

MEMORANDUM

VIA EMAIL

TO: JAMIE MILLER, EPA
WENDY NAUGLE, CDPHE

FROM: DAVE HINRICHS, NEWFIELDS
KERRI SITLER, NEWFIELDS

SUBJECT: SURFACE WATER AND GROUNDWATER MONITORING IN 2018
EAGLE RIVER MINE SITE

DATE: JANUARY 22, 2018

ATTACHMENTS: QUALITY ASSURANCE PROJECT PLAN; STANDARD OPERATING PROCEDURES

CC: JEFF GROY, CBS OPERATIONS INC.
RUSS CEPKO, CBS OPERATIONS INC.

This Memorandum describes the surface water and groundwater monitoring program that CBS Operations Inc. (CBS) proposes for 2018.

In the spring, typically described as March and April prior to snowmelt that generates flows greater than 150 cubic feet per second (cfs), copper, cadmium, and zinc concentrations within Segment 5 of the Eagle River has at times exceeded the Water Quality Standards that were made effective January 1, 2009. Numerous studies and zinc loading estimates have identified a seasonal metal load that enters Segment 5a of the Eagle River in the Belden area between stations E-3 and E-10 and at Rock Creek, Station T-10.

Monitoring Objectives

The objectives of the surface water monitoring are to assess the timing and duration of spring metals loading to the river, to provide data for monitoring long-term water quality trends, and to assess the on-going functionality of the remedy in Segment 5b. While data will be compared to the Water Quality Standards, true compliance monitoring will not commence at the Site until additional remedial activities have been completed.

The objective of the groundwater level monitoring near the East Trench is to ensure that the trench is functioning as designed to capture groundwater before it enters the Eagle River.

Since the completion of the CTP cap in 1996, zinc concentrations in groundwater at the CTP have decreased greatly. Wells DAP-MW 4R and NTP-MW 5R will be sampled in the fall to provide data for a trend analysis in the Annual Report.

The riser pipe on well REX MW-2 is cracked and will be replaced in 2018. The well will be bailed and sampled after the repair work is complete.



Surface Water Monitoring Locations

The Eagle River will be monitored at:

- E-3, Eagle River above Belden, Segment 2 – *when ice/snow conditions allow*
- E-10, Eagle River above Rock Creek, Segment 5a
- E-12A, Eagle River below Old Tailings Pile and Rex Flats, Segment 5a
- E-15, Eagle River below Cross Creek, Segment 5b
- E-22, Eagle River below Minturn, Segment 5c

Eagle River tributaries will be monitored at:

- T-10, Rock Creek at mouth
- T-18, Cross Creek at culvert near mouth.

Surface Water Monitoring Frequency

Water quality samples will be collected at each of the above-listed Surface Water Monitoring locations every other week in March and April, terminating when river flow exceeds approximately 150 cfs. An additional round of water quality samples will be collected from all listed locations in September or October. Samples will be obtained in accordance with the Quality Assurance project plan (QAPP) and Standard Operating Procedures (SOPs) in Appendix A of the *Focused Feasibility Study (FFS) Addendum, Arsenic Sampling Plan* submitted by NewFields March 13, 2015. The QAPP and SOPs are attached.

Surface Water Analyte List

The following field parameters and analyses will be measured in surface water samples:

- Specific Conductance, field
- Temperature, field
- Arsenic, total recoverable
- Cadmium, dissolved
- Calcium, dissolved
- Copper, dissolved
- Magnesium, dissolved
- Zinc, dissolved.

Flow Measurements

Flow estimates for the river will be made using the USGS gage at station E-12A and the correlation curves for other main stem stations established in the 2007 Eagle Mine Site Annual Report. Flow for Rock Creek station T-10 will be estimated during each sampling event using an equation for flow in a 72-inch diameter pipe. The estimate requires two measurements, the depth of water at the invert and the velocity of flow in feet/second (the culvert length of 95 feet divided by the time in seconds). Flow estimates for Cross Creek at station T-18 will be made using the USGS gage at Cross Creek near Minturn (USGS 09056100).

Underground Mill Pumping

The pool of water that accumulates in the underground Mill at Belden is periodically pumped out to the treatment plant to maintain a low Mill pool level. An estimate of the gallons pumped during the year will be recorded in the Annual report.



East Trench Groundwater Level Monitoring

A HOBO water level logger was installed in the ET-1 monitoring well at the East Trench in January 2013. The HOBO logger automatically record water levels at 18-hour intervals. Data from the data logger will be downloaded periodically and used to monitor the effect of maintenance activities on the East Trench groundwater collection system.

Groundwater Monitoring at the CTP

Monitoring wells DAP-MW 4R, NTP-MW 5R, and REX MW-2 will be sampled and analyzed for dissolved metals, per EPA Method 200.8, to provide data for a zinc trend analysis. The samples will be collected concurrent with the September or October surface water program.

The following field parameters and analyses will be measured in surface water samples:

- Specific Conductance, field
- Temperature, field
- Arsenic, dissolved
- Cadmium, dissolved
- Copper, dissolved
- Zinc, dissolved.

Prior to sampling, the water level in the wells will be measured with an electric water level meter (e.g., Solinst) then bailed with dedicated bailers until at least three borehole volumes has been removed from the 4-inch diameter well casing (0.65 gallons/foot). Temperature and specific conductance will be measured prior to sample collection. The extracted water will be collected and treated at the treatment plant.

The groundwater samples will be obtained following procedures set out in the aforementioned QAPP and SOPs submitted herewith.

Appendix A

Standard Operating Procedures

This document presents standard operating procedures (SOPs) for environmental sampling. The SOPs contained in this appendix are:

- SOP No. 1 Sample Handling and Documentation
- SOP No. 2 Decontamination Procedures
- SOP No. 3 Specific Conductance, Temperature, and pH Measurement
- SOP No. 4 Surface Water Sampling
- SOP No. 5 Flow Measurement
- SOP No. 6 Groundwater Sampling

The procedures have been developed from governmental and industrial guidance documents, NewFields field experience, and the standard methods and procedures as practiced throughout the industry.

These SOPs provide only general method and procedures which, by necessity, may be changed to suit a particular phase of the project. The SOPs are intended to augment the text of the report to which it is appended and the project-specific health and safety and quality assurance plans as appropriate. Detailed procedures may be described in the report text which go beyond those outlined herein and are specific to the requirements of the project. In any conflict between a procedure specified in the SOP and one specified in the text of the report to which it is appended, the procedure specified in the text of the report will rule.

Standard Operating Procedure No. 1

Sample Handling and Documentation

1.0 SAMPLE HANDLING

Water samples will be collected in accordance with sampling procedures listed in SOP Nos. 4 and 6 for surface waters and groundwater. Water samples for dissolved metals analysis will be filtered through a 0.45-micron membrane filter using a peristaltic pump. In the field, the initial 100 to 200 ml of filtrate will be used to rinse the filter apparatus and will be discarded prior to actually obtaining a filtered sample. If samples can be provided to the laboratory on the same day as sampling, the field personnel may choose to allow for laboratory filtering over field filtering, unless specifically instructed in the sampling plan to only field filter.

Water samples will be collected in containers provided by the laboratory. Table A-1 summarizes preservative and holding time requirements.

Table A-1 Preservatives and Holding Time Requirements by Analyte

Parameter	Preservative	Maximum Holding Time (days)
Dissolved Metals	Filter, 4 °C, HNO ₃	180
	Prefiltered, 4 °C	<24 hours until filtration and HNO ₃ ; then 180 days
Total Metals	4 °C, HNO ₃	180
Alkalinity	4 °C	14
Sulfate	4 °C	28
Ammonia as N	4 °C, H ₂ SO ₄	28
Nitrate+Nitrite as N	4 °C	28
Total Organic Carbon	4 °C, H ₂ SO ₄	28
Phosphate	4 °C	28
Total Suspended Solids	4 °C	7

2.0 DOCUMENTATION

2.1 Sample Labeling

Each sample that is collected will be labeled with the following information:

- Company and Project Identification
- Sample Identification Number
- Date
- Time
- Preservation
- Filtered or Unfiltered
- Name/Initials of Sampler.

2.2 Field Sampling Form

Information on the site location, sampling method, field measurements, and other pertinent information will be recorded on field sampling form/log sheet. All collected samples will be assigned a project sample identification number and logged in. Entries will be made in waterproof ink. Errors will be noted, initialed, and corrected. Additional information will be entered on daily field logs, including:

- Site name and number
- Well/sample location
- Date
- Time of collection
- Sample number
- Weather conditions
- Method of collection
- Water level (for well samples)
- Volume of water purged prior to sampling (for well samples)
- Water temperature (if appropriate)
- Field measurement of pH and specific conductance (if appropriate)
- Appearance of other relevant data
- Sample preparation
- Sampling personnel.

