



Quality Assurance Plan

Red Dog Mine, Alaska, USA

Water Quality Monitoring Program for the Integrated Waste
Management Permit 0132-BA002
Alaska Pollution Discharge Elimination System Permit AK0038652

Prepared for

Teck Alaska Incorporated



Prepared by



SRK Consulting (U.S.), Inc.
329100.030
August 2016

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List of Abbreviations

ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish & Game
APDES	Alaska Pollution Discharge and Elimination System
ASTM	American Standard Testing Methods
AWQS	Alaska water quality standards
CATS	Case Adjudication Tracking System
CFR	Code of Federal Regulations
COC	Chain of Custody
DI	deionized water
DMR	Discharge Monitoring Report
DMRQA	Discharge Monitoring Report – Quality Assurance
DQO	data quality objective
EC	electrical conductivity
EPA	U.S. Environmental Protection Agency
IDL	instrument detection limit
IWMP	Integrated Waste Management Permit
MDL	method detection limit
MQO	measurement quality objective
MS	matrix spike
MSD	matrix spike duplicates
MSDS	material safety data sheet
NA	not available
NAC	Northern Air Cargo
NIST	National Institute of Standards and Technology
PQL	practical quantitation limit
QA	quality assurance
QAP	Quality Assurance Plan
QA/QC	quality assurance/quality control
QC	quality control
RL	reporting limit
RPD	relative percent difference
VOA	volatile organic analysis
WAD	weak acid dissociable
WET	whole effluent toxicity
WQS	Water Quality Standards

1 Introduction

The Alaska Department of Environmental Conservation (ADEC) modified Alaska Pollution Discharge Elimination System (APDES) permit AK0038652 on May 8, 2014. This Quality Assurance Plan (QAP) was designed to support compliance with the APDES permit. This QAP serves as a supplemental document to incorporate applicable Alaska water quality standards (AWQS) and effluent limits as described in the Red Dog Monitoring Program, Waste Management Permit # 0132-BA002 (issued on December 2, 2009) for the Integrated Waste Management (IWMP) and APDES permits.

Management of sample collection, transport, custody, documentation, laboratory and field analyses, data management, reduction, and reporting is conducted in accordance with this QAP. This QAP was updated from the *Quality Assurance Plan for Red Dog Mine Water Quality Monitoring Program* (TAK 2014) and complies with the ADEC Quality Assurance Project Plan for Water Quality Monitoring Sampling and Analysis Activities (2011), the U.S. Environmental Protection Agency (EPA) Guidance for Quality Assurance Project Plans (2002) and EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations (2001).

1.1 Project Description

Red Dog Mine is located approximately 90 miles north of Kotzebue, Alaska in the DeLong Mountains. The mine has been in operation since 1989, extracting zinc and lead ore. Major activities at the mine include removing waste rock, extracting ore, processing ore into concentrate, and transporting concentrate to a port facility.

Infrastructure at Red Dog Mine includes the Aqqaluk (active) and Main (inactive) mine pits, mill, personnel accommodations complex, water treatment system, airport, and supporting facilities. The water treatment system includes industrial water treatment plants and a sewage treatment plant.

The industrial water treatment plant consists of the tailings storage facility (TSF), water treatment tanks, a high density sludge clarifier, and sand filters. Water from a variety of sources gravity drain or are pumped to the TSF. These sources may include mill tailings, other mill process waters, water treatment sludge, mine waters, ambient precipitation runoff, primary treatment domestic sewage wastewater, etc. TSF water, often called reclaim water, initially is treated for cadmium removal by adding sodium sulfide in the pipeline while it is pumped to the water treatment tanks. Reclaim water then flows through a series of tanks where reacted lime and recycled solids are added to adjust the pH to approximately 10.3. It is then sparged with compressed air in order to initiate metal hydroxides precipitation. The water then flows to the clarifier feed well, where flocculent may be added, before it enters the clarifier tank. Alternatively, flocculent may be added at the floc mix tank immediately upstream of the clarifier. Finally, treated reclaim water runs through sand filters before being discharged at Outfall 001 at the Middle Fork of Red Dog Creek.

1.2 Project Management Elements

1.2.1 Title and Approvals

Quality Assurance Plan (QAP) for Water Quality Monitoring Sampling and Analysis Activities at the Red Dog Mine.

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ADEC Division of Water (DOW)
Name: Doug Kolwaite
Title: ADEC Quality Assurance Officer
Organization: ADEC DOW
Signature: _____

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Date: _____

1.2.2 Project Organization

Teck Alaska, Inc. (TAK) develops and directs all aspects of the project with guidance from ADEC and EPA protocols. TAK contract laboratories conduct analyses and quality assurance and quality control (QA/QC) in accordance with ADEC and EPA analytical methodologies. TAK mine site personnel, positions, and their duties pertinent to this QAP are described below:

- Project Manager – General Manager of Red Dog Mine and responsible for overall operations of the mine and associated facilities.
- Senior Environmental Coordinator (Water) – directs all aspects of the aquatic biomonitoring and water quality compliance monitoring and sampling for the project.
- Environmental Coordinator(s) – responsible for permitting, regulatory compliance, and oversight of all aspects of implementing the QAP and Field Procedures Manual. The onsite Environmental Coordinator(s) is responsible for monitoring permit compliance, communicating with the ADEC and EPA concerning applicable permit compliance, checking final data packages provided by the laboratory and submitting results to appropriate agencies.
- Environmental Coordinator – Data Quality – responsible for maintaining the quality of field activities, sample collection, sample handling, laboratory and data analysis, and documenting the quality of data at each processing level. The role identifies major aspects of the project requiring specific quality control and demonstrates that quality control is a major focus for the project (e.g., importing laboratory results into the database, checking the final data packages provided by the laboratory, and submitting results to appropriate agencies).

- Environmental Technical Supervisor and Technicians – responsible for planning sample collection events, identifying sample locations in accordance with the APDES permit and the Integrated Waste Management Permit, implementing sample collection procedures and events, sampling the wastewater treatment plant discharge and at other water quality sampling sites, shipping samples, and entering the data into the TAK database.
- Contract Laboratories – responsible for analyzing environmental samples. Contract laboratories have a Director, QA/QC officer, and Project Manager assigned to TAK projects. Laboratory personnel ensure that analytical data are scientifically sound, legally defensible, of known and documented quality, and accurately reflect the material tested. Contract laboratories include:
 - Pace Analytical (Pace) in Minneapolis, MN (1-888-990-7223) with affiliates in Green Bay, WI, and other locations. Performs inorganic analyses.
 - ACZ Laboratories (ACZ) in Steamboat Springs, CO (1-800-334-5493). Performs inorganic analyses.
 - TRE Environmental Laboratory in Fort Collins, CO (1-970-416-0916). Performs toxicology testing.
 - CH2M Hill Toxicological Laboratory in Corvallis, OR (1-541-758-0235). An alternate toxicology testing laboratory.
 - Pollen Environmental Services in Fairbanks, AK (1-907-479-8368). Performs inorganic analyses as well as short hold time analyses (e.g., BOD₅).
 - TAK laboratory located at the mine site (1-907-754-5109). Performs total suspended solids (TSS) and other analyses associated with wastewater treatment plant #2.

Alaska Department of Environmental Conservation Staff/Division of Water

The Project Manager is responsible for ensuring that the permittee complies with required water quality monitoring as specified in the approved QAP. The Project Manager is also responsible for QA review, QAP approval, and oversight of QA activities to ensure collected data meets project's stated data quality goals.

