*Final*

# Quality Assurance Project Plan
# Faro Mine Remediation Project

Prepared for

**Government of Canada
as represented by Aboriginal Affairs and
Northern Development Canada and the
Government of Yukon**

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# Acronyms and Abbreviations

| | |
|---|---|
| %R | percent recovery |
| °C | degrees Celsius |
| µg/L | micrograms per litre |
| µm | micrometre |
| AANDC | Aboriginal Affairs and Northern Development Canada |
| ASTM | ASTM International (formerly American Society for Testing and Materials) |
| BC MOE | British Columbia Ministry of the Environment |
| CALA | Canadian Association for Laboratory Accreditation |
| CH2M HILL | CH2M HILL Canada Limited |
| CL | control limit |
| COC | chain-of-custody |
| DQO | data quality objective |
| EPA | U.S. Environmental Protection Agency |
| g | gram |
| $H_2SO_4$ | sulphuric acid |
| HCl | hydrochloric acid |
| $HNO_3$ | nitric acid |
| ICP | inductively coupled plasma |
| LCL | lower confidence limit |
| LCS | laboratory control sample |
| MB | method blank |
| MDL | method detection limit |
| mg/kg | milligrams per kilogram |
| mg/L | milligrams per litre |
| ml | millilitre |
| MS | matrix spike |
| NaOH | sodium hydroxide |
| PARCCS | precision, accuracy, representativeness, comparability, completeness, and sensitivity |
| PE | performance evaluation |
| QA | quality assurance |
| QAPP | Quality Assurance Project Plan |
| QC | quality control |
| RPD | relative percent difference |

| | |
|---|---|
| SOP | standard operating procedure |
| SPLP | Synthetic Precipitation Leaching Procedure |
| TAT | turnaround time |
| UCL | upper confidence limit |

SECTION 1

# Project Description

## 1.1 Introduction

CH2M HILL Canada Limited (CH2M HILL) has been contracted by the Government of Canada as represented by Aboriginal Affairs and Northern Development Canada and the Government of Yukon to conduct a design investigation at the Faro Mine Complex in the Yukon Territory, Canada.

This Quality Assurance Project Plan (QAPP) presents the quality assurance (QA) and quality control (QC) requirements designed to confirm that environmental data collected will be of the appropriate quality to achieve the project objectives.

The QAPP is intended for use by all contractors and subcontractors that provide services associated with the environmental data collection effort. This QAPP supplements the work plans and any other site-specific documents. Although the QAPP attempts to cover the data collection effort, it may not address future changes in sampling and analytical needs. If the need for such changes arises, the QAPP and the relevant site-specific documents will be updated and submitted to the regulatory agencies charged with project oversight for approval.

## 1.2 Task Description

The objectives of the investigation activities are discussed in the individual field sampling plans.

## 1.3 Analytical Data Quality Objectives

Analytical data quality objectives (DQO) were developed by comparing laboratory method detection limits (MDL) against the lowest screening criteria available for each analyte and matrix. Tables 5-1 through 5-3 list the methods to be used, the lowest laboratory MDL available for that analyte, the screening-level objectives, and the source of the screening-level objective. The screening-level objectives were chosen by selecting the lowest of the British Columbia Ministry of the Environment (BC MOE) and the Canadian Council of Ministers of the Environment (CCME) Guidelines.

**SECTION 2**

# Laboratory Certification Requirements

All laboratories providing analytical services will hold current Canadian Association for Laboratory Accreditation (CALA) certification for the analytical methods listed in this QAPP for which CALA certification is available. The laboratory managers will be responsible for ensuring that all personnel have been properly trained and are qualified to perform their assigned tasks.

SECTION 3

# Field Quality Control Samples

## 3.1 Quality Control Samples

QC samples will be collected to monitor accuracy, precision, and the presence of field contamination for definitive analytical methods to be performed by the contracted laboratories. They will be labelled similar to regular field samples. The frequency of QC samples is described in the following QC-specific section and will be monitored by the field crew by use of field logbooks and by the chemistry team by use of a sample tracking database.

QC samples will not be required for the geotechnical methods listed in Table 4-4.

Data will be flagged in accordance with Table 7-1 when the criteria are exceeded for the QC samples described in this section. Potential bias of sample results and impacts to data usability will be discussed in the data quality report described in Section 12.1.

### 3.1.1 Field Duplicate Samples

A field duplicate is an independent sample collected as close as possible to the original sample from the same source under identical conditions and is used to document sampling and analytical precision. Field duplicates will be collected at a minimum frequency of 10 percent for each matrix and for each type of analysis and will be sent double blind to the laboratory along with regular field samples. The sampling locations for field duplicate samples will be recorded in the field logbook. Field duplicate precision criteria are 30 percent for aqueous samples and 50 percent for soil, sediment, and tissue samples.

### 3.1.2 Equipment Rinsate Blanks

Equipment rinsate blanks will be collected to evaluate field sampling and decontamination procedures by pouring deionized (DI) water over the decontaminated equipment. Equipment rinsate blanks will be collected at a 5 percent frequency per matrix/method/sampling crew each day that sampling equipment is decontaminated in the field. The equipment blanks will be analyzed for the same parameters specified for the corresponding matrix.

If the equipment rinsate blanks exhibit excessive contamination, the field crew will be instructed to evaluate decontamination procedures and also to investigate the source of the rinsate blank water.

### 3.1.3 Trip Blanks

Trip blanks are used to monitor for contamination during sample shipping and handling, and for cross-contamination through volatile component migration among the collected samples. These blanks are prepared in the laboratory by pouring organic-free water into a volatile component sample container. The containers are then sealed, transported to the field, stay sealed while volatile component samples are taken, and transported back to the laboratory in the same cooler as the volatile component samples. One trip blank should accompany each volatile component sample cooler.

If the trip blanks exhibit excessive contamination, the field crew will be instructed to evaluate sample collection and shipping and handling procedures. The laboratory will also be instructed to investigate the source of the trip blank water and their trip blank preparation procedures.

## 3.2 Sample Documentation and Tracking

Sample containers should be received from the laboratory pre-labelled with the analysis designation. The laboratory will also provide the required preservatives Site- and time-dependent information will be added to the labels with indelible ink. The labels will be protected from water and solvents with clear, label-protection tape. Each label will contain the following information:

- Project name
- Name of collector

- Date and time of collection
- Place of collection
- Sample number
- Preservation
- Method of analysis

Sample identification and tracking procedures will incorporate the sample numbering system outlined in standard operating procedure (SOP) *Faro Mine Remediation, Standard Operating Procedure SMP011, Sample Nomenclature*. Field duplicate samples will be labelled and numbered so that the laboratory cannot distinguish them from other site samples.

SECTION 4

# Sample Handling and Custody Requirements

## 4.1 Containers and Preservatives

Laboratories will provide the required sample containers for all analytical samples. All containers will have been cleaned and certified to be free of the analytes of concern for the project. No sample containers will be reused. Preservatives, if required, will be provided by the laboratories and added to the sample containers in the field. The adequacy of preservation will be verified by the laboratory upon receipt of the samples, and additional preservative will be added, if necessary.

The containers, minimum sample quantities, required preservatives, and maximum holding times for the methods required for this project are shown in Tables 4-1 through 4-4.

TABLE 4-1
**Sample Collection Summary – Soil/Sediment**
*Faro Mine Remediation Project*

| Parameter | Analytical Method | Container | Preservative | Maximum Holding Times |
|---|---|---|---|---|
| 1N, pH 7.0 $NH_4OAc$ Extractable Ca, Mg, K, Na | CSSS (2008) 18.4 | One 125-ml (4-ounce), glass | Less than 6°C | None |
| 2N KCl extraction Ammonium and Nitrate | CSSS (2008) 6.2 | One 125-ml (4-ounce), glass | Less than 6°C | None |
| Neutralization potential | Modified Sobek | One 125 ml (4-ounce), glass | Less than 6°C | None |
| 1:2 $CaCl_2$ pH | CSSS 16.3 (2008) | One 125-ml (4-ounce), glass | Less than 6°C | None |
| Available Phosphorous (for pH<7.2) | SSSA (1996) P 894–895 | One 125-ml (4-ounce), glass | Less than 6°C | None |
| Available Phosphorous (for pH>7.2) | CSSS (2008) 7.2 and 7.3.1 | One 125-ml (4-ounce), glass | Less than 6°C | None |
| $Ca(H_2PO_4)2.H_2O$ extractable $SO_4$-S | S-11.10 in Gavlak et al. (2005) | One 125-ml (4-ounce), glass | Less than 6°C | None |
| DTPA Extractable Micronutrients (Zn, Fe, Cu, Mn) | CSSS (2008) 11.3 and 11.4 | One 125-ml (4-ounce), glass | Less than 6°C | None |
| Modified EPA 1312 SPLP using sulphuric acid at pH 5, 4, and 3 as extractant | SW1312/SW6010B | One 125-ml (4-ounce), glass | Less than 6°C | None |
| Modified Sequential Extractions | Modified Sequential Extractions in accordance with Attachment A/ SW6010B/SW6020A | One 125-ml (4-ounce), glass | Less than 6°C | None |
| Total Organic Carbon | SSSA 1996 P 995–996 | One 125-ml (4-ounce), glass | Less than 6°C | 28 days to analysis |
| Paste pH | CARTER-CSSS/APHA 4500H | One 125-ml (4-ounce), glass | Less than 6°C | 28 days to analysis |

