Integrated Waste Management Plan

Red Dog Mine, Alaska, USA

Prepared for

Teck Alaska Incorporated

Prepared by

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

Integrated Waste Management Plan

Red Dog Mine, Alaska, USA

August 2016

Prepared for

Teck Alaska Incorporated
3105 Lakeshore Drive, Building A, Suite 101
Anchorage, AK 99503
United States

Tel: 1 907 466 2170
Web: www.teck.com

Prepared by

SRK Consulting (U.S.), Inc.
Suite E-12, 4700 Business Park Blvd
Anchorage, AK 99503
United States

Tel: 1 907 677 3520
Web: www.srk.com

Project No: 329100.030
File Name: IWMP_RedDogMine_329100030_20160805.docx

Executive Summary

This Integrated Waste Management Plan (IWMP) describes procedures for managing solid wastes and hazardous materials generated at the Red Dog Mine. This Plan also includes procedures for reusing and recycling materials wherever possible, which is a priority of Teck Alaska, Inc.'s (TAK) Red Dog Mine.

Decisions that may affect the generation of solid wastes are made with consideration to the following order of priorities:

1. Waste source reduction
2. Recycling of materials (including reuse)
3. Waste treatment
4. Waste disposal

Appropriate management begins at the procurement stage, before materials are purchased. Safety Data Sheets (SDS) of any new material proposed to be used at the Red Dog Mine is reviewed prior to purchasing. The goal is to avoid materials that could be classified as hazardous waste once the materials can no longer be used for their intended purposes, both for the protection of the workers handling these materials and for the benefit of the environment.

Methods to minimize the production of waste include proper handling and storage of hazardous materials to prevent accidental releases and cross-contamination of materials, providing appropriate secondary containment for hazardous materials to prevent releases and the associated generation of waste materials and spill residues, and the reuse and/or recycling of materials whenever possible. Materials that can be recycled include mill liners, antifreeze, batteries, lamps, tires, containers, scrap metal, and used oil.

Wastes are characterized to determine their appropriate management method. Non-liquid, non-hazardous wastes that cannot be recycled are disposed of at an onsite inert landfill (18 AAC 60.460). Liquids, hazardous wastes, and other materials that cannot be managed onsite are shipped off-site for recycling or disposal; this includes solvents, lamps, batteries, liquid paints, co-product mercury, and assay lab waste.

An inert solid waste landfill is permitted at the mine site and located within the Waste Rock Dumps (WRD).

Water resources and reclamation/closure management information for the onsite solid waste facilities (i.e., Tailing Storage Facility, Waste Rock Dumps, etc.) is provided in Appendix B *Red Dog Mine Tailings and TSF Water Management Plan* (SRK 2016a), Appendix C *Red Dog Mine Waste Rock Management Plan* (2016b), and in the *Red Dog Mine Reclamation and Closure Plan* (SRK 2016d).

The environmental monitoring plan that incorporates monitoring of all solid waste facilities for the Red Dog Mine during operation and post-closure is in Appendix D *Red Dog Mine Monitoring Plan* (SRK 2016c).

Table of Contents

List of Tables

List of Figures

Appendices

List of Abbreviations

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish & Game
ADNR	Alaska Department of Natural Resources
ANFO	ammonium nitrate and fuel oil
APDES	Alaska Pollutant Discharge Elimination System
AS	Alaska Statute
CERCLA	Comprehensive Environmental Responsibility and Compensation Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
DMTS	DeLong Mountain Regional Transportation System
EPA	United States Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
HAZMAT	Hazardous Material Transportation Training
HID	High-intensity Discharge
IAEA	International Atomic Energy Agency
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IMDG	International Maritime Dangerous Goods Code
ISO	International Organization for Standardization
IWMP	Integrated Waste Management Plan
LED	Light Emitting Diodes
LDR	Land Disposal Restriction
LQG	large quantity generator
MSHA	Mine Safety and Health Administration
NANA	NANA Regional Corporation, Inc.
NRC	National Response Center
OSHA	Occupational Safety and Health Administration
Plan	Integrated Waste Management Plan
PPE	personal protective equipment
RCRA	Resource Conservation and Recovery Act
RQ	reportable quantity
SOP	Standard Operating Procedures
SDS	Safety Data Sheets
SQG	small quantity generator
SRK	SRK Consulting (U.S.), Inc.
TAK	Teck Alaska Incorporated
TDG	Transport Canada's Transportation of Dangerous Goods
TSCA	Toxic Substances Control Act
TSDF	Treatment Storage and Disposal Facility
TSF	Tailings Storage Facility
USCG	United States Coast Guard
USDOT	United States Department of Transportation

USFWS	United States Fish and Wildlife Service
WIS	Waste Information System
WRD	Waste Rock Dump

Units of Measure

°C	degrees Celsius
°F	degrees Fahrenheit
g	gallon
kg	kilogram
lb	pound
L	liter
mm	millimeter
ppm	parts per million

1 Introduction

1.1 Purpose

This Integrated Waste Management Plan (IWMP) describes the required procedures for managing solid wastes[1] and hazardous materials (wastes) generated at the Red Dog Mine facilities. The Plan also includes procedures for reusing and recycling materials wherever possible, which is a priority of the Red Dog Mine.

This Plan also includes the following management plans:

- Appendix B - *Tailings and TSF Water Management Plan*
- Appendix C - *Waste Rock Management Plan*
- Appendix D - *Monitoring Plan*

The environmental monitoring program for the Red Dog Mine, which is associated with this IWMP, includes monitoring of surface water, groundwater, seepage, and wildlife, as described in the *Red Dog Mine Monitoring Plan* (SRK 2016c).

In addition, this Plan includes the following supporting document for the IWMP and *Red Dog Mine Reclamation and Closure Plan* (SRK 2016d):

- Appendix E - Water and Load Balance Update

1.1 Project Description

Teck Alaska Incorporated's (TAK) Red Dog Mine is located in northwestern Alaska, approximately 82 miles north of Kotzebue, and 46 miles inland from the coast of the Chukchi Sea (Figure 1). The mine is located on the Middle Fork of Red Dog Creek in the DeLong Mountains of the western Brooks Range, on private land owned by NANA Regional Corporation, Inc. (NANA). Some of the support facilities are on both State of Alaska and NANA lands. Red Dog Mine is a joint venture between NANA and TAK, whereby Teck Alaska is the mine operator and NANA is the landowner.

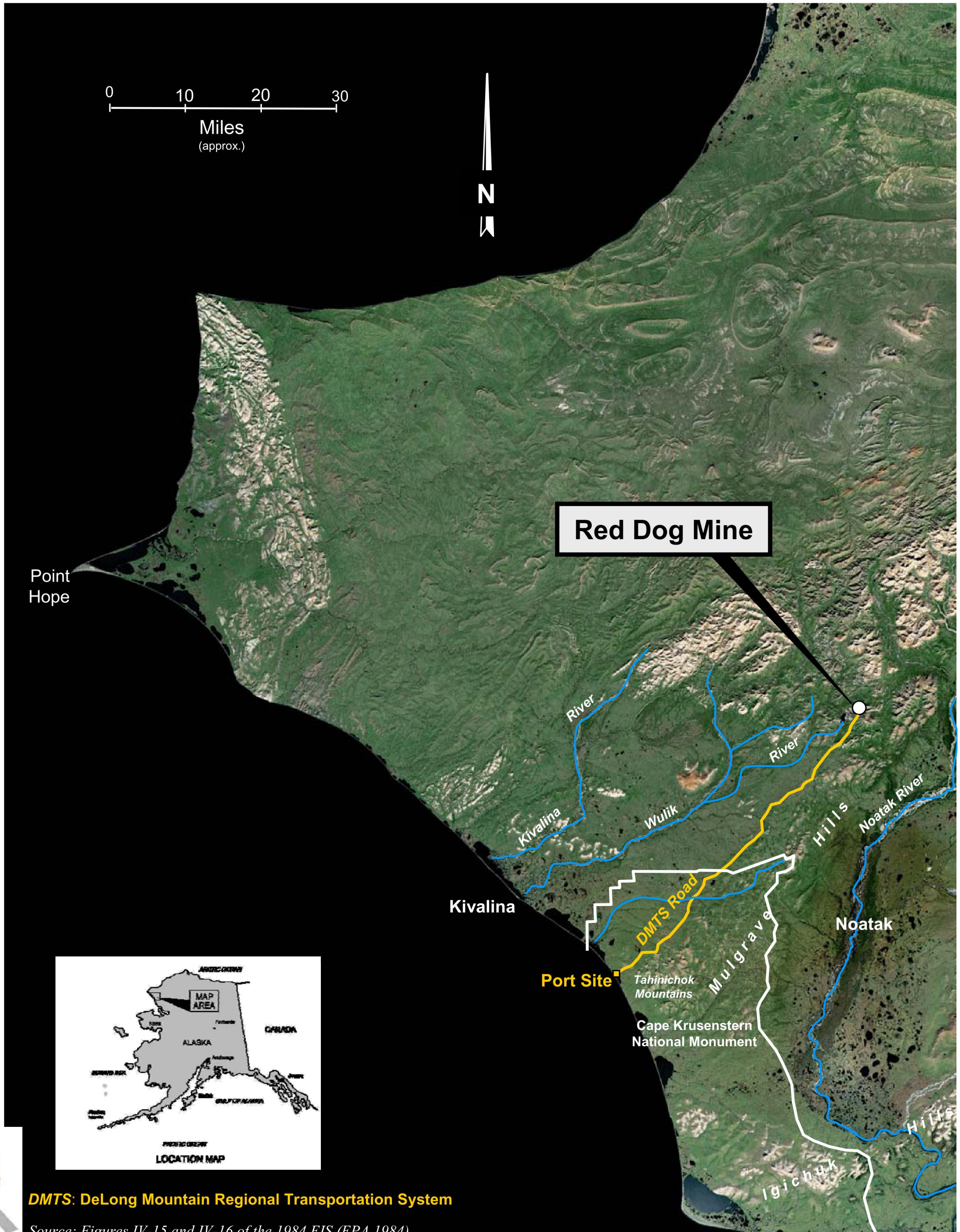
Figure 1 shows the location of the Red Dog Mine. Figure 2 shows the boundary of the area considered in this plan. The boundary is the limits of the Waste Management Permit #2016DB0002 and coincides with the boundary of the Air Quality Permit #AQ0290TVP02P. The boundary encompasses all of the areas that are likely to be directly impacted by operations at the site (Appendix A).

The operation consists of an open pit zinc/lead mine, mill, and support facilities. Construction of the mill began in 1988, with the first ore delivered to the mill in November 1989. Conventional drill and blast mining methods are employed. The mineral processing facilities use conventional grinding and sulfide flotation methods to produce zinc and lead concentrates. The concentrates are shipped to markets in North America, Europe, and Asia from the DeLong Mountain Regional

[1] AS 46.03.900(26)"solid waste" means garbage, refuse, abandoned, or other discarded solid or semi-solid material, regardless of whether subject to decomposition, originating from any source.

Transportation System (DMTS) port facility located on the Chukchi Sea. Access to the Port is via the 52-mile DMTS haul road, owned by the Alaska Industrial Development and Export Authority.

The ore deposits are massive sulfide zinc-lead-silver deposits. The ore and host rocks contain high concentrations of sulfide minerals, and the majority of the waste rock is acid generating, potentially acid generating, or has potential for metal leaching. Additional information on waste rock management is in Appendix C. Water from the mine operations area, e.g., open pit, ore stockpiles, and waste rock dumps is pre-treated where possible and stored in the tailings storage facility (TSF). During the open water season (May to October), water from the TSF is treated and discharged to the Middle Fork of Red Dog Creek. Further information on water management is provided in Appendix B.



DMTS: DeLong Mountain Regional Transportation System

Source: Figures IV-15 and IV-16 of the 1984 EIS (EPA 1984)

TOPOGRAPHY AND LAYOUT BASED ON INFORMATION PROVIDED BY RED DOG, 2014.

Red Dog Mine

DESIGN: SDT

DRAWN: JBM

REVIEWED:

APPROVED:

IF THE ABOVE BAR
DOES NOT MEASURE 1 INCH,
THE DRAWING SCALE IS ALTERED

PREPARED BY:

srk consulting

PROJECT:

RED DOG MINE
RECLAMATION AND CLOSURE PLAN

FIGURE TITLE:

SITE VICINITY LOCATION

DATE: MARCH 2016

REVISION:

FIGURE NO.: 1

SRK PROJECT NO.: 329100.030

P:\Teck Alaska - Red_Dog\329100.030 IWMP\329100.030 IWMP\040_AutoCAD_GIS\Rec Plan Figures\Agency Draft Rev 2 -Figures SRK\2238-F1 (IWMP).dwg

TOPOGRAPHY AND LAYOUT BASED ON INFORMATION PROVIDED BY RED DOG, 2014.

DESIGN: SDT	PREPARED BY: srk consulting	FIGURE TITLE: SOLID WASTE PERMIT BOUNDARY	
DRAWN: JBM			
REVIEWED:			
APPROVED:	PROJECT: **RED DOG MINE INTEGRATED WASTE MANAGEMENT PLAN**	DATE: MARCH 2016	REVISION:
IF THE ABOVE BAR DOES NOT MEASURE 1 INCH, THE DRAWING SCALE IS ALTERED		SRK PROJECT NO.: 329100.030	FIGURE NO.: 2

Red Dog Mine

P:\Teck Alaska - Red_Dog\329100.030 IWMP\329100.030 IWMP\040_AutoCAD_GIS\Rec Plan Figures\Agency Draft Rev 2 -Figures SRK\2238-F2 (IWMP).dwg

2 Waste Management Requirements

The following sections provide an overview of the regulatory requirements applicable to the management of solid wastes and the management procedures that are employed at the Red Dog Mine to handle wastes safely and in accordance with all applicable regulations. The locations of the mine footprint and site facilities are shown in Figure 3. Key waste management facilities include solid inert waste landfill (located within the Main Waste Rock Dump), the TSF and Waste Rock Dumps (WRD) as shown in Figure 3.

Management of wastes at the Red Dog Mine begins before the materials are purchased by evaluating the potential environmental impacts of materials being considered for the project. In general, the Red Dog Mine minimizes the overall generation of waste to the extent practical and minimizes the use of materials regulated as hazardous wastes when they no longer serve their intended purpose. Materials are reused and recycled whenever possible. A permitted, solid waste landfill is located onsite for the disposal of inert solid wastes, in accordance with the landfill permits administered by the Alaska Department of Environmental Conservation (ADEC) and the regulations contained in Title 18 Alaska Administrative Code (AAC) Chapter 60 (18 AAC 60).

Materials that cannot be managed onsite, such as liquid wastes, hazardous wastes, certain items to be recycled or reused, and wastes prohibited from disposal in the landfills, are shipped off-site for reuse, recycle, treatment, or disposal at appropriate facilities.

The waste management methods discussed in this section are based on the applicable regulations at the time this Plan was written. Changes to management methods may be required as regulations are modified. Additionally, the Waste Management Permit may contain additional provisions that may necessitate changes to the methods discussed herein.

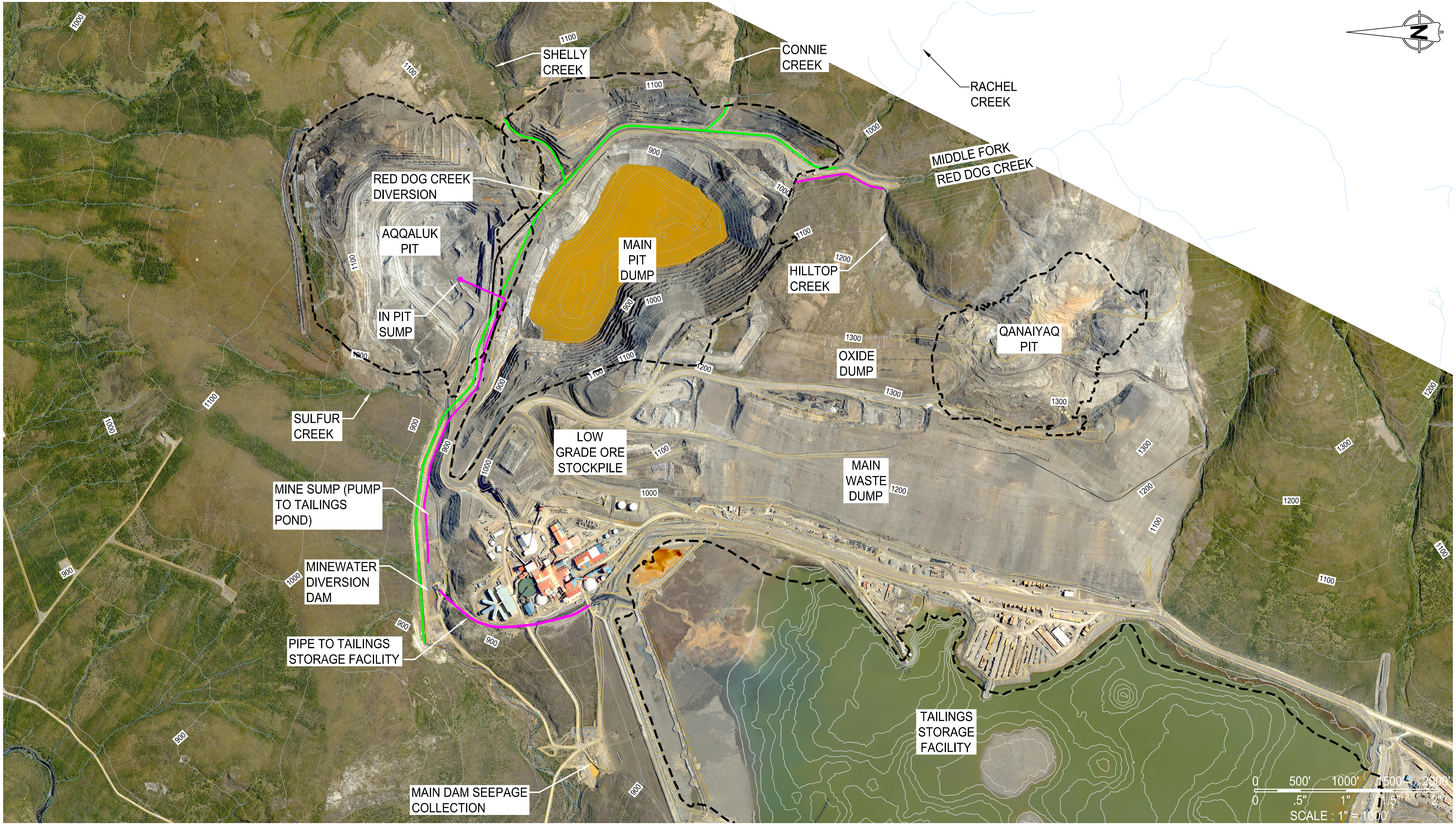
2.1 Regulatory Review

Solid wastes are regulated in the State of Alaska under two main bodies of regulations:

- The Resource Conservation and Recovery Act (RCRA) federal regulations contained in Title 40 Code of Federal Regulations (CFR), Parts 260 to 279.
- The State of Alaska regulations contained in 18 AAC 60, Solid Waste Management.

Hazardous wastes are regulated by the U.S. Environmental Protection Agency (EPA), Region 10 in Alaska, in accordance with RCRA regulations. Alaska does not have the authority to administer hazardous waste regulations and, therefore, defers to federal regulations. Non-hazardous solid wastes, tailings, and waste rock are mainly managed under the state regulations in 18 AAC 60, which includes permitted solid waste inert landfills.

When a material can no longer be used for its original purpose, or otherwise meets the definition of *solid waste* as defined in Section 2.1.1, a determination must be made as to whether the solid waste is a *hazardous waste* or not as defined in Section 2.1.2. Waste determinations are discussed in Section 2.5. Once a waste determination has been made, the appropriate management method for the waste can be identified.



RED DOG CREEK DIVERSION SYSTEM

MINE WATER COLLECTION SYSTEM

TOPOGRAPHY AND LAYOUT BASED ON INFORMATION PROVIDED BY RED DOG, 2014.

Red Dog Mine

DESIGN: SDT
DRAWN: JBM
REVIEWED:
APPROVED:

IF THE ABOVE BAR DOES NOT MEASURE 1 INCH, THE DRAWING SCALE IS ALTERED

PREPARED BY: srk consulting

PROJECT: **RED DOG MINE INTEGRATED WASTE MANAGEMENT PLAN**

FIGURE TITLE: CURRENT MINE AREA LAYOUT

DATE: MARCH 2016

REVISION:

FIGURE NO.: 3

SRK PROJECT NO.: 329100.030

P:\Teck Alaska - Red_Dog\329100.030 IWMP\329100.030 IWMP\040_AutoCAD_GIS\Rec Plan Figures\Agency Draft Rev 2 -Figures SRK\2238-F3 (IWMP).dwg

2.1.1 Definition of Solid Waste

The EPA definition of solid waste found in 40 CFR §261.2. A solid waste is any material, liquid or solid, with the exception of materials excluded from the regulations that are a discarded ***material***, meaning a material that is:

- Abandoned:
  - disposed of or
  - burned or incinerated or
  - accumulated, stored, or treated (but not recycled) before, or in lieu of, being abandoned by disposal, burned, or incinerated.
- Recycled or accumulated, stored or treated before recycling if it is:
  - used in a manner constituting disposal
  - burned for energy recovery
  - reclaimed
  - accumulated speculatively
- Considered inherently waste-like; or
- A military munition identified as a solid waste in 40 CFR §266.202.

There are several exclusions to the definition of solid waste, as provided in 40 CFR §261.4(a), such as domestic sewage and point source discharges subject to regulation under Section 402 of the Clean Water Act (CWA).

2.1.2 Definition of Hazardous Waste

As defined in 40 CFR §261.3, a solid waste is ***hazardous*** if:

- It is not *excluded* from regulation as a hazardous waste under 40 CFR §261.4(b).
- It is a *characteristic hazardous* waste, i.e., it exhibits one of the characteristics of hazardous waste defined in Subpart C of 40 CFR §261:
  - ignitability
  - corrosivity
  - reactivity
  - toxicity
- It is a *listed hazardous waste,* i.e., a waste listed in Subpart D of 40 CFR §261 and has not been excluded in 40 CFR §260.20 or 260.22.
- It is a *mixture* of solid waste and one or more listed hazardous wastes, and it has not been excluded from regulation as a hazardous waste by an exemption to the regulations.
- *Rebuttable presumption for used oil*, i.e., used oil containing more than 1,000 parts per million (ppm) total halogens is presumed to be a hazardous waste because it has been mixed

with halogenated hazardous waste listed in Subpart D of 40 CFR §261. Persons may rebut this presumption by demonstrating that the used oil does not contain hazardous waste.

Solid wastes that are exempt from hazardous waste regulations are listed under 40 CFR §261.4(b). Additionally, a number of exemptions are also listed in 40 CFR §261.3, which defines a hazardous waste. Some of the important exemptions that apply to the Red Dog Mine include:

- Household waste (e.g., for products used for personal use at the camp facilities).
- Mining overburden returned to the mine site.
- Solid wastes from the extraction, beneficiation, and processing of ores and minerals, also known as the Bevill Exclusion[2] (e.g., tailings).
- Non-terne-plated used oil filters that are not mixed with a "listed hazardous waste" and have been gravity hot-drained.
- Exemptions for mixtures that involve de minimis losses of certain hazardous wastes and laboratory wastewater discharged to water treatment systems regulated under an Alaska Pollutant Discharge Elimination System (APDES) permit.

It is important to note that intentionally mixing a hazardous waste with a non-hazardous solid waste can render the entire mixture a hazardous waste, subject to the full RCRA regulations and is not an acceptable method of waste disposal. There are a few exemptions to the mixture rule, however, they are only applicable under very specific circumstances and must be managed carefully to maintain compliance with RCRA.

2.1.3 Waste Management Priorities

In accordance with the State of Alaska Statute (AS) 46.06.021, in order to prevent and/or minimize the present and future generation of wastes, management decisions that may affect waste generation at the Red Dog Mine consider the following options, in order of priority:

1. Waste source reduction
2. Recycling (includes reuse)
3. Waste treatment
4. Waste disposal, in accordance with applicable law

In order to accomplish this, the following procedures are followed:

- Operations that generate wastes are periodically reviewed to identify opportunities for waste reduction and these opportunities are implemented whenever possible.
- The properties of materials are reviewed prior to purchase and every effort is made to minimize the use of hazardous materials and those classified as hazardous wastes once they can no longer be used for their intended purpose.

[2] The "Bevill Exclusion or Bevill Exemption" is an amendment to the RCRA, which provides that "mining and mineral processing wastes generated by extraction, beneficiation, and processing activities" are exempt from regulation as hazardous wastes.

- Methods for reusing and recycling materials are promoted and implemented whenever possible to reduce waste.
- Non-hazardous solid wastes that are permitted for disposal onsite are disposed of at onsite, permitted, solid waste inert landfills, regulated by the ADEC, in accordance with 18 AAC 60.
- Materials that cannot be managed onsite are sent off-site to appropriate facilities for recycling, reuse, treatment, and/or disposal.

2.1.4 Purchasing of Materials

The following procedures are followed when purchasing materials:

- Whenever possible, the Red Dog Mine reduces the generation of hazardous wastes by avoiding the purchase of materials that will be regulated as hazardous wastes once the materials are no longer required for their intended purpose.
- To the extent practical, materials are purchased in containers (e.g., totes or drums) that can be returned to the vendor.
- The Safety Data Sheets (SDSs) for new materials are reviewed prior to purchasing to ascertain if the materials require special management under RCRA, Emergency Planning and Community Right to Know Act (EPCRA), Comprehensive Environmental Responsibility and Compensation Liability Act (CERCLA), Clean Air Act, and Toxic Substances Control Act (TSCA) (See EPA's "List of Lists" 2012).
- For materials requiring special handling or those classified as a hazardous waste if disposed of, the Red Dog Mine evaluates the material to determine if a suitable substitute is available that is considered "less hazardous." Less hazardous can include a waste not classified as a hazardous waste if disposed of, requires no special handling under the above-noted governing acts, generates less waste when disposed of, can be reused or recycled, or is generally considered to have less of an impact on the environment (e.g., a material with less discharges to the environment when treated and/or disposed).

2.1.5 Waste Minimization

Efforts to minimize waste begin at the purchasing phase and continue to the recycling and reuse materials such as:

- Use primarily low-toxicity solvents in parts washers:
  - Many solvents contain compounds that require the solvent be managed as hazardous waste when disposed of and are harmful to the environment.
  - Parts washers reuse the same solvent repeatedly, thereby reducing the amount of waste solvent generated.
  - Use of low-toxicity solvents minimizes the volume of hazardous wastes generated, provided the solvent is not mixed with other wastes that would render the solvent mixture hazardous.
  - The use of low-toxicity solvents also minimizes the volume of other wastes that could be generated such as rags.

- Use low-mercury, fluorescent lamps (“green end cap”) and recycling of lamps and bulbs:
  - Many lamps must be regulated as hazardous waste once disposed of due to mercury and lead content. Recycling fluorescent lamps prevents them from entering the waste stream (EPA 2006b).
  - Low-mercury, fluorescent lamps are currently available. The mercury levels in these lamps are sufficiently low so they are not regulated as hazardous waste when disposed. These types of fluorescent lamps are preferred for use at the mine site.
- Recycle or reuse of materials such as antifreeze, batteries, and reusable light vehicle tires, scrap metal, and used oil, as discussed in Section 2.1.6 below.
- Return containers to vendors or recycling them as scrap metal, which prevents the need for disposal of containers in landfills.
- Appropriate container management, including the provision of secondary containment and proper labeling(EPA 2005):
  - Proper container management is *key* to reducing waste volumes.
  - Unlabeled containers holding unknown materials may require testing of the materials to determine the chemical constituents of the material.
  - Containers that are left uncovered and exposed to the elements may result in the material in the container becoming contaminated and unusable.
  - Containers without proper secondary containment that become damaged can result in the contamination of other materials, such as soil, and may cause harm to the environment or personnel.
- Prevention of mixing of hazardous wastes with non-hazardous wastes through waste segregation, established procedures, and personnel training:
  - Mixing hazardous and non-hazardous wastes may result in the entire mixture being regulated as hazardous waste and should be avoided.
  - Mixing hazardous and non-hazardous waste is particularly important in the management of solvents and used oil.

2.1.6 Recycling and Reuse of Materials

Red Dog Mine recycles materials to the extent practical. Due to the logistics of shipping recycled materials from the mine site by air or barge and the costs associated with recycling materials, the Red Dog Mine evaluates the cost/benefit of their recycling program on a regular basis. Recycling opportunities are based on the need for recycled materials, vendors available to handle recycled materials, costs, economic factors, etc. The Red Dog Mine adjusts its recycling practices to respond to these changes.

The alternative to recycling depends on the nature of the material. Materials that are considered hazardous (e.g., certain types of batteries) have a high priority for determining viable recycling alternatives since the only disposal alternative is off-site disposal in a hazardous waste disposal facility. Other materials that are not hazardous (e.g., scrap metal) may be disposed of onsite in an appropriate manner if recycling becomes impractical.

Some of the key materials that may be recycled are listed below:

- antifreeze (ethylene and propylene glycol) – recycled and reused onsite whenever possible
- mill liners – returned to vendor or shipped offsite for recycling as scrap metal
- hazardous batteries – returned to vendor for recycling or reclaimed offsite
- hazardous lamps – recycled offsite
- compressed gas cylinders – returned to vendor for reuse or recycled as scrap metal
- pallets – reused and/or recycled offsite
- reagent containers – returned to vendor for reuse
- reusable parts – sold/reused onsite or offsite where possible
- returnable/recyclable drums – returned to vendor for reuse and/or recycled as scrap metal
- scrap metal – recycled offsite
- reusable light vehicle tires – returned to vendor for recycling
- used oil – burned for energy recovery in space heaters and process boilers onsite (and offsite for recycling when not possible to burn for energy recovery onsite)
- aluminum and plastic containers – recycled off-site

2.1.7 Waste Segregation

Waste management includes appropriate segregation and management of wastes in accordance with applicable regulations and the specific waste handling procedures described in Section 0 as follows:

- Wastes destined for the incinerator (e.g. putrescible food waste, oily waste, etc.) are placed in incinerator dumpsters. These dumpsters are kept closed to prevent attraction of wildlife.
- Inert wastes destined for the landfill are either taken directly to a landfill or placed in landfill dumpsters.
- Dumpsters are marked in a manner such that personnel are able to distinguish between incinerators and landfill dumpsters.
- Hazardous wastes are placed in containers at Satellite Accumulation Areas (Section 2.7 for less than 55 gallons of waste) or placed in containers, appropriately labeled and then brought directly to a primary Hazardous Waste Accumulation Area.
- Universal Wastes (lamps, batteries, mercury containing equipment) are placed in containers at Universal Waste Accumulation Areas according to the procedures outlined in Section 2.9.
- Materials to be recycled are placed in segregated containers designated for the specific type of material and managed as outlined in Section 2.1.6.
- All containers are appropriately labeled and managed as described in Section 2.1.8 below.

2.1.8 Container Management

Containers are managed in accordance with all applicable regulations as follows:

- All containers are appropriately labeled according to the U.S. Department of Labor Occupational Safety & Health Administration (OSHA), Mine Safety & Health Administration (MSHA) hazard communication standards (OSHA "HCS" at 29 CFR §1910.1200 or MSHA "HazCom" at 30 CFR §47) or EPA Standards for Small Quantity Handlers of Universal Waste (40 CFR §273 Subpart B).
- Hazardous wastes are labeled according to the requirements of RCRA:
  - Containers in satellite accumulation areas must be labeled with words describing the contents of the container or the words "*Hazardous Waste.*"
  - Containers in hazardous waste accumulation areas must be labeled with the words, "*Hazardous Waste,*" and the accumulation start date (Appendix F).
  - Containers holding universal waste must be labeled with the words, "*Universal Waste – waste type,*" "*Waste – waste type,*" or "*Used – waste type*" where "*waste type*" is either batteries, lamps, thermostats, or mercury-containing equipment.
- Containers of used oil are labeled with the words "Used Oil".
- Hazardous materials are stored within appropriate secondary containment systems designed to contain at least 110%[3] of the volume of the largest container within the containment.
- Safety precautions listed in the SDS for each material stored are followed.
- Containers are kept closed except when adding or removing materials as required by RCRA for hazardous wastes, or as needed to prevent contamination of the material or harm to the environment or personnel.
- Inspections are conducted as required by the regulations and as needed to manage containers appropriately.
- Containers are emptied appropriately (Section 2.1.9).
- Small containers of flammable materials are stored in flame-resistant containers/cabinets.
- Incompatible materials are segregated.
- Appropriate firefighting and/or spill response equipment are available.
- The applicable training, inspection, reporting, preparedness, spill prevention, contingency planning, and emergency procedures required by RCRA and ADEC Division of Spill Prevention and Response is implemented.

[3] U.S. Environmental Protection Agency. 2005. *Chapter 4: Secondary Containment and Impracticability.4.2.4 Sufficient Freeboard* (2002)

2.1.9 Procedures for Emptying Containers

An empty container is a non-hazardous waste provided it has been emptied according to the procedures described below. Residues from emptying the containers must be managed according to the hazard classification.

1. A container holding a *compressed gas* is considered empty when the pressure in the container approaches atmospheric pressure.
2. Containers that held an *acutely hazardous waste* [P-code wastes in 40 CFR §261.7 (b)((3)], such as cyanide, are considered empty when:
   (a) the container or inner liner has been triple-rinsed using a solvent capable of removing the material;
   (b) the container or inner liner has been cleaned by another method that has been shown in the scientific literature, or by tests conducted by the generator, to achieve equivalent removal; or
   (c) in the case of a container equipped with an inner liner that prevented contact of the commercial chemical product or manufacturing chemical intermediate with the container has been removed.
3. Containers that held *hazardous waste* are considered empty when:
   (a) all wastes have been removed that can be removed using the practices commonly employed to remove materials from that type of container, e.g., pouring, pumping, and aspirating; and
   (b) no more than 1 inch of residue remains on the bottom of the container or inner liner; or
   (c) no more than 3% by weight of the total capacity of the container remains in the container or inner liner if the container is less than or equal to 119 gallons in size.
4. Red Dog Mine applies the standards for a container that held hazardous waste and for all containers that held non-hazardous waste (other than compressed gas cylinder and aerosol cans), in addition to the following requirement:
   (a) As required by the vendor, 55-gallon drums that are returned to the vendor are emptied to less than 1% residue.
5. Containers that have been appropriately emptied would be indicated by applying an empty label or tag.
6. All plugs or caps are replaced to seal inlets/outlets from water or snow.
7. Marking, labeling, or placarding required by the U.S. Department of Transportation's (USDOT) hazardous materials regulations are retained until the packaging is sufficiently cleaned of residue and purged of vapors to remove any potential hazards.
8. Until containers have been appropriately emptied and indicated as empty, they are kept in secondary containment where required and the labels, markings, and placards are left in place.

2.1.10 Onsite Waste Management

Solid waste management facilities include inert solid waste landfills, the TSF, and WRD. These key waste management areas are regulated by ADEC under a waste management permit and are discussed in the following sections.

2.1.11 Solid Waste Landfill

A solid waste landfill is located at the mine site for the disposal of inert, non-hazardous, solid waste. The landfill is permitted by the ADEC in accordance with 18 AAC 60.

In general, inert landfills are designed and operated to keep runoff from outside the landfill area separate from the solid wastes and in such a way as to prevent the attraction of wildlife. Wastes are stored in suitable containers prior to incineration (e.g. putrescible wastes and sewage sludge) and/or disposal in the respective landfills trenches. Windblown litter and littered refuse from the areas around the landfill are collected and returned to the landfill for disposal. Visual monitoring is conducted on the facilities to verify compliance with the provisions of 18 AAC 60. The location and volume of waste placed in the landfill is surveyed annually. Landfills are closed and reclaimed in accordance with the requirements of ADEC.

2.1.12 Mine Site Inert Landfill

Inert, general mine refuse (e.g., pac1kaging, non-recyclable empty containers, non-putrescible refuse, etc.) are placed directly into the permitted onsite landfill trenches in a designated section of the Main WRD. Putrescibles are incinerated. Residues from the incinerator are disposed of in the landfill. Unusable, small vehicle tires that cannot be returned to the vendor are disposed of in the landfill. Large loader and truck tires that are not sent to the vendor are buried in a designated area of the Main WRD.

The surface surrounding the open landfill trenches are graded to prevent precipitation from ponding or draining into the trench. Loose refuse is consolidated, compacted in 4-foot-thick lifts, and covered with 6 inches (minimum) of compacted waste rock as needed to prevent windblown litter. An intermediate cover of approximately 12 inches of waste rock is applied to portions of the landfill that are inactive for 90 days or more. Once a landfill trench is filled to within 4 feet of the surface, it is covered with a layer of rock. By the nature of the WRD construction, another layer of rock, a minimum of 20 feet thick, may be placed over the filled trenches when the next lift is placed on the WRD. The additional cover minimizes the chance of water percolating through the rock material and into the refuse trench. The landfill will maintain a minimum separation of 50 feet from any surface water drainage feature or the facility boundary. The maximum landfill working face width shall not exceed 200 feet. The maximum height of the working face shall not exceed 10 feet. Landfill trenches closed during final reclamation will have a minimum of 24 inches of cover material placed, as required by ADEC.

2.2 Monitoring

The environmental monitoring program for the Red Dog Mine is described in Appendix D, *Red Dog Mine Monitoring Plan* (SRK 2016c). This includes monitoring and characterization of surface water, groundwater, tailings, waste rock, seepage, and wildlife observation, in addition to visual monitoring of facilities.

2.3 Reporting and Record Keeping

Regular reporting, as required by the ADEC permit and RCRA, is provided on waste management activities and results of environmental monitoring. An operating record is maintained onsite, as specified in 18 AAC 60.

The Red Dog Mine's Waste Information System (WIS) is a web-based system that allows Red Dog Mine employees to identify and manage wastes efficiently in compliance with government regulations, Red Dog Mine polices, and this IWMP. WIS provides access to job-specific waste training, identification of different wastes, one-page guidelines, Standard Operating Procedures (SOP), and forms/checklists necessary to accurately maintain records and meet reporting requirements.