1.3 Project Data Quality Objectives

The objective of the QAP is to be consistent with the terms and conditions of the APDES Permit and the Integrated Waste Management Permit and to accurately measure the chemical constituents and selected physical parameters at Outfall 001, ambient and receiving streams, mine water management stations, and biomonitoring stations. Data Quality Objectives (DQOs) are qualitative and quantitative statements derived from the DQO process that:

- Clarify monitoring objectives (i.e., determine water/wastewater pollutant concentrations of interest and how these values compare to water quality standards regulatory limits).
- Define the appropriate type of data needed. To accomplish monitoring objectives, the appropriate types of data required are defined by the respective water quality standards (WQS). For WQS pollutants, compliance is determined by specific measurement requirements. The measurement system is designed to produce water pollutant concentration data that are of the appropriate quantity and quality to assess compliance.

As a result, DQOs for this project are as follows:

1. Provide procedures for quality control beginning with sample collection and proceeding through data interpretation;
2. Provide procedures to ensure that data are of known and acceptable precision, accuracy, representativeness, completeness, and comparability;
3. Collect samples in accordance with relevant sampling methodologies;
4. Obtain effluent data representative of operations;
5. Package and ship samples to an outside laboratory;
6. Analyze samples using strict QC procedures as outlined in EPA guidance for analytical methodologies;
7. Evaluate and qualify data under the laboratories' QA/QC programs; and
8. Submit data, fully qualified, to the EPA and ADEC, or other stakeholders as needed.

1.3.1 Measurement Quality Objectives

Measurement Quality Objectives (MQOs) are a subset of DQOs and are summarized in Table 1. MQOs are designed to evaluate and control various phases (sampling, preparation, and analysis) of the measurement process to ensure that the total measurement uncertainty is within the range prescribed by project DQOs. MQOs define the acceptable quality (data validity) of field and laboratory data for the project. MQOs are defined in terms of the following data quality indicators:

- Detectability
- Precision
- Bias (accuracy)
- Completeness
- Representativeness
- Comparability
- Traceability

Table 1: Red Dog Project Measurement Quality Objectives (MQOs)

Group	Analyte	ACZ			PACE			Precision (RPD)	Accuracy (% Recovery)	Completeness
		Method	MDL	MRL	Method	MDL	PQL			
General	pH (pH units)	4500-H+	0.05				±0.2	±20%	±0.1	95%
	Temperature	(Field) In situ (electronic probe) EPA 170.1	NA		(Field) In situ (electronic probe) EPA 170.1		0.1°C	±0.2°C	±0.2°C	95%
	Conductivity (mS/cm)	SM 2510	10.0				40	±15%	75-125%	95%
	Cyanide, WAD (µg/l)	SM4500-CN-CE	3.0	10	SM4500-CN-CE	0.6	3.0	±20%	90-110%	95%
	Total Dissolved Solids (mg/L)	SM2540C	10	50	SM2540C	2.83	10.0	±10%	80-120%	95%
	Total Suspended Solids (mg/L)	SM2540C	5	20	SM2540C	2.83	10.0	±10%	80-120%	95%
	Hardness as CaCO ₃ (mg/L)	SM 2340B	Calculation	-	SM 2340B	0.04	1.0	±15%	75-125%	95%
Major Cations	Calcium (dissolved) (mg/L)	EPA 200.7	0.2		EPA 200.7	.522	0.11.0	±20%	75-125%	95%
	Manganese (µg/L)	EPA 200.8/200.7	0.1	0.5	EPA 200.8/200.7	0.0361	1.0	±20%	75-125%	95%
	Magnesium (dissolved) (mg/L)	EPA 200.7	0.2		EPA 200.7	.0193	0.1	±20%	75-125%	95%
	Sodium (dissolved) (mg/L)	EPA 200.7	0.3	1.0	EPA 200.7	0.00518	1.0	±20%	75-125%	95%
	Potassium (mg/L)	EPA 200.7	0.3	1.0	EPA 200.7	0.0404	1,000	±20%	75-125%	95%
Major Anions	Alkalinity as CaCO ₃ (mg/L)	SM 2320B	2.0	20	SM 2320B	0.307	5.0	±20%	75-125%	95%
	Bicarbonate as CaCO ₃ (mg/L)	SM 2320B	2.0	20	SM 2320B	0.307	5.0	±20%	75-125%	95%
	Sulfate (mg/L)	EPA 300.0 rev. 21	10	50	EPA 300.0 rev. 21	0.088	1.0	±20%	75-125%	95%
	Chloride (mg/L)	EPA 300.0 rev. 21	1	5	EPA 300.0 rev. 21	0.015	0.5	±20%	75-125%	95%
Nutrients	Nitrate and nitrite as N (mg/L)	SM 4500NO3-F					0.1	±20%	75-125%	95%
	Aluminum (µg/L)	EPA 200.8/200.7	1	5	EPA 200.8/200.7	0.977	20	±20%	75-125%	95%
Metals	Cadmium (µg/L)	EPA 200.7/200.8	0.1	0.5	EPA 200.7/200.8	0.017	0.1	±20%	75-125%	95%
	Chromium (µg/L)	EPA 200.8/200.7	0.1	0.5	EPA 200.8/200.7	0.0349	2.0	±20%	75-125%	95%
	Copper (µg/L)	EPA 200.8/200.7	0.5	3	EPA 200.8/200.7	0.0785	1.0	±20%	75-125%	95%

Analyte	ACZ			PACE			Precision (RPD)	Accuracy (% Recovery)	Completeness
	Method	MDL	MRL	Method	MDL	PQL			
Iron (µg/L)	EPA 200.7	20	50	EPA 200.7	3.37	10	±20%	75-125%	95%
Lead (µg/L)	EPA 200.8/200.7	0.1	0.5	EPA 200.8/200.7	0.0553	0.1	±20%	75-125%	95%
Mercury (µg/L)	EPA 1631	0.0002	0.0005	EPA 1631	0.00012	0.0005	±20%	75-125%	95%
Nickel (µg/L)	EPA 200.8/200.7	0.6	3	EPA 200.8/200.7	0.0823	2.0	±20%	75-125%	95%
Selenium (µg/L)	EPA 200.8/200.7	1	5	EPA 200.8/200.7	0.00589	0.5	±20%	75-125%	95%
Zinc (µg/l)	EPA 200.8/200.7	2	10	EPA 200.8/200.7	0.469	5.0	±20%	75-125%	95%

Note:

*APDES permit samples are analyzed for total recoverable metals. Integrated Waste Management Permit samples are analyzed for parameters identified according to the Monitoring Plan.

Detectability is the ability of the analytical method to reliably measure a constituent concentration above background. ADEC, Division of Water uses two components to define detectability: the method detection limit (MDL) and the practical quantification limit (PQL) or reporting limit (RL).

- The MDL is the minimum value that the instrument can discern above background but with no certainty as to the accuracy of the measured value. For field measurements, the manufacturer’s listed instrument detection limit (IDL) can be used.
- The PQL or RL is the minimum value that can be reported with confidence (usually some multiple of the MDL).

Note: The measurement method of choice should, at a minimum, have a practical quantification limit or reporting limit 3 times more sensitive than the respective ADEC WQS and/or permitted level (for permitted facilities). Sample data measured below the MDL is reported as ND or non-detect. Sample data measured ≥ MDL but ≤ PQL or RL is reported as estimated data. Sample data measured above the PQL or RL is reported as reliable data unless otherwise qualified per the specific sample analysis.

Precision is the degree of agreement among repeated measurements of the same parameter and provides information about the consistency of the method. Precision is expressed in terms of the relative percent difference between two measurements (A and B).