TABLE 4-1
**Sample Collection Summary – Soil/Sediment**
*Faro Mine Remediation Project*

| Parameter | Analytical Method | Container | Preservative | Maximum Holding Times |
|---|---|---|---|---|
| Petroleum Hydrocarbons-Diesel and Motor Oil Range | BCMELP CSR | One 125-ml (4-ounce), glass | Less than 6°C | 14 days to extraction; 40 days to analysis |
| Petroleum Hydrocarbons-Gasoline Range | BCMELP CSR | One 125-ml (4-ounce), glass | Methanol, Less than 6°C | 7 days to extraction; 40 days to analysis |
| 1:1 Paste pH | Sobek et al. (1978) | One 125-ml (4-ounce), glass | Less than 6°C | 28 days to analysis |
| Soluble Salts | CSSS (2008) 15.3 | One 125-ml (4-ounce), glass | Less than 6°C | 28 days to analysis |
| Electrical Conductivity of Saturation Paste | CSSS (2008) 15.2.1 | One 125-ml (4-ounce), glass | Less than 6°C | 28 days to analysis |
| Sodium Absorption Ratio | CSSS (2008) 15.3.2, 14.4.4 | One 125-ml (4-ounce), glass | Less than 6°C | 28 days to analysis |
| Calcium Carbonate Equivalent | CSSS (2008) 20.3 | One 125-ml (4-ounce), glass | Less than 6°C | 28 days to analysis |
| SMP Buffer pH | CSSS (2008) 12.2 | One 125-ml (4-ounce), glass | Less than 6°C | 28 days to analysis |
| Sulphide-S | ALS SOP VA-TM-1020/APHA 4500S2 | One 125-ml (4-ounce), glass | Less than 6°C | 7 days to analysis |
| Total Inorganic Carbon | SSSA (1996) P 455-456 | One 125-ml (4-ounce), glass | Less than 6°C | 28 days to analysis |
| Total Metals | EPA 200.2/EPA 245.7/SW6020A | One 125-ml (4-ounce), glass | None | 180 days; 28 days for mercury |
| Total Nitrogen | SSSA (1996) P 973-974 | One 125-ml (4-ounce), glass | Less than 6°C | 28 days to analysis |
| Total Phosphorous | EPA 200.2/SW6020A | One 125-ml (4-ounce), glass | Less than 6°C | 28 days to analysis |
| Total Sulphur | ISO 15178:2000 | One 125-ml (4-ounce), glass | Less than 6°C | None |
| 96-hour DI Water Leachate/Metals | DI Leach/SW6020A | One 125-ml (4-ounce), glass | Less than 6°C | 14 days to leach/180 days to analysis |
| 96-hour DI Water Leachate/pH | DI Leach/APHA 4500-H | One 125-ml (4-ounce), glass | Less than 6°C | 14 days to leach/15 minutes to analysis |
| 96-hour DI Water Leachate/Oxidation-Reduction Potential | DI Leach/ASTM D1498-00 | One 125-ml (4-ounce), glass | Less than 6°C | 14 days to leach/immediate analysis |

TABLE 4-1
**Sample Collection Summary – Soil/Sediment**
*Faro Mine Remediation Project*

| Parameter | Analytical Method | Container | Preservative | Maximum Holding Times |
|---|---|---|---|---|
| 96-hour DI Water Leachate/Conductivity | DI Leach/APHA 2510 | One 125-ml (4-ounce), glass | Less than 6°C | 14 days to leach/28 days to analysis |
| 96-hour DI Water Leachate/Alkalinity | DI Leach/SM2320B | One 125-ml (4-ounce), glass | Less than 6°C | 14 days to leach/14 days to analysis |
| 96-hour DI Water Leachate/Acidity | DI Leach/SM2310 | One 125-ml (4-ounce), glass | Less than 6°C | 14 days to leach/14 days to analysis |
| 96-hour DI Water Leachate/Sulfate | DI Leach/E300.0 | One 125-ml (4-ounce), glass | Less than 6°C | 14 days to leach/28 days to analysis |
| Acid Soluble Sulfate | EPA 600/2-78-054 | One 125-ml (4-ounce), glass | Less than 6°C | None |
| Soil Waste Characterization Curve on DI Leach | ASTM D6836 | One 125-ml (4-ounce), glass | Less than 6°C | None |
| Barium | SW6020A – Lithium Metaborate Fusion | One 125-ml (4-ounce), glass | Less than 6°C | None |

Notes:

AOAC = Association of Analytical Communities
APHA = American Public Health Association
ASTM = ASTM International (formerly American Society for Testing and Materials)
BCMELP CSR = British Columbia Environmental Laboratory Manual
$^{o}C$ = degrees Celsius
COMM SOIL SCI = Communications in Soil Science and Plant Analysis
CSSS = Canadian Society of Soil Science
ml = millilitre
NCR = Recommended Soil Test Procedures for the North Central Region
EPA = U.S. Environmental Protection Agency
EPA 1312 SPLP = Synthetic Precipitation Leaching Procedure
SSSA = Soil Science Society of America

TABLE 4-2
**Sample Collection Summary – Aqueous/Liquid**
*Faro Mine Remediation Project*

| Parameter | Analytical Method | Container | Preservative | Maximum Holding Times |
|---|---|---|---|---|
| Acidity | SM2310 | 500-ml polyethylene | Less than 6°C | 14 days to analysis |
| Acidity – Hot Peroxide | SM2310 (Hot Peroxide for some samples) | 500-ml polyethylene | Less than 6°C | 14 days to analysis |
| Dissolved Metals | SW6010B/SW6020A/SW7470A/EPA 245.7 | 500-ml polyethylene | filtered through a 0.45 -µm membrane upon collection; $HNO_3$ to pH<2 | 180 days to analysis; 28 days for mercury |
| Alkalinity | SM2320B | 500-ml polyethylene | Less than 6°C | 14 days to analysis |
| Anions ($SO_4$, $Cl^-$, $F^-$, $NO_3^-$, $NO_2^-$, $PO_4$) | EPA 300.0/SM4110B/SW4500P | 500-ml polyethylene | Less than 6°C | 28 days to analysis, 3 days for $NO_3^-$, $NO_2^-$ |
| Reactive Phosphorous (orthophosphate) | EPA 300.0/SM4110B/SM4500P | 250-ml polyethylene | Less than 6°C | 3 days to analysis |
| Free Cyanide | ASTM 7237 | 500-ml polyethylene | NaOH to pH>12 | 14 days to analysis |
| Weak Acid Dissociable Cyanide | APHA 4500-CN I | 500-ml polyethylene | NaOH to pH>12 | 14 days to analysis |
| Total Cyanide | ISO 14403:2002 | 500-ml polyethylene | NaOH to pH>12 | 14 days to analysis |
| Ferrous Iron | Ferrozine Method | 250-ml acid-washed opaque plastic | filtered through a 0.1 -µm tortuous-path membrane upon collection; HCl to pH<2; Less than 6°C | 180 days to analysis |
| Ammonia | JEM (2005) 7, 37-42/SM4500N-Org | 250-ml polyethylene | $H_2SO_4$ to pH<2; Less than 6°C | 28 days to analysis |
| Dissolved Organic Carbon | SM5310 | 125-ml glass or 2x40-ml vials | filtered through a 0.45 µm membrane upon collection; $H_2SO_4$ to pH<2; Less than 6°C | 28 days to analysis |
| Total Organic Carbon | SM5310C | 125-ml glass or 2x40-ml vials | $H_2SO_4$ to pH<2; Less than 6°C | 28 days to analysis |
| Dissolved Inorganic Carbon | SM5310 | 125-ml glass or 2x40-ml vials | filtered through a 0.45 µm membrane upon collection; Less than 6°C | 14 days to analysis |
| Total Inorganic Carbon | SM5310C | 125-ml glass or 2x40-ml vials | Less than 6°C | 14 days to analysis |
| Total Dissolved Solids | SM2540C | 250-ml polyethylene | Less than 6°C | 7 days to analysis |

TABLE 4-2
**Sample Collection Summary – Aqueous/Liquid**
*Faro Mine Remediation Project*

| Parameter | Analytical Method | Container | Preservative | Maximum Holding Times |
|---|---|---|---|---|
| Totals Suspended Solids | SM2540D | 250-ml polyethylene | Less than 6°C | 7 days to analysis |
| Hardness | SM2340B | 500-ml polyethylene | HNO3 to pH<2 | 180 days to analysis |
| Lime demand and solids formed | Lime demand and solids formed SOP | 500-ml polyethylene | Less than 6°C | None |
| Petroleum Hydrocarbons-Diesel and Motor Oil Range | BCMELP CSR | Three, 40-ml VOA vials | HCl to pH<2; Less than 6°C | 14 days to analysis |
| Petroleum Hydrocarbons-Gasoline Range | BCMELP CSR | Two, 1-L amber glass | Less than 6°C | 7 days to extraction; 40 days to analysis |
| Total Metals | SW6010B/SW6020A/E245.7 | 500-ml polyethylene | $HNO_3$ to pH<2 | 180 days to analysis; 28 days for mercury |
| Total Phosphorous | SM4500P | 250-ml polyethylene | $H_2SO_4$ to pH<2; Less than 6°C | 28 days to analysis |
| Bioassay – acute and chronic Ceriodaphnia dubia. | Environment Canada, Report EPS 1/RM/21, February 1992. | 2-L polypropylene | Less than 6°C, store in dark | Testing must begin within 5 days of sample collection |
| Bioassay – acute and chronic rainbow trout | Environment Canada, Report EPS 1/RM/13, July 1990 | 50- or 100-L polypropylene (depending on fish size) | Less than 6°C, store in dark | Testing must begin within 5 days of sample collection |
| Kjeldahl Nitrogen | SM4500NorgD | 1-L polyethylene | $H_2SO_4$ to pH<2; Less than 6°C | 28 days to analysis |
| Chlorophyll a | EPA 445.0 | Filter | Freeze | 30 days to analysis |