2.4 Materials Managed Offsite

In addition to liquid wastes and hazardous wastes, certain materials (wastes) are shipped offsite for recycling or disposal, including some of the recyclable materials listed in Section 2.1.6. These materials are segregated, as described in Section 2.1.7 and ultimately delivered to the mine site warehouse for processing as described below.

- All materials received at the warehouse are verified for appropriate labeling (e.g., type of material, date waste generated, etc.).
- Containers are assigned a unique container number and entered into an inventory.
- Material characterization testing is conducted if required.
- The material is placed in an appropriate accumulation area (e.g., hazardous waste accumulation area).
  - The material is shipped to an appropriate recycling and/or disposal facility depending on the type of material (e.g., solid or hazardous waste). All hazardous wastes are shipped to appropriate facilities (e.g., Treatment Storage and Disposal Facility [TSDF]).

All materials are shipped in accordance with the applicable regulations.

2.5 Hazardous Waste Determinations

As required by 40 CFR §262.11, hazardous waste determinations are made on all solid wastes generated. Determinations are made by reviewing the regulations, and, if required, testing the waste, or applying generator knowledge.

2.6 Hazard Waste Accumulation

The following procedures are followed while hazardous wastes are accumulated:

- In general, hazardous waste is accumulated in satellite accumulation areas. Once containers become full (55 gallons or less), they are delivered to a hazardous waste accumulation area within three days of becoming full.
- Hazardous wastes not accumulated in a satellite accumulation area, such as wastes generated infrequently, are delivered to the hazardous waste accumulation area immediately.
- All wastes are shipped offsite within the required timeframe from their accumulation start date based on the generator status during the month the waste was generated.
- All containers are appropriately labeled as described in Section 2.1.8 and managed according to the applicable regulations.

2.7 Satellite Accumulation Areas

Up to 55 gallons of hazardous waste, or 1 quart of acutely hazardous waste, can be accumulated in satellite accumulation areas, provided the requirements of 40 CFR §262.34(c) are met. Containers must be at or near the point of generation of the wastes; under the control of the operator of the process generating the waste; in good condition; made of, or lined with materials that are compatible with the waste. Containers are to be kept closed at all times (except when adding/removing waste); opened, handled, and stored in a manner that prevents ruptures or leaks; and labeled with the words, “Hazardous Waste,” or a description of the contents. This allows the accumulation of waste without a time limit until a container becomes full. Once a container in a satellite accumulation area becomes full, the date must be written on the label. Full containers would then be transferred to a central hazardous waste accumulation area within three days of becoming full.

2.8 Shipments of Hazardous Waste

Hazardous wastes are shipped offsite to appropriate facilities in accordance with the applicable requirements of USDOT (Section 2.15). Additional requirements may apply depending on the mode of shipment, as mandated by the ICAO, IATA, or IMDG code. Shipments will be accompanied by a hazardous waste manifest and the appropriate land disposal restriction (LDR) notification and certification forms where applicable.

2.9 Universal Waste Management

The universal waste regulations (40 CFR §273) are streamlined hazardous waste management regulations that can be applied to the management of batteries, pesticides, mercury-containing equipment, and lamps. Generators of these wastes can choose to manage them as universal waste rather than under the more complex hazardous waste requirements. The intent of the universal waste regulations is to promote and facilitate the recycling and proper handling of these widely-generated hazardous wastes.

The main types of universal wastes generated at the Red Dog Mine include batteries, mercury-containing equipment, and lamps. Red Dog Mine is a small-quantity handler of universal waste, meaning less than **13,228 lbs. (6,000 kg)** of universal waste is accumulated onsite at any time.

Universal waste is managed in accordance with the regulations at 40 CFR §273. This includes accumulation in appropriate containers that are labeled as specified in 40 CFR §273.14, using a method that clearly demonstrates the length of time the universal wastes are accumulated from the date it became a waste or was received.

Red Dog Mine trains all employees handling or responsible for managing universal waste in emergency procedures appropriate to the type(s) of universal waste handled.

Universal waste is sent offsite to a permitted destination facility[4], or a foreign destination (consistent with the export requirements of 40 CFR §273) within one year of the accumulation start date. Universal wastes meeting the definition of a hazardous material under the USDOT regulations are packaged, labeled, marked, and placarded, and appropriate shipping papers are prepared according to the applicable USDOT regulations under 49 CFR Parts 171 through 180.

2.10 Used Oil Management

Used oil is defined as “any oil that has been refined from crude oil or any synthetic oil that has been used and as a result of such use is contaminated by physical or chemical impurities” and is regulated under RCRA 40 CFR §279.

Mixing used oil with other hazardous wastes may render the mixture a hazardous waste, in which case, the mixture could no longer be managed as used oil. Mixtures of used oil are regulated as follows:

- A mixture of used oil and a listed hazardous waste is regulated as hazardous waste.
- A mixture of used oil and a characteristic hazardous waste, or a listed hazardous waste that is listed solely because it exhibits one or more hazardous waste characteristic, is regulated as:
  - *hazardous waste* if the mixture exhibits any characteristic of hazardous waste; and
  - *used oil* if the mixture does not exhibit a characteristic of hazardous waste.
- Note that used oil containing more than 1,000 ppm of halogens is presumed to be hazardous waste (referred to as the “rebuttable presumption for used oil.”). This presumption can be rebutted if the generator can prove the used oil was not mixed with hazardous waste.

[4] Destination facility means a facility that treats, disposes of, or recycles a particular category of Universal Waste, with the exception of the management activities described in 40 CFR §273.13 (a) and (c) and 40 CFR §273.33 (a) and (c).

Used oil generated at the Red Dog Mine, which meets the requirements to be regulated as used oil, is burned for energy recovery in reciprocating diesel engines (generators), space heaters, and process boilers when possible, or shipped offsite for recycling. Used oil that must be regulated as hazardous waste is shipped offsite to an appropriate facility for proper handling and disposal.

The general requirements for managing used oil include:

- Records of used oil burned onsite and shipped offsite as specified in 40 CFR §279.
- Containers are in good condition and labeled with the words “Used Oil”.
- Any records produced as part of the management of used oil are kept on file for at least three years.
- Containers are provided with secondary containment as required under applicable regulations (40 CFR §112, 40 CFR §279 Subpart D, and 18 AAC 75).

2.11 Employee Training

Employees handling hazardous materials are trained in the appropriate and safe handling of these materials as required by OSHA, MSHA, RCRA, and/or USDOT based on the duties of the employees. This includes:

- Employees of SQGs and LQGs involved in handling hazardous wastes must be trained on proper waste handling and emergency procedures relevant to their responsibilities during normal facility operations and emergencies.
- Employees of small quantity handlers of universal waste must be trained on proper handling and emergency response procedures appropriate for the type of universal waste handled.
- Personnel involved in shipping hazardous materials and wastes, including preparing packages, preparing/signing/reviewing manifests, loading/unloading materials, and transporting materials, will complete the appropriate USDOT hazardous materials (HAZMAT) transportation training (49 CFR §172.702).
- Employees handling hazardous materials are trained according to the Hazard Communication Standard under OSHA/MSHA.
- Employees are required to complete the mandatory 24-hour new miner training and annual 8-hour refresher course required under MSHA.

Records of training are maintained on file according to the applicable regulations.

2.12 Inventory of Hazardous Materials

Inventories of all hazardous materials used and stored at the site are maintained with warehouse records. Inventories of the locations of hazardous waste, universal waste, and satellite accumulation areas are maintained in WIS.

2.13 Safety Data Sheets

A list of SDS for each hazardous material is maintained onsite, kept up-to-date, and made readily available to employees and contractors employed at the Red Dog Mine.

2.14 Inspections

Inspections of certain hazardous materials are conducted as required to verify hazardous materials are handled appropriately, in compliance with all applicable regulations, and in accordance with the inspection requirements of applicable permits and/or plans.

2.15 Transportation of Hazardous Materials

Hazardous materials are transported in accordance with all applicable regulations.

3 Specific Waste/Material Handling Methods

The following sections describe the specific management methods that are followed for waste streams and other materials generated at the Red Dog Mine. Adherence to these methods by employees and contractors is essential in order to operate in compliance with all applicable regulations and permits and to protect the safety of employees, contractors, and the environment.

This Plan is kept updated as needed, e.g., as new waste streams are added, procedures or processes are changed, or in response to modifications to the applicable regulations.

3.1 Absorbents

Absorbents, including absorbent pads, socks and booms; absorbent granules; and floor sweep are commonly used to collect spilled products. The disposal of absorbents is dictated by the material collected on the absorbent:

- Absorbents used to collect petroleum products are considered non-hazardous waste once no free liquid can drain from the absorbent. These absorbents are incinerated onsite. The collected liquid is managed as used oil.
- Absorbents managed as hazardous waste are those contaminated with a material classified as hazardous waste if disposed of (e.g., silver nitrate hazardous material spills in the laboratory). These absorbents are shipped offsite to an appropriate facility (e.g. TSDF). Any collected liquid that cannot be used for its original purpose is also being shipped offsite to an appropriate facility.
- Absorbents managed as non-hazardous waste are those contaminated with a material classified as a non-hazardous waste if disposed of. These absorbents are incinerated onsite. Collected liquid that cannot be reused or managed onsite are shipped offsite to an appropriate facility.

3.2 Antifreeze/Coolant

Ethylene glycol and propylene glycol are commonly referred to as antifreeze or coolants. Ethylene glycol is typically used as a coolant in equipment such as vehicles and generators. Propylene glycol is commonly used in liquid cooling systems such as heat exchangers. Both ethylene and propylene glycol can be used as de-icing fluid for airplanes. Glycol is managed as follows (EPA 1999):

- Used glycol is recycled whenever possible. Depending on the specifications of the equipment and the type of glycol used, glycol may be reused through the addition of additives or a combination of a glycol recycling unit and additives.
- Glycol that cannot be recycled is shipped offsite to the appropriate facility for management. Glycol that is found to be a hazardous waste is shipped to an appropriate facility.
- Propylene glycol and ethylene glycol are managed separately due to their differences in properties and applications.
- Filters from glycol recycling units are tested to determine if they are a hazardous waste. If the filters are not a hazardous waste, they are incinerated or landfilled onsite. If the filters are a hazardous waste, they are shipped offsite for disposal at an appropriate facility.

3.3 Asbestos and Lead Based Paint

If over the course of the mine life, facilities constructed offsite are relocated to the project, the presence of asbestos or lead-based paint would be determined prior to any demolition or renovation activities. If asbestos or lead-based paint are present, certified and trained asbestos and lead paint abatement contractors would be used for any required removal and disposal activities.

Asbestos removal and disposal will be in compliance with 40 CFR §61, Subpart M. Any asbestos containing material purchased and brought to site will be documented and tracked.

3.4 Batteries

Batteries that may be used onsite include alkaline, lithium, nickel cadmium, nickel metal hydride, and lead acid batteries. *Non-hazardous waste* batteries are shipped offsite for recycling or landfilled onsite. Hazardous batteries are managed as *Universal Waste* and shipped offsite for recycling. Lead-acid batteries are shipped offsite for reclamation. A brief description of the battery types and management methods is provided below:

- Alkaline batteries are commonly used disposable batteries. Alkaline batteries are managed as non-hazardous waste.
- There are several types of lithium batteries, including rechargeable lithium-ion (Li-ion) and lithium-polymer (Li-poly) batteries and disposable lithium batteries such as lithium sulfur dioxide batteries (Li-SO2). Lithium batteries are managed as universal waste.
- Nickel metal hydride (NiMH) batteries are commonly used, rechargeable batteries. NiMH batteries are managed as non-hazardous waste.
- Nickel cadmium batteries, also known as NiCad batteries, are rechargeable batteries. NiCad batteries are managed as universal waste.
- Lead-acid batteries are used in vehicles and equipment; smaller, sealed lead-acid batteries are used in miner lights. Lead-acid batteries are managed as exempt from the hazardous waste regulations if reclaimed.

3.5 Building Construction and Demolition Materials

Construction refuse from initial or subsequent facility construction is assessed and appropriately managed for onsite disposal, offsite shipment for disposal, or recycling.

A complete survey of any building or structure to be demolished will be made prior to demolition to assess the potential environmental concerns and to determine appropriate management methods for any wastes or recyclable materials generated. If removal of asbestos is necessary, the procedures in Section 3.3 would be followed.

3.6 Camp Waste

Household-type waste generated from employees and contractors at the mine site camp facilities, including employee/contractor rooms, cafeteria, and kitchen is incinerated. Camp wastes are managed to prevent putrescible wastes from being placed in the onsite landfills and becoming an attractant to wildlife. These wastes may include but are not limited to:

- food scraps.
- cooking oil and grease from the kitchen.
- other industrial-type wastes generated by maintenance and housekeeping activities is managed according to the procedures for the specific waste provided in this Plan.
- aerosol cans (i.e., cleaners, disinfectants, etc.) are punctured at an aerosol can puncturing unit prior to disposal (Section 3.10.1).
- plastics, paper, glass, batteries, and soft drink cans (aluminum) are placed in designated recycling bins located at the facility for recycling offsite.

3.6.1 Sewage Sludge

Domestic sewage from the mine facilities undergoes primary treatment, which removes solids, and the effluent is pumped to the TSF. Solids are dewatered prior to incineration and the ash from the incinerator is then disposed of in the landfill.

3.7 Chemical Reagents

Any spilled or expired chemicals, reagents or wastes are managed on a case by case basis and according to both federal and state waste regulations.

3.8 Containers/Packaging

All containers and packaging must be emptied appropriately prior to disposal, reuse onsite, or return to vendor, according to the requirements in Section 2.1.9. Appropriately, emptied containers are identified by applying an “empty” label or tag. *Until containers have been appropriately emptied and indicated as empty*, they are kept in secondary containment where required and any original labels, markings, and placards are left in place (EPA 1996).

3.9 Empty Drums

Drums that contained acutely hazardous waste are emptied according to provisions identified in Section 2.1.9, which requires triple rinsing.

Drums that contained all other hazardous wastes are emptied according to provisions listed in Section 2.1.9, items 3 and 4 of which requires emptying containers according to the RCRA requirements. All large, non-recyclable containers (over 5 gallons) are crushed in or prior to disposal in the landfill. The generator of the empty containers is responsible for ensuring containers are crushed and disposed of in the landfill.

3.10 Compressed Gas Cylinders

Compressed gas cylinders include those containing oxygen, acetylene, propane, ether, carbon dioxide, argon, and nitrogen. The majority of large cylinders are returned to the vendor and refilled. Large propane cylinders are refilled onsite whenever possible.

Cylinders are segregated by type and are managed according to safe handling procedures for compressed gas cylinders, which include ensuring they are stored in a secured upright position in a dry, cool, well-ventilated, secure area, protected from the weather, away from combustible materials.

Smaller cylinders such as those containing ether, propane, or calibration gases, with the valve inside the top fitting, are depressurized through use; valve stems are then removed and the cylinders are then recycled as scrap steel or landfilled.

3.10.1 Aerosol Cans

All aerosol cans are punctured and drained using Aerosolv® brand or equivalent aerosol can puncturing units.

The puncturing device is attached directly to the 2-inch bung of a 30-gallon can. Cans are punctured with a non-sparking puncture pin, and the liquid is collected in the drum. A filter is attached to the ¾-inch bung on the drum to collect volatile organic compounds. The punctured and drained aerosol cans are considered *non-hazardous waste* and either landfilled or recycled as scrap metal.

Residues and filters from puncturing aerosol cans are tested to determine if they are hazardous waste. Typically, these wastes must be managed as *hazardous wastes* and are shipped to an appropriate facility.

3.11 Contaminated Soil

The following sections describe procedures for handling specific types of contaminated soil.

3.11.1 Petroleum-Contaminated Soil

Petroleum-contaminated soil is managed onsite and is considered a *non-hazardous waste.* Petroleum-contaminated material is removed and processed through the mill.

Soil samples are collected depending on the size and location of the spill and based on regulatory guidance or direction to verify the spill area has been cleaned up according to the appropriate ADEC soil cleanup levels (18 AAC 75).

3.11.2 Caustic / Acid Spills Outside the Mill and Secondary Containment

Caustic compounds are also known as bases or alkaline compounds and have a pH greater than 7. Examples include potassium hydroxide, ammonia, and sodium hydroxide.

Acidic compounds have a pH of less than 7. Examples include sulfuric, hydrochloric and nitric acid (inorganic) or acetic and formic acid (organic).

Where required, caustic and acid spills are neutralized onsite and managed as *non-hazardous waste* either in-situ or by removing the contaminated soil and subsequently neutralizing[5] the material.

Confirmation samples are taken when required. For in-situ remediation, if the material has been appropriately neutralized, it will be left in place. Otherwise, the material is removed and neutralized. Removed contaminated soil that has been neutralized is placed in the WRD.

3.12 Filters

There are a number of filters used onsite, including those from vehicles, buildings, baghouses, glycol recycling units, aerosol can puncturing devices, assay lab, refinery, etc. In general, filters classified as non-hazardous waste are landfilled or incinerated. Filters classified as hazardous waste are shipped offsite for recycling.

The following sections describe procedures for managing filters collected throughout the facilities:

- Filters from glycol recycling units would likely be non-hazardous waste, in which case, they are incinerated or landfilled onsite.
- Filters from aerosol can puncturing units are typically hazardous waste and are managed as described in Section 3.10.1.
- The majority of the filters from vehicles, equipment, and buildings onsite are non-hazardous waste and are disposed of in the onsite landfill. Hazardous waste filters are shipped off-site to an appropriate facility.
- Used oil filters include oil filters from vehicles or equipment and fuel filters from diesel equipment:
  - – Used oil filters are considered exempt from hazardous waste regulations if they are gravity hot-drained according to one of the methods described below and if they are non-terne-plated:
    - Puncturing the filter anti-drain back valve or the filter dome end and hot-draining (EPA recommends minimum hot-drain time of 12 hours).

5 For materials meeting the characteristic of corrosivity (40 CFR §261.22), these activities are conducted according to the RCRA requirements for an elementary neutralization unit (40 CFR §260.10)

  - hot-draining and crushing
  - dismantling and hot-draining

- Note that hot-draining means the oil or diesel must be near engine-operating temperature and above room temperature 64°F - 73°F (20°C - 25°C).
- Once appropriately gravity hot-drained, used oil filters are incinerated or landfilled.
- Drained oil or diesel is collected and managed as used oil. Containers are marked "Used Oil."
- Used oil filters are managed as used oil until gravity hot-drained, into containers marked "Used Oil."
- Used oil filters that cannot be managed according to the above procedures are shipped offsite for handling.

3.12.1 Food Waste (Putrescibles)

- To prevent attraction of wildlife, food waste is incinerated onsite and not disposed of in onsite landfills. Inert ash from incineration is placed in the onsite landfill.
- Food wastes are placed in trash cans designated for food waste in the cafeteria and break rooms. All trash bags containing putrescibles are placed in an incinerator dumpster. Incinerator dumpsters are kept closed to prevent the attraction of wildlife.

3.13 Lab Waste

- Hazardous wastes generated in the assay laboratory are shipped off-site for disposal or recycled in the appropriate facility. Other non-hazardous wastes are landfilled.
- Assay lab acid or base solutions are neutralized[6] and pumped into the process plant.
- Laboratory sample preparation wastes are returned to the process plant to recover any valuable minerals.
- Personal Protective Equipment (PPE), i.e. gloves, masks, respirator cartridges, etc. are tested[7] to determine if they are hazardous. PPE found to be a hazardous waste are shipped offsite to an appropriate facility. Non-hazardous waste PPE is landfilled onsite.

3.14 Light Bulbs/Lamps

Many used bulbs are considered hazardous waste when disposed of and the bulbs can be managed as *universal waste,* if intact (EPA 2006a). Bulbs classified as hazardous waste that are intentionally broken or crushed must be managed as *hazardous waste*. Red Dog Mine looks for off-site facilities that recycle bulbs whenever possible.

[6] For materials meeting the characteristic of corrosivity (40 CFR §261.22), these activities are conducted according to the RCRA requirements for an elementary neutralization unit (40 CFR §260.10).

[7] Testing for the characteristic of toxicity is conducted according to the Toxicity Characteristic Leaching Procedure (TCLP), EPA test Method 1311 in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," EPA Publication SW-846.

3.14.1 Hazardous Lamps

- Lamps containing mercury may include fluorescent bulbs (except as described in Section 3.14.2), high-intensity discharge (HID) bulbs, and neon/argon lamps. Examples of HID bulbs include mercury vapor, metal halide, high-pressure sodium bulbs, and blue plasma vehicle headlights. The lamps may be classified as *hazardous waste* when disposed.
- Many lamps contain lead in the solder, which cause them to be classified as *hazardous waste* when disposed, including incandescent lamps.
- Used bulbs that are intact and classified as hazardous waste are managed as *universal waste* and shipped offsite for disposal.
- Used bulbs classified as hazardous waste that are intentionally broken or crushed are managed as *hazardous waste* and shipped offsite for disposal.

3.14.2 Non-Hazardous Lamps

Environmentally friendly, low-mercury, fluorescent lamps ("green end cap") and light-emitting diodes (LED) are currently available and classified as *non-hazardous waste* when disposed. Red Dog Mine purchases environmentally friendly fluorescent bulbs whenever possible. Halogen lamps are also typically *non-hazardous waste.* Non-hazardous lamps are sent offsite for recycling or landfilled onsite.

3.15 Lubricants/Petroleum Products

3.15.1 Brake Fluid

Brake fluid is managed as used oil and burned for energy recovery or shipped offsite for recycling.

3.15.2 Grease

Grease that cannot be used onsite is shipped offsite for disposal. Grease buckets and other containers with less than 3% residue remaining in the container are considered empty and are crushed and disposed of in the onsite landfill. Grease-contaminated trash is disposed of at the onsite landfill or incinerated once any excess grease has been removed.

3.15.3 Used Oil

Used oil generated that meets the applicable RCRA regulatory requirements is burned in space heaters and process boilers to recover energy (Section 2.10 addresses use for oil management requirements). Used oil that cannot be used onsite is shipped to an offsite facility for recycling.

All used oil containers must be labeled "Used Oil" and contained in appropriate secondary containment. Quantities of used oil generated and burned for energy recovery or shipped offsite are logged.

3.16 Miscellaneous Materials

- Styrofoam packaging and products are landfilled onsite. Styrofoam peanuts and other small pieces are placed in boxes or bags prior to disposal to maintain confinement to the landfill or dumpster. Fiberglass insulation and plastic materials are placed in the onsite landfill. Hoses are drained to the extent they would not drip any previous contents and landfilled onsite. Rubber products are placed in the onsite landfill, unless contaminated with product. Contaminated rubber is evaluated, a waste determination is made, and the material is handled accordingly.
- Draeger test tubes may be *non-hazardous waste* or *hazardous waste* depending on the type. *Non-hazardous waste* tubes are landfilled onsite. *Hazardous waste* tubes are shipped offsite to an appropriate facility. The manufacturer provides a letter with general comments on disposal requirements (based on chemical reactants).

3.17 Oily Waste

Oil- or grease-contaminated rags, pads, gloves, or absorbents are considered non-used oil. Once the free-flowing used oil has been removed from these materials, they are not considered used oil and are managed as solid waste as long as they do not exhibit a hazardous waste characteristic. These materials are incinerated onsite. The collected liquid is managed as used oil.

3.18 Paints and Paint Thinner

- Any unused water-based, latex or acrylic paint in solid form or related painting materials (e.g., rags, brushes, rollers), are *non-hazardous waste* and are landfilled onsite; unused paint in liquid form is shipped offsite.
- Oil-based paints in solid form[8], or related painting materials, are considered *non-hazardous waste* and are landfilled onsite; unused paint in liquid form may be *hazardous waste* and are characterized and managed appropriately.
- Thinners and solvent-based or lead-based paint in liquid or solid form, or related painting materials, may be *hazardous waste* and are characterized and managed appropriately.

3.19 Radioactive Materials

Radioactive materials used onsite include level gauges, scales, analysis equipment and exit signs containing cesium and tritium. These materials are handled by the Radiation Safety Officer according to the applicable regulations of:

- The U.S. Nuclear Regulatory Commission, which regulates the use of source, by-product, and special nuclear material under the authority of the U.S. Atomic Energy Act (10 CFR Parts 1 to 171).
- The USDOT regulations, which establish criteria for the safe transport of radioactive materials in the United States (49 CFR Parts 171 to 178).

[8] Purposely leaving paint containers that contain hazardous waste paints open to dry to render them non-hazardous is not permitted.

- The EPA, which regulates the disposal of low-level radioactive material mixed with hazardous waste (40 CFR §261).

3.20 Rags

Rags are washed and reused whenever possible. The disposal of rags is dictated by the material on the rag:

- Rags contaminated with petroleum products are considered non-hazardous waste once no free liquid can drain from the rag and are incinerated or washed onsite. Collected oil is managed as used oil.
- Rags contaminated with other materials are classified based on the classification of the material used on the rag, if the materials were to become a waste.
- Rags managed as hazardous waste are those contaminated with a material that is a hazardous waste if disposed. These rags are shipped offsite to an appropriate facility.
- Rags managed as non-hazardous waste are those contaminated with a material that is not a hazardous waste if disposed. Excess liquid is removed from these rags, and they are incinerated or disposed. Any collected liquid is managed according to the procedures described in this Plan for the particular liquid.

3.21 Scrap Metal

Scrap metal includes building materials, empty drums, aluminum soft drink cans, welding rod, compressed gas cylinders, grinding ball chips, mill liners, crusher liners, and copper wire. To the extent practical, scrap metals are recycled. Scrap metal that cannot be recycled is disposed of in the landfill.

3.22 Solvents

Eco-friendly, non-toxic, “Green” solvents are primarily used at the Red Dog Mine. These solvents are non-hazardous. Provided they are appropriately managed and not mixed with other wastes or materials, the solvents can be disposed of as non-hazardous waste. The main solvents generated are those from the parts washers. The solvent is reused and must be periodically replaced. Solvents from parts washers are sampled and characterized to determine if they are hazardous waste. Sludge from the parts washers are also sampled and characterized. Parts washer solvents and sludge are shipped off-site to an appropriate facility.

3.23 Tires

Worn out tires are used onsite for a variety of applications e.g., safety berms, bumpers on tugboats, and those that cannot be used are disposed of onsite within the WRD as non-hazardous waste.

3.24 Wildlife

Red Dog Mine handles wildlife mortalities in accordance with the procedures identified in the *Red Dog Mine Monitoring Plan* (SRK 2016c).

3.25 Wood, Paper and Cardboard

Wood, paper, and cardboard products are disposed of onsite or burned in a properly designed burn pit or incinerator. Residue ash and debris from open burning or incineration is landfilled onsite.

4 Spill Prevention and Response

The regulations governing spill prevention and response involve multiple agencies, including ADEC, USCG, and EPA.

Table 1 provides a list of required oil spill response plans, the applicable agency with jurisdiction, and the geographical area. In addition to oil spill response, the Red Dog Mine requires the use, storage, transport, and disposal of other hazardous substances.

Table 1: Oil Spill Response Plans

Plan	Application	Jurisdiction	Reference
Spill Prevention, Control, and Countermeasures (SPCC) Facility Response Plan	Containers of oil/fuel ≥ 55 gallons Port tank farm/fuel transfer facility Mine site oil/fuel storage	EPA	40 CFR 112
State of Alaska Oil Discharge Prevention and Contingency Plan	Port fuel storage/transfer facility piping Vessels and barges Mine site oil/fuel storage	ADEC	18 AAC 75

The spill response plans required by the State of Alaska are contained in TAK's *Facility Oil Discharge Prevention and Contingency Plan.*

4.1 Spill Reporting

Spill notification involves a number of different agencies depending on the substance and quantity spilled, including the EPA, USCG, National Response Center (NRC), and ADEC, as described below. The following requirements are for oil and hazardous substances. The requirements for reporting spills to ADEC are contained in 18 AAC 75, Article 3:

- *Any release of a hazardous substance* must be reported as soon as the person has knowledge of the discharge.
- *Any release of oil to water* must be reported as soon as the person has knowledge of the discharge.
- *Any release of oil to land* in excess of 55 gallons must be reported as soon as the person has knowledge of the discharge.
- *Any release of oil to land* in excess of 10 gallons, but 55 gallons or less must be reported within 48 hours after the person has knowledge of the discharge.
- A written report of any discharges of *oil from one to 10 gallons to land* shall be provided on a monthly basis.
- *Any release of oil in excess of 55 gallons to secondary containment* must be reported within 48 hours after the person has knowledge of the discharge.

- Spills to water, wetlands, or those areas that may affect wildlife or marine life are required to be reported to the Alaska Department of Fish & Game (ADF&G) and/or the U.S. Fish & Wildlife Service (USFWS).

- Spills occurring on state land must be reported to the Alaska Department of Natural Resources (ADNR).
- According to the EPCRA regulations in 40 CFR §355.40, certain releases of a hazardous substance require immediate reporting to the community emergency coordinator for the Local Emergency Planning Committee (LEPC) of any area likely to be affected by the release and the State Emergency Response Commission of any state likely to be affected by the release. In the case of the Red Dog Mine, reporting is made to the Northwest Arctic Borough LEPC. Reporting is required for releases of a reportable quantity (RQ) of any EHS or comprehensive environmental responsibility, CERCLA hazardous substance. (See EPA “List of Lists” for the reportable substances and associated RQs).
- Reporting to the EPA is required for any release (other than a federally-permitted release or application of a pesticide) of a hazardous substance in a quantity equal to or exceeding the RQ in a 24-hour period (EPA 2012). Reporting to the EPA can be accomplished by notifying the NRC.
- The EPA also requires reporting of discharges of oil in such quantities that the Administrator has determined may be harmful to the public health or welfare or the environment of the United States. This includes discharges of oil that violate applicable water quality standards; cause a film or sheen upon, or discoloration of, the surface of the water or adjoining shorelines; or cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines. Reporting to the EPA can be accomplished by notifying the NRC.
- Spills to navigable waters must be reported to the USCG, which can be also made through reporting to the NRC, run by the USCG.

Additional spill reporting notifications may be required depending on the area of the spill, substance spilled, and agreements made between agencies, landowners, stakeholders, and TAK.

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

Bill Jeffress
Principal Consultant

and reviewed by

Dan Neuffer
Senior Consultant

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

5 References

Alaska Department of Environmental Conservation 2010. Solid Waste Management, 18 AAC 60, September 5.

Alaska Department of Environmental Conservation 2012. Oil and Other Hazardous Substances Pollution Control, 18 AAC 75, April 8.

International Air Transport Association 2012. IATA Guidance Document, Transport of Lithium Metal and Lithium Ion Batteries. https://www.iata.org/whatwedo/cargo/dangerous_goods/Documents/Guidance-Lithium-Batteries-Transport-2012.pdf (accessed March 19, 2012).

International Air Transport Association 2011. IATA Dangerous Goods Regulations, Addendum, 52nd Edition, January. http://www.iata.org/whatwedo/cargo/dangerous_goods/Documents/52rev01EN-Jan%2020.pdf (accessed August 2014).

International Civil Aviation Organization ICAO 2014. Civil Aviation Regulations, http://www.icao.int/Pages/default.aspx

International Maritime Dangerous Goods IMDG Code, 2012. https://www.gov.uk/government/publications/international-maritime-dangerous-goods-imdg-code-amendment-2012

Mine Safety and Health Administration 2014. Hazardous Communication Standards, Title 30 CFR §47, July.

SRK (2016a). Red Dog Mine Tailings and TSF Water Management Plan. SRK Consulting (U.S.), Inc.

SRK (2016b). Red Dog Mine Waste Rock Management Plan. SRK Consulting (U.S.), Inc.

SRK (2016c). Red Dog Mine Monitoring Plan. SRK Consulting (U.S.), Inc.

SRK (2016d). Red Dog Mine Reclamation and Closure Plan. SRK Consulting (U.S.), Inc.

U.S. Environmental Protection Agency (2006a). Labeling/Marking, 40 CFR §273.14, July 1.

U.S. Environmental Protection Agency (1996). Hazardous Waste Regulations, Title 40 CFR Parts 260 to 279, April.

U.S. Environmental Protection Agency (1996). Oil Pollution Prevention, Title 40 CFR Parts112 to 279, April.

U.S. Environmental Protection Agency (2006b). Solid Waste and Emergency Response, EPA530-R-06-002, Mercury Lamp Drum -Top Crusher Study, August.

U.S. Environmental Protection Agency (2005). Solid Waste and Emergency Response, EPA530-K-05-010, Introduction to Containers, September.

U.S. Environmental Protection Agency (1999). Antifreeze Recycling, Best Environmental Practices for Auto Repair and Fleet Maintenance, November.

U.S. Environmental Protection Agency (2005). Secondary Containment and Impracticability, November.

U.S. Environmental Protection Agency (2011). Spill Prevention Control and Countermeasure (SPCC) Plan, Rectangular or Square Impoundment Structure, July.

U.S. Environmental Protection Agency (2012). List of Lists, Consolidated List of Chemical Subject to the Emergency Planning and Community Right-to-Know Act (EPCRA), CERCLA and Section 112 of the Clean Air Act. EPA 550-B-12-003, October.

Appendices

Appendix A : Legal Description of Property

1. INTRODUCTION

The boundary for the Solid Waste Permit for the Red Dog Mine, as previously approved, is identical to the 1999 Air Shed Ambient Air Quality Boundary. This boundary encompasses all the applicable facilities. In addition, it avoids duplicating the effort of determining the legal description and maintaining multiple permit boundaries.

2. LEGAL DESCRIPTION

Teck Alaska Incorporated submits this legal description of lands encompassed by the 1999 Air Shed Ambient Air Quality Boundary as the geographical boundary for the Solid Waste Permit for Red Dog Mine. It is referred to as the Solid Waste Permit Boundary and applies to the geographic area within the outline depicted on the drawing attached hereto as Figure 1 and located approximately within the following described lands:

Township 30 North, Range 18 West, Kateel River Meridian

Section 5:	NW¼NE¼, SW¼NE¼, W½, NW¼SE¼, SW¼SE¼
Section 6:	All
Section 7:	NE¼, N½NW¼, N½S½NW¼, SW¼SW¼NW¼, NE¼SE¼, NE¼NW¼SE¼
Section 8:	W½NE¼NE¼, NW¼NE¼, N½SW¼NE¼, SW¼SW¼NE¼, N½SE¼NE¼, NW¼, N½NW¼SW¼

Township 31 North, Range 18 West, Kateel River Meridian

Section 1:	SW¼SW¼
Section 2:	NW¼NW¼NE¼, S½NW¼NE¼, SW¼NE¼, SW¼SE¼NE¼, W½, SE¼
Section 3:	All
Section 4:	All
Section 5:	NE¼NE¼, NE¼NW¼NE¼, S½NW¼NE¼, S½NE¼, S½NE¼NW¼, SW¼NW¼, SE¼NW¼, S½
Section 6:	S½SE¼NE¼, E½SE¼, E½W½SE¼
Section 7:	NE¼NE¼, E½NW¼NE¼, S½NE¼, SE¼SE¼NW¼, NE¼SW¼, S½NW¼SW¼, S½SW¼, SE¼
Section 8:	All
Section 9:	All
Section 10:	All
Section 11:	All
Section 12:	W½NW¼NW¼, NW¼SW¼NW¼, W½SW¼SW¼
Section 13:	W½NW¼, N½SE¼NW¼, SW¼SE¼NW¼, SW¼NE¼NW¼, SW¼NW¼SE¼, SW¼SE¼, SW¼
Section 14:	All
Section 15:	All
Section 16:	All
Section 17:	All
Section 18:	All
Section 19:	All
Section 20:	All

Section 21: All

Section 22: N½NE¼NW¼, SW¼NE¼NW¼, W½NW¼, S½SE¼NW¼, SW¼, NW¼SE¼, W½SW¼SE¼

Section 23: N½NW¼NE¼, NE¼NE¼

Section 24: N½NW¼NE¼, SW¼NW¼NE¼, N½NW¼, N½SW¼NW¼, SE¼NW¼

Section 27: W½NW¼NE¼, W¼SW¼NE¼, NW¼, N½SW¼, N½S½SW¼

Section 28: N½, SW¼, N½SE¼, SW¼SE¼, N½SE¼SE¼, SW¼SE¼SE¼

Section 29: All

Section 30: All

Section 31: All

Section 32: N½NE, SW¼NE¼, W½, W½NW¼SE¼, SW¼SE¼

Section 33: N½N½NW¼, NW¼NW¼NE¼

Township 32 North, Range 18 West, Kateel River Meridian

Section 32: SE¼SE¼SE¼

Section 33: S½SW¼SW¼, NE¼SE¼SW¼, S½SE¼SW¼, S½SE¼

Section 34: NE¼NE¼SW¼, S½N½SW¼, S½SW¼, SE¼

Section 35: S½NW¼SW¼, SW¼SW¼, W½SE¼SW¼,

SE¼SE¼SW¼ Township 30 North, Range 19 West, Kateel River Meridian

Section 1: All

Section 2: NE¼, NE¼NW¼, E½NW¼NW¼, SE¼NW¼, NE¼SW¼, SE¼NW¼SW¼, E½SW¼SW¼, SE¼SW¼, SE¼

Section 11: NE¼, NE¼NW¼, NE¼NW¼NW¼, E½NW¼NW¼, E½SE¼NW¼, NE¼NE¼SW¼, N½SE¼, NE¼SW¼SE¼, N½SE¼SE¼

Section 12: N½, N½NE¼SW¼, SW¼NE¼SW¼, NW¼SW¼, N½SW¼SW¼, NW¼NW¼SE¼

Township 31 North, Range 19 West, Kateel River Meridian

Section 12: S½SW¼SE¼, SE¼SE¼

Section 13: E½, NE¼NW¼, NE¼NW¼NW¼, S½NW¼NW¼, S½NW¼, NE¼SW¼, N½NW¼SW¼, SE¼NW¼SW¼, SE¼SW¼

Section 24: E½, E½NW¼, E½NE¼SW¼, NE¼SE¼SW¼

Section 25: E½, E½SE¼NW¼, NE¼SW¼, S½NW¼SW¼, S½SW¼

Section 26: SE¼NE¼SW¼, E½SE¼SW¼, S½NE¼SE¼, NW¼SE¼, S½SE¼

Section 35: E½, E½NW¼, NE¼SW¼, E½SW¼SW¼, SE¼SW¼

Section 36: All

3. BOUNDARY DRAWING

The boundary for the Solid Waste Permit for the Red Dog Mine is shown on the attached drawing “Red Dog Mine Solid Waste Permit Boundary”.