2.3 Chain-of-Custody

A Chain-of-Custody form recording pertinent sample information will be prepared for all sample shipping containers leaving the project site. The Chain-of-Custody form will be routed with the samples through storage, transportation, and analysis. Completed Chain-of-Custody forms will be returned to NewFields with results from the analytical laboratory. A copy of these forms will be retained in project files.

All logs and forms will be completed in detail. Copies of the field logs and sampling forms will be made at the end of each work week and transmitted to the NewFields Denver office for project filing.

2.4 Sample Packing

Samples collected will be placed in sampling coolers in the field. Samples will be placed in the shipping container with sealed ice or blue ice packets, as required, overpacked with shipping materials, and securely sealed with fiber strapping tape. The completed Chain-of-Custody form will be placed in a Ziploc bag and included with the contents of the shipping container.

2.5 Shipping

Samples will be shipped in a timely fashion to meet analytical holding time requirements.

3.0 CONTROL OF MEASURING AND TEST EQUIPMENT

Selection of measuring and test equipment for monitoring activities shall be consistent with the requirements of this plan to assure that such items are of proper type, range, accuracy, and tolerance to accomplish the specified monitoring function.

- Measuring and test equipment shall be calibrated, adjusted, and maintained at prescribed intervals against certified equipment having known valid relationships to nationally recognized standards. If no nationally recognized standards exist, the bases for calibration shall be documented.
- The method and interval of calibration for each item shall be defined, based on the type of equipment stability characteristics, required accuracy, intended use, and other conditions affecting measurement control. When measuring and test equipment is found to be out of calibration, an evaluation shall be made and documented of the validity of previous inspection or test results, and of the acceptability of items previously inspected or tested. Out-of-calibration devices

shall be tagged or segregated and not used until they have been recalibrated. If any measuring or test equipment is consistently found to be out of calibration, it shall be repaired or replaced. A calibration shall be performed when the accuracy of the equipment is suspect. Calibration shall be performed in conformance with manufacturer's specification and/or as required by industry standards.

- Calibrated measuring and test equipment shall be identified by a serial number affixed in a suitable permanent manner, and with tags, labels, or stickers identifying the date of calibration and the next due date.
- A measuring and test equipment log shall be maintained to include the equipment/instrument identification, type of equipment instrument, date of last calibration, due date of next calibration, location of equipment/instrument.
- An equipment/instrument identification number shall be recorded on the appropriate documentation, at time of use.
- Calibrated equipment/instruments shall be traceable, via identification number, to certificate of calibration.
- Calibrated equipment/instruments shall be properly handled and stored to maintain accuracy.
- When required, controlled environmental conditions for instruments will be adhered to and documented.

Standard Operating Procedure No. 2

Decontamination Procedures

To eliminate the need for decontamination, equipment which comes in contact with the sampling media will be dedicated to a sampling station or monitoring well. This dedicated equipment will be clearly labelled to identify the sampling location/well and will be sealed or wrapped in plastic during storage. Equipment, which comes in contact with ground or other potential sources of contamination during sampling, will be decontaminated or discarded prior to sampling each site.

For non-dedicated equipment, equipment decontamination will be performed prior to each sampling event. Equipment which comes in contact with ground or surface water or other potential sources of contamination during sampling will be decontaminated or discarded prior to sampling each site.

To alleviate complicated equipment decontamination and to reduce the potential for cross-contamination between filtered samples, disposable 0.45-micron in-line filters will be used along with disposable hose. After each sample is filtered, the in-line filter will be discarded.

The following procedures will be followed for cleaning sampling equipment at the site:

- Clean the buckets or tubs with tap water and detergent, rinse with tap water, and final rinse with distilled water before cleaning equipment.
- Fill first bucket or tub with detergent and tap water.
- Fill second bucket or tub with tap water.
- Clean equipment thoroughly in detergent water. Use brushes and disposable handiwipes as necessary for soil sampling equipment.
- Rinse thoroughly with tap water.
- Rinse thoroughly with distilled water.
- Wrap equipment with plastic as appropriate for storage and transport.

If a non-dedicated pump is used to properly evacuate a well, it will be cleaned in the following manner:

- Clean the buckets or tubs with tap water and detergent, rinse with tap water, and final rinse with distilled water before cleaning equipment.

- Fill first bucket or tub with detergent and tap water.
- Fill second bucket or tub with tap water.
- Fill third bucket or tub with distilled water.
- Submerge the pump intake device into the detergent water and operate for 5 minutes.
- Submerge the pump intake device into the tap water and operate for 5 minutes.
- Submerge the pump intake device into the distilled water and operate for 5 minutes.
- Wrap pump in plastic until needed.

All surface water sampling equipment will be decontaminated prior to use in the field, between sampling points, and at the completion of the sampling program.

The following procedures will be used:

- At the beginning of each sampling episode, new sample collection and composite containers will be rinsed with de-ionized water.
- Prior to collecting each sample, a 1-gallon (analytical quality) plastic bottle will be triple-rinsed with the water that is to be sampled.
- Prior to collecting each sample, a 2.5-gallon (analytical quality) plastic jug will be triple-rinsed with the water that is to be sampled.
- Prior to processing the first sample, a new length of suction tubing will be installed on the peristaltic pump.
- A disposable 0.45 micron in-line filter will be attached to the tubing.
- Approximately 200 ml of distilled water or sample water will be pumped through the tubing and filter, making sure the filter is completely rinsed prior to contact with the sample.
- If distilled water is used, approximately 200 ml of sample water is then pumped through the tubing and filter, making sure to displace all distilled water in the filter.
- Upon completion, the filter is removed and discarded.
- Approximately 200 ml of distilled water is then pumped through the tubing.

- The outside of the tubing is washed with distilled water and wiped dry.
- Equipment will be wrapped and sealed in plastic as appropriate for storage and transport.

Standard Operating Procedure No. 3

Specific Conductance, Temperature, and pH Measurement

Field measurements at all locations will include pH, temperature, and specific conductance. pH will be measured from the composited sample using an Orion pH meter or equivalent. Specific conductance and temperature will be measured *in situ* using a YSI portable conductivity meter or equivalent. The manufacturers operating instructions and specifications for these instruments will be carried with the equipment. At minimum, all field equipment used during environmental monitoring activities will be calibrated/standardized each day prior to sampling according to the manufacturer's specifications. Field instruments will be calibrated/standardized with certified standards that, where applicable, bracket the measurements expected to be taken during the sampling effort. A recalibration will be performed when the accuracy of the equipment is suspect. If the manufacturer's specifications for calibration/standardization are not met, the field equipment will be taken out of service and new equipment will be obtained. Results of the calibration/standardizations will be documented in the field logbook.

1.0 SPECIFIC CONDUCTANCE AND TEMPERATURE MEASUREMENT

Specific conductance and temperature will be measured as follows:

- With the meter turned off, adjust the meter zero by turning the bakelight screw on the face to zero.
- Adjust the meter by turning the switch to *red line* and adjusting the meter needle with the red line control. If the batteries are depleted, the machine will not red line.
- Plug the probe into the probe jack on the side of the instrument and place the probe into the solution to be measured.
- Set the main switch to *temperature* and allow five minutes for equilibrium to occur between the probe temperature and the solution temperature. The temperature is read on the bottom scale of the meter to the nearest 0.5°C.
- Note and record the temperature reading on the sampling form or log.
- Specific conductance is read after switching to the *conductance* position. The range knob is switched to the highest setting, x100 µmhos/cm, and if the reading is below 50 on the 0 to 500 meter scale, the machine is switched to the next

lower range, x10 $\mu\text{mhos/cm}$. If the reading is still below 50, the instrument must be switched to the lowest scale, x1 $\mu\text{mhos/cm}$.

- Note and record the specific conductance readings on the sampling form or log.
- Each measured specific conductance value shall be recorded and subsequently adjusted from the measured temperature to a specific conductance value at 25°C using the following temperature correction equation:

$$S_C = S_M / [1 + 0.019(T_M - 25)]$$

where,

S_C =specific conductance corrected to 25°C ($\mu\text{mhos/cm}$)

T_M =measured temperature (°C)

S_M =measured specific conductance ($\mu\text{mhos/cm}$).

- To check the condition of the probe, the “Cell Test” is performed by switching the meter to x100 or x10 meter range conductance and depressing the cell test button. If deflection is greater than 2 percent of the reading, the probe is fouled.

2.0 pH MEASUREMENT

After the meter has been calibrated, the composited sample will be measured for pH immediately upon collection.

2.1 Calibration

- Select either a 4.0 and 7.0, or 7.0 and 10.0 buffer to bracket the expected sample range.
- Connect electrodes and ATC probe to meter.
- Select pH mode and resolution by sliding the *mode* switch to pH .1 or pH .01.
- Press *iso* and verify that the isopotential point is 7.00.
- Press *cal*. The display will alternate between .1. and the pH value of the buffer, indicating that the electrodes are in the first buffer and a value has not yet been entered.

