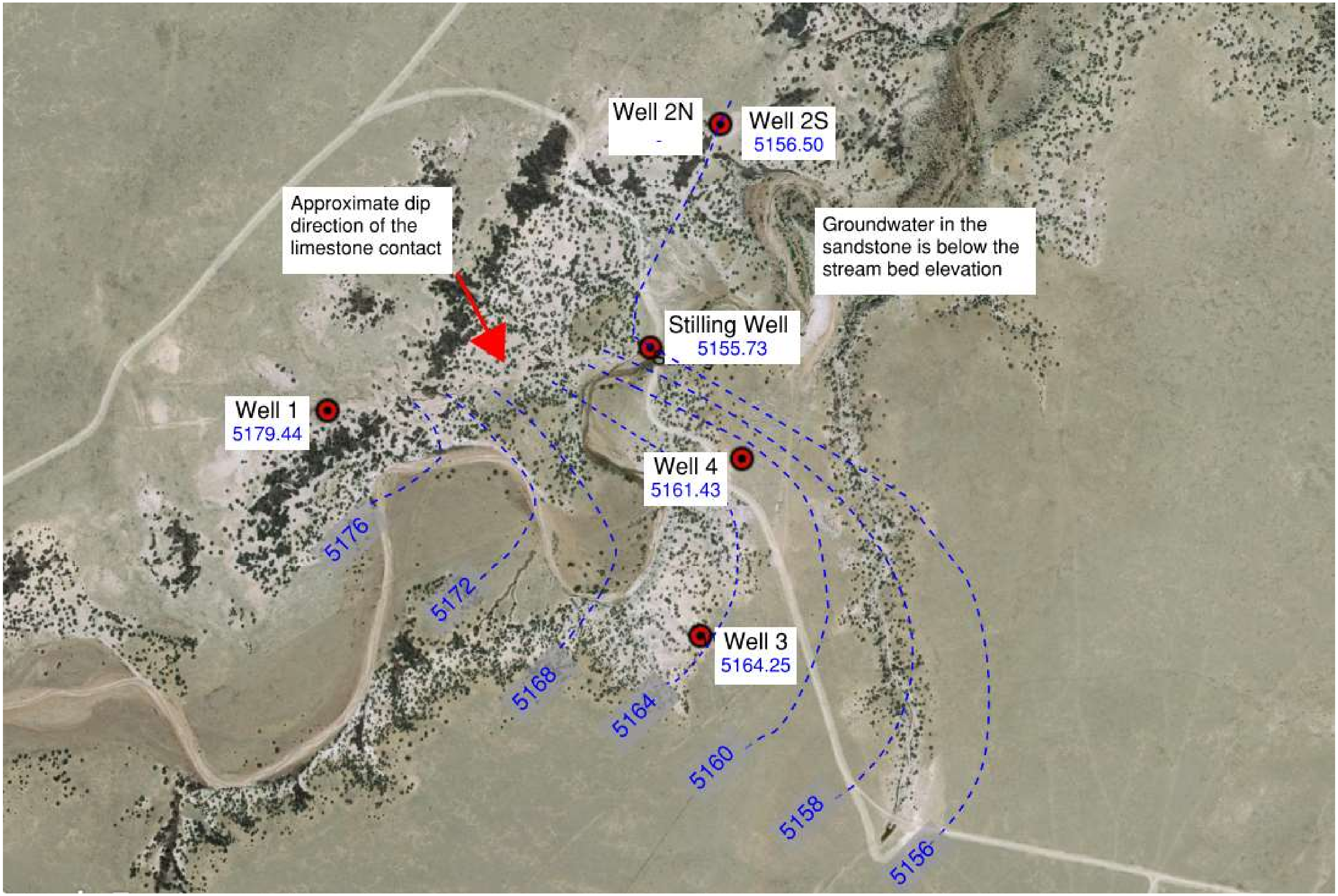
Date: June 2022
Project: 153625

Figure 3
Generalized Stratigraphic Column



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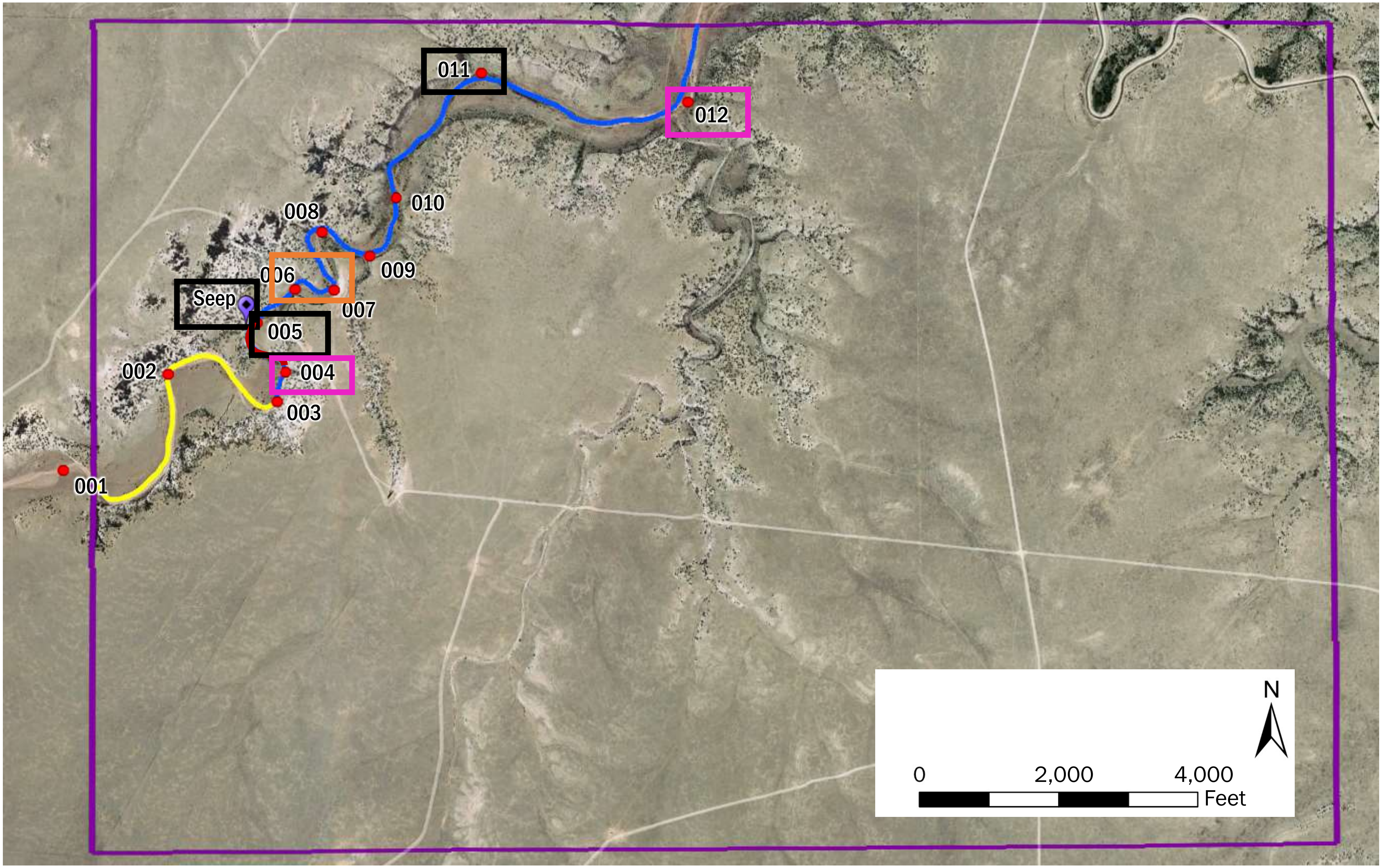
Project: 153625

Figure 4
Groundwater Contours and Well Locations



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Sampling and Analysis Plan

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Project: 153625

Figure 5
Surface Water Monitoring and Observation Locations

Appendix A: Analyte Lists

Appendix A - Analyte Lists

Analyte	Fraction Analyzed at RCQ	Method	Method Detection Limit (mg/l)	Colorado Water Quality Regulatiuons		
				WQCC Groundwater Regulation 41	WQCC Surface Water Regulation 32	CO0000671 Discharge Permit for 011A Outfall
Biological						
Total Coliforms	X				X	
E Coli	X			X		
Inorganic						
Alkalinity (Total, HCO3, CO3)	X	SM2320 B	2			
Asbestos	X				X	
Calcium	X	200.7	0.053			
Chloride	Dissolved	E300.0	0.4	Dissolved	Dissolved	
Chlorine	Dissolved	SM4500-Cl G	0.05	Dissolved		
Cyanide WAD	X	LACHAT	0.003			X
Cyanide [Free]	Dissolved			Dissolved		
Fluoride	X	E300.0	0.05		Dissolved	
Magnesium	X	200.8	0.025			
Nitrate	Dissolved	E300.0	0.006	Dissolved	Dissolved	
Nitrite	Dissolved	E300.0	0.003	Dissolved	Dissolved	
Total Nitrate+Nitrite	X				Dissolved	
Phosphorus	Dissolved	E365.1	0.008	Dissolved		
Potassium	X	200.8	0.05			
Sodium	X	200.7	0.051			
Sulfate	Dissolved	E300.0	0.4	Dissolved	Dissolved	
Sulfide	Dissolved	SM4500-S2	0.35	Dissolved		
Metals and Metalloids						
Aluminum	Total and Dissolved	200.8	0.02		Dissolved	Total
Antimony	Total and Dissolved	200.8	0.0001		Dissolved	
Arsenic	Total and Dissolved	200.8	0.0005	Total and Dissolved	Dissolved	Total and Dissolved
Barium	Total and Dissolved	200.7	0.002		Dissolved	
Beryllium	Total and Dissolved	200.7	0.0013		Dissolved	Total
Boron	Total and Dissolved	200.7	0.0074	Dissolved		Total
Cadmium	Total and Dissolved	200.8	0.00005	Dissolved	Dissolved	
Chromium	Total and Dissolved	200.8	0.0005		Dissolved	
Chromium +3	Total and Dissolved			Total and Dissolved		Total and Dissolved
Chromium +6	Total and Dissolved	SM3500-CR B	0.009			Total and Dissolved
Cobalt	Total and Dissolved	200.7	0.0023		Dissolved	
Copper	Total and Dissolved	200.7	0.0023	Dissolved	Dissolved	Total and Dissolved
Iron	Total and Dissolved	200.7	0.0031	Total	Dissolved	Total
Lead	Total and Dissolved	200.8	0.00013	Dissolved	Dissolved	Total and Dissolved
Lithium	Total and Dissolved				Dissolved	

Appendix A - Analyte Lists

Analyte	Fraction Analyzed at RCQ	Method	Method Detection Limit (mg/l)	Colorado Water Quality Regulatiuons		
				WQCC Groundwater Regulation 41	WQCC Surface Water Regulation 32	CO0000671 Discharge Permit for 011A Outfall
Manganese	Total and Dissolved	200.8	0.0004	Dissolved	Dissolved	Dissolved
Mercury	Total and Dissolved	245.1		Total and Dissolved	Dissolved	Total
Molybdenum	Total and Dissolved	200.8	0.00025	Total and Dissolved	Dissolved	
Nickel	Total and Dissolved	200.8	0.001	Dissolved	Dissolved	Total and Dissolved
Selenium	Total and Dissolved	200.8	0.0003	Dissolved	Dissolved	Total and Dissolved
Silver	Total and Dissolved	200.8	0.000025	Dissolved	Dissolved	Dissolved
Thallium	Total and Dissolved	200.8	0.00005		Dissolved	
Uranium	Total and Dissolved	200.8	0.00005	Dissolved	Dissolved	Total and Dissolved
Vanadium	Total and Dissolved	200.7	0.0007		Dissolved	
Zinc	Total and Dissolved	200.8	0.0025	Dissolved	Dissolved	Total and Dissolved
Radiological						
Gross Alpha Particle Activity	X				X	
Beta and Photon Emitters	X				X	
Radium 226 + 228	X					X
Other						
Ammonia	X	SM4500-NH3 D	0.04	X		
Chlorophyll	X			X		
Chlorophenol	X				X	
Color	X	SM2120B	2		X	
Corrosivity	X				X	
Foaming Agents	X				X	
Odor	X				X	
Phenol	X	E420.4	0.015		X	
Oil and grease	X	E1664A	3			X
TDS	X	SM2540C	5		X	
TSS	X	SM2450D	2.5			X
pH	X				X	

Note: "X" indicates the analyte is measured for the non-filtered water fraction

Appendix B: QAPP

FINAL

Quality Assurance Project Plan
Red Creek Quarry Monitoring Program

Prepared for
HolcimUS
October 2022

FINAL

Quality Assurance Project Plan
Red Creek Quarry Monitoring Program

Prepared for

HolcimUS

October 2022

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Table of Contents

1. Overview 1-1
2. Project Organization 2-1
    2.1 Project Manager 2-1
    2.2 QAO. 2-2
    2.3 Data Manager 2-2
3. Training, Certification, and Documentation Requirements 3-1
    3.1 Training Requirements 3-1
    3.2 Laboratory Certification 3-1
    3.3 Documents and Records 3-1
        3.3.1 Project Documents, Records, and Electronic Files 3-1
        3.3.2 Electronic File/Database 3-2
        3.3.3 Revisions to SAP, SOPs, and QAPP 3-2
4. DQOs and Criteria 4-1
    4.1 Accuracy 4-2
    4.2 Precision 4-2
    4.3 Data Representativeness 4-3
    4.4 Data Comparability 4-3
    4.5 Data Completeness 4-3
5. Data Generation and Acquisition 5-1
    5.1 Sampling Methods 5-1
    5.2 Sample Handling and Custody 5-1
    5.3 Analytical Methods 5-2
    5.4 Quality Control 5-2
        5.4.1 Field QC Checks 5-2
        5.4.2 Laboratory QC Checks 5-3
        5.4.3 Data Analysis QC Checks 5-4
6. Instrument and Equipment Testing, Inspection, and Maintenance 6-1
    6.1 Field Equipment 6-1
    6.2 Laboratory Equipment 6-2
7. Instrument/Equipment Calibration and Frequency 7-1
    7.1 Water Quality Field Instruments 7-1
    7.2 Laboratory Instruments 7-1
8. Inspection/Acceptance of Supplies and Consumables 8-1
9. Data Management 9-1
    9.1 Data Reduction 9-1
    9.2 Field Data 9-1

9.3 Analytical Data 9-1
9.4 Database Maintenance 9-1
9.5 Data Submittal 9-2
10. Assessment and Oversight 10-1
10.1 Assessments and Response Actions 10-1
10.2 Laboratory Assessment and Oversight 10-1
11. Data Validation and Usability 11-1
11.1 Data Review, Verification, and Validation Requirements 11-1
11.2 Verification and Validation Methods 11-1
11.3 Reconciliation with User Requirements 11-2
12. References 12-1
Appendix A: Laboratory QA Manual .... A
Appendix B: Data Validation Procedures .... B

List of Tables

Table 2-1. Key Project Personnel and Contact Information 2-1
Table 4-1. DQO Process 4-1
Table 7-1. Field Instrument Calibration and Frequency 7-1

List of Abbreviations

°C	degrees Celsius
COC	chain-of-custody
DO	dissolved oxygen
DQO	data quality objectives
EQuiS	Environmental Quality Information System
Holcim	HolcimUS
LCS	lab control sample
MS	matrix spike
MSD	matrix spike duplicate
NELAC	National Environmental Laboratory Accreditation Conference
NTU	nephelometric turbidity unit
ORP	oxidation-reduction potential
PM	project manager
QA/QC	quality assurance/quality control
QAO	quality assurance officer
QAPP	Quality Assurance Project Plan
RCQ	Red Creek Quarry
RPD	relative percent difference
SC	specific conductance
SAP	Sampling and Analysis Plan
SOP	standard operating procedure
USEPA	United States Environmental Protection Agency

Section 1

Overview

The primary objective of the surface water and groundwater monitoring program is designed to collect data to assess potential water resource impacts from mining operations conducted at the proposed HolcimUS (Holcim) Red Creek Quarry (RCQ). Additionally, the RCQ baseline Sampling and Analysis Plan (SAP) is designed to document the characteristics of surface water and groundwater prior to any mining to assist in evaluation of the RCQ permit applications.

This Quality Assurance Project Plan (QAPP) describes quality assurance/quality control (QA/QC) procedures that will be followed during implementation of the surface water and groundwater data collection. QA is a management function and refers to the systematic planning of procedures, methods, and standards to ensure that data generated by the testing program are suitable for their intended use. QC is process-oriented and focuses on error identification and verification that data meet the established standards. The following topics are covered in this QAPP:

- Project management and communication
- Training, certification, and documentation requirements
- Data quality objectives (DQOs) and standards
- Laboratory testing and analytical methods
- QC procedures for data generation and data management
- Program assessment and oversight
- Data validation and usability

The standards contained herein will be used for verification and validation of data generated by field personnel and laboratory subcontractors. The QAPP is intended to serve as a guide to field personnel and laboratory subcontractors for QC activities during the monitoring and reporting phases of this project. Specific details for sampling and analyses are provided in the RCQ Baseline Monitoring SAP and Standard Operating Procedures (SOPs). These documents along with this QAPP, provide a complete description of the monitoring programs that will be implemented during the project.

Section 2

Project Organization

Fieldwork, data validation, and reporting for the program will be performed by Holcim its contractors. The Project Manager (PM) and QA Officer (QAO) provide important QA/QC functions related to the generation, analysis, and reporting of data from the program. The management and QA/QC functions for the PM and QAO are described below. Overall project organization is presented in Table 2-1.

Table 2-1. Key Project Personnel and Contact Information

Organization	Role	Name	Contact Information
Holcim	Project Operations Manager/Permitting Manager	Michael Toelle	Manager Raw Materials and Quarries Holcim CIP-NA
Brown and Caldwell	PM	Paul Dupre	Direct: (303)239-5454 Mobile: (303) 909-0551 pdupre@brwncald.com
	Data Manager	Steve Dentico	Direct: (201)574-4731 Mobile: (201) 841-1677 sdentico@brwncald.com
	QAO	Jaclyn Lauer	Direct: (770) 673-3641 Mobile: (317) 408-8340 jlauer@brwncald.com
SGS National Laboratories	Laboratory PM	Parna Eskandari Payandeh	Phone: 303-425-6021 Parna.EskandariPayandeh@sgs.com

Descriptions of the key responsibilities for the Permit Operations Manager, Permitting Manager, Laboratory PM, and Laboratory Quality Manager are provided in Section 2 of the SOPs. Key responsibilities for the PM, Data Manager, and QAO are provided in the following sections.

2.1 Project Manager

The PM is responsible for technical content of the work, oversight of data generation activities, and schedule. The PM will implement the monitoring programs and has the authority to commit the necessary resources to meet the monitoring objectives. Specifically, the PM will do the following:

- Establish policy and procedures for the program including DQO specification, protocol testing, analytical methods, QC standards, and data validation procedures.
- Monitor and direct field sampling activities and analytical work performed by the analytical laboratory.
- Establish that project personnel have reviewed the POSs and SOPs, including the QAPP, SOPs, and Health and Safety Plan; are properly trained; and follow established policies and procedures.
- Review testing and analytical results so that they fulfill DQOs established in the SAP and QAPP.

- Oversee monitoring results report preparation.

The Monitoring Lead will assist the PM with the tasks listed above as well as provide oversight and direction for the sampling events. The Monitoring Lead will be responsible for directing the completion of data analysis and evaluation, data validation/verification, and completion of quarterly summary progress reports and annual reporting.

2.2 QAO

The QAO will provide independent QA oversight for the monitoring work. The QAO will provide data validation but not participate in data acquisition activities. The QAO will monitor the program so that QA/QC procedures described in the SOPs and QAPP are fully implemented and that DQOs are met. Specifically, the QAO will do the following:

- Provide independent QA oversight for the monitoring program as a whole.
- Review field books, data sheets, chain-of-custody (COC) forms, and laboratory analytical reports to determine whether data meet SAP and QAPP requirements.
- Assess analytical data to determine whether the data meet measurement quality objectives specified in the QAPP.
- Qualify data according to procedures contained in the QAPP.
- Prepare periodic data validation records to summarize the results of the data review and validation.
- Report data quality issues, QC failures, and non-conformance with established standards to the PM.
- Help identify corrective actions to be taken in the event of QC failures or non-conformance with protocols and standards specified in the SAP and QAPP.
- Maintain an accurate and complete database of analytical and hydrologic data generated during the monitoring program.

2.3 Data Manager

The Data Manager will compile all data related to the project in an Environmental Quality Information System (EQuiS) database which will be utilized to provide data entry, secure storage, access, and evaluation capabilities of data obtained during the monitoring efforts. The Data Manager will design report exports to automatically calculate surface water and groundwater standards, to provide timely review of analytical data against regulatory standards. The Data Manager will also facilitate production of tables and figures using direct exports from the EQuIS database. This role includes coordination with data validators, providing electronic data deliverables to validators to increase efficiency and capture of validation qualifiers in preparation of data validation/data usability reports.

Section 3

Training, Certification, and Documentation Requirements

The requirements for training, certification, and documentation for the Project are summarized in sections below.

3.1 Training Requirements

Field personnel who participate in data collection activities for the Project will review the SOPs and QAPP and will receive instruction from the PM about proper sampling procedures. Personnel will be trained prior to their initial entry to the field and biannually thereafter. Training topics will include proper sampling and monitoring techniques, instrument calibration, QA/QC procedures, field notes and documentation, and sample shipment to the analytical laboratory.

3.2 Laboratory Certification

Certification by the National Environmental Laboratory Accreditation Conference (NELAC) is required for laboratories providing analytical services for the Project. Documentation of NELAC certification and the contracted laboratory's QA manual are provided in Attachment A. If the laboratory changes, Attachment A will be revised to include the NELAC certification of the new laboratory and the laboratory's QA manual. The laboratory PM will be provided with a copy of the SOPs and QAPP and is responsible for ensuring that all analyses comply with the specified analytical methods, testing protocols, and standards.

3.3 Documents and Records

Project-related documents and recordkeeping are described in the following sections.

3.3.1 Project Documents, Records, and Electronic Files

Primary documents and records that will be generated during the Project include the following:

- **SAP.** The RCQ Baseline Surface Water and Groundwater SAP, of which this QAPP is an Appendix, provides detailed information on the data collection objectives, types of data to be collected, and data collection methods.
- **QAPP.** The QAPP (this document) contains detailed information about QA/QC procedures and DQOs for the Project. Revisions to the QAPP will be documented in writing and attached as addenda to this document to provide a permanent record of the change.
- **Field Records.** Field records generated during the sampling and monitoring activities will include field books, field data sheets, instrument maintenance and calibration records, COC forms, and shipping receipts. Field records will be prepared and maintained in the project files and will be made available for review at the request of the Agencies.
- **Laboratory Records.** In addition to analytical results, the laboratory will maintain sample receipt and storage documentation, instrument calibration logs, raw data, and QC sample records for the project. The records will be available for review at the request of the Agencies.

- **Data Validation Records.** Field data sheets, field QC results, COC forms, and laboratory reports from each sampling event will be reviewed by the QAO, and a data validation record will be generated that summarizes the quality of the collected data. Data validation records will be included as attachments in the monitoring reports.
- **Retention of project documentation:** Documents, field records, laboratory records, and logbooks generated during implementation of the Project will be maintained as part of the project record for a minimum of five years after the close of the Project.

3.3.2 Electronic File/Database

Information generated by monitoring will be compiled in a Microsoft Access-compatible database (e.g., EQuiS). The annual report will include a summary of data collected the prior year including discussion and available validated water quality data from sampling points in an electronic, easily editable format such as Excel or Access files.

3.3.3 Revisions to SAP, SOPs, and QAPP

Revisions to the SAP, SOPs, and QAPP will be updated as changes occur in the sampling program. Changes to the SAP and QAPP will be documented as written addenda to the original documents and/or incorporated into revised documents, as appropriate. The PM will be responsible for ensuring that revisions to the SAP, SOPs, and QAPP are distributed to project personnel as appropriate.

Section 4

DQOs and Criteria

DQOs are qualitative and quantitative statements that are intended to clarify the study objectives, define the data to be collected, determine the appropriate conditions for data collection, and specify the quantity and quality of the data needed to support the decision-making process. The DQO process outlined by the United States Environmental Protection Agency (USEPA) consists of seven iterative steps that are identified in Table 4-1. Table 4-1 defines the DQO steps for the Project and references what section of the SAP each step is addressed.

Table 4-1. DQO Process

DQO Step	RCQ	Section Addressed
Step 1: State the Problem	Ground disturbing activities, such as mining, have the potential to have an adverse impact on surface and groundwater quality.	-
Step 2: Identify the Goal of the Study	The goal of the Project is to characterize baseline water quality and hydrologic conditions prior to Project development.	Section 1 of the RCQ Baseline Surface Water and Groundwater SAP.
Step 3: Identify Information Inputs	The SAP describes the types of baseline data to be collected to assist in the evaluation of the RQC mining operations for permit applications.	Sections 3 through 4 of the SAP.
Step 4: Define the Boundaries of the Study	The study area consists of USGS Sections 24 and 25, T20S, R68W in Freemont County and Section 19, 20, 29 and 30, T20S, R67W in Pueblo County.	Figure 1 of the SAP.
Step 5: Develop the Analytic Approach	The suite of analyses to be conducted were developed to document the characteristics of surface water and groundwater prior to any mining.	Sections 3 through 4 of the SAP.
Step 6. Specify Performance or Acceptance Criteria	Sample performance and acceptance criteria are based on regulatory guidance and industry accepted sampling practices.	Performance and acceptance criteria are identified in the QAPP and specific SOPs
Step 7: Develop the Plan for Obtaining Data	The SAP and SOPs describe the overall sampling to be implemented.	The plan for obtaining data is described in the project Work Plan

The objective of QA/QC is to obtain analytical results from sample analyses that are representative of actual chemical and physical composition of the media sampled. Field QA/QC will consist of following standard protocols for sample collection and collecting and analyzing sample duplicates and field blanks. The duplicates are used to determine both field and laboratory precision. The field blank is used to check the integrity of sample collection and handling. Both the duplicate and field blank samples are stored and handled in the same manner as the normal samples.

The DQOs will be fulfilled by implementing the following QA/QC activities during data collection:

- Collection of field data and water quality samples according to the sampling design specified in the SAP and the medium-specific SOPs.
- Adherence to the SOPs for field measurements, sampling, sample handling, and sample COCs.
- Analysis of samples in accordance with standard method protocols specified in the SOPs.
- Adherence to data validation procedures specified in Attachment B of this QAPP.
- Implementation of training, quality auditing, and corrective/preventative action processes described in this QAPP.

The analytical data support level for the Project is as follows:

- Field screening data (i.e., field measurements of pH, water temperature, specific conductance [SC], dissolved oxygen [DO], and turbidity) will be at data quality Level I. Level I refers to field screening using portable instruments that are generally not compound specific or very quantitative.
- Laboratory analytical data will be at Level II. Level II refers to standard USEPA-approved methods with data reviewed by standard QA protocols.

Data quality indicators, including analytical accuracy, precision, representativeness, comparability, and completeness, are the principal metrics used to assess data quality. Data quality indicators for the Project are described in the following sections.

4.1 Accuracy

Accuracy is a measure of the agreement between a “true” or reference value and the associated measured value and is based on reported recoveries from the laboratory. The recoveries of lab control samples (LCSs) and matrix spike (MS) samples will be used to evaluate the accuracy of the measurements. Laboratory accuracy for each analysis is determined through statistical analysis of the laboratory equipment by the laboratory; the acceptable accuracy range for the laboratory equipment is typically 70 to 130 percent; however, laboratory method SOPs may deviate slightly from this range. Final recovery ranges are reported on each laboratory report for each parameter. Any outliers from the acceptable range in percent recovery, as determined by the laboratory, will be flagged by the laboratory.

4.2 Precision

Precision is a measure of agreement between two measurements of the same property under prescribed conditions. Sampling events may include duplicate samples (field replicates or split samples) or may rely on LCS split sample results. The relative percent difference (RPD) of duplicate samples will be used to assess data precision.

Precision will be based on field, LCS, and, if used, MS duplicates (MSD). The acceptable RPD range for the laboratory equipment will be indicated in the laboratory sheets. Field duplicate RPD goals are identified in the medium-specific SOPs. Appropriate measurement range is determined by reviewing results in comparison to the laboratory practical quantitation limits or method detection limits. Reporting requirements are determined prior to sampling through a review of historical data for the analytes and region of interest and reflected in the choice of analytical laboratories, analysis methods, and requested reporting levels or method detection limits.

4.3 Data Representativeness

Representativeness is the degree to which the sample data accurately and precisely represent site conditions. The representativeness criterion is best satisfied by confirming that sampling locations are properly selected, a sufficient number of samples are collected, sample collection procedures are appropriate and consistently followed, and analytical results meet DQOs. The monitoring programs described in the SAP have been designed to provide data that are representative of the sampling media and a sufficient number of samples to meet the project DQOs. Sampling procedures will follow the sampling procedures in the project-specific SOPs.

Representativeness is evaluated during data review, verification, validation, and reconciliation efforts by comparing the combination of data accuracy, precision, measurement range, and methods and assessing other potential sources of bias, including sample holding times, reported results of blank samples, and laboratory QA review.

4.4 Data Comparability

Comparability is the confidence with which one data set can be compared to another data set. Use of standard sampling and analytical procedures will maximize comparability. For data comparability, sample collection procedures will be consistently followed, the same analytical procedures will be used, and the same laboratory, which is certified by NELAC, will be used to analyze the samples.

4.5 Data Completeness

Completeness is calculated by subtracting the number of rejected and unreported results from the total planned results and dividing by the total number of planned results, expressed as a percentage.

Estimated results do not count against completeness because they are considered to be usable as long as limitations are identified. Results rejected because of out-of-control analytical conditions, matrix effects, broken or spilled samples, or samples that could not be analyzed for other reasons are subtracted from the total planned number of results. A completeness goal of 90 percent or greater is established for the Project. If a sampling event does not meet the completeness goal, the data will be discussed with the program manager and a course of action will be agreed upon. Any required departure from this goal will be justified and explained in the project records.

Section 5

Data Generation and Acquisition

This section provides sampling and analytical methods, handling and custody, and associated QC.

5.1 Sampling Methods

Proper sample collection procedures are essential so that representative and reliable data are collected. Samples will be collected in accordance with the SAP, this QAPP and SOPs. The QA/QC procedures will be fulfilled by adhering to the requirements detailed in this QAPP and the SOPs, and adherence will be demonstrated through appropriate documentation of sampling procedures within the field logbook and field sheets as described herein. Field audits by the QAO may also be part of QA/QC procedures.

The following general procedures will be followed during sample collection:

- Water quality samples will be collected into laboratory-supplied sampling containers. Refer to Table 6-1 of the SOPs for information regarding containers, preservatives, hold times, and temperature requirements for the various analytical methods.
- Samples will be collected using the specified equipment and methods necessary to obtain a sample that is representative of the desired medium at the given sampling station.
- Field QO samples, including equipment blanks, field blanks, duplicates and site-specific MS samples, will be collected for aqueous samples.
- Samples will be handled carefully to minimize exposure to external influences such as wind, dust, or rain.
- Sample bottles will be labeled with a minimum of date, time of collection, sample identification, preservative information, filtered or unfiltered, and the sampler's initials.
- Sampling date and time and the sampler's initials will be added to the COC form immediately after sampling.
- If problems occur during sampling, the QAO will be notified. The source of the problem will be identified, and the appropriate corrective action taken. These incidents will be documented in the monitoring reports, the project folder, and filed with the appropriate data package. If the problem compromises the quality of collected data, the data will be flagged within the database.

5.2 Sample Handling and Custody

Once sample containers have been filled, they will be labeled, placed in re-sealable plastic bags, and stored in a cooler on ice to maintain a temperature below 6 degrees Celsius (°C) and above freezing (0°C). Soil samples do not require preservation with ice.

Identification information for each sample will be recorded on the appropriate field data sheet at the time of sample collection. COC forms are to be completed immediately after sample collection and before the samples are released to another individual or organization.

The samples shall be transported or shipped to the analytical laboratory in insulated containers to arrive within the appropriate holding time and temperature for the specified analyses and will be accompanied by a COC form that identifies the sample bottles, date and time of sample collection, and analyses requested. If shipment is needed, the samples will be packaged with custody seals and shipped in accordance with United States Department of Transportation standards.

The original COC form will be given to the laboratory with the samples, and the monitoring contractor will retain a copy in the project files. Once received by the laboratory, a sample receipt and storage record will be generated. Refer to the SOPs in the SAP for more information, including a sample COC form.

5.3 Analytical Methods

Samples for groundwater quality analysis will be collected and submitted to SGS National Labs or another qualified, certified laboratory. Sample containers, labels, and preservatives will be obtained from the analytical laboratory, laboratory supplier, or laboratory equipment provider. Samples must be preserved and analyzed within the holding times. The laboratory will be notified by the PM prior to sample shipment so that the holding time is not exceeded. Sample collection and preparation instructions provided by the analytical laboratory will be followed throughout the duration of each project.

Field measurements will be conducted using portable meters and field test kits that employ USEPA-approved methods. Field measurements in surface water will include measurement of instantaneous discharge, temperature, pH, SC, oxidation-reduction potential (ORP), DO, and turbidity. Field measurements in groundwater will include depth-to-water, temperature, pH, DO, ORP, SC, and turbidity. Measurements will follow procedures recommended by the manufacturer of the meter or test kit and procedures discussed in the groundwater sampling SOP. Results of field measurements will be recorded in bound field logbooks, electronically (using tablets), or on field data sheets.

The required analytical QC procedures are outlined in Section 5.4.2. The QAO will be responsible for ensuring that laboratory QC is performed in accordance with the specified method and the procedures contained in this QAPP.

5.4 Quality Control

QC is a means of measuring or estimating the potential variability involved with sample collection, analysis, or measurement activities, both in the field and in the laboratory.

5.4.1 Field QC Checks

QC for field measurements will be assessed using the following methods:

- Field instruments will be inspected, maintained, and calibrated prior to each sampling event.
- A calibration check will be performed to verify accuracy at the beginning of each sampling day by analyzing a calibration standard.
- A drift check will be performed at the end of each sampling day; mid-day drift checks will be performed if instruments are not performing normally or are subjected to adverse conditions.
- If a mid-day drift check indicates that a parameter reading is outside of acceptable performance limits, a recalibration of that parameter will be performed.
- If a drift check indicates that the instrument is outside of acceptable performance limits, field staff will qualify the field data collected prior to the drift check.
- Results of the QC tests will be recorded on a field data sheet.

Field QC samples sent to the laboratory will include duplicates and blanks that will be submitted blind (not identified with the parent sample) for analysis. Field duplicates will be collected at a frequency of at least one per sampling event. Equipment blanks will be collected at a frequency of once per sampling event for each time equipment that requires decontamination is used. Submission of QC samples will be scheduled so that field QC sample frequency is met for each medium-specific sampling event. Other field blanks may be specified by the PM on an as-needed basis.

5.4.1.1 Duplicates

Duplicate samples are two samples collected from the same location, representing the same sampling event, and carried through assessment and analytical procedures in an identical manner. Duplicates can be “replicates” (samples taken one immediately after the other, separated only by the actual time required to fill the sample container) or “splits” (subsamples drawn from the same initial volume of matrix). Relevant information will be recorded for the duplicates, just like the normal samples, in the field logbook, or field data sheet. Results from the field duplicate analysis will be included in the analytical report.

5.4.1.2 Equipment Blanks

A blank is a sample of known matrix where the specific constituents requested for analysis are known to be absent or are present at concentrations less than the laboratory minimum limit of detection.

Equipment blanks consist of blank sample matrix passed through or over non-dedicated sampling equipment to check the decontamination process between samples or sample sites. Equipment blanks may be collected when sampling equipment requiring decontamination (e.g., portable pumps and sampling manifolds) are carried from location to location. When collected, equipment blanks will also be submitted blind for analysis.

5.4.2 Laboratory QC Checks

Laboratory QC checks are routinely performed as part of the analytical process and include internal checks for sample analysis activities. The frequency and type of QC samples are often analytical method dependent. The laboratory will report any variance from laboratory-assigned QC limits impacting the quality of sample results and may report details of internal laboratory QC if requested. Laboratory QC checks include the types of samples described below.

5.4.2.1 Method Blank Samples

Method blank samples are used to assess laboratory contamination during all stages of sample preparation and analysis. Method blank samples will be prepared by the laboratory using reagent-grade water and are carried through the entire preparation and analytical process. The laboratory will analyze method blank samples at a frequency of one sample for each batch of up to 20 samples.

5.4.2.2 Laboratory Control Samples

LCSs are multi-element matrix-specific standards with known analyte concentrations that are carried through the entire preparation and analytical process. LCSs are used to confirm the method control, accuracy, and precision of analyses for constituents that are analyzed on a total concentration or total recoverable concentration basis. The laboratory will analyze LCSs at a frequency of one sample for each batch of up to 20 samples.

5.4.2.3 Calibration Verification Samples

Calibration verification samples are method standards with known concentrations used to assess analytical precision, accuracy, and stability of the instrument calibration. The laboratory will analyze calibration verification samples at a frequency of one sample for each batch of up to 10 samples and at the end of each workgroup.

5.4.2.4 MS Samples

MS samples will be used to evaluate the effect of the sample matrix on the recovery of constituents. An MS sample is a split of a submitted sample that is fortified with a spiking solution containing known concentrations of the target analytes. The fortified split is carried through the entire digestion and analytical process. Analyses for the MS are compared to the non-spiked split, and recovery of the target analytes is calculated using the equation discussed in Section 4.1. Recovery data for MS samples are used to determine the accuracy of the measurement and the prevalence of matrix effects. MS samples are also used in conjunction with MSD samples to evaluate analytical precision. The laboratory will analyze MS samples at a frequency of 1 sample for each batch of up to 20 samples.

5.4.2.5 MSD Samples

MSD samples are duplicate samples of MS samples that are used to assess matrix effects on analytical precision. Precision is evaluated by calculating the RPD for the MS and MSD pair. The laboratory will analyze MSD samples at a frequency of 1 sample for each batch of up to 20 samples.

5.4.2.6 Additional QA/QC Requirements

The analytical laboratory will have the appropriate facilities to store, prepare, and process samples and appropriate instrumentation and staff to provide data with the required quality within the period dictated by the project. The laboratory shall provide, upon request, information documenting its ability to conduct the analyses with the required level of data quality. Such information may include results from inter-laboratory performance evaluation studies, control charts, summary data from internal QA/QC checks, and results from analyses of certified reference materials.

5.4.3 Data Analysis QC Checks

The QC check data may be checked/reviewed for quality by the PM or the QAO at any time during the project and must be checked after the data are collected. Corrective actions, as needed, will be documented in the event that control limits are exceeded. Data qualifiers will be assigned following appropriate data verification/validation procedures.

Section 6

Instrument and Equipment Testing, Inspection, and Maintenance

The instruments and/or equipment used during the Project will be inspected and maintained according to the sections below.

6.1 Field Equipment

The following field measurement equipment may be used during the project:

- **Handheld multi-parameter meter (YSI ProDSS Multimeter or equivalent).** This meter is capable of measuring DO, temperature, pH, ORP, and electrical conductivity. The meter requires calibration before each sampling event and periodic maintenance per the manufacturer's recommendations.
- **Field turbidimeter (Hach Model 2100Q Portable Turbidimeter or equivalent).** This meter will be used to measure turbidity in the field. The meter employs a tungsten-filament light source and two light detectors to measure scattered (at 90°C) and transmitted light. The unit has a reported range of 0.01 to 1000 nephelometric turbidity units (NTU).
- **Velocity meter (Marsh-McBirney Flow Meter or equivalent).** This meter will be used to measure surface water discharge. The meter uses an electromagnetic sensor to measure the velocity in a conductive liquid such as water. The velocity is in one direction and displayed on a digital display as feet per second or meters per second.
- **Field monitoring equipment.** Inspection and preventive maintenance will be performed for applicable field equipment in accordance with the manufacturer's specifications prior to each sampling event. This maintenance includes battery checks, routine replacement of membranes, and cleaning of conductivity electrodes, among other tasks. Equipment will be re-inspected between each sampling site and after each sampling event. If problems occur and/or repair is needed during the sampling event, the field data sheet will be used to document the corrective action taken. If significant damage or equipment malfunctions are noted, the instrument(s) will be sent to the manufacturer for immediate repair.

A maintenance and calibration log will be kept by the monitoring coordinator or other designee that details the dates of instrument and sampling gear inspection, calibrations performed in the lab or field, battery replacement, reagent and standard replacement, and any problems noted with instruments, samplers, or reagents. The logbook will also be used to document corrective action that was taken if equipment deficiencies were noted during an inspection. A small inventory of critical spare parts for field equipment (DO membranes, o-rings, and temperature and conductivity probes) taken to the field if needed; however, perishable supplies or expensive parts may not be kept on hand and will need to be ordered when needed. Spare parts and supplies will be obtained through the equipment manufacturer or other reputable sources.

6.2 Laboratory Equipment

Laboratories providing support for the project will maintain analytical equipment in accordance with relevant SOPs, which include those specified by the manufacturer and those specified by the method. The laboratories will maintain a logbook documenting equipment inspections and preventive and corrective maintenance.

Section 7

Instrument/Equipment Calibration and Frequency

This section describes the calibration of field instruments used during the Project and those used by the laboratory.

7.1 Water Quality Field Instruments

Field instruments will be calibrated according to the schedule presented in Table 7-1. Standards will be purchased from a chemical supply company or prepared by (or with the assistance of) a commercial laboratory. Calibration records will be kept in the maintenance/calibration log in the project files where they can be accessed before and after equipment use. Calibrations performed by personnel in the field will also be recorded on the field data sheets to indicate which samples were analyzed pre- and post-calibration for the specific sampling event. If calibration is not successful or other issues pertaining to calibration arise, the instrument will not be used, and the equipment manufacturer will be contacted to determine the appropriate corrective action. The problem and corrective action will be documented in the maintenance/calibration logbook. Alternate instruments will be used until the malfunctioning instrument is fixed and calibration is successful. Calibration type and frequency are described in Table 7-1.

Table 7-1. Field Instrument Calibration and Frequency

Parameter	Calibration Frequency	Standard or Calibration Instrument Used
pH	Every sampling day	pH 7.0, 4.0, and 10.0 buffers
DO	Every sampling day	Water-saturated air, according to manufacturer's instructions and post-deployment check
SC	Every sampling day	Conductivity standard (1,413 microSiemens per centimeter) and distilled water
Turbidity	Every sampling day	20, 100, and 800 NTU solutions
ORP	Every sampling day	Zobell solution or equivalent

7.2 Laboratory Instruments

The analytical laboratory performs calibration practices and calibration checks as part of the method SOPs. The QAO shall review these practices and confirm that they comply with project requirements.

Section 8

Inspection/Acceptance of Supplies and Consumables

Project supplies and consumables that may directly or indirectly affect the quality of results include the following:

- SC, pH, ORP, DO, and turbidity standards
- Sample filters
- Miscellaneous supplies including batteries, DO membranes, o-rings, clean tubing, spare bottle sets, nitrile gloves, Liquinox® and deionized water for decontamination, ice, desiccant for transducers

The PM will check that the inspection/testing specifications and acceptance criteria are met. Upon receipt, buffer solutions, standards, reagents, and miscellaneous supplies will be inspected by the PM or other designee for leaks or broken seals, and the age of each reagent will be compared to the manufacturer's recommended shelf-life. Additionally, conductivity, pH, and turbidity standards will be checked by comparing their readings with those generated by the current lot of standards. Other sampling equipment will be inspected for broken or missing parts and will be tested to ensure proper operation.

Section 9

Data Management

Field and laboratory data for the RCQ project will be recorded in a project-specific Microsoft Access-compatible database (e.g., EQuiS). The data will be reviewed and qualified by the Database Manager prior to entry into the database.

9.1 Data Reduction

Data reduction includes the processes that change the numeric value of the raw data. Most field data will be generated by directly reading the instrumentation (i.e., no calibration curves are generated). Therefore, no data reduction will be performed for flow measurements, temperature, pH, DO, SC, ORP, or turbidity.

Laboratory data reduction will be performed in accordance with the specified analytical method and presented as analytical results. The laboratory data will be reviewed to verify that the appropriate units are assigned to all concentrations. Additionally, further data reduction may include graphing using spreadsheet or database software and preparing descriptive statistics.

9.2 Field Data

Field data will be documented per the applicable SOP either in a field logbook, electronically (e.g., tablet), or on field data sheets. Field staff will complete all relevant sections of the data sheet during the sampling event. Field data will be collected and uploaded to the project database.

9.3 Analytical Data

The laboratory will provide reports summarizing analytical results and QC results in both hard copy and electronic formats. Requirements for electronic data deliverables will be provided to the laboratory at the start of data collection and will include, at a minimum, the sample ID, sampling date/time, test method, extraction date/time, analysis date/time, analytical results, QA sample results, instrument and equipment calibration summary information, and a description of any corrective action taken to resolve data quality issues.

9.4 Database Maintenance

The Database Manager will be responsible for maintaining an accurate and complete project database. Analytical data reports will be verified, validated, and uploaded to the project database within 1 month of receipt from the laboratory.

9.5 Data Submittal

Records will be maintained in the monitoring contractor’s files to maintain the project record. Records to be maintained include the following:

- COC forms
- Discrepancy/deficiency reports
- Laboratory analytical reports
- Tabulated analytical results with supporting QC information

Section 10

Assessment and Oversight

Assessments conducted throughout the course of the Project will be implemented as outlined in the following sections.

10.1 Assessments and Response Actions

Periodic assessments will be conducted so that data are collected according to requirements presented in this QAPP. The QAO will have the primary responsibility for assessing compliance with the QAPP and SAP/SOP requirements pertaining to sample collection and handling procedures, field analytical procedures, and laboratory analytical procedures. In addition, the QAO is responsible for assessing compliance with the QAPP, SAP, and SOPs. The QAO will review field sampling and analysis procedures at the beginning of the project. Laboratory analyses will be continually assessed by evaluating the results of QC samples.

If an assessment reveals discrepancy in the methodology used to collect data or the analytical results, the QAO will discuss the discrepancy with the PM to determine if the data are accurate, the cause of the discrepancy, how the discrepancy impacts data quality, and the corrective action. The QAO will then follow up so that the corrective action is implemented, and data are qualified as needed.

The QAO has the power to stop sampling and analytical work by both sampling personnel and contract laboratories if the discrepancies noted are determined to be detrimental to data quality.

10.2 Laboratory Assessment and Oversight

Data quality will be evaluated based on sampling techniques and analytical QC. The laboratory is NELAC-certified; therefore, formalized audits of laboratory systems will not be performed as part of the Project. Informal audits of field work will be sufficient to ensure that SOPs are being followed. Performance of both field and laboratory QA systems will be assessed based on results of laboratory and field QC samples. A general evaluation of data quality will consider potential sources of error including gross errors, systematic errors, and random errors.

Section 11

Data Validation and Usability

Requirements for data validation and methodology are summarized in the following sections.

11.1 Data Review, Verification, and Validation Requirements

Data verification and validation are integral steps in the transition between data collection and data use and interpretation. The USEPA has developed a comprehensive guidance document titled Guidance on Environmental Data Verification and Data Validation (USEPA, 2002). The purpose of the document is to explain how to implement data verification and data validation, offer practical advice, and provide references.

Although data verification and data validation are commonly used terms, they are defined and applied differently by various organizations and quality systems. For the purposes of the project, the terms are defined as follows:

- **Data verification.** Confirmation by examination and provision of objective evidence that specified requirements have been fulfilled. Data verification is the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements. This confirmation is done to determine whether everything that was agreed upon was actually completed.
- **Data validation.** Confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled. Data validation is an analyte- and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance (i.e., data verification) to determine the analytical quality of a specific data set. In other words, what is the quality of this specific data set?

Data generated by project activities will be reviewed against project DQOs and flagged (qualified) if the objectives are unmet. Data will also be assessed to determine whether the QC practices were in place during data collection. If data were collected without the stated QC practices in place, the data will be set aside until the impact of the QC failure on data quality can be evaluated. If the impact of the QC failure on data quality is minimal, the data will be qualified and included within the database. Data that does not meet the DQOs will be evaluated to determine the cause of the problem and whether corrective actions can be implemented so that DQOs are met in the future.

11.2 Verification and Validation Methods

Laboratory data will be validated in accordance with the USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review (USEPA, 2017). These documents serve as the equivalent of an SOP for data review and validation. Level II data validation will be performed on the analytical data. Specific data evaluation and qualification guidelines for inorganic and general chemistry data review are included in Attachment B, including the review items, method, review criteria, action criteria, and reason codes.

Data verification/validation will be performed by the QAO and designated reviewers/validators. Data reviewers will be responsible for reviewing field data sheets, COC forms, and analytical lab reports from each sampling event to determine whether collected data meets the contractual requirements. The data validators will add to the data review by checking field equipment calibration records and

QC results, assessing whether DQOs have been achieved, and flagging data that did not meet specific requirements. Data qualifiers will be added to the database to alert data users of data limitations and uncertainties. A data quality assessment will be completed to summarize the results of the review and validation.

If corrective action is necessary based on the data verification/validation process, the QAO will be responsible for communicating the nonconformance and the corresponding corrective actions to the laboratory, the PM, or other designee. A data quality assessment section summarizing qualified results and including any corrective actions will be included in the summary reports.

11.3 Reconciliation with User Requirements

To fulfill the identified data needs, it is important that the data collected for the project meet the DQOs. If data do not meet the project specifications, the results will be flagged in the database to alert the data user of the data limitations and the following actions will be taken. First, the QAO and PM or other designee will review the errors and determine if the problem is equipment failure, calibration/maintenance techniques, or monitoring/sampling techniques. The QAO, PM, or designee will suggest corrective action.

If the problem cannot be corrected by training, revision of techniques, or replacement of supplies/equipment, then the technical advisor will review the DQOs and determine if the DQOs are feasible. If the specific DQOs are not achievable, they will determine whether the specific DQO can be relaxed or if the parameter should be eliminated from the monitoring program. Any revisions to DQOs will be reviewed by the project team prior to approval and QAPP revision.

The database will continue to be maintained for 5 years after the completion of the Project.

Section 12

References

United States Environmental Protection Agency (USEPA), 2002. *Guidance on Environmental Data Verification and Data Validation*. EPA QA/G-8.

USEPA, 2017. *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review*. USEPA-540-R-2017-001, January.

Appendix A: Laboratory QA Manual

Appendix B: Data Validation Procedures

Technical Memorandum

Prepared for: HolcimUS, Colorado Division of Reclamation, Mining and Safety

Project Title: Red Creek Quarry Project

Technical Memorandum

Subject: Data Verification and Validation Procedures for Inorganic Laboratory Analytical Data for the Red Creek Quarry

Date: October 2022

To: Red Creek Quarry Project Team

1. Introduction

This technical memorandum describes the procedures for verifying and validating data for the Red Creek Quarry (RCQ). These procedures will be followed during active mining and reclamation operations and are included in the quality assurance project plan (QAPP) for surface water and groundwater monitoring.

The following procedures apply to inorganic parameters in surface and groundwater samples collected at the RCQ site. Analytical methods, preservation, method detection limits, and holding times are provided in the QAPP.

Data verification and validation are performed to ensure that data are of sufficient quality to be used for environmental decision-making. The person completing the verification and validation will have knowledge of the QAPP, standard operating procedures, and other project planning documents, as necessary.

2. Database Loading

Prior to receiving the laboratory data package, the following steps are completed:

- Verification of correct sample IDs, collection times, and requested analyses by reviewing and comparing laboratory receipts and login forms, chains-of-custody (COCs), and field and geochemistry lab notes. The temperatures of samples received by laboratory are also checked.
- Preparation of the database, by entering sample collection information (ID, collection time, etc.) and field measurements (pH, flow, etc.) from field and geochemistry lab notes. This includes linking field duplicates to the appropriate associated sample.

After the laboratory data package is received, the following steps are completed:

- Preparation of laboratory-provided electronic data deliverable (EDD) for loading into database. The database is set up with checks, so only recognized analytical methods, units, etc., can be uploaded. Preparing the EDD also involves catching any errors that may have been missed by the laboratory.
- Loading of the prepared EDD into the database. During the data loading process, the laboratory data is merged with the field data.

3. Data Verification

The laboratory data package includes a pdf report and an EDD. After these are received, and the data is loaded into the database, a data verification report is produced from the database. The data verification report is then compared to the COCs and laboratory report to verify the following:

- The laboratory data has merged with the correct field data.
- All expected analyses and results are present for each sample.
- Any duplicate analytical results are properly coded to ensure that only the correct result will be reported.
- The data has loaded correctly and all fields are correctly filled.
- Numerical results and units in the database match the laboratory report (approximately 10 percent of results are checked) to ensure that the EDD and data loading processes have not compromised the data.

Any issues that arise are resolved, and the database is updated with the corrected information.

4. Data Validation

The analytical laboratory applies qualifiers to data based on the laboratory quality assurance plan. These laboratory-assigned qualifiers are reviewed by the data validator to determine if the laboratory-identified issue has affected data usability. The laboratory-assigned qualifiers are stored in the database and are not modified. As part of the data validation process, the data validator assigns additional qualifiers based on Environmental Protection Agency guidance (2010), which is outlined in the following sections. The validation qualifiers are also stored in the database. For reporting purposes, results are always reported with their associated validation qualifiers. Additional reason codes may be developed as necessary as the project database is populated.

Data validation consists of the following steps:

- Review of sample receiving temperatures and holding times compared to sample handling requirements listed in the relevant QAPP.
- Review of laboratory quality control (QC) results (blanks, spikes, duplicates, etc.) provided in the pdf report, as well as a comparison of the detection limits against those requested.
- Review of field duplicates, field equipment blanks, and geochemical laboratory equipment blanks compared to the acceptance criteria listed in the relevant QAPP.
- Review of calculated QC parameters including cation-anion balance and measured/calculated TDS ratio.

During the validation process, qualifiers are assigned, if necessary, as described in Table 1. The valid data qualifiers that the data validator adds are defined as follows:

U - Analyte was not detected at the detection limit concentration.
J - Reported value is an estimated concentration.
UJ - Analyte was not detected at an estimated detection limit concentration.
R - This data was rejected and was not used for any purposes.
UR - The analyte was not detected. The detection limit is unreliable and may be representative of a false negative. This data was rejected and is not usable for any purpose.