For field measurements, precision is assessed by measuring replicate (paired) samples collected at the same locations as soon as possible to limit temporal variance in sample results. Field and laboratory precision is measured by collecting blind (to the laboratory) field replicate or duplicate samples. For paired and small data sets, project precision is calculated using the following formula:

$$Precision = \frac{(A - B)}{\left(\frac{(A + B)}{2}\right)} \times 100$$

For larger sets of paired precision data sets (e.g., overall project precision) or multiple replicate precision data (RSD), the following formula is used:

$$RSD = \frac{\textit{Standard Deviation}}{\textit{Mean}} \times 100$$

Bias (accuracy) is a measure of confidence that describes how close a measurement is to its “true” value. Methods to determine and assess accuracy of field and laboratory measurements include instrument calibrations, various types of QC checks (e.g., sample split measurements, sample spike recoveries, matrix spike duplicates, continuing calibration verification checks, internal standards, field and lab sample blank measurements, and external standards), performance audit samples (e.g., Discharge Monitoring Report – Quality Assurance [DMRQA] and blind Water Supply or Water Pollution Performance Evaluation samples from American Association for Laboratory Accreditation, etc.). Bias/accuracy is usually assessed using the following formula:

$$\textit{Accuracy} = \frac{\textit{Measured Value}}{\textit{True Value}} \times 100$$

Completeness is a measure of the percentage of valid samples collected and analyzed that yield sufficient information to make informed decisions with statistical confidence. Project completeness is determined for each parameter using the following formula:

$$\textit{Completeness} = \left(\frac{T - (I + NC)}{T} \right) \times 100$$

Where:

T = Total number of expected sample measurements

I = Number of invalid sample measured results

NC = Number of sample measurements not produced (e.g., spilled sample)

The data quantity must be sufficient to prevent misinterpretation, to detect patterns and trends, and to achieve objectives of the study. Adverse weather is the main uncontrollable factor that may interfere with sampling and affect completeness. Sampling sites may be inaccessible due to a variety of factors, including:

- Snow conditions may prevent accessibility to sample stations;
- High-flowing streams during freshet and during periods of high rainfall may not be crossable and may limit and/or block access to other streams;
- Storms and fog may prevent access to sampling stations by aircraft or other means; and
- Mechanical breakdowns of aircraft, snowmobiles, or the Terra Track can also affect sampling progress.

In addition to the above sampling obstacles, cargo plane delays and cancellations may delay shipment of samples. For those samples with a short holding time, a shipping delay could result in expiration of sample holding time. Completeness for this project is defined as the valid return of the minimum number of required samples collected and analyzed. To prevent an incomplete data

set, monthly samples will be collected early in the month and weekly samples will be collected early in the week so that re-sampling can be conducted, if necessary.

Representativeness is sampling a matrix to describe the matrix (either physically or chemically) at the desired level of accuracy. Obtaining a representative sample in the field is achieved through careful, informed selection of the sampling site and through proper collection and handling of samples to avoid interferences and prevent contamination and analytical loss.

Representativeness assigns what parameters to sample for, where to sample, type of sample (grab, continuous, composite, etc.) and frequency of sample collection.

Comparability is a measurement that shows how data can be compared to other data collected by standard methods. Comparability is demonstrated by referencing the appropriate measurement method as specified in federal and/or state regulatory and guidance documents/methods for the parameter/s to be sampled and measured (e.g., approved ASTM, Standard Methods, and EPA methods as referenced in EPA's Guidelines Establishing Test Procedures for the Analysis of Pollutants ([40 CFR Part 136]).

As with representativeness and completeness, comparability is determined during project development.

Traceability is the extent to which data can be substantiated by hard-copy documentation. Traceability documentation exists in two essential forms: that which links quantification to an authoritative standard and that which explicitly describes the history of each sample from collection to analysis. Chain-of-custody forms follow each batch of samples; from the Red Dog sample preparation room to the contract laboratory and then are returned to Red Dog in the final data package.

1.4 Training Requirements

The Environmental Technical Supervisor is responsible for the implementation and adherence to the QAP. The supervisor is responsible for the proper training of the Environmental Technicians (Table 2).

Environmental Technicians receive extensive on-the-job instruction and training in proper sample collection, handling, and shipping techniques based on ADEC and EPA protocols. The training is supplemented by written standard operating procedures (SOPs). Each individual tasked with sample collection will sign a statement that the individual has read, understands, and will follow the sampling procedures outlined in this plan. TAK requires that all contract laboratories have participated in the previous year's DMRQA study.

Table 2: Training Requirements

Specialized Training/Certification	Field Staff	Lab Staff	Monitoring Supervisor	Lab Supervisor	Project QA Manager & Officer
Safety training	X	X	X	X	X
Water sampling techniques	X		X		X
Instrument calibration and QC activities for field measurements	X		X		X
Instrument calibration and QC activities for laboratory measurements		X		X	X
QA principles			X	X	X
QA for water monitoring systems			X		X
Chain of Custody procedures for samples and data	X	X	X	X	X
Handling and shipping of hazardous goods	X	X	X	X	X
Specific EPA-approved field measurement method training	X		X		X
Specific EPA-approved lab analytical method training		X		X	X

2 Documentation and Records

The Environmental Coordinator – Data Quality is responsible for updating, revising, and distributing the QAP as necessary. The QAP will be updated and amended as procedures are added or changed from the existing plan.

A requirement of the APDES permit (Section II, F) is to maintain records of all monitoring information, including calibration and maintenance records, strip chart recordings, raw datalogger files, copies of all reports, and a copy of the permit, at the mine site for at least FIVE years after the information was generated.

2.1 Field Notes

A field log book is necessary to provide a record of data and observations from sample collection. Log book entries will be made at the time noted, initialed, and dated. Field log book pages will not be removed for any reason. Field log entries will be deleted by drawing a single line through the text, initialed, and dated. Under no circumstance will information be erased or rendered illegible. There should be no blank lines or blank pages between logbook entries. Blank lines or pages should be crossed or lined out, initialed, and dated. Photographs of the field conditions will be noted in the field log book. Each field team will have one person responsible for log book entries. Duties and notes of each field team member will be recorded in the log book.

Field log books will be retained for a minimum of 5 years after the permit expires. At a minimum, the following items need to be recorded in the field logbook:

- Dates and sample collection time
- Weather and other conditions such as ice thickness
- Names of all present
- Samples collected, including any QA/QC samples
- Serial number or identification number of field instruments
- Water quality measurements (instrument readings)
- Specific site location (note if different from designated location)
- Mode of transportation used to get to the sampling site
- Unusual circumstances such as turbid water, low or high flow, discoloration, etc.
- Time, date, and location of photographs

2.2 Analytical Reports

The electronic laboratory analytical report and data are stored indefinitely on the TAK computer server and in the EQUIS database respectively. The analytical laboratory reports and QA/QC packages are maintained for a minimum of five years at the laboratory facility. Table 3 lists all documents and records that will be produced and their location and retention time.