Notes:

| | | |
|---|---|---|
| µm | = | micrometre |
| APHA | = | American Public Health Association |
| ASTM | = | ASTM International (formerly American Society for Testing and Materials) |
| BCMELP CSR | = | British Columbia Environmental Laboratory Manual |
| $^oC$ | = | degrees Celsius |
| EPA 1312 SPLP | = | Synthetic Precipitation Leaching Procedure |
| HCl | = | hydrochloric acid |
| $HNO_3$ | = | nitric acid |
| $H2SO_4$ | = | sulphuric acid |
| ISO | = | International Organization for Standardization |
| JEM | = | Journal of Environmental Monitoring |
| ml | = | millilitre |
| NaOH | = | sodium hydroxide |
| SM | = | Standard Methods for the Examination of Water and Wastewater |
| EPA | = | U.S. Environmental Protection Agency |

TABLE 4-3
**Sample Collection Summary – Tissue**
*Faro Mine Remediation Project*

| Parameter | Analytical Method | Container | Preservative | Maximum Holding Times |
|---|---|---|---|---|
| Total Metals | EPA 200.3/SW6010B/SW6020A | Ziploc Bag, 200g | 4°C | 2 years frozen at <18°C |
| 2N KCl extraction Ammonium and Nitrate | WREP-125 2nd Ed. P-3.10 | Ziploc Bag, 200g | 4°C | 2 years frozen at <18°C |
| EPA 1312 SPLP sulphuric acid at pH 5, 4, and 3 | SW1312/SW6010B | Ziploc Bag, 200g | 4°C | 2 years frozen at <18°C |
| Total Nitrogen | SSSA (1996) P 973-974 | Ziploc Bag, 200g | 4°C | 2 years frozen at <18°C |
| Total Phosphorous | COMM. Soil Sci 16:943/ APHA 3120B | Ziploc Bag, 200g | 4°C | 2 years frozen at <18°C |

Notes:
°C = degrees Celsius
g = gram
SSSA = Soil Science Society of America
EPA = U.S. Environmental Protection Agency
WREP-125 2nd Ed. = Soil, Plant and Water Reference Methods for the Western Region, 2nd Edition, 2003 (WCC-103 Publication)

TABLE 4-4
**Sample Collection Summary – Geotechnical**
*Faro Mine Remediation Project*

| Parameter | Analytical Method | Matrix | Sample Requirements | Maximum Holding Times |
|---|---|---|---|---|
| Compressive Strength | ASTM D7012 | Rock | 100 mm (4-in.) or larger block of unfractured rock, collect multiple samples as backups for each test requested in case they break during coring in the laboratory | None |
| Specific Gravity and Absorption | ASTM D6473 | Rock | Minimum of eight rock pieces, each weighing at least 1 kg (2.2 pounds) | None |
| Petrographic Examination | ASTM C295 | Rock | 40 L (10 gallons) | None |
| LA Abrasion | ASTM C131, ASTM C535 | Rock | 40 L (10 gallons) | None |
| Point Load Index | ASTM D5731 | Rock | 30–85-mm in dimension or diameter | None |
| Rock Durability Tests – Freeze/Thaw | ASTM D5312 | Rock | Minimum of eight pieces, each greater than 13 cm (5 inches) on a side | None |
| Rock Durability Tests – Wet/Dry | ASTM D5313 | Rock | Minimum of eight pieces, each greater than 13 cm (5 inches) on a side | None |
| Rock Soundness Tests | ASTM D5240 | Rock | Minimum of eight pieces, each greater than 13 cm (5 inches) on a side | None |

TABLE 4-4
**Sample Collection Summary – Geotechnical**
*Faro Mine Remediation Project*

| Parameter | Analytical Method | Matrix | Sample Requirements | Maximum Holding Times |
|---|---|---|---|---|
| Rock Total hardness | ASTM D5873 | Rock | Minimum 47 mm core, 15 cm long, or 15 cm (6 inches) block of unfractured rock | None |
| Slake Durability | ASTM D4644 | Rock | 10 pieces 40–60-g and 450–550-g total | None |
| Atterberg Limits | ASTM D4318 | Soil | 2 kg (4 pounds) | None |
| Cation Exchange Capacity | CSSS (2008) 18.4 or ASTM D7503 | Soil | 500-g (1 pound) | None |
| Consolidation Tests | ASTM D2435 | Soil | 5 by 15 cm (2 by 6 inches) brass sleeve pr Shelby tube | None |
| Porosity, Dry Bulk Density, Moisture Content | ASTM D7263 | Soil | 5 by 15 cm (2 by 6 inches) brass sleeve or Shelby tube | None |
| Shear Strength | ASTM D4767 | Soil | Three 5 by 15 cm (2 by 6 inches) brass sleeves or one Shelby tube for undisturbed specimens, or 4 L (1 gallon) for disturbed specimens | None |
| Sieve | ASTM D6913 | Soil | 0.5 kg (1 pound) | None |
| Gradation Sieve,Hydrometer, or both | ASTM D422 | Soil | 0.5 kg (1 pound) | None |
| Specific Gravity | APHA 2710F, ASTM D854, or ASTM C127, as specified | Soil | 0.5 kg (1 pound) | None |
| Soil Compaction | ASTM D698 or ASTM D1557, as specified | Soil | 0. 25 kg (50 pounds) for clay, silt, or sand; 50 kg (100 pounds) for gravel | None |
| Moisture Content | ASTM D4643 | Soil | One 500-ml (16-fluid ounces) baggie, 5 by 15-cm (2 x 6-inch) brass sleeve or Shelby tube; protect from sun/heat | 14 days |
| Direct Shear Test | ASTM D3080 | Soil | 5- by 15-cm (2- x 6-inch) brass sleeve or Shelby tube for undisturbed specimens, or 2.5 kg (5 pounds) for disturbed specimens | None |
| Gradation by Sieve | CSA A23.2-2A | Aggregate | Aggregate testing requires 2 to 3 pails (5 gallons each) per sample "set" assuming 10-cm (4-inch) maximum particle size in deposit. If larger, need additional 1 to 2 pails for oversize cobbles (assume would be crushed for aggregate) | None |
| Organic Impurities | CSA A23.2-7A | Aggregate | | None |
| Petrographic Examination | CSA A23.2-15A | Aggregate | | None |
| Relative Density and Absorption | CSA A23.2-6A and -12A | Aggregate | | None |
| Alkali-Aggregate Reactivity | CSA A23.2-25A | Aggregate | | None |

TABLE 4-4
**Sample Collection Summary – Geotechnical**
*Faro Mine Remediation Project*

| Parameter | Analytical Method | Matrix | Sample Requirements | Maximum Holding Times |
|---|---|---|---|---|
| Sulfate Soundness | CSA A23.2-9A | Aggregate | | None |
| Micro-Deval Abrasion | CSA A23.2-23A and -29A | Aggregate | | None |
| Particle Shape | CSA A23.2-13A | Aggregate | | None |

Notes:

| | | |
|---|---|---|
| APHA | = | American Public Health Association |
| ASTM | = | ASTM International (formerly American Society for Testing and Materials) |
| Cm | = | centimetre |
| COMM SOIL SCI | = | Communications in Soil Science and Plant Analysis |
| CSSS | = | Canadian Society of Soil Science |
| g | = | gram |
| kg | = | kilogram |
| mm | = | millimetre |

## 4.2 Chain-of-Custody

Procedures must be used to preserve and confirm the integrity of all samples from the time of collection through analysis. Records of the custody of samples must be maintained both in the field and in the laboratory. A sample is considered to be in someone's custody if it is either in his or her physical possession or view, locked up, or kept in a secured and restricted area. Until the samples are shipped, their custody will be the responsibility of the sampling team leader.

Chain-of-custody (COC) forms are used to document sample collection and shipment to the laboratory. COC procedures in the field follow *Faro Mine Remediation, Standard Operating Procedure PSC003, Sample Custody*.

Custody must be maintained at the laboratory once samples are received until all tests are completed. This will be accomplished using an internal custody system that requires samples to be kept in a secured and restricted area when not in use, and to be checked out and checked back in by the analysts who use them. Internal custody records must be maintained by the laboratory as part of the documentation file for each sample. If analyses are to be subcontracted to another laboratory or another location within the laboratory network, copies of COC forms transferring custody to the secondary laboratory must also be included in the laboratory data package and must also include the information listed above. The primary laboratory must ask the CH2M HILL project chemist for approval prior to subcontracting analyses to a laboratory not identified in the original proposal.

## 4.3 Transfer of Custody and Shipment

Sample shipping procedures follow *Faro Mine Remediation, Standard Operating Procedure PSC002, Sample Packing and Shipping – Environmental*.