These valid data qualifiers are mapped in the database to reason codes that identify why they were added. The valid reason codes that the data validator adds are defined as follows:

1 - Holding time violation
2 - Preparation blank (Method blank) contamination
4H - Matrix Spike/Matrix Spike Duplicate or Analytical Spike/Analytical Spike Duplicate recovery outside limits (high bias)
4L - Matrix Spike/Matrix Spike Duplicate or Analytical Spike/Analytical Spike Duplicate recovery outside limits (low bias)
5 - Matrix Spike/Matrix Spike Duplicate or Analytical Spike/Analytical Spike Duplicate precision outside limits
6H - Laboratory Control Sample recovery outside limits (high bias)
6L - Laboratory Control Sample recovery outside limits (low bias)
7 - Equipment blank contamination
8 - Field duplicate precision outside limits
9 - Other deficiencies (including cooler temperature)
B - Laboratory Control Sample/Laboratory Control Sample Duplicate precision outside limits
D - Laboratory duplicate precision outside limits
E - Value exceeds linear calibration range
T - Trace level compound, detected below the practical quantitation limit (PQL)

Appendix C: SOPs

SOP-1 – Field Notes and Documentation

SOP-2 – Equipment Calibration

SOP-3 – Equipment Decontamination

SOP-4 – Sample Preservation

SOP-5 - Groundwater Well Water Level Measurement

SOP-6 – Groundwater Quality Sampling

SOP-7 – Surface Water Quality Sampling

SOP-8 – Surface Water Flow Measurements

SOP-1
Field Notes and Documentation

Standard Operating Procedure

Revised January 2022

SOP-1
Field Notes and Documentation

Standard Operating Procedure

Revised January 2022

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Table of Contents

Field Notes and Documentation 2
Section 1: Objective 2
Section 2: Scope and Applicability 2
Section 3: Responsibilities 2
Section 4: Required Materials 2
Section 5: Procedures 2
5.1 Field Logbooks 3
5.2 Photographs 4
5.3 Additional Field Forms/Records 4
Section 6: Corrections 5
Section 7: Documentation Reviews 5
Section 8: Field Record Backup 5
Section 9: Documentation Archive 5

SOP-1

Field Notes and Documentation

Section 1: Objective

The objective of this standard operating procedure (SOP) is to establish a consistent method and format for the use and control of documentation generated during daily field activities. Field notes and records are intended to provide sufficient information that can be used to recreate the field activities, as well as, the collection of environmental data. Information placed in these documents and/or records shall be factual, detailed and objective.

Section 2: Scope and Applicability

This procedure will be used during all field activities, regardless of the purpose by all project team personnel and subcontractors who conduct field investigations. These activities may include, but are not limited to, all types of media sampling (soil vapor, soil, groundwater, wastewater, etc), utility clearance, well installation, sample point locating and surveys, site reconnaissance, free product removal, remediation, and waste handling.

Section 3: Responsibilities

The Project Manager (PM), or designee, will have the responsibility to oversee and ensure that field documentation is collected in accordance with this SOP and any site-specific or project specific planning documents. The field sampling personnel will be responsible for the understanding and implementation of this SOP during all field activities, as well as, obtaining the appropriate field logbooks, forms and records necessary to complete the field activities. Field personnel shall ensure all field activities are documented completely at the end of each field day. Field personnel are responsible for tracking the location of all field documentation, including field logbooks. Field personnel are responsible for assuring that the original documentation (or copies of the field log book, if needed for another project at the same site), are filed at the end of the field project or during a long project (greater than month) every couple of weeks.

Section 4: Required Materials

The materials required for this SOP include the following:

- Bound field logbooks, and
- Black waterproof and/or indelible ink pens
- Field Forms

Section 5: Procedures

This SOP primarily includes the documentation procedures for the field logbooks. However, procedures discussed in this SOP are applicable to all other types of field documentation collected and should be universal in application. Details of other field records and forms (e.g., boring logs, sample labels, chain of custody records, and waste containment labels) are discussed in the specific SOP associated with that particular field activity (e.g., borehole drilling, sample handling, investigative derived waste), and not covered in detail in this SOP. Attachment A has example field sheets for groundwater sampling.

5.1 Field Logbooks

Field personnel will keep accurate written records of their daily activities in a bound logbook, or project specific work sheets that will later be bound, that will be sufficient to recreate the project field activities without reliance on memory. This information will be recorded in chronological order. All entries will be legible, written in black waterproof or indelible ink, and contain accurate and inclusive documentation of field activities, including field data observations, deviations from project plans, problems encountered, and actions taken to solve the problem. Each page of the field logbook will be consecutively numbered, signed and dated by the field author(s). Pages should not be removed for any reason.

There should be no blank lines or partial pages. Any blank part of a page should be lined to the end of the page at the end of the day.

In addition to documenting field activities, field logbooks will include, but are not limited to, the following:

- Date and time of activities,
- Site location
- Purpose of site visit,
- Site and weather conditions,
- Personnel present, including sampling crew, facility/site personnel and representatives (including site arrival and departure times),
- Subcontractors present,
- Regulatory agencies and their representatives (including phone numbers, site arrival and departure times),
- Level of health and safety protection,
- Sampling methodology and information,
- Sample numbers or descriptions,
- Sample Locations (sketches are very helpful),
- Source of sample(s), sample identifications, sample container types and preservatives used, and lot numbers for bottles and preservatives (if applicable and if not recorded on other forms or in a sample control logbook),
- A chronological description of the field observations and events,
- Specific considerations associated with sample acquisition (e.g., field parameter measurements, field screening data, HASP monitoring data, etc.) (if not recorded on another form),
- Wastes generated, containment units (including volumes, matrix, etc), and storage location (if not recorded on another form),
- Field quality assurance/quality control samples collection, preparation, and origin (if not recorded on other forms or in a sample control logbook),
- Physical or quantitative measurements.

The manufacturer, model and serial number of field instruments (e.g., OVM, water quality, etc.) shall be recorded, if not using a calibration form. Also, source, lot number and expiration date of standard shall be recorded if calibrated in the field.

- Well construction materials, water source(s), and other materials used on-site (if not recorded on another form).

- Sample conditions that could potentially affect the sample results,
- If deviating from plan, clearly state the reason(s) for deviation,
- Persons contacted and topics discussed,
- Documentation of exclusion zone set-up and location,
- Documentation of decontamination procedures, and
- Daily Summary.

Field situations vary widely. No general rules can specify the extent of information that must be entered in a logbook. However, records should contain sufficient information so that someone can reconstruct the field activity without relying on the collector's memory. Language used shall be objective, factual, and free of personal opinions. Hypothesis for observed phenomena may be recorded, however, they must be clearly indicated as such and only relate to the subject observation.

Logbooks will be assigned to a specific sampling team. If it is necessary to transfer the log book or sheets to alternative team member during the course of field work, the person relinquishing the log book will sign and date the log book at the time of transfer.

Field logbooks should consist of a bound book, in which the insertion or removal of pages will be visibly noticeable after the logbook has been assembled. Logbooks can be prepared by gluing or laminating pages together either at the left side or top of the page. If inclement weather is expected, logbooks may have plastic laminated front and back covers to protect the interior pages, and should not be broken apart for copying. Loose-leaf binding, such as comb binding is not considered hard binding. To maintain the integrity of the logbook, pages should be consecutively numbered prior to use. Logbook pages can be of any format, and may include blank pages for recording or field forms that are used for specific tasks. As an alternative, commercially bound and consecutive page numbered field logbooks may also be used.

5.2 Photographs

Photographs provide the most accurate demonstration of the field worker’s observations. They can be significant to the field team during future inspections, informal meetings, and hearings. Photographs should be taken with a camera-lens system having a perspective similar to that afforded by the naked eye. Telephoto or wide-angle shots cannot be used in enforcement proceedings. Some industrial clients do not permit photographs on their sites. In industrial and military settings, confirm with the project manager that photographs are allowed.

A photograph must be documented if it is to be a valid representation of an existing situation. Therefore, for each photograph taken, several items shall be recorded in the field logbooks:

- Date and time photograph taken;
- Name of photographer;
- Site name, location, and field task;
- Brief description of the subject and the direction taken;
- Sequential number of the photograph and the roll number; and
- For digital photographs, ensure that the date and time settings in the camera are accurately set before taking pictures.

5.3 Additional Field Forms/Records

Additional field records may be required for each specific field event. The use of these records and examples are described in other SOPs specific for the activity (e.g. Borehole Logging SOP, Groundwater Sampling and Purging SOP, etc.). These other records may include:

- Borehole Logs during drilling

- Well Construction and Development records (groundwater, soil vapor, extraction, etc.),
- Groundwater Purge and Sample Collection Records,
- Soil Vapor Purge and Sample Collection Records,
- Water Level Monitoring and Product Removal Records,
- NAPL Removal Records,
- Investigation Derived Waste (IDW) Tracking Records,
- Instrument Calibration Records, and
- Health and Safety Monitoring Records and sign-off sheets.

Prior to field activities, the field sampling personnel will coordinate with the Project Manager, or designee, to determine which additional records will be required for the specific field task. These additional records will be maintained in a field file or a three-ring notebook throughout the duration of the field activities or included in a specially prepared site-specific notebook. If the field notebook is being created, the forms may be part of the laminated book.

Section 6: Corrections

If an error is made in the field, logbook corrections will be made by drawing a single line through the error, entering the correct information, and initialing and dating the change. Materials that obliterate the original information, such as correction fluids and/or mark-out tapes, are prohibited. All corrections will be initialed and dated. Some projects require that a brief reason for the change must also be added where the correction was made. Ask the Project Manager, if this requirement is necessary.

Section 7: Documentation Reviews

Periodically, the Project Manager, or designee, will review the field logbooks pertaining to the activities under their supervision. The elements of this review will include technical content, consistency, and compliance with the project plans and SOPs. Discrepancies and errors identified during the review should be resolved between reviewer and author of the field documentation. Corrections and/or additions of information shall be initialed and dated by the field author or reviewer.

Section 8: Field Record Backup

Periodically, the Project Manager, or designee, will determine if and when field logbooks and records need to be photocopied. Photocopies will be maintained in the project files and can be used as backup in the event that the original field logbook or records are lost or damaged. In addition, the field logbook can be scanned and an electronic copy in .pdf format will be stored in the electronic file for the project.

Section 9: Documentation Archive

At the completion of the project, all original field logbooks and records will be stored in the project files in accordance with Brown and Caldwell procedures. Typically project files lifetimes are controlled and spelled out in contractual agreements with clients. Typically, project files are archived after project finalization and kept indefinitely in archive

SOP-2
Water Monitoring Equipment Calibration

Standard Operating Procedure

Revised January 2022

SOP-2
Water Monitoring Equipment Calibration

Standard Operating Procedure

Revised January 2022

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Table of Contents

Water Monitoring Equipment Calibration 2
Section 1: Objective 2
Section 2: Scope and Applicability 2
Section 3: Responsibilities 2
Section 4: Required Materials 2
Section 5: Methods 2
    5.1.1 Accuracy Requirements 4
    5.1.2 Records 4
    5.1.3 Equipment Specific Procedure- Micro TPW Turbidity Meter 4
    5.1.4 Equipment Specific Procedure- YSI 556 MPS 5
Section 6: Quality Assurance/Quality Control 10
Section 7: Records 11
Section 8: References 11
Section 9: Attachments 11

SOP-2

Water Monitoring Equipment Calibration

Section 1: Objective

The objective of this Standard Operating Procedure (SOP) is to provide general procedures for the calibration of field instruments used during surface and groundwater field investigations. These instruments are used for field screening and field measurements.

Section 2: Scope and Applicability

This general procedure will be followed during all field activities when field instruments are used for the collection of field data. The general use and calibration of these instruments are discussed in this SOP and always should be supplemented (or superseded, if necessary) with the manufacturer's calibration and maintenance instructions.

Section 3: Responsibilities

The *Project Manager*, or designee, will have the responsibility to oversee and ensure that field instruments are calibrated and that written documentation of calibration is maintained.

The *field sampling personnel* will be responsible for understanding and implementing this SOP during all field activities, as well as, obtaining the appropriate field logbooks, field records, instruments, materials and calibration standards necessary to complete the field task..

Section 4: Required Materials

The materials required for this SOP include the following:

- Bound field logbooks,
- Black or blue water proof and/or indelible ink pens,
- Disposable nitrile gloves
- Instrument calibration form(s),
- Standard solutions, and materials and secondary collection containers,
- Replacement batteries and parts (if applicable), and

Instruments used during field activities may include, but are not limited to, the following:

- Water quality instruments (e.g., pH, temperature, conductivity, dissolved oxygen [DO], turbidity, oxidation-reduction potential [ORP])

Section 5: Methods

This SOP includes the general methods for field instrument calibration, calibration documentation and corrective action procedures that will be implemented during field activities. Detailed instrument calibration procedures should be provided by the manufacturer and will be different for each field instrument used. Field personnel should be familiar with the calibration procedures prior to using the equipment in a field setting.

Prior to field activities, it will be determined which instruments will be needed for the field activities. Some instruments may be available from an office equipment pool or from an equipment rental/supply company. Field personnel should locate, order and coordinate delivery of the necessary instruments, standard solutions, and other necessary equipment and materials at least three days before the beginning of the field activities. Consideration should be made for specialty instruments and materials that may take longer to obtain.

Prior to field mobilization, instruments that will be used during the field activities will be checked for possible malfunctions, cleaned and calibrated. Some equipment provided by a rental company is shipped pre-calibrated and a completed calibration sheet is sent with the equipment. These activities will be conducted in accordance with manufacturer's procedures, where applicable. If manufacturer procedures are not available, standard acceptable calibration procedures will be used.

Calibration verification will be performed on field instruments prior to their initial use, at least once daily, or whenever indications of instrument malfunction or questions in readings are observed. Some instruments, such as field water quality meters, may require more frequent calibration verification depending upon project quality objectives. In general, instrument identification and calibration will include the following steps:

1. Determine which instruments are needed for the specific field tasks;
2. Obtain the necessary instruments and standard solutions for calibration;
3. Check expiration dates on standard solutions, replace if out of date;
4. Assemble the instrument and turn it on, allowing the instrument to warm up;
5. Check battery charge, charge or replace if necessary;
6. Clean the instrument (if necessary);
7. Calibrate the instrument prior to field use in accordance with manufacturer's procedures, and if necessary adjust the instrument to meet calibration specifications (this step is sometimes referred to as the initial calibration);
8. If the instrument malfunctions and cannot be corrected, obtain another instrument and have the other repaired (see Section 7.0 for Corrective Action Procedures);
9. Clean and decontaminate the instrument after use, and before storage;
10. Conduct final calibration verification at the end of each day, or at completion of field measurement collection for the day;
11. Document all calibration activities and results; and
12. Recharge batteries at the end of each day or as needed. This should be carried out in a non-hazardous area.

Some manufacturers recommend field calibration procedures that are inadequate for verifying instrument linearity and calibration range. Some commercially-available water quality meters sometimes have a stock calibration mixture that is used during an "easy to conduct" calibration which consists of pressing a "calibrate" button on the instrument while the probes are in stock solution. The problem with this calibration method is that it only provides a one point calibration. This is inadequate for the field measurements collected during water quality monitoring because of the wide range of conditions that may be encountered. Instrument calibration and accuracy should be checked by using at least two different, commercially-available standard solutions over a range of values (e.g., pH buffers at 4, 7 and 10) to check that the meter is providing accurate readings over a range of conditions. These solutions should be separate from any solution provided by the manufacturer.

5.1.1 Accuracy Requirements

For an instrument to be considered calibrated and ready for use, the instrument must read within at least 10 percent (%) of the calibration standard. If the instrument reads >10% difference from the standard, it should be recalibrated or taken out of service. Consult the manufacturer's instruction manual for more specific details on the instrument in use.

Personnel responsible for the use of these instruments will read the manufacturer's instruction manual and will be trained for the use, calibration, and maintenance of the instrument prior to instrument use. The calibration, maintenance and use of these instruments will be conducted in accordance with the manufacturer's specifications and procedures. If instrument calibration cannot be met or if the instrument is malfunctioning, obtain another instrument and repair the malfunctioning instrument immediately (see Section 7.0 Corrective Action).

5.1.2 Records

A record will be maintained of the calibrations and calibration verification. The records will include the following information, where applicable:

- Date and time of activities,
- Project name and number,
- Personnel conducting the calibration,
- Serial and/or meter numbers,
- Instrument name and model number,
- Standard solutions used, including concentration lot numbers and expiration dates,
- Instrument readings after calibration, and
- Instrument readings of calibration standards at the end of the day or working period.

Calibration activities will be recorded in the field logbooks or on the Calibration Form. An example of this calibration record is included as an attachment. This record can be modified as necessary to accommodate specific instruments. Records of equipment repair and maintenance shall be recorded in the Instrument Calibration Field Book.

5.1.3 Equipment Specific Procedure- Turbidity Meter

Equipment necessary:

- Turbidity Meter
- 0.02, 10 and 1,000 NTU Manufacturer's standard calibration solutions
- Daily Calibration form.

Calibration Procedure:

1. Examine and clean (if necessary) cuvette to make sure that cuvette is free of smudges, scratches etc.
2. Record the expiration dates of each of the three standard solutions to be used on Daily Calibration form.
3. Index the three standard solutions by holding down the (↵) button and slowly rotating the calibration standard one complete revolution (360°) pausing between increments to allow the display to update.

4. While rotating the standard, observe the turbidity reading and locate the cuvette position with the lowest turbidity reading.
5. With the calibration standard positioned at the location having the lowest turbidity reading, install the Indexing Ring over the black light shield on the standard so that the pointer of the Ring aligns with the reference arrow on the instrument.
6. Select the calibration function of the instrument by pressing the “CAL” button once. The “CAL” icon will be illuminated on the display with “1000” flashing indicating the standard required for this step of the calibration.
7. Insert the 1000 NTU standard into the sample well and press down until the cuvette snaps fully into the instrument. Align the indexing ring with the arrow on the instrument.
8. Press and hold down the (↲) button while making fine adjustments to the indexing. Release the button to initiate the calibration.
9. When the instrument has completed the calibration on the 1000 standard, it will briefly display 1000 to indicate that it was calibrated and then prompts for the 10 NTU standard
10. Repeat steps for 10 and 0.02 NTU standards.
11. When instrument has completed all calibration standards, the instrument returns to the read mode and is ready for use in the field.
12. After calibration, read the standard solutions and record readings on daily Calibration Form.

5.1.4 Equipment Specific Procedure- YSI 556 MPS

Equipment necessary:

- YSI 556 MPS Water Quality Instrument
- 4.0, 7.0, 10.0 pH Buffer Solutions-pH
- 447, 1413, 8974, 15,000 Conductivity Solutions-SC
- 220 millivolt (mV) Standard Solution-ORP
- Zero Oxygen Solution-DO
- Rinse water
- Daily Calibration form
- Batteries
- Conditioning solution containers
- Waste Solution Collection container

General Calibration Procedure:

1. Plug data cable into port located on the bottom of YSI, turn on instrument by pressing ON button, allow instrument to warm up for approximately five minutes. Observe battery status and change batteries if necessary.
2. Fill out Daily Calibration form. Record date and time of calibration and expiration dates of the standard solutions used in calibration. Record the Unit ID, Serial Number, assigned user and person conducting the calibration.
3. Use the transport/calibration cup that comes with the probe module as a calibration chamber for all calibrations. Ensure that an o-ring is installed in the o-ring groove of the

transport/calibration cup bottom cap, and that the bottom cap is securely tightened. Do not over-tighten as this could cause damage to the threaded portions.

4. For maximum accuracy, use a small amount of previously-used calibration solution to pre-rinse the probe module. Old calibration standards are saved during the course of the event for the purpose of conditioning the probe before calibration. Insert YSI probe module into calibration cup and swish. Do not rinse the cup between the conditioning step and the calibration step. The conditioning solution should never be used as calibration solution.
5. Pour new calibration solution into calibration cup and ensure that there is enough solution to cover the probe that you are calibrating. Many of the calibrations factor in readings from other sensors (ie: temperature sensor). The top vent hole of the conductivity sensor must also be immersed during some of the calibrations. Insert YSI probe module into the calibration cup with the calibration solution, tighten the cup and follow calibration steps below for each parameter.
6. Rinse calibration solution cup and probe module at least three times with ambient-temperature rinse water between each solution.
7. Have several clean, absorbent paper towels or cotton cloths available to dry the probe module between rinses and calibration solutions.
8. When calibration is finished, discard the last solution into glassware (to be saved as conditioner for next calibration or drift check) and add a small amount of water or pH 4 solution to calibration cup. Place probe module into calibration cup. Damage may occur if the probes are allowed to dry. Do not use distilled water.
9. The key to successful calibration is to ensure that the sensors are completely immersed when calibration values are entered. Use recommended volumes when performing calibrations.

pH Probe

pH is calibrated using three-point calibration standard solutions, usually 4.0, 7.0 and 10.00. In very low pH situations, 2.0, 4.0 and 7.0 solutions can be used.

1. Press the On/Off key to display the run screen.
2. Press the Escape key to display the main menu screen.
3. Use the arrow keys to highlight the Calibrate selection.
4. Press the Enter key (↵). The Calibrate screen is displayed.
5. Use the arrow keys to highlight the pH selection and press Enter.
6. Select “3 point” and Press Enter.
7. For maximum accuracy, use a small amount of previously-used calibration solution to pre-rinse the probe module.
8. Place the correct amount of pH buffer into a clean dry or pre-rinsed calibration cup. For pH, the approximate volume used is 30 milliliters (ml).
9. Carefully immerse the sensor end of the probe module into the solution and gently rotate and/or move the probe module up and down to remove any bubbles from the pH sensor. The sensor must be completely submerged.
10. Screw the calibration cup on the threaded end of the probe module and securely tighten.

11. Use the keypad to enter the calibration value of pH 7.0 solution at the current temperature and press Enter. See table below for calculated pH values verses temperature.
12. Allow at least one minute for temperature equilibration before proceeding.
13. Observe the reading under pH, when the reading shows no significant change for approximately 30 seconds, press Enter. The screen will indicate that the calibration has been accepted and prompt you to press Enter again to continue.
14. Press Enter. This returns you to the specified pH Calibration Screen.
15. Rinse the probe module, calibration cup and sensors in tap or purified water and dry.
16. Repeat steps above for pH 4.0 and 10.0.
17. After the YSI has been calibrated for all three points of pH, press the Escape key until the main menu screen is displayed. Select Run.
18. Add 30 ml of pH 7.0 solution and observe the reading under pH when the reading shows no significant change for approximately 30 seconds. Record the reading on the field form.
19. Repeat this step for pH 4.0 and 10.0.

Calculated pH					
Temperature	pH	Temperature	pH	Temperature	pH
ºC	4.00	ºC	7.00	ºC	10.00
0	4.01	0	7.12	0	10.20
10	4.00	10	7.06	5	10.06
20	4.00	20	7.02	10	10.12
25	4.00	25	7.00	15	10.08
30	4.01	30	6.99	20	10.04
35	4.01	35	6.98	25	10.00
40	4.03	40	6.97	30	9.96
60	4.09	60	6.98	35	9.92
80	4.16	80	7.04	40	9.88
90	4.22	90	7.09	50	9.80

Specific Conductivity Probe

Specific Conductivity is calibrated to a single calibration solution. A standard solution below the calibrated solution and a standard solution above the calibrated solution are read and recorded on the daily calibration form. For instance, calibrate to a 1413 solution and read/record a 447 solution and an 8974 solution.

1. Press the Escape key to display the main menu screen.
2. Use the arrow keys to highlight the Calibrate screen.
3. Press the Enter key. The Calibrate screen is displayed.
4. Use the arrow keys to highlight the Conductivity selection. Press Enter. The Conductivity Calibration Selection Screen is displayed.

5. Use the arrow keys to highlight the Specific Conductance selection. Press Enter. The Conductivity Calibration Entry Screen is displayed.
6. For maximum accuracy, use a small amount of previously-used calibration solution to pre-rinse the probe module.
7. Place the correct amount of conductivity standard into a clean, dry or pre-rinsed calibration cup. For conductivity, the approximate volume is 55 ml. The sensor must be completely immersed past its vent hole.
8. Before proceeding, make certain that there are no salt deposits around the oxygen and pH/ORP sensors, particularly if you are employing standards of low conductivity.
9. Carefully immerse the sensor end of the probe module into the solution and gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.
10. Screw the calibration cup on the threaded end of the probe module and securely tighten.
11. Use the keypad to enter the calibration value of the standard you are using. Be sure to enter the value in milliSiemens per centimeter (mS/cm) at 25 degrees Celsius (ºC) (1413 would be entered as 1.413).
12. Press Enter. The Conductivity Calibration Screen is displayed.
13. Allow at least one minute for temperature equilibration before proceeding.
14. When the reading shows no significant change for approximately 30 seconds, press Enter. The screen will indicate that the calibration has been accepted and prompt you to press Enter again to continue.
15. After the YSI has been calibrated for conductivity, press the Escape key until the main menu screen is displayed. Select Run.
16. Add 55 ml of the standard solution that was used to calibrate and observe the reading under specific conductivity when the reading shows no significant change for approximately 30 seconds. Record the reading on the field form.
17. Repeat this step with a standard solution higher than the point that was calibrated and with a standard solution lower than the point that was calibrated. Record the readings on the field form.

ORP Probe

ORP is temperature sensitive so the temperature reading will also be recorded on the Daily Calibration form. The ORP solution standard has a chart on the side of the bottle relating ORP values to Temperature. It is the corresponding Temperature-ORP value that should be entered.

1. Press the Escape key to display the main menu screen.
2. Use the arrow keys to highlight the Calibrate screen.
3. Press the Enter key. The Calibrate screen is displayed.
4. Use the arrow keys to highlight the ORP selection. Press Enter. The ORP calibration screen is displayed.
5. Place approximately 30 ml of ORP solution into a clean, dry or pre-rinsed calibration cup.
6. Carefully immerse the sensor end of the probe module into the solution and gently rotate and/or move the probe module up and down to remove any bubbles from the ORP sensor. The sensor must be completely immersed.
7. Screw the calibration cup on the threaded end of the probe module and securely tighten.

8. Use the keypad to enter the correct value of the calibration solution you are using at the current temperature. See table below for ORP values versus temperature (i.e. - 220 mV ORP standard @ 22 °C = 223mV).
9. Press Enter. The ORP calibration screen is displayed.
10. Allow at least one minute for temperature equilibration before proceeding. Verify that the temperature reading matches the value that was used in the table.
11. Observe the reading under ORP. When the reading shows no significant change for approximately 30 seconds, press Enter. The screen will indicate that the calibration has been accepted and prompt you to press Enter again to continue.
12. Press Enter. This returns you to the calibrate screen.
13. After the YSI has been calibrated for ORP, press the Escape key until the main menu screen is displayed. Select Run.
14. Add 30 ml of ORP solution and observe the reading under ORP when the reading shows no significant change for approximately 30 seconds. Record the reading on the field form.

ORP versus Temperature	
Temperature °C	**ORP**
-5	270.0
0	263.5
5	257.0
10	250.5
15	244.0
20	237.5
25	231.0
30	224.5
35	218.0
40	211.5
45	205.0
50	198.5

Dissolved Oxygen (DO) Probe

DO is calibrated to open air and then a Zero Oxygen Solution is read. DO is pressure sensitive so the barometric pressure (found in the lower right side of instrument) reading will also be recorded on the Daily Calibration form. The instrument must be on for at least 20 minutes to polarize the DO sensor before calibrating so this parameter is calibrated last.

1. Press the Escape key to display the main menu screen.
2. Use the arrow keys to highlight the Calibrate screen.
3. Press the Enter key. The Calibrate screen is displayed.
4. Use the arrow keys to highlight the DO selection. Press Enter. The DO calibration screen is displayed.
5. The current barometric pressure in millimeters of mercury (mmHg) will be visible on "Enter baro mmHg line". Press Enter to accept this value.
6. Use the arrow keys to highlight the DO% selection. Press Enter. The DO Barometric Pressure Entry Screen is displayed.
7. Place approximately three mm (1/8 inch) of water in the bottom of the calibration cup.
8. Place the probe module in the calibration cup. Make sure that the DO and temperature sensors are NOT immersed in the water.
9. Engage only one or two threads of the calibration cup to ensure that the DO sensor is vented to the atmosphere. Do not completely tighten the cup as the DO probe should be in a moisture saturated environment and still be allowed to equalize to atmospheric pressure.
10. Press Enter. The DO% saturation calibration screen is displayed.
11. Allow approximately ten minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate before proceeding.
12. Observe the reading under DO%. When the reading shows no significant change for approximately 30 seconds, press Enter. The screen will indicate that the calibration has been accepted and prompt you to press Enter again to continue.
13. Place a small amount of Zero Oxygen Solution in calibration cup. Place the probe module into the calibration cup. Securely tighten and turn upside down so that the DO probe is submerged.
14. Observe the reading under DO when the reading shows no significant change for approximately 30 seconds, press Enter. The screen will indicate that the calibration has been accepted and prompt you to press Enter again to continue. Record the reading on the Calibration Form. Take care to keep the cap on the DO Zero Oxygen Solution to minimize contact with air. Discard Zero Oxygen solution that has been opened for more than two weeks.

Section 6: Quality Assurance/Quality Control

If an instrument cannot be successfully calibrated or if it is malfunctioning, the instrument will be repaired immediately. If this occurs during the course of the field activities, it will be the field personnel's responsibility to ensure that a replacement instrument is obtained as quickly as possible and that the Project Manager, or designee, is immediately notified. Under no circumstances should field personnel continue with activities until a replacement or approval from the PM or their designee is obtained. Instances of instrument failure and corrective actions taken will be documented in the field logbook.

Field instruments can be affected by changes in temperature, humidity, and barometric pressure. Instrument calibration should be checked when significant changes in weather occur. In addition, instrument calibration should be checked if maintenance activities (e.g. battery replacement or probe replacement) are required, if instrument malfunctions occur, or when questionable readings are observed. Calibration verification and recalibration activities shall be conducted and documented as outlined in Section 6.0.

Verification readings (drift check) shall be completed at the end of each day or work period. When parameters ORP, DO, Turbidity and Specific Conductivity read ± 10% different from the calibration standard, or when pH reads $\Delta > 0.20$, they will be flagged on field data forms “R” as rejected and the data shall not be used in data reports.

Section 7: Records

Corrections and reviews of calibration records will be completed in accordance with the SOP for Field Notes and Documentation. Errors will be corrected by drawing a single line through the error, entering the correct information, initialing and dating the change. Materials that obliterate the original information, such as correction fluids and/or mark-out tapes, are prohibited. All corrections will be initialed and dated.

Periodically, the Project Manager, or designee, will review the calibration records pertaining to the activities under their supervision. These records will be reviewed to confirm that instrument calibrations are being conducted and documented. Discrepancies and errors identified during the review should be resolved between reviewer and author of the calibration records. Corrections and/or additions of information shall be initialed and dated by the field author or reviewer..

Section 8: References

YSI Incorporated, 2004. YSI 556 MPS Multi Probe System Operations Manual.

HF Scientific Incorporated, December 2009. Owner’s Manual MicroTPI and MircroTPW Field Portable Turbidimeters. Manual Part No. 24378 (1/09), Rev. 1.8.

Section 9: Attachments

Attachment A: Water Quality Equipment Calibration Form

Attachment A

Water Quality Equipment Calibration Form

Water Quality Equipment Calibration Form

Project:____ Date: ____________________________

Unit Name/ID: ________________________________ Serial Number: ________________________

Calibrated By: ____

	Temp. Adjust	Cal Std. Expiration Date	**Initial Calibration**		Re-Calibration		**Drift Check**	
			Time:		Time:		**Time:**	
			Cal	**Read**	Cal	Read	**Read**	Acceptable Performance
Begin Temp:							**End Temp:**	
pH (3-point)								± Δ 0.2
Buffer 2.0								
Buffer 4.0								
Buffer 7.0								
Buffer 10.0								
Conductivity								± 10%
447 uS/cm	--							
1413 uS/cm	--							
8974 uS/cm	--							
15,000 uS/cm	--							
80,000 uS/cm	--							
ORP								± 10%
220 mv								
@ Temp		--						
Dissolved Oxygen								± 10%
Open Air mg/L	--	--						
Zero Oxy Std mg/L	--							--
Barometer (mm Hg)	--	--						

Turbidity Meter

Unit Name/ID: ________________________________ Serial Number: ________________________

Calibrated By: ____________________________ Assigned User: ______________________________

	Cal Std. Expiration Date	**Initial Calibration**		Re-Calibration		**Drift Check**	
		Time:		Time:		**Time:**	
		Cal	**Read**	Cal	Read	**Read**	Acceptable Performance
Turbidity							± 10%
0.02 Standard							--
10.0 Standard							
1,000 Standard							

SOP-3
Equipment Decontamination

Standard Operating Procedure

Revised January 2022

SOP-3
Equipment Decontamination

Standard Operating Procedure

Revised January 2022

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Table of Contents

Equipment Decontamination 2
Section 1: Objective 2
Section 2: Scope and Applicability 2
Section 3: Responsibilities 2
Section 4: Definitions 2
Section 5: Required Materials 3
Section 6: Procedures 3
6.1 Decontamination Station Set-up 3
6.2 Remove Gross Contamination 4
6.3 Remove Residual Contamination 5
    6.3.1 Removal of residual contamination consists of the following steps: 5
6.4 Prevent Recontamination After Decontamination 5
Section 7: Record Keeping 5
Section 8: Quality Assurance/Quality Control 5

SOP-3

Equipment Decontamination

Section 1: Objective

The objective of this standard operating procedure (SOP) is to establish consistent methods to reduce or eliminate:

- Contamination and cross-contamination of environmental samples by sample equipment, other samples, or personnel.
- Health and environmental risk caused by the spread of contaminants.

Section 2: Scope and Applicability

Decontamination should occur any time a sampling tool or instrument used in field investigations may contact sampled media or personnel using the equipment. This procedure will be used in conjunction with use of reusable equipment during field activities associated with handling, sampling, or measuring environmental media such as soil, groundwater, soil gas, or air. These procedures are to be implemented primarily on-site such as at the point of use or at a designated equipment decontamination station at the project site. Equipment decontamination should be completed before each use and prior to transporting off-site.

Examples of soil and groundwater sample collection equipment usually requiring decontamination includes pumps, bailers, water/interface level indicators, tubing, hand augers, split spoon samplers, and other related equipment used for the collection of samples or the measurement of field parameters.

These procedures are general minimum standards. They may be modified or supplemented for a specific project by site-specific workplans or health and safety plans.

Section 3: Responsibilities

The project manager is responsible for ensuring will have the responsibility to oversee and ensure that equipment decontamination procedures are implemented in accordance this SOP and any other site-specific or project-specific planning documents.

The field personnel are responsible for understanding and implementing this SOP during all field activities, as well as obtaining the appropriate field logbooks, forms, and records necessary to complete the field activities.

The site safety officer, typically the supervising field manager, is responsible for overseeing the health and safety of employees and for stopping work if necessary to fix unsafe conditions observed in the field.

Section 4: Definitions

SDS. Safety Data Sheets. - These documents need to be kept on site and discuss the physical and toxicological aspects for a particular substance used during decontamination or encountered during contamination.

Decontamination area. - An area that is not expected to be contaminated and is upwind of the exclusion zone

Exclusion zone. - The area in which contaminants are known or suspected to be present.

Measurement/monitoring equipment. - Any equipment used to check or evaluate site conditions.

Potable. - Drinkable.

Sampling equipment. - Any equipment used during the process of sample collection.

HASP. Site Health and Safety Plan. - Plan written to coordinate and outline precautions that will be taken to initiate and monitor worker safety.

Section 5: Required Materials

The equipment and supplies required for this SOP include the following (not every project will require all of these materials):

- Clean buckets or tubs to hold wash and rinse solutions of a size appropriate to the equipment to be decontaminated.
- Tap water.
- Deionized or distilled water
- Long-handled brushes for scrubbing. Flat-bladed scrapers, garden type spray bottles (no oil lubricated parts).
- Non-phosphate detergent such as Alconox or Liqui-Nox.
- Plastic sheeting for the decontamination area.
- Plastic bags and/or aluminum foil to keep decontaminated equipment clean until the next use.
- Gloves, aprons, safety glasses, and any other PPE required in the HASP.
- Towels and wipes.
- Dispensing bottles.

Section 6: Procedures

Decontamination consists of physically removing contaminants from personnel or equipment. To prevent the transfer of harmful materials, procedures have been developed and are implemented before anyone enters a site and continue throughout site operations.

A decontamination plan should be based on the worst-case scenario (if information about the site is limited). The plan can be modified, if justified, by supplemental information. Initially, the decontamination plan assumes all protective clothing and equipment which leave the exclusion zone are contaminated. Based on this assumption, a system is established to wash and rinse all non-disposable and non-dedicated equipment. Decontamination plans will be site-specific and presented in the HASP and/or the work plan’s SAP/QAPP for each site.

The decontamination area should be located, if possible, where decontamination fluids and soil wastes can be easily discarded or discharged after receipt of analytical results which determine if discharge parameters have been met. Decontamination wastewater should be managed in accordance with the Investigation Derived Waste Plan or as directed in the SAP or QAPP.

6.1 Decontamination Station Set-up

A decontamination pad should be established for cleaning of heavy equipment or large sampling tools. This pad can be a prefabricated area that already exists on site for washing large equipment or can be constructed. If a prefabricated area exists, it needs to have characteristics that allow for collecting fluids and solids that will fall off the large equipment. Decontamination pads can be constructed in a variety of ways, but things to consider during construction are the following:

The pad will need to be constructed so it provides complete secondary containment. Hence all sides will require berms to prevent off pad migration of fluids. The berms need to be constructed by considering the balance between sump pump removal rates and the amount of fluid that will be generated.

Fluids from decontamination processes cannot escape and be directly discharged vertically into the ground; hence if plastic sheeting is used it should be minimally double layered and thick (greater than 8 mil).

The pad will have to drain in one general direction where a sump pump can collect fluids. The pad will need to be located near power and water, if possible. However, a generator can supply power and water can be trucked in.

For small equipment decontamination and PPE decontamination a smaller station is established, usually in the contaminant reduction zone, between the exclusion zone and buffer zone. For this station, clean buckets or tubs (5 gallon buckets are most common) should be used. There should be enough room within this area for storing used and unused drums. Buckets should be placed on plastic sheeting to prevent spillage to the ground, and to help keep the decontamination area and equipment as clean as possible. The buckets should be filled half to three-quarters full as follows:

- Bucket 1 - Tap water with non-phosphate detergent such as Liqui-Nox made up as directed by the manufacturer.
- Bucket 2 - Tap water or deionized water for rinsing
- Bucket 3 - Deionized or distilled water for the second rinsing

1) If additional rinses using wash or dispensing bottles are called for in the project-specific documents, an additional bucket to catch the discharge from the final rinse will be necessary.
2) A clean area, generally covered with plastic sheeting or large clean plastic bags, is also needed to set down decontaminated equipment prior to reuse or air drying and packaging for later use. A stainless steel rack (e.g., grill for barbecue) can often help drying activities.
3) After the decontamination area is set up, equipment decontamination is comprised of four general steps:
4) Removal of gross (visible) contamination
5) Removal of residual contamination
6) Prevention of recontamination, and
7) Disposal of wastes associated with the decontamination

6.2 Remove Gross Contamination

Gross contamination generally applies to soil sampling equipment, which may have significant residue clinging to the piece of equipment. This can be removed by dry brushing or scraping or by a high-pressure steam or water rinse often, in areas not grossly contaminated, steam washes may be all that is applied to larger equipment, such as drill casings. If utilizing high-pressure steam or water, the rinse water should be containerized as investigation derived waste. Since a significant amount of wastes may be generated, this operation is often best conducted on a decon pad, which has been designed as a secondary containment area to collect wastes. Materials used and generated during gross contamination removal should be treated in a similar fashion to the waste stream that is being utilized at the Site. For example, if groundwater is treated as hazardous waste at the site then decontamination water and/or drill cutting should be treated as hazardous waste and be properly disposed. Disposal of investigative derived waste should follow procedures outlined in the project specific documents.

6.3 Remove Residual Contamination

All sampling equipment used at the site must be cleaned prior to any sampling effort, after each sample is collected, and after the sampling effort is accomplished.

6.3.1 Removal of residual contamination consists of the following steps:

Place the item in the first bucket (detergent wash) and scrub the entire surface area of each piece of equipment to be decontaminated. Utilize scrub brushes to remove all visible contamination. For submersible pumps, connect a length of tubing (dedicated to the cleaning process) to the pump and place the other end in the bucket and circulate the detergent wash water through the pump until the water runs clean or at least 1 minute. Change the water periodically to minimize the amount of residue carried over into the second rinse.

Place the item in the second bucket (clear water rinse – tap or deionized water) and rinse. Change the water periodically to minimize the amount of residue carried over into the third rinse. Recirculate rinse water through the submersible pump for at least 1 minute.

Place the item in the third bucket (deionized or distilled water) and repeat the rinsing procedure. Change water as necessary.

Unless the Work Plan or FSP directs additional rinses, place the item on a clean surface such as plastic sheeting to await reuse or packaging for storage (e.g., wrapping foil).

Wash water and materials from residual decontamination should be treated in a similar fashion to the waste stream that is being utilized at the Site. For example, if groundwater is treated as hazardous waste at the site then decontamination water and/or drill cutting should be treated as hazardous waste and be properly disposed. Disposal of investigative derived waste should follow procedures outline in the project specific documents.

6.4 Prevent Recontamination After Decontamination

After the decontamination process, equipment should be stored to preserve its clean state to the extent practical. The method will vary by the nature of the equipment. Protection measures include covering or wrapping in plastic or sealable plastic bags or wrapping with oil-free aluminum foil.

Section 7: Record Keeping

The decontamination method should be documented within the field documentation designated for the project. Entries documenting the procedure used, fluids used, lot numbers for fluids, and any changes and approval for changes should be entered into a bound field notebook or on project-specific forms (see Field Notes and Documentation SOP for field forms). Upon completion of the field activity, it is the responsibility of the field personnel to ensure the project/task manager receives copies of all of the field documentation.

Section 8: Quality Assurance/Quality Control

Quality assurances for sample handling centers upon following procedures outlined above and double checking as samples are collected. Checks should be performed either by field personnel, or preferably, by a project chemist or other personnel that constantly checks field COC forms versus laboratory receipt acknowledgment forms, discusses condition of samples as received by laboratory personnel, and communicates constantly with the laboratory project manager to prevent quality assurance issues from starting or becoming significant problems should they occur.

SOP-4
Sample Preservation

Standard Operating Procedure

Revised February 2022

SOP-4

Sample Preservation

Standard Operating Procedure

Revised February 2022

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Table of Contents

Sample Preservation........1
Section 1: Objective........1
Section 2: Scope and Applicability........1
Section 3: Responsibilities........1
Section 4: Definitions........1
Section 5: Required Materials........2
Section 6: Methods........2
Section 7: References........3

SOP-4

Sample Preservation

Section 1: Objectives

The objective of this standard operating procedure (SOP) is to establish procedures that allow the chemical integrity of a sample to be maintained from time of collection until chemical analysis.

Section 2: Scope and Applicability

This SOP documents the procedures and chemicals to be used for the preservation of aqueous field samples. These procedures apply to all project team personnel and subcontractors involved with the collection, shipping, and chemical analysis of groundwater samples.

Section 3: Responsibilities

The project manager (PM) (or designee) shall ensure that the sampling procedures used, including provisions for proper storage, preservation, and shipping, are adequate to maintain sample integrity until custody is assumed by the laboratory. The PM shall develop or direct the preparation of a detailed sampling plan for sampling water, which shall describe the procedures used to preserve samples during the interval from sampling until receipt by the laboratory.

The project quality assurance officer (QAO) (or designee) shall ensure the samples are collected in terms of the analytical methods and in compliance with sampling protocols. The field supervisor is responsible for maintaining adequate supplies of containers and preservatives. The PM will determine the roles and personnel for each project.

The field supervisor (or designee) shall be responsible for ensuring the competence of field sampling personnel and their training. The field supervisor shall ensure that specified preservation and storage procedures are followed during sampling and during shipment to the laboratory. The field sampling personnel will be responsible for the understanding and implementation of this SOP during all field activities. Field personnel are also responsible for checking the collected samples and verifying that they are preserved with the prescribed range.

Section 4: Definitions

Maximum Holding Time. Maximum holding time is the maximum length of time that may elapse before sample preparation (e.g., extraction or digestion) or analysis is completed. It is calculated from the date and time of collection in the field. Holding times are usually measured to the nearest day with the exception of those analyses that must be completed within 24 or 48 hours.

Preservation. Preservation refers to temperature control and/or pH adjustment procedures performed to prevent or slow the loss of target analytes through precipitation, volatilization, decomposition, or biodegradation.

Temperature. Temperature is defined as the temperature within the refrigerator, cooler, or ice chest that holds the samples. Samples shall be held at 6 degrees Celsius (°C) or less.

Section 5: Required Materials

The materials required for this SOP include:

- Bound field logbooks
- Black or blue waterproof and/or indelible ink pens
- Field forms
- Chain-of-custody (COC) forms
- List of requested analyses
- Sample labels
- Packaging tape
- Bubble wrap (provide by Pace Analytical, LLC [Pace] and placed in the bottom of the cooler)
- Ice or ice packs
- Large plastic (e.g., Ziploc®) bags or large trash bags
- Shipping label(s)

Section 6: Methods

Proper communication between the PM (or designee) and the analytical laboratory is essential prior to sampling, preferably in writing. This is necessary so that the proper type and number of containers and preservatives can be specified, and all technical and regulatory requirements can be met regarding the analyses.

The QAO (or designee) should coordinate in writing with the laboratory typically 2 weeks before the sample container kits are to be shipped from the lab to identify the analytes to be requested. The information exchange between the QAO (or designee) and field personnel include the project identification, sample kit shipment address, quality assurance/quality control (QA/QC) regulatory requirements, required turnaround requirements, and the number and type of laboratory analyses.

Most chemical and biological reactions and many physical processes are slowed by lowering the temperature. As a general rule, all samples need to be cooled at the time of collection and maintained slightly above freezing until preparation for final analysis.

Aqueous samples may be presumed to be homogenous and amenable to chemical preservation. The following general approaches for chemical preservation shall be employed depending on the analyte(s):

- Volatile acids (hydrogen cyanide [HCN], hydrogen sulfide [H_2S]) are rendered involatile in the presence of a strong base (sodium hydroxide [NaOH], pH greater than 12.0)
- Volatile bases (e.g., ammonia) are rendered involatile in the presence of strong acid (sulfuric acid [H_2SO_4], pH less than 2.0)

- Biodegradation of organic compounds is retarded under strongly acidic conditions (hydrogen chloride [HCl] or H_2SO_4, pH less than 2.0)
- Dehydrohalogenation (loss of HCl) of chlorinated solvents is counteracted in the presence of acid (HCl, pH less than 2.0)
- Oxidation of target analytes by the chlorine found in drinking water is eliminated by destroying the chlorine with a reducing agent such as sodium thiosulfate

Many soluble metal salts tend to adhere to the walls of the container or form precipitates with time. This can be prevented by the addition of nitric acid to a pH of less than 2.0, which maintains the metals as soluble nitrate salts. Groundwater samples for dissolved metals analysis are filtered (usually with an 0.45-micron filter) before preservation with the appropriate preservative. The filtrate is added directly to the plastic container, which has been supplied with the proper amount of preservative.

The required chemical preservatives for aqueous samples will normally be added to the appropriate containers by the subcontracting laboratories before delivery to the field. There are two reasons why already-preserved containers are preferred. First, the laboratory scheduled to perform the analysis maintains control over sample integrity and container cleanliness; second, field crews are generally not equipped to appropriately handle hazardous chemicals like hydrochloric acid.

Sufficient ice chests and quantities of ice to manage all samples collected during the day (or shift) shall be maintained at the sampling site. Samples are maintained on ice, or if available in refrigerators at 6°C or less, from the time the sample control manager assumes custody until the samples are packed for shipment and relinquished to the shipper or other transport agent. All samples are shipped in ice chests packed with sufficient ice to maintain a temperature range of 6°C for at least 24 hours.

Analyses with associated containers, preservatives, and holding times must be provided in project-specific planning documents.

Section 7: Quality Assurance/Quality Control

Required chemical preservatives will be provided by the subcontracting laboratories in pre-preserved bottles or in separate containers that are added following sample collection. Field personnel shall

The receiving laboratory will measure the temperature within the ice chest immediately upon assuming custody of a shipment of samples. This temperature will be noted on the lab sample receipt form. Temperatures in excess of 6°C will be reported immediately to the project QAO. After consultation with the PM, the QAO will communicate whether re-sampling is necessary. Laboratories will check the pH of incoming samples to ensure that they have been properly preserved. If additional acid must be added to the samples by the lab, it shall notify the project manager or field supervisor and the samples must sit for an additional 18 hours before analysis.

Section 8: Documentation and Recordkeeping

Sample preservatives should be identified on the chain of custody form.

Section 9: References

Baird, R., & Bridgewater, L. 2017. Standard methods for the examination of water and wastewater. 23rd edition. American Public Health Association.U.S. Environmental Protection Agency (EPA). 1990a. *Statement of Work for Inorganics Analysis*, Document Number ILMO1.0, USEPA Contract Laboratory Program, March. November.

EPA. 1990b. *Test Methods for Evaluating Solid Waste*, Physical/Chemical Methods, SW-846, Third Edition, Final Update I, EPA Office of Solid Waste.

EPA. 1991. *Statement of Work for Organics Analysis*, Document Number OLMO1.0, EPA Contract Laboratory Program, June.

EPA. 1982. *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-82-055, December.

SOP-5
Groundwater Well Water Level Measurement

Standard Operating Procedure

Revised May 2022

SOP-5
Groundwater Well Water Level Measurement

Standard Operating Procedure

Revised May 2022

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Table of Contents

Groundwater Well Water Level Measurement 2
Section 1: Objective 2
Section 2: Scope and Applicability 2
Section 3: Responsibilities 2
Section 4: Definitions 2
4.1 Required Materials 3
4.2 Manual Measurement 3
4.3 Continuous Measurement 3
Section 5: Procedures 3
5.1 Preparation for Water Well Water Levels 4
5.2 Review of Existing Data 4
5.3 Well Inspection 4
5.4 Manual Water Level Measurement 4
5.5 Continuous Water Level Measurement 5
    5.5.1 Equipment Installation 5
    5.5.2 Data Retrieval and Reduction 5
Section 6: Quality Assurance/Quality Control 5
Section 7: Records 6
Section 8: References 6
Section 9: Attachments 6

SOP-5

Groundwater Well Water Level Measurement

Section 1: Objective

The objective of this standard operating procedure (SOP) is to provide the methods to be used for the consistent measurement of groundwater elevations in site monitoring wells.

Section 2: Scope and Applicability

This procedure is intended for the field acquisition and documentation of monitoring well water level data, measured as the depth to water from a surveyed reference point elevation. Groundwater levels may be monitored continuously using electronic data loggers and pressure-sensitive transducers, or obtained manually with a water level indicator or steel surveyor tape, at a prescribed frequency (e.g., weekly, monthly, or quarterly).

During a field investigation, groundwater levels may be obtained in association with monitor well development, purging and sampling, or aquifer testing. Successive measurements of groundwater levels over time in association with a long-term monitoring program may be used to assess seasonal and/or diurnal fluctuations, as well as the effects of any pumping wells on groundwater flow direction and gradient.

Section 3: Responsibilities

The project manager is responsible for ensuring that groundwater measurements are implemented in accordance with this SOP and any other site-specific or project-specific planning documents.

The field personnel are responsible for understanding and implementing this SOP during all field activities, as well as obtaining the appropriate field logbooks, forms, and records necessary to complete the field activities.

The site safety officer, typically the supervising field manager, is responsible for overseeing the health and safety of employees and for stopping work if necessary to fix unsafe conditions observed in the field.

Section 4: Definitions

Hydrograph. A plot of monitor well water level elevation versus time.

Potentiometric Surface. The level to which water will rise in a cased well under atmospheric pressure conditions.

Reference Point: Survey marker at the top of the well casing, or other selected point, at which a water level is to be measured from.

4.1 Required Materials

Planning for a groundwater-level monitoring event entails assessing, selecting, and testing the types of equipment and supplies necessary to perform the scope of work. Listed below are the basic types of equipment and supplies used for the measurement of water levels.

4.2 Manual Measurement

The following materials are necessary for performing manual groundwater measurements:

- Water level indicator (two-wire electrical sounder or conductivity meter), equipped with a sufficient length of cable to reach the deepest anticipated water level; the cable should be graduated into 0.01-foot intervals
- Extra batteries for the water level indicator
- Field forms (see Attachment A)
- Decontamination supplies (e.g., Alconox or other non-phosphate detergent, deionized or distilled water, brush, plastic bucket, clean spray bottles, paper towels, and clean plastic sheeting) used for decontamination of the water level indicator, interface probe and cable, or steel tape
- Keys for locked protective casings
- Tools (e.g., wrenches), as needed, to enter well vault boxes
- Health and safety monitoring equipment

4.3 Continuous Measurement

The following materials are needed for conducting continuous measurements of groundwater levels:

- Electronic data logger (with the appropriate number of channels, a function of the number of wells to be monitored simultaneously).
- Communications cables for dedicated downhole equipment, if applicable.
- Laptop computer for downloading data.
- Water level indicator (as described above).
- Pressure-sensitive transducers and barometric pressure transducer compatible with both water quality and anticipated pressure-sensitivity ranges in a given well
- Decontamination supplies (as described above).
- Keys for locked protective casings.

Section 5: Procedures

Groundwater-level measurements in monitoring wells shall be obtained manually using a two-conductor, battery-powered water level indicator (e.g., electrical sounder or conductivity meter) or steel surveyor tape. Continuous water level measurements may be obtained using a pressure transducer capable of storing measurements internally for periodic download. Monitoring of water levels will be conducted during groundwater sampling events, and at scheduled times during the field season. When water levels are measured during sampling events, the measurement will be collected before beginning any purging or water sampling activities.

5.1 Preparation for Water Well Water Levels

In preparation for a monitoring event, the geologist/environmental engineer shall review the site-specific planning documents to obtain the following information:

- The identification number(s) of the well or wells to be monitored
- The locations of the wells as shown on a site map
- Records listing the most recent water level measurements for the well(s) (if available)
- Well access requirements (e.g., permission of owner, locked gates, locked wells, and road conditions)
- Reference point (i.e., measuring point [MP]) information (e.g., elevation of casing and location of reference point)
- The types of equipment needed to perform the scheduled monitoring activity
- Calibration requirements for the equipment (if applicable)
- Health and safety considerations, as appropriate

Prior to water level measurements, an MP will be identified for each well and/or piezometer. The MP will be located on the north side of the top of well casing. The MP will be marked with a notch in the casing or marked with a permanent marker. This MP elevation will be surveyed by a licensed surveyor and will reference this elevation to an appropriate datum (i.e., above mean sea level). A well monitoring form, or similar form, shall be used to record groundwater level measurements and supporting information. In addition, fluid level measurements should be recorded in a bound field notebook.

5.2 Review of Existing Data

The geologist/environmental engineer may elect to prepare a hydrograph with the groundwater level data available for each well (or update an existing hydrograph) prior to going to the field. A hydrograph provides a visual record of groundwater level fluctuations over time. A hydrograph can be useful to identify any water level measurements that appear anomalous because of changes in conditions (e.g., a groundwater level rise because of a rainfall event or events, or a drop in water level because of the initiation of pumping at a nearby well).