Meridian Kateel River T32N R19W
Meridian Kateel River T32N R18W
Meridian Kateel River T31N R19W
Meridian Kateel River T31N R18W
Meridian Kateel River T30N R19W
Meridian Kateel River T30N R18W
Alaska State Land Boundary
NANA Land Boundary
162°58'0"W
162°56'0"W
162°54'0"W
162°52'0"W
162°50'0"W
162°48'0"W
162°46'0"W
162°44'0"W
162°42'0"W
68°8'0"N
68°7'0"N
68°6'0"N
68°5'0"N
68°4'0"N
68°3'0"N
68°2'0"N
68°1'0"N
68°0'0"N
Red Dod Mine Solid Waste Permit Boundary
N
W
E
S
0
2,900
5,800
Feet

Appendix B : Tailings and TSF Water Management Plan

Red Dog Mine

Tailings and TSF Water Management Plan

Red Dog Mine, Alaska, USA

Prepared for

Teck Alaska Incorporated

Prepared by

srk consulting 1974 40 2014

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

Tailings and TSF Water Management Plan

Red Dog Mine, Alaska, USA

August 2016

Prepared for

Teck Alaska Incorporated
3105 Lakeshore Drive
Building A, Suite 101
Anchorage, AK 99503
United States

Tel: +1 907 754 6170
Web: www.teck.com

Prepared by

SRK Consulting (U.S.), Inc.
Suite E-12, 4700 Business Park Blvd.
Anchorage, AK 99503
United States

Tel: +1 907 677 3520
Fax: +1 907 677 3620
Web: www.srk.com

Project No: 329100.030
File Name: TailingsWater_RedDogMine_329100030_20160805.doc

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ADNR	Alaska Department of Natural Resources
AMSL	above mean sea level
ARD	acid rock drainage
DD2	diversion ditch 2
DMTS	DeLong Mountain Regional Transportation System
EPA	United States Environmental Protection Agency
Golder	Golder Associates Inc.
IDF	Inflow Design Flood
IWMP	Integrated Waste Management Plan
ML/ARD	metal leaching/acid rock drainage
MWD	Main Waste Dump
NANA	NANA Regional Corporation, Inc.
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SRK	SRK Consulting (U.S.), Inc.
TAK	Teck Alaska Incorporated
TDS	total dissolved solids
TSF	Tailings Storage Facility
URS	URS Corporation
WRD	Waste Rock Dump
WTP	Water Treatment Plant

1 Introduction

Teck Alaska Incorporated (TAK) is submitting the *Red Dog Mine Tailings and TSF Water Management Plan* to the Alaska Department of Environmental Conservation (ADEC), as required by Alaska Statute (AS) S 46.03.100(c) and Title 18 Alaska Administrative Code (AAC) Chapter 60 (18 AAC 60). This Plan is a supporting document to the *Red Dog Mine Reclamation and Closure Plan* (SRK 2016a) and an appendix to the *Red Dog Mine Integrated Waste Management Plan* (SRK 2016b). This document collects commitments for the *Red Dog Mine Reclamation and Closure Plan* and the *Red Dog Mine Integrated Waste Management Plan* and provides further details. The topics are grouped into two main categories, as follows:

- Tailings management:
  - Main and Back Dams;
  - Tailings beach requirements;
  - Water cover; and
  - Tailings deposition.
- Tailings Storage Facility (TSF) water management:
  - Reduction of pond volume;
  - Pre-treatment of the largest sources of constituent loading; and
  - Construction of improved Main Waste Dump (MWD) Seepage Collection System.

Operational procedures associated with each of these areas are discussed herein. Specific plans pertaining to normal and routine management of tailings and water at Red Dog Mine are maintained separately by Teck Alaska Incorporated (TAK). Mine plans, schedules, and quantities pertaining to tailings and water management were provided by TAK unless otherwise noted.

2 Tailings Management

The Red Dog Mine Tailings Storage Facility (TSF) is located in the upper valley of the South Fork of Red Dog Creek (Figure 1). Tailings are impounded by the Main Dam at the north end, the Back Dam at the south end, and the surrounding topography.

As of June 2014, when the water and load balance update (SRK 2016c) was initiated, the TSF contained an estimated 46,800,000 tonnes of tailings. If the tailings were uniformly distributed within the TSF, this would be equivalent to a “struck-level” elevation of approximately 949 feet above mean sea level (amsl). The surveyed water level as of May 2014 was 965 feet amsl, at which time it was estimated that the TSF contained approximately 3.5 billion gallons of water.

The current estimate of total tailings production is approximately 81,700,000 tonnes by the end of ore processing in 2030. Estimates of final dry bulk tailings density are 88.0 pounds per cubic foot (pcf) for tailings from Main Pit ore and 94.9 pcf for tailings from Aqqaluk Pit ore (respectively, 1.41 and 1.52 tonnes per cubic meter). Using these density estimates, and the 2013 TSF bathymetry, the final struck-level tailings surface is estimated to be at an elevation of 978 feet amsl. The estimate of the final tailings struck elevation will be refined as mining proceeds.

The *Red Dog Mine Water and Load Balance Update* (SRK 2016c) indicates that the TSF with a dam crest elevation of 986 feet amsl could reach capacity in 2025. The many assumptions behind that result are presented in detail in in SRK 2016c.

The estimate of final tailings density is one of the most significant uncertainties, and continued monitoring of bathymetry will reduce that uncertainty over time. Should that monitoring demonstrate a need for additional tailings storage volume, several options are available. These include raising the TSF dams, increasing tailings density, and/or decreasing tailings production.

TAK will evaluate the uncertainties and options for addressing TSF capacity before the next Integrated Waste Management Permit/Reclamation Plan Authorization renewal application.

2.1 Main Dam

Information on the Main Dam is sourced from URS (2014) unless otherwise noted. The Main Dam crest is currently at an elevation of 976 feet amsl. By 2017, TAK anticipates raising the dam to a crest elevation of 986 feet amsl. The dam is a zoned rockfill embankment constructed in a downstream configuration. The upstream face of the dam is lined with geomembrane extending to competent bedrock for seepage control. The Wing Wall extends the Main Dam crest to the east and south, using the same zoned rockfill and liner system (Figure 1). The Main Dam and Wing Wall also use cutoff and curtain walls, respectively, that extend below the embankments for seepage control. Seepage from the Main Dam is collected in the Seepage Collection Pond immediately downstream of the Main Dam and pumped back to the TSF. Routine operation and maintenance requirements for the Main Dam are described by URS (2013).

URS (2008) summarized flood storage capacity in the TSF for a dam crest elevation of 986 feet amsl; tailings struck elevation of 975 feet amsl, and presented a preliminary spillway design to be installed west of the Main Dam at closure. The spillway would provide engineered conveyance of water around the Main Dam in the event that the capacity of the TSF was exceeded.

The URS (2008) results are summarized in Table 1. Storage volumes considered in URS (2008) analysis were:

1. Spring freshet: average monthly runoff into TSF in May, including thaw and runoff of November to April precipitation, minus evaporation and seepage losses
2. Probable Maximum Flood (PMF) series: runoff from the 24-hour Probable Maximum Precipitation (PMP) event plus 40% of the runoff from another PMP event
3. 100-year flood: runoff from the 24-hour, 100-year precipitation event

Additional inputs for the URS (2008) spillway design were:

1. Inflow Design Flood (IDF): depth of flow during a one-half PMF event
2. Freeboard: wind setup and wave run-up during the IDF, assuming a 600-foot-wide beach sloping at 1%

Table 1: Surcharge and Spillway Capacity for Main Dam at Crest Elevation of 986 feet (URS 2008)

Component of Storage	Depth (feet)	Resulting Elevation (feet AMSL)
Tailings Surface	N/A	975.0
Minimum Water Cover	2.0	977.0
Spring Freshet	1.4	978.4
Probable Maximum Flood Series	4.2	982.6
100-year Flood	0.9	983.5
Spillway Crest	N/A	983.5
Inflow Design Flood	1.4	984.9
Freeboard for Wind/Wave	1.1	986.0
Dam Crest	N/A	986.0

The current estimate of final tailings elevation is 978 ft amsl, higher than was assumed in the URS (2008) work. The spillway design will need to be revised once the final tailings elevation is determined.

TAK commissioned a geophysical survey of the Wing Wall to evaluate potential seepage pathways (Willowstick 2013). The survey identified a possible preferential flow path beneath the Wing Wall. In 2014, TAK installed two piezometers in the possible preferential flow path: one piezometer was installed upstream of the Wing Wall and one piezometer was installed downstream of the Wing Wall. TAK will monitor the piezometers to develop an understanding of the possible preferential flow path beneath the Wing Wall and provide an update to ADEC and ADNR when the preferential flow path can be confirmed or ruled out, along with plans for additional actions, if needed.

2.2 Back Dam

The Back Dam is located at the south end of the TSF and straddles the divide between the TSF and Bons Creek (Figure 1). The Back Dam crest is currently at an elevation of 976 feet amsl

(Golder 2014a). By 2017, TAK anticipates raising the dam to a crest elevation of 986 feet amsl. Raises of the Back Dam will need to be timed in accordance with Main Dam raises. The dam is a zoned rockfill embankment constructed in a centerline configuration. A vertical, plastic-concrete, cut-off wall extends downward from the center of the dam crest for seepage control. Seepage from the Back Dam is collected in a sump between the Back Dam and Overburden Dump and pumped back to the TSF. Routine operation and maintenance requirements for the Back Dam are described by Golder (2014b).

2.3 Tailings Beaches

Since 1997, tailings have been used to form beaches that limit seepage from the TSF. Beach development is phased and ongoing, and based on the dam crest elevation and operational considerations are expected to continue throughout mining.

By 2000, tailings placed along the upstream face of the Main Dam formed a complete beach. TAK's objective is to maintain a 600-foot-wide beach along the Main Dam and Wing Wall during operation. Seepage records maintained by TAK indicate that the tailings beach contributes to seepage control. A seepage analysis conducted by URS (2007) demonstrated that a wide tailings beach reduces seepage from the Main Dam.

TAK plans to start constructing a tailings beach upstream of the Back Dam to control seepage from the TSF into Bons Creek. A seepage analysis conducted by Golder (2006) demonstrates that a 600-foot-wide tailings beach reduces seepage from the Back Dam. Monitoring of seepage during operations may lead to the conclusion that a narrower beach is adequate.

TAK may develop tailings beaches in other locations in the TSF. Measures to control dust from beaches are currently in place and will be maintained in compliance with air quality regulations.

2.4 Water Cover

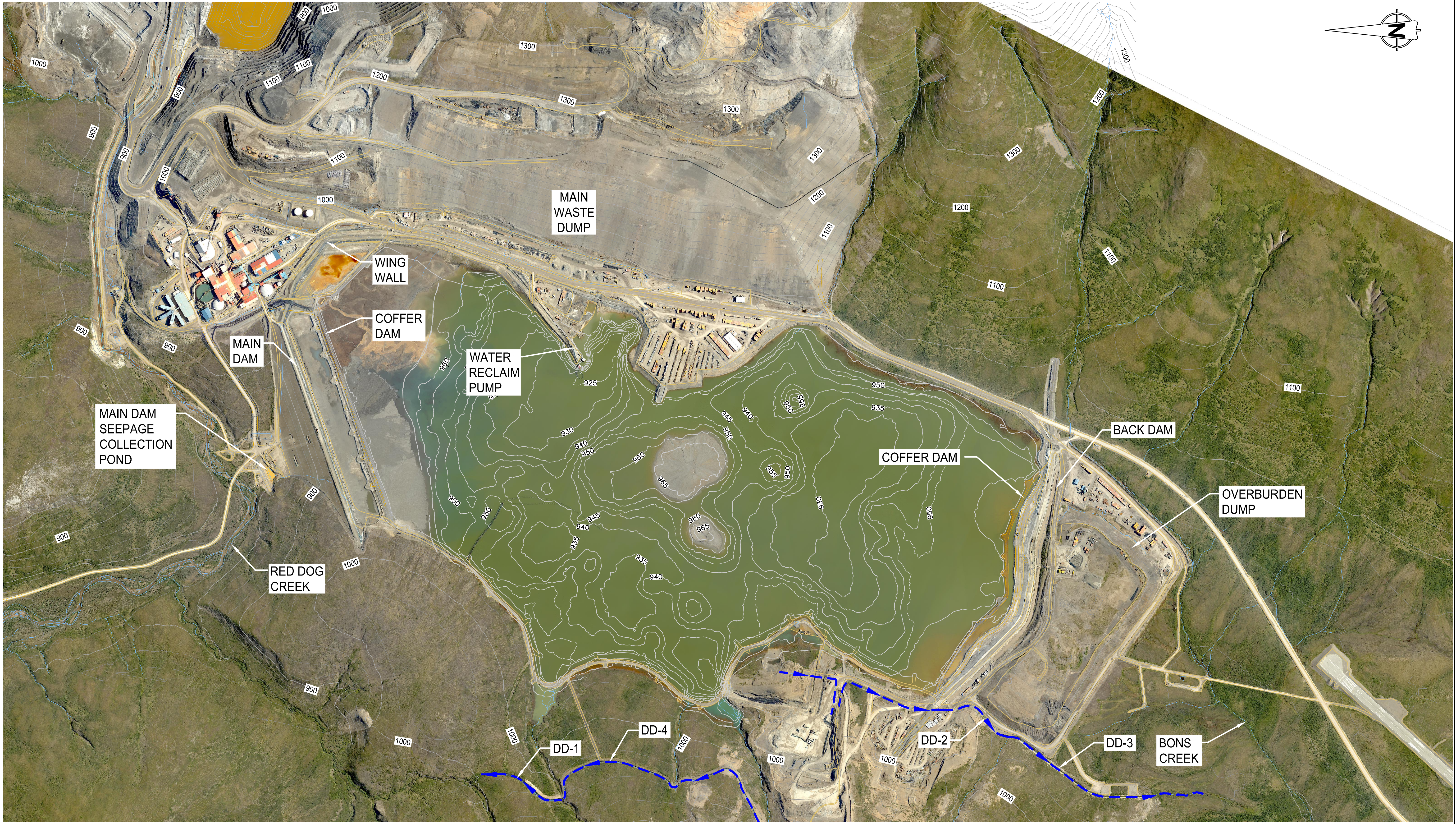
Tailings produced at Red Dog Mine are potentially acid generating. A minimum water cover of two feet should be maintained over the tailings surface throughout operation to minimize metal leaching and acid rock drainage (ML/ARD). More details on management of the water cover are provided in Section 3.

2.5 Tailings Deposition

To minimize tailings oxidation, which can contribute to acid generation, tailings are deposited below the water surface (subaqueous deposition). Tailings may be deposited subaerially during periods of plant maintenance and during placement along dam faces as beaches, but subaqueous deposition is the principal method used.

Subaqueous deposition has resulted in the formation of tailings cones. To ensure that the tailings cones are uniformly distributed, TAK moves the deposition point. To more evenly distribute tailings subaqueously, TAK is evaluating alternative strategies for winter deposition, including deposition from a perforated pipe. TAK reports that perforated pipes have been used successfully since early in 2014.

In addition, to maximize tailings storage capacity and provide 2-foot-deep water cover above the tailings, TAK is evaluating alternatives for tailings redistribution that level the tailings surface as much as practicable. Several methods have been used at other facilities, but further evaluation is required prior to implementation. For example, in areas of shallow water a shallow-water boat equipped with a harrow could be used to grade tailings. Similarly, barge-mounted dredges could be employed to spread large accumulations of shallow tailings. TAK will continue evaluating alternative methods and to the extent practicable, identify and implement a preferred tailings deposition and/or redistribution method(s) to level the tailings surface no later than 2025.



CLEAN WATER DIVERSION

0 500' 1000' 1500' 2000'
0 .5" 1" 1.5" 2"
SCALE : 1" = 1000'

TOPOGRAPHY AND LAYOUT BASED ON INFORMATION PROVIDED BY RED DOG, 2014.

Red Dog Mine

DESIGN: DPN	PREPARED BY: srk consulting
DRAWN: JBM	
REVIEWED:	
APPROVED:	PROJECT: RED DOG MINE TAILINGS AND WATER MANAGEMENT PLAN
IF THE ABOVE BAR DOES NOT MEASURE 1 INCH, THE DRAWING SCALE IS ALTERED	

FIGURE TITLE: CURRENT LAYOUT AND BATHYMETRY OF TAILINGS STORAGE FACILITY

DATE: MARCH 2016 | REVISION: 0 | FIGURE NO.: 1

SRK PROJECT NO.: 329100.030

P:\Teck Alaska - Red_Dog\329100.030 IWMP\329100.030 IWMP\040_AutoCAD_GIS\Rec Plan Figures\Agency Draft Rev 2 -Figures SRK\2238-F1 (TAILINGS AND WATER).dwg

3 TSF Water Management

3.1 TSF Pond Volume Reduction

TAK plans to reduce the water volume in the TSF pond to achieve a two-foot water cover by closure in 2031. Prior to closure, TAK plans to reduce constituent concentrations in the TSF by pre-treating the largest sources of loading, and by maximizing capture of seepage from the Main Waste Dump (MWD).

Tailings water management is linked to the closure objective for the TSF pond. Significantly reducing the TSF volume will allow the benefits of capturing and treating inflows to be attained in a much shorter time. The *Red Dog Mine Water and Load Balance Update* (SRK 2016c) indicates that reducing constituents, such as total dissolved solids (TDS) and metals, in the TSF the last few years of operation prior to closure will improve the quality of the water entrained in the upper few feet of tailings. SRK 2016c indicates that reducing constituents such as TDS and metals in entrained water in the upper few feet of tailings will improve the water quality in TSF pond at closure of the Red Dog Mine.

Reducing the water level to approximately two feet above the surface of the tailings by 2031 will require an average annual discharge of about 1.6 billion gallons (Appendix A). All water will be treated and discharged at Outfall 001. Upon reaching the target water cover depth, subsequent water discharges would need to average about 0.3 billion gallons per year (Appendix A). Actual discharge requirements may vary depending on precipitation, evaporation, and diversion effectiveness.

3.2 Pre-treatment of Largest Load Sources

Red Dog Mine operates three water treatment plants (WTPs) as summarized in Table 2. WTP3 began operating in 2006. The plant was designed to treat some of the MWD seepage and Mine Sump water before it entered the TSF. Under current capacity limitations, WTP3 and WTP1 treat MWD seepage as a priority. An estimated 200 to 250 million gallons of MWD water is treated annually with the current configurations of WTP3 and WTP1.

Expanding WTP capacity will allow pre-treatment of additional load sources to the TSF, including:

- The portion of MWD seepage that currently escapes capture and treatment; and
- Water from the Main and/or Aqqaluk pits.

TAK is considering a number of options to increase WTP treatment capacity. The lime slaking and handling system was upgraded in 2015. Future modifications may include winterizing WTP3, but further analysis and engineering are required before options are selected and implemented.

Table 2: Water Treatment Plant Summary

Treatment Plant	Description of Current Role	Operation
WTP1	Treats MWD water and discharges to TSF (winter and part of summer). Treats water from TSF pond for discharge to Red Dog Creek (part of summer)	Year-round
WTP2	Treats water from TSF pond for discharge to Red Dog Creek	Summer
WTP3	Treats MWD water and discharges to TSF	Summer

3.3 MWD Seepage Collection System

The MWD Seepage Collection System captures a portion of the seepage from the MWD and pumps the water to WTP3 or WTP1 for treatment. Uncaptured seepage flows to the TSF. The current seepage collection system captures approximately 30% of the water reporting to the toe of the MWD.

Maximizing the capture of MWD seepage is expected to improve water quality in the TSF. TAK plans to increase capture of MWD seepage to approximately 75% by 2019. MWD Seepage Collection System upgrades may include construction of a cutoff wall and/or additional seepage collection wells. Final design will need to be integrated with construction of the Main Dam Wing Wall, which may include cutoffs along a parallel alignment.

This report, *Tailings and TSF Water Management Plan*, was prepared by SRK Consulting (U.S.), Inc. with data supplied by TAK.

____
Daniel Neuffer, Senior Consultant

and reviewed by

____
Daryl Hockley, Corporate Consultant

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

4 References

Golder Associates, Inc. (2006). Detailed Design Tailings Impoundment – Back Dam Cut-Off Wall, Red Dog Mine, Alaska. Draft Report prepared for Teck Cominco Alaska Inc. November 2006.

Golder Associates (2014a). Stage III Tailings Back Dam Raise Design, Red Dog Mine.

Golder Associate. (2014b). Operations and Maintenance Manual (Revision 2): Tailings Back Dam, Red Dog Mine.

SRK (2016a). Red Dog Mine Reclamation and Closure Plan. SRK Consulting (U.S.), Inc.

SRK (2016b). Red Dog Mine Integrated Waste Management Plan. SRK Consulting (U.S.), Inc.

SRK (2016c). Red Dog Mine Water and Load Balance Update. SRK Consulting (U.S.), Inc.

URS (2007). Seepage Analysis Report, Red Dog Tailings Main Dam, Future Raises to Closure, Red Dog Mine, Alaska.

URS (2008). Preliminary Spillway Design, Red Dog Tailings Main Dam, Ultimate Closure Configuration.

URS (2014). Design Report: Stage X Widening, Red Dog Tailings Main Dam, Red Dog Mine, Alaska.

URS (2013). Operations and Maintenance Manual, Red Dog Tailings Main Dam, NID ID# AK 00201, Red Dog Mine, Alaska.

Willowstick (2013). Willowstick Investigation of Red Dog Mine Tailings Pond.

Appendix C : Waste Rock Management Plan

Red Dog Mine

Waste Rock Management Plan

Red Dog Mine, Alaska, USA

Prepared for

Teck Alaska Incorporated

Prepared by

srk consulting

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

Waste Rock Management Plan

Red Dog Mine, Alaska, USA

August 2016

Prepared for

Teck Alaska Incorporated
3105 Lakeshore Drive
Building A, Suite 101
Anchorage, AK 99503
United States

Tel: +1 907 754 6170
Web: www.teck.com

Prepared by

SRK Consulting (U.S.), Inc.
Suite E-12, 4700 Business Park Blvd.
Anchorage, AK 99503
United States

Tel: +1 907 677 3520
Fax: +1 907 677 3620
Web: www.srk.com

Project No: 329100.030
File Name: RedDogMine_WasteRock_329100030_20160805.docx

Table of Contents

List of Figures

List of Tables

List of Appendices

List of Abbreviations

ADEC	Alaska Department of Environmental Conservation
ADNR	Alaska Department of Natural Resources
AS	Alaska Statute
AMSL	above mean sea level
ML/ARD	Metal Leaching/Acid Rock Drainage
MPD	Main Pit Dump
MWD	Main Waste Dump
S	Sulfide
TAK	Teck Alaska Incorporated
TSF	Tailings Storage Facility
WTP1	Water Treatment Plant 1
WTP3	Water Treatment Plant 3

1 Introduction

Teck Alaska Incorporated (TAK) is submitting the *Red Dog Mine Waste Rock Management Plan* (Plan) to the Alaska Department of Environmental Conservation (ADEC) and the Alaska Department of Natural Resources (ADNR), as required by Alaska Statute (AS) 27.19.010 and AS 46.03.100 (c). This Plan is a supporting document to the *Red Dog Mine Reclamation and Closure Plan* (SRK 2016a) and an appendix to the *Red Dog Mine Integrated Waste Management Plan* (SRK 2016b).

The Plan presents strategies for managing waste rock at the Red Dog Mine (Mine) which are summarized in the above referenced plans. Topics are grouped into three categories:

- The current status and plans for waste rock dump construction, in a geometry that is compatible with the closure plan (SRK 2016a)
- Concurrent reclamation of completed waste rock dump areas
- Segregation of waste rock to obtain clean material suitable for dam and cover construction and, where possible, to place the waste rock with a high sulfide content that is potentially self-heating (high S waste rock), below the ultimate water level in the Main Pit Dump (MPD)

Waste rock management procedures are specified in the Red Dog Mine Waste Rock Management Procedures (TAK 2013). Mine plans, volumes, and timing provided in this document are found in the Operational Life of Mine Plan (TAK 2014b). These documents will not be further referenced herein.

2 Current Status and Construction Plan for Waste Rock Dumps

2.1 Overview

Waste rock dumps are used to dispose of waste rock that is not expected to have economic value before the end of the mine life. There are currently four waste rock dumps and a low-grade stockpile at the Mine (Figure 1), and there are plans to backfill the Qanaiyaq Pit with waste rock. Brief descriptions of each of these dumps and stockpiles are provided in Table 1, with further details in the following sections.

Waste rock dumps have been designed to accommodate projected waste volumes and to minimize re-sloping requirements at closure. Where possible and to facilitate reclamation activities (e.g., cover placement), dumps have been constructed to enable final surface slopes of approximately 3H:1V.

2.2 Main Waste Dump

The Main Waste Dump (MWD) is located east of the Tailings Storage Facility (TSF) and contains waste rock from the Main Pit and from the development of the Aqqaluk Pit. The ultimate height of the dump is maintained at an elevation to meet navigational requirements for the airstrip. The surface of the MWD was graded to a slope of 3H:1V or less and the surface has been compacted. Final reclamation will be completed prior to closure as described in Section 3.

Seepage from the MWD is collected in the MWD Collection System, which consists of a series of drains and sumps between the western dump slope toe and the TSF. The collection system intercepts a portion of the seepage and runoff potentially affected by metal leaching and acid rock drainage (ML/ARD), and the remainder enters the TSF. During the summer months the captured water is pre-treated in Water Treatment Plant 3 (WTP3) and in the winter months the water is pre-treated in Water Treatment Plant 1 (WTP1), before being discharged into the TSF.

REVISIONS		
REV.	DESCRIPTION	DATE

FILE NAME: 2238-FIG 1 (WRMP).dwg

DESIGN: SDT
DRAWN: JBM
REVIEWED:
APPROVED:

IF THE ABOVE BAR DOES NOT MEASURE 1 INCH, THE DRAWING SCALE IS ALTERED

PREPARED BY: srk consulting

PROJECT: WASTE ROCK MANAGEMENT PLAN

FIGURE TITLE: RED DOG DUMP AND STOCKPILE LOCATIONS

DATE: MARCH 2016

REVISION:

FIGURE NO.: 1

SRK PROJECT NO.: 329100.030

P:\Teck Alaska - Red_Dog\329100.030 IWMP\329100.030 IWMP\040_AutoCAD_GIS\Rec Plan Figures\Agency Draft Rev 2 -Figures SRK\2238-FIG 1 (WRMP).dwg

Table 1: Existing and Future Waste Rock Dumps and Low-Grade Ore Stockpiles

Facility	Description
Main Waste Dump	Contains waste rock accumulated from mining the Red Dog deposit (Main Pit) and the initial development of the Aqqaluk deposit (Aqqaluk Pit).
Overburden Dump	Contains a mixture of mineralized and non-mineralized material excavated from the tailings and mill site during initial construction. This dump is currently used for storage.
Main Pit Dump	Since the cessation of mining of the Main Pit in 2012, the pit (now referred to as the Main Pit Dump) is and will continue being backfilled with waste rock until final closure.
Oxide Dump	Weathered rock that meets the mine's grade cutoff criteria but is not economically recoverable with the available technology. As of the publication date of this document, TAK has no plans to recover metals from this material. This material may be recovered in the future due to changes in economic conditions and/or technology.
Qanaiyaq Pit Dump	This pit will be backfilled with waste rock upon the completion of mining of Phase 1 of the Qanaiyaq Pit and will continue to be backfilled until the completion of mining.
Low Grade Ore Stockpile	Material between the mill cutoff and operating cutoff grades is stored in the Low Grade Ore Stockpile. This material may be processed at some time in the future if economic conditions change or at the end of the mine life when other operating costs are at a minimum.

2.3 Overburden Dump

The Overburden Dump is located between the south end of the TSF and the Bons Creek watershed. The dump consists of Kivalina shale (non-mineralized material) inter-mixed with mineralized material, which is a minor source of zinc loading.

The Overburden Dump Collection System captures potentially affected runoff from the Overburden Dump via two catchment basins, which is then pumped into the TSF for treatment.

2.4 Main Pit Dump

TAK began placing waste rock from the Aqqaluk Pit in the Main Pit Dump (MPD) in 2012 and will continue to use this dump through the remaining mine life (TAK 2014a). The MPD will also receive waste from Phase I of the Qanaiyaq Pit. The Main Pit began flooding in May 2012 and reached its operating elevation of 840 ft above mean sea level (AMSL)[1] in May 2015. TAK plans to maintain water levels at this elevation for the remainder of operations, and will allow the pit to flood to a final elevation of 850 ft AMSL at closure. To the extent possible, the rock with potential for self-heating (high S waste rock) will be placed below the ultimate water level.

Extraction of high S waste rock from the Aqqaluk Pit is expected to be minimal for the first decade. Therefore, other types of waste rock are dumped from higher dump platforms, starting at the south end of the pit and progressing to the north, to maximize the available flooded area for the high S waste rock in the future.

The MPD will be closed and sides sloped upon completion of the Aqqaluk Pit in 2030. Initial side sloping will be 3.7H:1V to allow the final resloped surface to be composed of engineered

[1] All elevations are in feet above mean sea level and reported as "feet" in this document.

channels and slopes of 3H:1V, varied where possible to enhance erosional stability and provide more natural-looking landforms.

2.5 Oxide Dump

The Oxide Dump is located east of the MWD, immediately east of the Landfill Area. This dump is no longer in use and has been re-contoured. This dump is being used for a large scale cover system trial that began in 2004. These trials consist of a 20-inch layer of compacted, weathered shale overlain by a 20-inch layer of lightly compacted, weathered shale, which was then seeded. For further information, see the *Red Dog Mine Reclamation and Closure Plan* (SRK 2016a).

2.6 Qanaiyaq Pit Dump – Planned

Waste from the second phase of the Qanaiyaq Pit will be dumped into the first phase of the Qanaiyaq Pit, currently planned for 2023. Waste from the Aqqaluk Pit will be dumped into the second phase, currently planned to begin in 2027 when mining of the Qanaiyaq Pit is complete, and will continue until the completion of mining in 2030. This pit is thought to be entirely above the water table; therefore, waste will not be segregated.

2.7 Low Grade Ore Stockpile

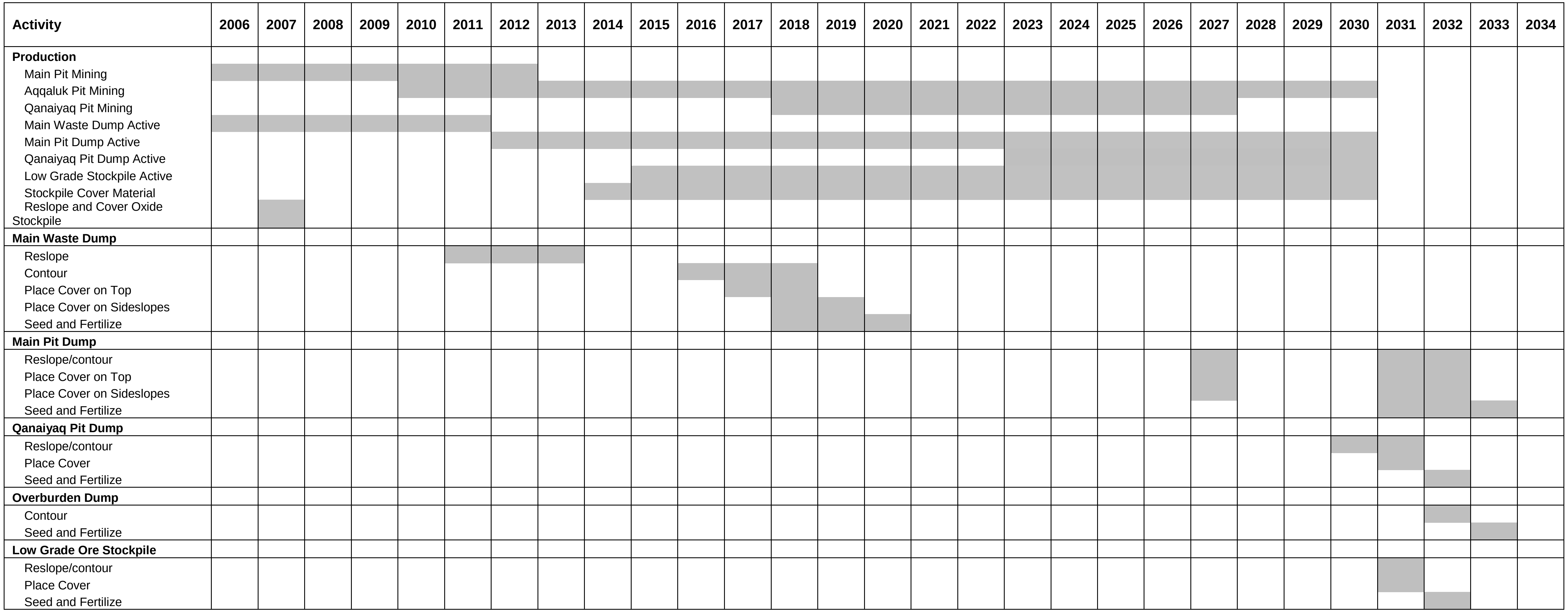
The Low Grade Ore Stockpile, located north of the MWD, contains rock that meets the criteria for economic mill feed, but does not meet other current economic parameters. At this time, the stockpile is not in active use. However, depending on economic conditions, it may be used for additional storage of low grade ore, or it may be processed at some point in the future. Any material remaining at the end of the mine life will be reclaimed.

3 Concurrent Reclamation Plan

Waste rock dumps will be concurrently reclaimed during operations to the extent practical. The primary objective of concurrent reclamation is to reduce geochemical loads to the TSF and subsequently to the water treatment plants. In addition, concurrent reclamation will efficiently utilize existing equipment and reduce the volume of cover material stockpiles managed by mining operations.

A schedule for implementation is provided in Figure 2, and described as follows:

- Completed or ongoing activities
  - Cover trials were conducted in 2008 on the existing waste rock test cells located on the MWD. Cells were fully instrumented to collect data needed for the final cover design (O’Kane 2009a).
  - A large scale cover trial was constructed on the Oxide Dump in 2007 (O’Kane 2004 & O’Kane 2009b). The cover trial was instrumented to collect data for final design and monitoring (O'Kane 2014).
  - A new cover trial using geosynthetic/geocomposite materials for the MWD is ongoing and expected to be completed by the end of 2016. If the current cover design is not optimal, TAK will engage with interested stakeholders and propose a modification to the *Reclamation and Closure Plan*.
- Planned Activities
  - Cover placement on the MWD will depend on the availability of suitable cover materials, equipment and manpower. Cover construction could start as early as 2017. Cover construction is anticipated to take three years, with the cover completed on roughly a third of the dump each year starting on the southern end. Once cover sections are complete, this area would be seeded and fertilized. Operations will maintain access to the Low Grade Ore Stockpile and the Qanaiyaq Pit during cover activities.
  - The MPD will be in use until the end of mine life. It may be possible to cover portions of this dump in 2026, with the remainder being covered within two years of cessation of mining.
- The Qanaiyaq Pit Dump will be in use until the end of mine life, and covered within two years of cessation of mining the Qanaiyaq deposit.
  - Depending on economics at the time of closure, it may be possible to process ore in the Low Grade Ore Stockpile. This would most likely occur in the last year of mining. If it is not economic to process this material, it will be re-sloped and covered within two years of the cessation of mining.
  - Suitable material will be required to cover the exposed tailings beaches at the end of the mine life. Material may be stockpiled for this purpose.



P:\Teck Alaska - Red_Dog\329100.030 IWMP\329100.030 IWMP\080_Deliverables\Waste Rock Mgt Plan\Final Draft\Figures\WRMP_Figure 2_329100-030_20141003_sdt.xls

Figure 2: Reclamation Schedule

4 Waste Rock Classification and Segregation

TAK has developed procedures (TAK 2013) to implement the classification, segregation, and placement of waste rock and to minimize the need for re-handling. More recently, TAK, with assistance from SRK, assessed the geochemical characteristics of material from the Key Creek Plate, and developed procedures for identifying and segregating this material for use in cover construction (SRK 2016c, provided as Appendix A). TAK has modified the segregation criteria for high S waste rock that considers rates of sulfide oxidation, potential for self-heating, and production schedules (TAK, in preparation).

Waste Rock is currently subdivided into four categories:

1. Rock with low ML/ARD that is suitable for tailings dam construction
2. Rock with low ML/ARD that is suitable for cover material
3. Waste rock with a high sulfide content that is potentially self-heating (high S waste rock)
4. Rock that does not fit any of these other classifications

TAK has identified different types of rock with suitable characteristics for construction and cover material (Table 2). The updated segregation criteria for both cover material and for high S waste rock are defined in Table 3.

Table 2: Red Dog Mine Construction and Cover Materials

Material	Characteristics	Application
Siksikpuk Shale (S-Shale)	High silica [Si] content and very low total organic carbon [TOC] content	Preferred construction material due to high Si content. The material has insufficient TOC and does not adequately support cover crops.
Kivalina and Kayak Shale of the Key Creek Plate	Low Si and high TOC content. Low potential for ARD	Preferred cover material due to relatively high TOC supporting cover crops. Due to the low Si content, Kiv-Shale breaks down easily and is inadequate for other construction purposes.