- Wait for the pH value to stabilize. Press *enter*. The correct display will freeze for 3 seconds, then advance to .2., indicating the meter is ready for the second buffer.
- Rinse electrodes and ATC probe and place in the second buffer and repeat as above.
- Wait for the pH value to stabilize. Press *enter*. The letters *pH* will be displayed. The meter is now calibrated and automatically advances to sample mode.
- Press *slope* and record this value in field logbook.

2.2 Measurement

- A beaker is triple-rinsed with de-ionized water and then triple-rinsed with the sample.
- The water sample is placed in a beaker.
- The pH electrode and temperature probe are rinsed with de-ionized water.
- The pH probe and temperature probe are completely immersed in the sample.
- The pH meter is turned on and pH control mode is switched to pH 0.1.
- Allow the display to stabilize for one minute and record measurement.
- Rinse probes with de-ionized water in preparation for next sample.
- Note and record the pH measurement on the sampling form or log.

Standard Operating Procedure No. 4

Surface Water Sampling

1.0 SAMPLE COLLECTION METHODS

1.1 Depth-Integrated Equal-Width Increment Method

A measuring tape will be extended across the channel and staked perpendicular to the direction of flow. Subsamples will be collected at a minimum of six equally spaced points across the channel. From each sampling point across the width of the channel, samples will be collected using a 1-gallon (analytical quality) plastic bottle and each subsample will be composited into a larger (analytical quality) plastic compositing jug. The collection and compositing bottles will be triple-rinsed with the water to be sampled prior to collection of the sample. The hand-held sample bottle will be lowered to the bottom and raised at a constant rate without overflowing to obtain a representative depth-integrated sample. A sufficient volume of water will be collected to meet the requirements for field and lab water quality testing. The following is a description of the USGS equal-width-increment method from the National Handbook of Recommended Methods for Water-Data Acquisition, 1977.

3.D.1.b.1.d.2.b. EWI method - In the EWI method (ETR method), depth integration is performed at a series of verticals in the flow section that are equally spaced across the transect to obtain a series of subsamples (ASCE, 1975, p. 335). Unlike the EDI method, however, the vertical transit rate used at each vertical is exactly the same as that used at every other vertical, and the subsamples are composited even though they are of different volumes. This procedure provides a transect sample whose concentration is discharge weighted both vertically and laterally and whose volume is proportional to the water discharge in the sampled zone. Because the transect sample is a composite, more than one vertical can be collected in a single sample container. An advantage of the EWI method is that a knowledge of the lateral distribution of discharge is not required. On the other hand (1) it is sometimes difficult to maintain the same vertical transit rate at all verticals, (2) more verticals must be sampled for a given accuracy than with the EDI method, and (3) wherever the flow is not essentially perpendicular to the transect, the width increment between sampling verticals must be adjusted by dividing it by the sine of the angle between the flow lines and the transect. Generally, 10 to 20 verticals will provide an accurate mean discharge-weighted concentration by the EWI method (Guy and Norman, 1970).

1.2 Depth-Integrated Equal-Discharge Increment Method

Prior to sample collection, discharge will be measured using the mid-section method as described in SOP No. 5. Upon completion of the measurement, the cross-sectional area will be divided into a series of lateral subsections, each with equal discharge. The measurements discerning the subsections will be noted on a discharge measurement form. Depth integration is then carried out at the half-way mark of each subsection. The same vertical transit rate is to be used for each subsection so that the sample volume of each subsection will be the same. The vertical transit rate will be measured with a stopwatch. Each subsection is to be sampled with a 1-gallon (analytical quality) plastic bottle and poured into a 2.5 gallon (analytical quality) plastic compositing jug. Prior to sampling, both containers will be triple-rinsed with the water to be sampled. The following is the description of the USGS equal-discharge-increment method from the National Handbook of Recommended Methods for Water-Data Acquisition, 1977.

3.D.1.b.1.d.2.a. EDI-Method - In the EDI method, the cross-sectional area is divided laterally into a series of subsections, each of which conveys the same water discharge (U.S. Inter-Agency Report, 1963). Depth integration is then carried out at the vertical in each subsection where half of the subsection discharge is on one side and half is on the other side. In each individual subsection, a vertical transit rate is used that will provide a sample volume for the vertical which is equal to the sample volumes for every other vertical. Thus, the procedure provides a group of subsamples that are the same size and that represent the same proportion of the total water discharge through the sampled zone. Such subsamples can be combined to provide a single composite sample. Alternatively, if the subsample volumes are different, the concentrations of all subsamples can be averaged to give the sample concentration. In either case, the concentration is discharge-weighted both vertically and laterally. Generally, if more than five verticals (more than five subsections) are sampled, an accurate mean discharge-weighted concentration will be obtained (Guy and Norman, 1970; Hubbell and others, 1956). The primary disadvantage of the EDI method is that the lateral distribution of water discharge must be known or measured each time prior to sampling.

1.3 Grab Sample

The sample will be collected using a hand-held plastic scoop or bottle, depending on the depth of water, and composited into a plastic container. Laboratory bottles will be filled from the plastic compositing container. All samples will be handled in accordance with SOP No. 1.

2.0 SAMPLE PROCESSING

All samples will be processed in the field as follows:

- Sample containers labels will be completed and affixed to the sample containers. The labels will contain information as discussed in SOP No. 1.
- The container with the composited sample will be shaken thoroughly.
- A beaker for measurement of pH will be filled from the sample container.
- Those bottles not requiring filtering will be filled directly from the sample composite container, and preservative added as appropriate.
- Analytes, which require filtering, will be processed in accordance to procedures in SOP No. 1. Preservatives are added to the sample bottles, as appropriate.
- The filled sample bottles are placed inside a cooler for storage (see SOP No. 1).
- Equipment will be wrapped and sealed in plastic as appropriate for storage and transport (see SOP No. 2).

Standard Operating Procedure No. 5

Flow Measurement

Flow is measured in the Eagle River, tributaries, seeps, and from controlled release points. This SOP provides nine methods of measuring flow dependent on the point where the flow is being measured and site conditions such as weather. These methods include:

- Wading method
- Six-tenths depth method
- Two-point method
- Suspension method
- Ice method
- Bucket and stopwatch method
- Portable flume
- Weirs
- Surface or floating stick method.

1.0 WADING METHOD

Cross sections at most gaging locations allow the safe access by wading for flows up to approximately 200 cfs. As a rule-of-thumb, if the depth times velocity is greater than 10, the stream is unsafe to enter. However, experience and proper judgment must be applied in all cases to provide a reasonable level of safety. Under no circumstances should a stream be entered if conditions are believed to be unsafe.

Two popular types of vertical-axis type current meters are available for measuring stream discharge by wading methods at the Site. Both AA and mini type vertical-axis current meters attach to a top-setting wading rod, which is 4 feet in length. Each revolution of the current meter bucket wheel creates a contact closure and sends a signal to a battery-operated headset, which generates an audible signal. Each click is counted and the total number of counts over a time interval of 40 seconds or greater is logged on a note sheet, which is later used to calculate velocity.

Current Meter	Rating Limits (ft/s)	Recommended Depth (ft)	Minimum Spin Test (seconds)	Velocity Equation
AA	0.1-20.0	> 1.5	> 90	r < 40 V = REV/TIME [2.18 + 0.02] r > 40 V = REV/TIME [2.17 + 0.03]
Mini	0.05-3.0	0.3-1.5	> 30	V = REV/TIME [0.977 + 0.028]

Where:

r = number of revolutions
V = velocity in feet per second

The following equipment is required to perform a discharge measurement by wading method:

- Current meter (AA or mini)
- Spare parts for current meters
- Wading rod (top-setting or standard)
- Headset with spare battery
- Measuring tape (100 feet length with 0.1 foot increments)
- Waders
- Current meter rating table for the meter used
- Discharge measurement form (copied on write-in-rain paper)
- Hand-held calculator
- Pencil or ball-point pen.

Following are general procedures for performing a discharge measurement by wading method.