If groundwater levels are obtained at a regular frequency (e.g., monthly or quarterly), the geologist/environmental engineer may plot groundwater elevation contour maps based on the data obtained during each monitoring event at a given site. Changes in the interpretation of the potentiometric surface configuration may be readily observed when the contour maps are compared, and may be indicative of a change(s) in conditions in the hydrogeologic regime.

5.3 Well Inspection

Prior to obtaining a water level in a given well, its condition shall be inspected. Any signs of vandalism, unauthorized entry, or settlement and/or ponding around the well surface completion shall be noted.

5.4 Manual Water Level Measurement

Prior to measuring depth to water, the well cover shall be removed and left off for at least 3 minutes prior to conducting measurements. Indications of air movement in or out of the well should be noted.

The probe of the electric water level indicator shall be lowered into the riser casing until water is encountered, as indicated by the instrument signal. The water level is then measured with respect to the “top-of-casing” reference point and entered on the field log. Two additional water level measurements shall be made to verify the initial reading obtained. It is good practice to visually inspect the measuring tape/probe to ensure that it is not missing sections and the numbers are accurate. The electric water level meter shall be calibrated at least once during and prior to each data collection event by comparison to a steel surveyor’s tape.

The water level measurement shall be compared to the most recent water level obtained for the well (if any). If the measurements differ by more than 0.5-foot, the depth to water shall be measured a second time for verification purposes. A remark shall be made on the field log if a probable cause for the discrepancy is known (e.g., rainfall event, or startup of a nearby pumping well).

Field measurements of water levels for a given well shall be recorded on the field form, including the following information:

- The type of measurement device used
- Date and time of the measurement
- Any pertinent remarks concerning the well condition, instrument malfunction, variation of the sounded depth versus the installed depth of the well, etc.

5.5 Continuous Water Level Measurement

Continuous water level data may be required for certain field investigation activities. Dedicated pressure transducers equipped with internal memory to store water level readings are typically used for continuous water level measurement on a short-term (e.g., aquifer test) or long-term (i.e., multi-year) basis.

5.5.1 Equipment Installation

The pressure transducer cable shall be installed by the geologist/environmental engineer in accordance with the manufacturer's instructions. The transducer cable shall be lowered into the well and secured with plastic tie strips to the riser casing or protective well casing. The cable shall be positioned such that it does not interfere with closing and locking of the well protective casing; the cable shall be positioned such that it is not pinched.

5.5.2 Data Retrieval and Reduction

Data from the transducers are downloaded on a regular basis (ex. quarterly), typically concurrent with the groundwater well water quality sampling events. Manual water level and the depth to water indicated on the transducer at the time of manual measurement should be recorded for comparison.

Instructions for data download are specific to each brand of pressure transducer equipment. The instruction manuals in Attachment A are specific to the site equipment being used, the software for the type of transducers, and methods for data reduction.

Section 6: Quality Assurance/Quality Control

To promote consistency of data, water level measurements in a given well should be obtained with the same measuring device as used during previous monitoring events.

As a quality assurance/quality control (QA/QC) check on the accuracy of pressure transducer water level measurements, periodic manual measurement of water levels shall be performed as a check on the water level data readings from a pressure transducer.

Section 7: Records

The geologist/environmental engineer shall submit copies of water level forms to the project manager (or designee) immediately following the monitoring event for checking and revision purposes. The project manager (or designee) shall review and transmit the completed forms for incorporation into the project file.

Section 8: References

American Society of Testing and Materials (ASTM). 1988. D 4750-87. *Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)*.

U.S. Environmental Protection Agency (EPA). 1986. *RCRA Groundwater Monitoring Technical Enforcement Document*, OSWER-9950.1.

EPA. 1987. *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001.

Section 9: Attachments

Attachment A: Transducer Instruction Manuals

Attachment A: Transducer Instruction Manuals

Quick Reference Guide

Barometric Compensation

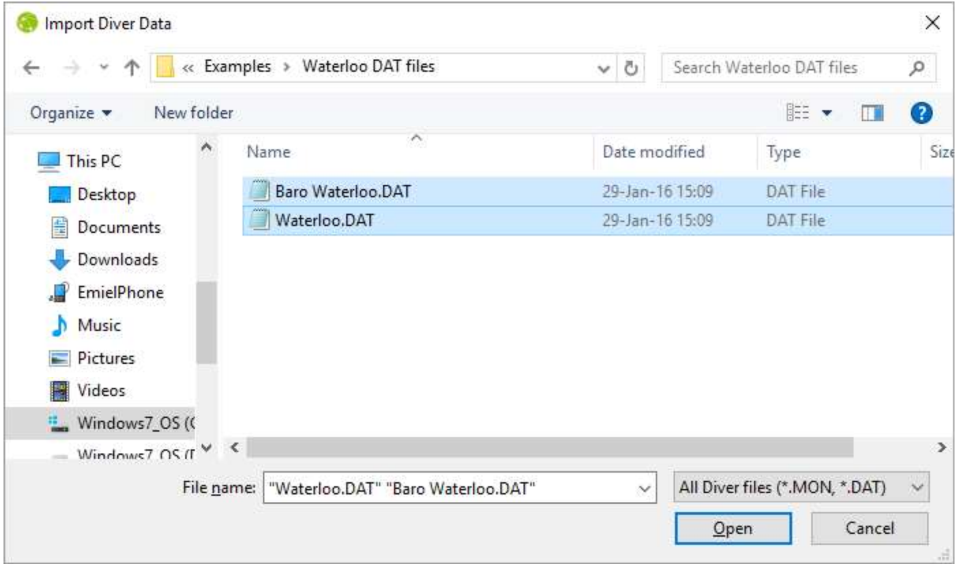
Introduction

This document outlines the basics to perform the barometric compensation. Please refer to the Diver-Office help for more details.

Importing Sample Data

Diver-Office comes with example data. The default folder is **C:\Program Files\Diver-Office\Examples**.

1. In Diver-Office click on the menu bar item **Import > Diver Data...** (CTRL+E). **I**n the dialog that opens navigate to the **Waterloo DAT files** folder in the **Examples** folder (**C:\Program Files\Diver-Office\Examples\Waterloo DAT files**). **Change the Files** of type to **DAT**.



Name	Date modified	Type	Size
Baro Waterloo.DAT	29-Jan-16 15:09	DAT File	
Waterloo.DAT	29-Jan-16 15:09	DAT File	

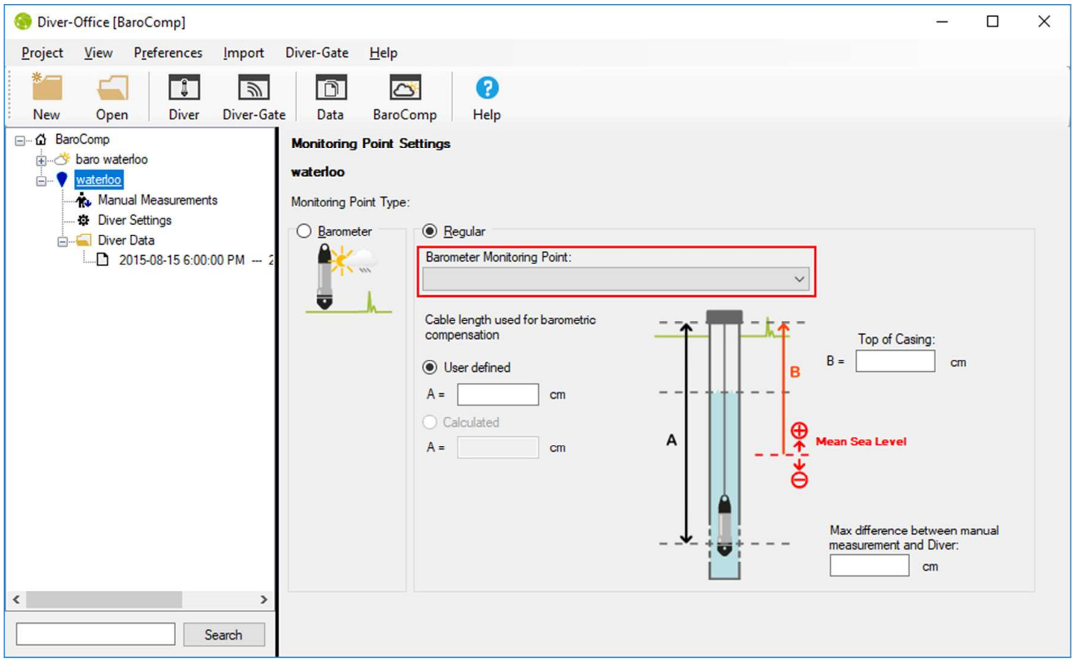
File name: "Waterloo.DAT" "Baro Waterloo.DAT"

All Diver files (*.MON, *.DAT)

2. Select the two files and click **[Open]**.

Setting the barometer

One of the imported data series is now shown. Click on **Waterloo** in the tree view on the left. The screen should no look something like the window shown below. Note that the **Barometer Monitoring Point** field is blank. To perform the barometric compensation this field must contain a value.



Monitoring Point Settings

waterloo

Monitoring Point Type:

○ Barometer ● Regular

Barometer Monitoring Point:

Cable length used for barometric compensation

● User defined

A = cm

○ Calculated

A = cm

Top of Casing:

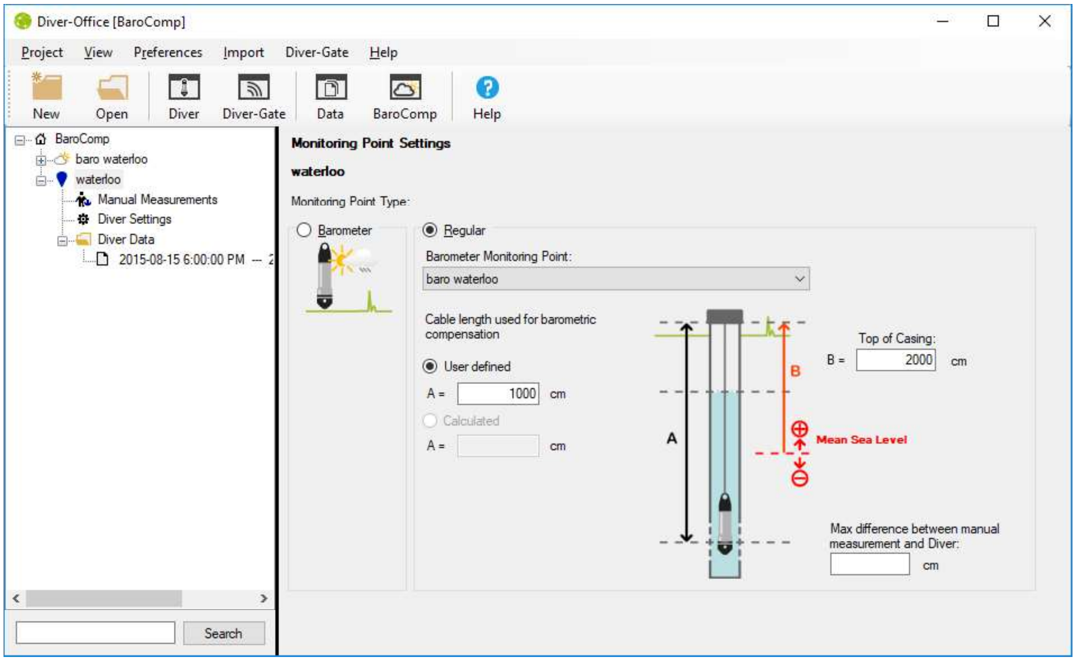
B = cm

Max difference between manual measurement and Diver:

cm

1. From the **Barometer Monitoring Point** dropdown list select **baro waterloo**.
2. Enter a value for the cable length (**A**) if the barometric compensation should calculate the depth to water
3. Enter a value both (**A**) and for the top of casing (**B**) if the barometric compensation should calculate the water level with respect to Mean Sea Level.

The window should now be similar to the window shown below:



Monitoring Point Settings

waterloo

Monitoring Point Type:

○ Barometer ● Regular

Barometer Monitoring Point: baro waterloo

Cable length used for barometric compensation

● User defined

A = 1000 cm

○ Calculated

A = cm

Top of Casing:

B = 2000 cm

Max difference between manual measurement and Diver:

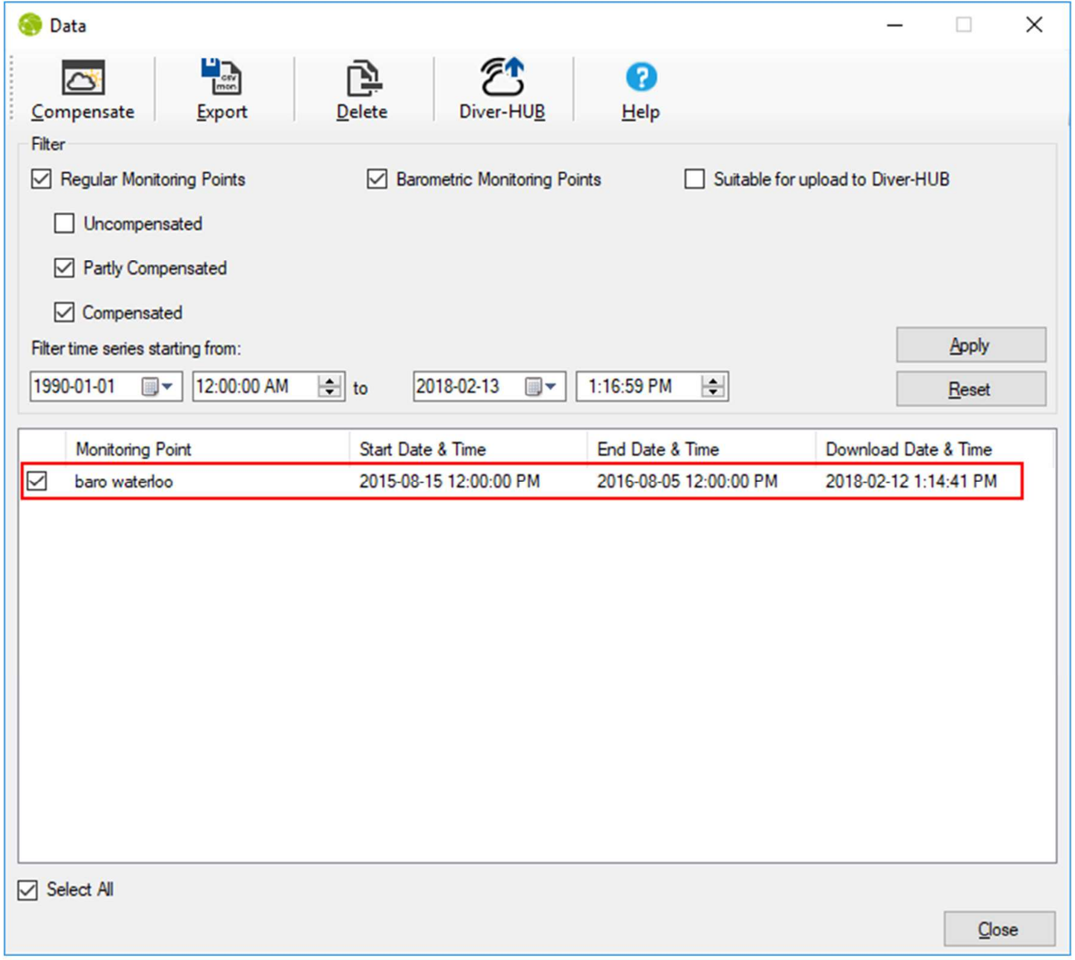
cm

Compensating Diver Data

1. Click the **BaroComp** button from the main toolbar.

   *You may also right click on the data set in the project tree to go directly to the BaroCompensation dialog.

2. Select one or more time-series data from the Data dialog.



Filter

☑ Regular Monitoring Points ☑ Barometric Monitoring Points ☐ Suitable for upload to Diver-HUB

☐ Uncompensated

☑ Partly Compensated

☑ Compensated

Filter time series starting from:

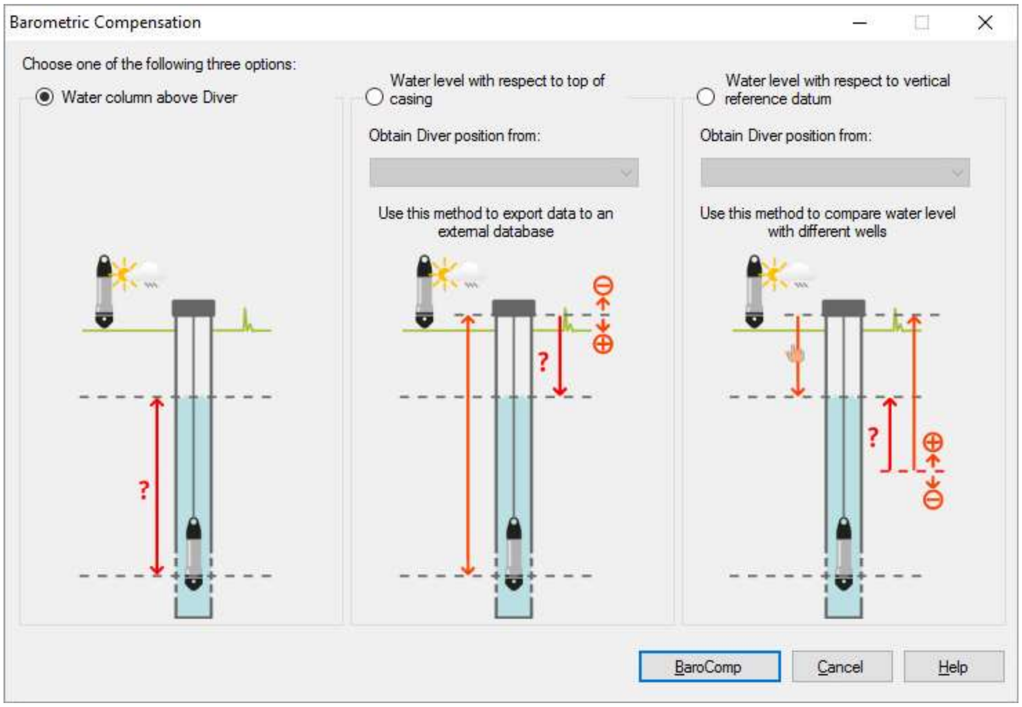
1990-01-01 12:00:00 AM to 2018-02-13 1:16:59 PM

	Monitoring Point	Start Date & Time	End Date & Time	Download Date & Time
☑	baro waterloo	2015-08-15 12:00:00 PM	2016-08-05 12:00:00 PM	2018-02-12 1:14:41 PM

☑ Select All

3. Select the **BaroComp** button from the Data dialog toolbar.
4. Select the desired barometric compensation method from the **BaroComp** dialog (shown on following page). You may choose from five barometric compensation methods:
   a. Water Column above Diver
   b. Water level with respect to Top of Casing *using Cable Length*
   c. Water level with respect to Top of Casing *using Manual Measurement*
   d. Water Level with respect to VRD *using Cable Length*
   e. Water Level with respect to VRD *using Manual Measurement*

   Note: Each barometric compensation method requires that certain data be entered before the compensation can be performed. Please refer to the Diver-Office user's manual for more information on the data requirements for each compensation method.



Barometric Compensation

Choose one of the following three options:

● Water column above Diver

○ Water level with respect to top of casing

Obtain Diver position from:

Use this method to export data to an external database

○ Water level with respect to vertical reference datum

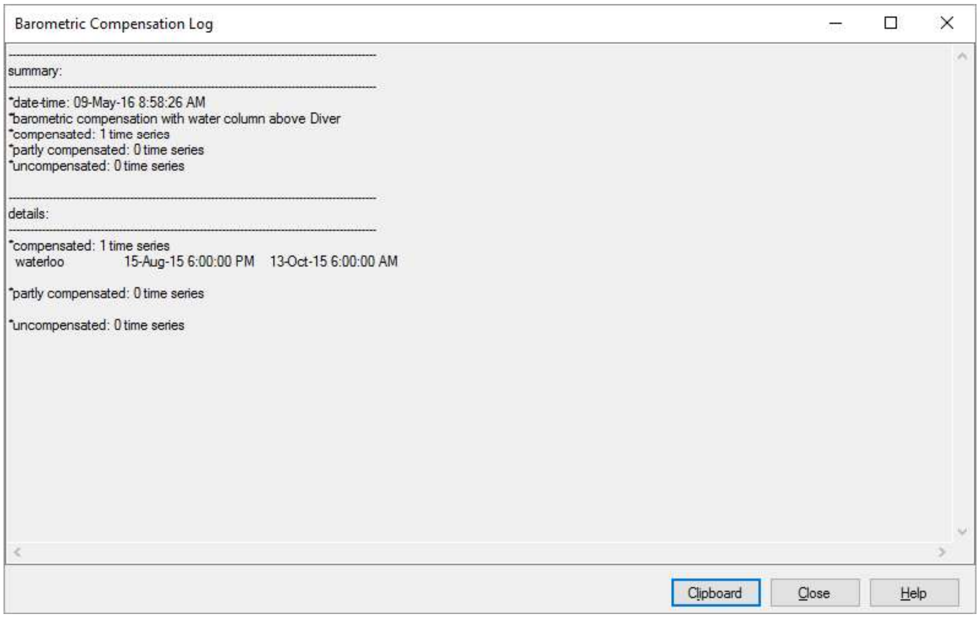
Obtain Diver position from:

Use this method to compare water level with different wells

5. Once the method is chosen, select the **[BaroComp]** button to perform the barometric compensation.

   Note: If the compensation fails, the type of missing information will be indicated in the log dialog.

6. When the compensation is complete, the barometric compensation log will show, displaying a summary with details.



Barometric Compensation Log

```
--------------------------------------------------------------------------------
summary:
--------------------------------------------------------------------------------
*date-time: 09-May-16 8:58:26 AM
*barometric compensation with water column above Diver
*compensated: 1 time series
*partly compensated: 0 time series
*uncompensated: 0 time series

--------------------------------------------------------------------------------
details:
--------------------------------------------------------------------------------
*compensated: 1 time series
 waterloo             15-Aug-15 6:00:00 PM    13-Oct-15 6:00:00 AM

*partly compensated: 0 time series

*uncompensated: 0 time series
```

7. Click the **[Close]** button to finish. You can now view the compensated data in the time series table and plot. You will notice that the time series symbol in the **Project Tree** will change once compensation has been performed:

    - 🗋⚠ means that the data was Partially Compensated
    - 🗋✓ means that all the data in the time series was Compensated
    - 🗋 means that the data is Uncompensated.

Quality Systems Manual

Effective Date: 5/27/2022

Rebecca Nichols
General Manager (pending)

Rebecca L Nichols
Signature

Kaprie S. Santjer
Quality Assurance Officer

Kaprie Santjer
Signature

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Introduction

The SGS North America Inc. Quality Assurance System, detailed in this plan, has been designed to meet the quality program requirements of The National Environmental Laboratory Accreditation Program (NELAP) and other National environmental monitoring programs. The plan establishes the framework for documenting the requirements of the quality processes regularly practiced by the Laboratory. The Quality Assurance Officer is responsible for changes to the Quality Assurance Program, which are appended to the Quality System Manual (QSM) during the annual program review. Changes that are incorporated into the plan are itemized in a summary of changes following the introduction.

The SGS North America Inc. Quality System Manual is supported by Standard Operating Procedures (SOPs), which provide specific operational instructions on the execution of each quality element and assure that compliance with the requirements of the plan are achieved. SGS North America Inc. employees are responsible for knowing the requirements of the SOPs and applying them in the daily execution of their duties. These documents are updated as changes occur and the staff is trained to apply the changes.

At SGS North America Inc., we believe that satisfying client requirements and providing a product that meets or exceeds the standards of the industry is the key to a good business relationship. However, client satisfaction cannot be guaranteed unless there is a system that assures the product consistently meets its design requirements and is adequately documented to assure that all procedural steps are executed, properly documented and traceable.

This Quality System Manual has been designed to assure that this goal is consistently achieved. We strive to have the SGS North America Inc. products withstand the rigors of scrutiny that are routinely applied to analytical data and the processes that support its generation.

Summary of Changes
SGS North America Inc. – Wheat Ridge

Section	Description
-----------	Updated cover Page, Revision Number and Date
1.2	Revision & updated statement
2.2	updated & combined Quality responsibilities into section, added operations manager & QAO
2.3	Updated Chain of Command, added Mark Beech, Jason Savoie, Rebecca Nichols
2.4	Revised & updated Org. Chart with generic form
3.0	changed title to Quality System; combined quality responsibilities with section 2.2
3.8	revised and included 24-hr phone & website hotline
4.1	Added operations manager & QAO
5.3	Added section: electronic signature log
6.0	Added section: control documents
6.6	Added section: operator's manuals
7.2.1	Added Section: weights requirements
throughout	changed EHS to IE
throughout	added general manager
Revised sections	Sections: 7.0, 7.1, 7.2, 7.4, 7.5, 7.8, 8.10, 8.15,9.1, 11.0-11.2, 12.10, 17.2.1, 18.8
Editorial changes	Sections: 3.1, 3.2, 3.3, 3.4, 3.6, 3.7, 3.9, 3.10, 4.1, 4.2, 5.0, 6.3, 6.5, 6.6, 6.8, 6.9.6, 6.12, 6.14, 6.15, 8.3, 8.6.2, 8.6.5, 8.7.2.2, 8.8, 8.9, 8.11.4, 8.12, 8.13, 8.14, 9.2 (+added indelible ink), 9.3-9.10, 9.13, 10.0, 10.1, 10.3-10.6, 10.6.3, 12.0, 12.2.2, 12.2.3, 12.2.4, 12.3, 12.3.1, 12.3.5-12.3.7, 12.4-12.7, 12.7.1, 12.7.4, 12.8, 12.9, 13.1.3, 13.2.2, 13.3, 14.1, 14.3-14.5, 14.7, 15.1, 15.2, 15.4, 16.0, 16.1, 17.2.2, 17.3, 17.4, 18.1, 18.3, 18.7, 19.2, 19.3
Appendix I	Added & amended terms
Appendix II	updated
Appendix III	updated
Appendix IV	removed specific table; referenced document outside of QSM
Appendix V	updated

Table of Contents

Section **Title** **Page**

Mission and Quality Policy 5
Organization 8
Quality System 12
Job Descriptions of Key Staff 19
Signatory Approvals 24
Documentation and Document Control 26
Reference Standard Traceability 31
Test Procedures, Method References, & Regulatory Programs 34
Sampling, Sample Management, Login, Custody, Storage & Disposal 41
Laboratory Instrumentation and Measurement Standards 48
Instrument Maintenance 51
Quality Control Parameters, Procedures, and Corrective Action 53
Corrective Action System 61
Procedures for Executing Client Specifications 64
Client Complaint Resolution and Data Inquiry Procedure 67
Control of Nonconforming Product 68
Confidentiality Protection Procedures 69
Quality Audits & System Reviews 71
Health & Safety 73

Appendices

I. Glossary of Terms 76
II. Analytical Capability 87
III Certification Summary 92
IV. Laboratory Equipment 93
V. Active SOP List 94

MISSION AND QUALITY POLICY

<u>SGS North America Inc. Mission</u>:

SGS North America Inc. provides analytical services to commercial and government clients in support of environmental monitoring and remedial activities as requested. SGS North America Inc.'s mission is dedicated to providing reliable data that satisfies client's requirements as explained in the following statement:

"Deliver value to our clients by providing easy access to accurate and timely analytical information which meets or exceeds client expectations."

These services are provided impartially and are not influenced by undue commercial or financial pressures which might impact the staff's technical judgment. SGS North America Inc. does not engage in activities that endanger the trust in our independent judgment and integrity in relation to the testing activities performed.

QUALITY POLICY AND PROFESSIONALISM STATEMENT:

Quality and professionalism are integral parts of the SGS's operations and the cornerstone for ensuring high levels of customer satisfaction. Through mutually beneficial partnerships and continued operational excellence we ensure the long-term sustainability of our business.

IT IS OUR AIM TO

- Deliver world-class services that meet our customers' needs.
- Build strong customer relationships based on trust, mutual respect and the prioritization of the needs of the customer.
- Be known and recognized for our superior knowledge, reliability, accuracy and consistency.
- Nurture and encourage a culture of quality within SGS with the full support of management and engagement of all employees.

IT IS THEREFORE OUR COMMITMENT TO

- Place customers at the heart of everything we do, engaging proactively with their needs.
- Maintain flexibility, listening to industry and customer needs and expectations and actively evolving our quality statement to meet them.
- Continuously challenge ourselves to improve our quality management system by setting and reviewing our objectives, risks, KPIs, results and customer satisfaction levels.
- Develop and maintain the processes we need to deliver high quality, optimized and coherent services.
- Continuously measure, maintain and increase SGS's knowledge base through a sustainable processes of talent recruitment and training.
- Respect client confidentiality and individual privacy while remaining transparent in all other aspects of our work.
- Protect SGS's intellectual property and know-how.
- Embody the SGS brand and its independence in all that we do.

Delivering quality and professionalism is an individual responsibility for all of us, at every level within our organization.
These commitments apply to all SGS employees and contractors.
Management is responsible for ensuring full compliance with SGS policies.

FRANKIE NG
Chief Executive Officer

This version cancels and replaces all previous Quality policy statements.

The English version of this document constitutes the binding version.

WHEN YOU NEED TO BE SURE SGS

The following is implied in this policy:

- Commitment to comply with the latest requirements of The NELAC Institute
- Commitment to continually improve the effectiveness of the quality management system
- Commitment to good professional practices
- Commitment to the quality of our services
- Commitment that analytical testing will be carried out to stated methods and client requirements
- All personnel must familiarize themselves with the Quality Policy, Quality System Manual and implement all policies and procedures related to their jobs.

Management ensures that this quality policy is communicated and understood within SGS North America Inc. The policy is reviewed periodically for continued suitability.

ORGANIZATION

Organizational Entity. SGS North America Inc. is part of the SGS organization with headquarters in Geneva, Switzerland. Conventional US laboratories are maintained in Dayton, New Jersey; Orlando, Florida; Houston, Texas; Wheat Ridge, Colorado; and Scott, Louisiana. SGS North America Inc. - Wheat Ridge is the Colorado division of SGS North America Inc. The facility is located in Wheat Ridge, Colorado where it has conducted business since 1988.

Management Job Responsibilities and Quality Responsibilities

Requirement: Each laboratory facility has an established chain of command. The duties and responsibilities of the management staff are linked to the Vice President of Industries and Environment (IE) of SGS North America Inc. who establishes the agenda for all company activities. Each member of the management team has a defined responsibility for the Quality System. System implementation and operation are designated as an operational management responsibility.

Vice President IE SGS North America Inc. Primary responsibility for all operations and business activities. Responsible for process improvements to all business aspects of the company. Establishes the company mission and objectives in response to business needs. Delegates authority to Vice President of Operations – Conventional Lab Services, US and laboratory directors/general managers to conduct day to day operations and execute quality assurance duties. Each of the five operational entities (New Jersey, Florida, Texas, Colorado, and Louisiana) report to the Vice President Operations – Conventional Lab Services, US.

Vice President of Operations – Conventional Lab Services, US. Design, oversight, and facilitation responsibility for all operational activities, including the quality system elements identified in the quality program. Identifies product, process, or operational quality defects for improvement via corrective action. Has the authority to delegate quality system implementation responsibilities. Empowered with the authority to halt production if quality issues warrant immediate action. Reports directly to the Vice President IE SGS North America Inc.

Laboratory Director/General Manager. Executes day to day responsibility for laboratory operations including technical aspects of production activities and associated logistical procedures and the quality program. Responsible for implementing and operating the Quality System in all laboratory areas. Responsible for the design and implementation of corrective action for defective processes. Has the authority to delegate Quality System implementation responsibilities. Empowered with the authority to halt production if quality issues warrant immediate action. Reports directly to the Vice President of Operations – Conventional Lab Services, US.

Operations Manager. Responsible for the daily function of business operations, including but not limited to, the organics and inorganics laboratories and sample management. They coordinate the laboratory and operations to meet clients' expectations. The Operations Manager manages sample through put through the entire operation to ensure turnaround times are met while maintaining data quality that meets or exceeds industry standards. They are responsible for promoting a safe working environment and culture throughout the laboratory. Reports directly to the Laboratory Director/General Manager.

Quality Assurance Director *(corporate).* Design, implementation, support, training, monitoring, oversight, and facilitation responsibility for all Quality System elements identified in the Quality Program. Identifies product, process, or operational defects using statistical monitoring tools and processes audits for elimination via corrective action. Empowered with the authority to halt production if quality issues warrant immediate action. Monitors implemented corrective actions for compliance. Responsible for Quality System standardization and continuous improvement across the conventional US network. Reports directly to the Vice President IE SGS North America Inc. **and remains independent of operations.**

Quality Assurance Officer (QAO) *(local).* Responsible for design support, implementation support, training, and monitoring support for the quality system. Conducts internal audits to identify product, process, or operational defects using statistical monitoring tools, and processes audits for elimination via corrective action, quality training, training records, document control and accreditations. Provides support for and monitors implemented corrective actions for compliance. Empowered with the authority to halt production if quality issues warrant immediate action. Individual laboratory Quality Assurance Officers report to the Director of QA and are independent of operations.

Technical Managers (Organics/Inorganics). Responsible for day to day operations and activities of the organics and inorganics laboratories including scheduling, production and data quality, and for overseeing the technical aspects of the Quality System as they are integrated into method applications and data quality control. The Technical Managers review and acknowledge the technical feasibility of proposed QA systems involving technical applications of applied methodology. Technical Managers meet the requirements of Section 5.2.6.1 of the 2016 TNI Standards. Reports directly to the Operations Manager.

Department Managers. Executes day to day responsibility for specific laboratory areas including technical aspects of production activities and associated logistical procedures. Responsible for applying the requirements of the Quality System in their departments and assuring the staff apply all Quality System requirements. Initiates, designs, documents, and implements corrective action for quality deficiencies. Reports directly to the Operations Manager.

Section Supervisors and Team Leaders. Executes day to day responsibility for specific laboratory units including technical aspects of production activities, associated logistical procedures and the quality program. Responsible for applying the requirements of the Quality System to their departments and assuring the staff applies all Quality System requirements. Initiates, designs, documents, and implements corrective action for quality deficiencies. Reports directly to the Department Manager.

Bench Analysts, QA Responsibilities. Responsible for applying the requirements of the Quality System to the analyses they perform, evaluating QC data and initiating corrective action for quality control deficiencies within their control. Implements global corrective action as directed by superiors.

Chain of Command

The responsibility for managing all aspects of the Company's Wheat Ridge operation is delegated to specific individuals, who have been assigned the authority to act in the absence of the senior staff. These individuals are identified in the following Chain of Command:

Marcus Maguire, Vice President IE SGS North America Inc.
Mark Beech, Vice President Operations – Conventional Lab Services, US
Jason Savoie, Laboratory Director/General Manager
Rebecca Nichols, Laboratory Director/General Manager (pending)

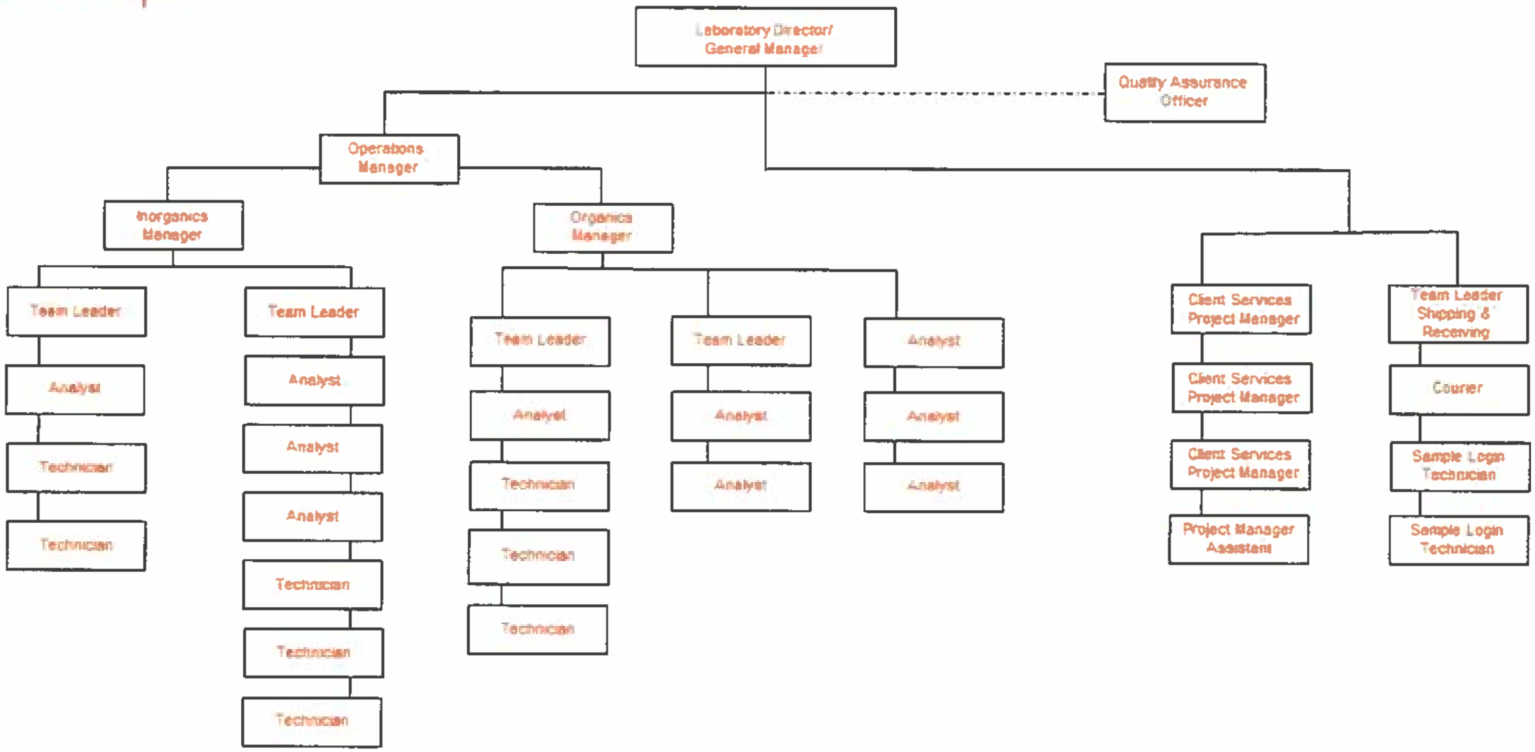
Organization Chart

The hierarchy of the Company's operational control and oversight is illustrated in the SGS North America Inc. Organization Chart.

If a Technical Manager is absent for a period of time exceeding fifteen (15) consecutive calendar days, the laboratory shall designate another staff member meeting the qualifications of the technical manager to temporarily perform this function. If this absence exceeds thirty-five (35) consecutive calendar days, the primary accreditation body shall be notified in writing. Some State Accrediting Bodies require notification within 30 days.

A general organization chart is presented in this document. A detailed organization chart is kept as a separate document outside of this document.

SGS NORTH AMERICA INC. – WHEAT RIDGE, CO



QUALITY SYSTEM

Program Authority for program implementation originates with the Vice President IE SGS North America Inc. who bears the ultimate responsibility for system design, implementation, and enforcement of requirements. This authority and responsibility are delegated to the Vice President of Operations – Conventional Lab Services, US, who performs quality functions independently without the encumbrances or biases associated with operational or production responsibilities to ensure an honest, independent assessment of quality issues.

Data Integrity Policy. The SGS North America Inc. Data Integrity Policy reflects a comprehensive, systematic approach for assuring that data produced by the laboratory accurately reflect the outcome of the tests performed on field samples and have been produced in a bias free environment by ethical professionals. The policy includes a commitment to technical ethics, staff training in ethics and data integrity, an individual attestation to data integrity, and procedures for evaluating data integrity. Senior management assumes the responsibility for assuring compliance with all technical ethics elements and operation of all data integrity procedures. The staff is responsible for compliance with the ethical code of conduct and for practicing data integrity procedures.

The SGS North America Inc. Data Integrity Policy is as follows:

"SGS North America Inc. is committed to producing data that meets the data integrity requirements of the environmental regulatory community. This commitment is demonstrated through the application of a comprehensive data integrity program that includes ethics and data integrity training, data integrity evaluation procedures, staff participation and management oversight. Adherence to the specifications of the program assures that data provided to our clients is of the highest possible integrity and can be used for decision making processes with high confidence."

Data Integrity Responsibilities

Management. Senior management retains oversight responsibility for the data integrity program and retains ultimate responsibility for execution of the data integrity program elements. Senior management is responsible for providing the resources required to conduct ethics training and operate data integrity evaluation procedures. This also includes the responsibility for creating an environment of trust among the staff and being the lead advocate for promoting the Data Integrity Policy and the importance of technical ethics. The Vice President IE SGS North America Inc. is the designated ethics officer for the Company.

Staff. The staff is responsible for adhering to the company ethics policy as they perform their duties and responsibilities associated with sample analysis and reporting. By executing this responsibility, data produced by SGS North America Inc. retains its high integrity characteristics and withstands the rigors of all data integrity checks.

The staff is also responsible for adhering to all laboratory requirements pertaining to manual data edits, data transcription and data traceability. These include the application of approved manual peak integration and documentation procedures. It also includes establishing traceability for all manual results calculations and data edits.

Ethics Statement. The SGS North America Inc. Ethics Statement reflects the standards that are expected for businesses that provide environmental services to regulated entities and regulatory agencies on a commercial basis. The Ethics Policy is comprised of key elements that are essential to organizations that perform chemical analysis for a fee. As such, it focuses on elements related to personnel, technical, and business activities.

SGS North America Inc. provides analytical chemistry services on environmental matters to the regulated community. The data the Company produces provide the foundation for determining the risk presented by a chemical pollutant to human health and the environment. The environmental industry is dependent upon the accurate portrayal of environmental chemistry data. This process is reliant upon a high level of scientific and personal ethics.

It is essential to the Company that each employee understands the ethical and quality standards required to work in this industry. Accordingly, SGS North America Inc. has adopted a code of ethics, which each employee is expected to adhere to as follows:

- Perform chemical and microbiological analysis using accepted scientific practices and principles.
- Perform tasks in an honest, principled and incorruptible manner inspiring peers & subordinates.
- Maintain professional integrity as an individual.
- Provide services in a confidential, honest, and forthright manner.
- Produce results that are accurate and defensible.
- Report data without any considerations of self-interest.
- Comply with all pertinent laws and regulations associated with assigned tasks and responsibilities.

Data Integrity Procedures. Four key elements comprise the SGS North America Inc. Data Integrity System. Procedures have been implemented for conducting data integrity training and for documenting that employees conform to the SGS North America Inc. Data Integrity and Ethics policy.

The data integrity program consists of routine data integrity evaluation and documentation procedures to periodically monitor and document data integrity. These procedures are documented as SOPs. SOPs are approved and reviewed annually following the procedures employed for all SGS North America Inc. SOPs. Documentation associated with data integrity evaluations is maintained on file and is available for review.

Data Integrity and Ethics Training. SGS North America Inc. employees receive technical ethics training shortly after new employee orientation and sign a Data Integrity and Ethical Conduct Agreement. Employees are also required to refresh their ethical conduct agreement annually, which verifies their understanding of SGS North America Inc. ethics policy and their ethical responsibilities. The refreshed agreement is stored in each individual's training file.

The training focuses on the reasons for technical ethics training, explains the impact of data fraud on human health and the environment, and illustrates the consequences of criminal fraud on businesses and individual careers. SGS North America Inc.'s ethics policy and code of ethics are reviewed and explained.

Training on technical data integrity procedures are conducted for groups involved in data operations. These include procedures for manual chromatographic peak integration, traceability for manual calculations, and data transcription.

Data Integrity Training Documentation. Records of all data integrity and ethics training are maintained in individual training folders. Attendance at all training sessions is mandatory for all staff and is documented and maintained for all staff.

SGS North America Inc. Data Integrity and Ethical Conduct Agreement.
All employees are required to sign a Data Integrity and Ethical Conduct Agreement annually. The signed agreements are retained for the duration of an employee's employment in their individual training file.

The Data Integrity and Ethical Conduct Agreement is as follows:

I. I understand the high ethical standards required of me with regard to the duties I perform and the data I report in connection with my employment at SGS North America Inc.

II. I have received formal instruction on the code of ethics that has been adapted by SGS North America Inc. and agree to comply with these requirements.

III. I have received formal instruction on the elements of SGS North America Inc.'s Data Integrity Policy and have been informed of the following specific procedures:

a. Routine data integrity monitoring is conducted on sample data, which may include an evaluation of the data I produce,

b. Formal procedures for the confidential reporting of data integrity issues are available, which can be used by any employee,

c. A data integrity investigation is conducted when data issues are identified that may negatively impact data integrity.

IV. I have attended the Data Integrity training detailing SGS North America Inc. Laboratory's Data Integrity and Ethics Program and have read the SGS North America Inc. - Wheat Ridge Data Integrity and Ethics SOP as required.

V. I am aware that data fraud is a punishable crime that may include fines and/or imprisonment upon conviction.

VI. I also agree to the following:

a. I shall not intentionally report data values (QC results, dry labbing), which are not the actual values observed or measured.

b. I shall not intentionally modify (through the use of) improper manual integration, unwarranted software manipulation, QC misrepresentation) data values unless the modification can be technically justified through a measurable analytical process.

c. I shall not intentionally report dates and times of data analyses that are not the true and actual times the data analyses were conducted.

d. I shall not condone any accidental or intentional reporting of inauthentic data by other employees and immediately report its occurrence to my superiors.

e. I shall immediately report any accidental reporting of inauthentic data by myself to my superiors.

f. I will, at all times, handle client samples and SGS North America Inc. instrumentation as required by the SGS North America Inc. Standard Operating Procedures.

g. I will not intentionally deviate from, or fail to follow, the SGS North America Inc. Standard Operating Procedures at any time except as authorized by this document.

h. I understand that deviations from a Standard Operating Procedure are allowed only when the deviations are clearly presented in writing by supervisory, managerial or director level staff and when those deviations do not contradict any part of the SGS North America Inc. ethics policy. No other personnel are allowed to approve Standard Operating Procedure deviations.

i. Anytime someone suggests, recommends, or requests that I do not follow an SGS North America Inc. Standard Operating Procedure, other than as noted in h. above, I shall immediately notify my supervisor, manager, a Quality Assurance Officer, the Laboratory Director, or the Director of Human Resources.

j. Anytime I am uncomfortable or unsure about an action that I am requested to perform, I shall immediately notify my supervisor, manager, a Quality Assurance Officer, the Laboratory Director, or the Director of Human Resources. By doing so, I understand that I will not be punished or penalized for asking for guidance or reporting potential wrongdoing.

k. If I intentionally disregard the SGS North America Inc. Standard Operating Procedures without written authorization to do so, I may face disciplinary action up to and including termination of my employment. Note: unintentional deviation from a Standard Operating Procedure must be documented on discovery and appropriate corrective actions followed.

l. If I become aware of another person who appears to be disregarding the SGS North America Inc. Standard Operating Procedures without written authorization to do so, I *shall immediately report it to my supervisor, manager, a Quality Assurance Officer, the Laboratory Director, or the Director of Human Resources. By failing to do so, I may face disciplinary action up to and including termination of my employment.*

m. *I am aware that intentionally failing to follow an SGS North America Inc. Standard Operating Procedure, other than as noted in h. above, may be illegal and could be considered data fraud. In addition, providing instruction to another person to deviate from a Standard Operating Procedure, other than as noted in h. above, may be illegal and could be considered data fraud.*

n. *I am aware that data fraud is a crime and is punishable by fines and/or imprisonment upon conviction. It is the general policy of SGS North America Inc. to cooperate with law enforcement authorities in the investigation and prosecution of such matters.*

o. *I understand that SGS North America Inc. strictly prohibits unlawful retaliation, and I understand that if I report a violation of the SGS North America Inc. Standard Operating Procedures or an instruction that would violate the SGS North America Inc. Standard Operating Procedures, I will not be subjected in any way to any adverse employment action because of my report. I agree that if I believe I am being, or have been, subjected to an adverse employment action because of my report, I will immediately notify my supervisor, manager, a Quality Assurance Officer, the Laboratory Director, or the Director of Human Resources. I agree that SGS North America Inc. cannot address or correct any such retaliatory behavior unless it is reported and SGS North America Inc. is given an opportunity to address or correct such behavior.*

Data Integrity Monitoring. Documented procedures are employed for performing data integrity monitoring. These include regular data review procedures by supervisory and management staff (Section 12.8), supervisory review and approval of manual integrations and periodic reviews of GALP audit trails from the LIMS and all computer controlled analyses.

Data Review. All data produced by the laboratory undergoes several levels of review, which include two levels of management review. Detected data anomalies that appear to be related to data integrity issues are isolated for further investigation. The investigation is conducted following the procedures described in this section.

Manual Peak Integration Review and Approval. Routine data review procedures for all chromatographic processes include a review of all manual chromatographic peak integrations. This review is performed by the management staff and consists of a review of the software integration compared to the manual integration. Manual integrations, which have been performed in accordance with SGS North America Inc.'s manual peak integration procedures, are approved for further result processing and release. Identification of samples and analytes in which manual integration had been necessary may be recorded in a report case narrative specific to a particular client and project requirement.

Manual integrations which are not performed to SGS North America Inc. specifications are set aside for corrective action, which may include analyst re-training or further investigation as necessary. Annual manual integration training is conducted for all chromatography staff; refer to SOP MSQA-Ethics.

Data Integrity Review. Data integrity audits are comprehensive data package audits that include a review of raw data, process logbooks, processed data reports and GALP audit trails from individual instruments and LIMS. GALP audit trails, which record all electronic data activities, are available for the majority of computerized methodology and the Laboratory Information Management System (LIMS). These audit trails are periodically reviewed to determine if interventions performed by technical staff constitute an appropriate action. The review is performed on a recently completed job and includes interviews with the staff that performed the analysis. Findings indicative of inappropriate interventions or data integrity issues are investigated to determine the cause and the extent of the anomaly.

Confidential Reporting of Data Integrity Issues. Data integrity concerns may be raised by any individual to their supervisor. Employees with data integrity concerns should always discuss those concerns with their immediate supervisors as a first step unless the employee is concerned with the confidentiality of disclosing data integrity issues or is uncomfortable discussing the issue with their immediate supervisor or laboratory manager. The supervisor or laboratory manager makes an initial assessment of the situation to determine if the concern is related to a data integrity violation. Those issues that appear to be violations are documented by the supervisor and referred to the Laboratory Director/General Manager for investigation.

Documented procedures for the confidential reporting of data integrity issues in the laboratory are part of the data integrity policy. These procedures assure that laboratory staff can privately discuss ethical issues or report items of ethical concern without fears of repercussions with senior staff.

Employees with data integrity concerns that they consider to be confidential are directed to the Corporate Human Resources Manager in Dayton, New Jersey. The HR Manager acts as a conduit to arrange a private discussion between the employee and the Laboratory Director/General Manager and/or the local QA Officer. The 24-hour confidential SGS Integrity Helpline may also be called: 1-800-461-9330 or www.integrityhelpline.sgs.com.

The Laboratory Director/General Manager evaluates the situation presented by the employee to determine if the issue is a data integrity concern or a legitimate practice. If the practice is legitimate, the Laboratory Director/General Manager clarifies the process for the employee to assure understanding. If the situation appears to be a data integrity concern, the Laboratory Director/General Manager initiates a Data Integrity Investigation following the procedures specified in SOP MSQA-Ethics.

Data Integrity Investigations. Follow-up investigations are conducted for all reported instances of ethical concern related to data integrity. Investigations are performed in a confidential manner by the Laboratory Director/General Manager. The outcome of the investigation is documented and reported to the Vice President IE SGS North America Inc. who has the ultimate responsibility for determining the final course of action in the matter. Investigation documentation includes corrective action records, client notification information and disciplinary action outcomes.

The investigations are conducted by the senior staff and supervisory personnel from the affected area. The investigations team includes the Laboratory Director/General Manager, Quality Assurance Officer, the Technical Manager and the Laboratory Manager. Investigations are conducted in a confidential manner until it is completed and resolved.

The investigation includes a review of the primary information in question by the investigations team. The team performs a review of associated data and similar historical data to determine if patterns exist. Interviews are conducted with key staff to determine the reasons for the observed practices.

Following data compilation, the investigations team reviews all information to formulate a consensus conclusion. The investigation results are documented along with the recommended course of action.

Corrective Action, Client Notification & Discipline. Investigations that reveal systematic data integrity issues will be referred for corrective action resolution and disposition. If the investigation indicates that an impact to data has occurred and the defective data have been released to clients, client notification procedures will be implemented.

In all cases of data integrity violations, some level of disciplinary action will be conducted on the responsible individual. The level of discipline will be consistent with the violation and may range from re-training and/or verbal reprimand to termination. A zero-tolerance policy is in effect for unethical actions.

JOB DESCRIPTIONS OF KEY STAFF

Requirement: Descriptions of key positions within the organization are defined to ensure that clients and staff understand duties and the responsibilities of the management staff and the reporting relationships between positions.

Vice President IE SGS North America Inc. Responsible for all laboratory operations and business activities. Establishes the company mission and objectives in response to business needs. Direct supervision of the Vice President of Operations, each laboratory director, client services, management information systems, quality assurance and health and safety.

Information Technology Officer. Reports to the company Vice President IE SGS North America Inc. Develops the IT software and hardware agenda. Provides system strategies to compliment company objectives. Maintains all software and hardware used for data handling.

Chief Financial Officer. Reports to the company Vice President IE SGS North America Inc. Responsibilities include oversight of financial accounting.

Vice President of Operations – Conventional Lab Services, US. Reports to Vice President IE SGS North America Inc. Provides quality procedure implementation assistance to operations, oversees the quality program, monitors the quality system, and provides quality system feedback to senior management to be used for process improvement.

> Academic Training: The Vice President of Operations – Conventional Lab, US must have a bachelor's degree in chemical, environmental, biological sciences, physical sciences or engineering science and a minimum of four years of equivalent experience in a related field. A masters or doctoral degree in one of the above disciplines may be substituted for one year of experience.
>
> Experience: The Vice President Operations – Conventional Lab, US must have a minimum of two years of experience in the area of environmental analysis.

Laboratory Director/General Manager. Reports to the Vice President of Operations – Conventional Lab, US. Establishes and implements laboratory operations strategy, direct supervision of Technical Manager, Laboratory Manager, Quality Assurance Officer, client services, organic chemistry, inorganic chemistry, and sample management. Maintains operational responsibility for the Wheat Ridge Laboratory as defined in the SGS North America Inc. Organization Chart.

> Academic Training: The Laboratory Director/General Manager must have a bachelor's degree in chemical, environmental, biological sciences, physical sciences or engineering science and a minimum of seven (7) years of equivalent experience in a related field.
>
> Experience: The laboratory director must have a minimum of two years of experience in the area of environmental analysis.