Table 3: Current Segregation Criteria

Intended Use/Disposal Location	Allowable Rock Types	Criteria*
Dam Construction	Siksikpuk Shale	Single blast hole assays not to exceed: 1% Zn, 1% Pb, 3.5% Fe Average blast hole assays not to exceed: 0.5% Zn, 0.5% Pb, 2.5% Fe
Cover Material	Kivalina and Kayak Shale of the Key Creek Plate	Material must be from Key Creek structural plate. Identified as predominantly Kivalina and/or Kayak shale, based on visual estimation Must not contain greater than 10% visual percent sulfide over an area of more than 500 m^2. No more than 5 adjacent blast-holes to exceed 0.25% zinc.
High S Waste Rock (placed below the ultimate water level in the Main Pit Dump where possible, or blended to reduce the self-heating capacity)	Typically Ikalukrok	Self-Heating Capacity Risk Region 5 or greater**
Other Waste Rock – placed in Main Pit or Qanaiyaq pit dumps. To maximize space available for underwater disposal of the high S waste, it is preferable to place this material in locations that are above the ultimate water level in the Main Pit Dump	Waste Rock not meeting other criteria	

Notes: *Analytical criteria are only to be applied to the allowable rock type (*i.e*. rock type has precedence).
**Calculated as follows:

Self-Heating Capacity Risk Region = 3.41744 + (%Pb-%sPb) / 0.866 x (-0.33539 + 0.03897 x %Zn / 0.671) - 0.81502 x Log((%Ba / 0.5886) / (%Fe / 0.4654)).

This equation is based on an empirical relationship between heating capacity (in Joules/gram) and mineralogical data (Nesseteck 2009) and will be modified and refined as more data is gathered by Teck.

Where possible, waste rock suitable for construction or cover material is segregated and stockpiled. The remainder is obtained from local non-mineralized material sites.

The high S waste rock is, to the extent possible, placed below anticipated water table levels in the Main Pit. Where this is not possible, the high S waste rock is blended with other waste rock as required to reduce the potential for self-heating to a level below risk region 5 (Table 3). Where the blending ratio is less than 1 part high S waste rock to 1 part other waste rock, blending is accomplished by end-dumping alternating rows of high S/other material in the dumps. Where the blending ratios are more than 1 part high S waste rock to 1 part other waste rock, blending is accomplished by dumping single haul-truck loads of high S waste rock ahead of partial haul-truck loads of other waste rock and then mixing the two into each other with a bulldozer when pushing the material over the dump crest.

The remaining waste rock, comprising the majority of the rock in the waste dumps requires no special placement methods.

Elements of the segregation plans are outlined as follows:

- Segregation criteria are defined for dam construction materials, cover materials, and high S waste rock, as shown in Table 3.
- ML/ARD and resource models are used to identify general areas where these materials may be found and to update material handling schedules. Model and scheduling updates consider and incorporate data generated from routine pit operations.
- An automatic drill cutting sampler is used to collect samples from production blast holes. Samples are analyzed for iron, lead, and zinc content, and are classified by a qualified geologist.
- Material is classified based on geology (plate of origin, rock type, visual sulfide content) and/or applicable assay data (Table 2 and 3) to determine its suitability for dam construction, cover material, or disposal as waste rock. Haul truck drivers are directed to haul these materials to a designated cover stockpile, construction stockpile, or waste rock dump, as appropriate, or for blending where required.

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

Kelly Sexsmith, MS. PGeo
Principal Consultant, Environmental Geochemistry

and reviewed by

Bill Jeffress, Principal Consultant

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

5 References

Nessetech (2009). Self-Heating Tests – Revised Report #2 Pit Samples – Red Dog. Technical report prepared for Teck Cominco Alaska Incorporated. June 11, 2009.

O'Kane (2004). Teck Alaska Red Dog Operations – Development of a Cover System Design for the Waste Rock Stockpiles. Report No. 694-04. O'Kane Consultants Inc., prepared for Teck Cominco Alaska Incorporated.

O'Kane (2009a). Red Dog Operations – Little Bear Waste Rock Cell Cover Trials, Performance Monitoring Summary Report, O'Kane Consultants Inc.

O'Kane (2009b). Teck Alaska Red Dog Operations – Oxide Stockpile monitoring system record of installation. Letter report no. 694/3-01. O'Kane Consultants, Inc., prepared for Teck Alaska Incorporated, REVISED November 2009.

O'Kane (2014). Red Dog Mine Oxide Stockpile Full-Scale Cover System: 2012-2013 Annual Performance Monitoring Report. O'Kane Consultants Inc.

SRK (2016a). Red Dog Mine Reclamation and Closure Plan. SRK Consulting (U.S.), Inc.

SRK (2016b). Red Dog Mine Integrated Waste Management Plan. SRK Consulting (U.S.), Inc.

SRK (2016c). Red Dog Mine Segregation Plan for Cover Materia. SRK Consulting (U.S.), Inc.

TAK (2013). Red Dog Mine Waste Rock Management Procedures, Rev. 2, Document No. 2231. Teck Alaska Incorporated.

TAK (2014a). Drainage Management SOP. Teck Alaska Incorporated. Printed June 19, 2014.

TAK (2014b). Life of Mine Plan (2014-2030), Red Dog Operations, Alaska, USA. Teck Alaska Incorporated.

TAK (2015). Possibly Reactive Class Waste Rock Disposal Plan. Teck Alaska Incorporated.

Appendices

Appendix A : Segregation Plan for Cover Material at the Red Dog Mine, Alaska

Segregation Plan for Cover Material at the Red Dog Mine, Alaska

Prepared for

Teck Alaska Incorporated

Prepared by

SRK Consulting (Canada) Inc.
329100.030
August 2016

Segregation Plan for Cover Material at the Red Dog Mine, Alaska

August 2016

Prepared for

Teck Alaska Incorporated
3105 Lakeshore Drive
Building A, Suite 101
Anchorage, AK 99503
USA

Tel: + 907 754 6170
Web: www.teck.com

Prepared by

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2
Canada

Tel: +1 604 681 4196
Web: www.srk.com

Project No: 329100.030
File Name: CoverSegregationPlan_RedDogMine_329100030_20160805.docx

srk consulting 1974 40 2014

Table of Contents

List of Figures

List of Tables

Appendices

List of Acronyms

3D	3 dimensional
ABA	Acid Base Account
AP	Acid Potential
ARD	Acid Rock Drainage
ICP	Inductively Coupled Plasma
ML	Metal Leaching
NP	Neutralization Potential
NNP	Net Neutralization Potential
PAG	Potentially Acid Generating
WDXRF	Wavelength Dispersion X-ray Fluorimeter
XRF	X-ray Fluorimeter

1 Introduction

Teck Alaska Incorporated contracted SRK Consulting (Canada) Inc. to assist with the preparation of a revised segregation plan for waste rock that has a limited potential for metal leaching/acid rock drainage, and is therefore suitable for use in cover construction.

The material that has been selected for use in cover construction is located within a distinct thrust sheet identified as the Key Creek Plate, and located in the Northeast portion of the Aqqaluk pit. SRK compiled and evaluated both historical and new geological and geochemical data available for this area of the pit, and worked with site personnel to develop procedures for identifying and handling this material.

This report provides a summary of relevant background information, including a summary of previous segregation criteria, relevant information on the geology and mine plan, and findings of the geochemical evaluation. It then presents the approach and details that will be implemented to segregate cover material.

2 Background

2.1 Summary of Previous Classification Criteria

2.1.1 WRMP Classifications

The classifications for cover material as presented in the previous *Waste Rock Management Plan* (SRK 2007) were developed by Teck based on parameters that could be easily measured at the site using a portable x-ray fluorimeter (XRF). The criterion used for Kivalina shale and Okpikruak shale (for cover construction) was that the zinc content in single blast-hole assays must be less than 0.2% and the averages must be less than 0.1% Zn.

The intent of segregation was to obtain material with a low potential for metal leaching and acid rock drainage (ML/ARD).

2.1.2 ARD Classifications from SRK 2003

Classifications of ARD potential in various characterization programs completed at the site were based on a more complete set of test parameters, as described in *Consolidation of Studies on Geochemical Characterization of Waste Rock and Tailings* (SRK 2003). The ARD classifications from SRK 2003 were based on the pyritic sulfur content and total inorganic carbon (TIC) as a surrogate for neutralization potential (NP).

- Acid potential (AP) was calculated from pyritic sulfur, as follows:

  $S_{pyrite}(\%) = \text{Total } S(\%) – 32.1 \times (Zn(\%)/65.4) + Pb(\%)/207) + Ba(\%)/137)$

- Samples with NP/AP ratios of less than 1 were classified as PAG, and samples with NP/AP ratios of less than 2 were classified as having an uncertain potential for ARD. However, an exception was made for material with an AP of less than 10 kg $CaCO_3$ eq/t, which has a limited potential for ARD regardless of the NP content.

This approach was not used in the day-to-day operations because sulfur analyses are not completed as part of the routine analyses.

2.2 Geology and Mine Plan

The material that has been selected for use in cover construction is located within a distinct thrust sheet identified as the Key Creek Plate located in the Northeast portion of the Aqqaluk Pit. Figure 1 shows a three-dimensional view of the Key Creek Plate material in relation to the ultimate pit outline, and Figure 2 is a cross section through this area of the pit showing the location of the Key Creek Thrust Fault which was used to define the lower extent of this material in the model.

As of the end of the first quarter 2015, there was approximately 9.6 million tonnes of Key Creek Plate material remaining in this area of the pit under the current mine plan. TAK reports that approximately 1,926,000 tonnes of this material has already been stockpiled on the Main Waste Dump for use in cover construction. Material in the Key Creek plate is fully accessible, and could be extracted for use in cover construction even if the mine experienced premature closure.

Therefore, it is not expected that alternative borrow sources outside of the current mine area will be required to generate sufficient material for cover construction.

The Key Creek Plate overlies the Red Dog Plate which is the host for all of the deposits at Red Dog. Although the Key Creek plate contains rock units that are equivalent to those in the Red Dog Thrust plate, rocks in the Key Creek Plate formed many miles from the Red Dog deposit at the time the deposit was formed, and therefore, rocks in the Key Creek Plate do not contain the high concentrations of zinc and lead mineralization found in the Red Dog Plate.

As found in the Red Dog Plate, rocks within the Key Creek Plate are structurally complex, with minor thrust faulting and folding resulting in thickening and repetition of the stratigraphic sequence in a vertical direction. Breakage of rock along the thrust sheet boundaries has also produced chaotic rock types referred to as “mélange”. This material is a blocky mixture of rock types, resulting in a wide range of non-distinctive geochemical characteristics.

Drilling data indicates that the majority of the rocks in the Key Creek Plate are comprised of Kivalina shale or Kayak shale. There are also moderate amounts of melange, particularly near the base of the sequence. Kayak shale is also present in the active mining areas in the upper part of the Key Creek Plate. Volcanic intrusives are present within some of the Kivalina shale.

Approximately 48% of the samples in the geochemical data set for the Key Creek Plate are comprised of Kivalina shale, 47% are comprised of Kayak shale, and 4% are comprised of melange. Approximately 5% of the Kivalina shale samples contained appreciable amounts of volcanic intrusives.

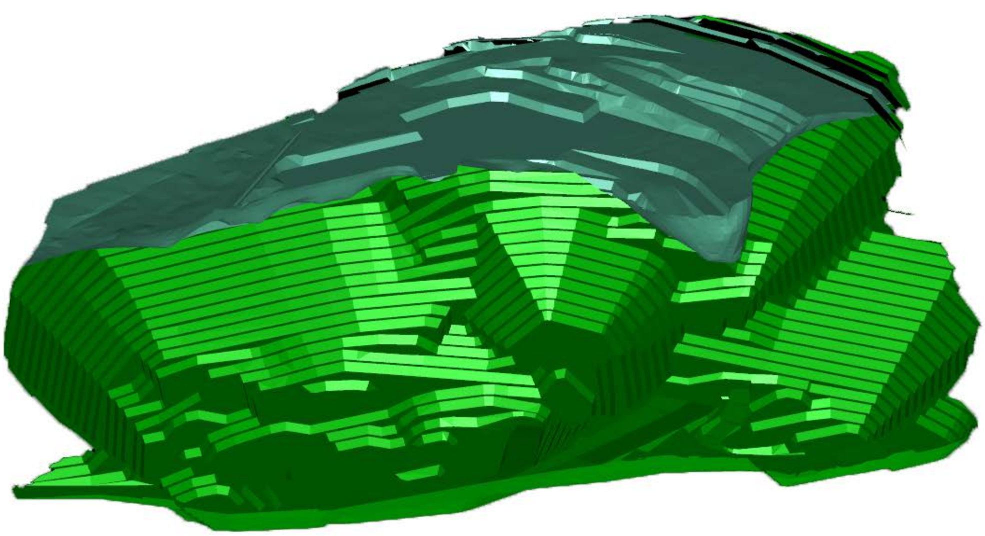


Figure 1: 3D view of Key Creek Model Unit in Aqqaluk Pit

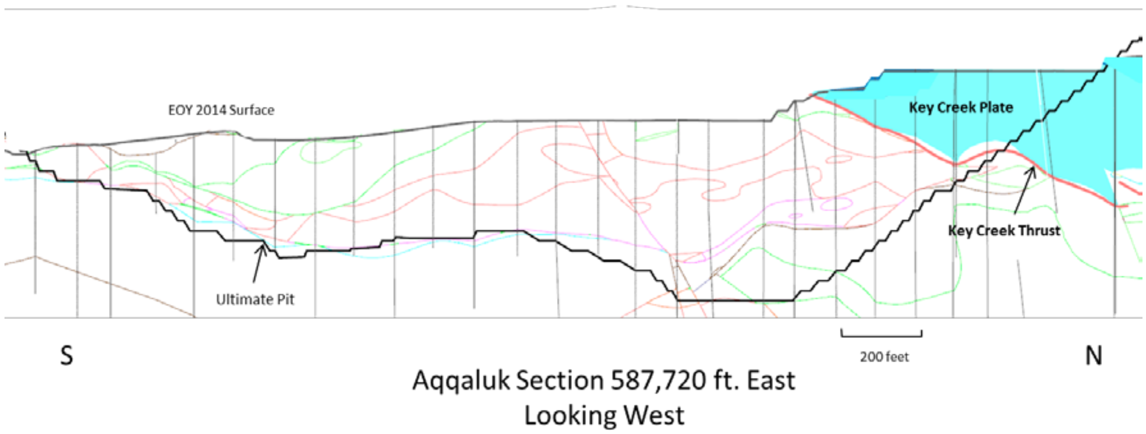


Figure 2: Geological Cross Section Showing Location of the Key Creek Plate and Thrust Fault

2.3 Geochemical Characterization

2.3.1 Overview

Geochemical characterization of waste rock from the Aqqaluk pit was completed in two phases, with methods and results reported in SRK (2003) and SRK (2009) respectively. The combined dataset was reviewed and results for all of the samples that were located within the Key Creek Plate (70 samples from ten drillholes) were extracted for use in this interpretation. Additionally, another 19 samples were collected from blast-hole cuttings located within this area, and were submitted for laboratory analyses. The sample locations are shown in Figure 3, and the combined dataset is presented in Appendix A.

2.3.2 Acid Base Accounting

Figure 4 shows a plot of the neutralization potential (NP) versus acid potential (AP) for all of the samples within this dataset. The results indicate that the majority (85%) of the samples had NP/AP ratios greater than 2 and were classified as not-potentially acid generating (non-PAG), a modest number (11%) had NP/AP ratios between 1 and 2 and were classified as having an uncertain potential for ARD, and only three samples (3.4%) were classified as potentially acid generating (PAG) with NP/AP ratios of less than 1. The overall average NP/average AP was 4.7, and the 25th percentile and 75th percentile NP/AP ratios were 2.4 and 10 respectively.

There was considerable overlap in the acid base accounting (ABA) results for the two main rock units. The only notable difference was that samples of Kayak shale tended to have more variable and sometimes lower NP in comparison to other units, resulting in a PAG or uncertain classification in a small portion of these samples (16%).

On the basis of these results, it is concluded that the majority of the material from the Key Creek Plate is geochemically suitable for use in cover construction, but that some efforts should be made to separate out samples with elevated concentration of sulphide. Section 3 of this report presents details on the proposed segregation plan to identify and handle this type of material.

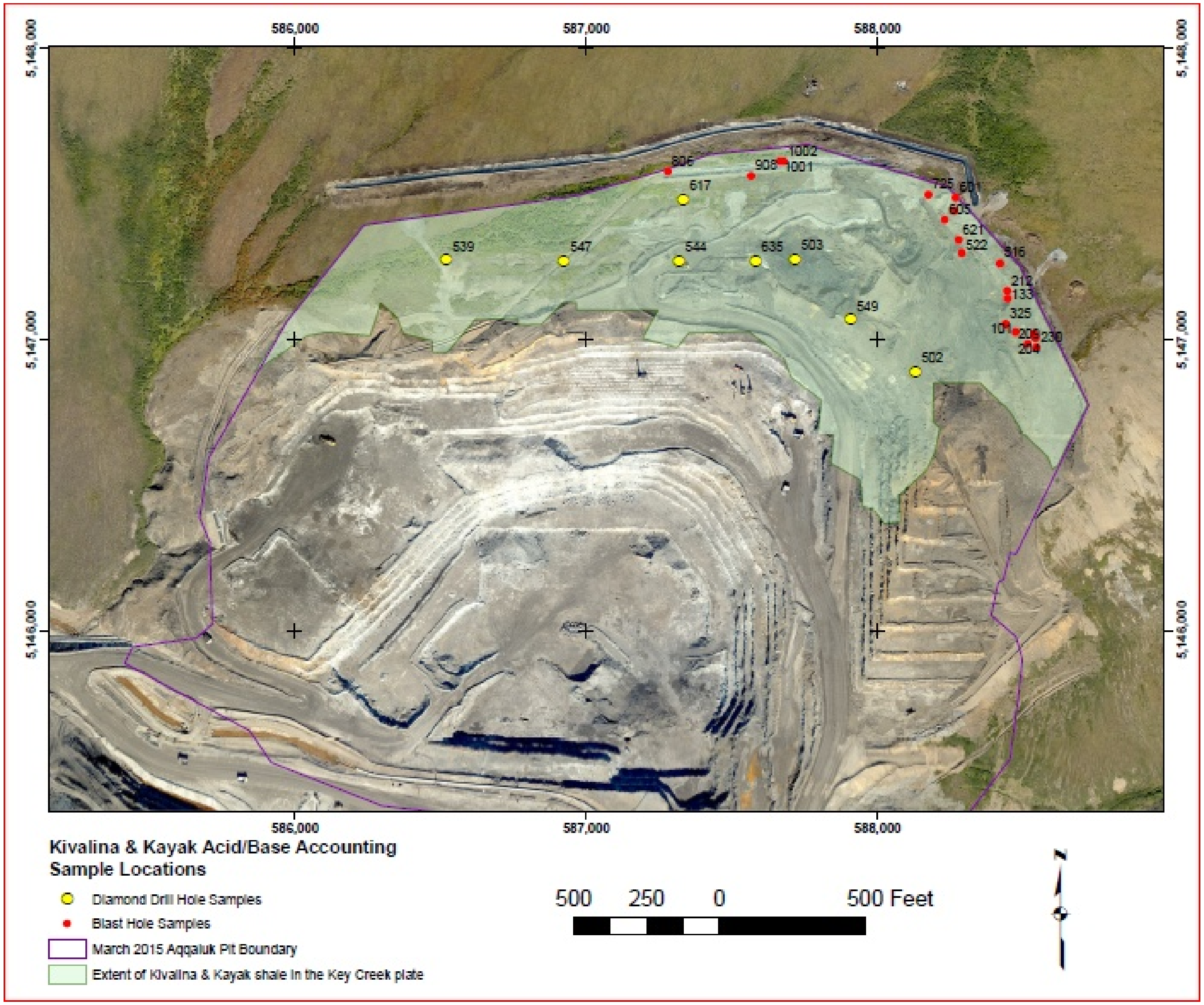


Figure 3: Sample Locations

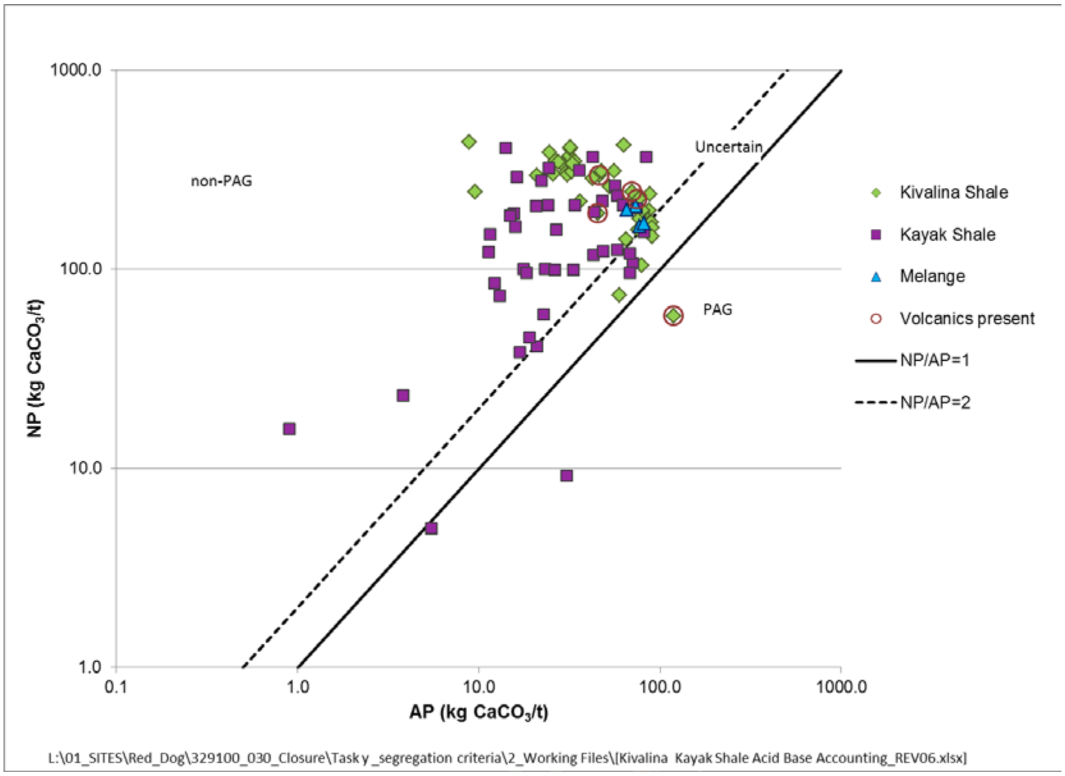


Figure 4: NP versus AP for Samples in the Key Creek Plate

2.3.3 Solid Phase Trace Element Analyses

A summary of the solid phase trace element analyses by ICP following aqua regia digestion is provided in Table 1. The results indicate substantially lower concentrations in comparison to results for comparable units in the Red Dog Plate. These concentrations were also consistently lower than the segregation criterion for Kivalina shale of 0.2% zinc that was previously in use at Red Dog (SRK 2007). Some differences in rock types were evident, with the lowest concentrations found in the Kivalina samples.

Table 1: Summary of Trace Element Concentrations

Group	Rock Units	Pb ppm	Zn ppm
Key Creek Samples	Kivalina Average	36	269
	Kayak Average	81	580
	Melange Average	26	552
	Overall Average	58	436
	Overall 95th Percentile	167	818
All Samples from Aqqaluk Pit (predominantly from the Red Dog Plate)	Kivalina Average	500	2,700
	Melange Average	1,400	4,700

2.3.4 Correlations between XRF Results and Other Static Test Parameters

Teck routinely analyzes blast-hole cuttings for iron, lead, zinc and barium by XRF. In the previous segregation plan, concentrations of zinc, as determined by XRF, were used to segregate Kivalina and Okpikruak shale. However, in the past, the XRF was not well calibrated for samples with low zinc concentrations, and for this reason there was essentially no correlation between actual zinc results (from ICP analysis), and the XRF results (Figure 5). Lead (not shown) suffers from similar issues, but iron showed a reasonable correlation between XRF and ICP results (Figure 6, correlation coefficient r = 0.70). Due to differences in mineralogy, the relationship in iron concentrations differs for the different rock units. In general, iron by ICP is less than iron in corresponding XRF results due to incomplete digestion of iron associated with silicate minerals in the aqua regia digestion method that was used. As discussed in Appendix B, Teck has developed a new low level calibration curve for the XRF, and this is expected to improve the reliability of the XRF analyses for lead and zinc in future.

Correlations were found between zinc and lead, and zinc and cadmium, as shown in Figures 10 and 11. However, despite having high correlation coefficients, the relationship between zinc and cadmium was weak due to a number of samples that were at the detection limit for cadmium, and the relationship between zinc and lead was weak in comparison to the full geochemical dataset for Red Dog due to generally low levels of both lead and zinc in the Key Creek Plate.

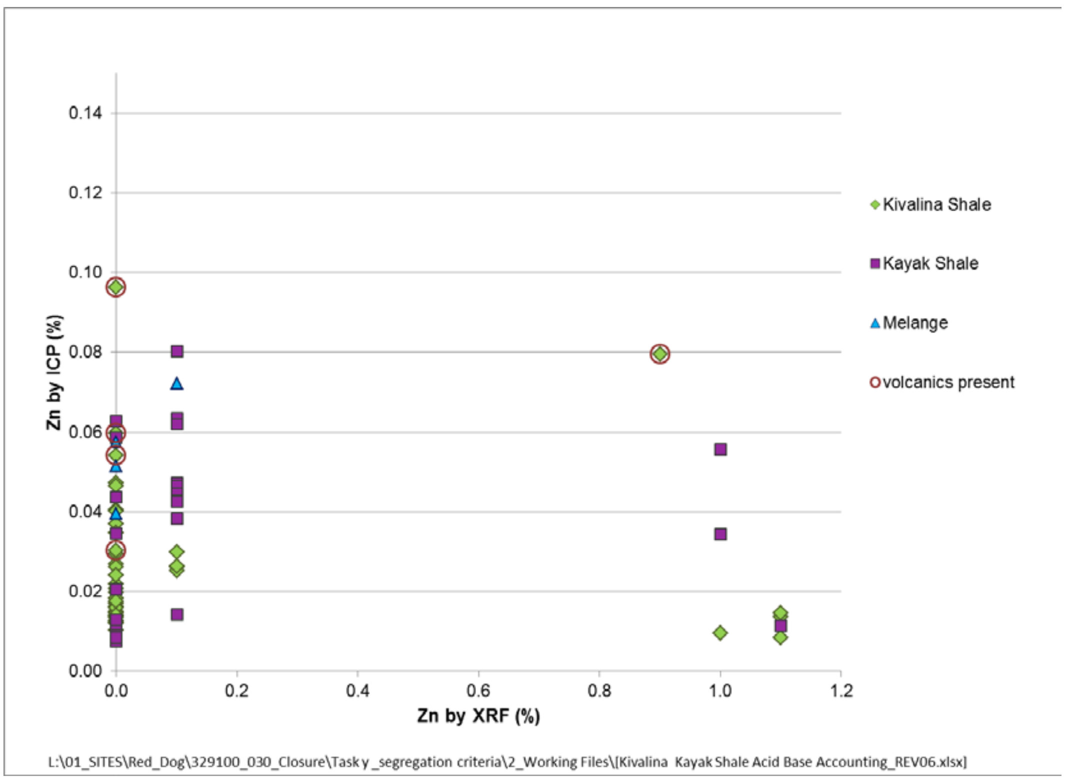


Figure 5: Zinc by ICP versus Zinc by XRF

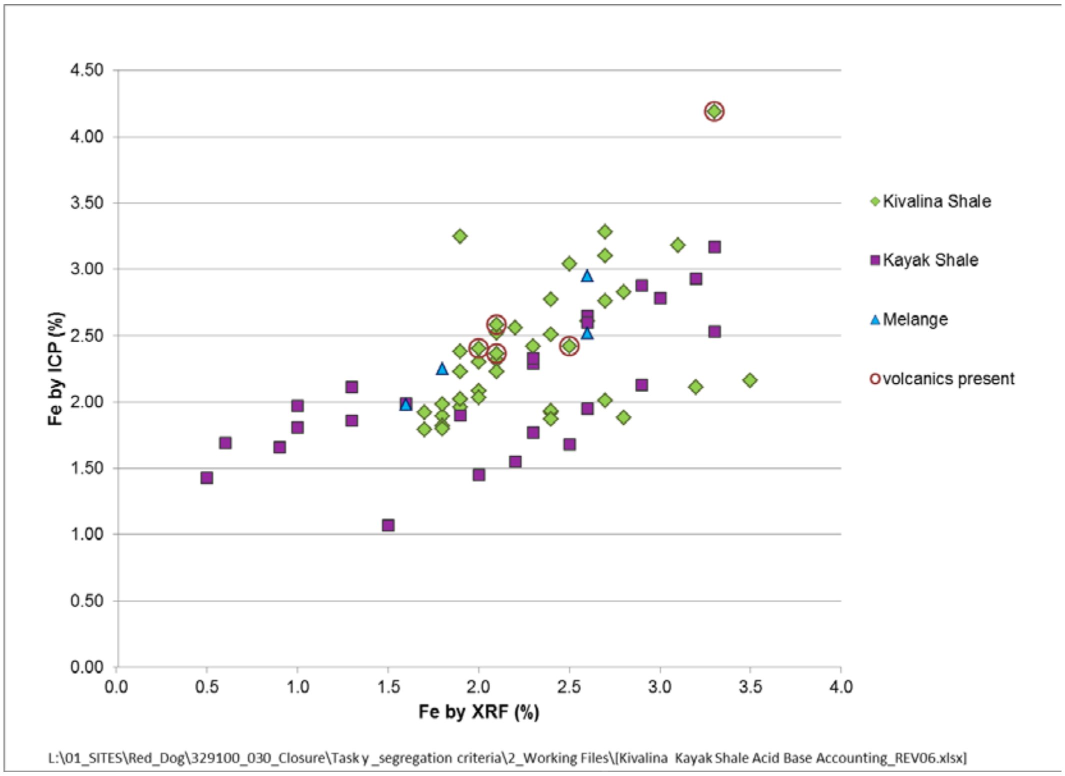


Figure 6: Iron by ICP versus Iron by XRF

Correlations with ABA Parameters

In the context of the segregation plan, XRF data are only useful for classifying the ARD potential of samples if there are correlations between the XRF results and the ABA parameters. Therefore, an evaluation of potential correlations between these two groups of parameters was completed to establish whether XRF results could be used to assess ARD potential. Due to the issues associated with the historical XRF data, ICP data were also considered in the evaluation.

Table 2 summarizes correlation coefficients (r) observed for each of the ABA parameters. Values of greater than +/-0.5, indicating there is a possibility of a relationship between these parameters. Barium was the only XRF parameter to show any reasonable correlations with NP, net neutralization potential (NNP) and NP/AP ratios (Figures 7, 8 and 9). This is thought to be due to substitution of small amounts of barium in calcite (pers. comm. Jeff Clark).

There were no relationships between iron, lead or zinc by XRF and any of the ABA parameters. Likewise, there were no relationships between lead or zinc by ICP and any of the ABA parameters, indicating that even if the accuracy of the XRF analyses for samples with low levels of these parameters were to improve, it is not likely that they could be used as an indication of ARD potential. Therefore, it is concluded that the XRF results are of limited use in determining the ARD potential of samples.

Table 2: Correlation Coefficients for XRF/ICP Parameters and ABA Parameters

Parameter	S%	NP kg $CaCO_3$ eq/t	NNP kg $CaCO_3$ eq/t	NP/AP
Fe by XRF	0.27	0.05	-0.02	-0.05
Pb by XRF	-0.03	-0.16	-0.14	-0.10
Zn by XRF	-0.22	-0.22	0.25	0.20
Ba by XRF		**0.57**	**0.57**	**0.51**
Fe by ICP	0.41	-0.25	-0.34	-0.23
Pb by ICP	-0.09	0.01	0.04	0.09
Zn by ICP	-0.03	-0.10	-0.08	-0.03

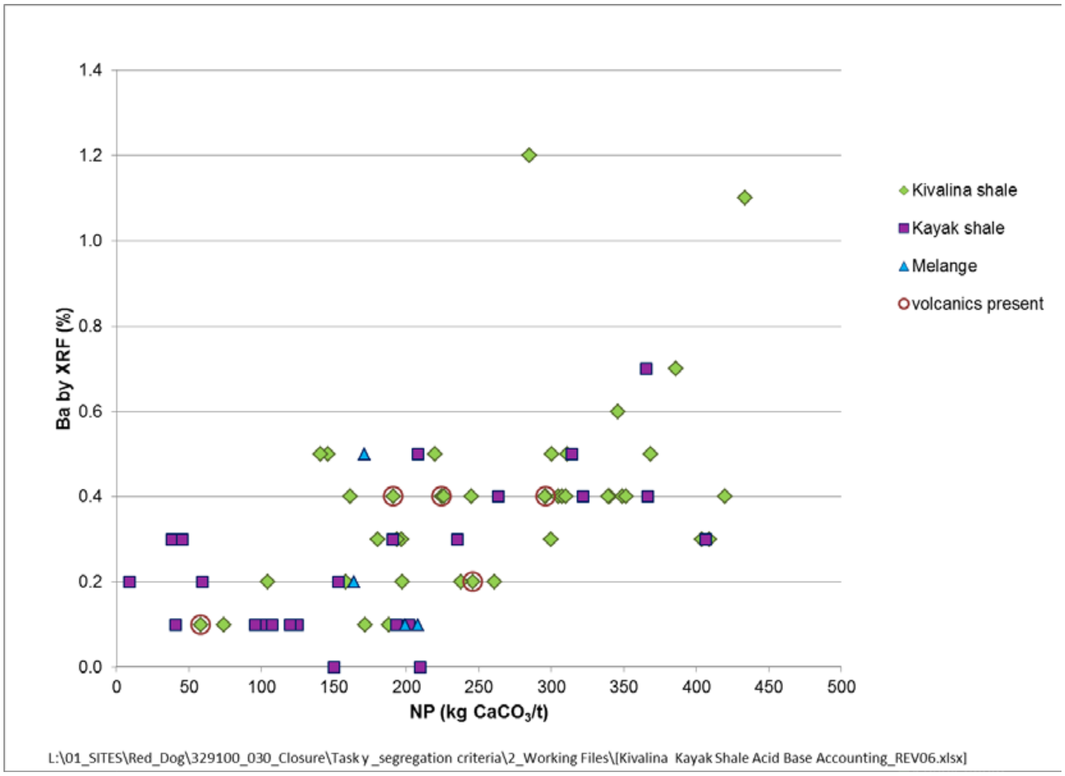


Figure 7: Barium by XRF versus NP

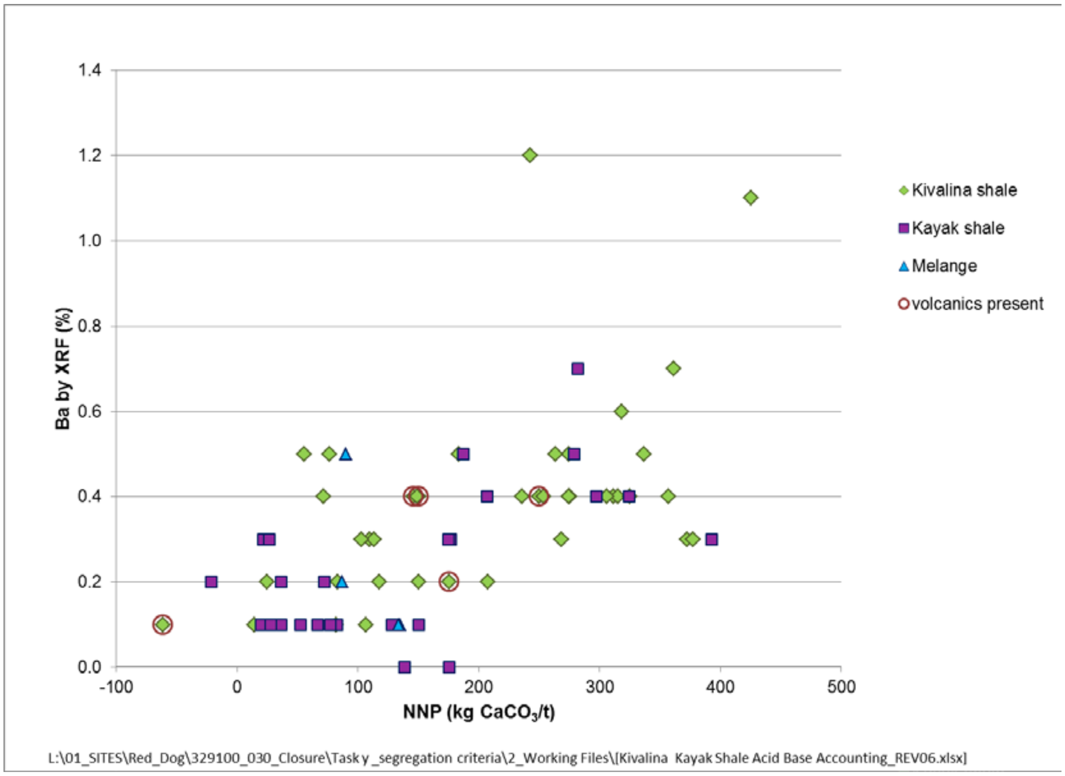


Figure 8: Barium by XRF versus NNP

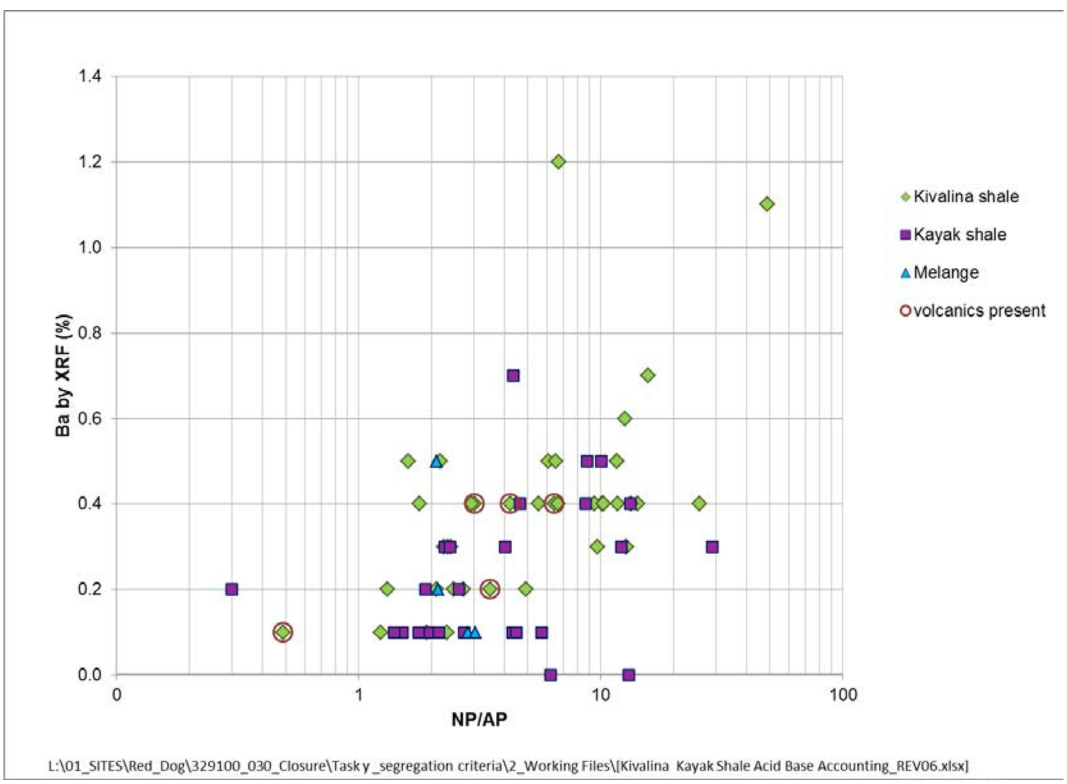


Figure 9: Barium by XRF versus NP/AP Ratios

Correlations with Other Trace Elements

In the context of the segregation plan, XRF data can be useful for identifying materials with anomalously high concentrations of trace elements that could indicate increased potential for metal leaching under neutral pH conditions. Therefore, correlations between the XRF parameters and other trace elements were also examined. Table 3 summarizes correlation coefficients between barium, iron, lead, and zinc by XRF, and cadmium, iron, lead and zinc by ICP. Selenium, which is an element of interest at Red Dog is not present in this dataset, and therefore could not be included. Correlation coefficients were also calculated between these same parameters and silver, arsenic, cobalt, chromium, copper and nickel, but all were below a value of 0.5 indicating there were no clear relationships.