1. Perform a spin test of the current meter to document the precision of the instrument (see minimum spin test time requirements).
2. Complete the following portions of the "front sheet" of a discharge measurement form: station ID, station description, date, cross section measurement location with respect to the gage or other landmark, observers initials, meter used, method used, weather conditions, stage height at beginning and end of measurement (if applicable).
3. Extend the measuring tape across the cross section to be measured and position the tape perpendicular to the primary flow thalweg. Cross section selection is very important. A good cross section can improve the accuracy of the discharge measurement substantially over a poor cross section. A different cross section

- can be utilized for a different flow condition. However, the same cross section should be utilized for the same flow condition in order to minimize variability between measurements. A professional hydrologist should select the appropriate cross section(s) for use under various flow conditions and this location(s) should be marked in the field so the hydrographer knows where to measure.
4. A reasonable number of partial sections (depth and velocity measurements) is 20 for most cross sections. The objective is to assure that no more than 10 percent of the total discharge is measured in any partial section. Research has shown that 20 "verticals" are typically required to maintain a reasonable level of accuracy. However, if the channel width is small and the distance between verticals is less than 0.3 feet using the mini meter or 0.5 feet using the AA-type meter, the number of partial sections should be reduced from 20.
 5. Measure the total width of the wetted portion of the channel cross-section and divide this value by 20. This will provide an estimate of the spacing of "verticals" required.
 6. Begin the measurement on the right bank (looking downstream).
 7. Record the time and stage height at the beginning of the measurement.
 8. Record the point measured on the tape that corresponds to the edge of water (zero depth).
 9. Use the 0.6-tenths depth method (depth from water surface) for depths less than or equal to 2.5 feet. Use the two-point method (0.2-tenths and 0.8-tenths depth from water surface) for depths greater than 2.5 feet.
 10. Take the first depth and velocity reading at the first location where depth and flow allow and record the results. Be sure the current meter is directed upstream towards the flow and that it is perpendicular to the measuring tape. Note any backwater or other abnormal flow conditions.
 11. Proceed with depth and velocity measurements at appropriately spaced verticals across the channel and record the results (see No. 4). Be sure the wading rod is held in a vertical position and that you are standing to the side and downstream from the current meter. All velocity measurements should be taken at the same approximate distance downstream from the measuring tape.
 12. Record the point measured on the tape that corresponds to the left edge of water (zero depth).

13. Record the time and the stage height at the end of the measurement.
14. Use the mid-section method to compute the discharge in the field and evaluate the result with respect to 1) the 10 percent accuracy criteria mentioned in No. 4 above, and 2) the discharge rating for the gage. Be sure to use the proper current meter rating for the current meter used.
15. Complete the cross section and flow characteristics, and any other pertinent information on a discharge measurement form.

The mid-section method of computing discharge will be used. The following is the description of the USGS mid-section method as described in the National Handbook of Recommended Methods for Water-Data Acquisition, 1977:

1.B.2.b.4.a. Mid-Section Method – The mid-section method of measurement assumes that the velocity sample at each depth sampling point represents the mean velocity in the partial rectangular cross-sectional area. The partial area extends laterally from half the distance from the preceding meter location to half the distance to the next, and vertically from the water surface to the sounded depth. The channel cross section is defined by depths at locations 1,2,3,4,...

2.0 SIX-TENTHS DEPTH METHOD

The six-tenths-depth method is used for velocity measurements whenever the depth of water is less than 2.5 feet. The following procedure will be used in the wading method to adjust the wading rod for placement of the current meter at 0.6 of the total depth below the surface:

1. Determine the depth of the water by direct reading from the graduated hexagon rod to the nearest 0.05 feet.
2. Set the number on the graduated vernier (the round aluminum rod), which is equal to the water depth in whole feet to correspond with the number on the handle, which is equal to the non-whole foot portion of the water depth in tenths of a foot.
3. Record the velocity measurement as described below.

The following is the description of the USGS six-tenths depth method as described in the National Handbook of Recommended Methods for Water-Data Acquisition, 1977:

1.B.2.c.1.b.1. Six-Tenths Depth Method – The six-tenths depth method (0.6 of the total depth below water surface) uses the observed velocity at this depth as the mean velocity in the vertical. This method gives extremely reliable results whenever the water depth is between 0.3 and 2.5 feet (.09 and 0.76 m), whenever the meter placement above a sounding weight makes it possible to obtain a 0.8 depth observation for the two-point method, whenever large amounts of slush ice or debris prevent observation of the 0.2 depth velocity for the two-point method, or whenever the stage or flow is changing rapidly and a measurement must be made quickly.

3.0 TWO-POINT METHOD

The two-point method is used for velocity measurements whenever the depth of water is greater than 2.5 feet. The following procedure will be used for the wading method to adjust the wading rod for placement of the current meter at 0.2 and 0.8 of the total depth below the water surface (see 0.6 method):

1. Determine the depth of the water by direct reading from the graduated hexagon rod.
2. Set the graduated vernier (the round aluminum rod) at one half the water depth to obtain the 0.8 depth measurement. The number on the vernier corresponds to the water depth in whole feet. This will be set to correspond to the numbers on the handle, which correspond to the non-whole foot portion of the water depth in tenths of a foot.
3. Record velocity measurement as described below.
4. Set the graduated vernier (the round aluminum rod) at twice the water depth to obtain the 0.2 depth measurement.
5. Record velocity measurement as described below.
6. The 0.8 and 0.2 velocity measurements will be averaged to determine the average velocity of the subsection for use in determination of discharge.

The following is the description of the USGS two-point method as described in the National Handbook of Recommended Methods for Water-Data Acquisition, 1977:

1.B.2.c.1.b.3. Two-Point Method – The two-point method (0.2 and 0.8 depth below the water surface) averages the velocities observed at these

relative depths at each location and this average is used as the same mean velocity in the vertical. Experience has shown that this method gives more consistent and accurate results than any of the other methods except the vertical-velocity curve method. The two-point method is generally not used at depths less than 2.5 feet (0.76 m) because the current meter settings would be too close to the water surface and stream bed for dependable results.

4.0 SUSPENSION METHOD

Suspension methods are typically used when the cross section is inaccessible due to excessive depth and streamflow. The principals of measuring discharge are the same for wading methods and suspension methods. The primary difference is the current meter is suspended from a cable with a sounding weight to hold the meter stationary for measurement. The type of suspension to be used at the Site is the bank-operated cableway at station E-12A. However, suspension from bridges may also be necessary.

The bank-operated cableway consists of a cable that extends across the channel and a mounting plate on one bank for the sounding reel. The mounting plate will accept an A-55 sounding reel. Sounding weights include 15 lb, 30 lb, 50 lb, or 75 lb units. The A-55 is designed for use with sounding weights up to 75 lbs. The AA current meter is designed for use with the A-55 sounding reel and headset.

The cross section at the cableway or bridge is fixed by the location. Therefore, correction factors must be applied for flows that are not perpendicular to the structure. The following procedure is deployed to measure discharge by suspension method.

1. Perform a spin test of the current meter to document the precision of the instrument (see minimum spin test time requirements).
2. Complete the following portions of the "front sheet" of a discharge measurement form: station ID, station description, date, cross section location with respect to the gage or other landmark, observers initials, meter used, method used, weather conditions, stage height at beginning and end of measurement.
3. Connect the end of the measuring tape to the traveler block directly above the current meter suspension cable and attach the current meter and sounding weight to the cable retainer.
4. The minimum number of partial sections (depth and velocity measurements) required is 20. The objective is to assure that no more than 10 percent of the total discharge is measured in one partial section. Research has shown that a

- minimum of 20 "verticals" is required to maintain a reasonable level of accuracy. Note: If the flow is changing rapidly, the number of partial sections can be reduced accordingly in an effort to complete the measurement during approximately the same stage/discharge conditions. This is a judgment that will be made by the hydrographer while the measurement is in progress.
5. Measure the total width of the wetted portion of the channel by traversing the cross section and divide this value by 20. This will determine the spacing of "verticals" or velocity and depth measurements required. The spacing can be reduced if the stage/discharge is changing rapidly to maintain a reasonable level of accuracy with the stage-discharge relationship.
 6. Begin the measurement on either bank, but preferably the right bank (looking downstream).
 7. Record the time and stage height at the beginning of the measurement.
 8. Record the point measured on the tape that corresponds to the edge of water (zero depth).
 9. Take the first depth and velocity reading at the first location where water is flowing at a depth adequate to submerge the meter, and record the results. Be sure the current meter is directed upstream towards the flow and that it is perpendicular to the cableway or bridge. Note any backwater or other unusual flow conditions.
 10. Center the "cups" or "propeller" of the current meter at the water surface, reset the depth counter to "zero", and lower the unit to take a depth sounding.
 11. Use the six-tenths depth method (depth from water surface) for depths less than or equal to 2.5 feet. Use the two-point method (two-tenths and eight-tenths depth from water surface) for depths greater than 2.5 feet. Note: During rapidly changing discharge conditions, the six-tenths method can be substituted for the two-point method at the hydrographer's discretion.
 12. Proceed with depth and velocity measurements at the pre-determined widths across the channel and record the results. Note: If the meter is not perpendicular to the cable or bridge, a horizontal velocity correction factor must be applied to the affected partial section before computing the measurement. These correction factors are printed on the outside edges of a discharge measurement form.

13. Record the point measured on the tape that corresponds to the opposite edge of water (zero depth).
14. Record the time and the stage height at the end of the measurement.
15. Use the mid-section method to compute the discharge in the field and evaluate the result with respect to 1) the 10 percent accuracy criteria mentioned in (4) above, and 2) the discharge rating for the gage. Be sure to use the proper current meter rating for the current meter used and to apply any necessary horizontal angle coefficients to the computation.
16. Complete the cross section, flow characteristic, and any other pertinent information on a discharge measurement form.