Operations Manager. Reports directly to the Laboratory Director/General Manager. Responsible for the daily function of business operations, including but not limited to, the organics and inorganics laboratories and sample management. They coordinate the laboratory and operations to meet clients' expectations. The Operations Manager manages sample through put through the entire operation to ensure turnaround times are met while maintaining data quality that meets or exceeds industry standards. They are responsible for promoting a safe working environment and culture throughout the laboratory.

Academic Training: The Operations Manager must have a bachelor's degree in a science field or a minimum five (5) years of progressive laboratory management experience.

Experience: The operations manager must have a minimum of a minimum five (5) years of progressive laboratory management experience.

Quality Assurance Director (QAD). Reports to the company Vice President IE SGS North America Inc. and functions independently from laboratory operations. Establishes the company quality agenda, develops quality procedures, provides assistance to operations on quality procedure implementation, coordinates all quality control activities, monitors the quality system, and provides quality system feedback to management to be used for process improvement.

Academic Training: The laboratory QAD must have a bachelor's degree in chemical, environmental, biological sciences, physical sciences or engineering science and a minimum of four years of equivalent experience in a related field. A masters or doctoral degree in one of the above disciplines may be substituted for one year of experience.

Quality Assurance Officer (QAO). Reports to the Laboratory Director/General Manager. Facilitates implementation of the company quality agenda, develops quality procedures, provides assistance to operations on quality procedure implementation, coordinates all quality control activities, monitors the quality system, provides quality system feedback to management to be used for process improvement and oversees health and safety. Keeps updated to regulatory guidelines and regulation changes that may affect laboratory procedures. Performs quality control data review for trend monitoring purposes. Conducts internal audits and prepares reports for management review. Oversees proficiency testing program, Standard Operating Procedures, control limits, demonstrations of capability, method detection limits, training files, and ethics and manual integration training. Process quality control data for statistical purposes.

Academic Training: The laboratory Quality Assurance Officer must have a bachelor's degree in chemical, environmental, biological sciences, physical sciences or engineering science and a minimum of four years of equivalent experience in a related field. A masters or doctoral degree in one of the above disciplines may be substituted for one year of experience.

Experience: The Quality Assurance Officer must have a minimum of two years of experience in the area of environmental analysis.

Client Services/Project Managers. Reports to the Laboratory Director/General Manager. Establishes and maintains communications between clients and the laboratory pertaining to client requirements which are related to sample analysis and data deliverables. Initiates client orders and supervises sample login operations. Develops, maintains and executes all client sample projects from initial to final analysis.

Manager, Organics (Organics Technical Manager). Reports to the Laboratory Director/General Manager. Directs the operations of the organics group, consisting of organics preparation, GC instrumental analysis, and GCMS instrumental analysis. Establishes daily work schedule. Supervises method implementation, application, and data production. Responsible for following Quality System requirements. Maintains laboratory instrumentation in an operable condition.

> <u>Academic Training</u>: The Organics Manager must have a bachelor's degree in chemical, environmental, biological sciences, physical sciences or engineering science and a minimum of four years of equivalent experience in a related field. A masters or doctoral degree in one of the above disciplines may be substituted for one year of experience.
>
> <u>Experience:</u> The Organics Manager must have a minimum of two years of experience in the area of environmental analysis.

Manager, Wet Chemistry (Wet Chemistry Technical Manager). Reports to the Laboratory Director/General Manager. Directs the operations of the wet chemistry and HPLC laboratory. Establishes daily work schedule. Supervises method implementation, application, and data production. Responsible for following Quality System requirements. Maintains laboratory instrumentation in an operable condition.

> <u>Academic Training</u>: The Inorganics Manager must have a bachelor's degree in chemical, environmental, biological sciences, physical sciences or engineering science and a minimum of four years of equivalent experience in a related field. A masters or doctoral degree in one of the above disciplines may be substituted for one year of experience.
>
> <u>Experience:</u> The Inorganics Manager must have a minimum of two years of experience in the area of environmental analysis.

Manager, Metals (Metals Technical Manager). Reports to the Laboratory Director/General Manager. Directs the operations of the metals laboratory. Establishes daily work schedule. Supervises method implementation, application, and data production. Responsible for following Quality System requirements. Maintains laboratory instrumentation in an operable condition.

> <u>Academic Training</u>: The Metals Manager must have a bachelor's degree in chemical, environmental, biological sciences, physical sciences or engineering science and a minimum of four years of equivalent experience in a related field. A masters or doctoral degree in one of the above disciplines may be substituted for one year of experience.
>
> <u>Experience:</u> The laboratory technical manager must have a minimum of two years of experience in the area of environmental analysis.

Manager, Sample Management. Reports to the Laboratory Director/General Manager. Develops, maintains and executes all procedures required for sample pickup, receipt of samples, verification of preservation, and chain of custody documentation. Responsible for maintaining and documenting secure storage, delivery of samples to laboratory units on request, and disposal following completion, and courier services. Responsible for following Quality Program requirements.

> Academic Training: The Sample Management Supervisor must have a bachelor's degree in chemical, environmental, biological sciences, physical sciences or engineering science and a minimum of four years equivalent experience in a related field.
>
> Experience: The sample management supervisor must have a minimum of one year of experience in the area to be supervised, preferably with a minimum of six months supervisory experience.

Environmental Health and Safety Officer. Reports to the Vice President IE SGS North America Inc. Responsible for implementing company safety program and chemical hygiene plan at the laboratory. Responsible for employee training on relevant health and safety topics. Manages laboratory waste management program. Documents employee training.

Supervisor, Wet Chemistry. Reports to the Inorganics Manager. Executes daily analysis schedule. Supervises the analysis of samples for wet chemistry parameters using valid, documented methodology. Maintains instrumentation in an operable condition. Reviews data for compliance to quality and methodological requirements. Responsible for following Quality System requirements. Assumes the responsibilities of the Inorganics Manager in her/his absence.

Supervisor, Metals. Reports to the Inorganics Manager. Executes daily analysis and metals preparation schedule. Supervises the analysis of samples for metallic elements using valid, documented methodology. Maintains instrumentation in an operable condition. Reviews data for compliance to quality and methodological requirements. Responsible for following Quality System requirements.

Supervisor, Organic Preparation. Reports to the Organics Manager. Executes the daily sample preparation schedule. Performs the extraction of multi-media samples for organic constituents using valid, documented methodology. Prepares documentation for extracted samples. Assumes custody until transfer for analysis. Responsible for following Quality System requirements.

Supervisor, Volatiles GC & GCMS. Reports to the Organics Manager. Coordinates the daily sample analysis schedule. Supervises the analysis for volatile organic compounds using valid, documented methodology. Maintains instrumentation in an operable condition. Responsible for following Quality System requirements.

Supervisor, Semi-Volatiles GC & GCMS. Reports to the Organics Manager. Coordinates the daily sample analysis schedule. Supervises the analysis for semi-volatile organic compounds using valid, documented methodology. Maintains instrumentation in an operable condition. Responsible for following Quality System requirements. Assumes the responsibilities of the Organics Manager in her/his absence.

Employee Screening, Orientation, and Training.

All potential laboratory employees are screened and interviewed by human resources and technical staff prior to their hire. The pre-screen process involves a review of their qualifications including education, training, and work experience to verify that they have adequate skills to perform the tasks of the job.

Newly hired employees receive orientation training beginning the first day of employment by the Company. Orientation training consists of initial health and safety training including general laboratory safety, personal protection and building evacuation. Orientation also includes quality assurance program training, data integrity training, and an overview of the Company's goals, objectives, mission, and vision.

All technical staff receives training to develop and demonstrate proficiency for the methods they perform. New analysts work under supervision until the supervisory staff is satisfied that a thorough understanding of the method is apparent and method proficiency has been demonstrated through a precision and accuracy study that has been documented, reviewed and approved by the Laboratory Manager and QA Officer. Data from the study are compared to method acceptance limits. If the data are unacceptable, additional training is required. The analyst may also demonstrate proficiency by producing acceptable data through the analysis of an independently prepared proficiency sample.

Individual proficiency is demonstrated annually for each method performed for methods that are applicable to precision and accuracy studies. Data from initial and continuing proficiency demonstrations are archived in the individual's training folder.

4.3 **Training Documentation.** The Quality Assurance Officer prepares a training file for every new employee. All information related to qualifications, experience, external training courses, and education are stored in the file. Documentation for orientation, health & safety, quality assurance, and ethics training is also included in the file.

Additional training documentation is added to the file as it is developed. This includes documentation of SOP understanding, data for initial and continuing demonstrations of proficiency, performance evaluation study data and notes and attendance lists from group training sessions.

SIGNATORY APPROVALS

Requirement: Procedures have been developed for establishing the traceability of data and documents. The procedure consists of a signature hierarchy, indicating levels of authorization for signature approvals of data and information within the organization. Signature authority is granted for approval of specific actions based on positional hierarchy within the organization and knowledge of the operation requiring signature approval. A log of signatures and initials of all employees is maintained by the QA Officer for cross-referencing purposes.

Signature Hierarchy.

Laboratory Director/General Manager. Authorization for contracts and binding agreements with outside parties. Approval of final reports, project specific QAPs, data review and approval in lieu of technical managers. Establishes and implements technical policy. Approval and acceptance of incoming work. Responsible for client satisfaction and corrective actions. Establishes staffing and hiring requirements.

Vice President, Chief information Officer. MIS policy.

Quality Assurance Officer. Approval of quality assurance procedures and documents. Implements established Quality Assurance Policy. Implements Quality Program at the laboratory level. Approval of SOPs and DOCs.

Client Service Manager. Project specific contracts, pricing, and price modification agreements. Approval and acceptance of incoming work, Client Services policy.

Managers, Technical Departments. Methodology and department specific QAPs. Data review and approval. Technical approval of SOPs. Department specific supplies purchase.

Manager, Sample Management. Initiation of laboratory sample custody and acceptance of all samples. Approval of department policies and procedures. Department specific supplies purchase.

Supervisors, Technical Departments. Data review approval, purchasing of expendable supplies.

Signature Requirements. All laboratory activities related to sample custody and generation or release of data must be approved using either initials, signatures or electronic, password protected procedures. The individual, who applies his signature initial or password to an activity or document, is authorized to do so within the limits assigned to them by their supervisor. All written signatures and initials must be applied in a readable format that can be cross-referenced to the signatures and initials log, if necessary.

Signature and Initials Log. The Quality Assurance Officer maintains a signature and initials log. New employee signatures and initials are appended to the log at the start of employment. Signatures of individuals no longer employed by the company are retained but annotated with the last day worked.

> Electronic Signature Log: The QA Department maintains an electronic signature log, in both image and stamp format. These signatures are appended to the log as they are created by their owners.

DOCUMENTATION & DOCUMENT CONTROL

Requirement: Document control policies have been established which specify that any document used as an information source or for recording analytical or quality control information must be managed using defined document control procedures. Accordingly, policies and procedures required for the control, protection, and storage of any information related to the production of analytical data and the operation of the Quality System to assure its integrity and traceability have been established and implemented in the laboratory. The system contains sufficient controls for managing, archiving and reconstructing all process steps which contributed to the generation of an analytical test result. Using this system, an audit trail for reported data can be produced, establishing complete traceability for the result. The laboratory shall establish and maintain procedures to control all documents that form part of its management system (internally generated or from external sources), such as regulations, standards, other normative documents, test and/or calibration methods, as well as drawings, software, specifications, instructions, and manuals.

Administrative Records. Administrative (non-analytical) records are managed by the Quality Assurance department. These records consist of electronic documents which are retained in a limited access electronic directory or paper documents which are released to the technical staff upon specific request.

Form Generation, Modification & Control. The Quality Assurance Officer approves and manages all forms used as either stand-alone documents or in logbooks to ensure their traceability. Forms are generated as computer files and are maintained in a limited access master directory. The QA Officer also manages and approves modifications to existing forms. Obsolete editions of modified forms are retained for a minimum of five years.

Approved forms are assigned an alphanumeric code that includes codes that designate the department that uses the form, the form number, and the version number.

The technical staff is required to complete all forms to the maximum extent possible. If information for a specific item is unavailable, the analyst is required to "Z" the information block or cross out the line. The staff is also required to "Z" the uncompleted portions of a logbook or logbook form if the day's analysis does not fill the entire page of the form. The person making the "Z" or cross-out line should then place their initials and the date at the bottom of the "Z" or close to end of the cross-out line.

Logbook Control. All laboratory logbooks are controlled documents that are comprised of approved forms used to document specific processes. Quality Assurance maintains logbook generation control. New logs are numbered and issued to the department, and the department is assigned responsibility for the log. Old logs are returned to QA for entry into the document archive system.

Old logbooks are filed and catalogued according to the document control number. Some logbooks may be scanned for electronic storage and named according to its document control number. Electronic copies of logbooks are to be retained for a minimum of six (6) years. If a logbook was not scanned for electronic storage, it must be kept for a minimum of six (6) years.

Controlled Documents. Key laboratory documents that are distributed internally and externally are numbered for tracking purposes. Controlled status simplifies document updates and retrieval of outdated documents. Control is maintained through a document numbering procedure and document control log designating the individual or department receiving the controlled document and the date of receipt. Key documents are also distributed as uncontrolled documents if the recipient does not require updated copies when changes occur. These documents will not be updated when revisions are made to the document.

Controlled documents must be retrieved/replaced when the document is revised or becomes obsolete. If a controlled document is submitted without the intent of retrieval, it is not considered controlled and must clearly be identified with an "UNCONTROLLED DOCUMENT" or "UNCONTROLLED" watermark or similar marking.

Controlled copies are returned to the Quality Assurance Officer when a new revision of the document is issued or the document is retired.

Quality Systems Manual (QSM). All QSMs are assigned a control number prior to distribution. The number, date of distribution, and identity of the individual receiving the document are recorded in the document control log. Only QSM copies that are for distribution in the laboratory will be controlled. Copies distributed to clients, auditing agencies, or regulatory authorities may be tracked, but not controlled. The numbering system is restarted with each new volume, which corresponds to the revision of the QSM. Electronic versions are distributed to clients as read only files that are password protected – or as .PDFs.

Standard Operating Procedures (SOPs). The SOP is assigned a control number prior to distribution. The original, signed copy of the SOP is maintained in the master SOP binder by the QA Officer. The QA Officer collects outdated versions of SOPs as they are replaced and archived.

Hardcopy SOPs may NOT be copied. Electronic SOPs may not be printed. Controlled copies must be issued through the Quality Assurance Officer. Partial SOPs can be issued, e.g., tables and charts for wall display, as controlled documents.

SOP copies distributed to clients, auditing agencies, or regulatory authorities are in the .PDF format and are not controlled.

Electronic versions of outdated SOPs are moved from the active SOP directory to the inactive (archive) directory. SOPs in process of updating or generation are stored in the Draft SOP directory on the local server.

Operators' Manuals are considered controlled documents and are stored in the appropriate department(s). QA staff maintains current listing of Operators' Manuals.

Technical Records. All records related to the analysis of samples and the production of an analytical result are archived in secure document storage or on electronic media and contain sufficient detail to produce an audit trail which re-creates the analytical result. These records include information related to the original client request, bottle order, sample login and custody, storage, sample preparation, analysis, data review, and data reporting.

Each department involved in this process maintains controlled documents which enable them to maintain records of critical information relevant to their department's process.

Quality Control Support Data & Records. All information and data related to the quality system are stored in a restricted access directory on the network server. Information on this directory is backed-up daily. Users of the quality assurance information and data have "read-only" access to the files contained in the directory. The QA staff and the Laboratory Director/General Manager have "write" capability in this directory.

This directory contains all current and archived quality system manuals, SOPs, control limits, MDL studies, precision and accuracy data, official forms, internal audit reports, proficiency test scores and metrics calibration information.

The following information (but not limited to) is retained in the directory:

Quality System Manuals
Standard Operating Procedures
Certification Documentation
Change Management Data
External Audit Reports
Internal Audit Reports
Corrective Action Database
Laboratory Forms Directory
Health & Safety Manuals
Inactive Standard Operating Procedures
Method Detection Limit Data
Metrics Inventory & Calibration Data
Performance Limits
Proficiency Test Scores & Statistics
Project Specific Analytical Requirements
QC Report Reviews
Regulatory Agency Quality Documents
Staff Bios and Job Descriptions

Analytical Records. All data related to the analysis of field samples are retained as either paper or electronic records that can be retrieved to compile a traceable audit trail for any reported result. All information is linked to the client job and sample number, which serves as a reference for all sample related information tracking.

Critical times in the life of the sample from collection through analysis to disposal are documented. This includes date and time of collection, receipt by the laboratory, preparation times and dates, analysis times and dates and data reporting information. Analysis times are calculated in hours for methods where holding time is specified in hours (e.g., ≤ 72 hours).

Sample preparation information is recorded in a separate controlled logbook or electronic log. It includes sample identification numbers, types of analysis, preparation and cleanup methods, sample weights and volumes, reagent lot numbers and volumes, and any other information pertinent to the preparation procedure.

Information related to the identification of the instrument used for analysis is permanently attached to the electronic record. The record includes an electronic data file that indicates all instrument conditions employed for the analysis, including the type of analysis conducted. The analyst's identification is electronically attached to the record. The instrument tuning and calibration data are electronically linked to the sample or linked though paper logs which were used in the documentation of the analysis. Quality control and performance criteria are permanently linked to the paper archive or electronic file.

Paper or electronic records for the identity, receipt, preparation and evaluation of all standards and reagents used in the analysis are documented in prepared records and maintained in controlled documents or files. Lot number information linking these materials to the analysis performed is recorded in the logbooks associated with the samples in which they were used.

Manual calculations or peak integrations that were performed during the data review are retained as paper or electronic (.PDF) documents and included as part of the electronic archive. Signatures for data review are retained on paper or as electronic versions of the paper record for the permanent electronic file.

Confidential Business Information (CBI). Operational documents including SOPs, Quality Manuals, personnel information, internal operations statistics, and laboratory audit reports are considered confidential business information. Strict controls are placed on the release of this information to outside parties.

Release of CBI to outside parties or organizations may be authorized upon execution of a confidentiality agreement between SGS North America Inc. and the receiving organization or individual. CBI information release is authorized for third party auditors and commercial clients in electronic mode as Adobe Acrobat .PDF format only.

Software Change Documentation & Control. Changes to software are documented as text within the code of the program undergoing change. Documentation includes a description of the change, reason for change and the date the change was placed into effect. Documentation indicating the adequacy of the change is prepared following the evaluation by the user who requested the change.

Report and Data Archiving. Data files from sample analysis are automatically backed up daily to an intranet server, which is cloned to another hard drive. SGS North America Inc. maintains the data files or image file copies of original reports in archive for a minimum period of five (5) years. This includes data reports and raw data for field sample analysis, proficiency test analysis and all associated quality control sample analysis. After a minimum of five years, the files may be automatically discarded. Contractual arrangements may exist which dictate a longer time period. Client or regulatory agency specific data retention practices may be employed that require a retention period of up to ten (10) years.

SGS North America Inc. archives an electronic (.PDF) copy of the original report and electronic (.PDF) copies of the organic and inorganic support data. Organic support data are archived according to instrument batch numbers. Closed client files and Chain of Custody documents are maintained in the office area until archiving is necessary. Paper copy data are archived as needed and placed in the on-site long-term storage area (or scanned and archived electronically). The data are placed in storage boxes and marked with the bracketing report numbers. Client report data are filed by the job number.

Method Detection Limit (MDL) studies are maintained as electronic data files in the Quality Assurance network directory. Raw data for MDL studies and P&A studies are stored in the same manner as described for inorganic and organic raw data.

__Training__. The company maintains a training record for all employees that documents that they have received instruction on administrative and technical tasks that are required for the job they perform. Training records for individuals employed by the company are retained for a period of at least five (5) years following their termination of employment.

__Training File Origination__. The Quality Assurance Officer prepares a training file for every new employee. QA retains the responsibility for the maintenance and tracking of all training related documentation in the file. The file is begun on the first day of employment. Information related to qualifications, experience, external training courses, and education are placed into the file. Information required for the file includes a copy of the individual's most current resume, detailing work experience and a copy of any college diplomas and transcript(s). Additional information added includes documentation of health and safety and Quality Assurance training, data integrity training, and a signed data integrity training and ethical conduct agreement.

Additional training documentation is added to the file as it is developed. This includes documentation of SOP understanding, data for initial and continuing demonstrations of proficiency, performance evaluation study data and notes and attendance lists from group training sessions.

Training documentation, training requirements, analyst proficiency information and other training related support documentation are held in paper training files by the Quality Assurance Officer and may be tracked using an SGS North America Inc. customized database application.

__Technical Training__. The supervisor of each new employee is responsible for developing a training plan for each new employee. The supervisor evaluates the employee's training progress at regular frequencies. Supporting documentation, including SOP documentation of understanding, demonstration of capability and precision and accuracy studies, which demonstrate an analyst's proficiency for a specific test, is added to the training file as completed. Documentation of understanding (DOU) for all assigned Standard Operating Procedures is verified in the QA Training database. Certificates or diplomas for any off-site training are also added to the file.

REFERENCE STANDARD TRACEABILITY

Requirement: Documented procedures, which establish traceability between any measured value and a national reference standard, are established by the laboratory as required. All metric measurements are traceable to NIST reference weights or thermometers that are calibrated on a regular schedule. All chemicals used for calibration of a quantitative process are traceable to a NIST reference that is documented by the vendor using a certificate of traceability. The laboratory maintains a documentation system that establishes the traceability links. The procedures for verifying and documenting traceability must be documented in Standard Operating Procedures.

7.1 ***Traceability of Metric Measurements - Thermometers***. SGS North America Inc. uses NIST thermometers to calibrate commercially purchased thermometers prior to their use in the laboratory. If necessary, these working thermometers are assigned correction factors determined during their calibration using a NIST-traceable thermometer as the standard. The correction factor is documented in a thermometer calibration database and on a tag attached to the working thermometer. The correction factor is applied to temperature measurements before recording the final measurement in the temperature log. Calibration of each thermometer is verified and documented on a regular schedule. Liquid-in-glass and metal type thermometers are calibrated against a NIST-traceable thermometer on an annual basis. Infrared type thermometers are verified at least on a quarterly basis. Digital thermometers, including Min/Max recording digital thermometers, are verified versus a NIST-traceable thermometer at least annually (every 12 months), and on a quarterly basis (every 3 months) for all digital thermometers used for drinking water samples and tests. The NIST-traceable thermometer is checked for accuracy by a qualified vendor a minimum of every five (5) years following the specifications for NIST thermometer calibration verification detailed in the United States Environmental Protection Agency's "Manual for the Certification of Laboratories Analyzing Drinking Water", Fifth Edition, January 2005. This calibration verification must be performed by an ISO/IEC 17025 – accredited contractor and include data points throughout the working range of the thermometer. Calibration log and Certificate(s) of Calibration are maintained on file with QA.

7.2 ***Traceability of Metric Measurements – Calibration Weights***. SGS North America Inc. uses calibrated weights, which are traceable to NIST standard weights to calibrate all balances used in the laboratory. Balances are calibrated to specific tolerances within the intended use range of the balance. Balance calibration verification checks are required on each day of use. If the tolerance criteria are not achieved, corrective action specified in the balance calibration SOP is applied before the balance can be used for laboratory measurements. Recertification of all calibration weights is conducted and documented a minimum of every five (5) years. This calibration verification must be performed by an ISO/IEC 17025 – accredited contractor.

7.2.1 A set of Class S or 1 certified weights certified to ISO/IEC 17025 may be set aside and not put into daily lab use so they may be used to annually check the corresponding weights used in the lab. The weights set aside will be held by the QA Officer. Where recalibrated weights are not available in the lab to annually verify lab weights, the lab weights may be annually verified by an outside balance calibration vendor.

7.3 ***Traceability of Metric Measurements – Top Loader and Analytical Balances.*** The laboratory top-loader and analytical balances are calibrated annually by an ISO/IEC 17025 – accredited contractor. The calibration must include the working range of the balance.

7.4 ***Traceability of Chemical Standards and Reagents***. All chemicals and reagents, purchased as reference standards for use in method calibration must establish traceability to NIST referenced material through a traceability certificate (Certificate of Analysis, CoA). Process links are established that enable a calibration standard solution to be traced to its NIST reference certificate.

Chemical standards used for analysis must meet the specifications of the method. These specifications must be stated in the reagents section of the method SOP.

7.5 ***Assignment of Reagent, Bulk Chemical, and Standard Expiration Dates.*** Expiration date information for all purchased standards, prepared standard solutions and unstable reagents is provided to SGS North America Inc. by the vendor as a condition of purchase. Neat materials, bulk chemicals including solvents, acids, and inorganic reagents are not required to be purchased with expiration dates. Certified prepared solutions are labeled with the expiration date provided by the manufacturer. In-house prepared solutions are assigned expiration dates that are consistent with the method that employs their use unless documented experience indicates that an alternate date can be applied. If alternate expiration dates are employed, their use is documented in the method SOP. For standards or reagents with a partially defined expiration date (i.e., month and year), the last day of the month will be used as the final expiration date. All containers shall be labeled with the date of preparation and the expiration date clearly indicated.

7.6 The earliest expiration date is always the limiting date for assigning expiration dates to prepared solutions. Expiration dates that are later than the expiration date of any derivative solution or material are prohibited.

7.7 ***Reagents and Supplies Verification***. Bulk chemicals/reagents and other consumable materials that may affect the quality of environmental tests are inspected or otherwise verified prior to use. If verification is necessary, an aliquot is removed and analyzed by the applicable test and verified to be free from contamination prior to use on a lot basis. Sample bottles may be verified for use on a lot basis by similar means. Other consumable materials are verified for use by various other means.

7.8 ***Documentation of Traceability***. Traceability information is documented in individual logbooks designated for specific measurement processes in use. The Quality Assurance group maintains calibration documentation for metric references in separate logbooks.

Balance calibration verification is documented in logbooks assigned to each balance. The individual conducting the calibration verification is required to initial and date all verification activities. Any defects that occur during verification are also documented along with the corrective action applied and a demonstration of return to control. Annual service and calibration reports and certificates are retained on file with QA staff.

Temperature control is documented in logbooks assigned to the equipment being monitored. A verified thermometer is assigned to each individual item. Measurements are recorded along with date and initials of the individual conducting the measurement on a daily or as used basis. Corrective action, if required, is also documented including the demonstration of return to control.

Initial traceability of chemical standards and reagents are documented via a vendor-supplied certificate that includes lot number and expiration date information. Solutions prepared using the vendor supplied chemical standards are documented in logbooks using a unique identification of the solution and assigned to specific analytical processes. Alternatively, documentation may be entered into the electronic standards and reagent tracking log. The documentation includes links to the vendor's lot number, an internal lot number, dates of preparation, expiration date, and the preparer's initials. SGS North America Inc. employs commercially prepared standard solutions whose traceability can be demonstrated through a vendor supplied certificate of analysis that includes an experimental verification of the standard's true concentration. Purchased standards which do not have a Certificate of Analysis cannot be used for calibration or calibration verification purposes and are rejected and may be returned to the vendor.

Supervisors conduct regular reviews of logbooks, which are verified using a signature and date.

TEST PROCEDURES, METHOD REFERENCES, AND REGULATORY PROGRAMS

Requirements: The laboratory employs client specified or regulatory agency approved methods for the analysis of environmental samples. A list of active methods is maintained, which specifies the type of analyses performed. Routine procedures used by the laboratory for the execution of a method are documented in Standard Operating Procedures. Method performance and sensitivity are demonstrated annually, where required. Defined procedures for the use of method sensitivity limits for data reporting purposes are established by the QA Officer and used consistently for all data reporting purposes.

8.1 ***Method Selection & Application***. SGS North America Inc. employs methods for environmental sample analysis that are consistent with the client's application, which are appropriate and applicable to the project objectives. SGS North America Inc. informs the client if the method proposed is inappropriate or outdated and suggests alternative approaches.

SGS North America Inc. employs documented, validated regulatory methods in the absence of a client specification and informs the client of the method selected. These methods are available to the client and other parties as determined by the client. Documented and validated in-house methods may be applied if they are appropriate to the project. The client is informed of the method selection.

8.2 ***Standard Operating Procedures***. Standard Operating Procedures (SOP) are prepared for routine methods executed by the laboratory, processes related to laboratory operations and sample or data handling. Test method SOPs are formatted to meet the specifications established by the National Environmental Laboratory Accreditation Conference, which are detailed in Module Four – Quality Systems of the established Standards. The procedures describe the process steps in sufficient detail to enable an individual, who is unfamiliar with the procedure to execute it successfully.

SOPs are evaluated annually and edited, if necessary. Reviewed SOPs that do not require modification include an evaluation summary form indicating that an evaluation was conducted and modifications were not needed. SOPs can be edited on a more frequent basis if changes are required for any reason. These may include a change to the methodology, elimination of systematic errors that dictate a need for process changes or modifications to incorporate a new version of the method promulgated by the originating regulatory agency. Modifications are indicated using a revision number. SOPs are available for client review at the SGS North America Inc. facility upon request.

The complete list of the laboratory's SOPs as of the date of publication of this QSM version are detailed in Appendix II.

8.3 ***Method Validation***. Standard methods from regulatory sources are primarily used for all analyses. Standard methods do not require validation by the laboratory. Non-standard in-house methods are validated prior to use. Validation is also performed for standard methods applied outside their intended scope of use. Validation is dependent upon the method application and may include the analysis of quality control samples to develop precision and accuracy information for the intended use. A final method validation report is generated which includes all data in the validation study. A statement of adequacy and/or equivalency is included in the report. A copy of the report is archived in the Quality Assurance directory of the company server.

Non-standard methods are validated prior to use. This includes the validation of modified standard methods to demonstrate comparability with existing methods. Demonstrations and validations are performed and documented prior to incorporating technological enhancements and non-standard methods into existing laboratory methods used for general applications. The demonstration includes method specific requirements for assuring that significant performance differences do not occur when the enhancement is incorporated into the method. Validation is dependent upon method application and may include the analysis of quality control samples to develop precision and accuracy information for the intended use.

The study procedures and specifications for demonstrating validation include comparable method sensitivity, calibration response, method precision, method accuracy and field sample consistency for several classes of analytical methods are detailed in this document. These procedures and specifications may vary depending upon the method and the modification.

8.4 ***Estimated Uncertainty.*** A statement of the estimated uncertainty of an analytical measurement accompanies the test result when required. Estimated uncertainty is derived from the performance limits established for spiked samples of similar matrices. The degree of uncertainty is derived from the negative or positive bias for spiked samples accompanying a specific parameter. When the uncertainty estimate is applied to a measured value, the possible quantitative range for that specific parameter at that measured concentration is defined. Well recognized regulatory methods that specify values for the major sources of uncertainty and specify the data reporting format do not require a further estimate of uncertainty.

8.5 ***Demonstration of Capability***. Confirmation testing is conducted to demonstrate that the laboratory is capable of performing the method before its application to the analysis of environmental samples. The results of the demonstration tests are compared to the quality control specifications of the method to determine if the performance is acceptable.

Capability demonstrations are conducted initially for each method on every instrument and annually on a method specific basis thereafter. Acceptable demonstrations are documented for individual training files and retained by the QA staff. New analytes, which are added to the list of analytes for an accredited method, are evaluated for applicability through a demonstration of capability similar to those performed for accredited analytes.

8.6 ***Method Detection Limit Determination***. Annual Method Detection Limit (MDL) studies are performed as appropriate for routine methods used in the laboratory. Some methods, e.g., EPA 300.0, require MDL studies semi-annually. MDL studies are also performed when there is a change to the method that affects how the method is performed or when an instrumentation change that impacts sensitivity occurs. The procedure used for determining MDLs is described in 40 CFR, Part 136, Appendix B, Revision 2, 2016. The TNI 2016 rules for MDL determination are the same.

Refer to the revised MDL procedure, Revision 2, EPA 821-R-16-006, for the specific procedure. Below are highlights of the procedure.

8.6.1 Studies are performed for each method on water and soil matrices for every instrument that is used to perform the method.

8.6.2 A minimum of seven (7) replicate blank spikes (BS)/laboratory control samples (LCS) and seven (7) method blank samples are prepared and analyzed at 1 to 5 times the concentration of the estimated detection limit. (Each BS sample is prepared and analyzed as a separate sample). The samples used for the MDL must be prepared in at least three batches on three separate calendar days and analyzed on three separate calendar days. (Preparation and analysis may occur on the same day.)

8.6.2.1 Soil volatile spikes are prepared by spiking 5 grams of sand and preserving with the appropriate solvent (water or methanol).

8.6.2.2 Soil semi-volatile spikes are prepared by spiking 20 to 30 grams of sand.

8.6.2.3 Spiking levels are determined by QA or the department manager using previous data and regulatory requirements.

8.6.3 All sample processing steps of the preparation and analytical method shall be included in the determination of the MDL. All method requirements, including holding times, must also be met for MDL samples.

8.6.4 If more than seven spikes are analyzed, all must be included in the MDL determination. Documented instances of gross failures (e.g., instrument malfunctions, mislabeled samples, cracked vials) may be excluded from the calculations, provided that at least seven spiked samples and seven method blanks are available. (The rationale for removal of specific outliers must be documented and maintained on file with the results of the MDL determination.)

8.6.5 The same prepared extract may be analyzed on multiple instruments so long as the minimum requirements of seven preparations in at least three batches on three separate calendar days and analyzed on three separate calendar days are maintained.

8.6.6 MDLs are established at the instrument level. The highest MDL of the pooled instrument data is used to establish a laboratory MDL.

8.6.7 The Quality Assurance staff manages the annual MDL determination process and is responsible for retaining MDL data on file. Approved MDLs are appended to the LIMS and used for data reporting purposes.

8.7 ***Limit of Detection (LOD).*** (TNI requirement) The Limit of Detection (LOD) for each method and target analyte of concern is established for each instrument that is used to perform the method. The LOD is established by spiking a water and/or soil matrix at approximately two to three times the calculated MDL (for a single-analyte standard) or one to four times the calculated MDL (for a multi-analyte standard). The LOD undergoes all sample processing steps and is validated by the qualitative identification of the analytes of interest. The spike concentration establishes the LOD and must be verified annually.

8.7.1 If the laboratory is not reporting a value below the Limit of Quantitation (LOQ), a Limit of Detection study is not required.

8.7.2 All sample-processing and analysis steps of the analytical method shall be included in the determination or validation of the LOD.

8.7.2.1 When required, the laboratory shall determine or verify the LOD for the method for each target analyte of concern in the quality system matrices.

8.7.2.2 The validity of the LOD shall be verified by detection (a value greater than zero) of the analyte(s) in a QC sample in each quality system matrix. This QC sample shall contain the analyte at no more than 3 times the LOD for single-analyte tests and no more than 4 times the LOD for multiple analyte tests. This verification shall be performed on every instrument that is to be used for analysis of samples and reporting of data. The validity of the LOD shall be verified as part of the LOD determination process. This verification shall be done prior to the use of the LOD for the sample analysis.

8.7.2.3 An LOD study is not required for any component for which spiking solutions or quality control samples are not available (e.g., temperature).

8.7.2.4 The LOD shall be initially determined for the compounds of interest in each method in a quality system matrix in which there are neither target analytes nor interferences at a concentration that would impact the results or the LOD shall be performed in the quality system matrix of interest.

8.7.2.5 An LOD shall be performed each time there is a change in the method that affects how the test is performed, or when a change in instrumentation occurs that affects the sensitivity of the analysis.

8.7.2.6 The LOD, if required, shall be verified annually for each quality system matrix, technology, and analyte.

8.8 ***Instrument Detection Limit Determination***. Instrument Detection Limits (IDLs) are determined for all Inductively Coupled Plasma Emission Spectrometers (ICP) and ICP–Mass Spectrometers (ICP-MS). The IDL is determined for the wavelength (emission) of each element and the ion (mass spectrometry) of each element used for sample analysis. The IDL data are used to estimate instrument sensitivity in the absence of the sample matrix. IDL determinations are conducted at the frequency specified in the appropriate SOPs for ICP and ICP-MS analyses.

8.9 ***Method Reporting Limit.*** The Method Reporting Limit is determined by the concentration of the lowest calibration standard in the calibration curve for most organic analyte methods. This value is adjusted based on several sample preparation factors including sample volume, moisture content (soils), digestion, distillation or dilution. The low calibration standard is selected by department managers as the lowest concentration standard that can be used for calibration while continuing to meet the calibration linearity and qualitative identification criteria of the method being used. The validity of the Method Reporting Limits is confirmed through the analysis of a spiked quality control sample (LOQ verification) at 0.5 to 2 times the Method Reporting Limit concentration. By definition, detected analytes at concentrations below the low calibration standard cannot be accurately quantitated and are qualified as estimated values.

The reporting limit for inorganic analyte methods is defined as the concentration which is greater than the MDL where method quality control criteria have been achieved. The reporting limit for general chemistry methods employing multiple point calibrations must be greater than or equal to the concentration of the lowest standard of the calibration range.

The reporting limit established for both organic and inorganic analyses is greater than the calculated method detection limit, where applicable.

8.10 ***Minimum Reporting Limit (MRL).*** Confirmation of the Minimum Reporting Limit (MRL) is required for drinking water test methods and some standard method tests. A BS/LCS is prepared at a concentration at or below the Method Reporting Limit and analyzed every analysis day. The recovery acceptance limit is usually **±50%**; specific method limits shall prevail. This shows that the laboratory is capable of making measurements at the reporting limit. The MRL must be below the MCL (Maximum Contamination Level).

8.11 ***Limit of Quantitation (LOQ).*** (TNI requirement) The Limit of Quantitation (LOQ) for each analyte of concern is determined. The LOQ is set within the range of calibration and is greater than the established LOD. Precision and bias criteria for the LOQ are established to meet client requirements and are verified annually.

8.11.1 All sample processing and analysis steps of the analytical method shall be included in the determination of the LOQ.

8.11.2 The LOQ study is not required for any component or property for which spiking solutions or quality control samples are not available or otherwise inappropriate (e.g., pH).

8.11.3 The validity of the LOQ shall be verified by successful analysis of a QC sample containing the analytes of concern in each quality system matrix at 0.5 to 2 times the claimed LOQ. A successful analysis is one where the recovery of each analyte is within the laboratory established method acceptance criteria or client data quality objectives for accuracy.

8.11.4 When an LOD is determined or verified by the laboratory, the LOQ shall be greater than the LOD.

8.11.5 The LOQ shall be verified annually for each quality system matrix, technology, and analyte.

8.12 ***Reporting of Quantitative Data.*** Analytical data for all methods are reported without qualification to the Reporting Limit established for each method. Data for organic methods may be reported to the established method detection limit depending upon the client's requirements provided that all qualitative identification criteria for the detected parameter have been satisfied. All parameters reported at concentrations between the Reporting Limit and to the Method Detection Limit are qualified as estimated values.

Data for inorganic methods are reported to the established Method Reporting Limits. Inorganic data for specific methods may also be reported to the established Method Detection Limit at client request. However, these data are always qualified as estimated values.

Measured concentrations of detected analytes that exceed the upper limit of the calibration range are either diluted into the range and re-analyzed or qualified as an estimated value. The only exception to this applies to ICP and ICP-MS analyses, which can be reported to the upper limit of the experimentally determined linear range without qualification.

8.13 ***Demonstration of Capability (DOC)***. Annual precision and accuracy (DOC) studies, which demonstrate the laboratory's ability to generate acceptable data, are performed for all routine methods used in the laboratory. The procedure used for generating organic DOC data is referenced in the majority of the regulatory methodology in use. The procedure requires quadruplicate analysis of a sample spiked with target analytes at a concentration in the working range of the method. These data may be compiled from a series of existing consecutive blank spikes or laboratory control samples. Accuracy (percent recovery) of the replicate analysis is averaged and compared to established method performance limits. Values within method limits indicate an acceptable performance demonstration. Precision and accuracy data are also used to annually demonstrate analytical capability for individual analysts. Annual DOC data are archived in individual training files.

Alternative methods for demonstrating capability may be the analysis of a PT or blind sample or quadruplicate analysis of a known standard. Capability is demonstrated using the PT sample if the results meet the PT provider's acceptance criteria. For quadruplicate analysis, capability is demonstrated if the standard deviations and recoveries of the analyses fall within the method acceptance criteria. If no standard deviation criteria exist, the supervisor reviews the results and makes a judgment regarding acceptability of the standard deviation results. For blind sample analysis, capability is demonstrated if the recoveries of the analyses fall within the method or SOP acceptance criteria or provider's acceptance criteria.

If analysis of spiked samples cannot be performed, analysis of authentic samples with results statistically indistinguishable from those obtained by another trained analyst may be used

8.14 ***Method Performance Limits***. The Quality Assurance Officer is responsible for compilation and maintenance of all precision and accuracy data used for performance limits. Quality control data from each method are compiled in the Laboratory Information Management System (LIMS) and used to develop performance limits and control limits for selected quality parameters. The pooled data are statistically evaluated and updated annually. Upper and lower control limits are developed for these parameters, which may replace the limits from the previous year. The new limits are used by the analysts to assess performance and determine compliance with the quality criteria of the method being used. The analyst is responsible for making decisions regarding corrective action using this information during the method set-up, sample analysis, and data review steps. Laboratory generated limits appear on all data reports.

8.15 ***Method Sources & References and Update Mechanism***. The Quality Assurance Officer maintains a list of active methods used for the analysis of samples. This list includes valid method references from sources such as US EPA, ASTM or Standard Methods designations and the current version and version date.

Updated versions of approved reference methodology may be placed into use as changes occur. The Quality Assurance Officer informs operations management of changes in method versions as they occur. The operations management staff selects an implementation date. The operations staff is responsible for completing all method use requirements prior to the implementation date. This includes modification of SOPs, completion of MDL and precision and accuracy studies and staff training. Documentation of these activities is provided to the QA staff that retains this information on file. The updated method is placed into service on the implementation date and the old version is de-activated.

Multiple versions of selected methods may remain in use to satisfy client specific needs. In these situations, the default method version becomes the most recent version. Client specific needs are communicated to the laboratory staff using method specific analytical method codes, which clearly depict the version to be used. The old method version is maintained as an active method until the specified client no longer requires the use of the older version.

SGS North America Inc. will not use methodology that represents significant departures from the reference method unless specifically directed by the client. If clients direct the laboratory to use a method modification that represents a significant departure from the reference method, the request will be documented in the project file.

8.16 ***Analytical Capabilities***. Appendix II provides a detailed listing of the methodology employed for the analysis of test samples.

SAMPLING, SAMPLE MANAGEMENT, LOGIN, CUSTODY, STORAGE AND DISPOSAL

Requirement: The laboratory must employ a system which ensures that client supplied product (the sample) is adequately evaluated, acknowledged, and secured upon delivery to the laboratory. The system also assures that product chain of custody is maintained, and that sample receipt conditions and preservation status are documented and communicated to the client and internal staff. The login procedure assigns, documents, and maps the specifications for the analysis of each unique sample to assure that the requested analysis is performed on the correct sample and enables the sample to be tracked throughout the laboratory analytical cycle. The system includes procedures for reconciling defects in sample condition or client provided data, which are identified at sample arrival. The system specifies the procedures for proper sample storage, transfer to the laboratory, and disposal after analysis. The system is also documented in Standard Operating Procedures.

Order Receipt and Entry. New orders are initiated and processed by the client services group (See Section 14.0, Procedures for Executing Client Specifications). The new order procedure includes mechanisms for providing bottles to clients which meet the size, cleanliness, and preservation specifications for the analysis to be performed.

For new orders, the project manager prepares a bottle request form which is submitted to sample management. This form provides critical project details to the sample management staff which are used to prepare and assemble the sample bottles for shipment to the client prior to sampling.

The bottle order is assembled using bottles that meet USEPA specifications for contaminant-free sample containers. SGS North America Inc. uses a combination of commercially supplied pre-cleaned bottles and bottles that have been tested for residual contamination and verified to meet USEPA specifications prior to use. Sterile bottles for microbiological samples are purchased from commercial sources.

Bottles, which are not purchased pre-cleaned, are checked to ensure that they are free of contamination from targeted analytes before being released for use. Acceptable cleanliness is demonstrated by the absence of the analyte(s) of interest at the detection limit of the method to be used for sample analysis. The QA staff maintains the responsibility for approving and releasing bottle lots for use following a review of the check data.

Preservative solutions that are specified for the analysis requested are dispensed into the sample bottle prior to shipment. All preservative solutions are prepared in the laboratory or purchased from commercial suppliers. Each solution is checked to ensure that it is free of contamination from the compounds being analyzed before being released for use.

Reagent water for trip and field blanks is poured into appropriately labeled containers. One temperature blank per cooler is provided. All bottles are packed into ice chests with blank chain of custody forms, State forms as applicable, and the original bottle order form. Completed bottle orders are delivered to clients for use in field sample collection using SGS North America Inc. couriers or commercial carriers.

Sample Receipt and Custody. Samples are delivered to the laboratory using a variety of mechanisms including SGS North America Inc. couriers, commercial shippers, and client self-delivery. Documented procedures are followed for arriving samples to ensure that custody and integrity are maintained, and handling/ preservation requirements are documented and maintained.

Sample custody documentation is initiated when the individual collecting the sample initiates the field samples. Custody documentation includes all information necessary to provide an unambiguous record of sample collection, sample identification, and sample collection chronology. Initial custody documentation employs either SGS North America Inc. or client generated custody forms.

SGS North America Inc. generates a chain of custody in situations where the individuals who collected the sample did not generate custody documentation in the field.

SGS North America Inc. defines sample custody as follows:

- The sample is in the actual custody or possession of the assigned responsible person,
- The sample is in a secure area.

The SGS North America Inc. facility is defined as a secure facility. Perimeter security has been established which limits access to authorized individuals only. Visitors enter the facility through the building lobby and must register with the receptionist prior to entering controlled areas. While in the facility, visitors are required to wear a visitor's badge and must be accompanied by their hosts at all times. After hours building access is controlled using a computerized password keypad system. This system limits building access to individuals with a pre-assigned authorization status. Clients delivering samples after hours must make advanced arrangements through client services and sample management to assure that staff is available to take delivery and maintain custody.

Upon arrival at SGS North America Inc., the sample custodian reviews the chain of custody for the samples received to verify the information on the form corresponds with the samples delivered. This includes verification that all listed samples are present and properly labeled, checks to verify that samples were transported and received at the required temperature, verifies the sample was received in proper container(s) and that sufficient volume is available to conduct the requested analysis, and checks individual sample containers to verify test specific preservation requirements, including the absence of headspace for volatile compound analysis.

Sample conditions and other observations are documented on the chain of custody by the sample custodian prior to completing acceptance of custody and in an online database that creates a permanent record of all sample login activities. The sample custodian accepts sample custody upon verification that the custody document is correct. Discrepancies or non-compliant situations are documented and communicated to the SGS North America Inc. Project Manager who contacts the client for resolution. The resolution is documented and communicated to sample management for execution.

The sample management staff maintains an electronic sample receipt log. This log details all sample-related information in a searchable database that is updated upon data entry and backed up daily. The log records include critical date information, numbers of samples, numbers of bottles for each parameter, descriptions of bottles for each parameter, preservation conditions, bottle refrigerator location, and bottle conditions. Data entry into the log is secured using individual passwords.

During initial login, each bottle is assigned a unique number and is labeled corresponding to that number with indelible ink.

Laboratory Preservation of Improperly Preserved Field Samples. SGS North America Inc. will attempt to preserve field samples received without proper preservation to the extent that it is feasible and supported by the methods in use. Laboratory preservation of improperly preserved or handled field samples is routinely performed for metals samples. Special handling procedures may also be applied to improperly preserved volatile organics samples.

Aqueous metals samples not nitric acid preserved to pH 2 in the field are laboratory preserved and held for twenty (24) hours to equilibrate prior to analysis. Aqueous metals samples requiring field filtration may be filtered in the laboratory within seventy-two (72) hours of receipt provided the sample has not been acid preserved.

Unpreserved volatile organics samples may be analyzed within seven (7) days of collection to minimize degradation of volatile organics if the laboratory is notified in advance of the failure to preserve upon collection. Laboratory preservation of unpreserved aqueous samples is not possible. A pH check of volatile organics samples prior to analysis will compromise the sample by allowing volatile organics to escape during the check. If the laboratory is not notified of the failure to field preserve an aqueous volatile organics sample, the defect will not be identified until sample analysis has been completed and the data qualified accordingly.

Sample Tracking Via Status Change. An automated, electronic LIMS procedure records sample changes in analytical status. This system tracks all preparation, analytical, and data reporting procedures to which a sample is subjected while in the possession of the laboratory. Each individual who receives samples must acknowledge the change in custody and operational status in LIMS. This step is required to maintain an accurate electronic record of sample status, dates of analytical activity, and custody throughout the laboratory.

Sample tracking is initiated at login where all chronological information related to sample collection dates and holding times are entered into the LIMS. This information is entered on an individual sample basis.

Sample Acceptance Policy. Incoming samples must satisfy SGS North America Inc.'s sample acceptance criteria before being logged into the system. Sample acceptance is based on the premise that clients have exercised proper protocols for sample collection. This includes complete documentation, sufficient volume, proper chemical preservation, temperature preservation, sample container sealing and labeling, and appropriate shipping container packing.

The laboratory staff will make every attempt to preserve improperly preserved samples upon arrival. However, if preservation is not possible, the samples may be refused unless the client authorizes analysis. No samples will be accepted if holding times have been exceeded or will be exceeded before analysis can take place unless the client authorizes analysis.

Sample acceptance criteria include proper custody and sample labeling documentation. Proper custody documentation includes an entry for all physical samples delivered to the laboratory with an identification code that matches the sample bottle and a date and signature of the individual who collected the samples and delivered them to the laboratory. All chains of custody and sample labels must be written in indelible ink.

SGS North America Inc. reserves the right to refuse any sample which in its sole and absolute discretion and judgment is hazardous, toxic and poses or may pose a health, safety or environmental risk during handling or processing. The company will not accept samples for analysis using methodology that is not performed by the laboratory or for methods that lab does not hold valid accreditations unless arrangements have been made to have the analysis conducted by a qualified subcontractor or a valid accreditation is unnecessary.

SGS North America Inc. does not accept radioactive samples. However, the policy for sample handling of Naturally Occurring Radioactive Materials (NORM) is described below:

Samples that meet the Federal Department of Transportation and International Air Transportation Association criteria could be accepted and handled following normal procedures (except for disposal) in the lab. This corresponds to samples with United Nations (UN) labels indicating levels of < 500 uR/hour. Samples containing levels at or higher than 500 uR/hour will not be accepted by SGS North America Inc. Clients must inform SGS North America Inc. of the level of radiation by screening the samples and documenting the level on the Chain of Custody or other form in order for the samples to be accepted.

SGS North America Inc. requires that any shipments containing samples of this type must be clearly labeled with UN labels showing the measured level of radioactivity as < 500 uR/hour.

These samples cannot be disposed of in our normal waste streams. Therefore, on completion of analysis, the samples will be returned to the client or disposed of using an alternate waste handler. In either case, the client will be responsible for the additional shipping or disposal charges, as well as processing charges for segregating the waste stream in the lab.

The reason for sample rejection must be documented. This documentation should be included in the job folder. All jobs must therefore be provided a number – even if rejected – in order to provide the lab with the means of maintaining documentation of any sample rejections.

Assignment of Unique Sample Identification Codes. Unique identification codes are assigned to each sample bottle to assure traceability and unambiguously identify the tests to be performed in the laboratory.

The sample identification coding process begins with the assignment of a unique alphanumeric job number. A job is defined as a group of samples received on the same day, from a specific client, and pertaining to a specific project. A job may consist of groups of samples received over a multi-day period. The first two characters of the job number are alpha characters that identify the laboratory facility ("D" is for Denver). The next characters are numeric and sequence by one number with each new job.

Unique sample numbers are assigned to each bottle collected as a discrete entity from a designated sample point. This number begins with the job number and incorporates a second series of numbers beginning at one (1) and continuing chronologically for each point of collection. The test to be performed is clearly identified on the bottle label. Multiple sample bottles collected for analysis of the same parameter are numbered bottle "1", "2", etc.

Alpha character suffixes may be added to the sample number to identify special designations such as subcontracted tests, in-house QC checks, or re-logs. Multiple sample bottles for a specific analysis are labeled "Bottle 1", "Bottle 2", etc.

Subcontracted Analysis. Subcontract laboratories are employed to conduct analyses not performed by SGS North America Inc. or the particular SGS North America Inc. Laboratory. The Laboratory Director and/or Quality Assurance department evaluates subcontract laboratories to assure their quality processes meet the standards of the environmental laboratory industry prior to engagement. Throughout the subcontract process, SGS North America Inc. follows established procedures to ensure that sample custody is maintained, and the data produced by the subcontractor meet established quality criteria.

Subcontracting Procedure. Subcontracting procedures are initiated through several mechanisms which originate with project or sample management. Samples for analysis by a subcontractor are logged into the SGS North America Inc. system using regular login procedures. The subcontract process is triggered if subcontract parameters are part of the project or sample management has received subcontracting instructions for a specific project. The Sample Manager or Client Services staff contacts an approved subcontractor that carries accreditation in the venue of the project location to place the subcontract order. The subcontract chain of custody is created by sample management. A copy is filed with the original client COC. Sample management signs the subcontract chain of custody and ships the sample(s) to the subcontractor.

Sample receipt by the subcontract laboratory is confirmed and documented. The documentation may consist of an acknowledgement form from the sub lab or a copy of the signed COC. For samples delivered by an SGS North America Inc. courier, a signed COC for the subcontracted analyses must be obtained immediately. All documents are filed with the original client COC. The status of the data will be tracked routinely by the Project Manager.

Clients are notified by e-mail or phone of the need to subcontract analysis as soon as the need is identified by the client services staff. This may occur during the initial project setup or at the time of login if the project setup had not been initiated through the Client Services staff.

Subcontractor data packages are reviewed by the Laboratory Director/General Manager or Project Manager to assess completeness and compliance with project requirements. If completeness defects are detected, the subcontractor is asked to immediately upgrade the data package. If data quality defects are detected, the QA Officer retains the package for further review. The QA Officer will pursue a corrective action solution before releasing defective data to the client.

Approved subcontract data are entered into the Laboratory Information Management System (LIMS) if possible and incorporated into the final report. All subcontract data are footnoted to provide the client with a clear indication of its source. Copies of original subcontract data are included in the data report.

Subcontract Laboratory Evaluation. The Laboratory Director/General Manager or QA Officer evaluates subcontract laboratories prior to engagement. At a minimum, the subcontract laboratory must provide SGS North America Inc. with proof of a valid certification to perform the requested analysis for the venue where the samples were collected and for a specific program should an approval or accreditation be required. In addition, the QA staff may require a copy of the laboratory's Quality Systems Manual, copies of SOPs used for the subcontracted analysis, a copy of the most recent performance evaluation study (PT) for the subcontracted parameter, copies of the internal data integrity policy and copies of the most recent regulatory agency or third-party accreditor audit report. Certification verification must be submitted to SGS North America Inc. annually. If possible, the QA staff may conduct a site visit to the laboratory to inspect the quality system. Qualification of a subcontract laboratory may be bypassed if the primary client directs SGS North America Inc. to employ a specific subcontractor.