When transferring the samples, from field to laboratory or from laboratory to laboratory, the individuals relinquishing and receiving the samples will sign, date, and note the time on the COC form. If the samples are to be shipped, the laboratory coordinators will be notified of when and how samples were sent. Notification will include the following information:

- Date of shipment
- Name of shipping company
- Airbill number
- Number of coolers

- Name, phone number, and facsimile number of point of contact
- Estimated date of shipment arrival
- Type of samples (water, sediment, soil, or tissue)

Upon receipt of each sample cooler and after verification of the COC forms, the laboratory will provide a sample confirmation report within 24 hours to the CH2M HILL project chemist that will document samples received and methods requested as well as discrepancies such as, but not limited to, the following:

- Inappropriate sample containers or preservation
- Broken sample containers
- Temperature greater than 6°C (where applicable)
- Missing COC form or QA sample form
- Errors on COC form or QA sample form
- Missing custody seals

The laboratory coordinator will notify the CH2M HILL project chemist of any such discrepancies within 24 hours of receipt of the samples. Notification can be via phone or email. The project chemist will discuss the discrepancy with the project team and inform the laboratory of the corrective action to be taken.

A subcontract laboratory must notify the primary laboratory of any such discrepancies within 24 hours of its receipt of the samples. The primary laboratory will relay this information to the CH2M HILL project chemist within 24 hours of notification.

SECTION 5

# Quality Assurance Program

## 5.1 Precision, Accuracy, Representativeness, Completeness, Comparability, and Sensitivity

Data quality will be evaluated based on data precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS).

### 5.1.1 Precision

Precision is a measure of reproducibility of analytical results. It can be defined as the degree of mutual agreement among individual measurements obtained under similar conditions. Total precision is a function of the variability associated with both sampling and analysis. Precision will be evaluated as the relative percent difference (RPD) between field duplicate sample results and laboratory duplicate sample results. Laboratory established precision limits will be followed. Precision limits are not applicable to the geotechnical analyses listed in Table 4-4.

### 5.1.2 Accuracy

Accuracy is the degree of agreement between a measured value and the "true" or expected value. As such, it represents an estimate of total error from a single measurement, including both systematic error, or "bias," and random error that may reflect variability due to imprecision. Accuracy is evaluated in terms of percent recoveries determined from results of MS and LCS analyses. Surrogate recoveries from samples analyzed for organic parameters are also used to assess accuracy. Laboratory established accuracy limits will be followed. Accuracy limits are not applicable to the geotechnical analyses listed in Table 4-4.

### 5.1.3 Representativeness

Representativeness is a qualitative term which refers to the degree to which data accurately and precisely depict the characteristics of a population, whether referring to the distribution of a contaminant within a sample, a sample within a matrix, or a contaminant at a site. Representativeness is determined by appropriate program design, with consideration of elements such as proper well locations, drilling and installation procedures, and sampling locations. Objectives for representativeness are defined for each sampling and analysis task and are a function of the investigative objectives. Assessment of representativeness will be achieved through use of the standard field, sampling, and analytical procedures. Standard analytical procedures are described in this QAPP.

### 5.1.4 Completeness

Completeness is a measure of the amount of valid data obtained compared with the amount that was expected to be obtained under correct, normal conditions. Valid data are data that are usable in the context of the project goals. Completeness is calculated and reported for each method, matrix, and analyte combination. The number of valid results divided by the number of possible individual analyte results, expressed as a percentage, determines the completeness of the data set. For completeness requirements, valid results are all results not qualified with an R-flag after a usability assessment has been performed. The completeness goal for this project is 90 percent for all matrices.

### 5.1.5 Comparability

Comparability is a qualitative indicator of the confidence with which one data set can be compared to another data set. The objective for this QA/QC program is to produce data with the greatest possible degree of comparability. The number of matrices that are sampled and the range of field conditions encountered are considered in determining comparability. Comparability is achieved by using standard methods for sampling and analysis, reporting data in standard units, normalizing results to standard conditions, and using standard and comprehensive reporting formats. Complete field documentation using standardized data collection forms will

support the assessment of comparability. Analysis of performance evaluation (PE) samples and reports from audits will also be used to provide additional information for assessing the comparability of analytical data produced among subcontracting laboratories. Historical comparability will be achieved through consistent use of methods and documentation procedures throughout the project. Assessment of comparability is primarily subjective and results should be interpreted by experienced environmental professionals with a clear knowledge of the DQOs and project decisions. Assessment should include a discussion of the level of uncertainty associated with the comparability of the specific data set and the potential consequences of using non-comparable data.

### 5.1.6 Sensitivity

Sensitivity is the ability of an analytical method or instrument to discriminate between measurement responses representing different concentrations. It is important to be able to detect the target analytes at the levels of interest. Sensitivity requirements include the establishment of various limits such as calibration requirements and method detection limits (MDL). The sensitivity limits are listed as MDL objectives in Table 5-1.

## 5.2 Method Detection Limits and Instrument Calibration Requirements

### 5.2.1 Method Detection Limits

The MDL is the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. Each participating laboratory will determine the MDL for each method, matrix, and analyte for each instrument that will be used to analyze samples. The MDLs will be initially determined prior to analyzing samples, and if there are any significant changes to the method, as specified in the *BC Laboratory QA/QC Manual,* Section A, part 3.0.

MDLs, as well as sample results, will be reported to two significant figures if less than 10 (regardless of the unit) and to three significant figures otherwise. They will be reported on a dry-weight basis for soil and sediment samples.

### 5.2.2 Instrument Calibration

Laboratory instruments will be appropriately calibrated by qualified personnel prior to sample analysis according to the procedures specified in each method. Calibration will be verified at the specified intervals throughout the analysis sequence. The frequency and acceptance criteria for calibration are specified for each analytical method. When multi-point calibration is specified, the concentrations of the calibration standards should bracket those expected in the samples. Samples should be diluted, if necessary, to bring analyte responses within the calibration range. When the shape of the calibration curve requires that a quadratic or higher order equation be used, the number of additional standards specified in the method must be analyzed. The initial calibration curve will be verified as accurate with a standard purchased or prepared from an independent second source. The initial calibration verification involves the analysis of a standard containing all the target analytes, typically in the middle of the calibration range, each time the initial calibration is performed, unless specified otherwise for a particular method in the QAPP.

Laboratory instruments will be appropriately calibrated by qualified personnel prior to sample analysis according to method specifications. Only certified standards of known purity may be used for calibration. Calibration will be verified at specified intervals throughout the analysis sequence as specified by each analytical method.

## 5.3 Elements of Quality Control

Laboratory QC checks are used to provide indications of the state of control that prevailed at the time of sample analysis. QC checks that involve field samples, such as matrix and surrogate spikes and field duplicates, also provide an indication of the presence of matrix effects. Field-originated blanks provide a way to monitor for potential contamination that field samples are subjected to. The QAPP specifies requirements for method blanks (MB), LCSs, surrogate spikes, and MS samples that must be followed by laboratories participating in the data

collection effort. Laboratory QC samples must be included with each preparation or analytical batch of 20 or fewer environmental samples (including MS samples) of similar matrix. Each preparation or analytical batch should be identified in such a way as to be able to associate environmental samples with the appropriate laboratory QC samples. Elements of QC will evaluated by the project chemistry team following data validation guidelines defined in Section 7.3.

The elements of QC listed below are not applicable to the geotechnical analyses listed in Table 4-4.

## 5.3.1 Laboratory Blanks

### 5.3.1.1 Method Blank

MBs are used to monitor each preparation or analytical batch for interference and/or contamination from glassware, reagents, and other potential contaminant sources within the laboratory. An MB is analyte-free matrix (laboratory reagent water for aqueous and tissue samples or Ottawa sand for soil and sediment samples) to which all reagents are added in the same amount or proportions as are added to samples. It is processed through the entire sample preparation and analytical procedures along with the samples in the batch. There should be at least one MB per preparation or analytical batch. If a target analyte is found at a concentration that exceeds the MDL, corrective action must be performed to identify and eliminate the contamination source. All associated samples must be reprepared and/or reanalyzed after the contamination source has been eliminated. No analytical data may be corrected for the concentration found in the blank.

### 5.3.1.2 Instrument Blank

Instrument blanks are used to check for carryover contamination after analysis of high concentration samples. An instrument blank is an aliquot of ASTM Type II water following the same analytical procedures as the samples. An instrument blank should be analyzed following a sample with one or more high concentrations of at least one target analyte. If a target analyte is found at a concentration that exceeds the MDL, the instrument blank is reanalyzed until no carryover is observed. If project samples are thought to be affected by carryover, they must be reprepared and/or reanalyzed after the carryover has been eliminated. No analytical data may be corrected for the concentration found in the blank.

## 5.3.2 Laboratory Control Samples

The LCS will consist of analyte-free matrix (laboratory reagent water for aqueous and tissue samples or Ottawa sand for soil and sediment samples) spiked with known amounts of analytes that come from a source different than that used for calibration standards. All target analytes specified in the QAPP will be spiked into the LCS. The spike levels should be less than or equal to the mid-point of the calibration range. If LCS recoveries are outside the specified control limits, corrective action must be taken, including sample repreparation and/or reanalysis, if appropriate. If more than one LCS is analyzed in a preparation or analytical batch, the results of all must be reported. A certified reference material can be used to satisfy LCS requirements.

## 5.3.3 Laboratory Duplicates

Laboratory duplicates are repeated measurements of the same sample. The duplicate must be performed by the same analyst, under the same conditions, and on the same day as the original analysis. The sample is split in the laboratory and each fraction is carried through all stages of sample preparation and analysis. Duplicate analyses are used to assess the precision of each analytical method. Laboratory duplicate analyses are performed for each analytical batch. Each analytical batch must contain a MS and laboratory duplicate.