The following is the description of the USGS method of current-meter measurements made from cableways from the National Handbook of Recommended Methods for Water-Data Acquisition, 1977:

1.B.2.d.2.b. Cableway – Current-meter measurements made from cableways usually have the advantage of unobstructed flow and small, if any, horizontal angles. Two minor problems involved in cableway measurements are (1) possible oscillation of the car and cable and (2) the sag of the cable.

The cableway should be normal to the flow of the channel at higher stages, high enough (1) to permit operation of the cablecar above the elevation of maximum flood, (2) to clear water-borne traffic, and (3) to provide a high degree of safety to personnel in case of entanglement of suspended equipment with floating debris.

Measurement of total width and sounding locations is normally determined from markings painted at selected intervals along the cableway. Depth soundings are made using large sounding weights suspended from the cablecar. (See Buchanan and Somers, 1969). Tags or colored streamers placed on the sounding line at a known distance above the center of the meter facilitates the measurement of depth, eliminates possible air-line corrections (See 1.B.2.b.3.), facilitates setting the meter at the proper depth, and prevents meter damage caused by ice and debris or the meter freezing in cold air.

The Price-Type AA current meter is recommended for most discharge measurements from a cableway. Columbus or C-type sounding weights

are recommended (See Buchanan and Somers, 1969, p. 11) because of their streamline shape and minimum resistance to flow.

Correction for horizontal angles is made as recommended for wading measurements (see 1.B.2.d.2.a.). See 1.B.2.b.d. for recommended corrections for vertical angles in deep, swift streams.

5.0 ICE METHOD

The following is the description of the USGS method of current-meter measurements made through ice from the National Handbook of Recommended Methods for Water-Data Acquisition, 1977:

1.B.2.d.2.e. Under Ice Cover – Measurement of discharge under ice cover can be frustrating, uncomfortable, and dangerous, but often necessary for the continuity and computation of discharge records during winter periods.

Selection of possible cross sections for measurement under ice cover is accomplished during periods of open water in order to evaluate the channel conditions. Total width and sounding locations can be measured by using a tag line stretched over the ice surface. Cutting or drilling holes in the ice, location of the depth soundings (stationing), and measurement of the effective depth of flow under the ice (See fig. 1-5 and sec. 1.B.2.b.3.) are extremely critical to the overall quality of the measurement. The hydrographer must be sure that (1) the flow is well distributed in the cross section, (2) no anchor or slush ice is affecting the flow, (3) part of the cross section is not effectively blocked by slush or frazil ice, (4) an adequate number of sections are obtained, (5) the meter is not affected by vertical velocities in the cut holes, and (6) the meter is not affected by icing caused by intermittent exposures to freezing temperatures.

The velocity distribution under ice cover is similar to that in a pipe with a lower velocity near the underside of the ice and near the bed.

6.0 BUCKET AND STOPWATCH METHOD

This method will be used where channel geometry and flow rates allow a hand-held bucket to capture the entire streamflow over a time period of at least 5 seconds (approximately <0.1 cfs). The elapsed time to fill a measured volume is recorded and the flow rate computed. Measurements will be recorded in a field logbook.

Measurement accuracy is relatively high. The method requires a graduated bucket and stopwatch.

7.0 PORTABLE FLUME

If the geometry of the channel is adequate, the flow is less than about 1.0 cubic feet per second and/or the depth is less than about 0.5 feet, a portable cut-throat flume may be installed in the channel to measure flow. The flume will be leveled and the flow channelized through the throat of the flume. The water level on the flume staff will be recorded and the standard rating supplied with the flume will be used to calculate the discharge. Measurements will be recorded in a field logbook.

8.0 WEIRS

In some locations weirs have been installed to measure discharge. The water level on the weir staff will be recorded and the standard rating table supplied with the weir will be used to calculate discharge. Measurements will be recorded in a field logbook.

9.0 SURFACE OR FLOATING STICK METHOD

This method will be used in open channels to approximate streamflow where the bucket and stopwatch, portable flume, weir, wading, and suspension methods are not feasible. Under most conditions, the measurement error can be expected to range from about 10 to 25 percent (USGS 1977). A representative section of channel with relatively uniform flow is chosen. Water depth is measured at several points across the channel in addition to the channel width. The cross-sectional area is computed and an appropriate length of channel measured. A floating object (stick, float, etc.) is placed in the center of the channel and the elapsed travel time over a measured distance recorded. This should be repeated five times and an average travel time computed. Measurements will be recorded in a field logbook. The average velocity (distance/time) is multiplied by a constant of 0.85 to convert surface velocity to a mean velocity in the vertical (USGS 1977). Finally, discharge is computed using the $Q=AV$, where Q = discharge in cubic feet per second, A = cross sectional area, and V = velocity in feet per second.

Standard Operating Procedure No. 6

Groundwater Sampling

1.0 WATER-LEVEL MEASUREMENT

Water-level measurements will be referenced to a known elevation datum. The measuring point at the top of the casing is permanently marked and surveyed. Water-level measurements will be taken from the same marked point.

Water levels will be measured with an electrical sounding device. Water levels are measured by lowering the probe into the well until contact with the water surface is indicated. The electric tape is read at the reference measuring point to obtain the depth to water below the reference point. Measurements will be compared to historic water levels at this well or piezometer during the same time of year. If measurement appears in error, a second and third reading of water levels will be taken to verify the first reading. Measuring devices will be decontaminated prior to and after each measurement (see SOP No. 2).

2.0 SAMPLING PROCEDURES

The following procedures will be used in the collection of ground-water samples:

- Visually check the well for damage, etc.
- Prepare field record sheets and record relevant data.
- Place plastic sheeting around and adjacent to the well.
- Remove the well cap.
- Lay out equipment on plastic sheeting adjacent to sampling location to prevent direct contact with the ground surface.
- Measure and record depth to water and time of measurement.
- Calculate well volume based on well diameter and length of water column.
- Purge well by evacuating water as described below.

- Prepare sampling system. If well recovery is insufficient to meet the three well volume requirement, evacuate to dryness and allow well to recover. Bail water for samples while well is recovering and note total evacuated volume in field log (A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001, December 1987).
- Collect samples using equipment used to purge the well, the bailer or the pump hose.
- Filter (if required) and/or preserve the sample as per SOP No. 1.
- Fill necessary sample bottles.
- Label sample bottle with appropriate labels, being sure to provide required information. Complete Chain-of-Custody documents and field logbook.
- Place the properly labeled sample bottle in an appropriate carrying container on ice.
- Either discard or decontaminate all items which contact the sample such as bailers, pumps, cables, tubing, probes, gloves, and beakers before proceeding to the next sampling location.

2.1 Pre-sampling Procedures

Pre-sampling procedures include preparation of records and decontamination and calibration of equipment. In addition, the condition of the well should be examined for potential problems.

Prior to sampling, information on the site location, monitoring well design, condition, and sampling technique will be recorded on the sampling form or log.

All equipment should be assembled, calibrated, and tested prior to sampling. Items, which may come in contact with the sample, should be decontaminated according to the procedures discussed in SOP No. 2. Between sampling locations, all items, which have come in contact with the sample, will be either discarded or decontaminated.

Equipment will be placed on plastic sheeting to prevent contact with the ground surface. If a truck tailgate is used as an equipment bench, it should also be covered with plastic sheeting. Field instruments, buffer solutions, and sampling equipment should be kept out of direct sunlight to avoid temperature fluctuations. SOP Nos. 1 and 3 discuss field measurement equipment.

2.2 Well Evacuation

At least three well volumes of water will be evacuated from the well before sampling. Water levels and total depth of well will be measured at the well or piezometer prior to well evacuation to calculate well volume. If conditions permit (*i.e.*, the well is rapidly recharged), evacuation will continue until the well water temperature, pH, and specific conductance are stabilized, or until at least three well volumes are removed, whichever occurs first. Operation and calibration specifications for the pH and specific conductance meters are included in SOP No. 3. Wells will be evacuated using either a bailer or a pump.

2.2.1 Bailing

Bailer construction will consist of stainless steel, Teflon, or PVC material. Procedures are:

- Decontaminate equipment, record total depth and water level, and calculate the fluid volume in the well.
- Collect bailed water for monitoring of pH and conductivity.
- Evacuate the well.

2.2.2 Submersible Pump

Procedures for submersible pump use are:

- Decontaminate equipment, record total depth and water level, and calculate fluid volume in the casing.
- Lower pump below the water level and begin pumping. Lower pump intake as required to maintain submergence.
- Measure rate of pump discharge frequently using a bucket and stopwatch.
- Evacuate the well.

2.3 Procedures for Sample Withdrawal from Wells

Once the well has been purged, sampling will begin. If recovery is slow, it may be necessary to wait until sufficient volume is available for all the necessary analyses.