Table 3: Correlation Coefficients for XRF/ICP Parameters and other Trace Elements

Parameter	Ba by XRF	Fe by XRF	Pb by XRF	Zn by XRF	Zn by ICP
Fe by XRF	-0.01	1.00			
Pb by XRF	-0.18	-0.25	1.00		
Zn by XRF	-0.09	0.01	**0.62**	1.00	
Zn by ICP	-0.38	-0.03	0.35	0.18	1.00
Cd by ICP	0.02	-0.03	0.31	0.21	**0.98**
Pb by ICP	-0.05	-0.07	0.31	0.18	**0.97**
Fe by ICP	0.03	**0.70**	-0.02	0.04	0.03

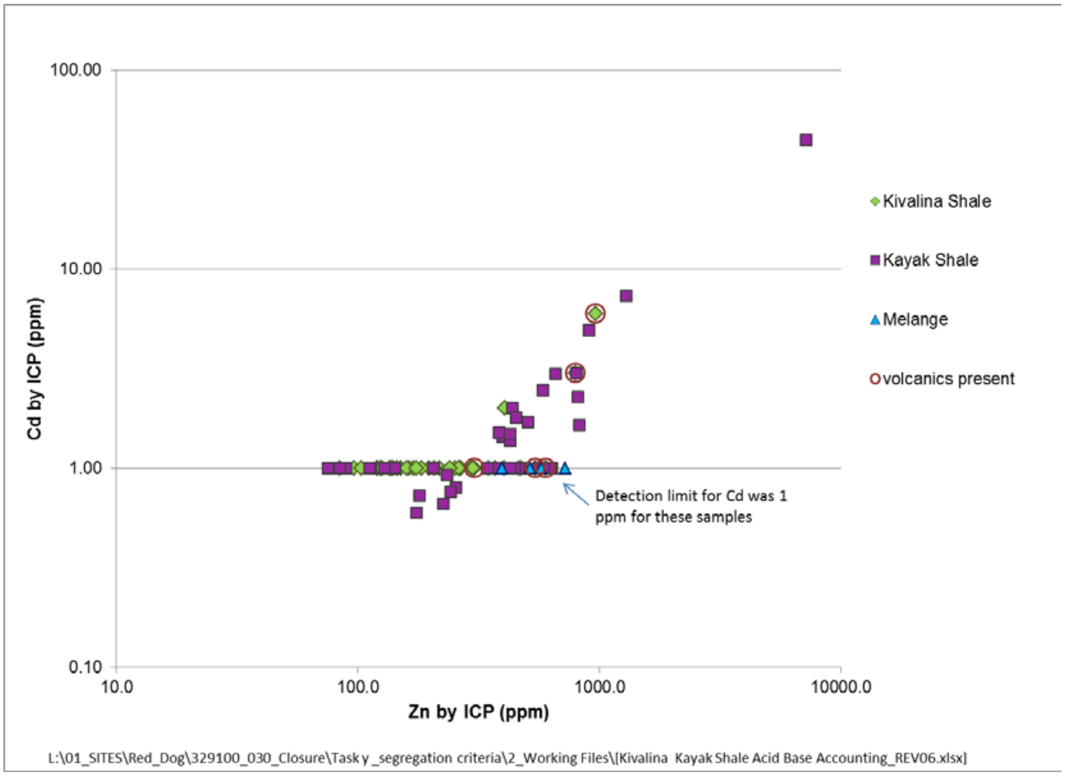


Figure 10: Zinc by ICP versus Cadmium by ICP

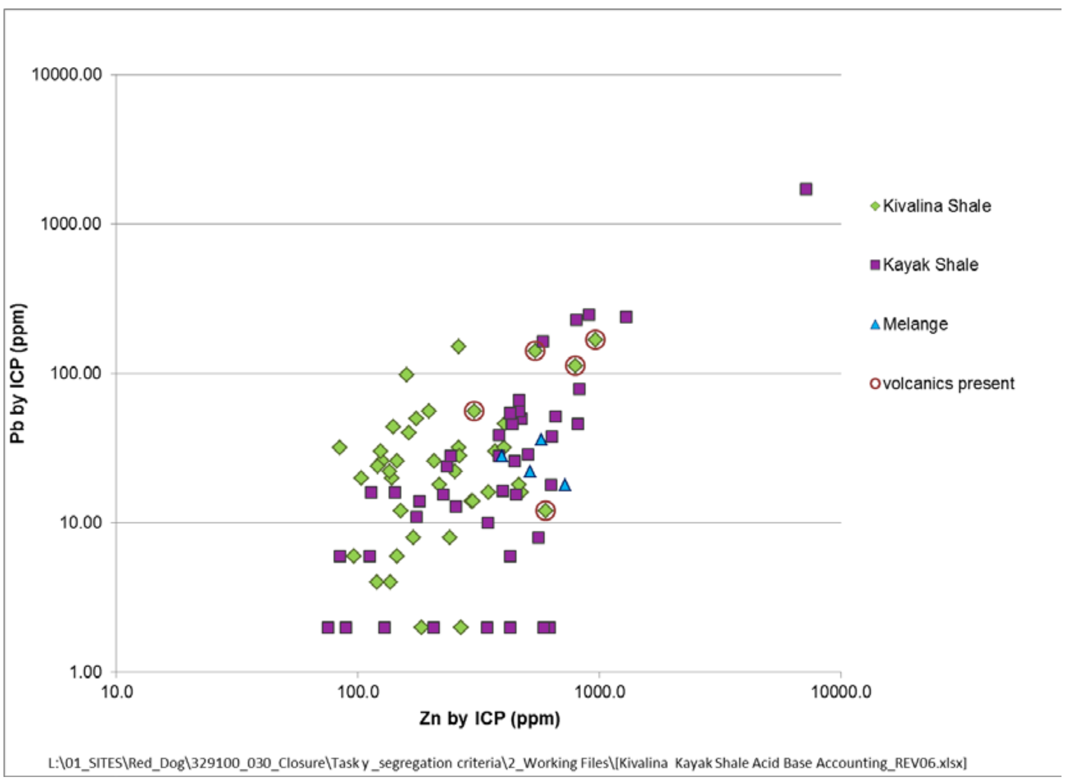


Figure 11: Zinc by ICP versus Lead by ICP

3 Segregation Plan

3.1 Approach

Based on the geochemical characterization results which indicate that material from the Key Creek Plate is predominantly non-PAG, Teck are proposing to use a geological approach to segregate material for use in cover construction. Geological inspections will be carried out on each blast to confirm that the material is predominantly Kivalina or Kayak shale and that it does not contain atypically high amounts of sulfide. If the material meets these criteria it will be directed to the cover stockpile. Both Kivalina and Kayak shale are acid neutralizing and both weather to acceptable growth medium in a short period of time.

Teck will continue to collect blast-hole samples for XRF analysis, and will examine the results to establish that there are no major anomalies in zinc content that could be indicative of a change in geology or mineralization. These results will also be used to inform the decision of whether to direct the material to the cover stockpile.

Lastly, Teck will report the incremental and cumulative amount of cover material that is stockpiled in their quarterly environmental report.

Details on the segregation criteria, segregation procedures, and reporting are described in the following sections.

3.2 Segregation Criteria

Material directed to the cover stockpile must meet the following criteria:

- The material must have its origins from the Key Creek structural plate.
- Must be identified as predominantly Kivalina and/or Kayak shale (i.e., greater than 90% of the material must be comprised of Kivalina and/or Kayak shale, based on visual estimation).
- Must not contain "atypically high levels of sulfides" over an area of more than 500 m^2. "Atypically high" is defined as greater than 10% visual percent sulfide, which is equivalent to 5% total sulfur or an AP of 310 kg $CaCO_3$ eq/t.
- No more than 5 adjacent blast-holes to exceed 0.25% zinc.

Geochemical characterization results presented in Section 2.3 indicate that the Kivalina and Kayak shale are predominantly non-PAG, and that they have relatively low zinc concentrations (average values of 0.04% and 95th percentile concentrations of 0.08%). Therefore, the geological identifications are considered to be sufficient for decision making.

The estimates of sulfide content and review of blast-hole data are intended to provide additional assurance that there are no large scale anomalies in the geochemical characteristics. Specific rational for these criteria are as follows:

- A threshold of 10% visual percent iron sulfide, which is approximately two times higher than the maximum sulfide content typically present in these rocks, was selected as the threshold for "atypically high" sulfide content because it is considered to be different enough that it will be possible to detect that it is different in a routine geological examination. Multiple handling of material by blasting, loading hauling and dumping will ensure that small amounts are well mixed when it reaches the site where it will be used as cover.

- A threshold of 0.25% zinc, which is six times the average zinc concentrations found in the Key Creek Plate, was selected as a threshold for identifying material with anomalous zinc concentrations. A higher multiplier is used in this case due to the potential for minor anomalies resulting from cross-contamination of the sample tubes which are also used within the ore zones. As described previously, multiple handling of this material will ensure that smaller anomalies are blended with more typical waste rock.

Lead and cadmium concentrations were not included in the list of criteria, but tend to be highly correlated with zinc concentrations in other parts of the deposit (Figures 10 and 11 in Section 2.3.4). Therefore, lead and cadmium concentrations are also expected to be low where zinc concentrations are low.

3.3 Segregation Procedures

The grade control geologist will examine the shot to confirm it is Kivalina or Kayak shale and that it does not contain zones of atypically high sulphide mineralization. The grade control geologist will also verify that the blast-hole assays meet the criteria described in Section 3.2. If there are zones of anomalously high sulphide or zinc content, dig limits will be established around those areas to segregate them from the cover material. The material with anomalously high sulphide or zinc content would be directed to the waste rock pile, and the rest of the waste rock would be directed to the cover stockpile(s). Cover stockpile(s) will be located on the Main Waste Stockpile, or other disturbed areas in the vicinity of the waste rock stockpiles.

The mine operations will then be directed to haul the material to the cover stockpile. The procedures for identifying and handling different types of waste rock are the same as those used to identify and handle ore, and are well established at the Red Dog Mine. To ensure that cover material is not affected by any adjacent material that does not meet the criteria, the grade control geologist will move out a minimum of one clean waste hole away from the unacceptable waste hole into the clean waste cut area. Additionally, blast movement and digface height will be taken into consideration in establishing dig limits.

3.4 Reporting Requirements

Teck will record the total amount of Key Creek Plate material, and the amount that was effectively segregated and stockpiled each month in their quarterly environmental report. The cumulative volumes in the stockpile will also be reported.

4 Summary and Conclusions

Teck have prepared a revised segregation plan to obtain waste rock that has a limited potential for metal leaching/acid rock drainage, and is therefore suitable for use in cover construction. The cover material will be obtained from a continuous block of Key Creek Plate material located in the northeast part of the Aqqaluk pit. As of the end of the first quarter 2015, there was approximately 9.6 million tonnes of Key Creek Plate material remaining in this area of the pit under the current mine plan. TAK reports that approximately 1,926,000 tonnes of this material has already been stockpiled for use in cover construction. Based on the geological origin of this material and the geochemical characteristics, the majority of this material is expected to be suitable for use in cover construction. Material in the Key Creek plate is fully accessible, and could be extracted for use in cover construction even if the mine experienced pre-mature closure. Therefore, it is not expected that alternative borrow sources outside of the current mine area will be required to generate sufficient material for cover construction.

Segregation will be based primarily on the geological characteristics (rock type and visual sulfide content) which will be verified by the grade control geologist. Blast-hole assays will also be checked to ensure there are no major anomalies in zinc concentrations.

The monthly and cumulative amounts of Key Creek Plate material that is mined and the monthly and cumulative amounts of Key Creek Plate material that is stockpiled for use in cover construction will be reported in the quarterly environmental report.

This report, *Segregation Plan – Red Dog Mine*, was prepared by SRK Consulting (Canada) Inc. with data supplied by TAK.

Kelly Sexsmith, PGeo (British Columbia)
Principal Consultant (Geochemistry)

and reviewed by

Kirsty Ketchum, PhD, PGeol
Senior Consultant (Geochemistry)

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

5 References

SRK Consulting (Canada) Inc., 2009. Supporting Document D3: Aqqaluk Geochemistry – Supplemental Testing Program. *In*: Red Dog Mine Closure and Reclamation Plan - Prepared for Teck Cominco Alaska Inc., May 2009.

SRK Consulting (Canada) Inc., 2007. Supporting Document B2 - Plan of Operations for Waste Rock Management. *In*: Red Dog Mine Closure and Reclamation Plan - Prepared for Teck Cominco Alaska Inc., May 2009.

SRK Consulting (Canada) Inc., 2003. Supporting Document D1: Consolidation of Studies on Geochemical Characterization of Waste Rock and Tailings. *In*: Red Dog Mine Closure and Reclamation Plan - Prepared for Teck Cominco Alaska Inc., May 2009.

Appendix A – Geochemical Results for Key Creek Plate Samples

Sample Info						On-site XRF Analyses				ABA Parameters (including calculated values)										
Sample#	Hole/Bench	From	To	Geology	Notes	% Zn	% Pb	% Fe	% Ba	TIC	Total S	S in BaSO4	S in ZnS	S in PbS-SO4	S in "FeS"	AP	NP	NP/AP	Classification	NNP
650201	502	15	35	Kayak shale		0.1	0.1	1.3	0.1	1.2	0.65	0.02	0.05	0.02	0.56	17.6	100.0	5.7	NPAG	82.43
650202	502	35	55	Kayak shale		0.1	0.1	0.5	0.1	1.2	0.83	0.02	0.05	0.02	0.74	23.2	100.0	4.3	NPAG	76.80
650203	502	55	75	Kayak shale		0.1	0.1	1.6	0.1	0.49	0.76	0.02	0.05	0.02	0.67	21.0	40.8	1.9	uncertain	19.82
650204	502	75	95	Kayak shale		0.1	0.1	0.9	0.1	2.32	1.47	0.02	0.05	0.02	1.38	43.2	193.3	4.5	NPAG	150.14
650205	502	95	115	Kayak shale		0.1	0.1	1.3	0.1	1.29	2.36	0.02	0.05	0.02	2.27	71.0	107.5	1.5	uncertain	36.49
650206	502	115	135	Kayak shale		0.1	0.1	1	0.1	1.15	2.27	0.02	0.05	0.02	2.18	68.2	95.8	1.4	uncertain	27.64
650207	502	135	155	Kayak shale		0.1	0.1	0.6	0.1	1.5	1.95	0.02	0.05	0.02	1.86	58.2	125.0	2.1	NPAG	66.80
650208	502	155	175	Kayak shale		0.1	0.1	1	0.1	1.44	2.26	0.02	0.05	0.02	2.17	67.9	120.0	1.8	uncertain	52.12
650209	502	175	195	Kivalina shale		0.1	0.1	1.9	0.1	2.06	2.95	0.02	0.05	0.02	2.86	89.4	171.7	1.9	uncertain	82.22
750201	502	195	215	Kivalina shale		0	0	2.5	0.3	2.361	2.86	0.07	0.00	0.00	2.79	87.2	196.8	2.3	NPAG	109.56
23028	502	200	205	Kivalina shale		0	0.01	2.34	0	1.67										
750202	502	215	235	Kivalina shale		0	0	2.7	0.4	1.937	2.98	0.09	0.00	0.00	2.89	90.2	161.4	1.8	uncertain	71.20
750203	502	235	260	Kivalina shale		0	0	2.4	0.5	1.752	3.02	0.12	0.00	0.00	2.90	90.7	146.0	1.6	uncertain	55.27
750204	502	260	285	Kivalina shale		0	0	2.1	0.2	1.252	2.59	0.05	0.00	0.00	2.54	79.5	104.3	1.3	uncertain	24.85
750205	502	285	310	Kivalina shale	Volcanics present	0	0	2.1	0.4	2.695	2.48	0.09	0.00	0.00	2.39	74.6	224.6	3.0	NPAG	150.00
750206	502	310	335	Kivalina shale	Volcanics present	0	0	3.3	0.1	0.697	3.84	0.02	0.00	0.00	3.82	119.3	58.1	0.5	PAG	-61.19
750207	502	335	360	Melange		0	0	1.8	0.1	2.495	2.37	0.02	0.00	0.00	2.35	73.3	207.9	2.8	NPAG	134.58
750208	502	360	385	Melange		0	0	1.6	0.1	2.392	2.13	0.02	0.00	0.00	2.11	65.8	199.3	3.0	NPAG	133.50
750302	503	85	110	Kivalina shale		0	0	2	0.5	2.636	1.27	0.12	0.00	0.00	1.15	36.0	219.7	6.1	NPAG	183.62
750303	503	110	135	Kivalina shale		0	0	2.1	0.4	4.082	1.02	0.09	0.00	0.00	0.93	29.0	340.2	11.7	NPAG	311.20
750304	503	135	160	Kivalina shale	Volcanics present	0	0	2.1	0.4	3.556	1.57	0.09	0.00	0.00	1.48	46.2	296.3	6.4	NPAG	250.18
750305	503	160	185	Kivalina shale	Volcanics present	0	0	2	0.4	2.296	1.54	0.09	0.00	0.00	1.45	45.2	191.3	4.2	NPAG	146.12
750306	503	185	210	Kivalina shale		0	0	2.7	0.5	1.693	2.19	0.12	0.00	0.00	2.07	64.8	141.1	2.2	NPAG	76.29
750307	503	210	235	Kivalina shale		0	0	1.9	0.2	3.128	1.74	0.05	0.00	0.00	1.69	52.9	260.7	4.9	NPAG	207.75
750308	503	235	250	Kivalina shale		0	0	1.9	0.1	0.889	1.94	0.02	0.00	0.00	1.92	59.9	74.1	1.2	uncertain	14.19
650301	503	250	270	Kivalina shale	Volcanics present	0.9	0.1	2.5	0.2	2.95	2.35	0.05	0.04	0.02	2.25	70.3	245.8	3.5	NPAG	175.55
753901	539	20	35	Kayak shale		1.1	0.1	1.9	0.3	4.88	0.54	0.07	0.01	0.02	0.45	14.0	406.7	29.0	NPAG	392.63
753902	539	35	50	Kivalina shale		1.1	0.1	2	0.5	4.42	1.15	0.12	0.01	0.02	1.01	31.6	368.3	11.7	NPAG	336.73
23034	539	50	55	Kivalina shale		0.03	0.02	2.86	5	3.78										
754401	544	16	41	Kivalina shale		0	0	2.4	0.4	3.55	0.76	0.09	0.00	0.00	0.67	20.8	295.8	14.2	NPAG	275.00
754402	544	41	66	Kivalina shale		0	0	2.4	0.4	3.66	1.06	0.09	0.00	0.00	0.97	30.2	305.0	10.1	NPAG	274.79
754403	544	66	91	Kivalina shale		0	0	2.4	0.4	4.19	1.18	0.09	0.00	0.00	1.09	34.0	349.2	10.3	NPAG	315.20
23048	544	89	94	Kivalina shale		0	0	1.19	6.8	5.58										
754404	544	91	110	Kivalina shale		0	0	2.7	1.2	3.42	1.64	0.28	0.00	0.00	1.36	42.5	285.0	6.7	NPAG	242.49
754701	547	21	46	Kivalina shale		1.1	0.1	2	0.4	4.22	0.96	0.09	0.01	0.02	0.84	26.4	351.7	13.3	NPAG	325.28
754702	547	46	71	Kivalina shale		1	0.1	1.8	0.3	4.85	1.11	0.07	0.00	0.02	1.02	31.9	404.2	12.7	NPAG	372.29
754703	547	71	96	Kivalina shale		0.1	0.1	1.9	0.3	4.91	1.16	0.07	0.05	0.02	1.03	32.1	409.2	12.8	NPAG	377.11
754704	547	96	121	Kivalina shale		1.1	0.1	3.1	0.4	5.04	2.13	0.09	0.00	0.02	2.02	63.0	420.0	6.7	NPAG	356.96
754901	549	12	37	Kayak shale		1	0.1	2.6	0	1.8	0.4	0.00	0.02	0.02	0.37	11.5	150.0	13.1	NPAG	138.51
754902	549	37	62	Kayak shale		1	0.1	2.9	0.2	0.71	0.82	0.05	0.03	0.02	0.73	22.8	59.2	2.6	NPAG	36.33
754903	549	62	87	Kayak shale		0.1	0.1	2.3	0.2	0.11	1.09	0.05	0.05	0.02	0.98	30.6	9.2	0.3	PAG	-21.43
754904	549	87	112	Kayak shale		0.1	0.1	3.3	0.4	3.16	1.97	0.09	0.05	0.02	1.81	56.6	263.3	4.6	NPAG	206.70
754905	549	112	137	Kayak shale		0.1	0.1	2.3	0.3	2.82	2	0.07	0.05	0.02	1.87	58.3	235.0	4.0	NPAG	176.70
754906	549	137	162	Kayak shale		0.1	0.1	2.6	0.2	1.84	2.71	0.05	0.05	0.02	2.60	81.2	153.3	1.9	uncertain	72.11
754907	549	162	187	Kivalina shale		0.1	0.1	2.7	0.2	1.9	2.52	0.05	0.05	0.02	2.41	75.3	158.3	2.1	NPAG	83.05
23055	549	180	185	Kivalina shale		0	0	2.53	1.39	2.57										
754908	549	187	212	Kivalina shale		0.1	0.1	2.8	0.4	2.71	2.62	0.09	0.05	0.02	2.46	77.0	225.8	2.9	NPAG	148.88
754909	549	212	240	Melange		0.1	0.1	2.6	0.2	1.97	2.58	0.05	0.05	0.02	2.47	77.2	164.2	2.1	NPAG	87.01
755601	556	16	41	Kayak shale		0	0	3	0.3	0.46	0.61	0.07	0.00	0.00	0.54	16.9	38.3	2.3	NPAG	21.46
755602	556	41	66	Kayak shale		0	0	3.2	0.3	0.544	0.68	0.07	0.00	0.00	0.61	19.1	45.3	2.4	NPAG	26.27
755603	556	66	91	Kayak shale		0	0	1.5	0	2.513	1.08	0.00	0.00	0.00	1.08	33.8	209.4	6.2	NPAG	175.67
755604	556	91	116	Kayak shale		0	0	2.6	0.1	2.425	2.4	0.02	0.00	0.00	2.38	74.3	202.1	2.7	NPAG	127.81
755606	556	141	166	Kivalina shale		0	0	2.8	0.1	2.256	2.62	0.02	0.00	0.00	2.60	81.1	188.0	2.3	NPAG	106.85
755607	556	166	191	Kivalina shale		0	0	3.2	0.3	2.321	2.64	0.07	0.00	0.00	2.57	80.3	193.4	2.4	NPAG	113.10
755608	556	191	216	Kivalina shale		0	0	3.5	0.2	2.852	2.85	0.05	0.00	0.00	2.80	87.6	237.7	2.7	NPAG	150.06

Sample Info						On-site XRF Analyses				ABA Parameters (including calculated values)										
Sample#	Hole/Bench	From	To	Geology	Notes	% Zn	% Pb	% Fe	% Ba	TIC	Total S	S in BaSO4	S in ZnS	S in PbS-SO4	S in "FeS"	AP	NP	NP/AP	Classification	NNP
760101	601	9	34	Kayak shale		0	0	2.2	0.5	2.494	0.78	0.12	0.00	0.00	0.66	20.7	207.8	10.0	NPAG	187.10
760102	601	34	59	Kayak shale		0	0	2.9	0.3	2.284	0.57	0.07	0.00	0.00	0.50	15.6	190.3	12.2	NPAG	174.71
760103	601	59	84	Kayak shale		0	0	2.5	0.4	3.86	0.87	0.09	0.00	0.00	0.78	24.3	321.7	13.3	NPAG	297.39
760104	601	84	109	Kayak shale		0	0	2	0.5	3.772	1.26	0.12	0.00	0.00	1.14	35.7	314.3	8.8	NPAG	278.60
760105	601	109	134	Kayak shale		0	0	2.3	0.4	4.401	1.45	0.09	0.00	0.00	1.36	42.4	366.8	8.6	NPAG	324.35
760106	601	134	159	Kayak shale		0	0	3.3	0.7	4.386	2.84	0.16	0.00	0.00	2.68	83.7	365.5	4.4	NPAG	281.85
761701	617	9	34	Kivalina shale		0	0	2.6	1.1	5.2071	0.54	0.26	0.00	0.00	0.28	8.9	433.9	48.9	NPAG	425.06
761702	617	34	59	Kivalina shale		0	0	2.1	0.5	3.605	0.94	0.12	0.00	0.00	0.82	25.7	300.4	11.7	NPAG	274.68
761703	617	59	84	Kivalina shale		0	0	1.8	0.6	4.15	1.02	0.14	0.00	0.00	0.88	27.5	345.8	12.6	NPAG	318.33
761704	617	84	109	Kivalina shale		0	0	1.9	0.3	3.595	1.06	0.07	0.00	0.00	0.99	30.9	299.6	9.7	NPAG	268.64
761705	617	109	134	Kivalina shale		0	0	1.8	0.4	3.69	1.14	0.09	0.00	0.00	1.05	32.7	307.5	9.4	NPAG	274.79
761706	617	134	159	Kivalina shale		0	0	1.8	0.5	3.731	1.64	0.12	0.00	0.00	1.52	47.6	310.9	6.5	NPAG	263.31
763501	635	14	39	Kivalina shale		0	0	1.7	0.4	2.941	0.4	0.09	0.00	0.00	0.31	9.6	245.1	25.6	NPAG	235.50
763502	635	39	64	Kivalina shale		0	0	1.7	0.7	4.633	0.95	0.16	0.00	0.00	0.79	24.6	386.1	15.7	NPAG	361.49
763503	635	64	89	Kivalina shale		0	0	1.9	0.4	4.07	1.15	0.09	0.00	0.00	1.06	33.0	339.2	10.3	NPAG	306.14
763504	635	89	114	Kivalina shale		0	0	2.3	0.4	3.721	1.89	0.09	0.00	0.00	1.80	56.2	310.1	5.5	NPAG	253.93
763506	635	139	164	Kivalina shale		0	0	2.2	0.3	2.163	2.54	0.07	0.00	0.00	2.47	77.2	180.3	2.3	NPAG	103.06
763507	635	164	189	Kivalina shale		0	0	2.4	0.2	2.368	2.6	0.05	0.00	0.00	2.55	79.8	197.3	2.5	NPAG	117.54
763508	635	189	210	Melange		0	0	2.6	0.5	2.055	2.72	0.12	0.00	0.00	2.60	81.4	171.3	2.1	NPAG	89.89
15-025	1100	139	101	Kayak shale		0.023	0.002	1.84	0.021	2.51	0.79	0.00	0.01	0.00	0.77	24.2	209.2	8.6	NPAG	184.98
15-020	1100	139	133	Kayak shale		0.040	0.002	2.28	0.076	1.47	0.40	0.02	0.02	0.00	0.36	11.3	122.5	10.8	NPAG	111.17
15-026	1100	139	206	Kayak shale		0.018	0.001	2.04	0.047	3.49	0.54	0.01	0.01	0.00	0.52	16.3	290.8	17.9	NPAG	274.58
15-027	1100	139	212	Kayak shale		0.026	0.001	1.90	0.043	2.23	0.50	0.01	0.01	0.00	0.48	14.9	185.8	12.5	NPAG	170.92
15-021	1100	139	230	Kayak shale		0.129	0.024	2.61	0.012	1.19	0.91	0.00	0.06	0.00	0.84	26.3	99.2	3.8	NPAG	72.90
15-022	1100	139	325	Kayak shale		0.043	0.005	2.66	0.011	1.19	1.09	0.00	0.02	0.00	1.07	33.3	99.2	3.0	NPAG	65.86
15-023	1100	139	405	Kayak shale		0.023	0.002	1.96	0.019	1.90	0.87	0.00	0.01	0.00	0.85	26.7	158.3	5.9	NPAG	131.65
15-024	1100	139	601	Kayak shale		0.714	0.172	2.03	0.012	3.35	1.09	0.00	0.35	0.03	0.71	22.2	279.2	12.6	NPAG	256.94
15-019	1100	139	621	Kayak shale		0.043	0.005	3.66	0.005	2.51	2.03	0.00	0.02	0.00	2.01	62.7	209.2	3.3	NPAG	146.44
15-028	1100	139	1101	Kayak shale		0.024	0.003	2.51	0.046	1.96	0.53	0.01	0.01	0.00	0.51	15.8	163.3	10.3	NPAG	147.49
15-017	1175	52	204	Kayak shale		0.038	0.004	2.35	0.012	1.42	1.39	0.00	0.02	0.00	1.37	42.7	118.3	2.8	NPAG	75.59
15-010	1175	52	209	Kayak shale		0.045	0.002	1.22	0.097	0.06	0.22	0.02	0.02	0.00	0.18	5.5	5.0	0.9	PAG	-0.47
15-011	1175	52	516	Kayak shale		0.082	0.008	3.39	0.008	1.48	1.60	0.00	0.04	0.00	1.56	48.6	123.3	2.5	NPAG	74.69
15-018	1175	52	522	Kayak shale		0.066	0.005	2.95	0.106	0.28	0.18	0.02	0.03	0.00	0.12	3.8	23.3	6.1	NPAG	19.51
15-012	1175	52	601	Kayak shale		0.018	0.001	2.35	0.012	2.64	1.55	0.00	0.01	0.00	1.54	48.1	220.0	4.6	NPAG	171.92
15-013	1175	52	605	Kayak shale		0.081	0.005	2.94	0.036	1.02	0.44	0.01	0.04	0.00	0.39	12.2	85.0	7.0	NPAG	72.78
15-014	1175	52	725	Kayak shale		0.058	0.016	2.76	0.215	0.19	0.11	0.05	0.03	0.00	0.03	0.9	15.8	17.5	NPAG	14.93
15-016	1175	52	908	Kayak shale		0.090	0.025	1.43	0.057	0.88	0.48	0.01	0.04	0.00	0.42	13.1	73.3	5.6	NPAG	60.25
15-009	1175	52	1002	Kayak shale		0.051	0.003	2.63	0.043	1.15	0.62	0.01	0.02	0.00	0.58	18.3	95.8	5.2	NPAG	77.56