Table 3: Project Documents and Records

Categories	Record/Document Types	Location	Retention Time
Site Information	Network description	QualTrax (APDES & IWMP Permit)	Indefinite
	Site characterization file	QualTrax (APDES & IWMP Permits)	Indefinite
	Site maps	QualTrax (APDES & IWMP Permits)	Indefinite
	Site pictures	QualTrax (APDES & IWMP Permits)	Indefinite
Environmental Data Operations	QA Project Plan	QualTrax	Indefinite
	Field Method SOPs	QualTrax	Indefinite
	Field Notebooks	Environmental Coordinator's Water Office	5 years after permit expires
	Sample collection/measurement records	EQuIS Database	Indefinite
	Sample Handling & Custody Records	EQuIS Database	Indefinite
	Chemical labels, MSDS sheets	TAK Electronic MSDS System	Indefinite
	Inspection/Maintenance Records	Environmental Technical Supervisor Office	5 years after permit expires
Raw Data	Lab data (sample, QC and calibration) including data entry forms	TAK Computer Server/EQuIS Database	Indefinite
Data Reporting	Discharge Monitoring Reports (DMRs, for permitted facility)	Environmental Library/Archive and/or TAK Computer Server	5 years after permit expires
	Progress reports		
	Project data/summary reports		
	Lab analysis reports		
	Investigation summary (CATS)		
	Inspection Report		
Data Management	Data management plans/flowcharts	EQuIS Database	Indefinite
	Data algorithms	EQuIS Database	Indefinite
Quality Assurance	Control charts	Environmental Library/Archive or TAK Computer Server or EMS System (SiteLine)	5 years after permit expires
	Data quality assessments		
	DMRQA and PE samples		
	Site audits		
	Lab audits		
	QA reports/corrective action reports		
	Response		
	Performance Evaluation Samples		

3 Sample Collection and Management

3.1 Sample Site Selection and Locations

Stream sampling sites near the confluence with upstream tributaries may prove difficult to collect a representative sample. The influx from upstream tributaries or point discharges may result in a chemically-heterogeneous stream for a short distance downstream of the confluence. Eventually, the different sources of water are mixed downstream to produce a chemically-homogeneous stream. The permanent sampling stations were established at well-mixed stretches of streams and are located at stations 12, 140, 150, 151, and 160.

Other site selection factors that may affect sample site locations are single or multiple channels, sloughing banks, structures affecting hydraulics, low flow to high flow continuity, debris, aquatic growth, springs, ice, depth, turbulence, sediment historical records, accessibility, and safety considerations.

Sampling sites are generally located in straight reaches of the channel where the flow is relatively uniform. Sites just above or below confluences or point sources will be avoided to minimize problems caused by backwater effects or poorly mixed flows. To obtain a representative sample from stations, grab samples are collected from a section of the creek that is well mixed and representative of the total flow in the creek. If necessary, the sample is composited across the stream to form one grab sample. Observations of any factors that may have affected the samples are recorded and kept on file.

3.2 Sampling Locations and Frequencies

Sample collection to comply with the APDES permit #AK0038652 is for Outfall 001 and five receiving water and ambient monitoring stations (Figure 2). Outfall 001 is downstream of the last treatment step (sand filtration inside of the sand filter building) before discharge to the receiving environment. The permit designates the sample collection stations in Section I, C of the permit. Sample collection stations are permanently established at well-mixed reaches of streams and are designated as Stations 12, 140, 150, 151, and 160. The sample parameters, analytical methods, and frequency of collection in accordance with the APDES permit #AK0038652 are summarized in Tables 4 and 5.

Additional monitoring stations and locations have been established to comply with the Red Dog Mine Integrated Waste Management Permit (IWMP) monitoring program. The sample frequency of collection, analytical methods, and parameters required under the IWMP monitoring program are summarized in Tables 6 and 7, respectively. Table 7 lists the analytical water quality parameters for Profile I and Profile II as identified for applicable samples listed in the *Red Dog Mine Monitoring Plan*, Waste Management Permit # 0132-BA002.

Samples will be collected consistently at locations representative of the entire stream flow. Sampling at the same location for each sampling event is preferred, but at times this is not practical or representative of the source being sampled. In such cases, the sample location may be adjusted. Factors that may affect the sample locations are single or multiple channels, sloughing banks, structures affecting hydraulics, low flow to high flow continuity, debris, aquatic growth, springs,

groundwater influences, ice, depth, turbulence, sediment, historical records, accessibility and safety considerations. Temporary changes in sample locations should be noted in field log books.

Sampling sites will be located in generally straight reaches of the channel where the flow is relatively uniform. Sites just above or below confluences or point sources will be avoided to minimize problems caused by backwater effects or poorly mixed flows. To obtain a representative sample from Stations 140, 12, 9, 150, 160, and 151 a grab sample will be collected from a section of the creek that is well mixed and representative of the total flow in the creek. If necessary, the sample will be composited across the stream to form one grab sample. Observations of any factors that may have affected the samples will be recorded and kept on file.

Samples are collected at locations known to be representative of the entire flow. If for any reason the sampling event has caused disturbed conditions such as increased turbidity, the sampling event should be postponed until normal conditions are re-established.

Surface Water Sampling Standard Operating Procedure (Qualtrax document 2291) and Sump Water Sampling Standard Operating Procedure (Qualtrax document 2292) will be followed when collecting stream and/or sump samples.

Figure 1: Mine Monitoring Locations

Table 4: Red Dog Mine APDES Permit #AK0038652 Sampling Schedule

Location	Frequency	Type	Analysis
Outfall 001	Continuously	Grab	Cumulative Flow
Outfall 001	Daily	Grab	Temperature
Outfall 001	1/Week	Grab	CN (WAD), pH, Conductivity
Outfall 001	1/Week	24 hr. Comp.	Cd, Cu, Se, Ni*, TDS, TSS
Outfall 001	1/Month	24 hr. Comp.	Ba, Al, Cr, Hg, Fe, Mn, Pb, Zn, *Carbonates, Chlorides, Sulfate, Ca, K, Mg, Na
Outfall 001	1/Week	24 hr. Comp.	NH ₃ -N
Outfall 001	1/Month	Grab	Turbidity
Outfall 001	1/Year	24 hr. Comp.	Organic Priority Pollutant Scan
Outfall 001	1/2 Months	Grab	Fecal Coliform
Outfall 001	1/Month	24 hr. Comp.	BOD
Outfall 001	1/Month	Grab	Total Residual Chlorine
Outfall 001	1/Month	24 hr. Comp.	Whole Effluent Toxicity
Station 151	2/Day	Grab	Flow
Station 151	1/Week	Grab	TDS***, Conductivity
Station 151	1/Month	Grab	**Carbonate, Chloride, Sulfate, Ca, K, Mg, Na
Station 151	2/Month	Grab	Al, Cd, Cr, Cu, CN(WAD), Fe, Pb, Mn, Hg, Ni, Se, Zn, NH ₃ -N, Hardness, Temperature, pH,
Station 150	1/Week	Grab	TDS, Conductivity
Station 150	1/Month	Grab	Carbonate, Chloride, Sulfate, Ca, K, Mg, Na
Station 140	2/Month	Grab	Al, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, Zn, NH ₃ -N, Cond., Hardness, Temperature, TDS, pH, Turbidity
Station 12	2/Month	Grab	Al, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, Zn, NH ₃ -N, Cond., Hardness, Temperature, TDS, pH, Turbidity
Station 160	1/Week	Grab	TDS, Conductivity
Station 160	1/Month	Grab	**Carbonate, Chloride, Sulfate, Ca, K, Mg, Na
Station 160	2/Month	Grab	Al, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, Zn, NH ₃ -N, Hardness, Temperature, pH

Notes:

* All metals total recoverable

** Carbonates estimated based on direct measurement of alkalinity

*** Calculate allowable TDS at Station 151 using the following equation: $Q_{allowable} = Q_E + (Q_{151(total)})(1500 - C_{151(total)}) / (C_E - 1500)$