Sample Storage. Following sample custody transfer, samples are assigned to refrigerated storage areas by the Sample Custodian depending upon the test to be performed and the matrix of the samples. The samples are stored in refrigerators maintained at ≤ 6°C, but not freezing, if required by the test, until analysis, except volatile soil bulk samples are stored at -7°C to -20°C until analysis. The temperature of each refrigerator or freezer is recorded each day using a dedicated thermometer calibrated against a NIST-traceable thermometer. A maximum/minimum reading thermometer may be used to monitor refrigerator or freezer temperatures in lieu of a direct reading for weekends and holidays. Corrective action is taken immediately if the temperature is outside of the acceptable range. The location (refrigerator/freezer and shelf) of each sample is recorded into the LIMS. Samples remain in storage until the laboratory technician transfers them into the laboratory for analysis.

Samples for volatile organics analysis are placed in storage in designated refrigerators by the sample custodian and immediately transferred to the organics group control. These samples are segregated to limit opportunities for cross contamination to occur.

The laboratory staff is authorized to retrieve samples from these storage areas for analysis. When analysis is complete, the samples are placed back into storage.

9.11 ***Sample Login***. Following sample custody transfer to the laboratory, the sample login group codes and enters sample and test information into the Laboratory Information Management System (LIMS). This process translates all information related to collection time, turnaround time, sample analysis, and deliverables into a code which enables client requirements to be electronically distributed to the various departments within the laboratory for scheduling and execution.

The technical staff is alerted to client or project specific requirements through the use of the comments field in LIMS. The comments will direct the technical staff to controlled specifications documents detailing the unique requirements.

9.12 SAMPLE RETRIEVAL FOR ANALYSIS The analyst is also the sample custodian. The sample custodian retrieves the sample from the refrigerator or freezer and returns it to the appropriately marked shelf for sample storage.

9.13 ***Sample Disposal*****.** SGS North America Inc. retains all samples and sample extracts under proper storage for a minimum of 30 days following completion of the analysis report. Longer storage periods are accommodated on a client specific basis if required. Samples may also be returned to the client for disposal.

SGS North America Inc. disposes of all laboratory wastes following the requirements of the Resource Conservation and Recovery Act (RCRA). The Company has obtained and maintains a waste generator identification number, COD190434860.

Sample management generates a sample disposal dump sheet from the LIMS tracking which lists all samples whose holding period has expired. Data from each sample are compared to the hazardous waste criteria established by RCRA Hazard Class Limits.

Samples containing constituents at concentrations greater than the criteria are labeled as hazardous and segregated into several separate waste categories for disposal as follows:

- Organic extracts: Chlorinated and non-chlorinated solvents
- Mixed flammable solvents (hexane, acetone, toluene, oil)
- Chlorinated solvents (methylene chloride)
- Soil (solids)/Oily solid waste
- Aqueous
- Cyanide Analysis Waste containing pyridine
- Mercury waste
- PCB Hazardous Waste (USEPA 40 CFR 761 criteria)

Non-hazardous aqueous samples are neutralized, diluted and disposed of directly into the laboratory sink.

Non-hazardous solids are disposed of in the dumpster. Laboratory wastes are collected by waste stream in designated areas throughout the laboratory. Waste streams are consolidated as necessary and transferred to stream specific drums for disposal through a permitted waste management contractor. Refer to SOP MSQA-DISP for the detailed procedures. Filled, consolidated drums are scheduled for removal from the facility for appropriate disposal based on the laboratory data.

Samples classified as PCB hazardous wastes are labeled and packaged according to the requirements in 40 CFR 761.

All solvent extracts and digestates are collected for disposal following the thirty-day holding period and drummed according to their specific waste stream category. Chlorinated solvent extracts are drummed as chlorinated wastes (i.e., Methylene Chloride). Non-chlorinated solvent extracts are drummed as non-chlorinated wastes (i.e., acetone, hexane, methanol, and mixed solvents).

10.0 LABORATORY INSTRUMENTATION AND MEASUREMENT STANDARDS

Requirement: The laboratory has established procedures which assure that instrumentation is performing to a pre-determined operational standard prior to the analysis of any samples. In general, these procedures follow the regulatory agency requirements established in promulgated methodology. The instrumentation selected to perform specified analysis is uniquely identified and capable of providing the method specified uncertainty of measurement needed. These procedures are documented and incorporated into the Standard Operating Procedures for the method being executed.

10.1 ***Mass Tuning – Mass Spectrometers***. The mass spectrometer tune and sensitivity are monitored to ensure the instrument is assigning masses and mass abundances correctly and the instrument has sufficient sensitivity to detect compounds at low concentrations. This is accomplished by analyzing a specific mass tuning compound at a fixed concentration. If the sensitivity is insufficient to detect the tuning compound, corrective action must be performed prior to the analysis of standards or samples. If the mass assignments or mass abundances do not meet criteria, corrective action must be performed prior to the analysis of standards or samples.

10.2 ***Wavelength Verification – Spectrophotometers***. Spectrophotometer detectors are checked on a regular schedule to verify proper response to the wavelength of light needed for the test in use. If the detector response does not meet specifications, corrective action (detector adjustment or replacement) is performed prior to the analysis of standards or samples.

10.3 ***Inter-element Interference Checks (Metals)***. Inductively Coupled Plasma Emission Spectrometers (ICP) are subject to a variety of spectral interferences, which can be minimized or eliminated by applying interfering element correction factors and background correction points. Interfering element correction factors are checked on a specified frequency through the analysis of check samples containing high levels of interfering elements. Analysis of single element interferent solutions is also conducted at a specified frequency.

If the check indicates that the method criteria have not been achieved for any element in the check standard, the analysis is halted and data from the affected samples are not reported. Sample analysis is resumed after corrective action has been performed and the correction factors have been re-calculated.

New interfering element correction factors are calculated and applied whenever the checks indicate that the correction factors are no longer meeting criteria. At a minimum, correction factors are replaced once a year.

Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) also is subject to isobaric elemental and polyatomic ion interferences. These interferences are corrected through the use of calculations. The accuracy of corrections is dependent on the sample matrix and instrument conditions and is verified by quality control checks on individual runs.

10.4 ***Calibration and Calibration Verification***. Many tests require calibration using a series of reference standards to establish the concentration range for performing quantitative analysis. Instrument calibration is performed using standards that are traceable to national standards.

Method specific procedures for calibration are followed prior to any sample analysis. In general, if a reference method does not specify the number of calibration standards, the minimum number is two (one of which is at the Reporting Limit or Limit of Quantitation).

Calibration is performed using a linear regression calculation or calibration factors calculated from the curve. The calibration must meet method specific criteria for linearity or precision. If the criteria are not achieved, corrective action (re-calibration or instrument maintenance) is performed. The instrument must be successfully calibrated before analysis of samples can be conducted.

Initial calibration for metals analysis performed using Inductively Coupled Plasma Spectrometers (ICP) employs the use of a single standard and a calibration blank to establish linearity. Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) can be calibrated using either a two point or a multi-point calibration, as long as all quality control criteria for the analysis can be achieved. The calibration blank contains all reagents that are placed into the calibration standard with the exception of the target elements. Valid calibration blanks must not contain any target elements at or greater than ½ the Reporting Limit (RL).

Initial calibrations must be verified using a single concentration calibration standard from a second source (i.e., separate lot or different provider). The continuing validity of existing calibrations must be regularly verified using a single calibration standard. The response to the standard must meet pre-established criteria that indicate the initial calibration curve remains valid. If the criteria are not achieved, corrective action (re-calibration) is performed before any additional samples may be analyzed.

If continuing calibration verification results are outside established criteria, data associated with the verification may be fully useable under the following conditions:

- When the acceptance criteria for the continuing calibration verification are exceeded high, i.e., high bias, and there are associated samples that are non-detects, those non-detects may be reported without qualification.

- When the acceptance criteria for the continuing calibration verification are exceeded low, i.e., low bias, those sample results may be reported if they exceed a maximum regulatory limit/decision level, however, the data must be qualified.

Calibration verification is also performed whenever it appears that the analytical system is out of calibration or no longer meets the calibration requirements. It is also performed when the time period between calibration verifications has expired, as defined by the individual test methods and SOPs.

Sample results are quantitated from the initial instrument calibration unless otherwise required by regulation, method, or program specific criteria.

10.5 ***Linear Range Verification and Calibration (ICP & ICP-MS Metals)***. Linear range verification is performed for all ICP and ICP-MS instrumentation. The regulatory program or analytical method specifies the verification frequency. A series of calibration standards are analyzed over a broad concentration range. The data from these analyses are used to determine the valid analytical range for the instrument. ICP instrument calibration is routinely performed using a single standard at a concentration within the linear range and a blank.

Some methods or analytical programs require a low concentration calibration check to verify that instrument sensitivity is sufficient to detect target elements at the reporting limit. The analytical method or regulatory program defines the criteria used to evaluate the low concentration calibration check. If the low calibration check fails criteria, corrective action is performed and verified through reanalysis of the low concentration calibration check before continuing with the field sample analysis. ICP-MS instrument calibration is normally performed using multiple standards within the linear range and a blank.

10.6 ***Retention Time Development and Verification (e.g. GC, HPLC, IC analysis).***

Chromatographic retention time windows are crucial to the identification of target compounds. Absolute retention times are used for compound identification in all GC, HPLC, and IC methods that do not employ internal standard calibration. Retention Time (RT) windows are established to compensate for minor shifts in absolute retention times as a result of sample loadings and normal chromatographic variability. The width of the retention time window should be carefully established to minimize the occurrence of both false positive and false negative results. Tight retention time windows may result in false negatives and/or may cause unnecessary reanalysis of samples when surrogates or spiked compounds are erroneously not identified. Overly wide retention time windows may result in false positive results that cannot be confirmed.

10.6.1 An initial experimental study is performed which establishes the width of the retention window for each compound. The retention time width of the window defines the time ranges for elution of specified target analytes on the primary and confirmation columns, if applicable. Retention time windows are established upon initial calibration, applying the retention time range from the initial study to each target compound. Retention times are regularly updated through the analysis of an authentic standard during calibration verification. If the target analytes do not elute within the defined range during calibration verification, the instrument must be re-calibrated and new windows defined. New studies are performed when major changes, such as column replacement, are made to the chromatographic system or if a GC column has been shortened during maintenance.

10.6.2 RT windows also should be re-evaluated anytime a target analyte is not detected within the established window for a calibration standard.

10.6.3 GC and HPLC: The center of the retention time window for each analyte and surrogate can be established from the calibration verification standard at the beginning of each analytical shift.

10.7 ***Equipment List.*** See Appendix III for a listing of all equipment used for measurement and/or calibration in laboratory processes.

INSTRUMENT MAINTENANCE

Requirement. Procedures must be established for equipment maintenance. The procedure may include a maintenance schedule, if required, or documentation of daily maintenance related activities. All instrument maintenance activities must be documented in instrument specific logbooks. All equipment out of service (both analytical and auxiliary) must be clearly marked "Out of Order".

11.1 ***Routine, Daily Maintenance***. Routine, daily maintenance is required on an instrument specific basis and is performed each time the instrument is used. Daily maintenance traditionally includes activities to insure a continuation of good analytical performance. This may include performance checks that indicate if non-routine maintenance is needed. If performance checks indicate the need for higher level maintenance, the equipment is taken out of service until maintenance is performed. Analysis cannot be continued until the performance checks meet established criteria. Instrument return to control and parameters used to assess return to control must be documented. Daily maintenance is the responsibility of the individual assign to the instrument used for the analysis he is performing .

11.2 ***Non-routine Maintenance***. Non-routine maintenance is initiated for catastrophic occurrences such as instrument failure. The need for non-routine maintenance is indicated by failures in general operating systems that result in an inability to conduct required performance checks or calibration. Equipment in this category is taken out of service, tagged accordingly and repaired before attempting further analysis. Before initiating repairs, all applicable safety procedures for safe handling of equipment during maintenance, such as lock-out/tag-out are followed. Analysis is not resumed until the instrument meets all operational performance-check criteria, is capable of being calibrated and a return to operational control has been demonstrated and documented. Section supervisors are responsible for identifying non-routine maintenance episodes and initiating repair activities to bring the equipment back within operational control. This may include initiating telephone calls to maintenance contractors, if necessary. Section supervisors are responsible for documenting all details related to the occurrence and repair.

11.3 ***Scheduled Maintenance***. Modern laboratory instrumentation rarely requires regular preventative maintenance by outside service personnel. If required, the equipment is placed on a schedule which dictates when maintenance is needed. Examples include annual balance calibration by an independent provider or ICP preventative maintenance performed by the instrument manufacturer. Section supervisors are responsible for initiating scheduled maintenance on equipment in this category. Scheduled maintenance is documented using routine documentation practices.

11.4 ***Maintenance Documentation***. Routine and non-routine maintenance activities are documented in logbooks assigned to instruments and equipment used for analytical measurements. The logbooks contain either a daily checklist for instruments requiring daily maintenance activities (e.g., semi-volatiles) or a general section to describe non-routine maintenance activities (volatiles and semi-volatiles). The analyst who performs the maintenance activity is required to check the activity upon its completion and initial the form. Non-routine maintenance (repairs, upgrades) is documented in the appropriate area in the same logbook. This documentation also includes verification that the instrument has been returned to operational control following completion of the activity. Maintenance logbooks must include the following information: instrument ID and type, manufacturer name and model, serial number, date received and put into use (if available).

QUALITY CONTROL PARAMETERS, PROCEDURES, AND CORRECTIVE ACTION

Requirement: All procedures used for test methods must incorporate quality control parameters to monitor elements critical to method performance. Each quality parameter includes acceptance criteria that have been established by regulatory agencies for the methods in use. Criteria may also be established through client dictates or through the accumulation and statistical evaluation of internal performance data. Data obtained for these parameters must be evaluated by the analyst and compared to the method criteria in use. If the criteria are not achieved, the procedures must specify corrective action and conformation of control before proceeding with sample analysis. QC parameters, procedures, and corrective action must be documented within the Standard Operating Procedures for each method. In the absence of client specific objectives, the laboratory must define qualitative objectives for completeness and representativeness of data.

12.1 ***Procedure***. Bench analysts are responsible for methodological quality control and sample specific quality control. Each method specifies the control parameters to be employed for the method in use and the specific procedures for incorporating them into the analysis. These control parameters are analyzed and evaluated with every designated sample group (batch).

The data from each parameter provide the analyst with critical decision-making information on method performance. The information is used to determine if corrective action is needed to bring the method or the analysis of a specific sample into compliance. These evaluations are conducted throughout the course of the analysis. Each control parameter is indicative of a critical control feature. Failure of a methodological control parameter is indicative of either instrument or batch failure. Failure of a sample control parameter is indicative of control difficulties with a specific sample or samples.

12.1.1 Sample Batch. All samples analyzed in the laboratory are assigned to a designated sample batch which contains all required quality control samples and a defined maximum number of field samples that are prepared and/or analyzed over a defined time period. The maximum number of field samples in the batch is 20. SGS North America Inc. has incorporated the NELAP batching policy as the sample-batching standard. This policy incorporates the requirement for blanks and spiked blanks as a time-based function as defined by NELAP. Accordingly, the specified time period for a sample batch is 24 hours. Matrix spike/matrix spike duplicate, matrix spikes and duplicates are defined as sample frequency-based functions and may be applied to several batches until the frequency requirement has been reached. A matrix spike/matrix spike duplicate, matrix spikes and/or duplicate is required a minimum every 20 samples. Test method requirements must be met if criteria are more stringent.

Client criteria that define a batch as a time-based function which includes a matrix spike/matrix spike duplicate as a contractual specification will be honored. The typical batch contains a blank and a Laboratory Control Sample (LCS or spiked blank). Batch documentation includes lot specifications for all reagents and standards used during preparation of the batch.

12.2 ***Methodological Control Parameters and Corrective Action***. Prior to the analysis of field samples, the analyst must determine that the method is functioning properly. Specific control parameters indicate whether critical processes meet specified requirements before continuing with the analysis. Method specific control parameters must meet criteria before sample analysis can be conducted. Each of these parameters is related to processes that are under the control of the laboratory and can be adjusted if out of control.

12.2.1 Method Blank (MB). A method blank is analyzed during the analysis of any field sample. The method blank is defined as a sample. It contains the same standards (internal standards, surrogates, matrix modifiers, etc.) and reagents that are added to the field sample during analysis, with the exception of the sample itself. If the method blank contains target analytes(s) at concentrations that exceed method or client requirements (typically defined as Method Detection Limit or Reporting Limit concentrations), the source of contamination is investigated and eliminated before proceeding with sample analysis. Systematic contamination is documented for corrective action and resolved following established corrective action procedures. In specific cases, contamination detected in the method blank may be acceptable if the concentrations do not exceed regulatory limits or client defined reporting limits.

12.2.2 Laboratory Control Samples or Spiked Blanks (LCS or BS). A Laboratory Control Sample [Spiked Blank (BS) or commercially prepared performance evaluation sample] is analyzed along with field samples to demonstrate that method accuracy is within acceptable limits. These spike solutions may be from different sources than the sources of the solutions used for method calibration depending upon the method and SOP requirements. The performance limits are derived from published method specifications or from statistical data generated from the analysis of laboratory method performance samples. Spiked Blanks are blank matrices (reagent water or clean sand) spiked with target analytes and analyzed using the same methods used for samples. Accuracy data are compared to laboratory derived limits to determine if the method is in control. Laboratory Control Samples (LCS) that are commercially prepared have performance limits pre-established by the commercial entity preparing the sample. The sample is analyzed in the laboratory as an external reference.

Accuracy data are compared to the applicable performance limits. If the spike accuracy exceeds the performance limits, corrective action, as specified in the SOP for the method is performed and verified before continuing with field sample analysis. In some cases, decisions are made to continue with sample analysis if performance limits are exceeded, provided the unacceptable result has no negative impact on the sample data.

Blanks and spikes are routinely evaluated before samples are analyzed. However, in situations where sample analysis is performed using an autosampler, they may be evaluated after sample analysis has occurred. If the blanks and spikes do not meet criteria, sample analysis is repeated.

12.2.3 Proficiency Testing. Proficiency Test (PT) samples are single- or double-blind spikes introduced to the laboratory to assess method performance. PTs may be introduced as double-blinds submitted by commercial clients, single- or double-blinds from regulatory agencies, or internal blinds submitted by the QA group.

A minimum of two single-blind studies must be performed each year for every parameter in aqueous and solid matrices for each field of testing for which the laboratory maintains accreditation. Proficiency samples must be purchased as blinds from an NIST/NVLAP accredited vendor. Data from these studies are provided to the laboratory by the vendor and reported to accrediting agencies. If unsatisfactory performance is noted, corrective action is performed to identify and eliminate any sources of error. A new single-blind must be analyzed if required to demonstrate continuing proficiency.

PT samples performed for accrediting agencies or clients which do not meet performance specifications require a written summary that documents the corrective action investigation, findings, and corrective action implementation.

Single- or double-blind proficiency test samples may be employed for self-evaluation purposes. Data from these analyses are compared to established performance limits. If the data do not meet performance specifications, the system is evaluated for sources of acute or systematic error. If required, corrective action is performed and verified before initiating or continuing sample analysis.

Analysis of Proficiency Test samples must be performed in the same manner as client samples. Proficiency samples may not receive special treatment.

12.2.4 Trend Analysis for Control Parameters. The Quality Assurance staff is responsible for continuous analytical improvement through quality control data trend analysis. Accuracy data for spiked parameters in the spiked blank are statistically evaluated for trends indicative of systematic problems. Data from LCS parameters and surrogates are pooled on a method, matrix, and instrument basis. These data are evaluated by comparison to existing control and warning limits. Trend analysis is performed automatically as follows:

- Any point outside the control limit
- Any three consecutive points between the warning and control limits
- Any eight consecutive points on the same side of the mean
- Any six consecutive points increasing or decreasing

The results of the trend analysis are transmitted as .PDF files for evaluation. Trends that indicate the potential loss of statistical control are further evaluated to determine the impact on data quality and to determine if corrective action is necessary. If corrective action is indicated, the supervisor informs the analysts of the corrective actions to be performed. Return to control is demonstrated before analysis resumes.

12.3 ***Sample Control Parameters and Corrective Action***. The analysis of samples can be initiated following a successful demonstration that the method is operating within established controls. Additional controls are incorporated into the analysis of each sample to determine if the method is functioning within established specifications for each individual sample. Sample QC data are evaluated and compared to established performance criteria. If the criteria are not achieved the method or the SOP specifies the corrective action required to continue sample analysis. In many cases, failure to meet QC criteria is a function of sample matrix and cannot be remedied. Each parameter is designed to provide quality feedback on a defined aspect of the sampling and analysis episode.

12.3.1 Duplicates. Duplicate sample analysis is used to measure analytical precision. This can also be equated to laboratory precision for homogenous samples. Precision criteria are method dependent. If precision criteria are not achieved, corrective action or additional action may be required. Recommended action must be completed before reporting sample data.

12.3.2 Laboratory Spikes & Spiked Duplicates. Spikes and spiked duplicates are used to measure analytical precision and accuracy for the sample matrix selected. Precision and accuracy criteria are method dependent. If precision and accuracy criteria are not achieved, corrective action or additional action may be required. Recommended action must be completed before reporting sample data.

12.3.3 Serial Dilution (Metals). Serial dilutions of metals samples are analyzed to determine if analytical matrix effects may have impacted the reported data. If the value of the serially diluted samples does not agree with the undiluted value within a method-specified range, the sample matrix may be causing interference, which may lead to either a high or low bias. If the serial dilution criterion is not achieved, it must be flagged to indicate possible bias from matrix effects.

12.3.4 Post Digestion Spikes. Digested samples are spiked and analyzed to determine if matrix interferences are biasing the results when the pre-digestion spike (matrix spike) recovery falls outside the control limits. It may also be used to determine potential interferences per client's specification. The sample is spiked at the concentration specified in the method SOP. No action is necessary if the post digestion spike is outside of the method criteria, unless a preparation problem is suspected with the spike, in which case the post digestion spike should be re-prepared and re-analyzed.

12.3.5 Surrogate Spikes (Organics). Surrogate spikes are organic compounds that are similar in behavior to the target analytes but unlikely to be found in nature. They are added to all quality control and field samples to measure method performance for each individual sample. Surrogate accuracy limits are derived from published method specifications or from the statistical evaluation of laboratory generated surrogate accuracy data. Accuracy data are compared to the applicable performance limits. If the surrogate accuracy exceeds performance limits, corrective action, as specified in the method or SOP is performed before reporting sample data.

12.3.6 Internal Standards (Organic Methods). Internal standards are retention time and instrument response markers added to every sample for applicable test methods to be used as references for quantitation. Their response is compared to reference standards and used to evaluate instrument sensitivity on a sample specific basis. Internal standard retention time is also compared to reference standards to assure that target analytes are capable of being located by their individual relative retention time.

If internal standard response criteria are not achieved, corrective action or additional action may be required. The recommended action must be completed before reporting sample data.

If the internal standard retention time criteria are not achieved, corrective action or additional action may be required. This may include re-calibration and re-analysis. Additional action must be completed before reporting sample data.

12.3.7 Internal Standards (ICP and ICP-MS Metals). Internal standards are used on ICP instruments to compensate for variations in response caused by differences in sample matrices. Multiple internal standards are used for each sample on ICP-MS instruments to compensate for variations in response caused by differences in sample matrices. This adjustment is performed automatically during sample analysis. The internal standard response of replicated sample analysis is monitored to detect potential analytical problems. If analytical problems are suspected, the field samples may be re-analyzed or re-analyzed upon dilution to minimize the interferences. A different internal standard may be employed for quantitation in situations where the field sample contains the element typically used as the internal standard.

12.4 ***Laboratory Derived Quality Control (QC) Criteria.*** Control criteria for in-house methods and client specific modifications that exceed the scope of published methodology are defined and documented prior to the use of the method. The Quality Assurance Officer is responsible for identifying additional control criteria needs. Control parameters and criteria, based on best technical judgment, are established using input provided by the operations staff. These control parameters and criteria are documented and incorporated into the method.

The laboratory-derived criteria are evaluated for technical soundness on spiked samples prior to the use of the method on field samples. The technical evaluation is documented and archived by the Quality Assurance staff.

When sufficient data from the laboratory-developed control parameter are accumulated, the data are statistically processed, and the experimentally derived control limits are incorporated into the method.

12.5 ***Bench Review & Corrective Action***. The bench chemists are responsible for all QC parameters. Before proceeding with sample analysis, they are required to successfully meet all instrumental QC criteria. They have the authority to perform any necessary corrective action before proceeding with sample analysis. Their authority includes the responsibility for assuring that departures from documented policies and procedures do not occur.

The bench chemists are also responsible for all sample QC parameters. If the sample QC criteria are not achieved, they are authorized and required to perform the method specified corrective action before reporting sample data.

Whenever possible, samples are analyzed without dilution to achieve the lowest possible detection and reporting limits. If dilutions need to be applied, the minimum dilution is used to bring the target compounds in the range of the curve. This dilution may be determined from the original analysis or from screening data. If the target range is large, multiple dilutions may be required to optimize reporting limits for the maximum number of targets. In some cases, very high levels of an interfering target may force larger dilutions for other target compounds. In all cases, a conservative approach to dilution is applied to minimize the increase in detection and reporting limits.

12.6 **Data Qualifiers.** An alpha character coding system is employed for defining use limitations for reported data. These limitations are applied to analytical data by the analyst to clarify the usefulness of the reported data for the data user. Common data qualifiers and their definitions are as follows:

Organics.

J: Indicates an estimated value. Applied to calculated concentrations for tentatively identified compounds (TIC) and qualitatively identified compounds whose concentration is below the reporting limit, but greater than or equal to the MDL.

N: Indicates qualitative evidence of a tentatively identified compound (TIC) whose identification is based on a mass spectral library search and is applied to all TIC results.

B: Used for analytes detected in the sample and its associated method blank at or greater than the reporting limit.

E: Applied to compounds whose concentration exceeds the upper limit of the calibration range.

*: Duplicate or matrix spike duplicate analysis not within control limits.

Metals and Inorganics.

B: Applied if the reported concentration value was less than the reporting limit, but greater than or equal to the MDL.

U: Applied if the reading is less than the MDL.

N: Spike sample recovery not within control limits.

*: Duplicate or matrix spike duplicate analysis not within control limits.

12.7 ***Data Package Review***. SGS North America Inc. employs multiple levels of data review to assure that reported data has satisfied all quality control criteria and that client specifications and requirements have been met. Each production department has developed specific data review procedures, which must be completed before data are released to the client.

12.7.1 Analytical Review. The analyst conducts the primary review of all data. This review begins with a check of all instrument and method quality control and progresses through sample quality control, concluding with a check to assure that the client's requirements have been executed. Analyst checks focus on a review of qualitative determinations and checks of precision and accuracy data to verify that existing laboratory criteria have been achieved. Checks at this level may include comparisons with project specific criteria, if applicable. The analyst has the authority and responsibility to perform corrective action for any out-of-control parameter or nonconformance at this stage of review.

Analysts who have met the qualification criteria for the method in use may perform secondary, peer level data reviews. Analyst qualification requirements include a valid demonstration of capability and demonstrated understanding of the method SOP. Section supervisors may perform secondary review in-lieu of a peer review. Supervisors review 100% of the data produced by their department. It includes a check of all manual calculations, an accuracy check of manually transcribed data from bench sheets to the LIMS, a check of calibration and continuing calibration, a check of all QC criteria, and a comparison of the data package to client specified requirements. Also included are checks to assure the appropriate methodology was applied and that all anomalous information was properly flagged for communication in the case narrative. Supervisors have the authority to reject data and initiate re-analysis, corrective action, or reprocessing.

All laboratory data requiring manual entry into LIMS are double-checked by the analysts performing initial data entry and the section supervisor. Verification of supervisory review is indicated on the raw data summary by the supervisor's initials and date.

Electronic data manually edited at the bench by the primary analyst are automatically flagged by the instrument data system indicating an override by the analyst. All manual overrides must be verified and approved by a supervisor who initials and dates all manual changes.

Electronic copies of manually integrated chromatographic peaks are electronically printed to clearly depict the manually drawn baseline. The electronic copy is reviewed and approved by the section supervisor (electronically initialed and dated) and included in the data package of all full tier reports or the archived batch records of commercial report packages.

Edits to electronic data that have already been committed to the LIMS database are controlled through the use of the Master Edit function in LIMS. Permission to access this program is limited to those approved by the upper levels of laboratory management and is controlled by the Information Technology staff. These edits may be required if corrections are indicated during the final review. A GALP electronic audit record trail is maintained for all changes that are made and is automatically appended to the record.

12.7.2 Report Generation Review. The report generation group reviews all data and supporting information delivered by the laboratory for completeness and compliance with client specifications. Missing deliverables are identified and obtained from the laboratory. The group also reviews the completed package to verify that the delivered product complies with all client specifications. Non-analytical defects are corrected before the package is sent to the client.

12.7.3 Quality Control Review. Spot-check reviews are performed by the Quality Assurance Officer. This review focuses on all elements of the deliverable including the client's specifications and requirements, analytical quality control, sample custody documentation and sample identification. Detected deficiencies are brought to the laboratory's attention and corrective actions initiated as necessary. QA reviews at this step in the production process are geared towards systematic process defects, which require procedural changes to affect a corrective action. However, if defects are identified that have an adverse effect on data, the client is immediately informed following standard notification procedures. QA data review is not used in lieu of a peer level review or a supervisory review.

12.7.4 Data Reporting. Analytical data are released to clients following a secondary review by the group supervisor or Department Manager. Data release at this stage of the process is limited to electronic information, which is released to clients through a secure, encrypted, password protected, Internet connection. Hard copy support data are compiled by the report generation group and assembled into the final report. The report is sent to the client following reviews by the report generation staff.

All data reports include specified information, which is required to identify the report and its contents. This information includes a title, name and address of the laboratory, a unique report number, total number of pages in the report, clients name and address, analytical method identification, arriving sample condition, sample and analysis dates, test results with units of measurement, authorized signature of data release, statement of applicability, report reproduction restrictions and TNI Standard requirements certification.

12.8 ***Electronic Data Reduction***. Raw data from sample analysis are entered into the Laboratory Information Management System (LIMS) using automated processes or manual entry. Final data processing is performed by the LIMS using procedures developed by the Company.

All LIMS programs are tested and validated prior to use to assure that they consistently produce correct results. The Information Technology Staff performs software validation testing. The testing procedures are documented in an SOP. Software programs are not approved for use until they have demonstrated that they are capable of performing the required calculations.

12.9 ***Representativeness***. Data representativeness is based on the premise that qualitative and quantitative information developed for field samples is characteristic of the sample collected by the client and analyzed in the laboratory. The laboratory objective for representativeness defines data as representative if the criteria for all quality parameters associated with the analysis of the sample are achieved.

12.10 ***Comparability***. Analytical data are defined as comparable when data from a sample set analyzed by the laboratory are representatively equivalent to other sample sets analyzed separately regardless of the analytical logistics, e.g., ammonia ≤ total nitrogen; dissolved metals ≤ total recoverable metals; Influent > Effluent on land. The laboratory will achieve 100% comparability for all sample data which meets the criteria for the quality parameters associated with its analysis using the method requested by the client.

CORRECTIVE ACTION SYSTEM

Requirement. The laboratory employs policies and procedures for correcting defective processes, systematic errors, and quality defects enabling the staff to systematically improve product quality. The system includes procedures for communicating items requiring corrective action to responsible individuals, corrective action tracking procedures, corrective action documentation, monitoring of effectiveness, and reports to management. The system is fully documented in a standard operating procedure. Individual corrective actions and responses are documented in a dedicated database.

Procedure. Corrective action is the step that follows the identification of a process defect. The type of defect determines the level of documentation, communication, and training necessary to prevent re-occurrence of the defect or non-conformance. The formal system is maintained by the Quality Assurance department. Operations management is responsible for working within the system to resolve identified deficiencies.

Routine Corrective Action. Routine corrective action is defined as the procedures used to return out of control analytical systems back to control. This level of corrective action applies to all analytical quality control parameters or analytical system specifications.

Bench analysts have full responsibility and authority for performing routine corrective action. The resolution of defects at this level does not require a procedural change or staff re-training. The analyst is free to continue work once corrective action is complete and the analytical system has been returned to control. Documentation of routine corrective actions is limited to logbook comments for the analysis being performed.

Process Changes. Corrective actions in this category require procedural modifications. They may be the result of systematic defects identified during audits, the investigation of client inquiries, failed proficiency tests, product defects identified during data review, or method updates. Resolution of defects of this magnitude requires formal identification of the defect, development and documentation of a corrective action plan, and staff training to communicate the procedural change.

Technical Corrective Action. Technical corrective action encompasses routine corrective action performed by bench analysts for out-of-control systems and corrective actions performed for data produced using out of control systems. Technical corrective action for routine situations is conducted using the procedures detailed above.

Non-routine corrective actions apply to situations where the bench analyst failed to perform routine corrective action before continuing analysis. Supervisors and Department Managers perform corrective action in these situations. Documentation of all non-routine corrective actions is performed using the corrective action system.

Sample re-analysis is conducted if sufficient sample and holding time remain to repeat the analysis using an in-control system. If insufficient sample or holding time remains, the data are processed, and qualifiers applied that describe the out-of-control situation. The occurrence is further documented in the case narrative and in the corrective action response. The corrective action must include provisions for re-training the analyst who failed to perform routine corrective action.

Documentation & Communication. Routine corrective actions are documented as part of the analytical record. Notations are made in the comments section of the analytical chronicle or data sheet detailing the nonconformance and corrective action. Continuation of the analysis indicates that return to control was successful.

Corrective actions for process changes are documented, tracked, and monitored for effectiveness. Supervisors or senior staff members may initiate corrective actions by generating a corrective action using the corrective action database application.

The corrective action database is an Access application. The initiator generates the corrective action investigation form, which is documented, tracked, distributed to responsible parties and archived through the application. The application assigns a tracking number, initiation date, and due date to each corrective action initiated and copies the corrective action form to the corrective action database. An e-mail message containing the form is automatically distributed to the responsible party for resolution.

The responsible party identifies the root cause of the defect, initiates the immediate fix and develops and implements the corrective action. Existing documentation such as SOPs are edited to reflect the change if a procedural change was made. The affected staff is informed of procedural changes through a formal training session, as applicable. The training is documented, and copies are placed into individual training files. The corrective action form is completed by the responsible party and returned to the QA staff via e-mail using the database application.

Initial and completed corrective action forms are maintained in the corrective action database. This entire database is backed-up and archived weekly. The corrective action tracking form is maintained as an active report in the database.

Monitoring. The QA staff monitors the implemented corrective action until it is evident that the action has been effective and the defect has been eliminated. The corrective action database is updated by QA to reflect closure of the corrective action. The QA staff assigns an error code to the corrective action for classification of the type of errors being committed. Additional monitoring of the corrective action is conducted during routine laboratory audits.

Additional monitoring of the corrective action is conducted by adding the corrective action to a verification list by the QA staff at closure. Verification is performed by the QA staff to assure that the corrective action has remained in effect and is scheduled for one (1) month after closure.

If QA determines that the corrective action response has not effectively remedied the deficiency, the process continues with a re-initiation of the corrective action. Corrective action continues until the defect is eliminated. If another procedural change is required, it is treated as a new corrective action which is documented and monitored using established procedures.

Client Notification. Defective processes, systematic errors, and quality defects, detected during routine audits, may have negative impacts on data quality. In some cases, data that have been released to clients may be affected. If defective data have been released for use, SGS North America Inc. will notify the affected clients of the defect and provide specific details regarding the magnitude of the impact to their data.

Management of Change

Management and Control of Change is intended to ensure that all major laboratory procedural changes affecting any aspect of the laboratory's operation are reviewed and approved by the appropriate management staff before the proposed change is implemented. Supporting documentation for changes are maintained on file.

Major changes to laboratory procedures are documented throughout the change period. The initiator of the change documents the need for the change, which is forwarded to the Laboratory Director/General Manager for approval. The approved form is returned to the initiator of the change request, who is responsible for planning, implementing, and monitoring the change. Prior to implementation, the initiator is responsible for communicating the change to the affected staff. All training and procedural changes are documented in individual training files.

Refer to the Management of Change SOP, MSQA-MOC, for system details.

PROCEDURES FOR EXECUTING CLIENT SPECIFICATIONS

Requirement. Systems have been established for evaluating and processing client specifications for routine and non-routine analytical services. The systems enable the client services staff to identify, evaluate, and document the requested specifications to determine if adequate resources are available to perform the analysis. The system includes procedures for communicating the specifications to the laboratory staff for execution and procedures for verifying the specifications have been executed.

Client Specific Requirements. The Laboratory Director/General Manager or Client Services (Project Manager) is the primary contact for clients requesting laboratory services. Client specifications are communicated using several mechanisms. The primary sources of information are the client's Quality Assurance Project Plan (QAPP) and the analytical services contract, both of which detail the analytical, quality control and data reporting specifications for the project. In the absence of a QAPP, project specifications can also be communicated using contracts, letters of authorization, or letters of agreement, which may be limited to a brief discussion of the analytical requirements and the terms and conditions for the work. These documents may also include pricing information, liabilities, and scope of work, in addition to the analytical requirements. QAPPs include detailed analytical requirements and data quality objectives which supersede those found in the referenced methods. This information is essential to successful project completion.

The managerial and client services staff provide additional assistance to clients who are unsure of the specifications they need to execute the sampling and analysis requirements of their project. They provide additional support to clients who require assistance in results interpretation as needed, provided they possess the expertise required to render an opinion.

The Laboratory Director or Project Manager is responsible for obtaining project documents, which specify the analytical requirements. Following an initial evaluation, copies are distributed to the QA Officer and the appropriate departmental managers for review and comment. The original QAPP is filed in a secure location.

Requirements for Non-Standard Analytical Specifications. Client requirements that specify departures from documented policies, procedures, or standard specifications must be submitted to SGS North America Inc. in writing. These requirements are reviewed and approved by the technical staff before the project is accepted. Once accepted, the non-standard requirements become analytical specifications which follow the routine procedure for communicating client specifications. Departures from documented policies, procedures, or standard specifications that do not follow this procedure are not permitted.

Evaluation of Resources. A resource evaluation is completed prior to accepting projects submitted by clients. The evaluation is initiated by the Laboratory Director/General Manager or Project Manager who communicates the logistical requirements of the project to the appropriate managers. Logistical specifications for new projects are summarized in writing for evaluation by the affected departments or discussed during a manager's meeting. The specifications are evaluated by the department manager from a scheduling and hardware resources perspective. The project is not accepted unless the department managers have the necessary resources to execute the project according to client specifications.

__Documentation__.

New projects may be initiated using a project set up form which would be completed prior to the start of the project. This form details all of the information needed to correctly enter the specifications for each client sample into the Laboratory Information Management System (LIMS). The form includes data reporting requirements, billing information, data turnaround times, QA level, state of origin, and comments for detailing project specific requirements. The Project Manager is responsible for obtaining this information from the client and completing the form prior to sample arrival and login.

Sample receipt triggers project creation and the login process. The information on the setup form and the chain of custody is entered into the LIMS immediately prior to logging in the first sample. The setup form may be accompanied by a quotation which details the analytical product codes and sample matrices. These details are also entered into the LIMS during login.

Special information is distributed to the laboratory supervisors and login department in electronic or hardcopy format upon project setup. All project specific information is retained by the Project Manager in a secure file. The Project Manager maintains a personal telephone log which details conversations with the client regarding the project.

Department managers prepare summary sheets detailing client-specific analytical requirements for each test. Bench analysts use these sheets to obtain information regarding client-specific analytical requirements before analyzing samples.

__Communication__. A pre-project meeting is held between the Laboratory Director/General Manager, Project Manager, and the Operations Manager to discuss the specifications described in the QAPP, contract, and/or related documents. Project logistics are discussed and finalized, and procedures are developed to assure proper execution of the client's analytical specifications and requirements. Questions raised in the review meeting are discussed with the client for resolution. Exceptions to any requirements, if accepted by the client, are documented and incorporated into the QAPP or project documentation records in LIMS.

Non-standard specifications for individual clients are documented in the LIMS at the client account level or program level. Simple specifications are documented as comments for each project. Once entered into the LIMS, these specifications become memorialized for all projects related to the client account.

__Operational Execution__. A work schedule is prepared for each analytical department on a daily basis. Analytical specifications from recently arrived samples have now been entered into the LIMS database. The database is sorted by analytical due date and holding time into product specific groups. Samples are scheduled for analysis by due date and holding time. The completed schedule which is now defined as a "work list" is printed. The list contains the client requested product codes and specifications required for the selected sample(s). Special requirements are communicated to the analyst using the comments section or relayed through verbal instructions provided by the supervisor. The bench analyst assumes full responsibility for performing the analysis according to the specifications printed on the work sheet.

Verification. Prior to the release of data to the client, laboratory section managers and the report generation staff review the report and compare the completed product to the client specifications documentation to assure that all requirements have been met. Project Managers may perform a spot check of projects with unique requirements to ensure the work was executed according to specifications.

CLIENT COMPLAINT RESOLUTION AND DATA INQUIRY PROCEDURE

Requirement. The laboratory follows a formal system for managing and reconciling client complaints and data inquiries. The system includes procedures for documenting client complaints/data inquiries and communicating the complaint or inquiry to the appropriate department for resolution. The system also includes a quality assurance evaluation to determine if the complaint is related to systematic defects requiring corrective action and process changes.

Procedure. Client complaints or inquiries are communicated to the Laboratory Director/General Manager, client services representative, Quality Assurance staff, or senior management staff for resolution. The individual receiving the complaint retains the responsibility for documentation and communicating the nature of the complaint to the responsible department(s) for resolution. The responsible party addresses the complaint. The resolution is communicated to Quality Assurance (QA) or documented in the SGS North America Inc. Data Inquiry application and to the originator for communication to the client. QA reviews the complaint/inquiry and resolution to determine if systematic defects exist. If systematic defects are present, QA initiates a corrective action for the responsible party who develops and implements a response to eliminate the defect. If systematic defects are not present and the resolution is satisfactory, the QA staff will close the complaint/inquiry with a "no further action is necessary" tag.

Documentation. Client's complaints/inquiries are documented by the individual receiving the complaint using a telephone conversation log or by receipt of an e-mail or letter. The complaint is distributed to all appropriate parties, and always to the Laboratory Director/General Manager. Documentation of the complaint is filed with the Quality Assurance Officer, Laboratory Director, and Project Manager, and may be filed with the project (as applicable).

Corrective Action. Responses to data queries are required from the responsible party. At a minimum, the response addresses the query and provides an explanation to the complaint. Formal corrective action may focus on the single issue expressed in the complaint. Corrective action may include reprocessing of data, editing of the initial report, and re-issue to the client. If the QA review indicates a systematic error, process modification is required. The defective process at the root of the complaint is changed. SOPs are either created or modified to reflect the change. The party responsible for the process implements process changes.

QA Monitoring. Process changes, implemented to resolve systematic defects, are monitored for effectiveness by QA. If monitoring indicates the process change has not resolved the defect, QA works with the department management to develop and implement an effective process. If monitoring indicates the defect has been resolved, monitoring is slowly discontinued, and the corrective action is closed. Continued monitoring is incorporated as an element of the annual system audit.

CONTROL OF NONCONFORMING PRODUCT

Requirement: Policies and procedures have been developed and implemented that describe the procedures employed by the laboratory when any aspect of sample analysis or data reporting do not conform to established procedures or client specifications. These procedures include steps to ensure that process defects are corrected and affected work is evaluated to assess its impact to the client.

Procedure. Nonconforming product is identified through routine internal review and audit practices or through client inquiry. The individuals who identify the nonconformance or receiving a nonconformance inquiry immediately inform the Laboratory Director/General Manager and the Quality Assurance Officer. The Laboratory Director initiates an evaluation of the nonconformance through the Quality Assurance department and takes full responsibility for managing the process and identifying the course of action to take, initiating corrective action and mitigating the impact of the nonconformance to the client.

Corrective Action. The outcome of the evaluation dictates the course of action. This includes client notification when the quality of data reported has been impacted and may also include corrective action, if applicable. Immediate corrective action is performed using the procedures specified in SGS North America Inc. SOP MSQA-CA. However, additional action may be required including cessation of analysis and withholding and or recalling data reports. If the evaluation indicates that nonconforming data may have been issued to clients, the client is immediately notified, and data may be recalled following the procedures specified in SOP MSQA-CA. If work has been stopped because of a nonconformance, the Laboratory Director/General Manager and Operations Manager are the only individuals authorized to direct a resumption of analysis.

Nonconformances caused by systematic process defects require re-training of the personnel involved as an element of the corrective action solution.

CONFIDENTIALITY PROTECTION PROCEDURES

Requirements: Policies and procedures have been developed to protect client data from release to unauthorized parties or accidental release of database information through accidental electronic transmission or illegal intrusion. These policies have been communicated to clients and staff. Electronic systems are regularly evaluated for effectiveness.

Client Anonymity. Information related to the Company's clients is granted to employees on a "need to know" basis. An individual's position within the organization defines his "need to know". Individuals with "need to know" status are given password access to systems that contain client identity information and access to documents and document storage areas containing client reports and information. Access to client information by individuals outside of the Company is limited to the client and individuals authorized by the client. Individuals outside of the Company may obtain client information through subpoena issued by a court of valid jurisdiction. Clients are informed when subpoenas are received ordering the release of their information.

Documents Client information may be released directly to regulatory agencies without receiving client authorization under specified circumstances. These circumstances require that the regulatory agency have statutory authority under the regulations for laboratory certification and that SGS North America Inc.'s operations fall under the purview of the regulation. In these situations, SGS North America Inc. will inform the client of the regulatory agencies request for information pertaining to his/her data and proceed with the delivery of the information to the regulatory agency.

Access to client documents is restricted to employees in "need to know" positions. Copies of all client reports are stored in secure electronic archives with restricted access. Reports and report copies are distributed to individuals who have been authorized by the client to receive them. Data reports or data are not released to third parties without verbally expressed or written permission from the client.

Electronic Data.

Database Intrusion. Direct database entry is authorized for employees of SGS North America Inc. only on a "need to know" basis. Entry to the database is restricted through a user specific multiple password entry system. Direct access to the database outside of the facility is possible through secure channels set up by SGS North America Inc. A unique password is required for access to the local area network. A second unique password is required to gain access to the database. All passwords are required to be changed periodically per current company policy. The staff receives read or write level authorization on a hierarchical privilege basis.

Internet Access. Access to client information is through an HTTP Web application only. It does not contain a mechanism allowing direct access to the database. Clients can gain access to their data only using a series of SGS North America Inc. assigned client and user specific passwords. The viewable data, which is encrypted during transmission, consist of an extraction of database information only.

Client Accessibility. Accessibility to client data delivered via electronic means follows strict protocols to insure confidentiality. Clients accessing electronic data are assigned a company account. The account profile which is established by the MIS staff grants explicit access to specific information pertaining to the client's project activity. Passwords are assigned on an individual basis within a client account. These accounts can be activated or deactivated by the MIS staff only.

Information Requests. Client specific data or information are not released to third parties without verbally expressed or written permission from the client. Written permission is required from third parties, who contact the Company directly for the release of information. Verbal requests will be honored only if they are received directly from the client. These requests must be documented in a record of communication maintained by the authorized recipient.

Transfer of Records. Archived data which have previously been reported and transmitted to clients are the exclusive property of SGS North America Inc. In the event of a cessation of business activities due to business failure or sale, the Company's legal staff will be directed to arrange for the final disposition of archived data.

The final disposition of archived data will be accomplished using the approach detailed in the following sequence:

1. All data will be transferred to the new owners for the duration of the required archive period as a condition of sale.
2. If the new owners will not accept the data or the business has failed, letters will be sent to clients listed on the most recent active account roster offering them the option to obtain specific reports (identified by SGS North America Inc. Job Number) at their own expense.
3. A letter will be sent to TNI accrediting authority with organizational jurisdiction over the company offering them the option to obtain all unclaimed reports at their own expense.
4. All remaining archived data will be recycled using the most expedient means possible.

QUALITY AUDITS AND SYSTEM REVIEWS

Requirement. The Quality Assurance group conducts regularly scheduled audits of the laboratory to assess compliance with quality system requirements, technical requirements of applied methodology, and adherence to documentation procedures. The information gathered during these audits is used to provide feedback to senior management and perform corrective action where needed for quality improvement purposes.

Quality System Reviews. The reviews are performed annually by the Quality Assurance Officer or the Laboratory Director/General Manager. In this review, the laboratory is evaluated for compliance with the laboratory Quality Systems Manual (QSM) and the quality system standards of TNI. Findings which indicate non-compliance or deviation from the QSM are flagged for corrective action. Corrective actions require either a return to compliance or a plan change to reflect an improved quality process. The Quality Assurance Officer is responsible for making and documenting changes to the QSM.

Quality System Audits are conducted to evaluate the effectiveness and laboratory compliance with individual quality system elements. These audits are conducted on an established schedule. Audit findings are documented and communicated to the management staff and entered into the corrective action system for resolution. If necessary, re-training is conducted to assure complete understanding of the system requirements.

Test Method Assessments (TMA) are performed throughout the year following an established schedule. Selected analytical procedures are evaluated for compliance with Standard Operating Procedures (SOPs) and method requirements. If non-conformances exist, the published method serves as the standard for compliance. SOPs are edited for compliance if the document does not reflect method requirements. Analysts are trained on the new requirements and the process is monitored by Quality Assurance. Analysts are re-trained in method procedures if an evaluation of bench practices indicates non-compliance with SOP requirements.

Documentation Audits. The audits are conducted during routine internal audits and as needed. This audit includes a check of measurement processes that require manual documentation. It also includes checks of data archiving systems and a search to find and remove any inactive versions of SOPs that may still be present in the laboratory and being accessed by the analysts. Non-conformances are usually corrected on the spot. Procedural modifications are implemented if the evaluation indicates a systematic defect.

Corrective Action Monitoring. Defects or non-conformances that are identified during client or internal audits are documented in the corrective action systems and corrected through process modifications and/or re-training. Once a corrective action has been designed and implemented, it is monitored for compliance on a regular basis by the QA staff. Spot corrections are performed if the staff is not following the new procedure. Monitoring of the corrective action continues until satisfactory implementation has been verified.

Preventive Action. Laboratory systems or processes which may be faulty and pose the potential for nonconformances, errors, confusing reports or difficulties establishing traceability may be identified during internal audits. These items are highlighted for systematic change using the corrective action system and managed to resolution using the procedures for corrective action identified in SOP MSQA-CA.

Client Notification. Defective processes, systematic errors, and quality defects detected during routine audits may have negative impacts on data quality. In some cases, data that have been released to clients may be affected. If defective data have been released for use, SGS North America Inc. will immediately notify the affected clients of the defect and provide specific details regarding the magnitude of the impact to their data.

Management Reports. Formal reports of all audit and proficiency testing activity are prepared for the management staff and presented as they occur. Additional reports may be presented orally at regularly scheduled staff meetings.

Notes from managerial and supervisory personnel reports are recorded during staff meetings.

Management reports also address the following topics as they arise:

- Suitability of policies and procedures,
- Status and results of internal and external audits,
- Status and results of internal and external proficiency testing,
- Identification of quality control problems in the laboratory,
- Discussion of corrective and preventive action issues,
- Changes in the volume and type of the work,
- Customer feedback and complaints,
- Status of external certifications and approvals,
- Status of staff training and qualifications,
- Discussion of new quality system initiatives.

Recommendations for further action on listed items are included in the report.

HEALTH AND SAFETY

Requirement.

The laboratory operates a formal Health and Safety Program that complies with the requirements established by the Occupational Safety and Health Administration (OSHA). The program consists of key policies and practices that are essential to safe laboratory operation. All employees are required to receive training on the program elements. Job specific training is conducted to assure safe practices for specific tasks. All employees are required to participate in the program, receive initial and annual training, and comply with the program requirements. All plan and program requirements are detailed in the Health and Safety Program Manual.

Policy.

SGS North America Inc. provides a safe and healthy working environment for its employees and clients while protecting the public and preserving the Company's assets and property. The company will comply with applicable government regulations pertaining to safety and health in the laboratory and the workplace.

The objective of the SGS North America Inc. Health and Safety Program is to promote safe work practices that minimize the occurrence of injuries and illness to the staff through proper health and safety training, correct laboratory technique application, and the use of engineering controls.

Responsibilities. The Health and Safety Program assists managers, supervisors and non-supervisory employees in control of hazards and risks to minimize the potential for employee and client injuries, damage to client's property, and damage or destruction to SGS North America Inc.'s facility.

The Director of Health and Safety is responsible for implementing the Program's elements and updating its contents as necessary. He/she also conducts periodic audits to monitor compliance and assess the program's effectiveness. The Health and Safety Director is also responsible for creating and administering safety training for all new and existing employees.

The employee is responsible for following all safety rules established for the protection of themselves and others and the proper use of protective devices provided by the Company. The employee is expected to comply with the requirements of the program at all times. Department managers and supervisors are responsible for ensuring the requirements of the Safety Program are practiced daily. The Vice President IE SGS North America Inc. retains the ultimate responsibility for the program design and implementation.

Program Elements.

Safety Education, Training and Communication is conducted to increase the staff's awareness of laboratory hazards and the knowledge of the safety practices and procedures required for protection. It is also used to communicate general safety procedures required for the safe operation of a chemical laboratory.

Initial health and safety training for new employees is conducted during orientation. The training focuses on the SGS North America Inc. Safety and Health Program, including specific training for the hazards that may be associated with the employees' duties. Training is conducted for all program elements focusing on general, acceptable, laboratory safety procedures. Targeted training is conducted to address hazards or safety procedures that are specific to individual employee's work assignments. All training activities are documented and archived in individual training folders.

Safety Committee. The safety committee meets on a regular basis and establishes an additional safety "presence" throughout the facility. The safety committee promotes knowledge of health and safety at all levels, identifies and notifies of any unsafe work practices and conditions, and participates in development of safety initiatives.

Hazard Identification and Communication. The hazard communication program enables employees to readily identify any laboratory hazards and protect themselves from those hazards. This program complies with the OSHA Hazard Communication Standard, Title 29 Code of Federal Regulations 1910.1200 that requires the company to adopt and adhere to the following key elements:

- Safety Data Sheets (SDS) must be available to any employee wishing to view them.
- The Company must maintain a Hazardous Chemical inventory (by location).
- Containers are properly labeled.
- All employees must be provided with annual Hazard Communication and Right to Know training.

Identification of Workplace Hazards. The workplace hazard identification procedures have been designed to ensure that hazards possibly causing personnel injury or destruction of property are identified, managed and/or systematically eliminated from the operation. This identification system eliminates hazards, limits the potential for injury, and increases the overall safety of the work environment.