Sample Info						ICP Analyses																													
Sample#	Hole/Bench	From	To	Geology	Notes	Ag ppm	Al %	As ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	K %	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sb ppm	Sc ppm	Sn ppm	Sr ppm	Ti %	V ppm	W ppm	Y ppm	Zn ppm	Zr ppm
650201	502	15	35	Kayak shale		9.8	0.6	15	370	1	5	3.79	3	3	162	103	1.86	0.18	0.64	175	8	0.03	154	4370	228	5	4	10	102	0.01	99	10	47	803	5
650202	502	35	55	Kayak shale		10.6	0.48	20	260	1	5	4.76	1	2	144	96	1.43	0.15	0.05	215	8	0.02	112	4010	50	5	2	10	106	0.01	90	10	35	473	7
650203	502	55	75	Kayak shale		7.8	0.69	15	260	1	5	3.1	1	3	163	81	1.99	0.2	0.05	115	8	0.02	102	9310	56	5	4	10	108	0.01	85	10	48	464	4
650204	502	75	95	Kayak shale		3.6	0.65	10	100	0.5	5	7.24	1	4	82	69	1.66	0.19	0.55	260	6	0.02	123	5920	66	5	4	10	141	0.01	50	10	40	465	3
650205	502	95	115	Kayak shale		6.4	0.82	20	50	1	5	7.43	1	6	177	109	2.11	0.23	0.08	205	10	0.02	141	8650	38	5	4	10	147	0.01	113	10	43	634	5
650206	502	115	135	Kayak shale		5.4	0.94	15	80	0.5	5	7.99	1	4	206	90	1.81	0.25	0.09	120	10	0.02	143	10000	46	5	4	10	142	0.01	119	10	50	431	4
650207	502	135	155	Kayak shale		4.6	0.95	10	80	0.5	5	6.96	1	6	137	78	1.69	0.26	0.1	160	6	0.02	142	8130	26	5	4	10	140	0.01	66	10	55	446	3
650208	502	155	175	Kayak shale		4.6	0.83	15	60	0.5	5	5.71	1	7	108	74	1.97	0.23	0.12	135	8	0.03	163	4340	28	5	4	10	94	0.01	61	10	36	383	4
650209	502	175	195	Kivalina shale		2.8	0.64	20	50	1	5	7.37	1	12	46	57	3.25	0.2	0.21	250	4	0.03	121	2100	32	5	6	10	87	0.01	37	10	33	262	5
750201	502	195	215	Kivalina shale		1.8	0.31	15	90	1	5	8.71	1	10	30	36	3.04	0.13	0.18	250	2	0.02	97	1840	12	5	5	10	126	0.01	26	10	31	150	4
23028	502	200	205	Kivalina shale																															
750202	502	215	235	Kivalina shale		2.6	0.31	20	70	1	5	7.37	1	10	35	42	3.1	0.12	0.17	310	4	0.02	108	2900	14	5	4	10	113	0.01	36	10	39	295	4
750203	502	235	260	Kivalina shale		4.4	0.32	15	60	1	5	6.6	1	8	81	68	2.77	0.12	0.19	420	8	0.01	173	3210	16	5	3	10	143	0.01	51	10	28	473	7
750204	502	260	285	Kivalina shale		4.4	0.47	15	60	1	5	5.61	1	9	58	66	2.52	0.14	0.25	280	6	0.02	181	5310	18	5	4	10	117	0.01	48	10	39	465	5
750205	502	285	310	Kivalina shale	Volcanics present	3	0.32	10	100	0.5	5	9.83	1	21	86	106	2.58	0.1	0.83	665	18	0.02	332	3010	12	5	6	10	232	0.01	42	10	27	597	6
750206	502	310	335	Kivalina shale	Volcanics present	3.6	0.4	20	30	0.5	5	2.71	1	16	81	90	4.19	0.11	0.32	335	10	0.02	211	1670	142	5	4	10	117	0.01	43	10	21	542	11
750207	502	335	360	Melange		6	0.43	15	80	1	5	7.59	1	6	79	76	2.25	0.14	1.35	385	6	0.02	174	5910	22	5	4	10	258	0.01	54	10	42	515	4
750208	502	360	385	Melange		5.4	0.37	15	90	0.5	5	7.38	1	6	69	75	1.98	0.13	0.85	345	6	0.02	169	4880	36	5	4	10	302	0.01	51	10	36	575	4
750302	503	85	110	Kivalina shale		1.6	0.27	10	150	0.5	5	8.94	1	8	27	21	2.3	0.11	0.66	200	2	0.02	64	1250	8	10	6	10	416	0.01	20	10	19	170	4
750303	503	110	135	Kivalina shale		1	0.2	5	180	0.5	5	12.15	1	6	21	12	2.31	0.08	1.08	310	2	0.02	40	620	26	5	4	10	351	0.01	17	10	14	126	3
750304	503	135	160	Kivalina shale	Volcanics present	1.6	0.26	10	110	0.5	5	11.36	6	9	26	27	2.36	0.1	0.89	430	2	0.02	67	1770	168	5	5	10	240	0.01	21	10	20	963	4
750305	503	160	185	Kivalina shale	Volcanics present	1.8	0.35	5	110	0.5	5	6.47	1	11	100	50	2.4	0.09	1.04	675	6	0.02	109	2720	56	5	6	10	150	0.01	27	10	25	303	3
750306	503	185	210	Kivalina shale		3.2	0.36	15	60	1	5	5.75	1	11	53	55	3.28	0.11	0.51	385	6	0.02	133	3060	30	5	7	10	151	0.01	28	10	33	369	6
750307	503	210	235	Kivalina shale		2.8	0.21	10	120	0.5	5	10.36	1	8	63	48	2.23	0.09	0.52	670	8	0.01	101	1440	18	5	4	10	250	0.01	22	10	22	218	7
750308	503	235	250	Kivalina shale		5.6	0.44	20	80	1	5	4.06	1	8	94	67	2.38	0.14	0.23	225	10	0.02	156	5010	16	5	4	10	104	0.01	51	10	39	348	7
650301	503	250	270	Kivalina shale	Volcanics present	4.2	0.26	15	100	0.5	5	7.47	3	9	67	63	2.42	0.09	1.27	560	8	0.02	140	1920	112	5	3	10	164	0.01	38	10	19	795	6
753901	539	20	35	Kayak shale		0.8	0.22	5	290	0.5	5	13.5	1	6	20	12	1.9	0.08	0.44	135	2	0.01	38	780	16	5	4	10	613	0.01	14	10	15	113	3
753902	539	35	50	Kivalina shale		1	0.25	10	170	0.5	5	11.8	1	8	21	15	2.08	0.1	0.85	145	2	0.02	48	1110	4	5	5	10	581	0.01	16	10	20	136	4
23034	539	50	55	Kivalina shale																															
754401	544	16	41	Kivalina shale		0.2	0.23	5	280	0.5	5	13.19	1	5	18	10	1.92	0.08	0.73	230	2	0.02	36	510	24	5	5	10	348	0.01	14	10	14	121	3
754402	544	41	66	Kivalina shale		0.2	0.31	5	190	0.5	5	11.78	1	7	15	25	1.93	0.1	0.4	290	2	0.02	43	610	56	5	5	10	306	0.01	14	10	16	197	3
754403	544	66	91	Kivalina shale		0.2	0.23	5	140	0.5	5	12.78	1	5	13	9	1.87	0.08	0.43	305	2	0.01	35	510	26	5	5	10	345	0.01	13	10	14	207	3
23048	544	89	94	Kivalina shale																															
754404	544	91	110	Kivalina shale		0.2	0.22	5	90	0.5	5	12.49	1	4	15	10	2.01	0.08	0.86	300	2	0.02	39	1680	20	5	4	10	292	0.01	16	10	20	138	4
754701	547	21	46	Kivalina shale		0.8	0.24	5	170	0.5	5	11.25	1	8	14	13	2.03	0.09	0.41	115	2	0.01	45	600	6	5	5	10	342	0.01	14	10	16	145	3
754702	547	46	71	Kivalina shale		0.6	0.23	5	230	0.5	5	13.66	1	6	17	10	1.89	0.1	0.46	145	2	0.02	38	620	6	5	5	10	438	0.01	15	10	16	96	3
754703	547	71	96	Kivalina shale		0.8	0.23	5	230	0.5	5	13.03	1	7	20	12	2.02	0.1	0.58	165	2	0.01	42	910	22	5	5	10	397	0.01	16	10	17	252	4
754704	547	96	121	Kivalina shale		1.2	0.2	10	90	0.5	5	11.62	1	7	27	17	3.18	0.08	2.04	280	2	0.01	47	2000	32	5	4	10	341	0.01	28	10	24	84	4
754901	549	12	37	Kayak shale		7.8	0.45	10	340	0.5	5	4.48	1	7	71	39	2.65	0.12	0.2	235	6	0.01	111	4490	2	5	4	10	93	0.01	34	10	29	343	3
754902	549	37	62	Kayak shale		3.8	0.52	15	230	1	5	2.33	1	13	82	66	2.88	0.15	0.17	180	8	0.02	184	5260	8	5	5	10	82	0.01	45	10	43	557	4
754903	549	62	87	Kayak shale		0.4	0.45	15	140	0.5	5	2.15	1	7	32	34	2.29	0.19	0.17	225	2	0.02	71	1620	16	5	4	10	49	0.01	19	10	16	142	3
754904	549	87	112	Kayak shale		2.6	0.44	10	90	0.5	5	7.53	1	9	59	43	3.17	0.15	1.62	460	4	0.02	159	4890	6	5	4	10	135	0.01	40	10	36	427	3
754905	549	112	137	Kayak shale		5.2	0.49	15	120	1	5	9.16	1	9	97	86	2.33	0.15	1.27	430	6	0.02	173	9310	2	5	4	10	201	0.01	73	10	47	619	4
754906	549	137	162	Kayak shale		6.2	0.55	30	70	0.5	5	7.03	1	5	133	65	2.6	0.17	0.08	145	12	0.02	179	10000	2	5	4	10	152	0.01	72	10	78	426	5
754907	549	162	187	Kivalina shale		2.2	0.49	15	90	1	5	7.09	1	10	44	42	2.76	0.17	0.17	175	2	0.02	113	6250	28	5	5	10	120	0.01	31	10	47	264	4
23055	549	180	185	Kivalina shale																															
754908	549	187	212	Kivalina shale		2.4	0.29	15	90	0.5	5	8.53	1	9	35	46	2.83	0.11	0.23	285	6	0.01	119	2950	14	5	4	10	134	0.01	31	10	37	299	6
754909	549	212	240	Melange		4	0.38	15	70	1	5	5.45	1	7	54	61	2.52	0.12	0.24	315	8	0.01	160	4940	18	5	3	10	134	0.01	48	10	39	722	6
755601	556	16	41	Kayak shale		2.4	0.46	15	390	0.5	5	2.96	1	10	69	58	2.78	0.13	0.17	285	10	0.02	192	5730	18	5	5	10	70	0.01	48	10	39	628	6
755602	556	41	66	Kayak shale		0.2	0.43	20	290	1	5	2.41	1	8	51	61	2.93	0.17	0.38	220	6	0.02	132	3870	10	5	6	10	76	0.01	21	10	27	345	4
755603	556	66	91	Kayak shale		1.6	0.3	10	200	0.5	5	9.22	1	2	66	28	1.07	0.12	0.09	170	6	0.02	70	4550	2	5	2	10	167	0.01	49	10	20	205	2
755604	556	91	116	Kayak shale		6.8	0.42	25	110	1	5	8.91	1	5	137	92	1.95	0.13	0.07	265	16	0.02	182	6770	2	5	3	10	134	0.01	74	10	43	586	9
755606	556	141	166	Kivalina shale		1.8	0.25	15	100	0.5	5	6.41	1	5	42	40	1.88	0.09	0.08	185	4	0.01	89	2700	2	5	3	10	96	0.01	48	10	30	268	4
755607	556	166	191	Kivalina shale		0.2	0.21	10	90	0.5	5	5.73	1	8	16	19	2.11	0.08	0.18	130	2	0.01	62	840	4	5	4	10	63	0.01	15	10	15	120	3
755608	556	191	216	Kivalina shale		0.2	0.26	10	110	0.5	5	6.84	1	7	22	20	2.16	0.1	0.13	135	2	0.01	61	850	2	5	4	10	73	0.01	16	10	16	183	3

Sample Info						ICP Analyses																													
Sample#	Hole/Bench	From	To	Geology	Notes	Ag ppm	Al %	As ppm	Ba ppm	Be ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	K %	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P ppm	Pb ppm	Sb ppm	Sc ppm	Sn ppm	Sr ppm	Ti %	V ppm	W ppm	Y ppm	Zn ppm	Zr ppm
760101	601	9	34	Kayak shale		0.2	0.26	10	200	0.5	5	7.57	1	8	12	12	1.55	0.09	0.08	100	2	0.02	42	570	6	5	5	10	193	0.01	9	10	15	112	3
760102	601	34	59	Kayak shale		0.2	0.16	5	200	0.5	5	11.83	1	1	16	6	2.13	0.06	1.66	165	2	0.01	31	440	2	5	3	10	312	0.01	16	10	10	89	3
760103	601	59	84	Kayak shale		0.2	0.23	5	160	0.5	5	10.33	1	5	10	11	1.68	0.08	0.32	175	2	0.01	35	660	2	5	4	10	289	0.01	12	10	15	129	3
760104	601	84	109	Kayak shale		0.2	0.14	5	250	0.5	5	14.01	1	4	16	7	1.45	0.06	0.45	185	2	0.01	28	530	2	5	3	10	398	0.01	10	10	11	75	3
760105	601	109	134	Kayak shale		0.2	0.22	5	130	0.5	5	11.24	1	4	19	9	1.77	0.08	0.6	190	2	0.01	35	1540	6	5	4	10	277	0.01	15	10	19	84	3
760106	601	134	159	Kayak shale		0.2	0.16	10	60	0.5	5	9.69	2	5	26	17	2.53	0.07	0.64	320	2	0.01	41	840	46	5	4	10	366	0.01	16	10	15	436	3
761701	617	9	34	Kivalina shale		0.2	0.28	5	420	0.5	5	15	1	3	15	10	2.61	0.08	1.12	310	2	0.02	31	570	20	5	5	10	358	0.01	18	10	16	103	4
761702	617	34	59	Kivalina shale		0.2	0.29	5	220	0.5	5	11.67	1	7	13	13	2.23	0.09	0.5	170	2	0.02	42	790	22	5	6	10	278	0.01	12	10	17	135	4
761703	617	59	84	Kivalina shale		0.2	0.22	5	190	0.5	5	13.13	1	5	14	10	1.82	0.08	0.51	170	2	0.02	36	730	40	5	5	10	319	0.01	11	10	16	163	3
761704	617	84	109	Kivalina shale		0.2	0.27	5	210	0.5	5	11.53	1	6	17	11	1.96	0.09	0.44	200	2	0.02	38	520	26	5	5	10	295	0.01	11	10	14	145	3
761705	617	109	134	Kivalina shale		0.2	0.21	5	160	0.5	5	10.36	1	5	11	11	1.8	0.08	0.51	210	2	0.01	37	680	30	5	5	10	280	0.01	11	10	13	124	3
761706	617	134	159	Kivalina shale		0.2	0.21	5	120	0.5	5	11.72	2	6	35	21	1.98	0.09	0.37	225	4	0.02	55	870	46	5	4	10	276	0.01	14	10	15	405	3
763501	635	14	39	Kivalina shale		0.2	0.26	5	560	0.5	5	9.89	1	6	35	14	1.92	0.11	0.22	340	2	0.02	46	690	152	5	4	10	220	0.01	14	10	15	261	3
763502	635	39	64	Kivalina shale		0.2	0.16	5	220	0.5	5	14.6	1	6	10	10	1.79	0.07	0.38	370	2	0.01	36	550	98	5	4	10	297	0.01	13	10	16	159	3
763503	635	64	89	Kivalina shale		0.2	0.26	5	150	0.5	5	11.85	1	5	27	13	2.02	0.1	1.15	315	2	0.01	45	780	44	5	5	10	228	0.01	15	10	14	140	4
763504	635	89	114	Kivalina shale		0.2	0.3	5	90	0.5	5	10.39	1	3	41	17	2.42	0.11	1.54	360	4	0.02	51	2950	50	5	4	10	182	0.01	23	10	18	175	4
763506	635	139	164	Kivalina shale		1.2	0.23	15	90	0.5	5	8.2	1	8	72	61	2.56	0.1	0.22	320	12	0.01	133	1110	32	5	4	10	223	0.01	27	10	27	402	10
763507	635	164	189	Kivalina shale		1	0.28	15	120	0.5	5	8.85	1	8	52	47	2.51	0.11	0.14	240	8	0.01	109	1980	8	5	3	10	142	0.01	24	10	22	241	6
763508	635	189	210	Melange		3.4	0.32	15	90	0.5	5	9.78	1	5	89	58	2.95	0.11	0.5	470	12	0.02	140	5050	28	5	5	10	269	0.01	46	10	42	395	8
15-025	1100	139	101	Kayak shale		1.67	0.75	11.5	210	0.63	0.13	7.06	0.66	6.6	40	18.9	1.84	0.23	0.54	113	4.72	0.02	57.7	1620	16	0.82	4.9	0.4	365	0.005	31	0.11	19.4	225	3.4
15-020	1100	139	133	Kayak shale		5.48	0.55	23.3	760	0.85	0.22	4.28	1.44	7	62	58.4	2.28	0.15	0.15	297	12.85	0.01	126.5	3940	16	2.41	4.4	0.6	152.5	0.005	38	0.62	30.8	396	6.2
15-026	1100	139	206	Kayak shale		1.74	0.64	13.5	470	0.66	0.11	9.73	0.73	5.3	39	17.8	2.04	0.18	1.17	160	5.96	0.02	52.8	3360	14	0.67	4	0.3	483	0.005	37	0.11	21.6	180	4.2
15-027	1100	139	212	Kayak shale		1.93	0.56	16.2	430	0.71	0.15	7.67	0.80	7.1	30	24.8	1.9	0.17	0.33	119	5.89	0.01	64.2	2800	13	0.74	4.6	0.4	426	0.005	25	0.17	29.5	255	4.3
15-021	1100	139	230	Kayak shale		2.52	0.63	19.3	120	0.73	0.23	2.86	7.37	12.2	40	47.2	2.61	0.17	0.54	326	7.89	0.02	127	2750	238	3.92	5.6	0.5	121	0.005	25	0.4	21.3	1290	2.6
15-022	1100	139	325	Kayak shale		2.54	0.74	16.2	110	0.7	0.19	2.88	1.38	12.4	47	46.3	2.66	0.23	0.53	324	5.83	0.02	115.5	2570	54	3.71	6.8	0.3	106.5	0.005	29	0.3	20.6	426	2.1
15-023	1100	139	405	Kayak shale		2.7	0.47	18.6	190	0.59	0.14	6.76	0.93	5.4	33	26.5	1.96	0.14	0.2	167	4.9	0.01	53.9	2910	24	2.64	4	0.4	404	0.005	28	0.31	25.1	234	4.4
15-024	1100	139	601	Kayak shale		3.87	0.42	20.5	120	0.56	0.13	9.18	44.70	11.7	29	26.2	2.03	0.12	1.38	146	11.85	0.01	53.5	2610	1720	6.15	4.2	0.9	479	0.005	27	0.78	22	7140	4.1
15-019	1100	139	621	Kayak shale		2.21	0.83	12.4	50	0.76	0.1	6.28	1.48	18.8	58	44.6	3.66	0.22	1.35	728	5.9	0.02	158	3490	54	3.75	8.4	0.3	227	0.005	32	0.22	26.8	427	2.2
15-028	1100	139	1101	Kayak shale		0.89	0.67	12.1	460	0.85	0.19	6.38	0.76	10	19	17.2	2.51	0.21	0.21	198	2.21	0.02	59.8	790	28	0.37	6.1	0.4	171	0.005	23	0.06	17.5	242	2.4
15-017	1175	52	204	Kayak shale		3.52	0.44	24.2	120	0.79	0.17	5.49	1.51	9.7	43	40.5	2.35	0.13	0.05	261	7.02	0.01	122.5	2930	39	1.01	4	0.5	106.5	0.005	38	0.36	32	382	3
15-010	1175	52	209	Kayak shale		3.51	0.53	20.5	970	0.65	0.2	0.52	1.79	3.7	85	94.6	1.22	0.2	0.1	135	11.95	0.01	73.2	1490	16	5.1	4.2	0.6	99.1	0.005	49	0.54	24.3	450	8.4
15-011	1175	52	516	Kayak shale		5.82	0.58	25	80	0.9	0.17	4.04	1.65	17	85	62.5	3.39	0.14	0.26	773	8.63	0.02	209	3670	78	2.56	6.1	0.5	219	0.005	55	0.52	41.3	822	5.3
15-018	1175	52	522	Kayak shale		3.7	0.86	23.6	1060	0.88	0.24	1.62	2.99	6.6	59	58.4	2.95	0.15	0.13	350	8.58	0.01	102.5	4490	52	14.45	4.7	0.5	147.5	0.005	55	0.85	34.2	657	1.1
15-012	1175	52	601	Kayak shale		0.93	0.58	13.6	120	0.72	0.15	9.51	0.60	8	22	20.8	2.35	0.19	0.13	207	3.24	0.02	61.1	1370	11	0.28	5.1	0.4	113.5	0.005	21	0.12	22.5	175	2.3
15-013	1175	52	605	Kayak shale		3.49	0.74	23.2	360	0.83	0.24	2.71	2.29	11.9	60	65.2	2.94	0.16	0.56	703	16.65	0.01	157.5	4230	46	2.39	5	0.5	127	0.005	44	0.77	32.4	812	4.4
15-014	1175	52	725	Kayak shale		2.25	1.46	15.5	2150	0.9	0.25	0.59	2.46	9.3	53	34.3	2.76	0.28	0.19	317	5.4	0.02	78.2	2050	165	3.54	4.8	0.6	50.2	0.005	52	0.59	20.3	581	0.8
15-016	1175	52	908	Kayak shale		5.2	0.89	15	570	0.67	0.14	4.03	4.94	3.3	111	54.6	1.43	0.27	0.06	82	6.64	0.01	69.4	8490	249	2.39	4.3	0.6	121.5	0.005	52	0.74	50	904	2.4
15-009	1175	52	1002	Kayak shale		1.79	0.75	19.8	430	0.82	0.19	4.16	1.70	9.7	36	31.2	2.63	0.23	0.11	231	4.96	0.02	96	1870	29	0.52	4.7	0.5	80.7	0.005	30	0.2	23.9	507	2.2

Appendix B – WDXRF analysis of clean waste samples

Red Dog Operations

Teck

TO: Piotr Zielinski
FROM: Kevin Lackey
DATE: 04/13/2015
SUBJECT: WDXRF analysis of clean waste samples

Situation

New permit requirements require accurate analysis of "clean waste" samples at lead and zinc levels that are considerably below those customarily analyzed in the Assay Laboratory.

Complication

1. There are no existing methods currently use in the laboratory either by atomic absorption spectroscopy (AAS) or wavelength dispersion X-Ray fluorescence spectroscopy (WDXRF).
2. Both methods may require substantial development time and testing before being suitable for routine analyses.

Focusing Questions

1. Can suitable methods for either or both analytical techniques be developed by the Assay Laboratory staff?
2. Will analysis for clean waste require AAS analysis, or is WDXRF suitable?
3. Will clean waste samples require secondary analysis, or is the existing method choice schema of the WDXRF able to provide accurate results?

Conclusions

1. Robust methods for both AAS and WDXRF analyses were developed.
2. The WDXRF will be used as the primary analytical technique. AAS will be used as a quality control measure to confirm WDXRF results.
3. Routine WDXRF analysis using the method choice schema is suitable without additional analyses.

Recommendations

Immediately employ the pressed-pellet WDXRF procedure to analyze both potential ore and clean waste samples. The method choice schema, in conjunction with the existing analytical procedure and enhanced calibration curves will provide accurate and precise analyses.

Kevin Lackey, Assay Laboratory Supervisor

Discussion

This section will provide a summary of the method and development project. The primary method development work was performed by Vince Karp and David Merritt with technical assistance and direction provided by the Assay Laboratory chemist, Zachary Pickett. They will provide a detailed description of the method development process, the final approved methods and a statistical analysis of the study data in the near future. That written description will be available on request.

Historically, the laboratory has provided analysis of lead, zinc and iron samples in the general concentration ranges of 1.5% (tails samples) to 65% (concentrate samples) contained metal. The lowest standards used to calibrate the AAS or WDXRF were only slightly below the lower levels. No particular attempt to provide precise analyses below those levels was made, as it was not considered significant to the milling process.

Recently, we have been requested to provide analysis for lead and zinc at significantly lower levels. The upper limit for lead analysis was 0.5%, and zinc 0.1%. A short study of the existing AAS and WDXRF methods showed that neither was accurate in that range. As a short term solution, the mine operations group leased a portable EDXRF that was calibrated in the needed ranges. A method development project was undertaken by the laboratory in order to provide the needed analyses in the future.

AAS is a referee method for low-level metal determination. The first effort was to develop an AAS method that would allow reproducible results in very low concentrations. Analysis at similar levels is carried out on discharge samples, so success in the method development was anticipated. The primary difficulty was in overcoming rather significant matrix effects of the digested mine samples as compared to the pure discharge water samples. The tasks undertaken were:

1. Define and produce a set of AAS standards that are similar in concentration and matrix to the clean waste samples.
2. Develop the sample preparation techniques and instrument parameters that would allow analysis of the samples.
3. Test the method and demonstrate that it is stable over a wide range of sample types and over time.

The AAS method development required several weeks, and was completed in late February, 2015.

The WDXRF method development tasks were similar. Fortunately, the solid material used to create the AAS standards was also suitable for use as WDXRF standards. That essentially eliminated task 1. from the list above. The second and third steps were begun before the AAS method testing was complete. When a usable AAS analytical method appeared to be available, but before it had been thoroughly tested, the WDXRF method development began.

There were two major possibilities in the WDXRF method development process; either the clean waste samples could be run as routine samples, depending on the programming of the WDXRF to effectively analyze the samples, or they would require an entirely separate method, exclusive to clean waste. As the first option was desirable due to operational efficiency in the laboratory, that method was investigated first. Fortunately, it was successful.

The WDXRF has a programming feature ("method choice") that allows recalculation of results based on the concentration of each element first determined in a generic calibration. Rather than a single "calibration for all samples" analysis, our current method has seventeen calibration choices and well over one-hundred calibration curves. This requires approximately two hundred analytical standards to be run to generate the calibration data. The clean waste standards (thirteen in total) were added to the calibration sample set, and analytical criteria added to the method choice programming.

Several hundred samples, both replicates of the standards and clean waste material, were analyzed by both AAS and WDXRF. The assays were compared to assure that, regardless of the technique employed, the results would be both accurate and precise. Following statistical analysis of the data, the methods were approved for reporting mine data in March, 2015.

An ongoing program of running comparison samples by AAS and WDXRF has begun, and will continue. AAS is a direct measurement method; WDXRF is a modeled method. It is possible for matrix differences to affect the WDXRF analysis unexpectedly. Although in very low concentration samples this is unlikely, an ongoing program of comparison testing will assure that the WDXRF results remain accurate.

In addition, two powdered sample standards (CWQC2 and CWQC4) were prepared. Their lead, zinc and iron concentrations are in the range of the permit limits. By regularly testing the standards on both the AAS and WDXRF methods, we can be assured that the final results will not vary over time.

Appendix D : Monitoring Plan

Monitoring Plan
Red Dog Mine, Alaska, USA

Waste Management Permit # 2016DB0002

Prepared for

Teck Alaska Incorporated

Prepared by

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

Monitoring Plan
Red Dog Mine, Alaska, USA

Waste Management Permit # 2016DB0002

August 2016

Prepared for

Teck Alaska Incorporated
3105 Lakeshore Drive
Building A, Suite 101
Anchorage, AK 99503
United States

Tel: +1 907 754 6170
Web: www.teck.com

Prepared by

SRK Consulting (U.S.), Inc.
Suite E-12, 4700 Business Park Blvd.
Anchorage, AK 99503
United States

Tel: +1 907 677 3520
Fax: +1 907 677 3620
Web: www.srk.com

Project No: 329100.030
File Name: MonitoringPlan_RedDogMine_329100.030_20160805.docx

srk consulting

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish & Game
ADNR	Alaska Department of Natural Resources
APDES	Alaska Pollutant Discharge Elimination System
CEC	cation exchange capacity
DMTS	DeLong Mountain Regional Transportation System
EC	electrical conductivity
EPA	United States Environmental Protection Agency
IWMP	Integrated Waste Management Permit
ML/ARD	Metal Leaching/Acid Rock Drainage
MPD	Main Pit Dump
MWD	Main Waste Dump
NPDES	National Pollutant Discharge Elimination System
NANA	NANA Regional Corporation, Inc.
Plan	Integrated Waste Management Plan
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RMP	Risk Management Plan
SEP	Supplemental Environmental Project
SOP	Standard Operating Procedure
TAK	Teck Alaska Incorporated
TDS	Total Dissolved Solids
TSF	Tailings Storage Facility
TSS	Total Suspended Solids
WAD	weak acid dissociable
WTP1	Water Treatment Plant 1
WTP2	Water Treatment Plant 2
WTP3	Water Treatment Plant 3

Units of Measure

m	meter
m^2	square meter

1 Introduction

Teck Alaska Incorporated (TAK) is submitting the *Red Dog Mine Monitoring Plan* (Plan) to the Alaska Department of Environmental Conservation (ADEC) and the Alaska Department of Natural Resources (ADNR), as required by 18 AAC 15.090 and 18 AAC 60.210 (b)(3)(D) for the Waste Management Permit #2016DB0002. This Plan is a supporting document to the *Red Dog Mine Reclamation and Closure Plan* (SRK 2016a) and an appendix to the *Red Dog Mine Integrated Waste Management Plan* (SRK 2016b).

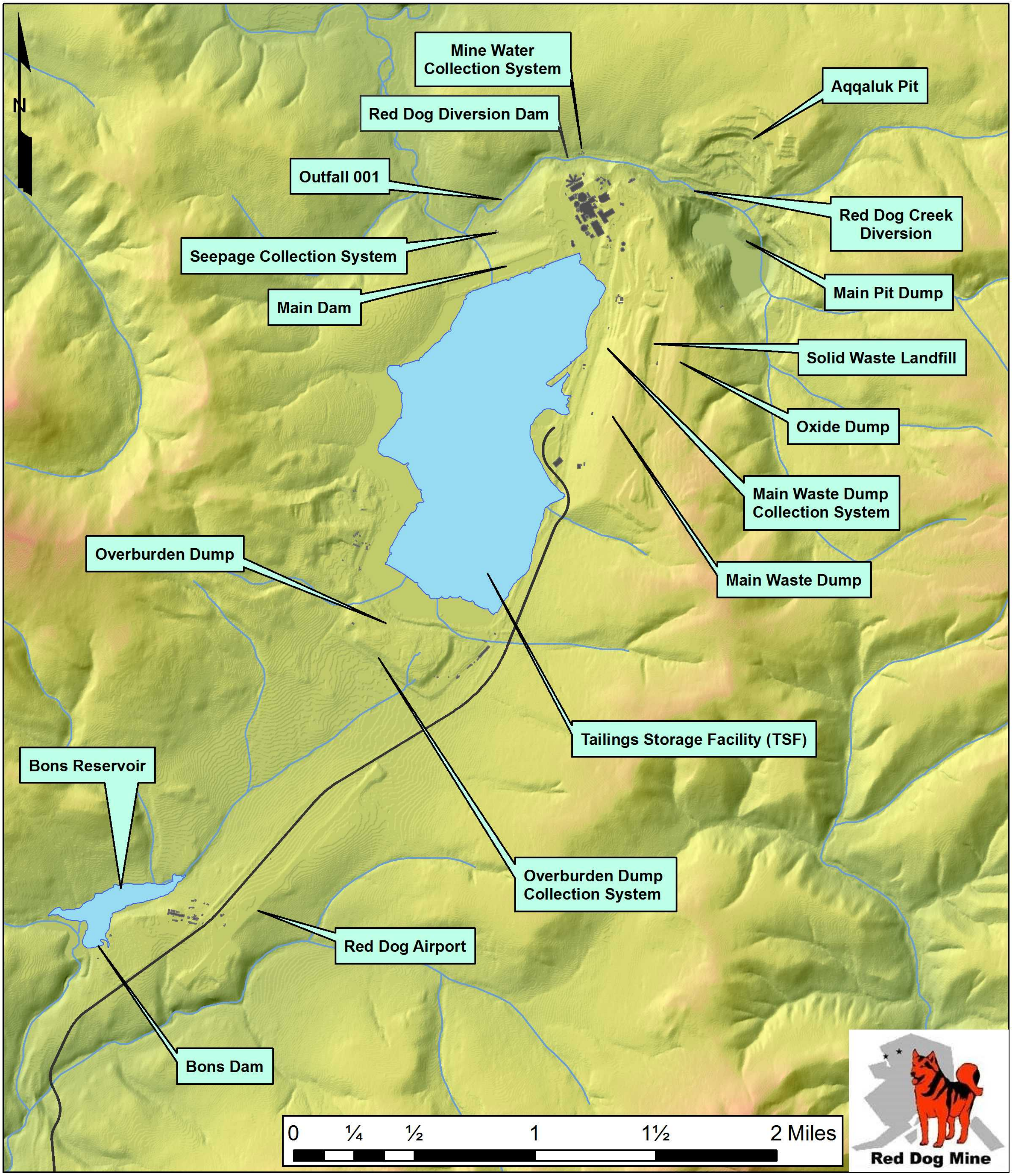
Monitoring described in this Plan complies with requirements set forth by the Integrated Waste Management Permit (IWMP) and the *Reclamation and Closure Plan*, and includes the following:

- Biomonitoring, including aquatic life and ambient water quality monitoring, in the Bons Creek and Red Dog drainages[1] (stipulated under the Alaska Pollutant Discharge Elimination System (APDES) permit which incorporates previous stipulations in the 1998 Red Dog Mine National Pollutant Discharge Elimination System (NPDES) Permit #AK-003865-2 and as part of the Bons Creek Monitoring Program under an agreement between TAK and ADEC)
- Permafrost and sub-permafrost groundwater monitoring (previously conducted under the Groundwater Supplemental Environmental Project [SEP])
- Inspections of the Red Dog Fish Weir (previously conducted under the Red Dog Creek Fish Weir Construction and Maintenance SEP)
- Water quality and flow monitoring at locations throughout the mine site and maintenance of water/load balances, including pit lakes and spillways (if applicable, and when possible)
- Monitoring of waste rock and tailings
- Monitoring of solid waste landfills
- Mining and milling activities
- Monitoring of reclamation activities, including cover performance and revegetation success.
- Fugitive dust
- Wildlife

Table 1 summarizes monitoring described in this Plan. Key facilities at the Red Dog Mine (Mine) included in this Plan are shown on Figure 1. This Plan covers the Mine only and excludes the DeLong Mountain Regional Transportation System (DMTS), which includes the road and port facilities.

Monitoring associated with the operations phase is described in Section 2. Section 3 addresses changes to the monitoring program required during the period of active mine closure, while Section 4 describes anticipated requirements for the post-closure period. Section 5 describes the Quality Assurance/Quality Control (QA/QC) programs in place. Reporting and report content requirements are described in Section 6.

[1] [1] This Plan includes some monitoring locations that are not part of the Bons Creek and Red Dog Creek drainages or are outside the jurisdiction of the Waste Management Permit boundary. These locations have been included for reference and program completeness



DESIGN:	PREPARED BY: srk consulting	DRAWING TITLE: MONITORING PLAN FACILITY MAP
DRAWN:		
REVIEWED: ST		
APPROVED:	PROJECT: **RED DOG MINE MONITORING PLAN**	DATE: 08/04/2014 REVISION: SRK PROJECT NO: 329100.030 DRAWING NO: Figure 1

Table 1 : Summary of Monitoring During Operations

Monitoring Program Element	Location	Parameters	Stipulation[2]	Plan Section	Monitoring Frequency	Reporting Frequency
Biomonitoring Program						
Bons Creek Monitoring Program	Buddy Creek (below falls and Station 221), Bons Creek (Station 220 and above pond), Anxiety Creek, Evaingiknuk Creek, Lower and Upper Bons Creek, Bons Reservoir, Dudd Creek	See Table 2 for specific parameters at each location (includes Ambient Water Quality Profile I, periphyton, aquatic invertebrates, fish presence and use, and juvenile Dolly Varden tissues	Waste Permit 2.5.1	2.1. 3	Ranges from monthly to yearly	Annual
Mine Drainage Monitoring Program	Wulik River, Ikalukrok Creek, Station 9, Station 160, Station 20, Station 10, Station 12, Rachel Creek, Connie Creek, Shelly Creek, Sulfur Creek, Station 150, and Station 145.	See Table 2 for specific parameters at each location (includes Ambient Water Quality Profile I, fall aerial surveys for overwintering Dolly Varden in Wulik River and for adult chum salmon in Ikalukrok Creek, periphyton, aquatic invertebrates, fish presence and use, juvenile Dolly Varden tissue metals analysis)	Waste Permit 2.5.1	2.1.4	Ranges from monthly to yearly	Annual
Permafrost and Sub-permafrost Groundwater Monitoring						
Permafrost and Subsurface Temperature	Thermistors T-95-004, T95-005, T95-008, T14-110; T-96-010, T96-012, T96-012S, T96-013, T96-015, T96-021, T96-022, T96-023; T-97-028, T97-029, T97-030; T-05-061	Ground temperature (Table 5)	Waste Permit 2.5.1	2. 2.2	Quarterly	Annual
Groundwater Level	Piezometers P-08A, P-08B; P-96-010, P-96-013, P-96-015; P-97-012, P-97-020, P-97-028; SPP-97-002	Water elevation around the tailings storage facility (TSF) (Table 6)	Waste Permit 2.5.1	2.2.3	Quarterly	Annual
Mine Water Management						
Water Quality and Flow	Main Dam Seepage Pumpback, Bons Creek Total Flow, East/West Overburden Sump, Tailings Water, Reclaim Water, WTP1/Mill Influent from Reclaim, WTP1 Influent from Mine Water Collection System, WTP2 Influent from Reclaim, WTP3 Influent from Main Waste Dump, WTP3 Influent from Mine Water Collection, WTP3 Effluent, Mine Water Collection System, Pit lakes, Mill Pad Runoff Collection System	See Table 7 for specific parameters at each location (includes total monthly water quality and) and quantity of water treated	Waste Permit 2.5.5, 2.5.6	2.3.2	Continuous, monthly	Quarterly
Water Balance	Mine site	Water quantity	Waste Permit 2.5.5	2.3.3	Continuous	Annual
Load Balance	Mine site	Chemical loadings	Waste Permit 2.5.5	2.3.3	Continuous	Annual

[2] Waste Permit, Sec 2.5.1 incorporates this table by reference. This may be stipulated in other plans.

Monitoring Program Element	Location	Parameters	Stipulation[2]	Plan Section	Monitoring Frequency	Reporting Frequency
Visual Monitoring	Diversion ditches, Red Dog Creek and other clean water diversions, Mine Water Collection System, pipelines and pipeline containment structures, Main Waste Dump seepage collection system, treated water discharge lines, Overburden Dump runoff collection system, Mill Pad runoff collection system	Signs of damage or potential damage; escape of waste or leachate or any unauthorized waste disposal; damage to the structural integrity of a containment structure or diversion structure; evidence of death or stress to fish, wildlife, or vegetation	Waste Permit 2.5.2	2.3.4	Weekly when flow is present, frost action, or thawing	Quarterly
	Fish weir	Signs of damage or potential damage	Waste Permit 2.5.1	2.3.4	2/year	Quarterly
Waste Rock Management						
Quantity	Waste rock and construction stockpiles	Volume placed in dumps, placed in stockpiles, or used for construction or cover	Waste Permit 2.5.9	2.4.2	Daily	Quarterly
Geochemical Monitoring	Geological and geochemical characterization of Blast hole cutting	As specified in the *Waste Rock Management Plan* (SRK 2016c).	Waste Permit 2.5.1	2.4.3	As scheduled	Quarterly
Visual Monitoring	Waste rock dumps	Signs of damage or potential damage; escape of waste or leachate or any unauthorized waste disposal; damage to the structural integrity of a containment structure or diversion structure; evidence of death or stress to wildlife, or vegetation; inspections to ensure geological properties are appropriate for designated location or use; inspections for waste rock dump fires or “hot spots”	Waste Permit 2.5.2	2.4.4	Weekly	Quarterly
Tailings Management						
Quantity	Tailings Storage Facility (TSF)	Volume of tailings produced and placed in TSF	Waste Permit 2.5.9	2.5.2	Daily	Quarterly
Geochemical Monitoring	Final tailings slurry	Percent iron, lead and zinc composition	Waste Permit 2.5.1	2.5.3	Continuous	Quarterly
Visual Monitoring	Diversion ditches, TSF, Main Dam	Signs of damage or potential damage, structural integrity of diversion ditches, evidence of death or stress to wildlife or vegetation	Waste Permit 2.5.2	2.5.4	Weekly	Quarterly
Inert Solid Waste Landfill						
Quantity	Landfill	Volume of solid waste placed in landfills	Waste Permit 2.5.1	2.6.2	1/year	Annual

Monitoring Program Element	Location	Parameters	Stipulation[2]	Plan Section	Monitoring Frequency	Reporting Frequency
Mining and Milling Activities						
Quantity	Mine site	Quantity of ore produced, waste rock removed and tailings produced	Waste Permit 2.5.1	2.7	Daily	Quarterly
Reclamation						
Area	Areas disturbed and reclaimed throughout mine site	Size of areas disturbed and reclaimed	Waste Permit 2.5.1	2.8.2	As scheduled	Annual
Research	Reclamation test plots and reclaimed areas	Various monitoring to assess effectiveness of reclamation research	Waste Permit 2.5.1	2.8.3	As scheduled	Annual
Visual Monitoring	Reclaimed areas	Soil properties, plant density and survival, plant cover and taxonomic richness, plant vigor	Waste Permit 2.5.1	2.8.3	As scheduled	Annual
Dust Monitoring						
Risk Management Plan (RMP)	Mine site	As specified in the RMP	Waste Permit 2.5.1	2.9	RMP	Annual
Wildlife Monitoring						
Wildlife	Mine site	Wildlife interactions and casualties	Waste Permit 2.5.14, 2.6.6	2.10	Weekly	Quarterly

1.1 Project Description

Red Dog Mine is located in northwestern Alaska, approximately 82 miles north of Kotzebue, and 46 miles inland from the coast of the Chukchi Sea. The Mine is located on the Middle Fork of Red Dog Creek in the DeLong Mountains of the western Brooks Range, on private land owned by NANA Regional Corporation, Inc. (NANA). Support facilities are situated on both State and NANA lands. The Mine is a joint venture between NANA and TAK, whereby TAK is the operator and NANA is the land owner.

The operation consists of an open pit zinc-lead mine, mill, and support facilities. Construction of the mill began in 1988, with the first ore delivered to the mill in November 1989. Conventional drill and blast mining methods are employed. Mineral processing facilities use conventional grinding and sulfide flotation methods to produce zinc and lead concentrates. The concentrates are shipped to markets in North America, Europe, and Asia from the DeLong Mountain Regional Transportation System (DMST) Port facility located on the Chukchi Sea. The Port is accessed via the 52-mile DMTS haul road, owned by the Alaska Industrial Development and Export Authority.