## 5.3.4 Surrogates

Surrogates are organic analytes that behave similarly to the analytes of interest but that are not expected to occur naturally in the samples. They are spiked into the standards, and into the samples and QC samples prior to sample preparation. Recoveries of surrogates are used as an indicator of accuracy, method performance, and extraction efficiency. If surrogate recoveries are outside the specified control limits, corrective action must be taken, including sample repreparation and/or reanalysis, if appropriate.

### 5.3.5 Matrix Spikes

A sample matrix fortified with known quantities of specific compounds is an MS. It is subjected to the same preparation and analytical procedures as the native sample. Target analytes specified in the QAPP are spiked into the sample. MS recoveries are used to evaluate the effect of the sample matrix on the recovery of the analytes of interest. The spike levels will be less than or equal to the mid-point of the calibration range. Samples identified as field blanks cannot be used for MS tests. Each analytical batch must contain an MS and a laboratory duplicate.

For metals analysis, it is not necessary to spike sodium, potassium, calcium, and magnesium into aqueous samples, or sodium, potassium, calcium, magnesium, iron, manganese, and aluminum into soil samples. The native concentrations of these low-toxicity metals are usually relatively high.

### 5.3.6 Internal Standards

Some methods require the use of internal standards to compensate for losses during injection or purging or losses due to viscosity effects. Internal standards are compounds that have properties similar to those of the analytes of interest, but are not expected to occur naturally in the samples. A measured amount of the internal standard is added to the standards, and to the samples and QC samples following preparation. When the internal standard results are outside the control limits, corrective action must be taken, including sample reanalysis, if appropriate.

### 5.3.7 Interference Check Samples

The interference check samples are used in inductively coupled plasma (ICP) analyses to verify background and interelement correction factors. They consist of two solutions, A and B. Solution A contains the interfering analytes, and Solution B contains both the analytes of interest and the interfering analytes. Both solutions are analyzed at the beginning and at the end of each analytical sequence. When the interference check sample results are outside the control limits, corrective action must be taken, including sample reanalysis, if appropriate.

### 5.3.8 Serial Dilutions

A dilution test must be carried out as specified for specific methods. It is performed to determine whether significant physical or chemical interferences exist due to the sample matrix. One sample per preparation batch must be processed as a dilution test. Samples identified as field blanks cannot be used for dilution tests. The test is performed by running a sample at a five-fold dilution. The results of the diluted sample, after correction for dilution, should agree within 10 percent of the original sample determination when the original sample concentration is greater than 100 times the MDL. If the results are not within 10 percent, the possibility of chemical or physical interference exists.

### 5.3.9 Dilution Test and Post-digestion Spikes

A dilution test must be carried out as specified for specific methods. It is performed to determine whether significant physical or chemical interferences exist due to the sample matrix.

One sample in every batch must be post-spiked with all of the analytes of interest at the instrument following sample preparation. Samples identified as field blanks cannot be used for post-digestion spike tests.

### 5.3.10 Retention Time Windows

Retention time windows for gas and ion chromatographic analyses must be established by replicate injections of the calibration standard over multiple days, as described in the appropriate method. The absolute retention time of the calibration verification standard at the start of each analytical sequence will be used as the centerline of the window. In order for an analyte to be reported as positive, its retention time must be within the window.

# 5.4 Additional Quality Control Requirements

## 5.4.1 Holding Time

The holding time requirements specified in this QAPP must be met. For methods requiring both sample preparation and analysis, the preparation holding time will be calculated from the time of sampling to the completion of preparation. The analysis holding time will be calculated from the time of completion of preparation to the time of completion of the analysis, including required dilutions, confirmation analysis, and reanalysis. For methods requiring analysis only, the holding time is calculated from the time of sampling to completion of the analysis, including required dilutions, confirmation analysis, and reanalysis.

## 5.4.2 Cleanup Procedures to Minimize Matrix Effects

To maintain the lowest possible MDLs, appropriate cleanup procedures should be employed when necessary. Methods for sample cleanup include, but are not limited to, gel permeation chromatography, silica gel, alumna, florisil, mercury (sulphur removal), sulphuric acid and acid/base partitioning. MBs, MSs, and LCSs must be subjected to the same cleanup procedures performed on the samples to monitor the efficiencies of these procedures.

## 5.4.3 Sample Dilution

Dilution of a sample results in elevated MDLs and ultimately affects the usability of the data related to potential actions at the sampling site. It is important to minimize dilutions and maintain the lowest possible MDLs. When dilutions are necessary due to high concentrations of target analytes, lesser dilutions should also be reported in order to fully characterize the sample for each analyte. The level of the lesser dilution should be such that it will provide the lowest possible MDLs without having a lasting deleterious effect on the analytical instrumentation.

## 5.4.4 Standard Materials and Other Supplies and Consumables

Standard materials must be of known high purity and traceable to an approved source. Pure standards must not exceed the manufacturer's expiration date or 1 year following receipt, whichever comes first. Solutions prepared by the laboratory from the pure standards must be used by the expiration date specified in the laboratory's SOP.

All other supplies and consumables must be inspected prior to use to confirm that they meet the requirements specified in the appropriate SOP. The laboratory's inventory and storage system should confirm their use by the manufacturer's expiration date and storage under proper conditions.

# 5.5 Method Detection Limit Objectives

The methods to be used, screening level objectives, screening level sources, and lowest laboratory MDL available for the selected analytes are listed in Tables 5-1 through 5-3. Analytes that do not have a screening level objective are not listed in Tables 5-1 through 5-3. For analytes that do not have a screening level objective, the laboratory's lowest achievable detection limit will be used for reporting. For analytes where the laboratory's lowest laboratory detection does not meet the screening level objective, the best available, industry-standard technology will be used to achieve the lowest detection limit possible.

TABLE 5-1
**Methods, Screening Level Objectives and Target Detection Limits for Aqueous Samples**
*Faro Mine Remediation Project*

| Parameter | Method | Screening Level Objective | Screening Level Source | Units | Lowest Laboratory MDL |
|---|---|---|---|---|---|
| Ammonia – Total | JEM (2005) 7,37-42/SM4500N-Org | 0.019 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater Long Term | mg/L | 0.005 |
| Chloride | EPA 300.0/SM4110B | 120 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater Long Term | mg/L | 0.5 |
| Fluoride | EPA 300.0/SM4110B | 0.12 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater Long Term | mg/L | 0.02 |
| Nitrate | EPA 300.0/SM4110B | 3 | British Columbia Water Quality Guidelines | mg/L | 0.005 |
| Nitrite | EPA 300.0/SM4110B | 0.02 | British Columbia Water Quality Guidelines | mg/L | 0.001 |
| Total Phosphorous | SM4500P | 0.005 | British Columbia Water Quality Guidelines | mg/L | 0.002 |
| Sulphate | EPA 300.0/SM4110B | 100 | British Columbia Water Quality Guidelines | mg/L | 0.5 |
| Total Organic Carbon | SM5310C | 4 | British Columbia Drinking Water Guidelines | mg/L | 0.5 |
| Total Dissolved Solids | SM2540C | 500 | British Columbia Drinking Water Guidelines | mg/L | 10 |
| Free Cyanide | ASTM 7237 | 0.005 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater Long Term | mg/L | 0.005 |
| Aluminum | SW6010B/SW6020A | 0.005 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater Long Term | mg/L | 0.0005 |
| Antimony | SW6010B/SW6020A | 0.006 | British Columbia Drinking Water Guidelines | mg/L | 0.00002 |
| Arsenic | SW6010B/SW6020A | 0.005 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater Long Term | mg/L | 0.00002 |
| Barium | SW6010B/SW6020A | 1 | British Columbia Water Quality Guidelines | mg/L | 0.00002 |
| Beryllium | SW6010B/SW6020A | 0.004 | British Columbia Drinking Water Guidelines | mg/L | 0.00001 |
| Boron | SW6010B/SW6020A | 1.2 | British Columbia Water Quality Guidelines | mg/L | 0.005 |
| Cadmium | SW6010B/SW6020A | 0.00001 | British Columbia Water Quality Guidelines | mg/L | 0.000005 |
| Calcium | SW6010B/SW6020A | 1,000 | CCME Sediment Quality Guidelines for the Protection of Agriculture – Livestock | mg/L | 0.03 |
| Cobalt | SW6010B/SW6020A | 0.004 | British Columbia Water Quality Guidelines | mg/L | 0.000005 |
| Copper | SW6010B/SW6020A | 0.00004 | British Columbia Water Quality Guidelines | mg/L | 0.0001 [a] |