Table 5: Red Dog Mine APDES AK0038652 Sample Parameters

Parameters	Method	Preservative	Holding Time	Sample Bottle
Acidity	SM 2310B	<6°C	14 days	1 L plastic
Alkalinity	SM 2320B	<6°C	14 days	1 L plastic
Aluminum	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Ammonia as Total-N	SM 4500 NH ₃	H ₂ SO ₄ , <6°C	28 days	250 mL plastic
Base Neutral & Acids	EPA 625	<6°C	7 days	1 L amber glass
BOD	not applicable	<6°C	48 hours	1 L plastic
Barium	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Calcium	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Cadmium	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Chloride	EPA 300.0 rev 2.1	<6°C	28 days	1 L plastic
Chromium	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Copper	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Cyanide, WAD	SM 4500-CN-E	NaOH, <6°C	14 days	1 L plastic
Hardness as CaCO ₃	SM 2340B	HNO ₃ , <6°C	6 months	250 mL plastic
Iron	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Lead	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Magnesium	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Manganese	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Mercury	EPA 1613	HCl <6°C	28 days	250 mL plastic
Nickel	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Potassium	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Selenium	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Sodium	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
Sulfate (SO ₄)	EPA 300.0 rev 2.1	<6°C	28 days	1 L plastic
Total Dissolved Solids (TDS)	SM 2540C	<6°C	7 days	1 L plastic
Total Purgeable Organics	EPA 624	HCl, <6°C	14 days	40 mL VOA
Total Suspended Solids (TSS)	SM 2540D	<6°C	7 days	1 L plastic
Whole Effluent Toxicity	EPA/600-4-91-002	None	36 hours	1 gal Cubitainers®
Zinc	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
pH	field instrument / field analysis kit	not applicable	15 minutes	in situ analysis/ 125 mL plastic bottle
Temperature				
Conductivity				
Turbidity				
Chlorine, Total Residual				
Fecal Coliform	SM 9221 / 9222	Sodium thiosulfate	6 hours	250 mL plastic

Table 6: Red Dog Mine Water Quality Profile Parameters

Monitoring Profile	Parameters	Method	Preservative	Holding Time	Sample Bottle*
Water Quality Profile I	Aluminium ¹	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
<i>Ambient surface water quality monitored as part of the Biomonitoring Program</i>	Calcium ¹	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Cadmium ¹	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Chloride ¹	EPA 300.0 rev 2.1	<6°C	28 days	1 L plastic
	Iron ¹	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Potassium ¹	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Magnesium ¹	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Sodium ¹	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Lead ¹	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Selenium ¹	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Zinc ¹	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Alkalinity	SM 2320B	<6°C	14 days	1 L plastic
	TDS	SM 2540C	<6°C	7 days	1 L plastic
	TSS	SM 2540D	<6°C	7 days	1 L plastic
	Sulfate (SO ₄)	EPA 300.0 rev 2.1	<6°C	28 days	1 L plastic
	pH	field instrument	not applicable	15 minutes	in situ analysis
	Temperature				
	Conductivity				
Water Quality Profile II	Aluminum ²	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
<i>Water quality monitored as part of the Mine Water Management Program</i>	Calcium ²	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Cadmium ²	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Chloride ²	EPA 300.0 rev 2.1	<6°C	28 days	1 L plastic
	Copper ²	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Iron ²	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Potassium ²	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Magnesium ²	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Manganese ²	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Sodium ²	EPA 200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Lead ²	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Zinc ²	EPA 200.8/200.7	HNO ₃ , <6°C	6 months	250 mL plastic
	Ammonia Nitrogen (NH ₃ -N)	SM4500 NH ₃	H ₂ SO ₄ , <6°C	28 days	250 mL plastic
	Acidity	SM 2310B	<6°C	14 days	1 L plastic
	TDS	SM 2540C	<6°C	7 days	1 L plastic
	Sulfate (SO ₄)	EPA 300.0 rev 2.1	<6°C	28 days	1 L plastic
	pH	field instrument	not applicable	15 minutes	in situ analysis
	Temperature				
Conductivity					

Notes:

¹ = total recoverable metals

² = dissolved metals

* Sample bottle volumes can vary per laboratory. The sample bottle volumes in this table are to be considered as general guidance.

Table 7: Red Dog Mine IWMP Monitoring Plan Sampling Schedule

Location	Frequency	Type	Analysis
Station 9	2/Month	Grab	Water Quality Profile I
Sulfur creek	1/ Month	Grab	Water Quality Profile I
Shelly Creek	1/ Month	Grab	Water Quality Profile I
Connie Creek	1/ Month	Grab	Water Quality Profile I
Rachel Creek	1/ Month	Grab	Water Quality Profile I
Station 145	1/ Month	Grab	Water Quality Profile I
Station 150	1/ Month	Grab	Water Quality Profile I
Main Dam Seepage Pumpback	1/ Month	Grab	Water Quality Profile II
East Overburden Sump	1/ Month	Grab	Water Quality Profile II
West Overburden Sump	1/ Month	Grab	Water Quality Profile II
Tailings Water	1/ Month	Grab	Water Quality Profile II
Reclaim Water	1/ Month	Grab	Water Quality Profile II
WTP3 Influent from Main Waste Stockpile	1/ Month	Grab	Water Quality Profile II
WTP3 Effluent	1/ Month	Grab	Water Quality Profile II
Mine Sump Collection Water	1/ Month	Grab	Water Quality Profile II
Buddy Creek	2/ Month	Grab	Water Quality Profile I
Buddy 221	2/ Month	Grab	Water Quality Profile I
Bons 220	2/ Month	Grab	Water Quality Profile I
Lower Bons Creek	2/ Month	Grab	Water Quality Profile I
Upper Bons Creek	2/ Month	Grab	Water Quality Profile I
Bons Reservoir	2/ Month	Grab	Water Quality Profile I
Dudd Creek	2/Month	Grab	Water Quality Profile I

3.3 Sampling Containers

Sample containers are provided by the laboratory or supplier in custody-sealed coolers or other shipping containers. Sample containers from laboratories include appropriate preservatives and are pre-labeled. Environmental personnel receiving sample bottles will ensure their custody has not been compromised. Tables 5 and 7 include a summary of the sample containers and preservatives needed for each parameter.

3.4 Sample Collection Methods

Preventing direct or cross-contamination is of primary importance and all reasonable precautions are taken to avoid contamination. The sample container is used for collection of grab samples in order to avoid cross-contamination that could result from use of a separate collection device. For composite samples, a Sigma brand sampler is used. In this case, a collection container is used and, upon termination of the sample collection, the sample is agitated for homogenization before it is transferred into the sample container(s).

At Outfall 001, a 24 hour composite sample will be collected with a Sigma composite sampler. Before each sample is collected, the instrument will be rinsed with a 10% nitric acid solution followed by three distilled water rinses.

There is a dedicated log book located with the Sigma sampler for the field personnel to record information during the sampling event. The dedicated log book is a bound, all-weather field notebook with pre-numbered pages and no missing pages. Only indelible ink should be used to record entries in the logbook. The logbook should contain the following information:

- Start and stop times for composite sample
- Time sample was collected
- Number of aliquots taken
- Size of aliquots and approximate total volume
- Count setting for flow proportionate samples
- Cabinet temperature
- Note that collection jug was cleaned
- Note when equipment blank was collected
- Note when sample tubing was changed

The rest of monitoring program samples are grab samples collected directly in bottles provided by the laboratory. For sample bottles containing preservative, it is imperative that the sample container is not overfilled.

A new pair of disposable, powder-free latex gloves is worn at each sampling site. Samplers do not touch the lip of the container, the inside of the cap, or inside of the container with their gloved hands. When transferring sample from a collection container to a sample container, the collection container is not allowed to touch the lip of the sample container. Samplers manage container caps so they do not become contaminated. After sampling, the cap is securely placed onto the container and it is transported in a cooler on ice- or frozen gel-packs back to the mine site, where it is stored at <6°C until shipped to the analytical laboratory.