Ore and host rocks of the mine contain high concentrations of sulfide minerals, and the majority of the waste rock is acid generating, potentially acid generating, or has potential for metal leaching. Water from the Main Pit / Main Pit Dump (MPD) and Aqqaluk Pit are collected in the Tailing Storage Facility (TSF). Water from the Main Waste Dump (MWD) is partially captured in the Main Waste Dump Collection System with the remainder reporting to the TSF. Water from the MWD Collection System is pre-treated and discharged to the TSF in the summer and winter. During the open water season (normally May to October), water from the TSF is treated and discharged to the Middle Fork of Red Dog Creek (Outfall 001). Water is not discharged during the remaining months.

1.2 Environmental Management

TAK actively complies with over 150 permits, regulations, agreements and environmental plans that contain more than 6,000 individual stipulations, involving over 27,000 tasks that must be met on a daily, weekly, monthly, quarterly, and/or annual basis.

To facilitate management of these tasks, TAK maintains and operates a web-based environmental management system that tracks daily compliance tasks that must be completed; tracks environmental and safety incidents and required corrective and preventive actions; and provides environmental training materials, records, and information on overall environmental performance. This tool is essential in ensuring that the monitoring included in this Plan is completed as required and consistent with stipulations in permits, regulations, plans, and company site-specific operating procedures.

TAK also maintains an environmental management database that stores environmental data, such as water quality data, and includes a system for managing environmental sampling results, including scheduling and preparation of Chain of Custody forms. The database also tracks receipt of data from contract laboratories to ensure that all requested analyses are received, as well as compliance with permit and regulatory standards.

2 Operations Monitoring

2.1 Water Quality and Biomonitoring Program

Biomonitoring in the Red Dog Creek area was initiated in 1990 with fish tissue sampling and expanded to the Bons Creek area in 2004. In 1996, invertebrate and periphyton sampling were added. Programs were updated in 2007 by the Alaska Department of Fish & Game (ADFG) in consultation with TAK. The programs include a combination of aquatic life and water quality monitoring with data collected at varying frequencies and reported annually (refer to Table 1).

2.1.1 Key Elements of the Monitoring Program

Key elements of the water quality and biomonitoring programs include:

- Aquatic life and ambient water quality monitoring within the Bons Creek drainage and Evaingiknuk Creek, simply referred to as the Bons Creek Monitoring Program.
- Aquatic life and ambient water quality monitoring within the Red Dog Creek drainage, Ikalukrok Creek and Wulik River, simply referred to as the Mine Drainage Monitoring Program.
- Additional monitoring of water quality and flow at select Mine Drainage stations related to discharge from Outfall 001.
- Flow measurements at selected sites in the Mine Drainage Program.

Sampling locations for the above-listed program are shown on Figure 2, 3, and 4. Details of the monitoring program are provided in the following sections.

2.1.2 Water Quality Profiles

Table 2 lists the analytical parameters included in the water quality profiles referenced in Sections 2.1.3 and 2.1.4.

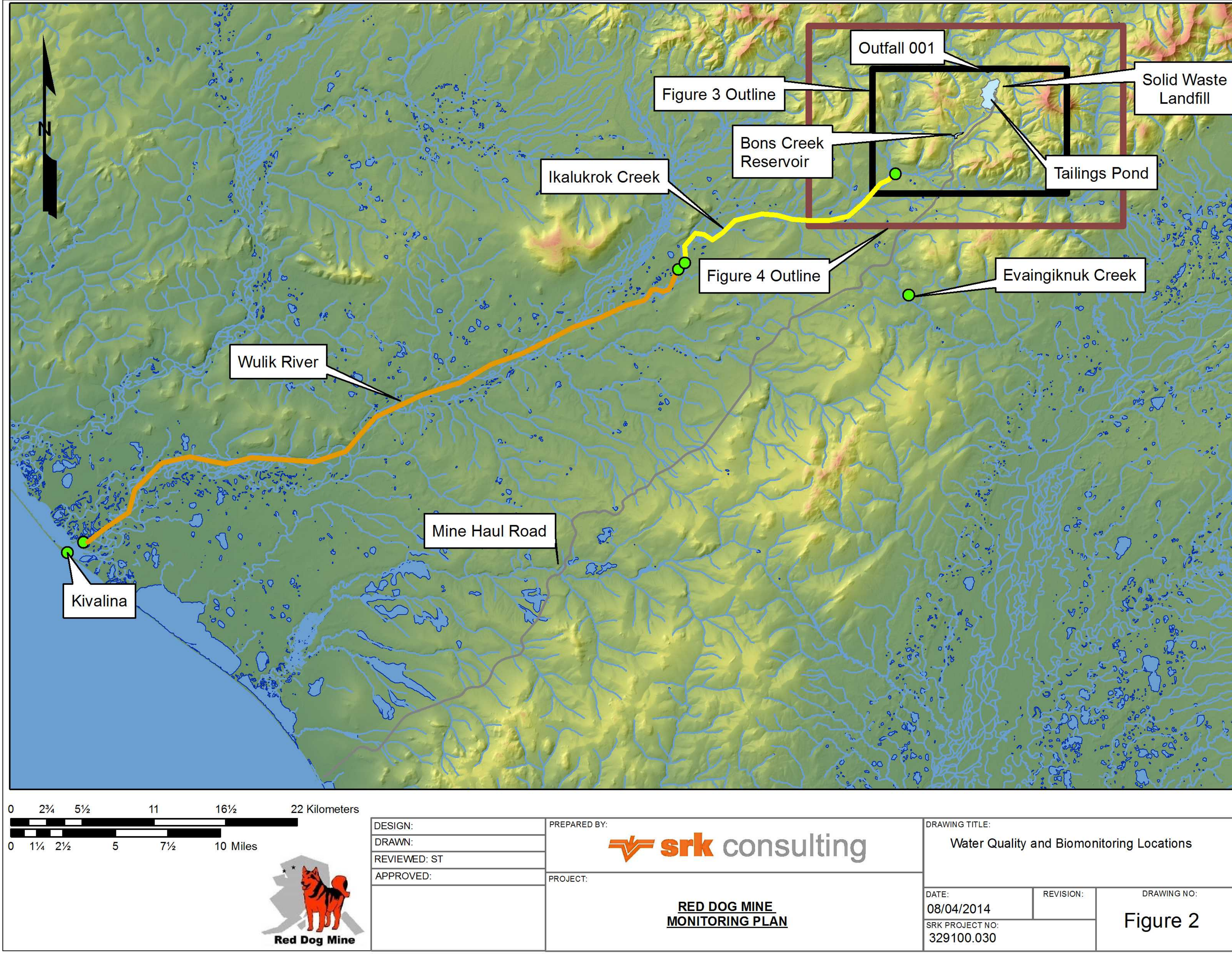
2.1.3 Bons Creek Monitoring Program

An augmented aquatic biomonitoring program was implemented in 2004 within the Bons Creek drainage, which included intensive assessment from 2004 through 2006 to establish current baseline conditions. The current baseline assessment included collection and analysis of fish tissues, evaluations of fish distributions and population estimates, invertebrate and periphyton sampling in Bons Creek, Bons Reservoir and Buddy Creek.

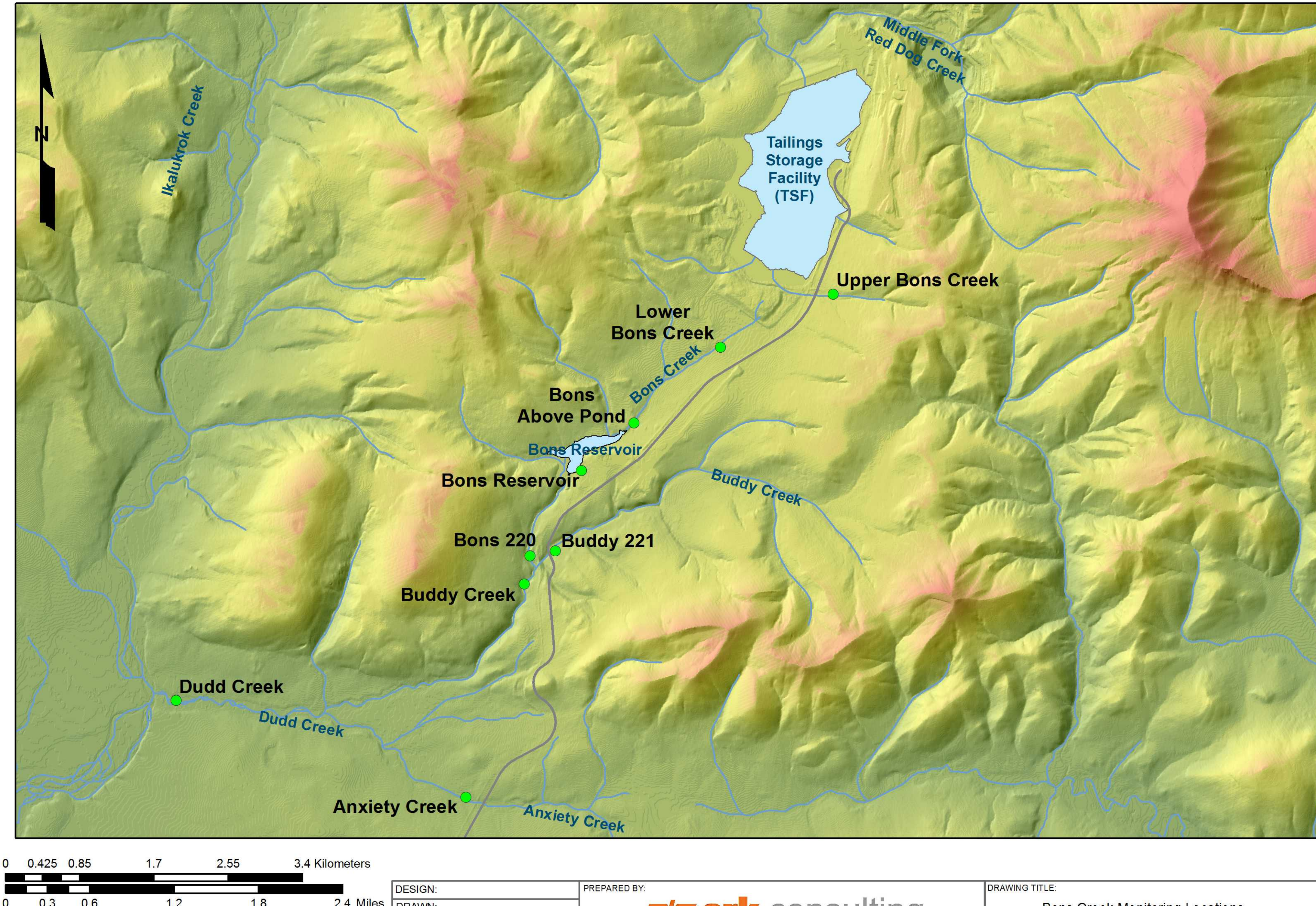
Tissue sampling of juvenile Dolly Varden in Anxiety Ridge Creek has been conducted since 1993, and continued nearly annually since 1998[33]. Tissue sampling of juvenile Dolly Varden in Buddy Creek was initiated in 2002.

[3] William Morris, ADF&G. Red Dog Biomonitoring (personal communication August 5, 2014).

Locations included in the Bons Creek biomonitoring program are shown in Figure 2 and Figure 3 and listed in Table 3. Table 3 also includes a description of the locations and the type of monitoring conducted at each location. Water quality parameters are discussed in Section 2.1.2.



DESIGN:	PREPARED BY: srk consulting	DRAWING TITLE: Water Quality and Biomonitoring Locations	
DRAWN:			
REVIEWED: ST			
APPROVED:	PROJECT: **RED DOG MINE MONITORING PLAN**	DATE: 08/04/2014 REVISION:	DRAWING NO: Figure 2
		SRK PROJECT NO: 329100.030	



Red Dog Mine

DESIGN:	PREPARED BY: srk consulting	DRAWING TITLE: Bons Creek Monitoring Locations	
DRAWN:			
REVIEWED: ST			
APPROVED:	PROJECT: **RED DOG MINE MONITORING PLAN**	DATE: 08/04/2014 REVISION:	DRAWING NO: Figure 3
		SRK PROJECT NO: 329100.030	

Table 2: Water Quality Profiles

Monitoring Profile	Parameters
Profile I Ambient surface water quality monitored as part of the Biomonitoring Program	Aluminum[1] Calcium[1] Cadmium[1] Chloride[1] Iron[1] Potassium[1] Magnesium[1] Sodium[1] Lead[1] Selenium[1] Zinc[1] Alkalinity Total Dissolved Solids (TDS) Total Suspended Solids (TSS) Sulfate (SO_4) pH Temperature Conductivity
Profile II Water quality monitored as part of the Mine Water Management Program	Aluminum[2] Calcium[2] Cadmium[2] Copper[2] Chloride[2] Iron[2] Potassium[2] Magnesium[2] Manganese[2] Sodium2 Lead[2] Zinc[2] Ammonia Nitrogen (NH_3-N) Acidity Total Dissolved Solids (TDS) Sulfate (SO_4) pH Temperature Conductivity

Notes: 1. Total recoverable metals
2. Dissolved metals

Table 3: Monitoring Locations in the Bons Creek Drainage

Location	Location Description	Sampling Frequency[1]	Parameters
Buddy Creek	Below falls	1/year	Periphyton[2]
		1/year	Aquatic invertebrates[3]
		1/year	Fish presence and use
		2/month	Water Quality Profile I
		1/year	Juvenile Dolly Varden metals in tissue[4]
Buddy 221	Buddy Creek, above road	1/year	Periphyton[2]
		1/year	Aquatic invertebrates[3]
		2/month	Water Quality Profile I
Bons 220	Bons Creek, below pond[5]	1/year	Periphyton[2]
		1/year	Aquatic invertebrates[3]
		2/month	Water Quality Profile I
Bons Above Pond	Above pond[5]	1/year	Periphyton[2]
		1/year	Aquatic invertebrates[3]
Anxiety Creek[6]	Below DMTS road	1/year	Fish presence and use
		1/year	Juvenile Dolly Varden metals in tissue[4]
Evaingiknuk Creek[6]	East of DMTS road	1/year	Fish presence and use
Lower Bons Creek	Below Overburden Dump Collection System	2/month	Water Quality Profile I
Upper Bons Creek	Above haul road	2/month	Water Quality Profile I
Bons Reservoir	Above reservoir spillway	2/month	Water Quality Profile I
		1/year	Juvenile Arctic grayling metals in tissue[6]
		1/year	Arctic grayling population estimate
Dudd Creek[6]	Above mouth	2/month	Water Quality Profile I

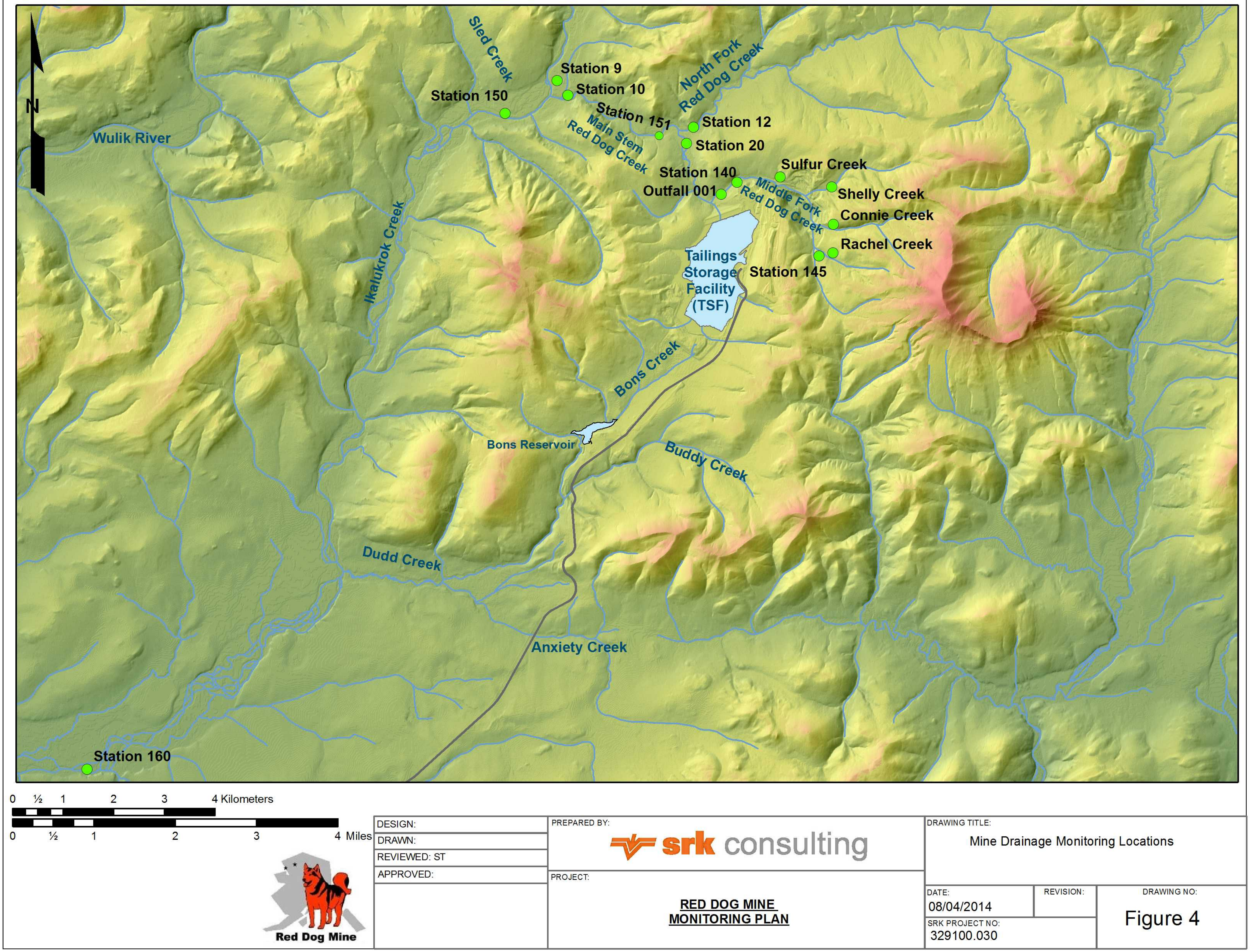
Notes:

1. Sampling conducted when flow is present.
2. Periphyton as Chlorophyll-a concentrations, in July.
3. Aquatic invertebrates monitored for taxonomic richness, abundance, and density, in July.
4. Metals analyzed in fish tissue: Zn, Pb, Se, Hg, and Cd.
5. The “pond” is the fresh water reservoir, referred to as Bons Pond, in the Bons Creek drainage.
6 Monitoring location is outside the jurisdiction of the waste management permit boundary

2.1.4 Mine Drainage Monitoring Program

Biomonitoring has been carried out in Red Dog Creek since 1990 with fish tissue sampling. Invertebrate and periphyton sampling was added in 1996. The program is designed to monitor and evaluate changes that may occur as a result of activities associated with wastewater discharge from the mine.

- Locations included in the Red Dog Creek biomonitoring program are shown in Figure 2 and Figure 4 and listed in Table 4. Table 4 also includes a description of the locations and the type of monitoring conducted at each location.
- Water quality profiles are discussed in Section 2.1.2.



DESIGN:	PREPARED BY: srk consulting	DRAWING TITLE: Mine Drainage Monitoring Locations	
DRAWN:			
REVIEWED: ST			
APPROVED:	PROJECT: RED DOG MINE MONITORING PLAN	DATE: 08/04/2014 REVISION:	DRAWING NO: Figure 4
		SRK PROJECT NO: 329100.030	

Table 4: Monitoring Locations and Parameters Monitored in the Mine Drainage Monitoring Program

Location	Location Description	Sampling Frequency[1]	Parameters
Wulik River[2]	Kivalina Lagoon upstream to about 6 miles upstream of the mouth of Ikalukrok Creek	1/year	Dolly Varden (fall aerial surveys)
Ikalukrok Creek[2]	Lower Ikalukrok Creek to mouth of Dudd Creek	1/year	Chum salmon (fall aerial adult surveys)
Station 151[5]	Downstream edge of mixing zone in Red Dog Creek		Water Quality Profile[8]
Station 140[5]	Middle Fork Red Dog Creek upstream of the influence of Outfall 001		Water Quality Profile[8]
Station 150[5]	Ikalukrok Creek below confluence with Red Dog Creek		Water Quality Profile[8]
		1/month	Water Quality Profile I
Station 145	Upper Middle Fork Red Dog Creek	1/month	Water Quality Profile I
Rachel Creek	Tributary to Red Dog Creek	1/month	Water Quality Profile I
Connie Creek	Tributary to Red Dog Creek	1/month	Water Quality Profile I
Shelly Creek	Tributary to Red Dog Creek	1/month	Water Quality Profile I
Sulfur Creek	Tributary to Red Dog Creek	1/month	Water Quality Profile I
Station 9[2]	Ikalukrok Creek upstream of confluence with Red Dog Creek	1/year	Periphyton[2]
		1/year	Aquatic invertebrates[3]
		1/year	Fish presence and use
		2/month	Water Quality Profile I
Station 160[2, 5]	Lower Ikalukrok Creek		Water Quality Profile[8]
		1/year	Periphyton[3]
		1/year	Aquatic invertebrates[4]
		1/year	Fish presence and use
Station 20	Middle Fork Red Dog Creek upstream of the confluence with North Fork Red Dog Creek	1/year	Periphyton[3]
		1/year	Aquatic invertebrates[4]
Station 10[2, 6]	Mouth of Red Dog Creek	1/year	Periphyton[3]
		1/year	Aquatic invertebrates[4]
		1/year	Fish presence and use
		1/year	Juvenile Dolly Varden metals in tissue[7]
Station 12[5]	North Fork Red Dog Creek		Water Quality Profile[8]
		1/year	Periphyton[3]
		1/year	Aquatic invertebrates[4]
		1/year	Fish presence and use
		1/year	Record of spawning activity
		Periodic	Capture/mark Arctic grayling

Notes: 1. Samples taken when flow is present.
2. Monitoring location is outside the jurisdiction of the waste management permit boundary, but has been included here for reference and program completeness.
3. Periphyton as Chlorophyll-a concentrations.
4. Aquatic invertebrates monitored for taxonomic richness, abundance, and density.
5. Ambient water quality is monitored at Stations 12, 140, 150, 151, and 160 under Red Dog Mine APDES permit #AK-003865-2.
6. Ambient water quality and stream gauge flow to support aquatic life monitoring for Station 10 is obtained from Station 151 under Red Dog Mine APDES permit #AK-003865-2.
7. Metals analyzed in fish tissue: Zn, Pb, Se, Hg, and Cd.
8. See Red Dog Mine APDES permit #AK-003865-2 for parameters.

2.2 Permafrost and Sub-permafrost Groundwater Monitoring

Groundwater monitoring is performed as part of the Groundwater Supplemental Environmental Project (SEP) for the Mine. Activities associated with the Groundwater SEP are outlined in Appendix B of the Consent Decree between Cominco Alaska Incorporated (now TAK) and the United States Environmental Protection Agency (EPA), entered on November 25, 1997 (U.S. v. Cominco Alaska Incorporated, Civil Action A97-267CV).

Results of Phase I and II of the SEP were used to develop a detailed understanding of permafrost and groundwater conditions in the vicinity of the TSF, and were the basis for the development of the *Long-Term Permafrost and Groundwater Monitoring Plan for the Tailing Impoundment* (WMCI 2001a), approved by EPA on January 11, 2002. The WMCI (2001) Plan was implemented under Phase III of the SEP and serves as the foundation of the monitoring program outlined here. Results from the first five years of monitoring were reported by Geomatrix (2007). The results included recommendations for minor refinements to the program. No changes to the monitoring program were made based on the second five year analysis (AMEC 2012).

2.2.1 Key Elements of the Monitoring Program

Key Elements of the Permafrost and Sub-permafrost Groundwater Monitoring Program include:

- Quarterly monitoring of background and dam area thermistors to assess trends in temperature changes in the permafrost
- Quarterly monitoring of background and dam area piezometers to assess water levels and gradients
- An annual data report
- A detailed assessment of subsurface trends and conditions every five years, including an evaluation of the requirement to update the thermal and numerical flow model developed as part of the SEP

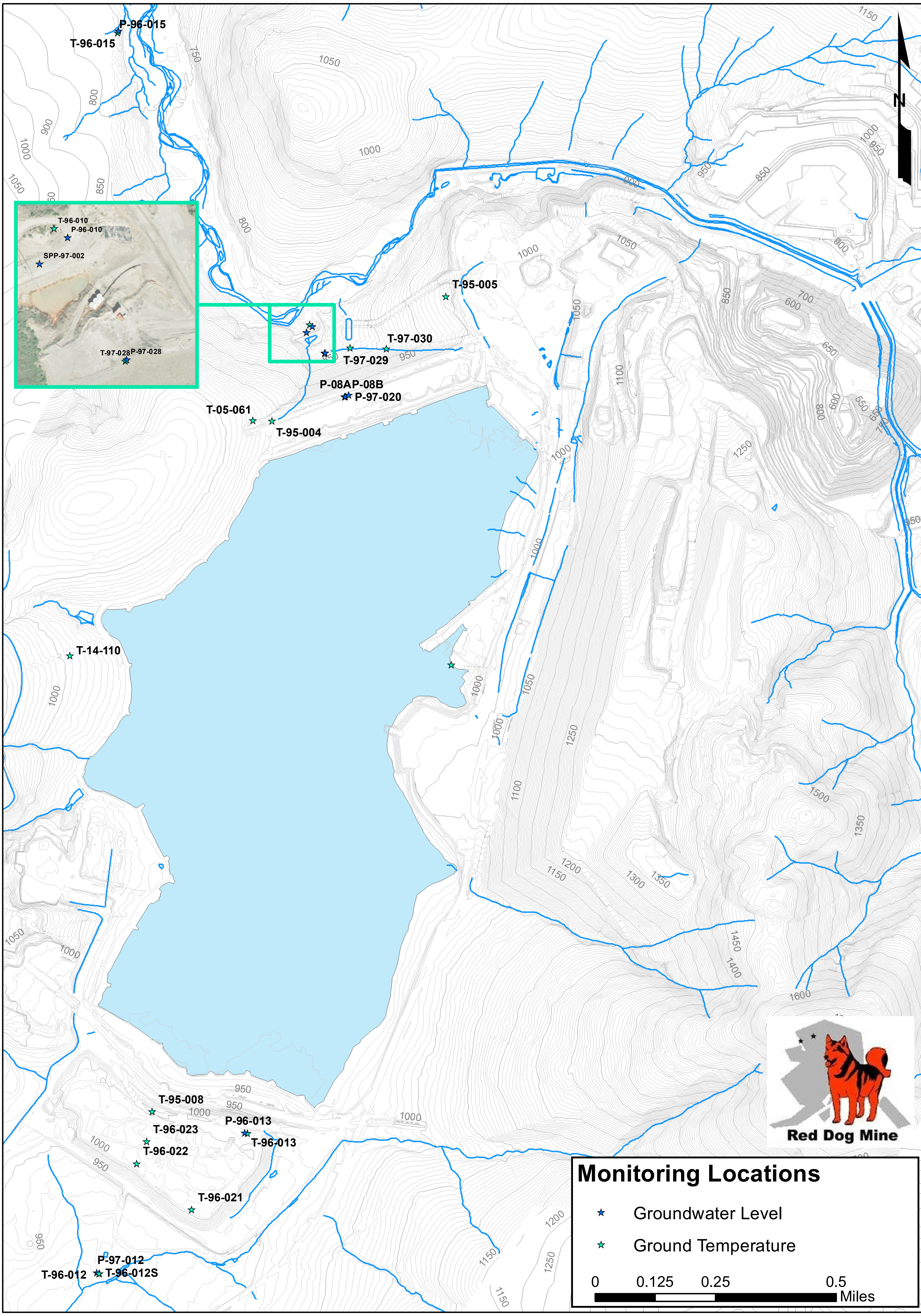
Groundwater monitoring shall continue for thirty years after the cessation of mining and/or milling operations unless it can be shown that with at least ten years of data from the monitoring program and other relevant data that there is no reasonable potential that waters from the TSF are being, or could be, discharged into groundwater connected with waters of the United States, other than as allowed by permit.

2.2.2 Permafrost and Subsurface Temperature Monitoring

Thermal modeling of the tailings impoundment performed during Phase II of the SEP indicated that the thermal impact of the TSF may affect the underlying permafrost. Long-term monitoring of subsurface temperatures is focused on collecting data sufficient to allow a continuing assessment of the subsurface thermal regime. Locations used to monitor long-term permafrost and subsurface temperatures are shown on Figure 5 and listed in Table 5.

2.2.3 Sub-permafrost Groundwater Level Monitoring

Data and analyses developed as part of the SEP demonstrated with relative certainty that virtually all shallow flow originating from the TSF is collected within the dam seepage collection system, and that no vertical flow is occurring between the impoundment and the sub-permafrost system. Because the SEP analysis did not indicate that any seepage pathways existed from the TSF, groundwater monitoring is not based on seepage pathways, but rather on assessing any changes over time from observed conditions. The focus of the groundwater monitoring system is therefore based on monitoring water level changes over time as a means to assess potential changes from baseline conditions. Monitoring locations used to measure groundwater levels are shown in Figure 5 and listed in Table 6.



DESIGN:	PREPARED BY: srk consulting	DRAWING TITLE: PERMAFROST AND SUB-PERMAFROST MONITORING LOCATIONS	
DRAWN:			
REVIEWED: DN			
APPROVED:	PROJECT: **RED DOG MINE MONITORING PLAN**	DATE: 03/29/2016	REVISION:
		SRK PROJECT NO: 329100.030	DRAWING NO: Figure 5

Table 5: Summary of Ground Temperature Monitoring

Thermistor	Data Objective	Sampling Frequency
Red Dog Creek		
T-96-015	Monitors background permafrost temperatures down-gradient of dam within Red Dog Creek alluvium	1/quarter
Dam Area		
T-05-061	T-05-061 will be monitored concurrently with T-95-004 until instrumentation or site access inhibits the use of T-95-004. At such time T-05-061 will become the primary thermistor for monitoring permafrost conditions in the vicinity of the west abutment of the dam.	1/quarter
T-95-005	Monitors background permafrost temperatures in dam area	1/quarter
T-96-010	Monitors permafrost temperatures in seepage dam area	1/quarter
T-97-028	Monitors subsurface temperatures within zone where permafrost is absent	1/quarter
T-97-029	Monitors permafrost temperatures along toe of dam	1/quarter
T-97-030	Monitors subsurface temperatures within zone where permafrost is absent	1/quarter
Tailings Storage Facility		
T-14-110	T-14-110 replaced T-95-009. T-95-009 was inundated by rising pond water.	1/quarter
Overburden Dump		
T-95-008	Monitors subsurface temperatures within Overburden Dump	1/quarter
T-96-013	Monitors subsurface temperatures within Overburden Dump	1/quarter
T-96-021	Monitors subsurface temperatures within Overburden Dump	1/quarter
T-96-022	Monitors subsurface temperatures within Overburden Dump	1/quarter
T-96-023	Monitors subsurface temperatures within Overburden Dump	1/quarter
Bons Creek		
T-96-012	Monitors background permafrost temperatures along Bons Creek	1/quarter
T-96-012S	Monitors shallow subsurface temperatures along Bons Creek	1/quarter

Table 6: Summary of Groundwater Level Monitoring

Piezometer	Data Objective	Sampling Frequency
Red Dog Creek		
P-96-015	Monitors sub-permafrost water levels along Red Dog Creek	1/quarter
Dam Area		
P-08A	Monitors shallow water levels within dam drain area	1/quarter
P-08B	Monitors shallow water levels within dam drain area	1/quarter
P-96-010	Monitors sub-permafrost groundwater within dam area	1/quarter
P-97-020	Monitors groundwater in area where permafrost is absent	1/quarter
P-97-028	Monitors shallow water levels down-gradient of dam toe	1/quarter
SPP-97-002	Monitors shallow water levels in seepage dam area	1/quarter
Overburden Dump		
P-96-013	Monitors sub-permafrost water levels in Overburden Dump area	1/quarter
Bons Creek		
P-97-012	Monitors sub-permafrost water levels along Bons Creek	1/quarter

2.3 Mine Water Management

Mining-impacted water throughout the mine site is collected from waste dumps, the pit, and seepage collection systems and stored in the TSF. Water from the TSF is reclaimed and either used in the milling process, or treated in Water Treatment Plant 1 (WTP1) or Water Treatment Plant 2 (WTP2) and subsequently discharged to Red Dog Creek at Outfall 001.

A number of diversion ditches have been constructed at the mine site to divert water that has not been affected by mining activities. The Red Dog Creek Diversion is located east of the MWD and is the largest onsite diversion ditch. It diverts water through mining areas and back into Red Dog Creek. Water from Shelly Creek and Connie Creek are diverted into the Red Dog Creek Diversion. A fish weir is located 1.3 miles downstream of where the Red Dog Creek Diversion returns water to the original Red Dog Creek channel and is designed to prevent fish passage.

Contact water east of the MWD is collected in the Main Pit, Aqqaluk Pit, and the Mine Drainage Collection System. Water from the Aqqaluk Pit is pumped to the Main Pit. Excess water from the

Main Pit (Main Pit Dump) will be pumped to the Mine Drainage Collection System or directly to the TSF once the water level in the pit reaches the appropriate level as specified in the *Red Dog Mine Waste Rock Management Plan* (SRK 2016c). Water in the Mine Drainage Collection System flows to the Mine Sump and is then pumped to the TSF. Depending on season and capacity, a portion of this water may be pre-treated in WTP1 or WTP3.

Water flowing to the west from the MWD is partially collected in the MWD Collection System, pre-treated in WTP1 or WTP3, and eventually pumped to the TSF.

Water within the TSF catchment, that is not diverted, drains into the TSF. A pump-back system collects runoff from the south side of the Overburden Dump and pumps it to the TSF. Mine water inputs to the TSF include:

- tailings
- water treatment sludge
- treated water from WTP3

Outflows from TSF include:

- seepage, which is pumped back to the TSF
- water that is treated and discharged at Outfall 001

Freshwater used for potable water, reagent mixing, cooling and other purposes is obtained from the Bons Creek Reservoir, located within the Bons Creek drainage.

TAK maintains a large number of flow and water quality sampling sites throughout the mine site to effectively monitor and manage water. In addition, water and load balances have been created and are maintained to model flows and chemical loads throughout the mine site. Monitoring conducted under the Mine Water Management Program is described below.

2.3.1 Key Elements of the Monitoring Program

Key elements of the Mine Water Management Program consist of the following:

- Flow monitoring at locations throughout the mine site
- Monitoring of water quality at locations throughout the mine site
- Water and load balances to model flows and associated chemical loadings
- Weekly visual monitoring of water management facilities
- Inspections of fish weir twice per year by a qualified professional

Details of the monitoring program are provided in the following sections.

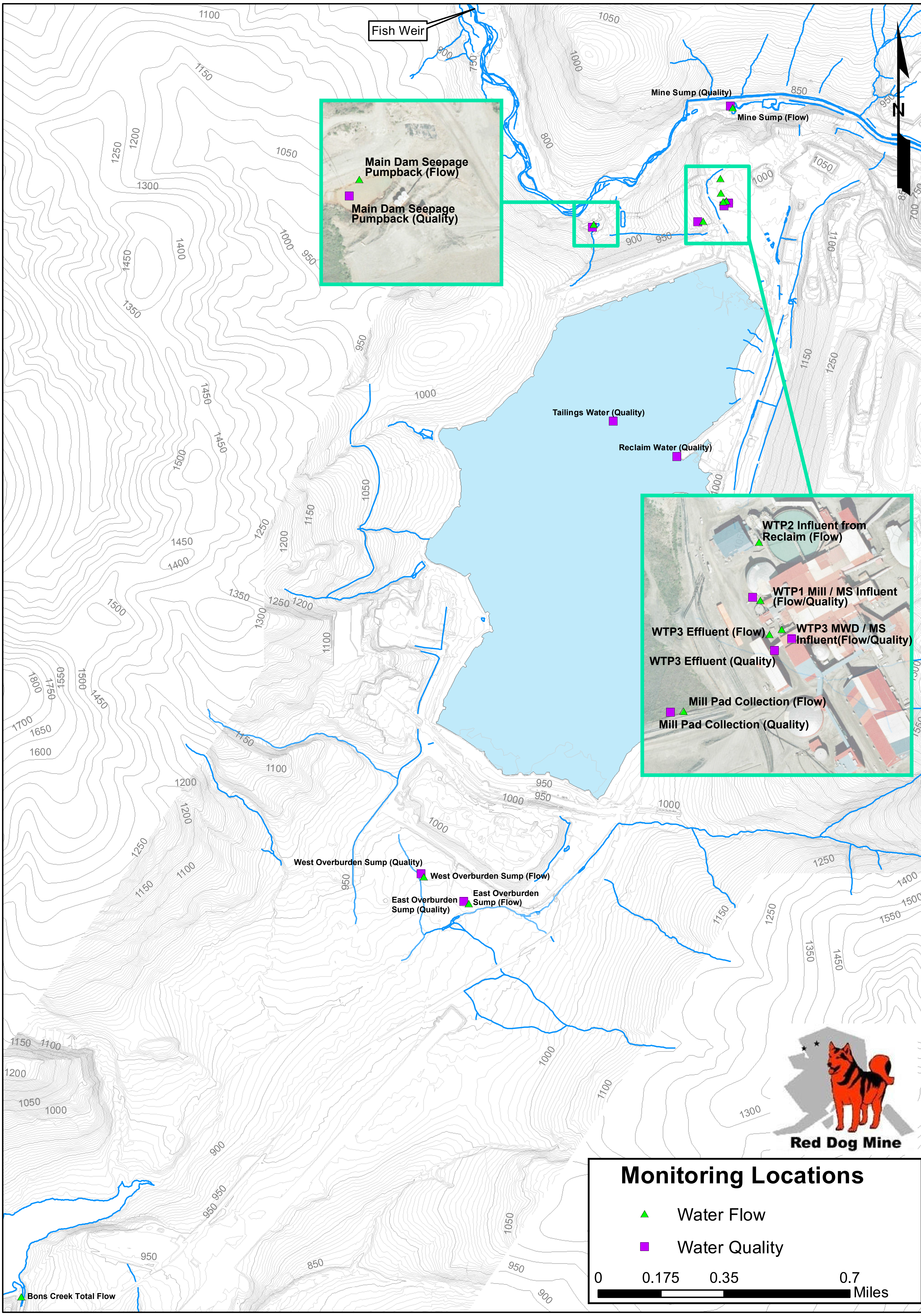
2.3.2 Flow and Water Quality Monitoring

Red Dog Operations currently maintains a number of flow meters that record volumes of each of the main flows in and out of the TSF. Water quality associated with flows into and out of the TSF is also monitored. This information is used in the water and load balances.