A new section of sampler cord or cable should be used at each monitoring well to minimize cross contamination, or equipment will be dedicated to individual wells.

Exposure of the water samples to the atmosphere or other gases may result in changes in the concentration of dissolved gases. These changes can alter the sample pH, which may result in the precipitation or dissolution of specific constituents, particularly metals. Similarly, changes in the redox potential and, consequently in the chemical species present, may result. Therefore, groundwater from the monitoring well will be collected, filtered immediately if required, and placed in appropriate sample bottles. The sample bottles will be placed in ice-filled coolers.

Appendix B

Quality Assurance Project Plan

1.0 INTRODUCTION

U.S. Environmental Protection Agency (EPA) policy requires environmental monitoring and measurement activities to be conducted in accordance with a quality assurance program. This requirement applies to all environmental monitoring and measurement efforts mandated or supported by EPA.

Data generated during environmental monitoring and measurement efforts must be valid (*i.e.*, supported by documented procedures), such that they can be used with confidence to support determinations regarding the need for and design of subsequent monitoring or the need for interim corrective measures. This Quality Assurance Project Plan (QAPP) presents the policies, organization, objectives, functional activities, and specific quality assurance (QA) and quality control (QC) activities designed to achieve the data quality goals of the specific activities not covered by previously approved Work Plans.

For the purpose of the project and this document, QA and QC are defined as follows:

- Quality Assurance - The program or structure used to define procedures for the evaluation and documentation of investigation functions (*e.g.*, sampling and laboratory methodologies) to provide a uniform basis for reporting and managing data and performing investigation functions.
- Quality Control - Tasks and procedures designed to provide measures of performance for analytical procedures, including accuracy and precision of data, and procedures for corrective action.

CBS Operations Inc. (CBS) and its contractors and subcontractors shall be responsible for performing environmental monitoring activities at the Eagle Mine Site (Site) in accordance with the requirements of the Consent Decree, Order, Judge and Reference to Special Master, Civil Action No. 83-C-2385, Remedial Action Plan (CD/RAP), as amended, and the Partial Consent Decree for Eagle Mine Operable Unit Number 1, Civil Action No. 95-N-2360 (D.Colo. June 12, 1996) (CD/SOW). Activities shall be conducted in accordance with approved work plans or sampling plans and this QAPP. This QAPP is a dynamic document that may be revised as the project progresses.

2.0 PROJECT DESCRIPTION

The Site is an abandoned metal mining and milling facility located along the Eagle River approximately five miles south of Minturn, Colorado. The Site is located in and around the areas of past mining activity between the towns of Red Cliff and Minturn. CBS is currently continuing to conduct environmental monitoring and remedial actions in accordance with the requirements of the CD/RAP, as amended, and CD/SOW.

This QAPP has been prepared to supplement and to be used in conjunction with future work plans and sampling and analysis plans for environmental monitoring activities. The requirements of this QAPP are not intended to supersede or supplement the requirements of any approved plan.

3.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

All project personnel are subject to the requirements of this QAPP. The responsibilities with respect to environmental monitoring of the project personnel are described in the following sections. One person can have the responsibilities of more than one of the following roles, with the exception of the Program Manger and Project QA Officer.

3.1 Program Manager

The Program Manager will assist CBS in negotiation efforts with EPA and CDPHE. The Program Manager will review all project deliverables with respect to compliance with all requirements of the CD/RAP and CD/SOW. Additional responsibilities for the Program Manager include the following:

- Review and approval of Work Plans, Sampling and Analysis Plans, and QAPP
- Obtain approval from CBS, EPA, and CDPHE for proposed changes to work plans or sampling plans and QAPP, which constitute major changes affecting the scope of the approved technical approach
- Assign duties to project staff and orient staff to the needs and requirements of the project, including all QA requirements
- Provide necessary training in project requirements for the project staff
- Provide sufficient resources to project team so it can respond adequately to the requirements of the project

- Review project deliverables for technical accuracy and completeness before their release
- Regularly communicate project status, progress, and any nonconformances or other problems to CBS and the Project Quality Assurance Officer
- Monitor compliance with the specific requirements of the Work Plans and QAPP.

3.2 Project Quality Assurance Officer

Responsibilities of the Project Quality Assurance Officer include:

- Develop the QAPP
- Identify and respond to QA/QC needs, assist in resolving quality problems, and respond to requests for QA/QC guidance or assistance
- Verify that appropriate corrective actions are taken for all QA/QC nonconformances
- Perform program QA audits and participate in project and site audits, when appropriate
- Provide for the performance of QA verification activities as requested by the Program Manager to verify compliance with the requirements and procedures contained in Work Plans and Sampling and Analysis Plans
- Provide other assistance requested by the Program Manager
- Provide for oversight of the contracted laboratory
- Provide for oversight of data validation efforts.

3.3 Site Safety Officer

The Site Safety Officer is responsible for ensuring that site personnel adhere to the site safety requirements. His/her responsibilities include:

- Supervise implementation of the site-specific Health and Safety Plan (HSP)
- Train new site personnel on site-specific health and safety items

- Interact with project personnel on health and safety matters
- Investigate and report accidents/incidents
- Maintain compliance with the site-specific HSP.

3.4 Monitoring Coordinator

The responsibilities of the Monitoring Coordinator include:

- Coordinate all Site monitoring activities with the Program Manager
- Review the Work Plans and Sampling and Analysis Plans for monitoring activities
- Assign duties to project staff and orient staff to the needs and requirements of monitoring activities
- Provide sufficient resources to project team so it can complete the monitoring activities
- Review monitoring deliverables for technical accuracy and completeness
- Regularly communicate monitoring activity status, progress, and any nonconformances or other problems to the Program Manager and Project Quality Assurance Officer
- Maintain compliance with the specific requirements of monitoring work or sampling plans.

4.0 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are established to promote collection of data that are sufficient and of adequate quality for their intended uses. Data will be obtained at the Site to meet the project objectives as outlined in approved monitoring documents.

Data quality will be assessed in terms of its precision, accuracy, representativeness, completeness, and comparability (PARCC). The PARCC objectives are defined in the following paragraphs. Acceptance limits for precision and accuracy are provided in Section 8.0.

Precision is the degree of reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a pair of

measurements compared to their average value, expressed as relative percent difference (RPD). The overall precision of a sampling event has a sampling and analytical component. Matrix spike duplicate (MSD), laboratory duplicate, and field duplicate data will be collected to evaluate sampling and analytical precision.

The RPDs of MSDs are a measure of precision for organic analyses. RPDs of laboratory duplicates are measures of precision for metals and inorganic, nonmetal analyses. MSD samples and laboratory duplicates will be analyzed for every batch of 20 samples or less. The RPDs of field duplicates are measures of combined sampling and analytical precision. Field duplicates will be collected at a 5 percent frequency.

RPD will be calculated according to the following equation, where A and B represent duplicate sample results:

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

Accuracy is a measure of bias in a measurement system. Sampling accuracy will be assessed by evaluating the results of field or rinsate blanks. Laboratory accuracy will be evaluated by comparing the analytical difference of measurements to reference values. Laboratory accuracy will be expressed as percent recovery (%R). The accuracy of data collected in support of the environmental monitoring activities will be assessed in the following manner:

- Calculation of the %R of matrix spikes (MSs), surrogates, and laboratory control samples (LCSs)
- Evaluation of the concentrations of target compounds present, if any, in blanks.

Percent recovery will be calculated according to the following calculations:

$$\text{For matrix spikes: \%R} = \frac{\text{Spiked Sample Result} - \text{Sample Result}}{\text{Spike Added}} \times 100$$

$$\text{For surrogates: \%R} = \frac{\text{Quantity Determined by Analysis}}{\text{Quantity Added to Sample}} \times 100$$

$$\text{For LCSs: \%R} = \frac{\text{Analyzed Value}}{\text{True Value}} \times 100$$

Representativeness indicates the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter which is most

concerned with the proper sampling program design. Analytical results obtained from duplicates, and individual and composite sample analyses, will be compared to assess representativeness.

Comparability is a qualitative parameter that indicates the confidence with which one data set can be compared to another. Comparability will be promoted by using approved sampling plans, standardizing analytical and field procedures, and reporting data in uniform units. Data will be grouped and evaluated according to sampling media and laboratory analytical methods.

Completeness is defined as the percentage of the total number of measurements judged to be acceptable for their intended use under normal conditions. Under normal sampling and analysis efforts, it is expected that a 90 percent completeness is realistic. For purposes of the environmental monitoring activities, the completeness goal will be to obtain a sufficient amount of valid data to address the objectives stated for the specific investigation and to reach the necessary conclusions. Data validators will assess completeness by calculating the percentage of valid data points compared to the total data set. A valid data point is a data point judged to be acceptable for its intended use.