TABLE 5-1
**Methods, Screening Level Objectives and Target Detection Limits for Aqueous Samples**
*Faro Mine Remediation Project*

| Parameter | Method | Screening Level Objective | Screening Level Source | Units | Lowest Laboratory MDL |
|---|---|---|---|---|---|
| Iron | SW6010B/SW6020A | 0.3 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater Long Term | mg/L | 0.001 |
| Lead | SW6010B/SW6020A | 0.001 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater Long Term | mg/L | 0.000005 |
| Magnesium | SW6010B/SW6020A | 100 | British Columbia Drinking Water Guidelines | mg/L | 0.03 |
| Manganese | SW6010B/SW6020A | 0.05 | British Columbia Drinking Water Guidelines | mg/L | 0.0005 |
| Molybdenum | SW6010B/SW6020A | 0.073 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater Long Term | mg/L | 0.00005 |
| Nickel | SW6010B/SW6020A | 0.025 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater Long Term | mg/L | 0.00005 |
| Potassium | SW6010B/SW6020A | 0.373 | British Columbia Water Quality Guidelines | mg/L | 0.05 |
| Selenium | SW6010B/SW6020A | 0.001 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater Long Term | mg/L | 0.00004 |
| Silver | SW6010B/SW6020A | 0.00005 | British Columbia Water Quality Guidelines | mg/L | 0.000005 |
| Sodium | SW6010B/SW6020A | 200 | British Columbia Drinking Water Guidelines | mg/L | 0.01 |
| Thallium | SW6010B/SW6020A | 0.0003 | British Columbia Water Quality Guidelines | mg/L | 0.000002 |
| Titanium | SW6010B/SW6020A | 2 | British Columbia Water Quality Guidelines | mg/L | 0.0005 |
| Uranium | SW6010B/SW6020A | 0.015 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater Long Term | mg/L | 0.000002 |
| Vanadium | SW6010B/SW6020A | 0.006 | British Columbia Water Quality Guidelines | mg/L | 0.00005 |
| Zinc | SW6010B/SW6020A | 0.03 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater Long Term | mg/L | 0.0005 |
| Mercury | SW7470A/SW7471A | 0.000001 | British Columbia Drinking Water | mg/L | 0.00001 [b] |

[a] For copper, the lowest laboratory MDL does not meet the screening level objective listed, which is the lowest of all screening level sources. This is hardness-dependent and applies only if hardness is greater than 50 mg/L. If hardness is less than 50 mg/L, the screening level objective for copper is 0.002 and is achievable by the lowest laboratory MDL.

[b] For mercury, the Lowest Laboratory MDL meets the British Columbia Water Quality Guidelines Screening Level Objective of 0.00002 µg/L.

TABLE 5-2
**Methods, Screening Level Objectives and Target Detection Limits for Soil Samples**
*Faro Mine Remediation Project*

| Parameter | Method | Screening Level Objective | Screening Level Source | Units (dry weight) | Lowest Laboratory MDL |
|---|---|---|---|---|---|
| Antimony | EPA 200.2/SW6010B/SW6020A | 20 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland or Agricultural | mg/kg | 0.1 |
| Arsenic | EPA 200.2/SW6010B/SW6020A | 12 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland or Agricultural or Commercial or Industrial | mg/kg | 0.05 |
| Barium | EPA 200.2/SW6010B/SW6020A | 500 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland | mg/kg | 0.5 |
| Beryllium | EPA 200.2/SW6010B/SW6020A | 4 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland or Agricultural | mg/kg | 0.2 |
| Boron | EPA 200.2/SW6010B/SW6020A | 2 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Agricultural | mg/kg | 10 [a] |
| Cadmium | EPA 200.2/SW6010B/SW6020A | 1.4 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Agricultural | mg/kg | 0.05 |
| Chromium | EPA 200.2/SW6010B/SW6020A | 64 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland or Agricultural | mg/kg | 0.5 |
| Cobalt | EPA 200.2/SW6010B/SW6020A | 40 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Agricultural | mg/kg | 0.1 |
| Copper | EPA 200.2/SW6010B/SW6020A | 63 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland or Agricultural | mg/kg | 0.5 |

TABLE 5-2
**Methods, Screening Level Objectives and Target Detection Limits for Soil Samples**
*Faro Mine Remediation Project*

| Parameter | Method | Screening Level Objective | Screening Level Source | Units (dry weight) | Lowest Laboratory MDL |
|---|---|---|---|---|---|
| Lead | EPA 200.2/SW6010B/SW6020A | 70 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Agricultural | mg/kg | 0.5 |
| Molybdenum | EPA 200.2/SW6010B/SW6020A | 5 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Agricultural | mg/kg | 0.5 |
| Nickel | EPA 200.2/SW6010B/SW6020A | 50 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland or Agricultural or Commercial or Industrial | mg/kg | 0.5 |
| Selenium | EPA 200.2/SW6010B/SW6020A | 1 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland or Agricultural | mg/kg | 0.2 |
| Silver | EPA 200.2/SW6010B/SW6020A | 20 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland or Agricultural | mg/kg | 0.1 |
| Sulphur | ISO 15178:2000 | 500 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Agricultural | mg/kg | 500 |
| Thallium | EPA 200.2/SW6010B/SW6020A | 1 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland or Agricultural or Commercial or Industrial | mg/kg | 0.05 |
| Tin | EPA 200.2/SW6010B/SW6020A | 5 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Agricultural | mg/kg | 2 |
| Uranium | EPA 200.2/SW6010B/SW6020A | 23 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland or Agricultural | mg/kg | 0.05 |

TABLE 5-2
**Methods, Screening Level Objectives and Target Detection Limits for Soil Samples**
*Faro Mine Remediation Project*

| Parameter | Method | Screening Level Objective | Screening Level Source | Units (dry weight) | Lowest Laboratory MDL |
|---|---|---|---|---|---|
| Vanadium | EPA 200.2/SW6010B/SW6020A | 130 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland or Agricultural or Commercial or Industrial | mg/kg | 0.2 |
| Zinc | EPA 200.2/SW6010B/SW6020A | 200 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland or Agricultural | mg/kg | 1 |
| Mercury | EPA 245.7/SW7471A | 6.6 | CCME Soil Quality Protection Guidelines for the Protection of Environmental and Human Health – Residential/Parkland or Agricultural | mg/kg | 0.005 |

[a] For boron, the lowest laboratory MDL does not reach the screening level objective. The lowest laboratory MDL represents industry-standard technology.

TABLE 5-3
**Methods, Screening Level Objectives and Target Detection Limits for Sediment Samples**
*Faro Mine Remediation Project*

| Parameter | Method | Screening Level Objective | Screening Level Source | Units (dry weight) | Lowest Laboratory MDL |
|---|---|---|---|---|---|
| Arsenic | EPA 200.2/SW6010B/SW6020A | 5.9 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater ISQG | mg/kg | 0.05 |
| Cadmium | EPA 200.2/SW6010B/SW6020A | 0.6 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater ISQG | mg/kg | 0.05 |
| Chromium | EPA 200.2/SW6010B/SW6020A | 37.3 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater ISQG | mg/kg | 0.5 |
| Copper | EPA 200.2/SW6010B/SW6020A | 18.7 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Marine ISQG | mg/kg | 0.5 |
| Lead | EPA 200.2/SW6010B/SW6020A | 30.2 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Marine ISQG | mg/kg | 0.5 |
| Zinc | EPA 200.2/SW6010B/SW6020A | 123 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Freshwater ISQG | mg/kg | 1 |
| Mercury | EPA 245.7/SW7471A | 0.13 | CCME Sediment Quality Guidelines for the Protection of Aquatic Life – Marine ISQG | mg/kg | 0.005 |

SECTION 6

# Analytical Procedures

Tables 5-1 through 5-3 listed the methods to be used, screening level objectives, screening level sources and lowest laboratory MDLs. This QAPP attempts to present a comprehensive list of methods and analytes that are expected to be used for the duration of the project. However, the QAPP may not address future changes in analytical needs. If the need for such changes arises, the QAPP and the relevant site-specific documents will be updated and submitted to the Government of Canada as represented by Aboriginal Affairs and Northern Development Canada and the Government of Yukon for approval. Only the affected portions of the QAPP will be submitted for review.

Analytical services will be provided by laboratories contracted by CH2M HILL. The contracted laboratories will be evaluated to make sure that analytical DQOs are achieved by comparing laboratory MDLs with the screening level objectives listed in Tables 5-1 through 5-3. Compliance with DQOs will also be evaluated throughout the project, during the data validation process. For analytes where the laboratory's lowest laboratory detection does not meet the screening level objective, the best available, industry-standard technology will be used to achieve the lowest detection limit possible.

The calibration and QC requirements specified for each method will be followed. Laboratory established precision and accuracy limits will be used to evaluate the data. Appropriate corrective action will be taken when acceptance criteria are not met. If corrective action is not effective, and data quality could be impacted, the occurrence must be documented in a corrective action report and in the data package case narrative. The laboratory manager or designee must notify the CH2M HILL project chemist.

The laboratory turnaround time (TAT) will be the standard 7 business days from sample receipt. Occasional rush TAT will be requested. TAT is calculated from the date the laboratory receives the samples and is not complete until both the hardcopy and electronic data are delivered and complete. Exceptions to TAT will be communicated to the project chemist. For samples received at the laboratory after 6:00PM, Day 1 for determining the TAT will begin on the next calendar day. Some geotechnical and specialty analyses will require longer TATs from 10 up to 60 business days; the longer TATs will be communicated to the project team as needed.

SECTION 7

# Data Management, Reporting, and Assessment

## 7.1 Data Management and Archival

CH2M HILL will have a system for maintaining, controlling, and archiving field records and will require that the primary laboratories maintain a similar system for laboratory records. This system will facilitate retrieval of documentation that affects reported analytical results.

All raw data will be maintained on file in the laboratory, and will be available upon request. Complete documentation of sample preparation and analysis and associated QC information will be maintained in a manner that allows easy retrieval in the event that additional information is required. The following minimum documentation should be kept for each project:

- Original work order, COC forms, and other pertinent documents received with the samples
- Records of communication between the laboratory, field personnel, and the client
- Corrective action reports
- Laboratory data reports
- Laboratory logbooks and all raw sample preparation and analytical data
- Electronic data and all pertinent SOPs

Field records to be retained as a minimum will include correspondence, COC forms, field notes, field equipment performance records, maintenance logs, field procedures, corrective action reports, field personnel files, and project-related reports.