3.5 Clean Hands/Dirty Hands Techniques

Some sampling events for trace metals require ultra-clean sampling methods. Low level mercury (Hg 1631) is one example. During these sampling events “clean hands/dirty hands” techniques shall be used. One sampler is designated as the “clean hands” sampler and handles the sampling equipment and the sample bottles. The “clean hands” sampler should not touch anything other than equipment intended to come in direct contact with the sample. The sampler designated as “dirty hands” will assist the “clean hands” sampler by handling items used to protect sampling equipment from contamination, such as containers used to transport sampling equipment and sample containers to and from the field.

If at any time the roles of the samplers reverse, their gloves will be replaced with new gloves before continuing!

All field measurements are taken directly in the effluent or stream flow. If a sample is needed for a laboratory analysis of pH, total residual chlorine, or turbidity, it is collected or an aliquot is split out in a separate clean container and discarded after use. An instrument probe is never placed into any sample that will be used later for another analysis.

3.6 Field QA/QC Sample Collection

Trip blank samples will be used to measure bias in samples such as the priority pollutant scan. The trip blank accompanies the primary samples from the lab to the site and is returned to laboratory. They are never to be opened by samplers. A trip blank is provided for each cooler of samples and is indicated on the chain of custody (COC).

Field blank samples are collected from deionized (DI) water brought to the sample collection location and decanted to a sample container. The transfer utilizes the same sample collection techniques and container used to collect the primary sample. Field blank samples provide a measure of bias associated with sample management, sample collection techniques, and/or from the ambient conditions. Field blanks are collected at a minimum of 5% of the primary samples collected: one field blank for every 20 primary samples. Field blanks are analyzed for the same suite of analytes as the primary sample associated with the specific location.

Equipment blanks are collected to measure the potential cross contamination associated with sample collection equipment such as Sigma samplers, pumps, and bailers. A grab sample of DI water is collected utilizing the Sigma collection tubing and a clean sample collection container. Equipment blanks are collected at a minimum of 5% of the primary samples collected: one equipment blank for every 20 primary samples. Equipment blanks are analyzed for the same suite of analytes as the primary samples.

Field duplicate samples provide a measure of precision of the sample collection effort. Duplicate samples are collected in a single container from which equal aliquots are transferred to separate sample containers. Field duplicate samples are collected at a minimum of 5% of the primary samples: one field blank for every 20 primary samples. Field duplicates are analyzed for the same suite of analytes as the primary sample and sent blind to the laboratory.

Field split samples are collected to measure precision. Split samples are collected in a single container from which equal aliquots are transferred into two or more separate sample containers. This process is repeated until all sample containers have been filled to the appropriate volume. Split samples may be sent to the same laboratory or to different laboratories to be analyzed by the same methods.

3.7 Sample Preservation and Holding Times

Samples are preserved to prevent chemical, physical, and biological processes from changing the concentration of analytes at the time of sampling. These processes include oxidation, reduction, precipitation, ion exchange, co-precipitation, volatilization, gas exchange, biological metabolism, and cell growth or lysis. Sample preservation methods may include storing at less than 6°C, exclusion of air, chemical preservative, proper container, and prescribed holding time prior to analysis. Preservation methods and holding times are in accordance with 40 CFR Part 136 EPA and/or ADEC methods are summarized in Tables 5 and 7.

Some properties or constituents may change within a few minutes or hours regardless of preservation techniques. Therefore, immediate analysis in the field is required for parameters such as temperature, conductivity, total residual chlorine, and dissolved oxygen.

3.8 Storage of Samples

Samples are stored under the direct control of the Environmental Department until relinquished to the shipper. The Environmental Clean Room and Bucking Room are kept locked at all times unless Environmental Personnel are present. The Environmental refrigerator is also kept locked unless adding or removing samples. Samples being stored after sample collection but before being shipped to the analytical laboratory are refrigerated at $<6^{\circ}\text{C}$. The temperature of the refrigerator is monitored and recorded on the log-sheet located on the refrigerator. If the temperature is found to be $>6^{\circ}\text{C}$, the maintenance department is notified and samples are moved to another refrigerator to ensure storage is maintained at $<6^{\circ}\text{C}$. Samples are shipped to the laboratory in insulated coolers with sufficient ice- and/or frozen gel-packs to maintain sample temperatures at $<6^{\circ}\text{C}$. A temperature blank is placed in each cooler shipped so temperature can be confirmed by laboratory upon receipt.

3.9 Sample Labels

A permanent marker is used to identify each sample collected by location, date, time, dissolved or total, and TAK sample number.

Sample containers are labeled with a sample identification number generated by the TAK database. Information such as the sample location, collection date and time, preservative, and environmental technician name(s) are included on the label.

3.10 Sample Log

The TAK computer Environmental database maintains records of all samples collected for analysis. Included are the sample number, sample location, date, time, sampler, analysis required, preservative, shipping destination, and results of field or in-house tests such as pH, temperature, conductivity, dissolved oxygen, and turbidity. Occasionally an alternative sample log will be used to record sample information and generate a COC. In these cases, the Environmental Coordinator – Data Quality will work to get all data imported into the database.

Environmental personnel are responsible for maintaining the database. Only designated personnel have access to this function of the database. The information is entered into the database at the earliest available time after the samples have been collected. The final analytical laboratory results are maintained in the database.

3.11 Chain of Custody

The COC provides an accurate written record of the sample custody from collection time through analyses. Figure 3 shows an example of a COC form generated using the TAK EQUIS database system.

The COC record includes sample and project information. One copy is retained by TAK, a second is retained by the laboratory, and a copy of the original is returned to TAK with the final data package.

The environmental technician fills out the COC, packages the samples for shipment, and is responsible for reviewing the COC for accuracy and completeness.

3.12 Packaging and Shipping

Sample containers are checked for secure closure and complete correct labels. A copy of the completed COC is taped to the inside lid of the cooler. Samples are protected with packing material such as bubble wrap and securely closed. A signed and dated custody seal or custody tape is secured across at least one side of the cooler to provide a proof of custody. Sample coolers are typically shipped to Anchorage, Alaska by Northern Air Cargo (NAC). For samples going to laboratories outside of Alaska, a freight forwarding company transfers the coolers from NAC to a commercial air freight company.

3.13 Samples with Special Requirements

3.13.1 Metals Analysis

Samples collected for analyses of metals will be further prepared for the total recoverable and dissolved metals analysis. The total recoverable fraction is representative of the ambient conditions. The dissolved fraction will be filtered through a 0.45 µm filter by the sampler prior to being placed in the sample container with the appropriate chemical preservation. These samples will be clearly identified as "filtered" or "dissolved" in the sample identification.

3.13.2 Whole Effluent Toxicity

Whole Effluent Toxicity (WET) tests for *Ceriodaphnia dubia* will be conducted on Outfall 001. EPA guidance for WET tests requires daily renewal of test solution with a new sample being used every other day for effluent samples (i.e., Outfall 001). This necessitates the collection and shipment of three sample aliquots (the initial sample and two refresh aliquots) over a five day period. The test date and sample number are associated with the first WET sample aliquot collected.

Due to the remoteness, weather conditions, and shipping logistics, the EPA allows a 36-hour sample holding time which can be extended to 48 hours with notification. Longer holding times (>48 hours) can be allowed with approval from EPA provided the sample aliquots are maintained at <6°C. Additionally, with approval from EPA, a WET test can be completed without one or both of the refresh aliquots.

With the potential exceptions noted above, WET tests shall be conducted as specified in Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, most recent edition, EPA/600-4-91-002.