Employee Exposure Assessment. Employee exposure assessment is performed to identify and evaluate potential exposure hazards associated with the employees workstation. The exposure assessment data is used to determine if any changes or modifications to the workstation are needed to limit exposure to laboratory conditions that could negatively affect an employee's health and/or disclosed existing medical conditions.

Bloodborne Pathogens. SGS North America Inc. has implemented awareness training on the OSHA Bloodborne Pathogen Standard, 29CFR1910.1030 to reduce occupational exposure to Hepatitis B Virus (HBV), Human Immunodeficiency Virus (HIV), and other bloodborne pathogens that employees may encounter in their workplace.

Chemical Hygiene Plan. The Chemical Hygiene Plan complies with the requirements of the OSHA Occupational Exposure to Hazardous Chemicals in the Laboratory Standard, 29 CFR 1910.1450. The plan establishes procedures, identifies safety equipment, personal protective equipment, and work practices that protect employees from the hazardous chemicals in the laboratory when properly used and applied.

Chemical Spill Response Plan. The chemical spill response plan has been designed to minimize the risks from a chemical spill or accidental chemical release in the laboratory. Risk minimization is accomplished through a planned response that follows a defined procedure.

Employees that are required to respond to an emergency spill are trained per the OSHA Hazardous Waste Operations and Emergency Response Standard, 29 CFR 1910.120.

Emergency Action & Evacuation Plan details the procedures used to protect and safeguard SGS North America Inc.'s employees and property during emergencies. Emergencies are defined as fires or explosions, gas leaks, building collapse, hazardous material spills, emergencies that immediately threaten life and health, bomb threats and natural disasters such as floods, hurricanes or tornadoes, terrorism or terrorist actions. The plan identifies emergency coordinators, building evacuation meeting areas, and contact information for local and national emergency responders.

Lockout/Tagout Plan ensures that laboratory employees and outside contractors take steps to render equipment inoperable and/or safe before conducting maintenance activities. The plan details the procedures for conducting maintenance on equipment that has the potential to unexpectedly energize, start up, or release energy or can be operated unexpectedly or accidentally resulting in serious injury to employees. The plan ensures that employees performing maintenance render the equipment safe through lock out or tag out procedures.

Personal Protection Equipment. Policies have been implemented which detail the personal protection requirements for employees. The policy includes specifications regarding engineering controls, personal protective equipment (PPE), hazardous waste, chemical exposures, working with chemicals and safe work practices. Safety requirements specific to processes or equipment are reviewed with the department supervisor or the IE Director before beginning operations.

Respiratory Protection Plan. The respiratory protection plan ensures that SGS North America Inc. employees are protected from exposure to respiratory hazards. This program is used in situations where engineering controls and/or safe work practices do not completely control the identified hazards. In these situations, respirators and other protective equipment are used. Supplemental respiratory protection procedures are applied to specified maintenance personnel, employees who handle hazardous wastes in the hazardous waste storage area, and any employee who voluntarily elects to wear a respirator.

Visitor and Contractor Safety. Visitors must sign in, wear a visitor badge, follow the instructions of their escort, and sign out before leaving the premises.

APPENDIX I

GLOSSARY OF TERMS

Acceptance Criteria: Specified limits placed on characteristics of an item, process, or service defined in requirement documents.

Accreditation: The process by which an agency or organization evaluates and recognizes a laboratory as meeting certain predetermined qualifications or standards, thereby accrediting the laboratory.

Accreditation body: Authoritative body that performs accreditation.

Accuracy: The degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations; a data quality indicator.

Aliquot: A discrete, measured, representative portion of a sample taken for analysis.

Analysis: A combination of sample preparation and instrument determination.

Analysis Date: The calendar date of analysis associated with the analytical result reported for an accreditation or experimental field of proficiency testing.

Analyst: The designated individual who performs the "hands-on" analytical methods and associated techniques and who is responsible for applying required laboratory practices and other pertinent quality controls to meet the required level of quality.

Analyte: The specific chemicals or components for which a sample is analyzed; it may be a group of chemicals that belong to the same chemical family and are analyzed together.

Assessment: The evaluation process used to measure the performance, effectiveness, and conformance of an organization and/or systems to defined criteria (i.e., to the standards and requirements of laboratory accreditation).

Audit: A systematic and independent examination of facilities, equipment, personnel, training, procedures, record keeping, data validation, data management, and reporting aspects of a system to determine whether QA/QC and technical activities are being conducted as planned and whether these activities will effectively achieve quality objectives.

Batch: Environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A **preparation batch** is composed of one to twenty (20) environmental samples of the same quality systems matrix, meeting the above-mentioned criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours. An **analytical batch** is composed of prepared environmental samples (extracts, digestates or concentrates) which are analyzed together as a group. An analytical batch can include prepared samples originating from various quality system matrices and can exceed twenty (20) samples.

Bias: The systematic or persistent distortion of a measurement process which causes errors in one direction (i.e., the expected sample measurement is different from the sample's true value).

Blank: A sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage or analysis. The blank is subjected to the usual analytical and measurement processes to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results. Blanks include:

> *Method Blank:* A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses.

Blind Sample: A sub-sample for analysis with a composition known to the submitter. The analyst/laboratory may know the identity of the sample but not its composition. It is used to test the analyst's or laboratory's proficiency in the execution of the measurement process.

BNA: Base, Neutral, and Acid; basic, neutral, and acidic organic compounds that are soluble in methylene chloride and capable of being eluted, without derivatization, as sharp peaks from a gas chromatographic fused-silica capillary column coated with a slightly polar silicone stationary phase.

Calibration: A set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards.

> 1) In calibration of support equipment, the values realized by standards are established through the use of reference standards which are traceable to the International System of Units (SI).
>
> 2) In calibration according to methods, the values realized by standards are typically established through the use of Reference Materials which are either purchased by the laboratory with a certificate of analysis or purity or are prepared by the laboratory using support equipment that has been calibrated or verified to meet specifications.

Calibration Curve: The mathematical relationship between the known values, such as concentrations, of a series of calibration standards and their instrument response.

Calibration Method: A defined technical procedure for performing a calibration.

Calibration Range: The range of values (concentrations) between the lowest and highest calibration standards of a multi-level calibration curve. For metals analysis with a single-point calibration, the low-level calibration "check" standard and the high-level standard establish the linear calibration range which lies within the linear dynamic range.

Calibration Standard: A substance or reference material used for calibration.

Case Narrative: A statement of non-conformances associated with a particular data report.

Certified Reference Material (CRM): Reference material, accompanied by a certificate, having a value, measurement uncertainty, and stated metrological traceability chain to a national metrology institute.

Chain of Custody (CoC): Record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and types of containers; the mode of collection; the collector; the date and time of collection; any preservation; and all requested analyses. See also Legal Chain of Custody Protocols.

Confirmation: Verification of the identity of a component through the use of an approach with a different scientific principle from the original method. This may include, but is not limited to second column confirmation, alternate wavelength, derivatization, mass spectral interpretation, alternative detectors, or additional cleanup procedures.

Continuing Calibration Blank (CCB): A standard solution which contains no analyte and is used to verify calibration (CCB) blank response and freedom from carryover, analyzed after the CCV and after the Interference Check Standard (ICS).

Continuing Calibration Verification (CCV): The required verification of the initial calibration that is performed during the course of analysis at periodic intervals. Continuing Calibration Verification applies to both external standard and internal standard calibration techniques, as well as to linear and non-linear calibration models.

Continuous Improvement (CIP): Any procedure, capital improvement, expansion, or addition that improves the quality of operations of the laboratory.

Controlled Copy: Controlled document distributed with the intention that all updates to the document are provided to the holder of the controlled copy and that the copy is returned when no longer needed. The controlled copies are numbered and a Tracking Sheet (is maintained which includes the holder's name and location.

Corrective Action: The action taken to eliminate the cause(s) of an existing nonconformity, defect or other undesirable situation in order to prevent recurrence.

Clean Water Act, CWA (Federal Water Pollution Control Act): The enabling legislation under 33 U.S.C. 1251 et seq., Public Law 92-50086 Stat. 816, that empowers EPA to set discharge limitations, write discharge permits, monitor, and bring enforcement action for noncompliance.

Data Audit: A qualitative and quantitative evaluation of the documentation and procedures associated with environmental measurements to verify that the resulting data are of acceptable quality (i.e., that they meet specified acceptance criteria).

Data Integrity: The condition that exists when data are sound, correct, and complete, and accurately reflect activities and requirements.

Data Reduction: The process of transforming the number of data items by arithmetic or statistical calculations, standard curves, or concentration factors and collating them into a more useable form.

Demonstration of Capability (DoC): A procedure to establish the ability of the analyst to generate analytical results by a specific method that meet measurement quality objectives (e.g., for precision and bias).

Detection Limit (DL): The smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration with 99% confidence. At the DL, the false positive rate (Type I error) is 1%. A DL may be used as the lowest concentration for reliably reporting a detection of a specific analyte in a specific matrix with a specific method with 99% confidence.

Documents: Written components of the laboratory management system (e.g., policies, procedures, and instructions).

Document Control: The act of ensuring that documents (and revisions thereto) are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly and controlled to ensure use of the correct version at the location where the prescribed activity is performed.

Documentation of Understanding (DOU): A document which indicates that a person has read and understood a procedure detailed in the reference standard operating procedure (SOP).

Duplicate Analyses (DUP): The analyses or measurements of the variable of interest performed identically on two sub-samples of the same sample. The results from duplicate analyses are used to evaluate analytical or measurement precision but not the precision of sampling, preservation or storage internal to the laboratory.

Field of Accreditation: Those matrix, technology/method, and analyte combinations for which the accreditation body offers accreditation.

False Negative: A result that fails to identify (detect) an analyte or reporting an analyte to be present at or below a level of interest when the analyte is actually greater than the level of interest.

False Positive: An item incorrectly identified as present in the sample, resulting in a high reporting value for the analyte of concern.

Field of Testing: NELAC's approach to accrediting laboratories by program, method and analyte. Laboratories requesting accreditation for a program-method-analyte combination or for an updated/improved method are required submit to only that portion of the accreditation process not previously addressed (see NELAC, Section 1.9ff).

Finding: An assessment conclusion referenced to a laboratory accreditation standard and supported by objective evidence that identifies a deviation from a laboratory accreditation standard requirement. The finding must be linked to a specific requirement (e.g., TNI standard, ISO requirements, analytical methods, contract specifications, or laboratory management systems requirements).

Holding Time (HT): The maximum time that may elapse from the time of sampling to the time of preparation or analysis, or from preparation to analysis, as appropriate.

Improper Actions: Intentional or unintentional deviations from contract-specified or method-specified analytical practices that have not been authorized by the customer.

Internal Standard: A known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method.

Instrument Blank: A clean sample (e.g., distilled water) processed through the instrumental steps of the measurement process; used to determine instrument contamination.

Laboratory Control Sample (LCS) [such as laboratory fortified blank (LFB), blank spike (BS), or QC Check Sample]: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes and taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a reference method. It is generally used to establish intra-laboratory or analyst-specific precision and bias or to assess the performance of all or a portion of the measurement system.

Laboratory Information Management System (LIMS): The database used to electronically store all client related information, matrix specific MDLs, RLs, spike amounts, and control limits for a given method. LIMS automatically applies the client's analytical specifications to the analytical data.

Legal Chain of Custody Protocols: Procedures employed to record the possession of samples from the time of sampling through the retention time specified by the client or program. These procedures are performed at the special request of the client and include the use of a Chain of Custody Form that documents the collection, transport, and receipt of compliance samples by the laboratory. In addition, these protocols document all handling of the samples within the laboratory.

Limit of Detection (LOD): A laboratory's estimate of the minimum amount of a substance that an analytical process can reliably detect. An LOD is analyte and matrix-specific and may be laboratory-dependent. LOD is the smallest concentration of a substance that must be present in a sample in order to be detected at the DL with 99% confidence. At the LOD, the false negative rate (Type II error) is 1%. A LOD may be used as the lowest concentration for reliably reporting a non-detect of a specific analyte in a specific matrix with a specific method at 99% confidence.

Limit of Quantitation (LOQ): The minimum level, concentration, or quantity of a target analyte that can be reported with a specified degree of confidence. LOQ is the lowest concentration that produces a quantitative result with known and recorded precision and bias. The LOQ shall be set at or greater than the concentration of the lowest initial calibration standard.

Linear Dynamic Range (LDR): Concentration range where the instrument provides a linear response.

Lot: A definite amount of material produced during a single manufacturing cycle intended to have uniform character and quality.

Management: Those individuals directly responsible and accountable for planning, implementing, and assessing work.

Matrix: The component or substrate that contains the analyte of interest. For purposes of batch and QC requirement determinations, the following matrix distinctions shall be used:

> Aqueous: Any aqueous sample excluded from the definition of Drinking Water matrix or Saline/Estuarine source. Includes surface water, groundwater, effluents, and TCLP or other extracts.

Drinking Water: Any aqueous sample that has been designated as a potable or potential potable water source.

Solids: Includes soils, sediments, sludges and other matrices with > 15% settleable solids.

Chemical Waste: A product or by-product of an industrial process that results in a matrix not previously defined.

Air: Whole gas or vapor samples including those contained in flexible or rigid wall containers and the extracted concentrated analytes of interest from a gas or vapor that are collected with a sorbent tube, impinger solution, filter, or other device.

Biota: Animal or plant tissue, consisting of entire organisms, homogenates, and/or organ or structure specific subsamples.

Matrix Duplicate: A replicate matrix prepared in the laboratory and analyzed to obtain a measure of precision.

Matrix Spike [spiked sample or fortified sample] (MS): A sample prepared, taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a referenced method, by adding a known mass of target analyte to a specified amount of sample for which an independent test result of target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency.

Matrix Spike Duplicate [spiked sample or fortified sample duplicate] (MSD): A second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.

MAXIMUM CONTAMINATION LEVEL (MCL): The maximum level of a contaminant allowed in drinking water which is delivered to any consumer.

Method: A body of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, quantification), systematically presented in the order in which they are to be executed.

Method Detection Limit (MDL): One way to establish a Limit of Detection.

National Environmental Laboratory Accreditation Conference (NELAC): A voluntary organization of State and Federal environmental officials and interest groups purposed primarily to establish mutually acceptable standards for accrediting environmental laboratories. A subset of NELAP.

National Environmental Laboratory Accreditation Program (NELAP): The overall National Environmental Laboratory Accreditation Program of which NELAC is a part.

National Institute of Standards and Technology (NIST): An agency of the US Department of Commerce's Technology Administration that is working with EPA, states, TNI, and other public and commercial entities to establish a system under which private sector companies and interested states can be accredited by NIST to provide NIST-traceable proficiency testing (PT) to those laboratories testing drinking water and wastewater.

NELAC Standards: The plan of procedures for consistently evaluating and documenting the ability of laboratories performing environmental measurements to meet nationally defined standards established by the National Environmental Laboratory Accreditation Conference.

Nonconformance: An indication or judgment that a product or service has not met the requirement of the relevant specifications, contract, or regulation; also, the state of failing to meet the requirements.

Operator Aid: A technical posting (such as poster, operating manual, or notepad) that assists workers in performing routine tasks. All operator aids must be controlled documents (i.e., a part of the laboratory management system).

OPP: Organophosphorus Pesticide; organic compounds that contain phosphorus and have been widely used as insecticides.

Organic-Free Reagent Water: All references to water in methods refer to water in which an interferant is not observed at the Lower Limit of Quantitation (LLOQ) for the compounds of interest. Preparation of organic-free reagent water may depend on the types of interferants of concern for the analysis and may include boiling, sparging with an inert gas, reverse osmosis purification, distillation, particle filtration, activated carbon filtration, ion exchange filtration, etc.

Performance Audit: The routine comparison of independently obtained *qualitative and* quantitative measurement system data with routinely obtained data in order to evaluate the proficiency of an analyst or laboratory.

Precision: The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.

Preservation: Any conditions under which a sample must be kept in order to maintain chemical and/or biological integrity prior to analysis.

Procedure: A specified way to carry out an activity or process. Procedures can be documented or not.

Proficiency Testing: A means of evaluating a laboratory's performance under controlled conditions relative to a given set of criteria, through analysis of unknown samples provided by an external source.

Proficiency Testing Program: The aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results and the collective demographics and results summary of all participating laboratories.

Proficiency Test Sample (PT): A sample the composition of which is unknown to the laboratory and is provided to test whether the laboratory can produce analytical results within specified acceptance criteria.

Qualitative Analysis: Analysis designed to identify the components of a substance or mixture.

Quality Assurance (QA): An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client and regulatory agencies.

Quality Control (QC): The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements for quality; also the system of activities and checks used to ensure that measurement systems are maintained within prescribed limits, providing protection against "out of control" conditions and ensuring that the results are of acceptable quality.

Quality Manual: A document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality and utility of its product to its users.

Quality System: A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required Quality Assurance (QA) and Quality Control (QC) activities.

Quantitation Limits: The maximum or minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be quantified with the confidence level required by the data user.

Quantitation Range: The range of values (concentrations) in a calibration curve between the LOQ and the highest successfully analyzed initial calibration standard used to relate instrument response to analyte concentration. The quantitation range (adjusted for initial sample volume/weight, concentration/dilution and final volume) lies within the calibration range.

Quantitative Analysis: Analysis designed to determine the amounts or proportions of the components of a substance.

Raw Data: The documentation generated during sampling and analysis. This documentation includes, but is not limited to, field notes, electronic data, magnetic tapes, untabulated sample results, QC sample results, print outs of chromatograms, instrument outputs, and handwritten records.

Reporting Limits (RL): The lowest concentration value of a target variable (e.g., analyte) that can be quantified with the confidence level required by the data user.

Reagent Blank (Method Reagent Blank or Method Blank): A sample consisting of reagent(s), without the target analyte or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps.

Reference Material: Material or substance one or more of whose property values are sufficiently homogeneous and well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials.

Reference Method: A reference method is a published method issued by an organization generally recognized as competent to do so. (When the ISO language refers to a "standard method", that term is equivalent to "reference method"). When a laboratory is required to analyze an analyte by a specified method due to a regulatory requirement, the analyte/method combination is recognized as a reference method. If there is not a regulatory requirement for the analyte/method combination, the analyte/method combination is recognized as a reference method if it can be analyzed by another reference method of the same matrix and technology.

Reference Standard: Standard used for the calibration of working measurement standards in a given organization or at a given location.

Replicate Analyses: The measurements of the variable of interest performed identically on two or more sub-samples of the same sample within a short time interval.

Requirement: Denotes a mandatory specification.

Resource Conservation and Recovery Act (RCRA): The enabling legislation under 42 USC 321 et seq. (1976) that gives EPA the authority to control hazardous waste from "cradle to-grave", including its generation, transportation, treatment, storage, and disposal.

Retention Time: The time between sample injection and the appearance of a solute peak at the detector.

Safe Drinking Water Act (SDWA): The enabling legislation under 42 USC 300f et seq. (1974), (Public Law 93-523) that requires the EPA to protect the quality of drinking water in the U.S. by setting maximum allowable contaminant levels, monitoring, and enforcing violations.

Sample: Portion of material collected for analysis, identified by a single, unique alphanumeric code. A sample may consist of portions in multiple containers, if a single sample is submitted for multiple or repetitive analysis.

SOC: Synthetic Organic Compounds.

Sample Duplicate (DUP): Two samples taken from and representative of the same population and carried through all steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variance of the total method including sampling and analysis.

Second source calibration verification (ICV): A standard obtained or prepared from a source independent of the source of standards for the initial calibration. Its concentration should be at or near the middle of the calibration range. It is analyzed following the initial calibration.

Signal to Noise Ratio (S/N): S/N is a measure of signal strength relative to background noise. The average strength of the noise of most measurements is constant and independent of the magnitude of the signal. Thus as the quantity being measured (producing the signal) decreases in magnitude, S/N decreases and the effect of noise on the relative error of a measurement increases.

SIM (Selected Ion Monitoring): A mode of Mass Spectrometry (MS) operation in which specific m/e ratios are monitored, as opposed to scanning the entire mass range.

Spike: A known amount of target analyte added to a blank sample or sub-sample; used to determine recovery efficiency or for other quality control purposes.

Standard: The document describing the elements of laboratory accreditation that has been developed and established within the consensus principles of standard setting and meets the approval requirements of standard adoption organizations procedures and policies.

Standard (Chemical): Standard samples are comprised of a known amount of standard reference material in the matrix undergoing analysis. A standard reference material is a certified reference material produced by the US National Institute of Standards and Technology (NIST) and characterized for absolute content, independent of analytical test method.

Standard Operating Procedures (SOPs): A written document detailing the process/method for an operation, analysis, or action, with thoroughly prescribed techniques and steps. SOPs are officially approved as the methods for performing certain routine or repetitive tasks.

Surrogate: A substance with properties that mimic the analyte of interest. It is unlikely to be found in environment samples and is added to field samples for quality control purposes.

Target Analytes: Analytes or chemicals of primary concern identified by the customer on a project-specific basis.

Technology: A specific arrangement of analytical instruments, detection systems, and/or preparation techniques.

Test Method: A definitive procedure that determines one or more characteristics of a given substance or product.

TNI Standards: The plan of procedures for consistently evaluating and documenting the ability of laboratories performing environmental measurements to meet nationally defined standards established by The NELAC Institute.

Traceability: The ability to trace the history, application, or location of an entity by means of recorded identifications. In a calibration sense, traceability relates measuring equipment to national or international standards, primary standards, basic physical constants or properties, or reference materials. In a data collection sense, it relates calculations and data generated throughout the project back to the requirements for the quality of the project.

Tuning: A check and/or adjustment of instrument performance for mass spectrometry as required by the method.

Unethical Actions: Deliberate falsification of analytical or quality control results where failed method or contractual requirements are made to appear acceptable.

United States Environmental Protection Agency (EPA): Federal governmental agency with the responsibility for protecting public health and safeguarding and improving the natural environment (i.e., the air, water, and land) upon which human life depends.

Validation: The confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled.

Verification: Confirmation by examination and objective evidence that specified requirements have been met.

NOTE: In connection with the management of measuring equipment, verification provides a means for checking that the deviations between values indicated by a measuring instrument and corresponding known values of a measured quantity are consistently smaller than the maximum allowable error defined in a standard, regulation or specification peculiar to the management of the measuring equipment.

The result of verification leads to a decision either to restore in service, to perform adjustment, to repair, to downgrade, or to declare obsolete. In all cases, it is required that a written trace of the verification performed shall be kept on the measuring instrument's individual record.

VOA: Volatile Organic Analysis.

VOC: Volatile Organic Compound.

Work Cell: A defined group of analysts that together perform the method analysis. Members of the group and their specific functions within the work cell must be fully documented. A "work cell" is considered to be all those individuals who see a sample through the complete process of preparation, extraction, or analysis. The entire process is completed by a group of capable individuals. Each member of the work cell demonstrates capability for each individual step in the method sequence.

APPENDIX II

ANALYTICAL CAPABILITIES

Method Capabilities by NELAC Accredited Fields of Testing

Analytes	Method Number	Program	Chemistry Field
Alkalinity	SM 2320B-2011	Drinking Water	Inorganic Wet Chem
Anions			
Bromide	EPA 300.0	Drinking Water	Inorganic Wet Chem
Chloride	EPA 300.0	Drinking Water	Inorganic Wet Chem
Fluoride	EPA 300.0	Drinking Water	Inorganic Wet Chem
Nitrate	EPA 300.0	Drinking Water	Inorganic Wet Chem
Nitrite	EPA 300.0	Drinking Water	Inorganic Wet Chem
o-Phosphate	EPA 300.0	Drinking Water	Inorganic Wet Chem
Sulfate	EPA 300.0	Drinking Water	Inorganic Wet Chem
Bromate, Chlorite, Chlorate	EPA 300.1	Drinking Water	Inorganic Wet Chem
Chlorine, Total Residual	SM 4500Cl-G-2011	Drinking Water	Inorganic Wet Chem
Color, Apparent	SM 2120B-2011	Drinking Water	Inorganic Wet Chem
Conductivity	SM 2510B-2011	Drinking Water	Inorganic Wet Chem
Corrosivity/Langelier Index	SM 203-1985	Drinking Water	Inorganic Wet Chem
Cyanide	EPA 335.4	Drinking Water	Inorganic Wet Chem
Organic Carbon, Total (TOC and DOC)	SM 5310B-2011	Drinking Water	Inorganic Wet Chem
Organic Carbon, Total (TOC and DOC)	SM 5310C-2011	Drinking Water	Inorganic Wet Chem
Perchlorate	EPA 314.0	Drinking Water	Inorganic Wet Chem
pH, Hydrogen Ion	EPA 150.1	Drinking Water	Inorganic Wet Chem
Total Dissolved Solids (TDS)	SM 2540C-2011	Drinking Water	Inorganic Wet Chem
Turbidity	SM 2130B-2011	Drinking Water	Inorganic Wet Chem
UV-254	SM 5910B	Drinking Water	Inorganic Wet Chem
Hardness – Total	SM 2340B-2011	Drinking Water	Metals
Mercury	EPA 245.1	Drinking Water	Metals
Metals – ICP	EPA 200.7	Drinking Water	Metals
Metals – ICP-MS	EPA 200.8	Drinking Water	Metals
Chlorinated Herbicides (temporarily off-line)	EPA 515.4	Drinking Water	Organics
Chlorinated Pesticides and PCBs	EPA 505	Drinking Water	Organics
DBCP & EDB	EPA 504.1	Drinking Water	Organics
Diquat & Paraquat	EPA 549.2	Drinking Water	Organics
Endothall	EPA 548.1	Drinking Water	Organics
Glyphosate	EPA 547	Drinking Water	Organics
Haloacetic Acids (HAA & Dalapon)	EPA 552.2	Drinking Water	Organics
N-Methylcarbamoyloximes & N-Methylcarbamates	EPA 531.1	Drinking Water	Organics
Organic Compounds, Semivolatile (SOC)	EPA 525.2	Drinking Water	Organics

Method Capabilities by NELAC Accredited Fields of Testing

Analytes	Method Number	Program	Chemistry Field
Trihalomethanes, Total (THM)	EPA 524.2	Drinking Water	Organics
Volatile Organic Compounds (VOC)	EPA 524.2	Drinking Water	Organics
Ammonia	SM 4500NH3-D-2011	Solid/Haz Waste	Inorganic Wet Chem
Ammonia with Distillation	SM 4500NH3-B/D-2011	Solid/Haz Waste	Inorganic Wet Chem
Anions			
Bromide	SW846 9056A	Solid/Haz Waste	Inorganic Wet Chem
Chloride	SW846 9056A	Solid/Haz Waste	Inorganic Wet Chem
Fluoride	SW846 9056A	Solid/Haz Waste	Inorganic Wet Chem
Nitrate	SW846 9056A	Solid/Haz Waste	Inorganic Wet Chem
Nitrite	SW846 9056A	Solid/Haz Waste	Inorganic Wet Chem
o-Phosphate	SW846 9056A	Solid/Haz Waste	Inorganic Wet Chem
Sulfate	SW846 9056A	Solid/Haz Waste	Inorganic Wet Chem
Cyanide	SW846 9012B	Solid/Haz. Waste	Inorganic Wet Chem
Cyanide (wipe)	SW846 9014	Solid/Haz. Waste	Inorganic Wet Chem
Free Liquid – Paint Filter	SW846 9095B	Solid/Haz. Waste	Inorganic Wet Chem
Ignitability	SW846 1010A	Solid/Haz. Waste	Inorganic Wet Chem
Oil & Grease – HEM	SW846 9071B	Solid/Haz. Waste	Inorganic Wet Chem
pH, Hydrogen Ion	SW846 9040C	Solid/Haz. Waste	Inorganic Wet Chem
pH, Soil and Waste	SW846 9045D	Solid/Haz. Waste	Inorganic Wet Chem
Phenols	SW846 9066	Solid/Haz Waste	Inorganic Wet Chem
Percent Solids	SM 2540 G-2011	Solid/Haz Waste	Inorganic Wet Chem
Reactivity (Cyanide)	SW846 7.3.3	Solid/Haz. Waste	Inorganic Wet Chem
Reactivity (Sulfide)	SW846 7.3.4	Solid/Haz. Waste	Inorganic Wet Chem
Sulfides Acid Soluble/Insoluble	SW846 9034	Solid/Haz. Waste	Inorganic Wet Chem
Total Organic Carbon (TOC)	SW846 9060A	Solid/Haz. Waste	Inorganic Wet Chem
Mercury, Liquid Waste	SW846 7470A	Solid/Haz. Waste	Metals Analysis
Mercury, Solid Waste	SW846 7471B	Solid/Haz. Waste	Metals Analysis
Metals – ICP	SW846 6010C, 6010D	Solid/Haz. Waste	Metals Analysis
Metals – ICP-MS (temporarily off-line)	SW846 6020A, 6020B	Solid/Haz. Waste	Metals Analysis
Metals, Solids	SW846 3050B	Solid/Haz. Waste	Metals Prep
Metals, Total – Water	SW846 3010A	Solid/Haz. Waste	Metals Prep
Metals, Total – Water, Rec. + Dissolved	SW846 3005A	Solid/Haz Waste	Metals Prep
SPLP Metals/Organics	SW846 1312	Solid/Haz Waste	Metals Prep
TCLP Metals/Semi Volatile Organics	SW846 1311	Solid/Haz. Waste	Metals Prep
TCLP Volatile Organics	SW846 1311	Solid/Haz. Waste	Organic Prep
Semivolatile Prep – Sulfur Cleanup	SW846 3660B	Solid/Haz. Waste	Organics Prep
Semivolatile Prep – Sulfuric Acid/MnO_2 Cleanup	SW846 3665A	Solid/Haz. Waste	Organics Prep
Semivolatile Prep – Waste Dilution	SW846 3580A	Solid/Haz. Waste	Organics Prep
Semivolatile Prep Solid – Microwave	SW846 3546	Solid/Haz. Waste	Organics Prep
Semivolatile Prep Water	SW846 3510C	Solid/Haz. Waste	Organics Prep
Volatile – Purge & Trap Solid	SW846 5035A	Solid/Haz. Waste	Organics Analysis

Method Capabilities by NELAC Accredited Fields of Testing

Analytes	Method Number	Program	Chemistry Field
Volatile – Purge and Trap Water	SW846 5030B	Solid/Haz. Waste	Organics Analysis
Alcohols	SW846 8015D	Solid/Haz. Waste	Organics Analysis
Base/Neutrals and Acids	SW846 8270C	Solid/Haz. Waste	Organics Analysis
Base/Neutrals and Acids	SW846 8270E	Solid/Haz. Waste	Organics Analysis
Diesel Range Organic	SW846 8015D	Solid/Haz. Waste	Organics Analysis
Dissolved Gas/Aqueous Media	RSKSOP-175 MOD	Solid/Haz Waste	Organics Analysis
Gasoline Range Organic	SW846 8015D	Solid/Haz. Waste	Organics Analysis
Glycol, Ethylene & Propylene	SW846 8015D	Solid/Haz. Waste	Organics Analysis
Organochlorine Pesticides	SW846 8081A	Solid/Haz. Waste	Organics Analysis
Organochlorine Pesticides	SW846 8081B	Solid/Haz. Waste	Organics Analysis
PCBs Aroclors	SW846 8082A	Solid/Haz. Waste	Organics Analysis
Volatile Organics (VOC)	SW846 8260B	Solid/Haz. Waste	Organics Analysis
Volatile Organics (VOC)	SW846 8260D	Solid/Haz. Waste	Organics Analysis
Hardness – Total as $CaCO_3$	SM 2340B-2011	Non-Potable Water	Metals
Mercury	EPA 245.1	Non-Potable Water	Metals
Metals – ICP	EPA 200.7	Non-Potable Water	Metals
Metals – ICP-MS	EPA 200.8	Non-Potable Water	Metals
Base/Neutrals and Acids	EPA 625.1	Non-Potable Water	Organics Analysis
Dissolved Gas/Aqueous Media	RSKSOP-175 Mod	Non-Potable Water	Organics Analysis
Nonylphenols	ASTM D7065-11	Non-Potable Water	Organics Analysis
Organochlorine Pests & PCBs	EPA 608.3	Non-Potable Water	Organics Analysis
Volatile Organics	EPA 624.1	Non-Potable Water	Organics Analysis
Acidity as $CaCO_3$	SM 2310B-2011	Non-Potable Water	Inorganic Wet Chem
Alkalinity as $CaCO_3$	SM 2320B-2011	Non-Potable Water	Inorganic Wet Chem
Ammonia	SM 4500NH_3-D/B-2011	Non-Potable Water	Inorganic Wet Chem
Anions			
Bromide	EPA 300.0	Non-Potable Water	Inorganic Wet Chem
Chloride	EPA 300.0	Non-Potable Water	Inorganic Wet Chem
Fluoride	EPA 300.0	Non-Potable Water	Inorganic Wet Chem
Nitrate	EPA 300.0	Non-Potable Water	Inorganic Wet Chem
Nitrite	EPA 300.0	Non-Potable Water	Inorganic Wet Chem
o-Phosphate	EPA 300.0	Non-Potable Water	Inorganic Wet Chem
Sulfate	EPA 300.0	Non-Potable Water	Inorganic Wet Chem
Bromate	EPA 300.1	Non-Potable Water	Inorganic Wet Chem
Chlorate	EPA 300.1	Non-Potable Water	Inorganic Wet Chem
Chlorite	EPA 300.1	Non-Potable Water	Inorganic Wet Chem
Biochemical Oxygen Demand (BOD)	SM 5210B-2011	Non-Potable Water	Inorganic Wet Chem
Carbonaceous BOD (CBOD)	SM 5210B-2011	Non-Potable Water	Inorganic Wet Chem
Chemical Oxygen Demand (COD)	SM 5220D-2011	Non-Potable Water	Inorganic Wet Chem
Chlorine, Free	SM 4500Cl-G-2011	Non-Potable Water	Inorganic Wet Chem
Chlorine, Total Residual	SM 4500Cl-G-2011	Non-Potable Water	Inorganic Wet Chem

Method Capabilities by NELAC Accredited Fields of Testing

Analytes	Method Number	Program	Chemistry Field
Chromium (VI)	SM 3500Cr-B-2011	Non-Potable Water	Inorganic Wet Chem
Color, Apparent	SM 2120B-2011	Non-Potable Water	Inorganic Wet Chem
Conductivity	SM 2510B-2011	Non-Potable Water	Inorganic Wet Chem
Cyanide, WAD	Lachat 10-204-00-1-WX	Non-Potable Water	Inorganic Wet Chem
Cyanide, Total	EPA 335.4	Non-Potable Water	Inorganic Wet Chem
Iron, Ferrous	SM 3500 Fe B-2011	Non-Potable Water	Inorganic Wet Chem
Oil & Grease – HEM	EPA 1664A	Non-Potable Water	Inorganic Wet Chem
Organic Carbon, Dissolved (DOC)	SM 5310B-2011	Non-Potable Water	Inorganic Wet Chem
Organic Carbon, Total (TOC)	SM 5310B-2011	Non-Potable Water	Inorganic Wet Chem
Perchlorate	EPA 314.0	Non-Potable Water	Inorganic Wet Chem
pH Hydrogen Ion	SM 4500H^+ B-2011	Non-Potable Water	Inorganic Wet Chem
Phenolics, Total	EPA 420.4	Non-Potable Water	Inorganic Wet Chem
Phosphorus, Total	SM 4500 P-B/E-2011	Non-Potable Water	Inorganic Wet Chem
Phosphorus, Total	EPA 365.1	Non-Potable Water	Inorganic Wet Chem
Residue – Filterable (TDS)	SM 2540C-2011	Non-Potable Water	Inorganic Wet Chem
Residue – Non-filterable (TSS)	SM 2540D-2011	Non-Potable Water	Inorganic Wet Chem
Residue – Total (TS)	SM 2540B-2011	Non-Potable Water	Inorganic Wet Chem
Residue – Volatile (VS)	SM 2540E-2011	Non-Potable Water	Inorganic Wet Chem
Salinity (NC)	SM 2520B-2011	Non-Potable Water	Inorganic Wet Chem
Solids, Total	SM 2540G-2011	Non-Potable Water	Inorganic Wet Chem
Sulfide	SM 4500S2-F-2011	Non-Potable Water	Inorganic Wet Chem
Sulfite – SO_3	SM 4500SO_3-B-2011	Non-Potable Water	Inorganic Wet Chem
TKN (Total Kjeldahl Nitrogen)	EPA 351.2	Non-Potable Water	Inorganic Wet Chem
Turbidity	SM 2130B-2011	Non-Potable Water	Inorganic Wet Chem
UV 254	SM 5910B	Non-Potable Water	Inorganic Wet Chem

Method Capabilities – Non-NELAC Methods

Analytes	**Method Number**	**Program**	**Chemistry Field**
Acidity as $CaCO_3$ (NC)	SM 2310B-2011 Mod	Solid/Haz Waste	Inorganic Wet Chem
Alkalinity (NC)	SM 2320B-2011	Solid/Haz Waste	Inorganic Wet Chem
Bomb Calorimeter (BTU)	ASTM D-240-64	Solid/Haz Waste	Inorganic Wet Chem
Chemical Oxygen Demand (NC)	SM 5220D-2011	Solid/Haz Waste	Inorganic Wet Chem
Exchangeable-sodium-percentage (NC)	US Dept Agr. Bk 60	Solid/Haz Waste	Inorganic Wet Chem
Flashpoint (NC)	ASTM D93, D92	Solid/Haz Waste	Inorganic Wet Chem
Flashpoint, Tag (NC)	ASTM D56	Solid/Haz Waste	Inorganic Wet Chem
Oxidation-Reduction Potential (temporarily off-line)	ASTM D1498-76	Solid/Haz Waste	Inorganic Wet Chem
Resistivity (calc from Conductivity; NC)	US Dept Agr. Bk 60; SM2510B	Solid/Haz Waste	Inorganic Wet Chem
Salinity (NC)	SM 2520B-2011	Solid/Haz Waste	Inorganic Wet Chem
Specific Conductance	US Dept Agr. Bk 60	Solid/Haz Waste	Inorganic Wet Chem
Specific Gravity of Solids	ASTM D5057	Solid/Haz Waste	Inorganic Wet Chem
Sulfide, Total	SM 4500S2-C/F MOD	Solid/Haz Waste	Inorganic Wet Chem
Volatile Solids, Total (NC)	SM 2540E-2011	Solid/Haz Waste	Inorganic Wet Chem
Carbon Dioxide	SM 4500CO2 D-2011	Non-Potable Water	Inorganic Wet Chem
Ferric Iron (NC)	SM 3500Fe B-2011	Non-Potable Water	Inorganic Wet Chem
Ionic Balance (Anion–Cation Balance) (NC)	SM 1030E-2011	Non-Potable Water	Inorganic Wet Chem
Oxygen, Dissolved	SM 4500O-G	Non-Potable Water	Inorganic Wet Chem
Specific Gravity	ASTM D287; D5057	Non-Potable Water	Inorganic Wet Chem
Sulfide, prep & calculation	SM 4500S2-B,H-2011	Non-Potable Water	Inorganic Wet Chem
Iron Related Bacteria (NC)	HACH IRB-BART	Non-Potable Water	Inorganic Wet Chem
Slime Forming Bacteria (NC)	HACH SLYM-BART	Non-Potable Water	Inorganic Wet Chem
Sulfate Reducing Bacteria (NC)	HACH SRB-BART	Non-Potable Water	Inorganic Wet Chem

NC= not certifiable

APPENDIX III

CERTIFICATION SUMMARY

Certifying Authority	Certification Program	Certification No.
California (NELAP)	Non-Potable, Solid/Hazardous Waste	pending
Colorado-primary	Potable Water	CO00049
Hawaii	Potable Water	CO00049
Louisiana DHH (NELAP)	Potable Water	LA150028
Nebraska	Private/Non-Compliance Potable Water	NE-OS-06-04
Nevada (NELAP)	Potable Water/Non-Potable, Solid/Hazardous Waste	CO00049
New Jersey (NELAP)	Potable Water/Non-Potable, Solid/Hazardous Waste	CO011
North Carolina (NELAP)	Potable Water	08701
North Dakota (NELAP)	Potable Water/Non-Potable, Solid/Hazardous Waste	R-027
Texas (NELAP)	Potable Water	T104704511
Utah (NELAP)-primary	Potable, Non-Potable Water, Solid/Hazardous Wastes	CO00049
Wyoming	Potable Water	Not Applicable

APPENDIX IV

LABORATORY EQUIPMENT

(A detailed equipment list is kept as a separate document outside of this document.)

APPENDIX V

ACTIVE SOP LIST

SGS North America Inc. – Wheat Ridge Laboratory Standard Operating Procedures

Section	Method #	Description	SOP Name
Wet Chem	SW846 1311	Toxicity Characteristic Leaching Procedure (TCLP)	MSGN-1311
Wet Chem	SW846 1312	Synthetic Precipitation Leaching Procedure (SPLP)	MSGN-1312
Wet Chem	SM2310 B	Acidity, Total	MSGN-ACID
Wet Chem	SM2320 B	Alkalinity, Total, Carbonate, Bicarbonate, and Hydroxide	MSGN-ALK
Wet Chem	SM4500-NH_3 D	Ammonia-N by Ion-Selective Electrode	MSGN-NH3-N
Wet Chem	EPA 300.0/SW846 9056A	Anions, Inorganic, by Ion Chromatography	MSGN-300.0
Wet Chem	SM5210 B	Biochemical Oxygen Demand (BOD)	MSGN-BOD
Wet Chem	ASTM D240-64	BTU Calorimetric	MSGN-BTU
Wet Chem	SM5220 D	Chemical Oxygen Demand (COD)	MSGN-COD
Wet Chem	SM2120 B	Color by Visual Comparison	MSGN-COLOR
Wet Chem	EPA 335.4/9012B	Cyanide Distillation / Sample Analysis	MSGN-CN-MICRO-W
Wet Chem	Lachat 10-204-00-1-WX	Cyanide, Weak Acid Dissociable (WAD) Distillation & Analysis	MSGN-CNWAD-Micro-W
Wet Chem	EPA 300.1	Inorganic Disinfection by Products	MSGN-DBP
Wet Chem	SM4500-S_2 F	Dissolved and Un-ionized Sulfide	MSGN-DU-SULF
Wet Chem	SM3500Fe B	Dissolved Ferrous Iron	MSGN-Fe2+
Wet Chem	D92/D93/D56/SW846 1010A	Flashpoint/Ignitability	MSGN-FLASH
Wet Chem	In-House	Glassware Cleaning-General Chemistry Department	MSGN-GLASS
Wet Chem	SM3500-Cr B	Hexavalent Chromium by Spectrophotometer	MSGN-Cr6-W
Wet Chem	SM16 203	Langelier Index	MSGN-LANG

SGS North America Inc. – Wheat Ridge Laboratory
Standard Operating Procedures

Section	Method #	Description	SOP Name
Wet Chem	ASTM D1498-76	Oxidation-Reduction Potential	MSGN-REDOX
Wet Chem	SW846 9095B	Paint Filter Test	MSGN-PAINT
Wet Chem	EPA 314.0	Anions, Inorganic, by Ion Chromatography	MSGN-PERCHLORATE-IC
Wet Chem	SM2540B/G Mod.	Percent Moisture for Soil/Sediment, Determination of	MSGN-MOIST
Wet Chem	SW846 9040C	pH – Aqueous Wastes by Electrometric Measurement	MSGN-PH-WS
Wet Chem	SW846 9045D	pH – of Soil and Waste by Electrometric Measurement	MSGN-PH-SWS
Wet Chem	SM4500-H$^+$ B/E150.1	pH – Waters (discharge/DW) by Electrometric Measurement	MSGN-PH-W
Wet Chem	EPA 420.4	Phenols, Micro Distillation	MSGN-PN-MICRO
Wet Chem	SM4500-P B/E	Phosphorus, Total	MSGN-T-PHOS
Wet Chem	EPA 365.1	Phosphorus, Total by Discrete Analyzer	MSGN-TP
Wet Chem	SW846 7.3	Reactivity	MSGN-REACT
Wet Chem	SM4500-Cl G	Residual Chlorine, Total and Free	MSGN-RS-Cl
Wet Chem	SM2520B	Salinity	MSGN-SALINITY
Wet Chem	SM2540 B/G, E	Solids, Total and Volatile (TS and VS)	MSGN-TS
Wet Chem	SM2540 C	Solids, Total Dissolved (TDS)	MSGN-TDS
Wet Chem	SM2540D	Solids, Total Suspended (TSS)	MSGN-TSS
Wet Chem	SM2510 B	Specific Conductance of Water and Soil	MSGN-COND
Wet Chem	SM4500-S^2 C/F	Sulfides, Total	MSGN-T-SULF
Wet Chem	SM4500-SO$_3^{2-}$ B	Sulfite (SO$_3$ $^{-2}$) (Titrimetric)	MSGN-SULFITE
Wet Chem	EPA 365.1	TKN by Discrete Analyzer	MSGN-TKN-DA
Wet Chem	SM5310 C	TOC & DOC in Drinking Water	MSGN-5310 TOC
Wet Chem	SM5310 B/SW846 9060A	TOC/DOC in Non-Drinking Water Samples	MSGN-TOC
Wet Chem	SM2130B	Turbidity	MSGN-TURB

SGS North America Inc. – Wheat Ridge Laboratory
Standard Operating Procedures

Section	Method #	Description	SOP Name
Wet Chem	SM5910B	UV 254 Absorbing Organic Material and SUVA – Specific UV Absorption @ 254nm	MSGN-UV254
Wet Chem	EPA 1664A	Hexane Extractable Material (HEM) for Oil & Grease and Silica Gel Treated HEM (SGT-HEM)	MSOG-1664
Wet Chem	SW846 9071B	n-Hexane Extractable Material (HEM) – Soxhlet Extraction	MSOG-9071
Metals Analysis	---	Metals Laboratory Calculations	MSMT-Metal Calcs
Metals Analysis	EPA 200.7	ICP metals by 200.7	MSMT-ICP-200.7
Metals Analysis	SW846 6010	ICP metals by 6010	MSMT-ICP-6010
Metals Analysis	EPA 200.8	ICP-MS metals by 200.8	MSMT-ICPMS-200.8
Metals Analysis	SW846 6020	ICP-MS metals by 6020	MSMT-ICPMS-6020
Metals Analysis	EPA 245.1/SW846 7470A	Digestion & Analysis of Aqueous Samples for Mercury	MSMT-HG
Metals Analysis	SW846 7471B	Digestion & Analysis of Solid or Semi-solid for Mercury	MSMT-7471B
Metals Prep	E200.7/E200.8/SW846 3005A	Digestion of Aqueous Samples for ICP/ICP-MS Analysis	MSMP-200
Metals Prep	SW846 3010A	Acid digestion aqueous for 6010 and 6020 analysis	MSMP-3010
Metals Prep	SW846 3010A mod	Digestion of Sodium Absorption Ratio (SAR) Samples for ICP & ICP-MS	MSMP-3010SAR
Metals Prep	SW846 3050B	Acid digestion solid for 6010 and 6020 analysis	MSMP-3050
Organic Prep	EPA 525.2	Prep Organic Compounds (SOC & OPP) in Drinking Water	MSOP-525.2
Organic Prep	EPA 548.1	Prep Endothall in Drinking Water	MSOP-548.1
Organic Prep	EPA 608.3	Prep Pesticides and PCBs in Water by Separatory Funnel	MSOP-608
Organic Prep	EPA 625.1	Prep SVOA in Municipal Wastewater	MSOP-625.1

SGS North America Inc. – Wheat Ridge Laboratory
Standard Operating Procedures

Section	Method #	Description	SOP Name
Organic Prep	SW846 3510C/8015	Prep DRO in Water by Separatory Funnel	MSOP-DRO-W
Organic Prep	SW846 3510C/OA-2	Prep of extractable Petroleum Hydrocarbons – Water	MSOP-OA-2-W
Organic Prep	SW846 3510C/8081/8082	Prep Pesticides/PCBs Waters by Separatory Funnel	MSOP-8081-2-W
Organic Prep	SW846 3510C/8270	Prep SVOA in Water by Separatory Funnel	MSOP-8270-3510
Organic Prep	SW846 3546	Prep of Pesticides and/or PCBs, DRO, or Semi-volatiles for GC & GC/MS in Solid or Soil	MSOP-3546
Organic Prep	SW846 3580A/8015	Prep Organic DRO by Waste Dilution	MSOP-DRO-O
Organic Prep	SW846 3580A/OA-2	Prep of extractable Petroleum Hydrocarbons – Waste	MSOP-OA-2-O
Organic Prep	SW846 3580A/8081/8082	Prep Pesticides/PCBs by Waste Dilution	MSOP-8081-2-O
Organic Prep	SW846 3580A/8081/8082	Prep Pesticides/PCB Wipes	MSOP-8081-2-WP
Organic Prep	SW846 3580A/3510C mod/8082 modified	Prep of PCB Screens	MSOP-8082-SCR
Organic Prep	SW846 3580A/8270	Prep Organic SVOA by Waste Dilution	MSOP-8270-O
Organic Prep	SW846 3660B	Prep Sulfur Cleanup Prior to Determination of PCB Aroclors by GC/ECD	MSOP-3660
Organic Prep	SW846 3665A	Prep Sulfuric Acid Cleanup of Hexane Extracts Prior to Determination of PCB Aroclors by GC/ECD	MSOP-3665
Organic Prep	SW846 5035A	Collection and Preservation of Solid Samples for Volatile Organics Analysis	MSOP-5035
Organic Prep	-----	Glassware Cleaning – Organics & Metals	MSOP-GLASS
Organics-GC	EPA 504.1	Prep and Determination of EDB/DBCP in Drinking Water	MSGC-504.1
Organics-GC	EPA 505	Prep and Determination of Chlorinated Pesticides/PCBs in Drinking Water	MSGC-505
Organics-GC	EPA 515.4	Prep and Determination of Chlorinated Acids (Herbicides) in Drinking Water	MSGC-515.4

SGS North America Inc. – Wheat Ridge Laboratory
Standard Operating Procedures

Section	Method #	Description	SOP Name
Organics-GC	EPA 531.1	Carbamates in Drinking Water	MSHP-531.1
Organics-GC	EPA 547	Glyphosate in Drinking Water	MSHP-547
Organics-GC	EPA 549.2	Diquat and Paraquat in Drinking Water	MSHP-549.2
Organics-GC	EPA 552.2	Prep and Determination of Haloacetic Acids (HAA) in Drinking Water	MSGC-552.2
Organics-GC	EPA 608.3	Pesticides/PCBs in Waste Water	MSGC-608.3
Organics-GC	SW846 5021	Screening Analysis of Aromatic Volatiles & TVH/GRO using Headspace	MSGC-5021
Organics-GC	SW846 8015D	Alcohols	MSGC-8015D-ALC
Organics-GC	SW846 8015D	Glycols	MSGC-8015D-GLY
Organics-GC	SW846 8015D	TEH/DRO – Diesel, Jet, ORO	MSGC-8015D-DRO
Organics-GC	OA-2	Analysis of Extractable Petroleum Hydrocarbons by GC/FID	MSGC-OA2
Organics-GC	SW846 8015	GC Fingerprint (prep and analytical)	MSGC-Fingerprt
Organics-GC	SW846 8021B/8015D	BTEX-TVH/GRO Combo	MSGC-8021-8015D-GRO
Organics-GC	SW846 8081/8082	Chlorinated Pesticides/PCB by GC/ECD	MSGC-8081-2
Organics-GC	SW846 8082 Mod.	PCB Screen Analysis	MSGC-8082SC
Organics-GC	RSKSOP-175 Mod.	Methane, Ethane, Ethene in Air by GC/FID	MSGC-RSK-A
Organics-GC	RSKSOP-175 Mod.	Methane, Ethane, Ethene in Water by GC/FID	MSGC-RSK-W
Organics-GCMS	EPA 524.2	Purgeable Organics (VOCs & THMs) in Drinking Water	MSMS-524.2
Organics-GCMS	EPA 525.2	Organic Compounds (SOC & OPP) in Drinking Water	MSMS-525.2
Organics-GCMS	EPA 548.1	Endothall in Drinking Water	MSMS-548.1
Organics-GCMS	EPA 624.1	VOAs 624.1	MSMS-624.1

SGS North America Inc. – Wheat Ridge Laboratory
Standard Operating Procedures

Section	Method #	Description	SOP Name
Organics-GCMS	EPA 625.1	BNAs 625.1	MSMS-625.1
Organics-GCMS	ASTM D7065-11	Preparation and Determination of Nonyphenol Compounds by GC/MS	MSMS-7065
Organics-GCMS	SW846 8260B	VOAs 8260	MSMS-8260
Organics-GCMS	SW846 8270C	Semi-VOAs 8270	MSMS-8270
Organics-GCMS	SW846 8270E	Semi-VOAs 8270	MSMS-8270E
Organics-GCMS	SW846 8270C SIM	Semi-VOAs 8270 by SIM	MSMS-8270SIM
Organics-GCMS	SW846 8270E SIM	Semi-VOAs 8270 by SIM	MSMS-8270ESIM
HS	-----	Proper Use of Compressed Gas Cylinders	MSHS-Comp Gas
HS	-----	Procedures for Disposal Of Non-Hazardous VOA Vials Using Prodeva 95-6 Glass Crusher	MSHS-CRUSHER
HS	-----	Procedures for Installation, Use, And Disconnection of The Fisherpak 200-Liter Methylene Chloride Solvent Delivery System	MSHS-DCM Drum
HS	-----	RCRA Contingency Plan	RCRA Contingency Plan-WR
QA	-----	Calibration and Use of Auto-Pipettes	MSQA-AUTOPIPET
QA	-----	Calibration and Use of Volumetric Dispensers for Volume Critical Processes	MSQA-CRIT DISP
QA	-----	Calibration Verification of Analytical & Top-loading Balances	MSQA-Balance
QA	-----	Calibration of Thermometers	MSQA-Therm-Cal
QA	-----	Calibration Review and Data Reconstruction (for calibrations)	MSQA-CAL RV
QA	-----	Corrective Action Procedure	MSQA-CA
QA	-----	Documentation of Analyst Training and Proficiency	MSQA-Training

SGS North America Inc. – Wheat Ridge Laboratory
Standard Operating Procedures

Section	Method #	Description	SOP Name
QA	-----	Documenting Corrections to Written Data	MSQA-CORR
QA	-----	Ethics and Legal Responsibilities	MSQA-Ethics
QA	-----	Management and Control of Change	MSQA-MOC
QA	-----	Manual Integration of Chromatographic Peaks	MSQA-MPI
QA	-----	Procedure for Login, Management, Handling, and Reporting of Proficiency Test (PT) Samples	MSQA-PT
QA	-----	Preparation, Approval, Distribution & Archiving of SOPs	MSQA-SOP
QA	-----	Procedures for the Purchase of Laboratory Supplies	MSQA-Purchasing
QA	-----	Refrigerator Storage Holding Blank Procedure	MSQA-Refrig Blk
QA	-----	Rounding and Significant Figures	MSQA-Rnd-Sig
QA	-----	Sample and Waste Disposal	MSHS-DISP
QA	-----	Spikes and Standards Logs	MSQA-STD LOG
QA	-----	Calibration Verification and Use of Microliter Syringes	MSQA-Syringe
QA	-----	Temperature Monitoring	MSQA-Temp Mon
QA	-----	Verification of Disposable Pipettes	MSQA-Class B Vol
QA	-----	Quality System Manual	MS-QSM
RP	-----	Report Generation	MSRP-RPT-GEN
SM	-----	Chain of Custody and Log in Procedure	MSSM-LOGIN
SM	-----	Cooler Cleaning, Packaging, and Shipping Procedure	MSSM-Cooler
SM	-----	Couriers, Procedures for Sample	MSSM-Courier
SM	-----	Sample Bottle Screening and Quality Control	MSSM-Bottle-SCR

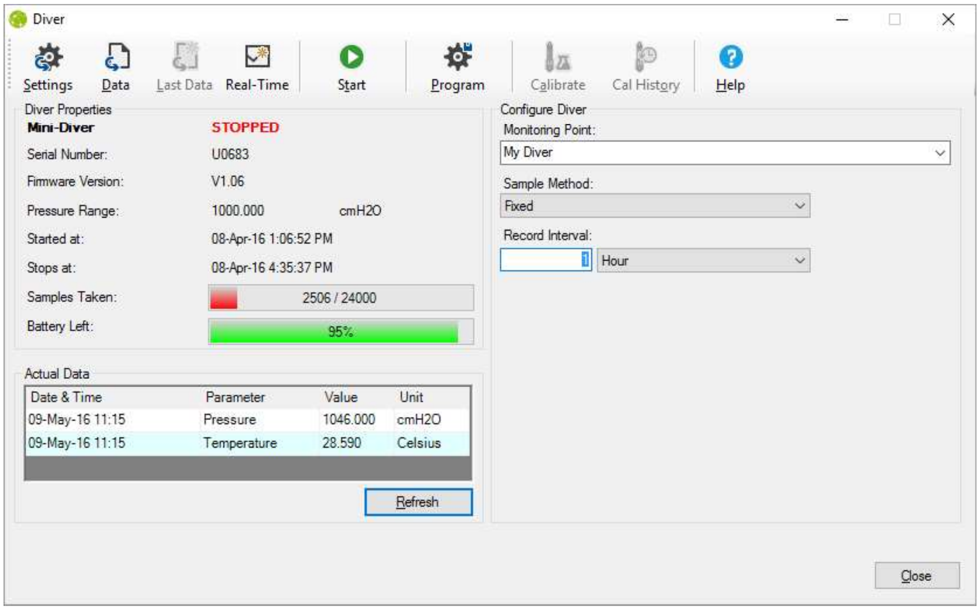
Quick Reference Guide

Working with Divers

Read Diver Settings

1. Place a Diver into the USB Reading Unit or connect to the PC interface cable. Ensure that your reading device is connected to your computer.
   Note: USB Reading Unit or PC interface cable must be connected prior to launching Diver-Office.