Field and laboratory record retention will be for a period of 10 years minimum after data acquisition.

## 7.2 Laboratory Data Reduction, Review, and Reporting

### 7.2.1 Data Reduction and Review

Data reduction will be done manually or using appropriate application software. Quantitation procedures specified for each method must be followed. If data reduction is done manually, the documentation must include the formulas used. Application software used for data reduction must have been previously checked for accuracy. Documentation on the software must be maintained on file in the laboratory. All documentation of data reduction must allow recreation of the calculations.

All data will undergo two levels of review at the laboratory prior to release. The analyst performing the tests will initially review 100 percent of the data. After the analyst's review has been completed, 100 percent of the data will be reviewed independently by a senior analyst or by the section supervisor for accuracy, compliance with calibration and QC requirements, holding time compliance, and completeness. Analyte identification and quantitation must be verified. Calibration and QC results will be compared with the applicable control limits. MDLs should be reviewed to make sure they meet the project objectives. Results of multiple dilutions should be reviewed for consistency. Discrepancies must be resolved and corrected. Laboratory qualifiers will be applied when there are nonconformances that could affect data usability. These qualifiers must be properly defined as part of the deliverables. All issues that are relevant to the quality of the data must be addressed in a case narrative. A final data review will be conducted by the laboratory manager or laboratory coordinator to confirm all required analyses were performed on all samples, and that all documentation is complete. Data review performed by the laboratory personnel must be documented.

The hardcopy and electronic laboratory reports for all samples and analyses will contain the information necessary to perform data evaluation.

### 7.2.2 Hardcopy Deliverables

Hardcopy deliverables, in summary format, containing the necessary information to perform data evaluation/data validation, are required. This project will require Level II reports. Alternate reporting formats require approval from the project chemist.

A Level II report will include, at a minimum (when applicable):

- Cover letter, with the following:
  - Title of report and laboratory unique report identification (Sample Delivery Group Number).
  - Project name and location.
  - Name and location of primary laboratory, secondary network laboratories or subcontracted laboratories.
  - Client name and address.
  - Statement of authenticity and official signature and title of person authorizing report release.
- Table of contents.
- Summary of samples received that correlates field sample IDs with the laboratory IDs.
- Laboratory qualifier flags and definitions.
- Field identification number.
- Sample matrix.
- Sample collection date.
- Date received.
- Date prepared.
- Date analyzed (and time of analysis if the holding time is less than or equal to 48 hours).
- Preparation and analytical methods.
- Preparation, analysis, or other batch reference numbers.
- Analyte name.
- Result for each analyte (dry-weight basis for soils and sediments, wet weight for tissue samples).
- Percent solids results for soil and sediment samples.
- Data qualifiers, if used.
- Dilution factor (provide both diluted and undiluted results when available).
- Sample-specific MDL adjusted for sample size, dilution/concentration.
- Units.
- Case narrative that contains a table summarizing samples received, providing correlation between field sample identification and laboratory identification numbers, and analytical test methods performed.
  - If a secondary network or subcontracted laboratory was used, the table should show which analytical test methods were performed by each laboratory.
  - Samples that were received but not analyzed should be identified.
  - Any holding time, calibration, or QC deviations should be noted.
  - Corrective actions taken by the laboratory in connection with these deviations should be discussed.
  - Identification and justification for sample dilution.

  - The case narrative should also discuss other information, such as sample temperature outside acceptable range, or visible signs of sample non-homogeneity, that could affect the quality of the data.

- Surrogate percent recoveries. Associated QC limits must also be provided.
- MS and LCS spike concentrations, native sample results, spiked sample results, and percent recoveries. Associated QC limits must also be provided.
- MB results.
- Analytical batch reference number that cross references samples to QC sample analyses.
- Executed COC form and sample receipt checklist.

A Level IV report may be requested by the project chemist to investigate anomalies or to use in conjunction with auditing laboratory performance. A Level IV report will consist of all of the elements included in a Level II report plus the following:

- Analytical sequence or laboratory run log that contains sufficient information to correlate samples reported in the summary results to the associated method QC information, such as initial and continuing calibration analyses.
- Calibration blank results for inorganic analyses (required in hardcopy format only).
- ICP interference check sample true and measured concentrations and percent recoveries (required in hardcopy format only).
- Method of standard addition results (if applicable; required in hardcopy format only).
- Post-digestion spike recoveries (if applicable; required in hardcopy format only).
- Serial dilution results (if applicable; required in hardcopy format only).
- Internal standard recovery and retention time information, as applicable.
- Initial calibration summary, including standard concentrations, response factors, average response factors, relative standard deviations or correlation coefficients, and calibration plots or equations, if applicable (required in hardcopy format only).
- Initial and continuing calibration verification summaries, including expected and recovered concentrations and percent differences (required in hardcopy format only).
- Instrument tuning and mass calibration information for ICP/mass spectrometry analyses.
- Any other method-specific QC sample results.
- Sample preparation logs that include the following information:
  - Preparation start and end times.
  - Beginning and ending temperatures of water baths and digestion blocks.
- Example calculation for obtaining numerical results from at least one sample for each matrix analyzed (provide algorithm).
- Reconstructed total ion chromatograms or selected ion current profiles for each sample (or blank) analyzed and mass spectra(s) for each compound identified, including:
  - Raw compound spectra.
  - Enhanced or background spectra.

## 7.2.3 Electronic Deliverables

Concurrent with the submittal of the hardcopy deliverables, the laboratory will deliver electronic data in the EQuIS format as defined in the project-specific laboratory statement of work. There will be no discrepancies between the hardcopy reports and the electronic reports.

All raw data will be maintained on file in the laboratory and will be available on request by project management. Complete documentation of sample preparation and analysis and associated QC information will be maintained in a manner that allows easy retrieval in the event that additional validation or information is required. All documentation must be retained for a minimum of 5 years after data acquisition.

The primary responsibility for the implementation of these procedures within the laboratory will reside with the laboratory manager or designee.

### 7.2.3.1 Data Validation

The analytical results of the data collection effort will be validated by CH2M HILL. Validation will be performed by the project chemist or designee. One hundred percent Level II validation will be performed as described below. Level IV validation will be performed as needed and directed by the project chemist as described below. Validation will not be required for the geotechnical analyses listed in Table 4-4.

Personnel involved in the data validation function will be independent of a data generation effort. The project chemist will have responsibility for oversight of the data validation effort. Data validation will be carried out when the data packages are received from the laboratory. It will be performed on an analytical batch basis using the summary results of calibration and laboratory QC, as well as those of the associated field samples. Data packages will be reviewed for all constituents of concern. Data validation will be performed by method and matrix.

Level II validation will include the following:

- A review of the data set narrative to identify issues that the laboratory reported in the data deliverable
- A check of sample integrity (sample collection, preservation, and holding times)
- An evaluation of basic QC measurements used to assess the accuracy, precision and representativeness of data, including QC blanks, LCS, MS, surrogate recovery when applicable, and field or laboratory duplicate results
- A review of sample results, target compound lists, and detection limits to verify that project analytical requirements are met
- Initiation of corrective actions, as necessary, based on the data review findings
- Verification that hardcopy results match electronic deliverable results
- Qualification of the data using appropriate qualifier flags, as necessary, to reflect data usability limitations

Level IV data validation will also include the following:

- Evaluation of initial and continuing calibration results
- Evaluation of internal standard results
- Other method-specific QC requirements
- Review of sample chromatograms
- Verification of analyte identification and calculations for at least 10 percent of the data

The flagging criteria in Table 7-1 will be used. The qualifier flags are defined in Table 7-2. Qualifier flags, if required, will be applied to the electronic sample results. If multiple flags are required for a result, the most severe flag will be applied to the electronic result. The hierarchy of flags from the most severe to the least severe will be as follows: R, U, UJ, and J.