3.13.3 Cyanide Samples

Samples collected for Weak Acid Dissociable (WAD) cyanide analysis are screened for the presence of sulfides. A sulfide scan is conducted by placing a drop of unpreserved grab sample

(125 mL collected for field tests) on lead acetate test paper previously moistened with acetic acid buffer solution at pH 4. Darkening or blackening of the paper indicates presence of sulfides. Each time the sulfide test is performed, it is recorded in the technician's field book and the environmental monitoring database along with results of the test. Sulfides have never been detected in Red Dog samples; however, if they are present, the discharge sample would need to be submitted to the TAK Assay Laboratory for "fixing" prior to being placed in the pre-preserved sample bottles.

A detailed Standard Operating Procedure (document number 159) for Cyanide sampling at Outfall 001 is stored in Red Dog's Qualtrax document control database.

3.13.4 Total Residual Chlorine

The analysis of total residual chlorine (TRC) is conducted within 15 minutes of sample collection. Sample collection and the TRC analysis time are recorded in the Outfall 001 dedicated logbook to verify that the sample was analyzed within 15 minutes of sample collection.

4 Field Measurements

Environmental Technicians will determine the field and analytical samples to be collected before the sample collection event. Field equipment employed includes the Sigma composite sampler, conductivity meters, dissolved oxygen meters, pH meters, flow rate meters, and discreet interval samplers. Field equipment will be calibrated, operated, and maintained according to manufacturers' instructions.

4.1 Flow Measuring

4.1.1 Outfall 001

Flow is measured continuously from Outfall 001 by SONARtrac flow meters. The flow meters are routinely maintained and inspected for operational soundness. Daily flow is electronically recorded in the mill process system (PI) database.

4.1.2 Stream Flow Measuring

Stations 12, 140, 150, 151, and 160 are equipped with instruments and dataloggers to measure and record stage (water surface elevation) every 30 minutes. Instrument systems used are summarized in Table 8.

Table 8: Stream Gauging Equipment

Site	Stage Determination*	Datalogger	Telemetry
Station 12	Bubbler – Pressure Transducer	Campbell Scientific CR-1000	Spread Spectrum
Station 140	Pressure Transducer	Campbell Scientific CR-1000	Spread Spectrum
Station 150	Bubbler – Pressure Transducer	Campbell Scientific CR-1000	Spread Spectrum & Iridium Satellite uplink
Station 151	Bubbler – Pressure Transducer	Campbell Scientific CR-1000	Spread Spectrum & Iridium Satellite uplink
Station 160	Bubbler – Pressure Transducer	Campbell Scientific CR-1000	Spread Spectrum & Iridium Satellite uplink

* A Submerged Pressure Transducer may be used as backup stage determination at any station.

The stage is converted to stream flow by an established rating equation for each station. The rating equation is developed by relating actual stream flow measurements to representative stream stages as measured during the season.

Stream flow measurements, calibrations, and calculations are conducted according to U.S. Geological Survey standard operating procedures defined in *Measurement and Computation of streamflow: Volumes 1 and 2, Geological Survey Water-Supply Paper 2175, 1982*.

During inspections the overall condition of each station and its equipment are assessed and a manual measurement of the water surface elevation is recorded, “tape down.” The tape down measurement is compared to measured data and any transducer drift corrected. At a minimum, an actual stream flow measurement is conducted monthly at each station. Activity at the stations

is documented in field log books and the gauge house sheets. Gauge house sheets maintain notes on tape downs, drift corrections, calibration changes, date, time, and personnel.

4.2 Total Dissolved Solids Estimation

Total dissolved solids (TDS) can be estimated from conductivity and temperature data. Based on temperature, raw conductivity data are converted into specific conductivity (SC), which can then be related to TDS concentrations. The following equations are used.

$$SC = \frac{EC_{\text{field}}}{1+T_f(T - 25)} \quad \text{Equation 1}$$

Where:

SC = Specific conductance

EC_{field} = Electrical conductivity, field determined (mS/cm)

T = Temperature (°C)

T_f = empirically derived temperature coefficient.

$$TDS = m \times (SC + b) \quad \text{Equation 2}$$

Where:

TDS = Total dissolved solids (mg/L)

m = slope

SC = Specific conductance from Equation 1

b = y- intercept

Estimated TDS concentrations at Stations 150, 151, and 160 are used to control the discharge rate from Outfall 001 relative to in-stream TDS limits. Coefficients and variables from Equations 1 and 2 have been established for the stations and are periodically updated with new data.

Stations 150, 151, and 160 are fitted with a Great Lakes Instruments Model 3600E electrodeless conductivity sensor and a Dryden Instrumentation bi-metal thermistor type temperature probe. Conductivity probes are checked weekly for accuracy against a calibrated hand held non-temperature compensated conductivity meter. Temperature probes are checked monthly in an ice water solution.

4.3 Evaporation and Precipitation

Daily evaporation and precipitation data requirements are outlined in the Section 1 D of the APDES Permit #AK0038652. A meteorological station between the airport and Bons Reservoir is operated to meet requirements for air modeling purposes and to provide meteorological data for the mine.

4.4 Field Instrument Maintenance

Instruments used for field analysis are operated, calibrated, and maintained according to the manufacturers' guidelines and recommendations. The Environmental Technical Supervisor is responsible for determining that instruments are properly calibrated for the appropriate parameter, range, and accuracy for the test being performed. Written calibration SOPs have been developed

for each specific instrument based on the manufacturers’ operating manuals and recommendations.

Field instruments are inspected at the start and finish of each day to ensure proper operating conditions. Malfunctions or irregularities in operation are noted and the necessary repairs made. Back-up instruments are available in case of malfunctions and are also used as a check to verify that equipment is functioning properly. Table 9 lists the field instruments and the calibration frequencies.

Table 9: Field Instruments and Calibration

Instrument	Calibration Frequency
pH Meter	Daily (every day used) Replace probe annually
Temperature Probes	Monthly (crosscheck with NIST thermometer)
Dissolved Oxygen	Daily (every day used)
Turbidimeter	Calibrate bimonthly as used with primary standards Check secondary standards daily as used.
Total Residual Chlorine	Check secondary standards daily as used, zero each sample Accuracy check annually
Conductivity Meter	Daily (every day used)

Calibrations and solution standards documented by lot numbers and expiration dates are recorded. Calibrations are recorded in a calibration log book. The log book is a bound notebook with pre-numbered pages and no missing pages. Only indelible ink is to be used to record entries in the logbook. The log book contains:

- Calibrator’s name
- Instrument name and model
- Date and time of calibration
- Standard lot numbers used and their source
- Temperature
- Results of calibration
- Calibration acceptance criteria
- Corrective actions, if any taken

4.5 Field Equipment

Prior to sampling, field personnel determine the types of samples to be collected and field measurements required in order to assemble the proper sampling equipment. Equipment is checked for proper operation. Maintenance work and calibrations are performed if necessary. Types of field equipment used include a Sigma composite sampler, conductivity meters, dissolved oxygen meters, pH meters, velocity meters, ice augers, snowmobiles, discreet interval samplers, dredges, temperature probes, and tape measures. All equipment is operated and maintained according to manufacturers’ instruction manuals.

5 Analytical Procedures

Analyses and associated methods are presented in the QA/QC manual of the contract laboratory performing the analysis. The documents are available on request from the laboratory or from the TAK Environmental Superintendent. The laboratory may substitute alternative methods for those specified in the permit or this QAP provided they are validated, standardized, referenced, and approved by the EPA and ADEC for waste waters.