2. From the Diver-Office toolbar, select the **Diver** button. The **Diver** dialog will open displaying the settings and status of the Diver.



Diver Properties

Mini-Diver	STOPPED	
Serial Number:	U0683	
Firmware Version:	V1.06	
Pressure Range:	1000.000	cmH2O
Started at:	08-Apr-16 1:06:52 PM	
Stops at:	08-Apr-16 4:35:37 PM	
Samples Taken:	2506 / 24000	
Battery Left:	95%	

Actual Data

Date & Time	Parameter	Value	Unit
09-May-16 11:15	Pressure	1046.000	cmH2O
09-May-16 11:15	Temperature	28.590	Celsius

Configure Diver

Monitoring Point: My Diver

Sample Method: Fixed

Record Interval: 1 Hour

Program Diver Settings

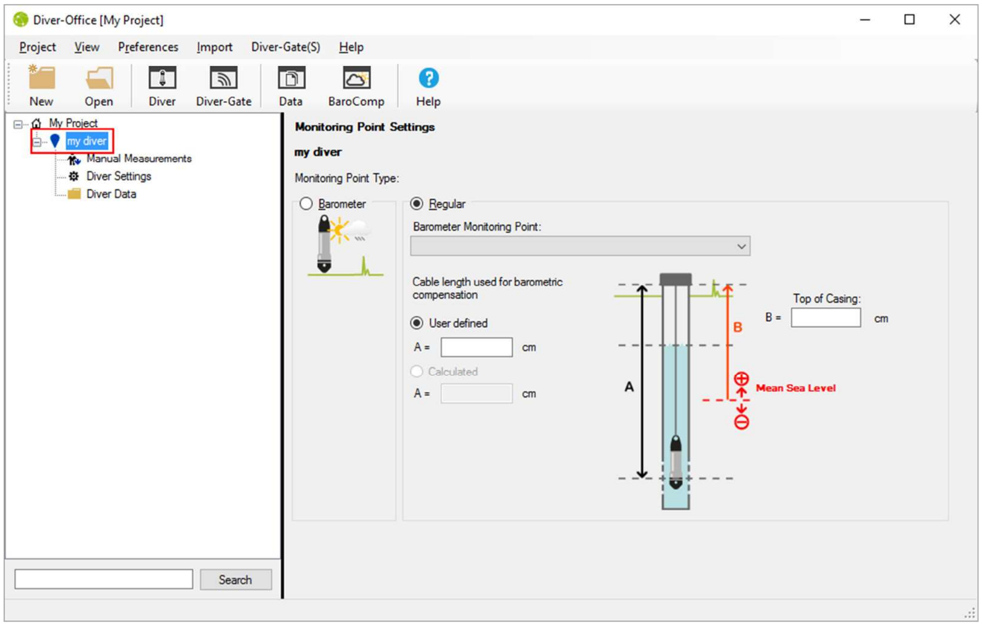
3. Enter the following information in the Diver dialog (shown above):

Monitoring Point	**Monitoring Point** name ***must be*** unique
Sampling Method	Choose between **Fixed**, **Averaging**, **Event Based**, **Setup A**, **B** or **C**, or **User Defined**
Record Interval	Enter a record interval (0.5 sec – 99 hr) * Fixed, Averaging or Event Based method only

4. Once the settings have been entered, click the **Program** button from the Diver toolbar.

Defining Monitoring Point Settings

5. Select the Monitoring Point name from the Project Tree. The Monitoring Point settings will load in the adjacent frame.



Monitoring Point Settings

my diver

Monitoring Point Type:

○ Barometer ● Regular

Barometer Monitoring Point:

Cable length used for barometric compensation

● User defined

A = cm

○ Calculated

A = cm

Top of Casing:

B = cm

6. Diver type, either **Regular** or **Barometer**, is automatically assigned but you can manually change this.
7. If the Diver type is **Regular**, enter the following settings:

Barometer Monitoring Point	Select the corresponding barometer location from the dropdown menu.

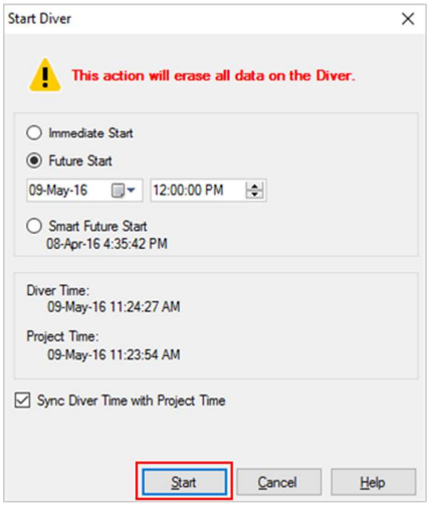
Note: This barometer location must already exist in your project

Cable Length (*optional*)	Enter the cable length measurement at the monitoring point
Top of Casing (*optional*)	Enter the top of casing measurement with respect to your vertical reference datum.

Starting a Diver

8. Click the ▶ **Start** Diver button from the Diver toolbar.
9. From the Start Diver dialog (shown below), select the appropriate start method, *i.e.*, **Immediate Start**, **Future Start** or **Smart Future Start**. These options are described in more

detail in the Diver-Office online help.



This action will erase all data on the Diver.

○ Immediate Start

● Future Start

09-May-16 12:00:00 PM

○ Smart Future Start
08-Apr-16 4:35:42 PM

Diver Time:
09-May-16 11:24:27 AM

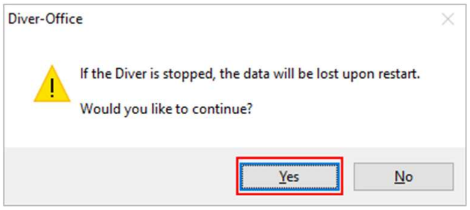
Project Time:
09-May-16 11:23:54 AM

☑ Sync Diver Time with Project Time

10. Click the **Start** button to complete the process.

Stopping a Diver

11. Click the ⏹ **Stop** button from the Diver toolbar.
12. Click the **Yes** button in the warning message that appears.



If the Diver is stopped, the data will be lost upon restart.

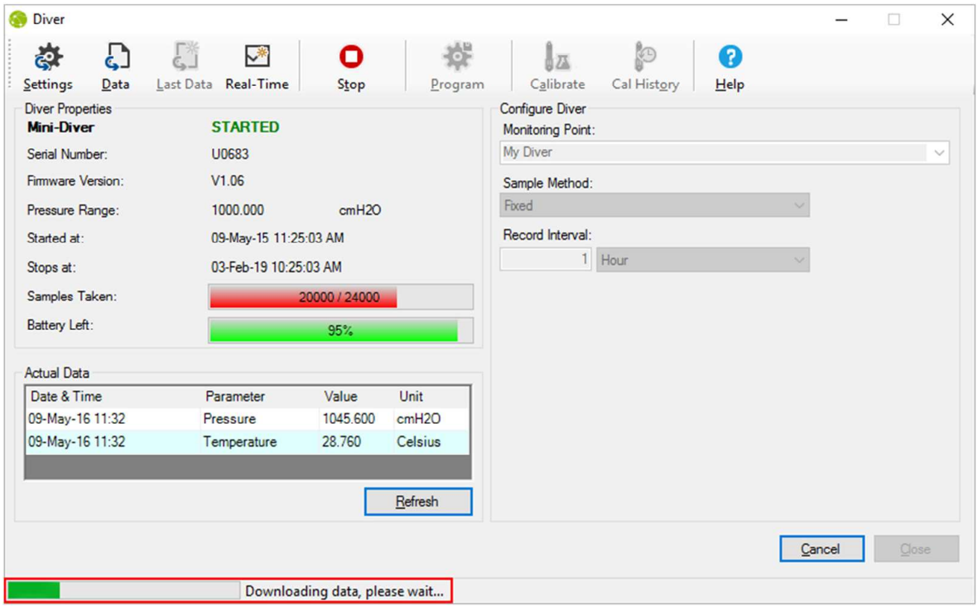
Would you like to continue?

Note Only the applicable option will show in the Diver dialog:

⏹ Stop Diver or ▶ Start Diver

Downloading Diver Data

13. Click the **Data** button from the Diver toolbar. The download progress is shown in the bottom left corner of the Diver dialog.



Diver Properties

Mini-Diver	STARTED	
Serial Number:	U0683	
Firmware Version:	V1.06	
Pressure Range:	1000.000	cmH2O
Started at:	09-May-15 11:25:03 AM	
Stops at:	03-Feb-19 10:25:03 AM	
Samples Taken:	20000 / 24000	
Battery Left:	95%	

Actual Data

Date & Time	Parameter	Value	Unit
09-May-16 11:32	Pressure	1045.600	cmH2O
09-May-16 11:32	Temperature	28.760	Celsius

Configure Diver

Monitoring Point: My Diver

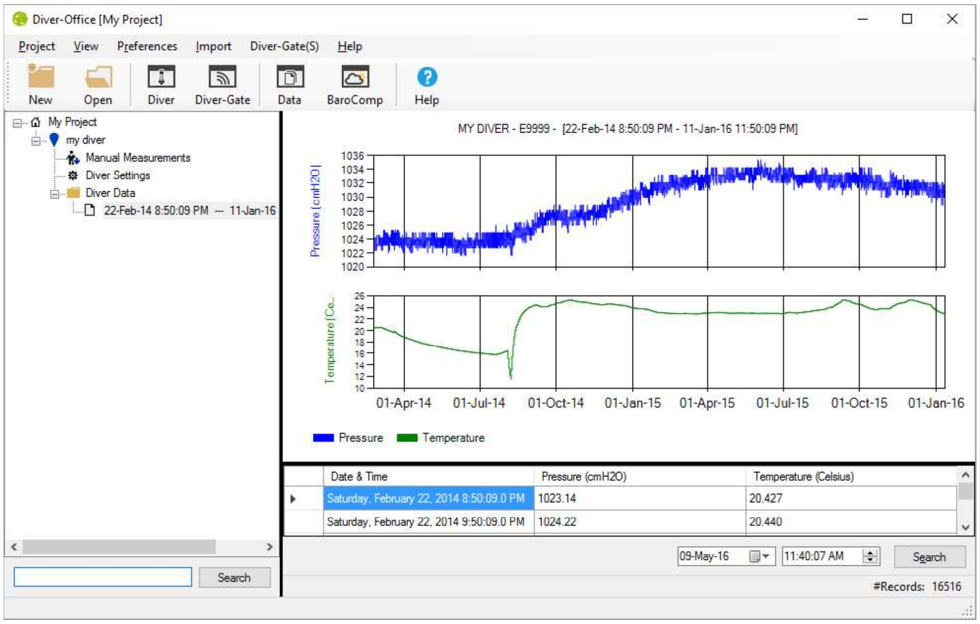
Sample Method: Fixed

Record Interval: 1 Hour

Downloading data, please wait...

Viewing Downloaded Diver Data

14. Once downloaded, your Diver dataset will be listed in the project tree and shown.



Date & Time	Pressure (cmH2O)	Temperature (Celsius)
Saturday, February 22, 2014 8:50:09.0 PM	1023.14	20.427
Saturday, February 22, 2014 9:50:09.0 PM	1024.22	20.440

09-May-16 11:40:07 AM

#Records: 16516

SOP-6
Groundwater Quality Sampling

Standard Operating Procedure

Revised January 2022

SOP-6
Groundwater Quality Sampling

Standard Operating Procedure

Revised January 2022

Brown AND Caldwell
1527 Cole Blvd.. Suite 300
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Table of Contents

Groundwater Quality Sampling....2
Section 1: Objective....2
Section 2: Scope and Applicability....2
Section 3: Responsibilities....2
Section 4: Definitions....2
Section 5: Required Materials....3
Section 6: Groundwater Sampling Methods....3
6.1 General Considerations....3
    6.1.1 Dedicated and Disposable Equipment....4
    6.1.2 Equipment Decontamination....4
    6.1.3 Sequence of Sampling....4
    6.1.4 Planning Phase....4
    6.1.5 Preparatory Activities....5
6.2 Purging and Sampling Procedures....6
    6.2.1 Preparatory Activities....6
    6.2.2 Water Level Measurements....7
    6.2.3 Well Purging....7
    6.2.4 Groundwater Sample Collection....9
6.3 Equipment Instructions....11
    6.3.1 Bladder Pump....11
    6.3.2 Small Diameter Electric Submersible Pump....13
    6.3.3 Bailer....15
    6.3.4 Peristaltic Suction Pump....16
6.4 Sample Shipment....17
Section 7: Quality Assurance/Quality Control....17
7.1 Equipment Rinsate Blanks....18
7.2 Field Blanks....18
7.3 Trip Blanks....18
7.4 Filter Blanks....18
7.5 Field Duplicate Samples....18
7.6 Matrix Spike/Matrix Spike Duplicate Samples....19
Section 8: Records....19
Section 9: References....20
Section 10: Attachments....20

SOP-6

Groundwater Quality Sampling

Section 1: Objective

The primary objective of this standard operating procedure (SOP) is to establish a uniform method for the monitoring and collection of representative groundwater samples from monitoring wells and to reduce the potential variability associated with purging and sampling. A further objective is to provide a detailed technical resource that can be used both for preparing detailed field sampling plans and for training.

Section 2: Scope and Applicability

This SOP will be used to support groundwater monitoring programs and conduct the field groundwater sampling activities. Groundwater sampling involves two primary operations: (1) purging stagnant water from a well, followed by (2) the collection of a sample from the same well. Groundwater sampling variables can be significantly controlled through the appropriate selection and use of purging and sampling equipment and through the use of procedures that are described in this SOP.

The methods described in this SOP have been developed in general conformance with the Environmental Protection Agency (EPA) Region 4 Groundwater Sampling SOP (EPA, 2017a), EPA Region 1 Low Stress (low flow) Purging and Sampling Procedure (EPA, 2017b), and applicable American Society for Testing and Materials (ASTM) standards including D4448 “Standard Guide for Sampling Ground-Water Monitoring Wells” and D6452 “Guide for Purging Methods for Wells Used for Ground-Water Quality Investigations”.

Section 3: Responsibilities

The project manager is responsible for ensuring that the project involving groundwater sampling is properly planned and executed and that the safety of personnel from chemical and physical hazards associated with the sampling is provided for. The field staff is responsible for conducting the sampling and to ensure that the project specifications defined in the project-specific planning documents are followed and that pertinent data are recorded on appropriate forms and in the field notebook. The site safety officer, typically the field geologist or engineer, is responsible for overseeing the health and safety of Brown and Caldwell employees and for stopping work if necessary to fix unsafe conditions observed in the field.

Section 4: Definitions

Dedicated equipment: Sampling equipment such as pumps and tubing that are either permanently installed or otherwise exclusively used in a single well.

Project-specific planning documents: Additional documents that are developed on a project by project basis that should be used in coordination with this and other SOPs. Examples include work and quality plans, laboratory scopes of work, and health and safety plans.

Stabilized water level: For purposes of determining the minimum purge volume during low-flow purging, a stabilized water level is the level at which drawdown ceases or becomes less than 0.3 feet as pump rates are adjusted.

Wellhead: The topmost portion of a well casing that provides access to the well. The well head, typically surveyed to allow water level elevation calculations, is the general access point for the well where sample ports, and pump discharge manifolds are located.

Section 5: Required Materials

Materials required for conducting groundwater sampling are variable depending upon the method chosen to conduct the sampling. The listing of materials is separated into two parts in this SOP. This section presents materials that are general in applicability—items that should be included regardless of sampling method. In Section 6, where specific methods and approaches are discussed, additional materials are listed. General materials that should be considered regardless of method are as follows:

- Well completion forms, project-specific planning documents (if applicable),and data from previous sampling efforts (if available)
- Water level indicator (steel tape) or water level meter (electronic)
- Decontamination supplies (5-gallon buckets, decontamination fluids, and squirt bottles)
- Water quality monitoring equipment with flow-through cell
- Purge water collection containers
- Graduated measuring container (low-flow purging) and/or 5 gallon bucket graduated to one gallon increments (three to five well volume purge)
- Permanent marking pens
- Field logbook
- Field forms (electronic and/or hard copy)
- Calculator
- Measuring tape
- Tools or keys, as needed, for locked protective casings
- Shipping labels and chain-of-custody (COC) forms
- Shipping coolers and ice
- Filters (0.45 micron [µm]), if appropriate
- Plastic garbage bags, Ziploc® storage bags, roll of plastic sheeting
- Tool kit including assorted basic tools, tubing cutters, wire cutters, hose clamps, waterproof connectors, wire ties, hose fittings, assorted pipe nipples and adapters, etc

Section 6: Groundwater Sampling Methods

This section describes the groundwater sampling methods.

6.1 General Considerations

Good communication is essential to the ultimate success of a groundwater sampling project. Good communication with the project team, laboratory, client, and—if appropriate—regulatory agencies, includes complete project-specific planning documents such as field sampling plans, quality assurance project plans (QAPPs), and scope-of-work documents for subcontracted laboratories. Plans should include detailed information with respect to site-specific requirements, with reference to SOPs wherever possible, and risk criteria that will be used to assess the data. The QAPP and laboratory scope of work (of which the QAPP can be part) should contain detailed information detailing what is expected from the laboratory regarding the methods to be used, quality assurance (QA) and calibrating corrective measures, and deliverables—especially electronic deliverable formats.

In addition to good communication, the project plans should consider sampling equipment, sampling sequence, and field quality assurance/quality control (QA/QC) samples.

6.1.1 Dedicated and Disposable Equipment

Use of dedicated and new disposable purging and sampling equipment is preferable to decontamination of reusable sampling equipment. Dedicated equipment and the use of new, disposable equipment eliminates cross-contamination between samples caused by incomplete decontamination. Dedicated equipment can also increase sampling efficiency through the elimination of the need to decontaminate and redeploy equipment for successive sampling. Furthermore, dedicated equipment can also help to reduce the physical handling of the equipment that can cause sample contamination through contact with potentially contaminated surfaces. New, disposable equipment may need to be decontaminated before use. Review project-specific planning documents regarding the decontamination of disposable equipment.

6.1.2 Equipment Decontamination

Any equipment that will come in contact with the sample must be decontaminated prior to and after each use. This is necessary to minimize inadvertent contamination of the sample. Decontamination is necessary in conjunction with reusable or non-dedicated equipment but is not required for dedicated equipment used during field activities associated with groundwater monitoring and sampling. This can be completed in the office prior to mobilizing to the field for the first sampling well.

Equipment decontamination procedures are described in the Equipment Decontamination SOP. Additional site-specific decontamination procedures may be specified in project-specific planning documents.

6.1.3 Sequence of Sampling

Wells that are sampled with non-dedicated equipment should always be conducted in a sequence that proceeds from wells containing the lowest concentrations to wells containing the highest concentrations, where feasible. Sampling in this order will further minimize the likelihood of sample cross-contamination that can be caused through improper handling or equipment cleaning. If water quality is not known, the wells upgradient of a suspected source area should be sampled first, followed by the wells farthest away and cross-gradient or downgradient.

6.1.4 Planning Phase

The planning phase should include the selection of specific field methods, including the well purging strategy and planning for the proper disposal of the purge water. The sampling program should be discussed in project-specific planning documents.

6.1.4.1 Sampling Equipment Selection

Some of the factors that should be considered in the selection of sampling devices include:

- Well yield
- Depth to water
- Well diameter and depth
- Required material of construction
- Analytical parameters
- Regulatory requirements
- Cost

6.1.4.2 Purging Strategies

Well purging strategies should be determined prior to sampling and presented in project-specific planning documents. Several different strategies are commonly used in order to assess the completeness of well purging. Typically, purging is continued until stabilization of certain indicator parameters are observed in successive measurements over a specified time or volume. Common indicator parameters include pH, specific conductivity, turbidity, temperature, oxidation/reduction potential (ORP), and dissolved oxygen (DO). The most common purging strategies are listed below.

- Purging three to five well volumes of water from the well.
- Low-flow purging
- Purging of low yield wells until the water level reaches the top of the well screen or until the well is essential dewatered and then allowing the well to partially recover prior to sampling

6.1.5 Preparatory Activities

Equipment and containers should be organized prior to embarking on a field sampling project to the extent practicable. The time spent in the field should be spent on sample collection, making field measurements, and recording data.

6.1.5.1 Prepare Sampling and Purging Equipment

The purging and sample collection equipment and all required hardware should be obtained, organized, and decontaminated prior to the initiation of the field sampling program. To accommodate waste generated during decontamination, these activities may be completed at the site prior to sampling.

6.1.5.2 Sample Containers and Preservatives

Field personnel should coordinate with the laboratory typically 2 weeks before the sample container kits are to be shipped from the lab. The information exchange between lab and field personnel includes the project identification, sample kit shipment address, QA/QC regulatory requirements, required turnaround requirements, and the number and type of laboratory analyses.

The required chemical preservatives for aqueous samples will be provided by the subcontracting laboratories.

Upon delivery, laboratories will check the pH of incoming samples to ensure that they have been properly preserved. If additional preservative must be added to the samples by the lab, the lab shall notify the project chemist or field supervisor and the samples must sit for an additional 18 hours before analysis. Sample preservatives should be identified on the COC.

Most chemical and biological reactions and many physical processes are slowed by lowering the temperature. As a general rule, all samples need to be cooled at the time of collection and maintained slightly above freezing until preparation for final analysis. Samples are maintained in ice, within a range of less than 6 degrees Celsius (°C), from the time the sample control manager assumes custody until the samples are packed for shipment and relinquished to the shipper or other transport agent.

See the *Sample Preservation* SOP more details on the proper handling and preservation procedures of samples.

6.1.5.3 Initiation of Field Data Records

Field data sheets may be initiated prior to the start of sampling. Examples of initial data to be recorded include site and sampling location identification, well depth, purging and sampling collection methods, and previous field data. Project-specific mobile applications (i.e., mobile apps) can simplify this process as data are pre-loaded and permanently stored on the device. If using a mobile app, new sampling locations must be added prior to mobilizing for the field.

6.2 Purging and Sampling Procedures

This section provides a description of the procedures to be used for groundwater sampling. These procedures include preparatory field activities, well purging, well sampling, and post-sampling activities.

6.2.1 Preparatory Activities

The following procedures should be conducted in the field prior to well purging and sampling.

6.2.1.1 Preparation of Well Area

A suitable work area should be established around the perimeter of the well. Sampling equipment should be placed on a clean surface such that it will not become inadvertently contaminated.

6.2.1.2 Calculation of Well Purge Volume

The volume of water standing in the well should be calculated through the application of the depth-to-water data, the known well depth, and the well diameter using the constants presented below. Well depth information obtained from the well completion records are generally sufficiently precise for the purpose of well volume calculations that would be used for subsequent purging determinations.

The following conversions allow quick calculation of well casing volumes:

Well casing diameter (inches)	Gallon(s) per foot of water
1.0	0.041
2.0	0.163
3.0	0.367
4.0	0.653
6.0	1.469

Alternatively, the well casing volume may be calculated using the formula $V = CF*d^2h$,

where:

V = volume of water (gallons)

d = interior diameter of well (inches)

h = height of water column (feet)

CF = conversion factor (0.0408) that includes conversion of cubic feet to gallons, inches to feet, and diameter to radius

Minimum purge volume for low-flow purging applications is discussed in the Well Purging Section.

6.2.2 Water Level Measurements

Water level measurements are collected during each groundwater sampling event, prior to purging or beginning any sampling activities. Procedures for manual and continuous water level measurements are discussed in the Groundwater Well Water Level Measurements SOP. Water level measurements are recorded in the field notebook and on the sample log.

6.2.3 Well Purging

Groundwater monitoring wells must be purged prior to sample collection to eliminate stagnant water in the well that may not be representative of aquifer conditions and reduce turbidity within the water column that may influence analyte concentrations. However, passive sampling or minimal/no-purge methods should be considered for low-yield wells in which common purging techniques are not feasible.

6.2.3.1 Indicator Parameter Stabilization

Stabilization of indicator parameters across three consecutive readings typically indicates an adequate purge has been achieved if the minimum well volume requirements described in the following sections have been met. With few exceptions, the water quality indicator parameters listed below shall be monitored while purging wells through an air-tight flow-through cell equipped with a multiprobe sonde field meter. Water for turbidity measurements should be obtained before water enters the flow-through cell by using a “T” coupling with a valve. However, if turbidity is known to be low (i.e., below 10 nephelometric turbidity units [NTUs]), water for turbidity measurements may be obtained from the flow-through cell discharge. If high flow rates are anticipated (<2-3 gallons), a manifold system may be used to direct a smaller volume to the flow-through cell while routing the bulk of the flow away from the well-head. Caution should be used when constructing a manifold to minimize or eliminate turbulent flows that can alter water quality parameters.

Flow-through cells should be transparent, so particulate build-up or air bubbles are visible. If the cell needs to be cleaned, continue purging and disconnect the cell, then reconnect after cleaning and continue monitoring activities while adding a note in the field logbook and/or on applicable sampling forms. Flow-through cells should be placed off the ground surface and as close to the wellhead as possible. Additional measures to protect the cell from ambient conditions (e.g., direct sunlight) should also be considered. Placing the cell at 45 degree angle with the discharge facing up may help prevent air bubble accumulation.

The frequency of readings may need to be adjusted based on purging method and equipment selection. At a minimum the frequency should allow for a full volume change of water for the flow cell and exposed tubing outside the wellhead. As a default, indicator parameters will be monitored at a 5- or 10-minute interval.

The following stabilization criteria for low-flow sampling guidance (EPA, 2017b) shall be used:

- Temperature: ± 3

- Specific conductivity: ± 3 percent
- pH: ±0.1 pH standard unit
- Oxidation-reduction potential (ORP): ± 10 millivolts (mV)
- Dissolved oxygen (DO): less than 0.5 milligram per liter (mg/L) or ± 10 percent when greater than 0.5 mg/L
- Turbidity: less than 5 nephelometric turbidity units (NTUs) or ±10 percent if greater than 5 NTUs

The following stabilization criteria for groundwater sampling guidance (EPA, 2017a) shall be used:

- Specific conductivity: ± 5 percent
- pH: ±0.1 pH standard unit
- Oxidation-reduction potential (ORP): ± 10 millivolts (mV)
- Dissolved oxygen (DO): ± 10 percent or ± 0.2 milligram per liter (mg/L) if less than 2 mg/L
- Turbidity: less than 10 nephelometric turbidity units (NTUs) or 10 percent RPD if greater than 10 NTUs

6.2.3.2 Three to Five Well Volume Purging

An adequate purge is normally achieved when three to five times the volume of standing water in the well has been removed. After three well volumes have been removed, sampling may proceed if the indicator parameters have stabilized according to the criteria set forth above If the parameters have not stabilized within five volumes, it is at the discretion of the project manager whether or not to collect a sample or continue purging. If a sample is taken after five volumes and the field parameters have not stabilized, this situation will be noted in the field logbook and/or applicable sampling forms.

Initially, groundwater withdrawal should occur no more than 3 to 5 feet below the water surface. If the recovery rate of the well is faster than the purge rate, and no observable drawdown occurs, the pump should be raised until the intake is within 1 foot of the top of the water column for the duration of purging. If the purge rate exceeds the well recovery rate, the pump will have to be lowered as needed based upon the amount of drawdown. To the extent possible, the purge rate should remain consistent between indicator parameter readings and throughout the sampling process. Fluctuations or changes in purge rate should be noted in the field logbook and/or applicable sampling forms.

6.2.3.3 Low-Stress or Low-Flow Purging

It is occasionally desirable to collect representative samples while exerting minimum stress on the water-bearing formation. Typically this is accomplished by limiting the flow rate during purging to the range of 100 to 500 milliliters per minute (mL/min) (0.025 to 0.130 gallon/min). For this procedure, the goal is to induce a steady flow rate while minimizing the drawdown.

Initially, the purge flow rate should start at approximately 200 mL/min (0.053 gallon/min), and the water level should be frequently monitored (approximately every 5 minutes). Flow rate should be adjusted so that drawdown will not exceed 0.3 foot or approximately 2 percent of the saturated thickness of low-permeability formations, whichever is greater.

After an optimal flow rate has been achieved, monitoring of water quality indicator parameters shall commence. In addition to stabilization of these parameters across three consecutive readings, the minimum volume described below should be purged prior to sample collection.

The minimum purge volume is calculated by adding the drawdown volume of the well casing at the stabilized water level, plus the volume of water in the submersible pump or bladder and submerged discharge tubing, as shown in the equation below. This minimum volume is adapted from EPA Region 1 guidance for low stress purging and sampling (EPA, 2017b).

$$V=[0.041(Cd^2)(I_w-S_w)]+P_v+0.041(Td^2)(Tl)$$

Where:

V = volume in gallons

Cd = casing diameter in inches

Iw = initial depth to water prior to purging in feet

Sw = stabilized depth to water during purging

Pv = pump or bladder volume in gallons (if applicable)

Td = inside diameter of water discharge tubing in inches

Tl = Length of submerged discharge tubing in feet (distance from depth to water to top of pump

In most cases, the minimum volume criterion will be met by the time indicator parameters stabilize. If indicator parameters have not stabilized after 1 hour, the sample may be collected and a note will be made in the field logbook and/or on applicable sampling forms.

6.2.3.4 Purging of Low Yield Wells

In some situations, even with slow purge rates, a well may be purged dry using the volume purge method or stable drawdown cannot be maintained using the low-flow method. In these cases, the well should be purged to dryness (evacuated) and sampled immediately upon: 1) recovery of adequate volume to fill sample containers and measure field parameters, 2) passing of a pre-determined time interval specified in project-specific documents not to exceed 24 hours, or 3) recovery to a pre-determined level specified in project-specific documents. Regardless of the sample criterion, field parameters should be measured and recorded at the time of sample collection.

In some cases, wells should be purged to the top of the screen and not to dryness as water cascading down the screen into the well may strip volatile compounds and elevate turbidity. Although suffering from other limitations, passive sampling or minimal/no purge methods may prove useful for these wells.

6.2.4 Groundwater Sample Collection

It is important that wells be sampled as soon as possible after purging. Consideration should be given to the order in which sample containers are to be filled for various parameter groups. The order should be determined on the basis of parameter sensitivity to volatilization, pH change, or oxidation, and the priority for analytical data in cases where the water volume in the well is less than what is required for analysis. In general, volatile organic compounds are the most sensitive constituents to volatilization, so the sample for these parameters should be containerized immediately. Likewise, pH change occurs rapidly in samples that are in contact with air, so pH measurements and the containerization of pH-sensitive parameters, such as anions (e.g., nitrate, sulfate) or metals (e.g., ferrous iron [Fe2+]), should also be implemented expeditiously.

The flow-through cell and “T” fitting with the valve should be removed after the final water quality parameters have been recorded. With some exceptions, samples are collected directly from the pump discharge. Chemical preservatives shall be added immediately upon sample collection if pre-preserved sample containers are not provided by the laboratories. Groundwater samples for dissolved analytes (e.g., dissolved metals or dissolved organic carbon) are filtered (usually with an in-line 0.45 micron filter) before preservation. The filter should be rinsed by allowing one filter volume to pass through before filling sample containers. The filtrate is added directly to the plastic container and immediately preserved with the appropriate preservative unless pre-preserved sample containers are used.

Some sampling equipment such as bailers or no-purge samplers may not be conducive to the use of in-line filters. In those cases, an additional volume of unfiltered sample adequate to fill the necessary sample containers and allow for rinsing of the filter shall be collected in a lab supplied container and filtered using a peristaltic pump or syringe filter. If filtering of samples is to be performed by the lab, samples should not be preserved and they should be provided to the lab as soon as possible to minimize sample quality degradation.

The following sections describe general sampling protocol based on purge method. Additional information regarding equipment specific sampling protocol is provided in the Equipment Instructions Section.

6.2.4.1 Three to Five Well Volume Sampling

As with purging equipment, there are a number of considerations in the selection of sample collection equipment. Typically, samples can be collected directly from the pump discharge after the flow-through cell is removed. However, it is common to use a different device for sample collection than for purging. An example would be to purge with the use of submersible pump and to collect the sample with the use of a disposable bailer. If samples are to be collected with the same equipment used to purge then the pump should not be moved and the flow rate should remain consistent. If different equipment is to be used to collect samples then the purge equipment should be removed carefully to minimize water column agitation.

6.2.4.2 Low-Stress or Low-Flow Groundwater Sampling

Sample collection following low-flow purging may commence directly from the pump discharge after disconnecting the flow-through cell. The sampling flow rate should not exceed the purge flow rate for which water quality indicator parameters stabilized. However, in some cases, a higher pressure for bladder pumps or a higher oscillation rate for peristaltic and submersible pumps may be required to push the sample water through the filter to maintain the same flow rate. Sampling equipment must be the same equipment that was used for purging and should not be moved between purging and sampling activities.

6.2.4.3 Sampling of Low Yield Wells

Sample collection following the purging of low-yield wells is similar to sample collection following both three to five volume and low-flow purging. Typically, the same equipment used to purge the well is used in sample collection. If feasible, sample equipment should remain in the well during recovery. If equipment must be removed in between purging and sampling then the equipment should be redeployed carefully to minimize water column agitation. Additionally, the equipment should be deployed at the same depth as the well was purged.

If adequate volume is present, then sample containers shall be filled based on analyte sensitivity and water quality parameter readings shall be collected last. If volume is limited then Sample containers should be filled in order of importance on a project-specific basis.

6.3 Equipment Instructions

This section provides specific instructions for the installation and use of various devices for both well purging and groundwater sample collection, and includes the following equipment:

- Bladder pump – compressed air or compressed gas cylinder driven
- Small-diameter (2-inch) electric submersible pump
- Bailer
- Peristaltic pump

It is recognized that a combination of the procedures may be employed. The specific methods to be used for purging and sampling a well will be determined based on site-specific field conditions.

6.3.1 Bladder Pump

A bladder pump is one of the easiest devices to operate for the purpose of low-flow purging and sample collection for depth up to 1000 feet. The bladder pump is often dedicated to the well and can be used in conjunction with an inflatable packer to minimize the purge volume necessary to accomplish effective purging. The compressed air source should be selected based on the pump depth. Typically, compressed gas cylinders should be used if the bladder pump is set below 200 feet as typical or household air compressors will not provide adequate pressure past this depth.

- Additional required equipment:
  - Bladder pump (if using non-dedicated equipment)
  - Skip-bonded tubing of appropriate diameter and material (if using non-dedicated equipment)
  - Stainless steel support cable or rope (if using non-dedicated equipment) for pump deployments greater than 300 feet or if non compression style tubing connections (i.e. nipples, push-to-connect, etc.,) are used for deployments greater than 150 feet
  - Drop tubing assembly (if applicable)
  - Well cap with water and discharge line fittings (for dedicated installations)
  - Discharge tubing that connects to and directs water from the well cap or wellhead
  - Bladder pump controller
  - Hoses to connect the compressed air source to the controller and from the controller to the wellhead
  - Compressed inert air source (gas-powered air compressor or compressed gas cylinder)
  - Compressed gas cylinder regulator (if needed)
  - Generator (if air compressor is electrically powered) or power extension cables (if near an electrical outlet)
  - Winterizing kit (if dedicated)
  - Basic tool kit including crescent wrenches, spare tubing connection fittings, pipe clamps, tubing cutters, and screwdrivers
- Installation instructions (initial installation or non-dedicated use):
  - Place new plastic sheet on suitable surface adjacent to well, taking care not to step on the plastic sheet.
  - Don a new pair of nitrile gloves.

  - Assemble the pump, tubing, drop tubing assembly, and support cable, as applicable, and lower into the well being careful not to contact any surface other than the interior of the well or the plastic sheeting.
    - Keep the weight on the support cable while lowering the pump assembly if used.
  - Install the tubing and support cable (if applicable) to the well cap for a dedicated installation. Tubing or a support cable (if applicable) may be attached to the protective casing using clamps or hangers for non-dedicated installations
  - A second length of tubing that attaches to the water discharge line on the well cap may be stored in a strong zip-lock bag and kept within the protective casing. This second length of tubing is used to direct water from the wellhead during purging. A winterizing kit (for dedicated installations) may be stored in a similar fashion
- Purging instructions:
  - Refuel the gasoline-powered compressor (if used) at a location that is remote from the well, being very careful not to spill any fuel on equipment or clothing that will be used at the well site
  - Place the gasoline-powered compressor as far from the well as possible in a down-wind direction to eliminate potential exhaust impact to sampling
  - Measure and record water level
  - Connect the compressed air source and pump controller to the pump as per manufacturer's instructions
    - If compressed gas cylinders are used, make sure the regulator on the bottle is set below the pressure rating of the pump controller
  - Don a new pair of gloves after handling the gasoline-powered compressor or compressed air cylinder
  - Determine the volume of water to be purged, as described previously
  - Start the pump by opening the regulator on the controller, which allows compressed air to flow into the system
    - Typically, 0.5 pounds per square inch (psi) is needed per foot of depth. For example, if the pump inlet is set at 100 feet then 50 psi should be sufficient.
  - Adjust the refill and discharge cycles on the controller. Typically, a 20 second refill and a 10 second discharge is adequate. For deeper wells (pump inlet is 300 feet or greater) a 40 second refill and 20 second discharge may be needed. However, other factors like amount of head above the pump inlet and larger tubing diameters may require longer refill and discharge cycles.
  - Direct the pump discharge to the graduated measuring container and determine the pumping rate
  - Collect purge water in container
  - Continue pumping until the necessary volume of water has been purged from the well
  - Monitor indicator parameters as discussed previously
- Sampling instructions:
  - Allow the well to recharge after completion of purging, if necessary

    - Resume pumping at a rate that does not exceed the pumping rate during purging
  - Collect the samples by pumping directly into each of the required containers
  - Fill bottles as outlined in project-specific planning documents—care should be taken to ensure that no head space remains in the volatile organic vials; certain other parameters may also require minimizing head space (e.g., reduced or ferrous iron)
  - Obtain filtered samples by installing an in-line, 0.45-µm disposable cartridge filter directly onto the pump discharge
  - After sampling is complete, perform winterization as needed for dedicated equipment. This is done by installing the winterizing tubing into the discharge line at the wellhead and allowing a 5 second discharge cycle at approximately 30 psi.
- Other considerations:
  - If water fails to discharge after a few cycles, place the discharge tubing into a clean container filled with distilled or deionized water. If bubbles are visible during the discharge cycle then water is moving up the tubing and should discharge soon. If bubbles cease after a few cycles then the pressure rating should be increased slightly. If no bubbles are visible, then your hose connections and regulator or compressor valves should be checked. If that doesn't work then your pump may need to be pulled and inspected.
  - If water flow cuts out before the discharge cycle ends, lower the pressure or lower the discharge cycle time to avoid damaging the bladder.
  - For long-term dedicated systems, consider storing all discharge tubing
  - Consider deploying a drop tubing assembly for deep wells that have long water columns. A drop tube assembly will allow a sample to be collected from the required depth but it will limit the amount of compressed gas and expensive skip-bonded tubing that is needed.
    - For example, a well with a desired sampling depth of 700 feet that has a static water level of 300 feet would be most efficiently sampled by setting the bladder pump to a depth of 350 feet and deploying a 350-foot drop tubing assembly.

6.3.2 Small Diameter Electric Submersible Pump

A small-diameter (2-inch) electric submersible pump (Grundfos Redi Flo2 or equivalent) can be operated with a wide variety of pumping rates such that it is versatile for both low-flow and three to five well volume purging and sample collection. This type of pump can be used in either a dedicated or non-dedicated mode. Collecting groundwater samples from these pumps is only appropriate if approved project-specific planning documents specifically include this technique for collecting samples.

- Required equipment:
  - Small-diameter electric submersible pump (if using non-dedicated equipment)
  - Tubing of appropriate diameter and material (if using non-dedicated equipment)
  - Pump shroud (when used in a 6-inch-diameter or larger well to minimize turbulence, to keep motor cool)
  - Check valve (optional)
  - Manifold with tee connectors and valves to direct a portion to of the flow to a flow cell (optional)

  - Electric pump controller with appropriate power plug
  - 230-volt, single-phase, electric power source (greater than 10 amperes)
    - DC kits with inverters may also be used
  - Tool kit including basic tools, tubing cutters, extra tubing connector bracket, electrical connectors, wire ties, etc.
  - Ground fault circuit interrupter (if not built into the pump controller)
- Installation instructions:
  - Don a new pair of gloves.
  - Assemble the pump, tubing, optional check valve, and electric power cables.
  - Decontaminate equipment and pump (if not dedicated).
  - Measure and record water level.
  - Lower pump slowly into the well, being careful not to make contact with any surface other than the interior of the well or the plastic sheeting. When lowering the pump, be particularly sensitive to areas that suggest drag or problems in the well where the pump could get stuck. If a problem arises, do not continue, but discuss with project manager or senior technical personnel ways to investigate.
  - Monitor the pump discharge and well hydraulics as discussed previously.
- Purging instructions:
  - Refuel the electric generator if used at a location that is remote from the well, being very careful not to spill any fuel on equipment or clothing that will be used at the well site.
  - Place the electric generator if used as far from the well as possible in a down-wind direction to eliminate potential exhaust impact to sampling.
  - Don a new pair of gloves after handling the generator.
  - Connect to electric power.
  - Determine the volume of water to be purged, as described previously.
  - Start the pump.
  - Direct the pump discharge to the graduated measuring container and determine the pumping rate.
  - Collect purge water into appropriate containers.
  - Continue pumping until the necessary volume of water has been purged from the well.
  - Shut off the pump rapidly whenever the pump stops pumping water.
  - Monitor indicator parameters as discussed previously.
- Sampling instructions:
  - Allow the well to recharge after completion of purging, if necessary.
  - Resume pumping at a rate that does not exceed the pumping rate during purging
  - Collect the samples by pumping directly into each of the required containers.
  - Fill bottles as outlined in project-specific planning documents. Care should be taken to ensure that no head space remains in the volatile organic vials. Certain other parameters may also require minimizing headspace (e.g., reduced or ferrous iron).

  - Obtain filtered samples by installing an in-line, 0.45-µm disposable cartridge filter directly onto the pump discharge.
- Other considerations:
  - Drop-tubing assemblies are available for some small diameter submersible pump models (e.g., Geosub) which can increase the sample collection depth as long the pump stays submerged within the operable range.

6.3.3 Bailer

A bailer is one of the simplest groundwater sampling devices that is commonly used for multiple-volume purging. A bailer may be used for sample collection after purging using different equipment (e.g., submersible pumps) but a single bailer can also be used for both purging and sample collection. **Since repeated deployment and retrieval of bailers agitates the water column leading to elevated turbidity and possible VOC loss, the use of bailers for groundwater sampling should be avoided if possible.** Bailers consist of a rigid tube equipped with a bottom and/or top check valve that is lowered into the well on a flexible cord. Disposable plastic bailers are preferable to reusable stainless steel bailers. Bailers that are only equipped with a bottom check valve can be used to collect water from the top of the water column while bailers featuring both a bottom and top check valve can be used to collect samples at a discreet depth.

- Required Equipment:
  - Bailer of appropriate size and material
  - New bailer cord of appropriate material and length
  - Clean 30 or 50 gallon trash can and supply of trash can liners, or new plastic sheeting
  - Bottom emptying device
  - A spare lab supplied container with peristaltic pump and silicon tubing or syringes and syringe filters. (if collecting samples requiring field filtration)
  - Gravity feed filters that attach directly to the bottom emptying device are preferable.
- Purging Instructions:
  - Calculate the volume of water to be purged, as described previously.
  - Place new plastic sheeting on suitable surface adjacent to well, taking care not to step on the plastic sheet or place a new can liner in the 30 or 50 gallon trash can
  - Don a new pair of nitrile gloves.
  - Decontaminate equipment (if using a reusable bailer)
  - Attach a cord to the bailer.
  - Lower the bailer into the well slowly to avoid minimize agitation of the water column
    - A bottom check valve bailer will be lowered to the top of the water column and allowed to fill from the bottom
    - A double check valve bailer will be lowered to the desired depth
  - Pull the bailer out of the well while placing the cord on the plastic sheet or in a lined trash can. An alternate method is to wind the bailer cord between the hands. Care should be taken to prevent the bailer or the cord from contacting any surface other than the interior of the well.
  - Empty the bailer into the pail.

  - Repeat the operation until the necessary volume of water has been purged from the well.
  - Monitor indicator parameters as discussed previously by fitting the bottom emptying device to the bottom of the bailer and filling the multi-probe sonde protection/calibration cup and turbidity meter vials
    - Temperature and pH should be recorded immediately. Specific conductivity, ORP, and DO may need additional time for the instrument to stabilize
- Sampling Instructions:
  - Prepare the well area and lower the bailer into the well following the method described previously for purging.
  - Allow the bailer to fill slowly and then gently retrieve the bailer from the well while avoiding contact with the sides of the well. Care should be taken to prevent the bailer or the line from contacting any surface other than the interior of the well or the plastic sheet or lined trash can.
  - Attach the bottom emptying device and fill the sample containers slowly.
  - Fill bottles as outlined in project-specific planning documents. Care should be taken to ensure that no head space remains in the volatile organic vials. Certain other parameters may also require minimizing headspace (e.g., reduced or ferrous iron).
  - Filtered samples can be obtained by filling a non-preserved sample receptacle, and then transferring the liquid through an in-line filter (typically a 0.45-µm disposable filter) into a preserved sample receptacle using a peristaltic pump or syringe filter. Gravity feed filters that attach directly to the bottom emptying device are preferred.

6.3.4 Peristaltic Suction Pump

A peristaltic pump can be used to purge shallow, small diameter wells at a low to modest rate with a lift capacity limited to groundwater depths of 25 to 30 feet (depending upon pump size and elevation). This type of pump is normally used with dedicated or disposable tubing. Special sampling procedures such as the use of a transfer cap for SVOCs and the “soda-straw” method for VOCs must be employed when using a peristaltic pump to collect samples for those constituents (EPA 2017a). Collecting groundwater samples from these pumps is only appropriate if approved project-specific planning documents specifically include this technique for collecting samples.

- Required Equipment:
  - Peristaltic pump, electric powered 12 VDC.
  - 12 VDC power source, such as a sealed motorcycle battery or connection to vehicle battery.
  - Tubing of appropriate diameter and material (typically 0.25 to 0.5-inch inside diameter polyethylene, polypropylene, or Teflon®)
  - Medical grade silicone tubing of appropriate diameter (typically 0.375-inch inside diameter)
  - Transfer cap of appropriate material (typically polyethylene or Teflon®) that can attach to SVOC sample containers (if applicable) [Include if following the EPA Region 4 Guidance on SVOC and VOC sampling using a peristaltic pump (EPA, 2017a)]
- Installation Instructions:
  - Place new plastic sheet on suitable surface adjacent to well, taking care not to step on the plastic sheet.
  - Don a new pair of nitrile gloves.

  - Replace the silicone tubing in the pump head if the pump will used for sample collection.
  - Lower the polyethylene, polypropylene, or Teflon® tubing into the well to the desired sample collection depth, being careful not to contact any surface other than the interior of the well or the plastic sheeting.
- Purging Instructions:
  - Connect the polyethylene, polypropylene, or Teflon tubing to the silicone tubing at the wellhead and connect the silicone tubing to the pump mechanism.
  - Calculate the volume of water to be purged, as described above.
  - Connect the pump to the power source
  - Start the pump.
  - Direct the pump discharge to the graduated measuring container.
  - Continue pumping until the necessary volume of water has been purged from the well.
  - Dispose of the tubing after use or store in sanitary conditions (if tubing is dedicated). Alternatively, dedicated tubing can be attached to the wellhead and stored inside the well.
  - Monitor indicator parameters as discussed previously.
- Sampling Instructions:
  - Allow the well to recharge after completion of purging, if necessary.
  - Resume pumping at a rate that does not exceed the pumping rate during purging.
  - Collect the samples by pumping directly into each of the required containers.
  - Fill bottles as outlined in project-specific planning documents—care should be taken to ensure that no head space remains in the volatile organic vials; certain other parameters may also require minimizing head space (e.g., reduced or ferrous iron)
  - Obtain filtered samples by installing an in-line, 0.45-µm disposable cartridge filter directly onto the pump discharge

6.4 Sample Shipment

As a general rule, all samples need to be cooled at the time of collection and maintained slightly above freezing until preparation for final analysis. Samples are maintained in ice, within a range of less than 6 degrees Celsius (°C), from the time the sample control manager assumes custody until the samples are packed for shipment and relinquished to the shipper or other transport agent.

Section 7: Quality Assurance/Quality Control

To assess the accuracy and precision of the field methods and laboratory analytical procedures, QA/QC samples are collected during the sampling program according to the project-specific planning documents. The frequency, types, and locations of QA/QC samples are typically specified in the project QAPP or monitoring plan.

Examples of QA samples include, but are not limited to, equipment rinsate blanks, field blanks, trip blanks, filter blanks, duplicate samples, and matrix spike/matrix spike duplicate samples.

7.1 Equipment Rinsate Blanks

An equipment rinsate blank is intended to check if decontamination procedures have been effective and to assess potential contamination resulting from containers, preservatives, sample handling, and laboratory analysis. Procedures for collection are as follows:

1. Rinse the decontaminated sampling apparatus with certified analyte-free water provided by the laboratory. Allow the rinsate to drain from the sampling apparatus directly into the sample bottle or into a secondary container, which is then poured into the sample bottle.
1. Add any preservatives associated with the sample analytical methods to the rinsate sample.
2. On COC, specifiy the same analytical methods for rinsate samples as is specified for the groundwater samples.
3. Assign the rinsate sample an identification number and record in the field book what equipment was rinsed and the location which the sample was collected.
4. Place the rinsate sample in a chilled cooler and ship it to the laboratory with the other samples.

7.2 Field Blanks

Analyses of field blanks are used to assess the contamination from ambient conditions during sample collection. Field blanks are prepared at a sampling location by pouring certified analyte-free water provided by the laboratory into a sample container. The field blank sample should be preserved and analyzed by the same methods as the groundwater sample. An identification number shall be assigned and recorded in the log book which groundwater sample location the field blank was prepared at. Field blanks shall be placed in a chilled cooler and shipped to the laboratory with the other samples. A field blank will be collected and analyzed for every 20 investigative samples (or fewer) that are collected.

7.3 Trip Blanks

Trip blanks, prepared by the laboratory, are taken to the sampling site and transported back to the laboratory to assess contamination introduced during shipping and field handling procedures. Trip blanks are typically only used when VOCs are suspected and being analyzed in the groundwater samples. One trip blank (three 40 ml vials for VOCs) will be included for each cooler that contains samples for VOC analysis. At no time should the trip blanks be opened by field personnel.

7.4 Filter Blanks

Filter blanks are used to assess potential contamination introduced during the field filtering of samples from the filter media and are applicable only if the sampling event requires filtering of water samples. Filter blanks are collected by passing certified analyte-free reagent water provided by the laboratory through a clean filter similar to that used during the sampling event and from the same filter batch provided by the supplier. The collected filter blank sample shall be analyzed by the same methods as the groundwater samples.

7.5 Field Duplicate Samples

Duplicate samples are collected to assess the precision of field and laboratory components of field samples. When collecting a duplicate groundwater sample, the original and duplicate sample containers should be filled simultaneously, or as close to simultaneous as possible, by moving the discharge tubing or bailer back and forth over each container until they are full. Alternatively, the sample could be collected in one larger container, mixed, and split into the original and duplicate samples. This method will give a more representative split but also is more likely to introduce contamination if the larger container is reused and is therefore not preferred.

To maximize the information available in assessing total precision, collect duplicate samples from locations suspected of the highest contaminant concentration. Use field measurements, visual observations, past sampling results, and historical information to select appropriate locations for duplicate analyses.

The duplicate sample is handled and preserved in the same manner as the primary sample and assigned a sample number, stored in a chilled cooler, and shipped to the laboratory with the other samples. Whenever possible, the sample identification numbers for the characteristic sample and its duplicate are independent such that the receiving laboratory is not able to distinguish which samples are duplicates prior to analysis.