Table 7-1
**General Data Qualifying Conventions**
*Faro Mine Remediation Project*

| QC Requirement | Criteria | Flag | Flag Applied to |
|---|---|---|---|
| Holding time | Time exceeded for extraction or analysis | J for positive results; UJ for nondetects[a] | All analytes in sample |
| Holding time | Time exceeded for extraction or analysis by a factor >2 | J for positive results; R for nondetects | All analytes in sample |
| Sample preservation | Sample not preserved; however, if sample preservation was not done in the field but was performed at the laboratory upon sample receipt, no flagging is required | J for positive results; UJ for nondetects | Sample |
| | Temperature out of control | J for positive results; UJ for nondetects | Sample |
| Instrument tuning | Ion abundance method-specific criteria not met | R for all results | All associated samples in analytical batch |
| Initial calibration | All analytes must be within method-specified criteria | J for positive results; UJ for nondetects | All associated samples in analytical batch |
| Second source check or continuing calibration | All analytes must be within method-specified criteria | J for positive results; UJ for nondetects | All associated samples in analytical batch |
| Interference check sample | All analytes must be within 20% of expected value | High bias: J for positive results<br>Low bias: J for positive results; UJ for nondetects | All associated samples in analytical batch |
| LCS or CRM | %R > UCL<br>%R < LCL<br>%R < LCL and <10% | J for positive results<br>J for positive results; UJ for nondetects<br>J for positive results; R for nondetects | The specific analyte(s) in all samples in associated analytical batch |
| Internal standards | Area > UCL<br>Area < LCL | J for positive results; UJ for nondetects<br>J for positive results | Sample |
| Surrogate spikes | %R > UCL<br>%R < LCL and >10%<br>%R <10%<br>Surrogate diluted out | J for positive results<br>J for positive results; UJ for nondetects<br>J for positive results; R for nondetects<br>No flag required | Sample |
| Blanks (method, equipment, trip, instrument) | Analyte(s) detected (use the blank of the highest concentration) | U for positive sample results ≤ 5 times highest blank concentration | All samples in preparation, field or analytical batch, whichever applies |
| Laboratory duplicates | RPD > CL and both results > MDLs<br>or<br>One result > MDL, one ND and difference >5xMDL | J for positive results<br>J for positive results; UJ for nondetects | The specific analyte(s) in all samples collected on same sampling date |

Table 7-1
**General Data Qualifying Conventions**
*Faro Mine Remediation Project*

| QC Requirement | Criteria | Flag | Flag Applied to |
|---|---|---|---|
| Field duplicates<br><br>(30% RPD for aqueous and 50% RPD for non-aqueous) | RPD > CL and both results > MDLs<br><br>or<br><br>One result > MDL, one ND and difference >5xMDL | J for positive results<br><br>UJ for nondetects | The specific analyte(s) in all samples collected on same sampling date |
| MS | MS %R > UCL<br><br>MS %R < LCL<br><br>MS %R < LCL and <10%<br><br>Sample concentration > 4 times spike concentration; excessive dilution | J for positive results<br><br>J for positive results; UJ for nondetects<br><br>J for positive results; R for nondetects<br><br>No flag required | The specific analyte(s) in parent sample and associated samples collected at the same site. |
| Post-digestion spike | All analytes must be within 25% of expected value | High bias: J for positive results<br><br>Low bias: J for positive results; UJ for nondetects | The specific analyte(s) in parent sample |
| Serial dilutions | All analytes must be within 10% of expected value | If Post Spike not analyzed; J for positive results | The specific analyte(s) in parent sample |
| Retention time window | Analyte within established window | R for all results | Sample |

Notes:
%R = percent recovery
CL = control limit
CRM = certified reference material
LCL = lower confidence limit
LCS = laboratory control sample
MDL = method detection limit
MS = matrix spike
ND = not detected
RPD = relative percent difference
UCL = upper confidence limit

TABLE 7-2
**Qualifier Flag Definitions**
*Faro Mine Remediation Project*

| | |
|---|---|
| J | Analyte was present but the reported value may not be accurate or precise. |
| R | This result has been rejected for use. |
| U | This analyte was analyzed for but not detected at the specified detection limit. |
| UJ | The analyte was not detected above the detection limit objective. However, the reported detection limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. |

SECTION 8

# Performance Evaluations and Audits

## 8.1 Laboratory Approval

Prior to project startup, each laboratory will be required to submit documentation that includes the following:

- CALA
- MDLs for all methods to be performed under the project
- Laboratory-established QC limits all methods/analytes to be performed under the project
- Results from most recent performance evaluation studies.

## 8.2 Performance Evaluations

PEs of the primary laboratories using PE samples will be conducted. This will happen early in the project so a second PE sample can be ordered in case of a failure.

PEs quantitatively assess the data produced by a measurement system. A PE involves submitting project-specific PE samples for analysis for selected analytical methods used in the project. The project-specific PE samples are selected to reflect the expected range of concentrations for the sampling program. The PE answers questions about whether the measurement system is operating within CLs and whether the data produced meet the analytical QA specifications.

The project-specific PE samples are made to look as similar to field samples as possible and are submitted as part of a field sample shipment so that the laboratory is unable to distinguish between them and project samples. This approach provides unbiased sample analysis and reporting by the laboratory.

The critical elements for review of PE sample results include (1) correct identification and quantitation of the PE sample analytes, (2) accurate and complete reporting of the results, and (3) measurement system operation within established CLs for precision and accuracy.

The concentrations reported for the PE samples will be compared to the known or expected concentrations spiked in the samples. The percent recovery will be calculated and the results assessed according to the accuracy criteria for the values from the PE sample provider. If the accuracy criteria are not met, the cause of the discrepancy will be investigated and a second PE sample may be submitted.

## 8.3 External Audits

CH2M HILL reserves the right to conduct announced and unannounced audits of the field operations and of the laboratories during any stage of the project.

## 8.4 Internal Audits

Annual audits of the laboratory will be conducted by the laboratory's quality assurance officer. The audits will verify, at a minimum, that written SOPs are being followed; standards are traceable to certified sources; documentation is complete; data review is being done effectively and is properly documented; and data reporting, including electronic and manual data transfer, is accurate and complete. All audit findings will be documented in QA reports to management. Necessary corrective actions will be taken within a reasonable time frame. The quality assurance officer will verify that such actions are effective and complete and will document their implementation in an audit closeout report to management.

SECTION 9

# Preventive Maintenance

The primary objective of a preventive maintenance program is to promote the timely and effective completion of a measurement effort. The maintenance program should be designed to minimize the downtime of crucial sampling and analytical equipment due to expected or unexpected component failure. In implementing this program, efforts should be focused on the following primary areas:

- Establishment of maintenance responsibilities
- Establishment of maintenance schedules for major and critical instrumentation and apparatus
- Establishment of an adequate inventory of critical spare parts and equipment

## 9.1 Maintenance Responsibilities

Maintenance of laboratory instruments is the responsibility of the participating laboratories. Generally, the laboratory manager or supervisor of a laboratory is responsible for the instruments in his or her work area. This responsible person will establish maintenance procedures and schedules for each instrument.

Maintenance responsibilities for field equipment are assigned to the field team leader for specific sampling tasks. However, the field team using the equipment is responsible for checking the status of the equipment prior to use and reporting problems encountered. The field team is also responsible for ensuring that critical spare parts are included as part of the field equipment checklist. Non-operational field equipment should be removed from service and a replacement obtained.

All field instruments will be properly protected against inclement weather conditions.

## 9.2 Maintenance Schedules

The effectiveness of any maintenance program depends to a large extent on adherence to specific maintenance schedules for each piece of equipment. Other maintenance activities are conducted on an as-needed basis. Manufacturers' recommendations should provide the primary basis for establishing maintenance schedules. Manufacturers' service contracts may be used for implementing the scheduled maintenance.

Each analytical instrument should be assigned an instrument logbook. All maintenance activities will be documented in this logbook. The information to be entered includes the following:

- Date of service
- Person performing service
- Type of service performed and reason for service
- Replacement parts installed (if appropriate)
- Date of next scheduled service
- Any other useful information

## 9.3 Spare Parts

In addition to a schedule for maintenance activities, an adequate inventory of spare parts is required to minimize equipment downtime. The inventory includes those parts and supplies that:

- Are subject to frequent failure
- Have limited useful lifetimes
- Cannot be obtained in a timely manner should failure occur

Field managers and the respective laboratory managers are responsible for maintaining an adequate inventory of spare parts. In addition to spare parts and supply inventories, an in-house source of backup equipment and instrumentation should be available.

SECTION 10

# Data Assessment

## 10.1 Data Quality Assurance

All data generated for this project will be evaluated according to the procedures discussed in Section 7.3. Limitations on data usability will be assigned, if appropriate, as a result of the data validation process described in Section 7.3.

## 10.2 Reconciliation with Data Quality Objectives

The project includes multiple investigation areas. The data for each investigation area will be evaluated against the screening level objectives in Tables 5-1 through 5-3 of this QAPP.

## 10.3 Data Management Plan

All data generated from this project will be handled according to the Faro Mine Data Management Plan.

SECTION 11

# Corrective Action

Corrective action may be required as a result of deviations from field or analytical procedures. Deficiencies identified in audits and data quality assessments may also call for corrective action.

The type of action to be taken requires judgment on the part of personnel directly involved with the situation. There should be a mechanism in place in the laboratory to allow for supervisory review of all deviations or deficiencies. A corrective action reporting system that requires immediate documentation of deviations or deficiencies and for supervisory review of the actions taken to correct them should be established. The corrective action report should include as a minimum:

- The type of deviation or deficiency
- The date of occurrence
- The impact of the deviation or deficiency, such as samples affected
- The corrective action taken

The only time that a corrective action report may be waived is when a deviation or deficiency is immediately corrected and its impact is precluded. An example would be an unacceptable initial calibration that is repeated before samples are analyzed.

Each corrective action report must be reviewed and approved by a person of authority, such as the field team leader or laboratory supervisor. Corrective action reports that could potentially affect data quality must be brought to the attention of the CH2M HILL project chemist. Disposition of the reports will be the responsibility of the project chemist. The project manager may be notified about a particular report at the project chemist's discretion. Copies of corrective action reports must be maintained in the project files.

SECTION 12

# Quality Assurance Deliverables

A data quality report will be submitted by CH2M HILL to the Government of Canada as represented by Aboriginal Affairs and Northern Development Canada and the Government of Yukon.

The results of the data validation will be summarized in the data quality report. The purpose of the report is to succinctly convey the overall results of the QA/QC effort to the reader. The number, matrices, and types of samples that were collected, as well as the tests that were performed, will be discussed. The major findings of the data assessment effort and their potential effects on the project sample data PARCCS will be discussed.

SECTION 13

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