This includes sample preparation and preservation methods. The laboratory will meet or exceed established control limits for the methods as published by the EPA for accuracy, precision, and sensitivity. Analysis of laboratory method blanks, spiked samples, duplicate samples, and reference standard are used to assess these parameters. Approximately five percent of the total number of samples should be devoted to internal laboratory QA checks. Appropriate corrective measures, as outlined in the analytical methods, will be required when QC results fall outside established control limits.

5.1 Quality Control Requirements

Data quality indicators provide a measure of the precision, accuracy, and comparability of analytical results. Laboratories have developed QC objectives for precision and accuracy to determine the acceptability of the data. The QC limits are either specified in the methodology or are statistically derived and are based on the laboratory's actual historical data for each analytical method. QA/QC methods follow guidance contained in EPA, Methods for Chemical Analysis for Water & Wastes, EPA 600/4-79-020, revised March 1983, and Test Methods for Evaluating Solid Waste, Physical Chemical Methods, SW-846, Fourth Edition, 2002.

5.2 Calibration Procedures and Frequency

The analytical laboratories document calibration procedures and frequency as specified in manufacturers' guidelines and recommended by EPA methods. Temperature control devices, analytical balances, and water purification systems, as well as the analytical instruments, are calibrated. Calibration standards will be used to demonstrate that instrument performance does not cause excessive error or bias in the analysis. The calibration will indicate instrument linearity, stability, and sensitivity of instrument conditions prior to and during analysis.

5.3 Data Reduction, Validation and Reporting

Data generated by the laboratory are reviewed by the laboratory in comparison to guidelines established in EPA SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. Analytical protocols are in accordance with 40 CFR 503.8 and 40 CFR 136.3. Analytical data generated are reviewed by comparing calibration, accuracy, and precision to the QC criteria listed in the method description. Integrity of data is assessed through the use of method blanks, matrix spikes, laboratory duplicates, laboratory control standards, and laboratory control standard duplicates. In addition, linearity of calibrations curves, system sensitivity, and QC standards are checked.

Laboratory data calculations and reductions are performed as described in the applicable method references. Raw data including laboratory worksheets, notebooks, sample tracking records,

instrument logs, standard and sample preparation logs, calibration data, and associated quality control records are retained by the laboratory for a minimum of five years, and available for inspection if necessary.

Laboratory reports contain the project title, date of report, name, address, and telephone number of laboratory, sample identification number and matrix, and date of analysis, to ensure that analysis results can be correlated with sampling information. Comments relevant for interpretation of data should be included on the laboratory report. Analyst and laboratory approval signatures should be included. The report should be signed by the laboratory manager, quality assurance manager, or project manager. Laboratory reports include the analysis results and a QC report.

Data for each parameter analyzed are recorded including the parameter name, analytical result with reporting limit, units associated with the results and reference to the analytical method employed. In addition, results of associated quality control analyses, including laboratory method blanks, spike recoveries, and duplicate samples are submitted with each report.

The laboratory director of each laboratory providing measurement results in support of the APDES discharge permit AK0038652 is required to sign the following statement:

"I certify that the measurement results in support of this permit, APDES permit AK0038652, are in compliance with requirements under 40 CFR 136 and other analytical requirements specified in this permit.

Signature: _____ Date: _____"

5.4 Quality Control Checks

Laboratory QC will comprise at least five percent of each data set generated and will consist of blanks, duplicates, standards, spikes, and quality control check samples. Depending upon the particular method used a minimum of one spike or laboratory replicate per twenty samples is analyzed for every analytical run.

5.5 Laboratory Blanks, Fortified and Replicated Samples

A method blank is analyte-free water that is subjected to the analytical process to demonstrate that the analytical system is not contaminated. A method blank is included with either every batch of samples in the laboratory, every twenty samples, or as stated in the method requirements, whichever is more frequent.

Analytical precision is measured by comparing laboratory duplicate data. The laboratory will duplicate an analyte in every batch of samples.

A matrix spike is a known amount of analyte which is added to a sample. Spike recovery measures the effects of interferences on the accuracy of the analysis. A matrix spiked sample is prepared for every twenty samples run in a batch. The relative percent difference between matrix spike (MS) samples and matrix spike duplicates (MSD) is a measure of the batch precision for a particular analytical method.

6 Reporting – Data Management

Preliminary data are, if requested, emailed from the laboratory to the Environmental Coordinators or Environmental Technical Supervisor. Generally, the laboratory will immediately notify the Environmental Department if preliminary data indicate a potential violation of the APDES permit limits. Potential violations are noted and if confirmed by the final analytical report, reported to the EPA, ADEC, Alaska Department of Fish & Game (ADF&G), and other agencies, as appropriate.

Contract laboratories email final data packages that can be directly imported into the EQiS database.

Environmental Coordinators are responsible for managing data, ensuring it is imported into the database, and submitting monthly reports to the appropriate agencies.

All data required by APDES permit #AK0038652 are reported to the EPA, ADEC, and ADF&G by the 20th day of the following month.

7 Assessment and Response

7.1 Non-valid Data

Data which are found to be non-valid after reviewing procedures (validation/verification) may require corrective action. Non-valid data exist when accuracy and precision requirements are not met, or when analysis, sampling, and operating problems or reporting errors are present. Non-valid data may also occur when samples are not received by the laboratory within the allowable holding time or when they are improperly preserved. Other examples are a non-representative sample, mislabelling of containers, malfunction of the Sigma composite sampler, and sampling of the wrong location.

Data that are determined to be invalid are flagged and/or removed from the active database population. Within the laboratory, corrective action may involve a review of the calculations, check of the instrument maintenance and operation, review of analytical techniques and methodology, and reanalysis of quality control and field samples.

7.2 Field Equipment

Field equipment found to be inoperable or functioning outside of acceptable performance limits will be repaired or replaced prior to continued use. Data collected from the instrument immediately prior to the repair or replacement is identified as questionable and appropriate actions will be taken including repeating measurements or sampling.

7.3 Missing or Destroyed Samples

A sample will be collected again if the sample is missing at the laboratory, sample holding times are exceeded, or the sample container is broken. Re-collected samples that can be resampled within the permit sample frequency requirements are not considered to be "missed" samples. Missing or destroyed samples that cannot be re-collected are noted in the database sample log and are reported to EPA and ADEC.

This report, *Quality Assurance Plan – Red Dog Mine*, was prepared by SRK Consulting (U.S.), Inc., with data supplied by TAK.

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Principal Consultant

and reviewed by

Lee Christoffersen
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Disclaimer - The opinions expressed in this document have been based on the information supplied to SRK Consulting (U.S.), Inc. (SRK) by Teck Alaska Incorporated (TAK). These opinions are provided in response to a specific request from TAK to do so, and are subject to the contractual terms between SRK and TAK. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this report apply to the site conditions and features, as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report.

8 References

- Alaska Department of Environmental Conservation (ADEC). 2011. Generic Tier 2 Quality Assurance Project Plan for Water Quality Monitoring Sampling and Analysis Activities. February.
- Teck Alaska, Inc. (TAK). 2014. Quality Assurance Plan for the Red Dog Mine Water Quality Monitoring Program NPDES AK-003865-2 and Waste Management Permit 0132-BA002. Revision 9. May.
- U.S. Environmental Protection Agency (EPA). 2001. EPA Requirements for Quality Assurance Project Plans. EPA QA/R-5. 2001.
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- EPA 1994. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms, most recent edition, EPA/600-4-91-002.
- U.S. Geological Survey, 1982. Measurement and Computation of Streamflow: Volumes 1 and 2, Geological Survey Water-Supply Paper 2175, (second printing) 1983.