5.0 SAMPLING PROCEDURES

The objectives of sampling procedures and field measurements are to obtain samples and measurements that represent the environment being investigated. Trace levels of contaminants from external sources must be eliminated through the use of experienced field personnel, good sampling techniques, proper sampling equipment, and adequate documentation.

Field measurements and sampling shall be performed in accordance with EPA-accepted procedures and are provided in the Standard Operating Procedures (SOPs) (see Appendix A of the report this QAPP as Appendix B is attached). Details of field measurements and sampling procedures will be described in monitoring documents and SOPs. Sample documentation, preservation, and labeling are described in detail in SOP No. 1.

The general QC objective is to ensure that data are not biased by contamination or sampling error. To meet this objective, the following QC samples will be collected in the field:

- Field duplicate samples will be collected at a 5 percent frequency annually in one of the sampling events (e.g., September) for each specific sample matrix. Duplicate samples will receive unique identification numbers so that the laboratory cannot associate them with their field sample counterparts. A record of the duplication will be made.

- Field blanks will be collected at a 5 percent frequency annually in one of the sampling events for sampling programs involving collection of liquid grab samples and will only be collected if rinsate blanks are not collected. Field blanks will consist of sample bottles filled at the sample collection location with de-ionized water provided by the laboratory. These samples will be used to evaluate potential contamination from sample containers and airborne contaminants.
- Rinsate blanks will be collected at a 5 percent frequency annually in one of the sampling events for sampling programs involving utilization of undedicated equipment (*i.e.*, bailers, peristaltic pumps, etc.). Rinsate blanks will consist of sample bottles which are filled with de-ionized water that is poured over or through the appropriate sampling devices after decontamination. Rinsate blanks will be used to detect any cross contamination from sampling equipment. These samples will be analyzed for the same parameters as their associated samples.

6.0 SAMPLE CUSTODY

The handling of all samples collected will be traceable from the time of collection, through analyses, until final disposition. Documentation of the sample history is referred to as chain-of-custody. The components of field chain-of-custody and procedures for their use are described in the following paragraphs.

A sample is considered to be under a person's custody if it is:

- In a person's physical possession
- In view of the person after he/she has taken possession
- Secured by that person so that no one can tamper with the sample
- In a secure area accessible only to authorized personnel.

At the time of sample collection, labels will be affixed to the sample containers. These labels will contain the following information:

- Sample identification number
- Date and time of sampling
- Preservative
- Filtered or unfiltered sample

- Parameter(s) to be analyzed
- Name or initials of sampler(s).

To establish the documentation necessary to trace sample possession from the time of collection, a chain-of-custody record must be completed and accompany every sample shipment. At a minimum, chain-of-custody records should contain the following information:

- Project name
- Sample identification
- Date and time of sample collection
- Type of matrix
- Number of containers
- Preservative
- Analyses requested
- Method of shipment
- Signature of sampler
- Date and time of each change in custody.

Each person who has custody of the samples must sign the record. The completed chain-of-custody record should be put in a waterproof plastic bag and placed inside the sample cooler. The sampler should keep a copy of each chain-of-custody record. Custody seals should be affixed to the front and back of the cooler and covered with clean tape.

The laboratory Sample Custodian will assess the integrity of the custody seals upon sample arrival. The Sample Custodian will also verify and document the following information upon sample receipt:

- Condition of shipping container
- Condition of sample container(s)
- Condition of custody seals

- Presence/absence of custody seals
- Presence/absence of custody records
- Presence/absence of airbill
- Presence/absence of sample labels
- Agreement/non-agreement of documents
- Cross-reference of laboratory numbers
- Temperature inside shipping container
- pH of water samples.

The Sample Custodian will document any problems or discrepancies with the samples or custody documents, contact the sampling organization, and document the resolution to the problems or discrepancies.

7.0 CALIBRATION PROCEDURES AND FREQUENCY

Field equipment used during sampling activities may include specific conductance/temperature meters, and pH meters. While on site, field personnel will maintain critical spare parts for all field equipment, such as batteries and probes. At a minimum, all field equipment used during environmental monitoring activities will be calibrated/standardized each morning, or prior to the day's sampling, according to the manufacturer's specifications. Field instruments will be calibrated/standardized with certified standards that, where applicable, bracket the measurements expected to be taken during the sampling effort. A recalibration will be performed when the accuracy of the equipment is suspect. If the manufacturer's specifications for calibration/standardization are not met, the field equipment will be taken out of service and new equipment will be obtained. Results of the calibrations/standardizations will be documented.

Laboratory calibration procedures and frequency are specified in Section 8.0.

8.0 LABORATORY ANALYTICAL PROTOCOLS

Laboratory analytical methods, target detection limits, calibration procedures and frequency, and criteria for laboratory QC samples are specified in the following sections. The analytical methods specified are based on current information on Site conditions

and are selected to meet the objectives of the environmental monitoring activities. In time, new considerations may need to be addressed and additional guidelines may be provided to maximize the quality and efficiency of the laboratory procedures. Any future changes in laboratory procedures will be included in revisions to this QAPP.

EPA approved methods will be used for all chemical analyses. Any omission in this QAPP of relevant requirements, tasks, and other items found in the referenced methods does not constitute a waiver of the omitted requirement, task, or item. The laboratory manager and analysts are expected to be cognizant of all relevant aspects of the referenced methods to the extent necessary to provide accurate, precise, and defensible data.

Laboratories will be subcontracted to perform sample analyses. CBS or its contractors will inform EPA and CDPHE in advance regarding which laboratories will be used and will ensure that EPA and CDPHE personnel have reasonable access to the laboratories and personnel used for analyses.

8.1 Laboratory Analytical Methods and Target Detection Limits

Analytical methods that may be used for environmental monitoring samples are listed in the monitoring plan. Analytical methods to be used for chemical analyses are fully described in *Test Methods for Evaluating Solid Waste (SW-846)*, and *Methods for Chemical Analysis of Water and Wastes* (EPA 1983, 1994). If methods other than those specified in the monitoring plan are used, they will be submitted to CDPHE and EPA for approval prior to performing analyses.

Target detection limits are also listed in the monitoring plan for the required analyses. Laboratories used for sample analyses will be required to demonstrate and document the ability to meet these target detection limits.

8.2 Calibration Procedures and Frequency

Laboratory instruments will be calibrated in accordance with the guidelines specified in the methods. General laboratory guidelines and a description of the procedures and their frequency for inorganic analyses are summarized below.

Instruments used for metals analyses will be calibrated each time the instruments are set up. The inductively coupled plasma (ICP) instrument will be calibrated according to the manufacturer's recommended procedures using mixed calibration standards containing all analytes of interest. Immediately after the system is calibrated, the highest mixed calibration standard will be re-analyzed. If the concentration values obtained deviate from the actual values by more than 5 percent, recalibration is required.

The calibration will be verified every 10 samples and at the end of the analytical run using a calibration blank and a single point check standard. If the results of the check standard are not within 10 percent (5 percent for Method 200.7/200.8) of the expected value, the analysis will be terminated and the instrument recalibrated. If recalibration is required, all samples analyzed after the last acceptable check standard should be re-analyzed.

Mercury will be analyzed by cold vapor atomic absorption (CVAA). For CVAA analyses, a calibration curve will be prepared each day with a minimum of a reagent blank and three standards. The established calibration curve will have a correlation coefficient greater than or equal to 0.995. The calibration curve will be verified every 10 samples (15 samples for mercury) by analyzing a standard at or near the midrange. If the analyzed concentration of the check standard is not within 20 percent of the true value, the run will be terminated, a new calibration curve generated, and all samples analyzed after the last acceptable check standard will be re-analyzed.

Instruments used for the analyses of nonmetal parameters will be calibrated in accordance with the instrument manufacturer's specifications and the method used. Control limits for acceptable instrument calibration will be those specified by the methods, or determined by the laboratory, whichever is more stringent.

8.3 Laboratory Quality Control Samples

QC samples that will routinely be analyzed in the laboratory include MSs/MSDs, surrogates, method blanks, duplicates, and LCSs. Established acceptance criteria for these samples, described in the following subsections, will be used to assess the acceptability of the data. The calculations to be used during this assessment are presented in Section 4.0.

8.3.1 Matrix Spikes/Matrix Spike Duplicates

An MS is an environmental sample to which predetermined quantities of stock solutions of certain analytes are added (spiked) prior to sample extraction/digestion. Samples are split to form MSs and MSDs. The percent recoveries of the spiked compounds will be calculated to assess analytical accuracy. The RPD between the MS and MSD will be calculated to assess analytical precision. An MS/MSD will be analyzed with each batch of samples analyzed for PCBs. A batch of samples is defined as 20 samples or less. Control limits for MS/MSD recoveries and RPDs for method 8080 will be determined by the laboratory. Control limits for MS recovery for metals will be 75 to 125 percent recovery. Control limits for MS recovery for non-metals will be determined by the laboratory.