7.6 Matrix Spike/Matrix Spike Duplicate Samples

An extra volume of sample media may be collected during the sampling event for performance of matrix spike (MS)/matrix spike duplicate (MSD) analyses by the laboratory to assess laboratory accuracy, precision, and matrix interference. Following shipment of the samples to the laboratory, the laboratory prepares MS and MSD samples by splitting the material into three separate sets of containers and spiking the split samples with appropriate analytes prior to performing the extraction in order to evaluate the total of the spiked compound and whatever quantity of the compound may be present in the sample. Results of the analyses are compared with the results of the primary sample and the known concentrations of the spike compounds. The percent recovery and relative percent difference are calculated and results are used to evaluate the precision and accuracy of the analytical method for various labeled "extra volume samples for MS/MSD." The sample volumes required for these analyses should be coordinated with the laboratory and described in the project-specific planning documents.

Section 8: Records

Accurate field records must be maintained to document groundwater sampling activities, whether on paper field forms or within a mobile app. These records include technical field data, sample identification labels, and COC information for each sample. Additional details are discussed in Field Notes and Documentation SOP.

Specifically for groundwater sampling, the field sampling records (field logs) should include, at a minimum, the following information:

- Sampling location
- Date and time
- Condition of the well
- Static water level (depth to water)
- Calculated well volume
- Purging method
- Actual purged volume
- Sample collection method
- Sample description
- Field meter calibration data

- Water quality measurements
- General comments (weather conditions, etc.)

All data entries should be made using black indelible ink and written legibly. Entry errors should be crossed out with a single line, dated, and initialed by the person making the correction. Deviations from project-specific planning documents will be documented and explained in daily field notes. The project manager (or designee) will be contacted to discuss project deviations. Field notes, sampling forms, and COCs will be submitted to the project manager (or designee) in a timely manner following the field event for quality checks and revision purposes and will be in the project file.

Section 9: References

American Society for Testing and Materials (ASTM), 2018. "D6452-18, Standard Guide for Purging Methods for Wells Used for Ground Water Quality Investigations."

ASTM, 2019. "D4448-01, Standard Guide for Sampling Groundwater Monitoring Wells."

ASTM, 2020. “D7929-20, Standard Guide for Selection of Passive Techniques for Sampling Groundwater Monitoring Wells.”

Interstate Technology & Regulatory Council (ITRC), 2004. Technical and Regulatory Guidance for Using Polyethylene Diffusion Bag Samplers to Monitor Volatile Organic Compounds in Groundwater. The Interstate Technology & Regulatory Council Diffusion/Passive Sampler Team. February 2004

ITRC, 2007. Protocol for Use of Five Passive Samplers to Sample for a Variety of Contaminants in Groundwater. Technical and Regulatory Guidance. The Interstate Technology & Regulatory Council Diffusion/Passive Sampler Team. February 2007.

United States Environmental Protection Agency (EPA) Region IV, 2017a. Groundwater Sampling. Science and Ecosystem Support Division. SOP No. SESDPROC-301-R4. Revised April 2017.

EPA Region I, 2017b. Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells. Quality Assurance Unit. SOP No. EQASOP-GW4. Revised September 2017.

Section 10: Attachments

Attachment A: Field Forms

Attachment A: Groundwater Quality Sampling Forms

Groundwater Sampling Log

inputs for calculations | inputs for individual well info | ✓ Stable | ✗ Not Stable | ✓ Not Stable

Brown AND Caldwell

Project:		**Event:**		**Well ID:**	**MW-6A**
Client:		**Date:**		**Static Water Level:**	
Project #:		**Sampling Method:**	**Bailing, 3-Volume**	**Reading Type (check one):**	**Manual:** **Transducer:**

Time		Pump Rate	Vol Removed	Temperature		SC		DO		pH		ORP		Turbidity		Depth to Water	
	min	gal/bail	gallons	Deg C	%RPD	uS/cm	%RPD	mg/L	%RPD or Δ	su	Δ	mV	%RPD or Δ	NTU	%RPD, NTU	Ft	Drawdown
Previous Field Parameters:																	
3	3	✓ 3	9														
Criteria	60 max	100-500 mL/min		3%		3%		10% (Δ0.1 mg/L if <2.0)		Δ0.1 pH		10% or Δ10 mV		<10 NTU or 10%		<0.3 ft	

Sample Date and Time:

Sampler:

Analysis Requested:

Volume | **Filtered** | **Preservative** | **QC Sample ID:**

Pump Information:

Pump deconned before use: Y N [✓ NA]

PSI:

Refill:

Discharge:

Bail Calculation (0.653 gal/ft)

Diam (in)	Length (in)	Volume (gal)	Required Bails
0.75	36	0.07	**#VALUE!**
1.75	36	0.37	**#VALUE!**
3	36	1.10	**#VALUE!**
	3 vol. purge (gal) =	#VALUE!	

Duplicate

MS/MSD

Field Blank

Eq. Rinsate Blank

Bladder Pump DC gasoline nitrogen gas

Dedicated Non-Ded

Geosquirt

Production Pump

Redi-Flo

Peristaltic Pump [✓ Other] Disposable Bailer

$$\% \text{ RPD} = 200 \times \frac{\text{Read 1} - \text{Read 2}}{\text{Read 1} + \text{Read 2}}$$

3 consecutive stable readings before sampling

Comments:

Field Review:

QA/QC Review:

Revised 11/30/2017 (arpd)

Groundwater Sampling Log

inputs for calculations　inputs for individual well info　✓ Stable　✗ Not Stable　✓ Not Stable

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Project:　**Event:**　**Well ID:**
Client:　**Date:**　**Static Water Level:**
Project #:　**Sampling Method:**　**Reading Type (check one):**　**Manual:**　**Transducer:**

Time		Pump Rate	Vol Removed	Temperature		SC		DO		pH		ORP		Turbidity		Depth to Water	
	h:mm	ml/min	Liters	Deg C	%RPD	uS/cm	%RPD	mg/L	%RPD or Δ	su	Δ	mV	%RPD or Δ	NTU	%RPD, NTU	Ft	Drawdown
Previous Field Parameters:																	
Criteria	60 max	100-500 mL/min		3%		3%		10% (Δ0.1 mg/L if <2.0)		Δ0.1 pH		10% or Δ10 mV		<10 NTU or 10%		<0.3 ft	

Sample Date and Time:　**Sampler:**

Analysis Requested:				Volume	Filtered	Preservative		QC Sample ID:				
										Duplicate		
										MS/MSD		
										Field Blank		
										Eq. Rinsate Blank		

Pump Information:
Pump deconned before use: Y N [✓ NA]
PSI:
Refill:　**Discharge:**
Bladder Pump DC gasoline [✓ nitrogen gas]
[✓ Dedicated] Non-Ded
Geosquirt
Production Pump
Redi-Flo
Peristaltic Pump　**Other**

$$\% \text{ RPD} = 200 \text{ X } \frac{\text{Read 1 - Read 2}}{\text{Read 1 + Read 2}}$$

3 consecutive stable readings before sampling

Comments:

Field Review:　QA/QC Review:

Revised 11/30/2017 (arpd)

Groundwater Sampling Log

inputs for calculations

inputs for individual well info

✓ Stable ✗ Not Stable ✓ Not Stable

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Project:
Event:
Well ID:
Client:
Date:
Static Water Level:
Project #:
Sampling Method:
Reading Type (check one): **Manual:** **Transducer:**

Time		Pump Rate	Vol Removed	Temperature		SC		DO		pH		ORP		Turbidity		Depth to Water	
	min	gal/min	Gallons	Deg C	%RPD	uS/cm	%RPD	mg/L	%RPD or Δ	su	Δ	mV	%RPD or Δ	NTU	%RPD, NTU	Ft	Drawdown
Previous Field Parameters:																	
Criteria		100-500 mL/min		3%		3%		10% (Δ0.1 mg/L if <2.0)		Δ0.1 pH		10% or Δ10 mV		<10 NTU or 10%		<0.3 ft	

Sample Date and Time:
Sampler:

Analysis Requested:	**Volume**	**Filtered**	**Preservative**	**QC Sample ID:**		
					Duplicate	
					MS/MSD	
					Field Blank	
					Eq. Rinsate Blank	

Pump Information:
Pump deconned before use: Y N [✓ NA]
PSI:
Refill:
Discharge:
Bladder Pump DC gasoline nitrogen gas
[✓ Dedicated] Non-Ded
Geosquirt
Production Pump
[✓ **Redi-Flo**]
Peristaltic Pump **Other**

$$\% \text{ RPD} = 200 \times \frac{\text{Read 1} - \text{Read 2}}{\text{Read 1} + \text{Read 2}}$$

3 consecutive stable readings before sampling

Comments:

Field Review:

QA/QC Review:

Revised 11/30/2017 (arpd)

Groundwater Sampling Log

inputs for calculations | inputs for individual well info | ✓ Stable | ✗ Not Stable | ✓ Not Stable

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Project:	**Event:**	**Well ID:**
Client:	**Date:**	**Static Water Level:** 12
Project #:	**Sampling Method:** Low flow purge	**Reading Type (check one):**

Manual: **Transducer:**

Time		Pump Rate	Vol Removed	Temperature		SC		DO		pH		ORP		Turbidity		Depth to Water	
	min	ml/min	Liters	Deg C	%RPD	uS/cm	%RPD	mg/L	%RPD or Δ	su	Δ	mV	%RPD or Δ	NTU	%RPD, NTU	Ft	Drawdown
Previous Field Parameters:																	
Criteria	60 max	100-500 mL/min		3%		3%		10% (Δ0.1 mg/L if <2.0)		Δ0.1 pH		10% or Δ10 mV		<10 NTU or 10%		<0.3 ft	

Sample Date and Time:

Sampler:

Analysis Requested:				Volume	Filtered	Preservative		QC Sample ID:				
										Duplicate		
										MS/MSD		
										Field Blank		
										Eq. Rinsate Blank		

Pump Information:

Pump deconned before use: Y N [✓ NA]

PSI:

Refill: **Discharge:**

Bladder Pump DC gasoline nitrogen gas

[✓ Dedicated] Non-Ded

Geosquirt

Production Pump

Redi-Flo

[✓ **Peristaltic Pump**] **Other**

Comments:

$$\% \text{ RPD} = 200 \times \frac{\text{Read 1} - \text{Read 2}}{\text{Read 1} + \text{Read 2}}$$

3 consecutive stable readings before sampling

Field Review:

QA/QC Review:

Revised 11/30/2017 (arpd)

SOP-7
Surface Water Quality Sampling

Standard Operating Procedure

Revised April 2022

SOP-7
Surface Water Quality Sampling

Standard Operating Procedure

Revised April 2022

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Table of Contents

Surface Water Sampling....2

Section 1: Objective....2

Section 2: Scope andApplicability....2

2.1 Limitations....2

Section 3: Responsibilities....2

Section 4: Definitions....2

Section 5: Required Materials....3

Section 6: Methods....3

6.1 General Considerations....3

6.2 Direct Grab Method....4

6.3 Peristaltic Pump....4

6.3.1 Transfer from Field Bottle to Lab Bottles....5

6.4 Decontamination....5

Section 7: Quality Assurance/Quality Control....5

Section 8: Documentation and Recordkeeping....6

Section 9: References....7

SOP-5

Surface Water Sampling

Section 1: Objective

The purpose of this standard operating procedure (SOP) is to describe the methods for surface water sampling. It describes the procedures and equipment to be used to obtain representative surface water samples that are capable of producing accurate quantification of water quality.

Section 2: Scope and Applicability

This procedure is intended for the collection of surface water samples to support site investigations as required by the project plan or other requirements. Surface water samples may be collected from a variety of water body types including springs and seeps, perennial and intermittent drainages, canals, ponds, and or lakes. Surface water sample locations may be man-made or naturally occurring, flowing or static, and the water body may be shallow or deep.

2.1 Limitations

This SOP does not address the health and safety concerns associated with the methods described herein, which may involve use of water and boating safety, hazardous materials, equipment, and operations. Accordingly, the user must establish appropriate health and safety practices according to the site-specific HASP.

Section 3: Responsibilities

The project manager is responsible for ensuring that surface water measurements are implemented in accordance with this SOP and any other site-specific or project-specific planning documents.

The field personnel are responsible for understanding and implementing this SOP during all field activities, as well as obtaining the appropriate field logbooks, forms, and records necessary to complete the field activities.

The site safety officer, typically the supervising field manager, is responsible for overseeing the health and safety of employees and for stopping work if necessary to fix unsafe conditions observed in the field. However, it is understood that all field personnel have “stop work” authority if unsafe conditions occur.

Section 4: Definitions

COC	Chain of Custody
GPS	Global Positioning System
PPE	Personal Protective Equipment

Section 5: Required Materials

Equipment needed for the collection of surface water samples may include (depending on technique chose):

- Maps/plot plan
- Tape measure (minimum length 100 feet)
- Safety equipment and personal protective equipment
- Nitrile gloves/paper towels
- GPS
- Field notebooks/logbooks/indelible markers/pens/whiteboard
- Camera/site identifier (ID) book
- Tape measure/stakes and mallet
- Waders/hip waders
- Decontamination equipment/supplies
- Sampling device(s) (e.g., bottle sampler)
- Field collection bottles
- Sample containers/preservatives
- Sample labels
- Filters (0.45 micron)
- Water quality monitoring equipment (e.g., pH/conductivity/dissolved oxygen meter)
- Turbidity meter and calibration jars
- Peristaltic pump/tubing/filters
- Lab-certified deionized water (for decontamination and equipment blank)
- Nitric acid (0.1 M) for decontamination)
- Cooler(s) and ice
- Shipping labels
- COC forms
- Field forms (hard copy)
- Batteries (double A, C, and D)
- Packing materials (tape, garbage bags, Ziploc® bags)

Section 6: Methods

A variety of sampling methods and equipment are available for the collection of surface water samples because of the varied conditions and locations where samples may be collected. Refer to the work plan and field sampling plan to determine which sampling method is appropriate for the project.

6.1 General Considerations

The objective of surface water sampling is to evaluate the surface water quality. There is a variety of equipment available for surface water sampling. Because each site may contain varied surface water conditions, collection of a representative sample may be difficult. In general, a sampling device will include the following characteristics:

- Be constructed of disposable or non-reactive material (e.g., Teflon™ 7, glass, or stainless steel)
- Be designed to maintain sample integrity and to provide the desired level of quality in achieving desired analytical results

The specific sampling method utilized will depend on the accessibility of the water body along with its size and depth, as well as the type of samples being collected. In most ambient water quality studies, grab samples will be collected; however, the objectives of the study will dictate the sampling method. General cautions for sampling are as follows:

- When wading, collect samples upstream from the body
- Avoid disturbing sediments in immediate area of sample location
- Sampling near structures may not provide representative data because of unnatural flow patterns
- Collect surface water samples from downstream toward upstream

If unable to measure field parameters in-situ (which is preferred), collect an additional sample or extra quantity of the collected sample should be poured off to a separate container for determination of field parameters such as pH, conductivity, dissolved oxygen, temperature, turbidity, odor, or other significant characteristics.

6.2 Direct Grab Method

For streams, rivers, lakes, and other surface waters, the direct method may be utilized to collect water samples directly into the sample container(s). For streams and rivers, it is important that samples be collected from flowing water. For lagoons and other impoundments specific conditions may exist that warrant the use of additional safety equipment. Using adequate protective clothing, access the sampling station by appropriate means:

1. Use an unpreserved sample container to collect the sample.
1. Slowly remove the container cap and slowly submerge the container, opening first, into the water.
2. Invert the bottle so the opening is upright and pointing toward the direction of water flow (if applicable); allow water to run slowly into the container until filled.
3. Return the filled container quickly to the surface.
4. When filling the container, leave a little room in the container for addition of preservatives and sample expansion unless the sample is being collected for volatile compounds. Samples for volatile constituent analysis require no headspace be present when the container is closed.
5. Securely cap container, label and complete field notes.
6. If preservatives have been added, invert the container several times to ensure sufficient mixing of sample and preservatives.

For shallow stream stations, collect the sample under the water surface while pointing the sample container upstream; the container must be upstream of the collector. When possible, collect samples in a downstream to upstream direction. Avoid disturbing the substrate.

When using the direct method, do not use pre-preserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation.

6.3 Peristaltic Pump

Peristaltic pumps are used for filtering samples in the field for dissolved analysis. Perform the following procedures when filtering with a peristaltic pump:

1. Prepare the peristaltic pump in accordance with manufacturer's instructions. When using a battery-operated pump, be sure battery is fully charged prior to entering the field.

2. It is necessary to change the filter, suction line, and the silicon pump tubing between sample locations to avoid cross-contamination. This action requires maintaining a sufficiently large stock of tubing material to avoid having to decontaminate the tubing in the field.
3. Gently lower the pump intake tube to the desired sample depth. Avoid unnecessary agitation (aeration) of the liquid to be sampled and bottom sediments.
4. Prior to activating the pump, note in which direction the pump will be rotating. (Most peristaltic pumps are capable of rotating in two directions.) Accidental reverse rotation of the pump will cause aeration of the liquid to be sampled.
5. Run the pump until no air bubbles are noted in the discharge.
6. Discharge water shall be released downstream from sampling area during sampling event.
7. To prevent excess agitation and/or aeration of the sampler, fill the sample containers by tilting the container and flow the sample water down the side of sampling container.

6.3.1 Transfer from Field Bottle to Lab Bottles

Following collection of surface water samples using either a DH-48 or Grab Sample, the sample will be transferred directly from the field bottle to the analytical laboratory-provided sample bottles. Surface water samples requiring filtration will be transferred from the field bottle to the analytical laboratory-provided sample bottles via the peristaltic pump and through a 0.45-micron filter.

6.4 Decontamination

Prior to and after each sampling event, all sampling equipment must be thoroughly decontaminated following the methods outlined below and in SOP-05 *Equipment Decontamination*. The primary purpose of equipment decontamination is to prevent the potential of cross-contamination within the samples collected.

Because decontamination procedures are time consuming, having a quantity of sampling tools available is recommended. If surface water samples are collected using the direct method, decontamination is not required as shared sampling equipment does not come into contact with the water sample and new sampling containers are used at each sampling location. For other collection techniques, all sampling equipment must be decontaminated prior to reuse. Equipment decontamination will consist of the following five steps:

1. Non-phosphate detergent wash (e.g., Liquinox)
2. Tap water rinse
3. 2 percent nitric acid rinse (diluted with deionized water)
4. Deionized water triple rinse
5. Air dry

Section 7: Quality Assurance/Quality Control

Quality assurance activities which apply to the implementation of these procedures are located in the site QAPP, including the collection of required QA/QC samples such as field duplicates, and equipment blanks. In addition, the following general procedures apply:

- All data must be documented on field data sheets or within site logbooks
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan

- Equipment calibration activities must occur prior to sampling/operation and they must be documented

All surface water monitoring data shall be documented on Surface Water Sample Sheets (Attachment B).

Descriptions of any deviations and the reason for deviations from the site QAPP or this SOP should be noted in the field notebook, as necessary.

Section 8: Documentation and Recordkeeping

Surface water sampling details will be documented in detail in the field. Field documentation will consist of a sampling chronology and notes in the site field book, including the field descriptions of each sample location and laboratory chains of custody. The field sample descriptions should include, at a minimum, the following:

- Weather Conditions
- Date and Time of Sample Collection
- Name of Sampler
- Location
- Sampling Method
- Analyte sampled for
- Unusual Environmental Conditions or Observations (if applicable)

Attachment A: Sampling with the US DH-48 Depth-Integrating Suspended-Sediment Sampler

Attachment B: Surface Water Sample Sheet

Section 9: References

The Design of Improved Types of Suspended Sediment Samplers, FISP Report 6, 1952, Project Offices of Cooperating Agencies at St. Anthony Falls Hydraulic Laboratory, Minneapolis, Minnesota, 103 p.

Laboratory Investigation of Suspended Sediment Samplers, FISP Report 5, 1941, St. Paul U.S. Engineer District Sub-Office Hydraulic Laboratory, University of Iowa, Iowa City, Iowa, 99 p.

Edwards, T. K., and Glysson, G. D., 1999, Field Methods for Measurement of Fluvial Sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. c2, 89 p.

Attachment A: Surface Water Field Sheet

SURFACE WATER SAMPLE SHEET

GENERAL INFORMATION (CHECK ALL THAT APPLY)

PROJECT NAME:			SAMPLE IDENTIFICATION:		
DATE AND TIME:			FIELD PERSONNEL:		
Northing:		Easting:	Duplicate (if app.)		
SURFACE WATER BODY NAME:			SAMPLE TYPE:	GRAB ☐	COMPOSITE ☐

CALIBRATION

INSTRUMENTS		DATE AND TIME OF INSTRUMENT CALIBRATION
TEMP, CONDUCTIVITY DO, pH, ORP	YSI 556	
TURBIDITY	HACH 2100p	
OTHER (SPECIFY):		

FIELD PARAMETER MEASUREMENTS

TEMPERATURE (°C)	CONDUCTIVITY (µS/cm)	DISSOLVED OXYGEN (mg/L)	pH (s.u.)	ORP (mV)	TURBIDITY (NTUs)

Field Notes:

STREAMS (CHECK ALL THAT APPLY)

LOCATION:	WADING ☐ | BANK ☐ | STATION GAGE: AT ☐ | ABOVE ☐ | BELOW ☐
	BRIDGE: UPSTREAM ☐ | DOWNSTREAM ☐ | BOAT ☐
	OTHER ☐ (SPECIFY): culvert
STREAM TYPE:	PERENNIAL ☐ | INTERMITTENT ☐
SAMPLING SITE:	POOL ☐ | RIFFLE ☐ | OPEN ☐ | BRAIDED ☐ | BACKWATER ☐
SAMPLER TYPE:	DH-48 ☐ | DIRECT GRAB ☐ | PERISTALTIC PUMP ☐ | DEPTH ☐
BOTTOM:	BEDROCK ☐ | ROCK ☐ | COBBLE ☐ | GRAVEL ☐ | SAND ☐ | MUD ☐ SILT ☐
HYDRAULIC EVENT:	ROUTINE SAMPLING ☐ | REGULAR FLOW ☐
	SNOWMELT ☐ | FLOOD ☐ | DROUGHT ☐ | OTHER ☐ (SPECIFY):
	ICE COVER ☐ THICKNESS: INCHES
STREAM COLOR:	CLEAR ☐ | BROWN ☐ | GREEN ☐ | BLUE ☐ | GRAY ☐
STREAM FLOW TYPE:	TURBULENT ☐ | LAMINAR ☐ | STAGNANT ☐
	EXCELLENT ☐ | GOOD ☐ | FAIR ☐ | POOR ☐

SPRINGS (CHECK ALL THAT APPLY)

SAMPLING SITE:	POOL ☐ | RIFFLE ☐ | OPEN ☐ | BRAIDED ☐ | BACKWATER ☐
BOTTOM:	BEDROCK ☐ | ROCK ☐ | COBBLE ☐ | GRAVEL ☐ | SAND ☐ | MUD ☐
STREAM COLOR:	CLEAR ☐ | BROWN ☐ | GREEN ☐ | BLUE ☐ | GRAY ☐
FLOW TYPE:	EXCELLENT ☐ | GOOD ☐ | FAIR ☐ | POOR ☐

SURFACE WATER FLOW SHEET

GENERAL INFORMATION					
PROJECT NAME:			SAMPLE IDENTIFICATION:		
DATE AND TIME:			FIELD PERSONNEL:		
Northing:		Easting:			
SURFACE WATER BODY NAME:			SAMPLE TYPE:	GRAB ☐	COMPOSITE ☐

FLOW MEASUREMENT METHOD (CHECK WHICH APPLY)			
MARSH McBIRNEY FLO-MATE	☐	VOLUMETRIC BUCKET	☐
BASKI CUTTHROAT FLUME	☐	OTHER (SPECIFY):	☐

FLOW MEASUREMENTS (CHECK WHICH APPLY)					
DOWNSTREAM GAUGE HEIGHT (ft):		UPSTREAM GAUGE HEIGHT (ft):		FLOW (CFS):	
STREAM WIDTH (FT):			SEGMENT WIDTH (FT):		

STATION LOCATION (ft)	STATION DEPTH (ft)	VELOCITY (ft/sec)	AREA (ft^2)	FLOW (CFS)
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			0.00	0.0000
			TOTAL CALCULATED FLOW:	**0.000**

Brown AND Caldwell

SOP-8
Surface Water Flow Measurements

Standard Operating Procedure

Revised May 2022

SOP-8
Surface Water Flow Measurements

Standard Operating Procedure

Revised May 2022

Table of Contents

Surface Water Flow Measurements 1

Section 1: Objectives 1

Section 2: Scope and Applicability 1

Section 3: Responsibilities 1

Section 4: Required Materials 2

Section 5: Surface Water Monitoring Methods 2

5.1 Cutthroat Flume Procedures 3
    5.1.1 Field Procedures 3
    5.1.2 Discharge Calculations 4
5.2 Marsh-McBirney Model 2000 Flowmeter Procedures 4
    5.2.1 Theoretical Considerations 4
    5.2.2 Required Measurement Conditions 5
5.3 The Velocity-Area Method 5
5.4 SonTek FlowTracker Handheld ADV 6
    5.4.1 Required Measurement Conditions 6
5.5 StreamPro Acoustic Doppler Current Profiler Procedures 6
5.6 Volumetric Measurement Procedures 7
5.7 Stream Gauge Height Pressure Transducer Procedures 7
    5.7.1 Site Selection Considerations 7
    5.7.2 Site Selection 7
    5.7.3 Base and Reference Gauge Description 8
    5.7.4 Staff Gauge Installation 8
    5.7.5 Gauge Datum 8
    5.7.6 Rating Curve Development 9
    5.7.7 Methodology 9

Section 6: Quality Assurance/Quality Control 11

Section 7: References 11

List of Tables

Table 1. Number of Subsections Based on Stream Width 5

SOP-8

Surface Water Flow Measurements

Section 1: Objectives

The purpose of this document is to define the standard operating procedures (SOPs) for monitoring surface water discharge in streams and rivers.

Discharge is defined as the volumetric flow rate of water. Discharge will be expressed in cubic feet per second (cfs). This document outlines the methods for measuring flow, which are by the use of: (1) cutthroat flumes, (2) the velocity-area method using the Marsh-McBirney Model 2000 Flow Meter, (3) SonTek FlowTracker2® Handheld-Acoustic Doppler Velocimeter (ADV)® featuring Smart QC, (4) StreamPro Acoustic Doppler Current Profiler (ADCP) during extreme high flows, (5) volumetric method during extreme low flows, and (6) stream gauge height pressure transducer installation and discharge measurement for year-round measurement. Because of the dynamic nature of surface water behavior, flow measurement by the methods described in this document may, on occasion, be impossible at some sites. The team will note the conditions that inhibited accurate flow measurement; this situation will be brought to the attention of the project manager.

Section 2: Scope and Applicability

This procedure is intended for the collection of surface water flow measurements to support site investigations as required by the baseline study or other requirements. Surface water flow measurements may be collected from a variety of streams or rivers under various flow rates.

Section 3: Responsibilities

The project manager is responsible for ensuring that surface water flow monitoring and sample collections are gathered in accordance with this SOP and any other site- or project-specific planning documents.

The field personnel are responsible for understanding and implementing this SOP during all field activities, as well as obtaining the appropriate field logbooks, forms, and records necessary to complete the field activities. Field personnel will ensure that all field activities are documented completely at the end of each field day. Field personnel are responsible for ensuring that the original documentation (or copies of the field logbook, if needed for another project at the same site) are filed at the end of the field project, or during a long project (greater than 1 month) every couple of weeks.

The site safety officer, typically the supervising field manager, is responsible for overseeing the health and safety of employees and for stopping work if necessary to fix unsafe conditions observed in the field. However, it is understood that all field personnel have “stop work” authority if unsafe conditions occur.

Section 4: Required Materials

Equipment needed for the collection of surface water flow measurements may include (depending on technique chosen):

- Maps/plot plan
- Safety equipment and personal protective equipment (PPE)
- Tape measure (minimum length 100 feet)
- Global Positioning System (GPS)
- Extra batteries (two "D" size for Marsh-McBirney; four "C" size for YSI; six "AA" size, including two for GPS unit and four for Turbidity Meter)
- Duct tape
- Garbage bags
- Ziploc® bags
- Waders/hip waders/wading boots
- Field notebooks/logbooks
- Whiteboard/dry erase pens/markers
- Camera
- Cutthroat flume
- Small level
- Marsh-McBirney Model 2000 Flo-Mate flow meter with top-setting rod
- StreamPro ADCP
- SonTek FlowTracker
- 1-liter bottle
- Stopwatch or equivalent
- Stakes (wood or rebar)
- Hammer
- Clamps
- Rope (8 to 10 millimeters [mm], 100-foot length)

Section 5: Surface Water Monitoring Methods

A variety of methods and equipment are available for the collection of surface water flow measurements because of the varied conditions and locations where surface water flow measurements may be collected. The six primary methods proposed for this baseline data collection effort are listed here and described below:

- Cutthroat flume
- Marsh-McBirney Model 2000 Flowmeter
- SonTek FlowTracker Handheld ADV featuring Smart QC
- Acoustic Doppler Current Profiler (StreamPro)
- Volumetric measurement
- Stream gauge height pressure transducer (installed at certain fixed locations for year-round measurements)

Selection of the stream flow measurement methods described in this SOP is based on the following conditions:

- Low-flow conditions where a stream is less than 3 feet wide and less than 0.2-foot deep may be measured using a Cutthroat flume
- Moderate-flow conditions where the stream flow rate is determined to be safe to access and depth is less than 4 feet may be measured using a Marsh-McBirney Model 2000 Flo-Mate flow meter
- Under high-flow conditions when it is unsafe to wade the stream, the StreamPro will be used
- Under extreme low-flow conditions, the volumetric method may be used
- A stream gauge pressure transducer will be used at a fixed location to monitor flow conditions year round

The method of discharge measurement to be used at each site will be described in the field logbook or by using the surface water flow sheet (see Surface Water Sampling SOP) for the site. Each of these methods will be presented in the following format:

- Method name
- Field procedures
- Discharge calculations

5.1 Cutthroat Flume Procedures

Flumes are specially shaped open-channel flow sections with a restriction in channel area and, in most examples, with a change in channel slope. Either or both of these shape changes cause velocities to increase and water levels to change while passing through the flume. Typical flumes consist of three sections:

- A converging section to accelerate the approaching flow
- A throat section, the width of which is used to designate flume size
- A diverging section, designed to ensure that the level downstream is lower than the level in the converging section

The stage of a stream is the height of the water surface above an established datum plane. The datum plane for a flume is the elevation at the bottom of the throat section. The water-surface elevation referred to some arbitrary gauge datum is called the gauge height. Stage or gauge height are usually expressed in feet and hundredths of a foot.

5.1.1 Field Procedures

If the site flow measurements are to be measured using the Cutthroat flume, then discharge will be measured as described below:

- Remove any material that may accumulate in the flume
- Place flume in a location (if possible) where stream slope is no greater than 1 percent for approximately 4 to 6 feet above the flume
- Place the flume in a location within the stream where all surface water can be captured and directed into the flume
- Level the flume using a small level
- Measure and record the throat width to the nearest 0.1 foot
- Record the time and date of the site measurement

- Use the staff gauge to measure and record the stage in the upstream and throat sections to the nearest 0.01 foot
- Calculate discharge as described below
- Record the calculated discharge

5.1.2 Discharge Calculations

Based on the stage (head or gauge height [Ha] in feet) and the throat width of the flume (size of flume [W]), the discharge is read directly from the Baski Collapsible Cutthroat Flume Discharge Table (see Attachment A). Note that approximate values of discharge for heads other than those shown in the table may be calculated by the following equation:

Flow rate (cfs) = Multiplier (depends on throat

width) x (Ha)2 where:

Throat width	Multiplier
1 inch	0.50
2 inch	1.02
4 inch	2.08
8 inch	4.22

5.2 Marsh-McBirney Model 2000 Flowmeter Procedures

Portable Marsh-McBirney flow meters may be used to collect stream velocity measurements for the computation of stream discharge by the velocity-area method. The Marsh-McBirney Model 2000 flow meter can output velocity in either feet per second (ft/s) or meters per second (m/s). A low-battery flag is displayed when batteries need to be replaced in the unit. The sensor on the Marsh-McBirney meter can be connected to the universal sensor mount on the top-setting wading rod and used to determine flows using either the six-tenths depth method or the two-tenths and eight-tenths depth method. Velocities can be measured in flows as shallow as 0.1 foot, and ranging from -0.50 to +19.99 ft/s.

5.2.1 Theoretical Considerations

The volumetric flow rate of water, which is commonly called discharge (Q), is the product of multiplying the average velocity (v) by the total cross-sectional area (a). The velocity-area method measurement is made by subdividing a stream cross-section into segments (sometimes referred to as sections, verticals, profiles, panels, or ensembles) and by measuring the depth and average velocity in a vertical profile within each segment (Sauer and Turnipseed 2010a).

By dividing the stream width into subsections (streams less than 10 feet wide have 10 subsections, and streams greater than 10 feet wide have 20 subsections [see Table 1]), total discharge is equal to the sum of the individual discharge measurements in each subsection.

Individual point velocity (v) is measured at each subsection (at a depth equal to six-tenths of water depth), and the subsection discharge is equal to the product of the point velocity and cross-sectional area (a) within the subsection. The cross-section is defined by depths at verticals 1,2,3,4, ... n. At each vertical, the average velocity is measured by a current meter for a period that ranges from 40 to 70 seconds.

Table 1. Number of Subsections Based on Stream Width

Approximate width (feet)	Approximate Number of subsections	Approximate distance between subsections (feet)
<5	10	0.1–0.5
5–10	10	0.5–1.0
>10	20	>0.5

5.2.2 Required Measurement Conditions

To make a velocity-area discharge measurement, the following conditions are required:

1. The stream must be channelized; observable banks must channel the entire stream flow
2. Depth must be greater than 0.5 foot across most of the cross-section being measured
3. The stream must have measurable velocities, greater than 0.5 ft/s in most of the cross-section

Conditions 2 and 3 often can be met in streams of very low discharge by conservatively modifying the stream channel to produce a narrower and slightly deeper cross-section to meet measurement requirements. These modifications will include removal of aquatic growth or ice, moving large stones that impact velocity upstream or downstream of the cross-section, and narrowing or deepening of the cross-section. By rearranging small amounts of native rock or sand, the sampler can produce a measurable cross-section. When such modifications are made, great care must be exercised to avoid unnecessary movement of sediments. After clearing the cross section, flow will be allowed to stabilize before the current-meter measurement of velocities begins.

5.3 The Velocity-Area Method

Stream discharge is the summation of the products of the subsection areas of the stream cross-section and their respective average velocities. The formula:

$$Q = \sum (av)$$

represents the computation, where Q is the total discharge, a is an individual subsection’s area, and v is the corresponding mean velocity of flow normal to the subsection. The summation of the discharges for all the subsections is the total discharge of the stream. The order for calculating discharge is:

- Use the distances from initial point recorded on the measurement notes to compute width for each section. The first width is computed by subtracting the first distance from the second distance, and dividing this quantity by two. The second width will be the quantity of difference between the third distance and the first distance, divided by two. For each subsequent width, subtract the distance on the line above the line you are calculating from the line below, and divide this quantity by two. This procedure is carried out for each line until you reach the final width calculation. This is calculated as the quantity of the difference between the final distance and the second-to-the-last distance, divided by two.
- Perform subsequent calculations as follows:
  - Calculate each discharge for each subsection by multiplying the width of the subsection times the depth times the velocity
  - Sum the discharges for each subsection to arrive at total discharge for the entire cross-section

- Check your math by summing the subsection widths.

Discharge through the cross-section is given by:

$$Q = \sum_{i=1}^{n} v_i a_i$$

where the area of each subsection, ai, is computed by:

$$a_i = z_i * \left(\frac{x_{i+1} - x_{i-1}}{2}\right)$$

where xi are cross-stream distances measured to successive verticals (i.e., subsections) from the starting point, the vi are the vertically averaged velocities at each vertical, and the zi are the depths at each vertical. x1 and xn are located at the ends of the section (left and right edges of the water, respectively, as the observer faces downstream), and xn-1 and xn+1 are taken as zero. The velocities at the ends of the section (v1 and vn) will always equal zero, and z1 and zn will also equal zero (unless the corresponding bank is vertical) (Dingman 2002).

5.4 SonTek FlowTracker Handheld ADV

The SonTek FlowTracker is a type of equipment used to collect stream discharge (Q) measurements by computation of stream velocity, depth, and section(s) widths. Output can either be in English (feet, ft/s, cfs) or metric (meters, meters/second, and meters cubed/second) units. A probe is mounted to a measuring rod along with a handheld controller. Discharge can be determined by using the standard Mid-Section Discharge method. The FlowTracker has a + 1 percent accuracy of measured velocity. Stream velocity, stream depth, and stream subsection widths are all recorded on the Handheld ADV that computes Q.

5.4.1 Required Measurement Conditions

To make a velocity-area discharge measurement, the following conditions are required:

1. The stream must be channelized; observable banks must channel the entire stream flow
2. Depth must be greater than 0.5 foot across most of the cross-section being measured
3. The stream must have measurable velocities, greater than 0.5 ft/s in most of the cross-section

Conditions 2 and 3 often can be met in streams of very low discharge by conservatively modifying the stream channel to produce a narrower and slightly deeper cross-section to meet measurement requirements. These modifications will include removal of aquatic growth or ice, moving large stones that impact velocity upstream or downstream of the cross-section, and narrowing or deepening of the cross-section. By rearranging small amounts of native rock or sand,

the sampler can produce a measurable cross-section. When such modifications are made, great care must be exercised to avoid the unnecessary movement of sediments. After clearing the cross-section, flow will be allowed to stabilize before the velocity measurement begins.

5.5 StreamPro Acoustic Doppler Current Profiler Procedures

The StreamPro ADCP measures discharge and velocity in streams from 15 to 225 centimeters (cm) deep. The StreamPro "bottom tracking" capability provides the ability to move continuously across the stream to obtain a discharge measurement in 2 or 3 minutes. The StreamPro design allows you to take measurements without even entering the water. The instrument can simply be put across the stream as a bridge is accessed on foot, or the unit can be attached to a tagline. Data are collected in real-time and transmitted via a wireless data link to a laptop personal computer (PC) loaded with Teledyne RDI software. The User's Manual provides a complete description of how to calibrate, trouble shoot, and use the StreamPro.

5.6 Volumetric Measurement Procedures

For very low flows when measurements using the Cutthroat flume or Marsh-McBirney are not possible, stream discharge can be measured using a volumetric approach based on the following formula:

Total Discharge = Volume/Time

The discharge rate can be determined by measuring the amount of time required for the flow to fill a container of a known volume—for example a 5-gallon bucket or a graduated cylinder. When using this method, it is necessary to channelize the flow so that all the water is being captured by the container. Perform three to five tests and use the average time to fill the container to compute the discharge rate, particularly if the time to fill the container is very short (less than 1 to 2 seconds). Averaging fill times helps to mitigate timing error associated with this method. Always note the volume of the container and the time required to fill the container in the field notebook.

5.7 Stream Gauge Height Pressure Transducer Procedures

5.7.1 Site Selection Considerations

This procedure is intended to provide direction for installation of a dedicated staff gauge, pressure transducers, rating curve development, and quality control and documentation of data.

Stream gauging station installation and development will be performed in accordance with applicable standards for the area of the investigation, this SOP and other project-specific planning documents. Final installation design for the stream gauging station will be dependent on the physical nature of the channel, bed materials (unconsolidated materials and/or consolidated materials) at the site, and the stream characteristics (riffle, run, pool). The following section within this SOP describes the general approach guiding installation of long-term, high-frequency stream gauging sites.

5.7.2 Site Selection

Choose the site for installation of a permanent stream gauging station based on the following criteria:

- Consider the data that will be generated at the site, including rating curves, streamflow, backflow, and other stream flow variables.
- Select the site so that the intakes or pressure transducer will be in a zone of calm water, where stream velocities are low, with minimal surface wave influence. Avoid areas of deposition, where siltation of the site may become an issue.
- If the gauge is located at or near a bridge, locate the gauge on the downstream side, where the bridge structure may help to protect your stream-gauging site.
- Place the gauge intakes or pressure transducer low enough to record the lowest expected stage. In cold climates, place your pressure transducer in an area with deeper water (2 to 3 feet at lowest stage anticipated) to minimize chances of freezing.

- Locate the instrument shelter or data logger location above the 0.5 percent exceedance (200-year) flood level, if possible. If not possible, locate the shelter as close to this point as possible.
- Ensure that the site has suitable locations for at least one auxiliary (or reference) gauge.
- Ensure that the site allows for establishment of an accurate datum. Locate reference marks both on and off the gauge structure, and check at regularly established intervals.

5.7.3 Base and Reference Gauge Description

For discussion in this SOP, the gauge used to collect primary gauge-height information is referred to as the base gauge. In addition to the installation of the base gauge, a reference gauge should also be installed. The reference gauge for an automatic recording gauging station is a non-recording gauge used to set recorders, data loggers and associated transducers, or transmitters from which the primary gauge-height record is obtained. For gauges without stilling wells, the reference gauge is usually mounted directly in or over the stream (dependent on type), designated specifically to be the reference gauge, and generally referred to as an outside gauge. The reference gauge can be a staff gauge, wire weight gauge, chain gauge, or other type of gauge. Ideally, the reference gauge is installed as close as possible to the base gauge and should be set to the same stage height as the base gauge, as read during installation of the system (Sauer and Turnipseed 2010b). The electronic data logger and transducer cables shall be installed by the geologist/environmental scientist in accordance with the manufacturer's instructions. All cabling should be protected from the elements and wildlife by installing it inside a conduit along its entire length. The data logger may be placed near the stilling well or mounted on a post. If mounted on a post, the data logger shall be housed in a protective cabinet.

5.7.4 Staff Gauge Installation

The staff gauge may be installed either vertically or inclined. The standard U.S. Geological Survey (USGS) vertical staff gauge consists of either a steel or fiberglass section approximately 0.33 feet wide, 3.50 feet long, with graduations showing stage height every 0.02 foot. Vertically installed staff gauges are set by leveling directly to the gauge and must be installed on a structure that will not receive damage from flood flows, ice, or debris in the channel. Inclined staff gauges usually consist of heavy timbers securely attached to a permanent foundation (Sauer and Turnipseed 2010b). Inclined staff gauges are generally less likely to be damaged by flood flows or ice but require a more rigorous installation and will induce an offset in reading produced by Campbell Scientific pressure transducers, which must be accounted for in order for the readings to be useful.

5.7.5 Gauge Datum

Once both the base and reference gauge are installed, the gauges must be surveyed and referenced to a recognized datum. The datum may be a recognized datum, such as the North American Vertical Datum of 1988 (NAVD 1988) or the National Geodetic Vertical Datum of 1929 (NGVD 1929) or an arbitrary datum near the site, chosen for convenience. If an arbitrary datum is chosen, the installer must be certain that the datum will remain stationary over very long time frames (greater than 25 to 50 years). A permanent gauge datum should be maintained, if at all possible, so that only one datum is used for the life of the gauging station. For each gauging station, a permanent datum should be maintained that has at least three permanent reference marks that are independent of the gauge structure. For gauging stations located at bridges, at least one reference mark should be used that is located away from the bridge structure, preferably out of the right-of-way easement (Sauer and Turnipseed 2010b). To ensure that the base and reference gauges have not changed relative to the datum, levels should be run periodically (e.g., every 2 to 3 years) to all gauges and reference marks. Further information concerning gauge datums, along with procedures and methodology for running levels in accordance with accepted USGS standards are outlined in Kenney (2010) and Sauer and Turnipseed (2010b).

5.7.6 Rating Curve Development

In surface water hydrology, a rating curve is a plot of stage versus discharge, for a given stream cross-section. The rating curve is developed from empirical evidence, collected from many (greater than 10) manual stream-gauging events. Upon installation of a permanent gauging station, the channel cross-section must be surveyed so that users of the rating curve and data generated from it will be able to ascertain if changes in channel geometry occur over time, as these changes have the potential to affect the rating curve. Once the channel geometry is surveyed and understood, data collection for development of the rating curve may begin. Methodologies for rating curve data collection are as follows:

- In the field logbook, note the date, time, weather conditions, stream channel conditions, stream turbidity, and any other pertinent information about the site.
- Collect and compute stream channel discharge using the velocity-area method.
- Manually read the reference (staff) gauge to the nearest 0.01 foot; if wave action precludes accurate reading, take the average of the highest and lowest readings observed during approximately 30 seconds.
- Collect stage data from the onsite data logger. Quality check the downloaded data set before leaving the site. Note the transducer stage reading closest to the time of the manual discharge measurement in the logbook.

The project manager or site geologist will input the collected data into the graph used to develop the rating curve.

5.7.7 Methodology

Installation. After a suitable location has been chosen for the base gauge, a stilling well or appropriate housing for the pressure transducer must be installed. For this installation, a screened galvanized-steel pipe, allowing hydraulic connectivity between the pipe and the surrounding stream water is appropriate. The pipe will be mounted securely either by driving the pipe into the bed material, or by securing the pipe to a steel post, bridge abutment, gabion, or other stationary point within the stream channel. Final gauge installation will be dependent upon site characteristics determined by the field geologist or environmental scientist during gauge installation.

The following list includes items that are needed for installation of a permanent gauging site:

- Campbell Scientific CS450 (or compatible) submersible pressure transducer, with adequate cable
- Campbell Scientific CR206X (or compatible) data logger
- Campbell Scientific RF430 (or compatible) spread spectrum transceiver
- Associated cables, wire, splices, for all loggers and peripherals
- 12-volt power source (battery and charging source)
- Digital multi-meter
- PC with LoggerNet software installed
- Peripheral data cables (RS-232 or RS-232 to USB converter)
- Weather proof enclosure for data logger and power source (Campbell ENC 10/12 Enclosure or compatible)
- Top-setting rod

- Flow meter
- Manufacturer's operating manuals
- Staff gauge
- Hardware/tools to complete install (2 by 4s, pipe, cordless drill, screwdrivers, hammer, etc.)
- Galvanized pipe with screened interval
- Concrete anchors
- Field logbook
- Field binder, including:
    - Transducer performance check and maintenance forms
    - Cross-section
- Measuring tape
- Waterproof ink pens
- Waders
- Paper towels
- Duct tape
- Desiccant packs
- Conduit
- Concrete
- Shovel

Data Retrieval. Once the rating curve is developed, data from the transducers will be downloaded on a monthly basis, typically concurrent with the monthly manual stream gauging and surface event sampling.

Preventive Site Maintenance and Troubleshooting. At every visit, field personnel will collect data and visually inspect wiring and physical conditions of the site. Field personnel will also check indicating desiccant or enclosure humidity indicator; service if necessary, check battery condition (inspect physical appearance and use a keyboard display or laptop to view the battery voltage and other recent data, adjust transducer offsets if necessary). When installing or otherwise handling any transducer, use caution to avoid dropping the transducer accidently, and never allow the transducer to freefall into a stilling well or standpipe. The pressure sensor is very sensitive, and sudden shock can damage the transducer. If the transducer is not functioning properly, inspect the cable for damage, check the connection to the data logger or power source, and inspect the vent cable for moisture. If the transducer cannot be repaired to proper functioning condition, remove it for service by the manufacturer. Never attempt to service a data logger or transducer by taking it apart.

Equipment Calibration. Pressure transducers are available that require no field calibration (e.g., In-Situ Inc. PXD-260); however, many need to be sent back to the manufacturer for occasional servicing. If maintenance is scheduled in advance, a rental unit can usually be procured to avoid gaps in data collection. Periodic manual measurement of the staff gauge shall be performed as a check on the water level data recorded by a data logger. Furthermore, validation of the rating curve will be performed using discharge data collected manually during each surface water sampling event.

Section 6: Quality Assurance/Quality Control

Quality assurance activities that apply to the implementation of these procedures are located in the site quality assurance project plan (QAPP). In addition, the following general procedures apply:

- All data must be documented on field data sheets or within site logbooks. Logbooks will contain a signature page that will list the printed name, signature, initials, and title of personnel entering information into a logbook. Any person entering information on a logbook page will initial the upper right-hand corner of the logbook. Any errors made will be corrected by striking through the erroneous information with a single line, and the person performing the correction will initial and date the correction.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment calibration activities must occur prior to sampling/operation, and they must be documented in the logbook, including the name, title, date, and signature of the person performing the calibration. Calibration standard lot numbers will be noted, as well as any unanticipated readings/behavior of the calibrated instrument.
- The Cutthroat flume will be inspected prior to measurement of discharge to determine that the flume is discharging freely. Any problems observed during the inspection will be noted and reported to the project manager.

Descriptions of any deviations and the reason for deviations from the site QAPP or this SOP should be noted in the field notebook, as necessary. In addition, the logbook should track pertinent measurement collection information such as:

- Date/time
- Personnel
- Weather conditions
- Location identification information
- Plan for the shift
- Brief summary describing activities conducted in the field, along with corresponding results and/or observations

Section 7: References

Marsh McBirney, Inc., 1990. *Flo-Mate Model 2000 Portable Flowmeter Instruction Manual*. December.

Teledyne RD Instruments, Inc. 2009a. *StreamPro ADCP Operational Manual*. November.

Teledyne RD Instruments, Inc. 2009b. *StreamPro ADCP Quick Start Manual*. November.

Teledyne RD Instruments, Inc. 2009c. *StreamPro Discharge Measurement Summary*. November.

Teledyne RD Instruments, Inc. 2009d. *StreamPro Software User's Guide*. November.

Section 8: Attachments

Attachment A: Baski Collapsible Cutthroat Flume Discharge

Attachment A: Baski Collapsible Cutthroat Flume Discharge Table

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Upstream Gauge (ft)	gpm 1"	gpm 2"	gpm 4"	gpm 8"	cfs 1"	cfs 2"	cfs 4"	cfs 8"
0.10	2.25	4.58	9.32	19.0	0.005	0.010	0.021	0.042
0.11	2.72	5.54	11.3	23.0	0.006	0.012	0.025	0.051
0.12	3.24	6.60	13.4	27.4	0.007	0.015	0.030	0.061
0.13	3.80	7.74	15.8	32.1	0.008	0.017	0.035	0.072
0.14	4.41	8.98	18.3	37.2	0.010	0.020	0.041	0.083
0.15	5.06	10.3	21.0	42.8	0.011	0.023	0.047	0.095
0.16	5.76	11.7	23.9	48.6	0.013	0.026	0.053	0.108
0.17	6.50	13.2	26.9	54.9	0.014	0.029	0.060	0.122
0.18	7.29	14.8	30.2	61.6	0.016	0.033	0.067	0.137
0.19	8.12	16.5	33.6	68.6	0.018	0.037	0.075	0.153
0.20	9.00	18.3	37.3	76.0	0.020	0.041	0.083	0.169
0.21	9.92	20.2	41.1	83.8	0.022	0.045	0.092	0.187
0.22	10.9	22.2	45.1	92.0	0.024	0.049	0.101	0.205
0.23	11.9	24.2	49.3	101	0.027	0.054	0.110	0.224
0.24	13.0	26.4	53.7	109	0.029	0.059	0.120	0.244
0.25	14.1	28.6	58.3	119	0.031	0.064	0.130	0.265
0.26	15.2	31.0	63.0	128	0.034	0.069	0.140	0.286
0.27	16.4	33.4	67.9	139	0.037	0.074	0.151	0.309
0.28	17.6	35.9	73.1	149	0.039	0.080	0.163	0.332
0.29	18.9	38.5	78.4	160	0.042	0.086	0.175	0.356
0.30	20.3	41.2	83.9	171	0.045	0.092	0.187	0.381
0.31	21.6	44.0	89.6	183	0.048	0.098	0.200	0.407
0.32	23.0	46.9	95.4	195	0.051	0.104	0.213	0.434
0.33	24.5	49.9	101	207	0.055	0.111	0.226	0.461
0.34	26.0	52.9	108	220	0.058	0.118	0.240	0.489
0.35	27.6	56.1	114	233	0.061	0.125	0.254	0.519
0.36	29.2	59.4	121	246	0.065	0.132	0.269	0.549
0.37	30.8	62.7	128	260	0.069	0.140	0.284	0.580
0.38	32.5	66.1	135	274	0.072	0.147	0.300	0.611
0.39	34.2	69.7	142	289	0.076	0.155	0.316	0.644
0.40	36.0	73.3	149	304	0.080	0.163	0.332	0.677
0.41	37.8	77.0	157	319	0.084	0.172	0.349	0.712
0.42	39.7	80.8	164	335	0.088	0.180	0.366	0.747

BASKI, Inc.

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Collapsible Cutthroat Flume

Upstream Gauge (ft)	gpm 1"	gpm 2"	gpm 4"	gpm 8"	cfs 1"	cfs 2"	cfs 4"	cfs 8"
0.43	41.6	84.7	172	351	0.093	0.189	0.384	0.783
0.44	43.6	88.7	180	368	0.097	0.198	0.402	0.820
0.45	45.6	92.7	189	385	0.102	0.207	0.421	0.857
0.46	47.6	96.9	197	402	0.106	0.216	0.439	0.896
0.47	49.7	101	206	420	0.111	0.225	0.459	0.935
0.48	51.8	106	215	438	0.116	0.235	0.478	0.975
0.49	54.0	110	224	456	0.120	0.245	0.499	1.02
0.50	56.3	115	233	475	0.125	0.255	0.519	1.06
0.51	58.5	119	242	494	0.130	0.265	0.540	1.10
0.52	60.8	124	252	514	0.136	0.276	0.562	1.14
0.53	63.2	129	262	534	0.141	0.287	0.583	1.19
0.54	65.6	134	272	554	0.146	0.298	0.606	1.23
0.55	68.1	139	282	575	0.152	0.309	0.628	1.28
0.56	70.6	144	292	596	0.157	0.320	0.651	1.33
0.57	73.1	149	303	617	0.163	0.332	0.675	1.38
0.58	75.7	154	314	639	0.169	0.343	0.699	1.42
0.59	78.3	159	324	661	0.175	0.355	0.723	1.47
0.60	81.0	165	336	684	0.180	0.367	0.748	1.52
0.61	83.7	170	347	707	0.187	0.380	0.773	1.58
0.62	86.5	176	358	730	0.193	0.392	0.798	1.63
0.63	89.3	182	370	754	0.199	0.405	0.824	1.68
0.64	92.2	188	382	778	0.205	0.418	0.851	1.73
0.65	95.1	194	394	803	0.212	0.431	0.877	1.79
0.66	98.0	200	406	828	0.218	0.444	0.905	1.84
0.67	101	206	418	853	0.225	0.458	0.932	1.9
0.68	104	212	431	879	0.232	0.472	0.96	1.96
0.69	107	218	444	905	0.239	0.486	0.989	2.02
0.70	110	224	457	931	0.246	0.500	1.02	2.07
0.71	113	231	470	958	0.253	0.514	1.05	2.13
0.72	117	237	483	985	0.26	0.529	1.08	2.19
0.73	120	244	497	1013	0.267	0.544	1.11	2.26
0.74	123	251	510	1040	0.275	0.559	1.14	2.32
0.75	127	258	524	1067	0.282	0.574	1.17	2.38