8.3.2 Surrogates

Surrogates are organic compounds which are similar to analytes of interest in chemical composition and chromatography, but which are not expected to be present in environmental samples. To evaluate laboratory performance on individual samples, all samples analyzed for organic compounds will be spiked with method-specified surrogate compounds prior to preparation. Control limits for surrogate recovery will be determined by the laboratory.

8.3.3 Method Blanks

A method blank consists of laboratory-grade pure water containing all of the reagents utilized in the analytical procedure. A method blank is prepared in the same manner as a sample and is processed through all of the analytical steps, including sample preparation. Method blanks will be analyzed to determine whether there is glassware, reagent, instrument, or laboratory contamination. Method blanks will be analyzed for each batch of samples.

No contaminants should be present in the method blanks above the detection limits. Sample results greater than the detection limits, but less than five times the concentration in a method blank, will be flagged as potentially biased by the data users.

8.3.4 Laboratory Duplicates

Laboratory duplicates are splits of environmental samples. For inorganic analyses, duplicates are indicators of laboratory precision based on each sample matrix. For metals, a control limit of 20 percent will be used for the RPD between duplicate water results greater than five times the EPA CLP CRDL. A control limit of 20 percent will also be used for inorganic nonmetal results greater than five times the method detection limit (MDL). A control limit of 35 percent will be used for the RPD between duplicate soil/solid results greater than five times the EPA CLP CRDL. A control limit of \pm the MDL or CLP CRDL will be used for duplicate water results and \pm 2 times the CLP CRDL or MDL will be used for soil/solid sample results less than five times the CLP CRDL or MDL, including the case when only one of the duplicate results is less than the CRDL or MDL. Laboratory duplicates will be analyzed for every batch of samples.

8.3.5 Laboratory Control Samples

Laboratory control samples are an interference-free matrix with known quantities of target analytes. Laboratory control samples serve as monitors of the overall performance of all steps in the analytical process, including sample preparation. Control limits for metals of 80 to 120 percent recovery will be used for all aqueous LCSs.

Control limits for nonmetals will be those provided by the source of the LCS or 80 to 120, whichever is appropriate. Control limits for solid LCSs will be those provided by the source. Laboratory control samples will be analyzed for every batch of samples.

9.0 DATA VALIDATION, REDUCTION, AND REPORTING

9.1 Data Validation

Data validation for a sampling effort involves an examination of all documentation for field QC and analytical method QC elements to ensure that all requirements have been met. Field and laboratory documentation will be verified by CBS, its contractors, or subcontractors by examining all field documents, chain-of-custody forms, etc. Laboratory data packages will be reviewed by CBS, its contractors, or subcontractors for submission of all documentation required to assess QC elements contained in the analytical methods and EPA guidelines for CLP data review, where appropriate. Laboratory data will also be assessed relative to the project-specific DQOs. The review of laboratory data will include, but will not necessarily be limited to, the following:

- Overview of the data package for inclusion of all appropriate raw data.
- Calculation of holding times for all analytes.
- Checking transcriptions and calculations with raw data documentation.
- Evaluating all QC samples for required frequency of analysis and required control limits.

During data review, EPA CLP data review guidelines will be used, where appropriate, for qualifying data. Sample results may be qualified as estimates or rejected if the QC criteria specified in Section 8.0 and in the EPA guidelines are not met. The purpose of the qualification is to alert the data users that biases may potentially be associated with the data. Data that have been qualified as estimated are usable for their intended purposes.

9.2 Data Reduction

Reduction of laboratory data and laboratory reporting of analytical parameters will be in accordance with the procedures specified for each analytical method. The calculation of one randomly selected result will be recalculated during the data validation process. If laboratory calculations are in error, the data reviewers will continue to recalculate results

until they are satisfied that the error is an isolated occurrence or if the data package should be returned to the laboratory for corrective action.

9.3 Final Reporting and Report Archival

Upon successful completion of the data validation process, analytical results will be entered into a computerized data management system. Hard copies of the data will be maintained for a period of three years and then will be turned over to CBS. Sample results will be reported to EPA and CDPHE annually.

10.0 INTERNAL QUALITY CONTROL CHECKS

Internal QC checks are all specific QC activities related to both field and laboratory efforts.

Internal QC checks for field efforts are described in Section 5.0. Internal QC checks for laboratory activities are specified in Section 8.0.

11.0 SYSTEM AND PERFORMANCE AUDITS

A system audit consists of evaluating all components of the measurement systems to determine their proper selection and use. This type of audit includes a careful evaluation of both field and laboratory QC procedures. System audits may be performed at any time during environmental monitoring activities to determine whether the QC procedures contained in this QAPP are being followed and, if they are, whether the QC procedures are adequate.

Performance audits are conducted to assess the accuracy of total measurement systems or component parts thereof. Performance audits may be conducted periodically during environmental monitoring activities.

The subcontract laboratory may be audited at any time. This audit will include a review of actual and written laboratory procedures. During this audit, auditors will verify that the laboratory's QA Officer has performed adequate internal audits of performance.

CBS, EPA, and CDPHE, or their designees have authority to conduct system, performance, and laboratory audits.

12.0 PREVENTIVE MAINTENANCE

Preventive maintenance of all laboratory equipment is essential to ensure the quality and efficiency of the analytical data produced. The laboratory selected to perform analyses will maintain service contracts for all major instruments to be used for the project. All instruments will receive routine preventive maintenance, which will be recorded in instrument-specific maintenance logs. Expendable items for all major instruments will be kept on hand to minimize downtime.

13.0 DATA ASSESSMENT PROCEDURES

Data assessment is the determination of data usability (e.g., screening only, human health risk, etc.) in terms of the project-specific DQOs and is part of the data validation process. When appropriate, data reviewers will prepare data assessment reports that explain data quality issues, taking into account potential biases, matrix effects, and predetermined DQOs.

14.0 CORRECTIVE ACTION PROCEDURES

Laboratory nonconformances are defined as any analytical procedure that deviates from standard protocol, or those data associated with QC samples that fail to meet acceptance criteria. Data reporting errors are also considered nonconformances. Laboratories typically use QC charts to assist in identifying nonconformances.

If, as a result of audits or QC sample analyses, analytical systems prove to be unsatisfactory, corrective action will be implemented. For immediate or long-term corrective actions, steps comprising a closed-loop corrective action system area as follows.

1. Define the problem.
2. Assign responsibilities for problem investigation.
3. Investigate and determine the cause of the problem.
 - a. Check all calculations.
 - b. Re-analyze the sample.
 - c. Verify the integrity of the standards, spiking solution, laboratory control sample, or calibration sample.
 - d. Check instrument operating conditions to preclude the possibility of malfunctions or operator error.

4. Determine the corrective action(s) necessary to eliminate the problem.
5. Assign and accept responsibilities for implementing the corrective action.
6. Evaluate the effectiveness of the corrective action and implement the corrective action.
7. Verify and document that the corrective action has eliminated the problem.

Depending upon the nature of the problem, the corrective action implemented may be formal or informal. In either case, occurrence of the problem, the corrective action employed, and verification that the problem has been eliminated must be documented.

15.0 QUALITY ASSURANCE REPORTS

QA reports are not required by the CD/SOW. QA reports can be prepared, when appropriate, as discussed in Section 13.0.

16.0 REFERENCES

U.S. Environmental Protection Agency (USEPA), 1983. *EPA Methods for Chemical Analysis of Water and Wastes (MCAWW)*

USEPA, 1986a. *Test Methods for Evaluation of Solid Wastes, Physical/Chemical Methods*, 1986. SW-846, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, as amended.

USEPA, 1986b. *National Enforcement Investigations Center (NEIC) Policies and Procedures*, 1986. EPA-330/9-78-001-R, U.S. Environmental Protection Agency, Office of Enforcement and Compliance Monitoring, May 1978 (Revised May 1986).

USEPA, 1994. *Methods for Chemical Analysis of Water and Wastes*. EPA-600/4-79-020, U.S. Environmental Protection Agency.

EPA, 2002. EPA Guidance for Quality Assurance Project Plans (QA-G-5). USEPA Office of Environmental Information; EPA/240/R-02/009. December 2002.

USEPA, 2004. National Functional Guidelines for Inorganic Data Review. October 2004.

USEPA, 2006a. EPA Requirements for Quality Assurance Project Plans (QA- R5). USEPA Office of Environmental Information; EPA/240/B-01/003. May 2006.

USEPA, 2006b. Guidance on Systematic Planning Using the Data Quality Objectives Process (QA/G4). USEPA Office of Environmental Information; EPA/240/B-06/001. February 2006. U.S. Environmental Protection Agency (EPA), 2007. CLP Statement of Work Method CLP ILM05.4

USEPA, 2010. U.S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review. EPA/540/R-10-011. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. January 2010.