Locations monitored and the period and frequency of monitoring are shown in Figure 6 and summarized in Table 7. Water quality parameters and profiles are discussed in Section 2.1.2. Inputs and outputs of the Water Treatment Plants vary with the needs of the operation and will be sampled based upon water treatment plant utilization

2.3.3 Water and Load Balances

A water and load balance model for the site is maintained by TAK. A summary of key results will be presented in the annual reports.



DESIGN:	PREPARED BY: srk consulting	DRAWING TITLE: MINE WATER MONITORING LOCATIONS
DRAWN:		
REVIEWED: DN		
APPROVED:	PROJECT: **RED DOG MINE MONITORING PLAN**	DATE: 03/29/2016
		REVISION:
		SRK PROJECT NO: 329100.030
		DRAWING NO: Figure 6

Table 7: Mine Water Monitoring Stations

Location	Description	Sampling Frequency[1]	Parameters	Measured Quantity[1]
Main Dam Seepage Pumpback	Main (tailings) Dam seepage water to TSF	1/month	Water Quality Profile II	Total Monthly Gallons
Bons Creek Total Flow	Total withdrawal from Bons Creek reservoir	Water quality not required (flow used in Mill water balance)		Total Monthly Gallons
East Overburden Sump	Runoff from Overburden Dump	1/month	Water Quality Profile II	Total Monthly Gallons
West Overburden Sump	Runoff from Overburden Dump	1/month	Water Quality Profile II	Total Monthly Gallons
Tailings Water	Tailings supernatant discharged to the TSF	1/month	Water Quality Profile II	Calculated[2]
Reclaim Water	TSF water	1/month	Water Quality Profile II	N/A[3]
WTP1/Mill Influent from Reclaim[4]	Reclaim water from TSF to WTP1	Water quality equivalent to Reclaim Water location		Total Monthly Gallons
WTP1 Influent from Mine Sump	WTP1 influent from the Mine Water Drainage Collection System	Water quality equivalent to Mine Sump location		Total Monthly Gallons
WTP2 Influent from Reclaim	Reclaim water from TSF to WTP2	Water quality equivalent to Reclaim Water location		Total Monthly Gallons
WTP3 Influent from MWD Collection System	Influent to WTP3 from the Main Waste Dump	1/month	Water Quality Profile II	Total Monthly Gallons
WTP3 Influent from Mine Sump	Influent to WTP3 from the Mine Drainage Collection System	Water quality equivalent to Mine Sump location		Total Monthly Gallons
WTP3 Effluent	Treated effluent from WTP3	1/month	Water Quality Profile II	Calculated[5]
Mine Sump	Water from the Mine Drainage Collection System	1/month	Water Quality Profile II	Total Monthly Gallons
Mill Pad Collection	Runoff from the Mill Pad	1/month	Water Quality Profile II	Total Monthly Gallons

Notes:
1. Sample taken when flow is present.
2. Tailings water volumes calculated from Mill water balance.
3. Reclaim water volumes are accounted for under WTP1 Influent from Reclaim and WTP2 Influent from Reclaim.
4. Reclaim water may or may not be treated in WTP1 prior to use in the Mill.
5. WTP3 Effluent = WTP3 Influent from Mine Water Collection + WTP3 Influent from Main Waste Dump.
6. In addition to Water Quality Profile II, samples from this location will also be analyzed for WAD cyanide.

2.3.4 Visual Monitoring

Visual monitoring of the following mine water management facilities will be conducted weekly when flow is present:

- Diversion ditches
- Red Dog Creek Diversion
- Mine Drainage Collection System
- Pipelines and pipeline containment structures
- Main Waste Dump Collection System
- Treated water discharge lines
- Overburden Dump Collection System

The fish weir will be inspected twice per year by a qualified individual.

2.4 Waste Rock Management

Waste rock from the Aqqaluk Pit is expected to be placed in the MPD. When the Qanaiyaq Pit is mined, waste rock from the first phase is expected to be placed in the MPD and waste rock from the second phase is intended to be placed in the completed first phase of the Qanaiyaq Pit. Waste rock from Aqqaluk Pit may be placed in the second phase of the Qanaiyaq Pit. The MWD is currently not active and has been recontoured (SRK 2016c).

2.4.1 Key Elements of Monitoring Program

Key elements of the Waste Rock Management program consist of the following:

- Monitoring of quantities and locations of waste rock placement
- Geological and geochemical monitoring of waste rock to ensure proper segregation of materials

- Weekly visual monitoring of facilities

Details of the monitoring program are provided in the following sections.

2.4.2 Quantity of Waste Rock

Waste rock production quantities are monitored daily using reported tonnes hauled from a blasted pit shot. Locations of waste rock placement and quantities of waste rock placed at each location are recorded and will be reported quarterly to ADEC.

2.4.3 Geochemical Monitoring

The *Waste Rock Management Plan* outlines criteria and methods for segregating waste rock from the mined areas. Waste rock is segregated into the following categories:

- Rock with low metal leaching and acid rock drainage (ML/ARD) potential suitable for tailings dam construction
- Rock with low ML/ARD potential suitable for cover material
- Rock with a high sulfide content that is potentially self-heating
- Rock that does not fit any of these other classifications

Table 8 summarizes the current waste rock segregation criteria.

Table 8: Current Segregation Criteria

Intended Use/Disposal Location	Allowable Rock Types	Criteria*
Dam Construction	Siksikpuk Shale	Single blast hole assays not to exceed: 1% Zn, 1% Pb, 3.5% Fe Average blast hole assays not to exceed: 0.5% Zn, 0.5% Pb, 2.5% Fe
Cover Material	Kivalina and Kayak Shale of the Key Creek Plate	Material must be from Key Creek structural plate. More than 90% of the material must be comprised of Kivalina and/or Kayak shale, based on visual estimation Must not contain greater than 10% visual percent sulfide over an area of more than 500 m^2. No more than 5 adjacent blast-holes to exceed 0.25% zinc.
High S Waste Rock (placed below the ultimate water level in the Main Pit Dump where possible, or blended to reduce the self-heating capacity)	Typically Ikalukrok	Self-Heating Capacity Risk Region 5 or greater**
Other Waste Rock – placed in Main Pit or Qanaiyaq pit dumps. To maximize space available for underwater disposal of the high S waste, it is preferable to place this material in locations that are above the ultimate water level in the Main Pit Dump	Waste Rock not meeting other criteria	

Notes: *Analytical criteria are only to be applied to the allowable rock type (*i.e*. rock type has precedence).
**Calculated as follows:

Self-Heating Capacity Risk Region = 3.41744 + (%Pb-%sPb) / 0.866 x (-0.33539 + 0.03897 x %Zn / 0.671) - 0.81502 x Log ([%Ba / 0.5886] / [%Fe / 0.4654]).

This equation is based on an empirical relationship between heating capacity (in Joules/gram) and mineralogical data (Nesseteck 2009), and will be modified and refined as more data is gathered by Teck.

Waste rock is segregated by rock type by a geologist and assay of blast hole cuttings. Further detail can be found in the *Red Dog Mine Waste Rock Management Plan* (SRK 2016c).

2.4.4 Visual Monitoring

Visual monitoring of un-reclaimed waste rock dumps will be conducted weekly for the following conditions:

- Damage or potential damage to the waste rock dumps from settlement, ponding, thermal instability, frost action, or erosion

- Escape of waste rock or any unauthorized waste rock disposal
- Damage to the structural integrity of diversion structures or drainage capture systems
- Evidence of death or stress to fish, wildlife, or vegetation that might be caused by the waste rock dumps
- Confirmation that geological properties of the rock are appropriate for the designated storage location or end use
- Waste rock fires or "hot spots"

2.5 Tailings Management

The *Red Dog Mine Tailings and TSF Water Management Plan* (SRK 2016d) describes procedures for management of tailings at the Mine. Disposal of tailings is in the TSF located in the South Fork of Red Dog Creek. TSF monitoring is stipulated in the IWMP.

2.5.1 Key Elements of the Monitoring Program

Key elements of the Tailings Monitoring program include:

- Calculation of quantity of tailings produced and placed
- Geochemical monitoring of final tailings stream
- Weekly visual monitoring of the facility

Additional TSF monitoring includes water quantity and quality monitoring (Mine Water Program Section 2.3.2).

2.5.2 Quantity of Tailings

Tailings production rates are estimated from mill production records, and summarized on a monthly basis.

2.5.3 Geochemical Monitoring

Monitoring of tailings solids will be conducted to determine variability in the geochemical composition of tailings solids over time. Tailings geochemistry is expected to be relatively uniform in comparison to waste rock, due to the methods used to stockpile and blend the ore. An inline analyzer calculates the percent iron, lead, and zinc in the final tailings slurry. Monthly average values of these analyses will be reported quarterly.

2.5.4 Visual Monitoring

Visual Monitoring of the TSF is specified in the Mine Water Management Program; refer to Section 2.3.4 of this Plan.

2.6 Inert Solid Waste Landfills

Currently, there is one active inert solid waste landfill at the Mine. The Main Waste Dump Landfill is located within the MWD (Figure 7). The landfill is operated as outlined in the Standard Operating Procedure (SOP) *Landfill, Main Waste Stockpile SOP* (Rev 5).

The former "Old Mine Landfills" were closed out in 2015 and are located within the TSF as depicted in Figure 8 - Red Dog Operations Former "Old Mine Landfill" Location Map.

2.6.1 Key Elements of Monitoring Program

Key elements of the solid waste landfill monitoring program include:

- Calculation of volumes of solid waste placed
- Monthly visual inspections and random inspections of incoming loads
- Submission of updated site development and use plans annually
- Document exact location of landfill trenches and closed trenches

Details of the monitoring program are provided below.

2.6.2 Quantity of Solid Waste

Estimates of disposal volumes based on fill volume will be conducted and summarized in the Annual Report.

2.6.3 Visual monitoring

Visual monitoring of the landfill includes the following which will be summarized and reported quarterly:

- Monthly visual inspections consistent with the SOPs
- Inspections for evidence of fire or combustion in the waste
- Random inspections of incoming loads consistent with the current landfill permit
- Inspections for evidence of death or stress to wildlife or vegetation that might be related to the landfill

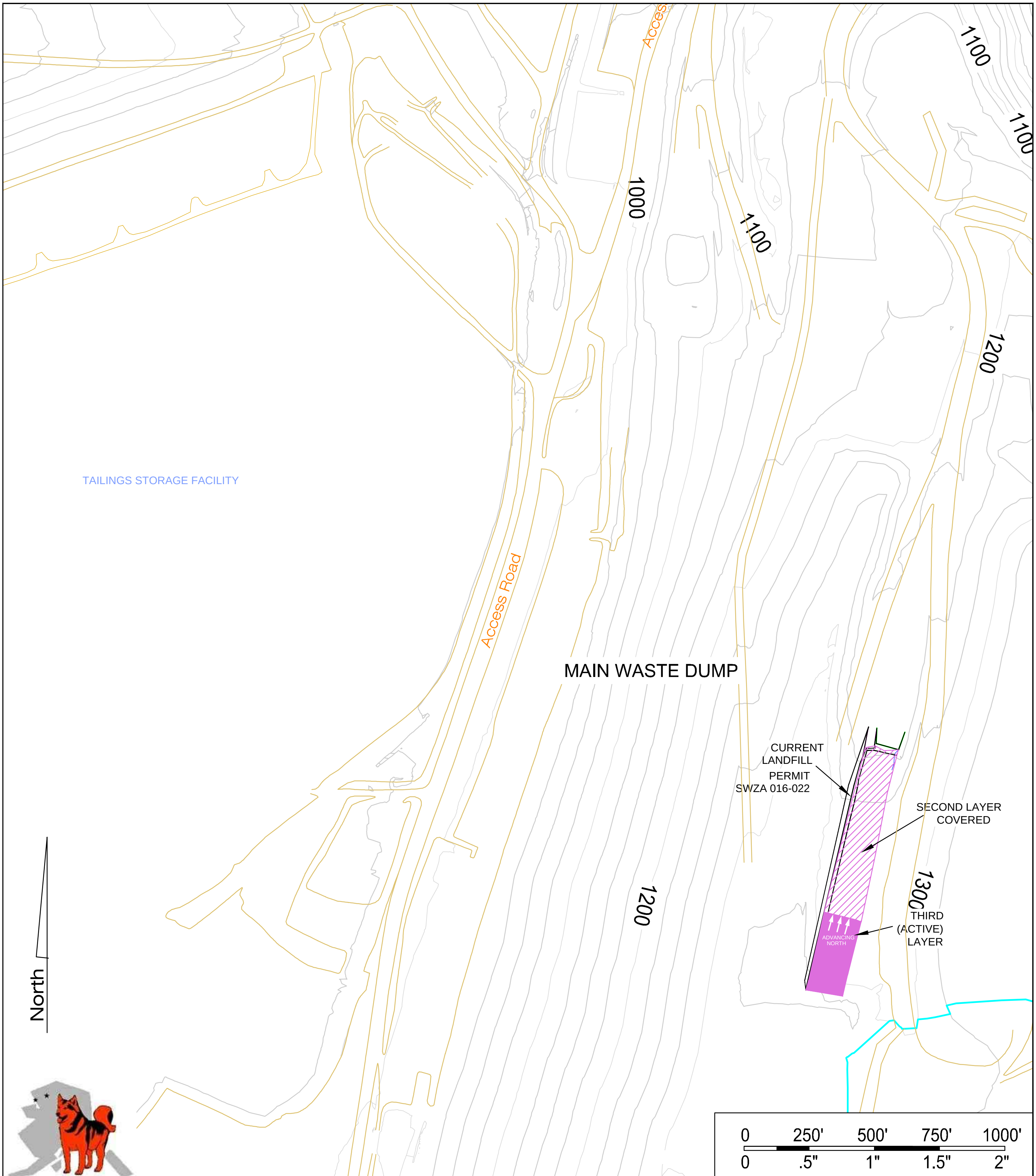
2.7 Mining and Milling Activities

Quantities of ore removed and processed, and waste rock and tailings generated are tracked in mine production and milling records, and summarized on a monthly basis. Quantities will be reported quarterly to ADEC.

2.8 Reclamation Monitoring Program

Two key mine closure methods proposed in the *Red Dog Mine Reclamation and Closure Plan* (SRK 2016a) have been and continue to be tested on site under various programs. These include covers to be placed on various mine waste materials, and revegetation of covered materials and other disturbed land. Concurrent reclamation of some parts of the site will be possible while the mine is still in production, which will include both cover placement and revegetation.

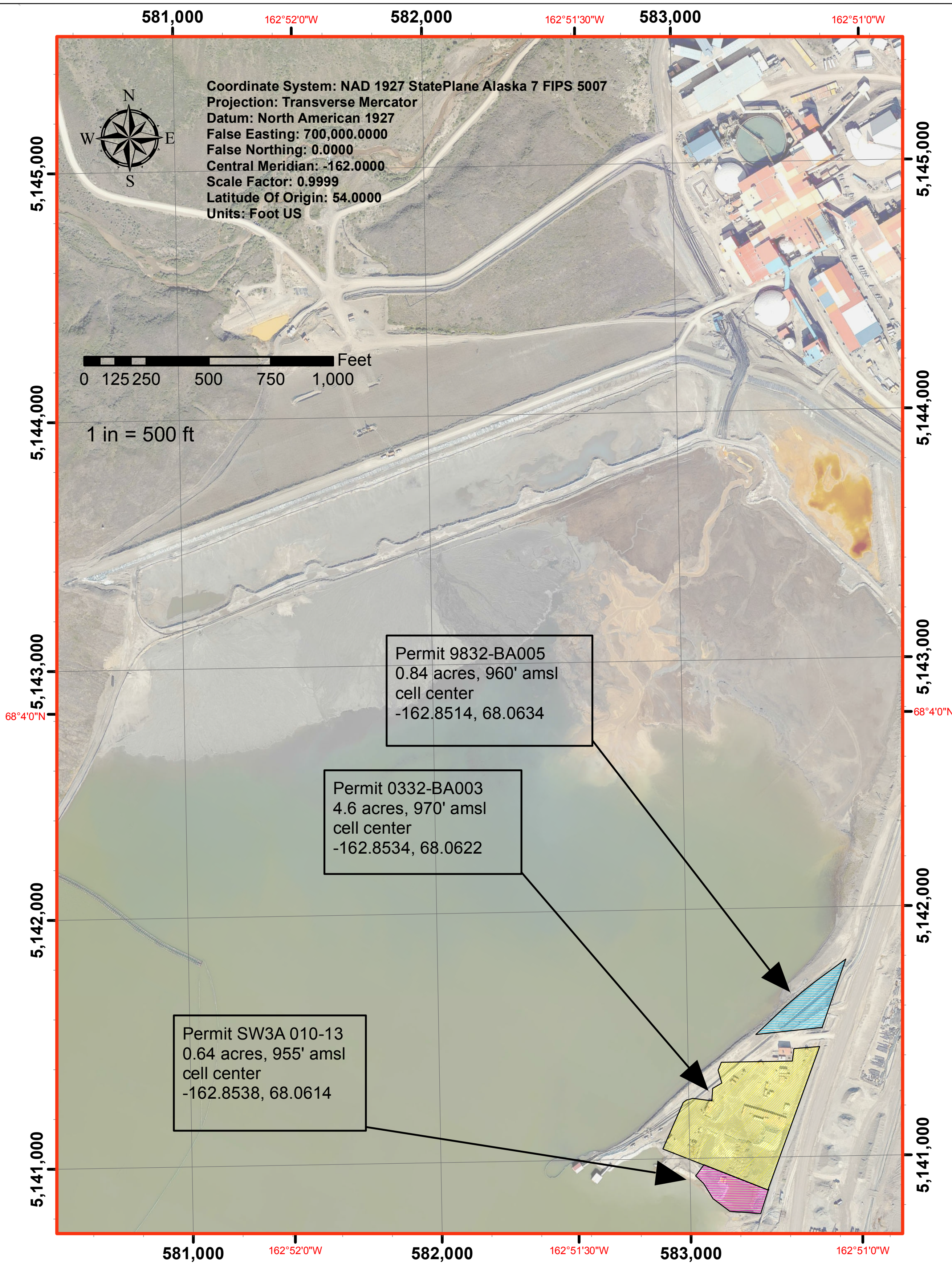
A summary schedule that includes anticipated dates for concurrent reclamation and tailings and water management activities is provided in the *Red Dog Mine Reclamation and Closure Plan* (SRK 2016a). In many cases, the precise scheduling of activities will depend on factors that are not fully predictable. The following sections describe monitoring planned for concurrent reclamation projects.



TOPOGRAPHY AND LAYOUT BASED ON INFORMATION PROVIDED BY RED DOG, 2014.

DESIGN: SDT DRAWN: TRP REVIEWED: SDT APPROVED:	PREPARED BY: srk consulting	FIGURE TITLE: INERT SOLID WASTE LANDFILL
IF THE ABOVE BAR DOES NOT MEASURE 1 INCH, THE DRAWING SCALE IS ALTERED	PROJECT: **RED DOG MINE MONITORING PLAN**	DATE: MARCH 2016 REVISION: SRK PROJECT NO.: 329100.030 FIGURE NO.: FIGURE 7

P:\Teck Alaska - Red_Dog\329100.030 IWMP\329100.030 IWMP\040_AutoCAD_GIS\Rec Plan Figures\Agency Draft Rev 2 -Figures SRK\2238-F7 (MP).dwg



DESIGN:	PREPARED BY: srk consulting	DRAWING TITLE: OLD MINE LANDFILL CLOSURE		
DRAWN:				
REVIEWED: BJ				
APPROVED:	PROJECT: **RED DOG MINE MONITORING PLAN**	DATE: MARCH 2016	REVISION:	DRAWING NO.: FIGURE 8
		SRK PROJECT NO.: 329100.030		

2.8.1 Key Elements of Monitoring Program

Key elements of the Reclamation Monitoring program include:

- Reporting of areas disturbed and reclaimed
- Research of reclamation methods
- Monitoring of reclamation activities

2.8.2 Areas Disturbed and Reclaimed

The size and locations of areas disturbed and reclaimed are recorded and will be summarized annually. Areas projected for disturbance or reclamation during the next calendar year will be reported annually. Each Annual Report will include a discussion of reclamation actions in sufficient detail, describing reclamation at each location and how it was accomplished.

Reclamation research will continue throughout the life of the operation. Examples may include: Oxide Dump cover instrumentation, seed mixes, transplanting, innovative fertilizers, native species establishment, and native seed collection and propagation. Information on reclamation research conducted during the year and reclamation research planned for the upcoming calendar year will be summarized and reported annually. Any reclamation research data or reports generated will be provided upon request.

2.8.3 Monitoring Approach

The following describes the general approach to monitoring existing revegetation sites and future revegetation undertaken on concurrent reclamation projects.

The success of reclaimed and revegetated areas will be evaluated by measuring parameters that are indicators of overall productivity and habitat quality. The measurements are intended to identify which species are most effectively established in disturbed areas; what factors may be contributing to enhanced or marginal growth; and what kind of recovery can be expected on the various mine disturbances over the long term. This information is needed so that corrective action can be taken in those areas where performance is poor, and to develop performance criteria that can be used to assess the success of revegetation efforts in meeting mine closure objectives.

Soil Properties

To assess the physical and chemical characteristics of reclaimed soils, samples will be collected from 1 to 4 inches in depth for analysis. Parameters measured will include particle size; percent organic matter; carbon and sulfur content; electrical conductivity (EC); cation exchange capacity (CEC); total and exchangeable nitrogen and phosphorous; and exchangeable potassium, sodium, calcium, and magnesium. Levels of micronutrients such as copper, zinc, iron, and manganese will also be measured.

Plant Survival and Density

Plant survival and density will be measured only for transplanted species to assess percent germination and survival in test plots. Density will be measured in one square-meter (m^2) plots, or within belt transects, depending on the size of the assessment area.

Plant Cover and Taxonomic Richness

For most areas, plant cover will be measured along transects using the point-intercept method, plant species are recorded intersecting points at 0.5–1.0 meter (m) intervals delineated along a 50 m or 100 m transect (100 points per transect). The length of each transect will depend on the size of the assessment area.

In some instances, cover may be measured using a point frame. This method is similar to the point intercept method except that sample points are measured within a quadrat (usually 1 m^2) rather than along a transect.

Plant Vigor

Plant vigor is subjectively ranked from 1–9, using the following criteria: plant tissue color, height, flower and/or seed production, and overall health. This ranking system may also be used for assessing the vigor of species in revegetated areas.

Schedule

Soil characteristics will be measured during the first year of seeding (or transplanting), as required depending on the vegetation response following treatment. Soil development occurs very slowly in an Arctic environment due to the low temperatures and short growing season. Thus, monitoring soil characteristics more frequently is unlikely to reveal any measurable differences.

The frequency of evaluating vegetation response will depend on objectives of the revegetation effort. For test plots, assessments would likely be conducted annually for the first three years documenting germination, survival and vigor, and vegetation cover. For mine development units, vegetation will be measured for the first two growing seasons following treatment, with additional monitoring occurring on the same schedule as described for the soils analysis. In some cases (e.g., experimental studies), more frequent monitoring may be required to satisfy specific research objectives. Monitoring will no longer be conducted after an area fulfills the performance standards developed for that unit.

2.9 Dust Monitoring

Recognizing that similar efforts to manage dust concerns were underway within a variety of programs, a decision was made to include the mine site within the scope of the area-wide *Fugitive Dust Risk Management Plan* (RMP). Therefore, any monitoring identified in the *Fugitive Dust Risk Management Monitoring Plan* and associated implementation plans, within the physical boundaries of the IWMP, is incorporated by reference into this Plan.

2.10 Wildlife Monitoring

TAK has procedures in place for reporting wildlife interactions, issuing wildlife alerts and controlling potential animal attractants. Monitoring of wildlife is conducted as part of the weekly visual monitoring of facilities. Wildlife casualties will be reported the appropriate state and federal agencies, and the Red Dog Subsistence Committee (if applicable).

3 Closure Monitoring

The period of intensive mine closure activity, after all mining and processing has ceased, is expected to last approximately two years. The *Red Dog Mine Reclamation and Closure Plan* (SRK 2016a), indicates that the closure phase is likely to occur in approximately 2031. Concurrent reclamation of some disturbed land can be undertaken while production continues and this will be done wherever reclamation would not affected by planned or potential future operations.

Project-specific closure monitoring programs will be designed and implemented for each reclamation task. The discontinuation of mining and implementation of closure activities will bring about changes to the Plan, as follows:

- Some additional localized surface water monitoring for specific closure projects, such as sedimentation monitoring.
- Discontinuation of tailings and waste rock monitoring.
- Modifications to flow and water quality monitoring and water and load balances according to changes associated with closure[4].
- Implementation of performance monitoring programs for specific closure measures.

[4] Water and load balances will continue to be maintained after mining operations cease.

4 Post Closure Monitoring

The “post closure” phase of the project begins immediately after the period of intensive closure activities. The current plan is for post closure phase to start in 2033. This period has no definite endpoint, but can be considered in three general phases with respect to required monitoring: Phase 1: 0 to 5 years after closure; Phase 2: 5-30 years after closure; and Phase 3: more than 30 years after closure. It is anticipated that many aspects of the existing monitoring will continue, with the possible modifications provided below:

0 to 5 Years after Closure

- Reduction in monitoring of physical stability of dams where risk of failure is reduced following closure.
- Addition of water quality monitoring of pit water once pit is flooded.
- Reduction of visual monitoring of closed waste management facilities and elimination of monitoring of decommissioned structures.
- Closure performance monitoring, based on annual assessments.

5 to 30 Years after Closure

- Reduction of monitoring of permafrost and sub-permafrost groundwater monitoring program.
- Further reduction of visual monitoring of closed waste management facilities.
- Reduction in closure performance monitoring.

Beyond 30 Years after Closure

- Further reduction in monitoring of closed waste management facilities, closure performance monitoring and visual monitoring of closed facilities.

The long-term plan requires a permanent staff presence to operate water collection and treatment systems. Site staff would carry out most of the routine monitoring plus undertake frequent monitoring of access roads, fuel and chemical storage areas, power infrastructure, water pipes, channels and sumps, tailings dams and spillways. Engineered structures with significant failure consequences, such as the dams and some water management infrastructure, would be inspected by a qualified engineer, as required, for as long as they remain active and present any significant risk.

Reclamation performance monitoring would commence immediately after reclamation works have been completed. Basic performance objectives for planned reclamation works have been presented in the *Red Dog Mine Reclamation and Closure Plan* (SRK 2016a), with detailed performance standards not yet defined. As such, plans for reclamation performance monitoring cannot be made yet. As information on the success of closure methods becomes available from monitoring concurrent reclamation projects over the next ten plus years, the design of closure projects will be refined and monitoring requirements better understood. In particular, further details of closure and post closure monitoring need to be developed for the planned waste material covers (Oxide Dump, waste rock and tailings beaches) and revegetation of covers and other disturbances.

5 Quality Assurance/Quality Control Program

The Quality Assurance/Quality Control (QA/QC) program for activities conducted under the APDES permit and the IWMP is described in the *Red Dog Mine Quality Assurance Plan* (SRK 2016e) (QAP). Some programs have additional QA/QC requirements as described below for the various environmental monitoring activities described in this Plan. Most QA/QC plans may require updates as methods, methodologies, regulations, and guidance change. Therefore, documents referenced below are subject to periodic revision.

5.1 Water Quality Monitoring

This is the primary focus of the *Red Dog Quality Assurance Plan* (SRK 2016e).

5.2 Biomonitoring Program

QA/QC procedures for the bioassessment program are described in Methods for Aquatic Life Monitoring to Satisfy Requirements of 2010 NPDES Permit, Red Dog Mine Site (Rev 1) (Ott et al 2010).

5.3 Groundwater Monitoring SEP

QA/QC for the Groundwater Monitoring SEP is detailed in the *Long-Term Permafrost and Groundwater Monitoring Plan for the Tailings Impoundment*. The Plan includes calibration checks and duplicate measurements.

5.4 Geochemical Monitoring

The TAK internal laboratory (Assay Lab) performs geochemical analyses in-house according to the Assay Laboratory Quality Assurance SOP.

6 Reporting

Reporting required under the IWMP and *Reclamation and Closure Plan* approval will be submitted as combined reports. The frequency of reporting varies and includes quarterly reports and a comprehensive Annual Report after the fourth quarter of each year. The Annual Report will cover the period from January 1 through December 31. Quarterly reports will be submitted within 60 days following the end of each calendar quarter with the Annual Report sent by March 1st. Contents of reports are detailed in Table 9.

Table 9: Reporting Requirements

Item	Plan Section	Reporting Requirement	Quarterly	Annual	Five-Year
Water Quality and Biomonitoring Program	2.1	An annual report on the biomonitoring conducted during the previous year, as described in Table 3 and Table 4. Report to be included in the first quarter report.		X	
Mine Drainage Monitoring Program	2.1.4	A summary of results of the water quality monitoring identified in Table 3. The Annual Report will provide water quality data in a flexible electronic format and include graphs over time for all parameters.			
Five-Year Data Analysis Report	2.2.1	The long-term trends in subsurface temperatures and groundwater levels are assessed in relation to historical site conditions. The next five-year review is scheduled for 2017 and will cover the period from January 1, 2012 to December 31, 2016 and will be submitted in lieu of the 2016 annual report.			X
Permafrost and Subsurface Temperature Monitoring	2.2.2	The temperature measurements from the thermistors identified in Table 5, including a summary of instrumentation problems and significant temperatures anomalies.		X	
Permafrost and Subsurface Temperature Monitoring	2.2.2	The groundwater level measurements from the piezometers identified in Table 6, including a summary of instrumentation problems and significant groundwater levels changes.		X	
Flow and Water Quality Monitoring	2.3.2	A summary of the metered mine water flows and the results of the water quality monitoring identified in Table 7. The Annual Report will provide water quality data in a flexible electronic format and include graphs over time for all parameters.	X		
Water and Load Balances	2.3.3	A summary of the changes and key results of the site water balance. The Annual Report will provide the data in a flexible electronic format and contain water and load balance schematics similar to those in the Red Dog Ming Closure and Reclamation Plan.		X	
Visual Monitoring	2.3.4	A summary of the visual monitoring conducted during the reporting period.	X		
		A summary of the fish weir inspections conducted during the reporting period.	X		
Significant Activity	2.3	A summary of significant activities associated with the mine water management and water treatment.	X		
Quantities	2.4.2	The amount and placement of waste rock.	X		
Geochemical Monitoring	2.4.3	The results of the geochemical monitoring of waste rock facilities.	X		
Visual Monitoring	2.4.4	A summary of the visual monitoring conducted of waste rock facilities.	X		
Significant Activity	2.4	A summary of significant activities associated with the waste rock storage facilities.	X		
Quantities	2.5.2	The amount of tailings produced and the location of discharge.	X		

Item	Plan Section	Reporting Requirement	Quarterly	Annual	Five-Year
		The pond elevation for the reporting period.	X		
Geochemical Monitoring	2.5.3	The results of the geochemical monitoring of TSF.	X		
Visual Monitoring	2.5.4	A summary of TSF visual monitoring conducted during the reporting period.	X		
Significant Activity	2.5	A summary of significant activities associated with the TSF.	X		
Fire	2.6	Notify the ADEC if any fires occur on the working face of the landfill.			
Quantities	2.6.2	The amount and placement of solid waste in the landfill.		X	
Visual monitoring	2.6.3	A summary of visual monitoring of the landfill conducted during the reporting period.	X		
Significant Activity	2.6	A summary of significant activities associated with the landfill facilities.	X		
Quantities	2.7	The amount of ore milled and mill production.	X		
Significant Activity	2.7	A summary of significant activities associated with the Mill and Mine areas.	X		
Areas Disturbed and Reclaimed	2.8.2	The location and size of disturbed and reclaimed areas and a summary of reclamation activity.		X	
Reclamation Research	2.8.2	A summary of research associated with the reclamation of the facility.		X	
Reclamation Monitoring	2.8.3	A summary of the reclamation monitoring.		X	
Significant Activity	2.8.3	A summary of significant activities associated with reclamation.	X		
Updates to financial assurance		A brief update on the adequacy of the existing financial assurance will be provided annually.		X	X
		A detailed assessment of the adequacy of financial assurance will be carried out every 5 years.			X
Fugitive Dust Risk Management Monitoring Plan	2.9	Summary of dust impact monitoring at the mine site and associated implementation plan.		X	
Wildlife interactions or casualties	2.10	Summary of wildlife interactions and casualties.	X		

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

Bill Jeffress, Principal Consultant

and reviewed by

Dan Neuffer, Senior Consultant

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

7 References

AMEC 2012. Long-Term Permafrost and Groundwater Monitoring Program for the Tailing Impoundment, Five-Year Permafrost and Groundwater Data Analysis, 2007 – 2011; prepared for Teck Alaska Inc. by AMEC Environment and Infrastructure Inc.

Geomatrix 2007, Five-Year Permafrost and Groundwater Data Analysis Report for the Long-Term Permafrost and Groundwater Monitoring Program; prepared for Teck Cominco Alaska by Geomatrix Consultants, Inc.

Ott, Alvin G., Morris, William A., Jacobs, Laura L. 2010. Methods for Aquatic Life Monitoring to Satisfy Requirements of 2010 NPDES Permit, Red Dog Mine Site (Revision 1), Technical Report No. 10-04, Alaska Department of Fish and Game, Division of Habitat, April 2010.

SRK 2016a. Red Dog Mine Reclamation and Closure Plan. SRK Consulting (U.S.), Inc.

SRK 2016b. Red Dog Mine Integrated Waste Management Plan. SRK Consulting (U.S.), Inc.

SRK 2016c. Red Dog Mine Waste Rock Management Plan. SRK Consulting (U.S.), Inc.

SRK 2016d. Red Dog Mine Tailings and Water Management Plan. SRK Consulting (U.S.), Inc.

SRK 2016e. Red Dog Mine Quality Assurance Plan. SRK Consulting (U.S.), Inc.

Exponent 2012. Fugitive Dust Risk Management Uncertainty Reduction Plan Prepared for Teck Alaska by Exponent. October 2012.

URS 2009. Operations and Maintenance Manual, Rev. 3, Fresh Water Dam, NID ID#00200, Red Dog Mine, Alaska. Prepared for Teck Cominco Alaska Inc. by URS Corporation. November 2009.

URS 2013. Operations and Maintenance Manual, Rev. 6, Red Dog Tailings Main Dam, NID ID#00201, Red Dog Mine, Alaska. Prepared for Teck Cominco Alaska Inc. by URS Corporation. December 2013.

Water Management Consultants, Inc. (WMCI) 2001. Red Dog Mine – Long-Term Permafrost and Groundwater Monitoring Plan for the Tailings Impoundment. March 2001.

William Morris, ADF&G. Red Dog Biomonitoring (personal communication, August 5, 2014.

Appendix E : Water and Load Balance Update

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2

T: +1.604.681.4196
F: +1.604.687.5532

vancouver@srk.com
www.srk.com

Memo

To:	Chris Eckert, TAK	**Client:**	Teck Alaska Incorporated
From:	Kathleen Willman	**Project No:**	329100.030
Cc:	Kelly Sexsmith, SRK Dan Neuffer, SRK Ivan Clark, SRK Bill Jeffress, SRK Daryl Hockley, SRK	**Date:**	August 5, 2016
Subject:	Red Dog Water and Load Balance Update		

1 Introduction

Teck Alaska Incorporated (TAK) has maintained site water balance models since 1983. TAK's GoldSim model was initially developed in 2004, and was based on a monthly operational water balance that was maintained in Excel. This GoldSim model has been modified over time since its inception, and is currently maintained and updated as needed by TAK for operational purposes. It is now a daily model that includes weather generating models and probabilistic simulation capabilities for modeling future conditions.

The annual water and load balance model was initially developed in 2006, and also used inputs from the monthly operational water balance. This model was used to support both the 2009 *Closure and Reclamation Plan* and permitting of the Aqqaluk deposit, and was designed to assess the effects of different water management and closure measures on flow, loading, and concentrations at various locations at the site over time. In the context of the 2009 *Closure and Reclamation Plan*, the two most important uses were to estimate the post-closure treatment requirements (treatment capacity and annual lime quantities) and to estimate water quality in the TSF pond.

In 2014, the annual water and load balance model was updated as part of the 2014 permit renewal process. The model is still an annual model, but was revised to be consistent with the flow assumptions in the current TAK GoldSim model. Data from the GoldSim model were also extracted and applied in the water and load balance model.

This memorandum includes a description of the water and load balance model, the key inputs and assumptions applied, and a summary of modeling results. The model allows numerous water treatment, reclamation and closure alternatives to be simulated. The results presented herein are for the base case scenario, which represents the current thinking for future operations and closure. Results are provided for the planned closure in 2031 and premature closure in 2015.

2 Model Description

2.1 Overview

The site wide annual water and load balance model for the Red Dog Mine was developed to support the Reclamation and Closure Plan approval application. The primary purpose of the model is to calculate lime usage for the development of treatment costs. Additionally, the model is used to estimate water quality in the tailings pond.

The water and load balance model simulates flows and loads throughout the key facilities at the mine site using average annual flow rates and chemical concentrations. The predicted chemical constituents include zinc, cadmium, sulfate[1] and TDS. Other constituents can be incorporated as required. Loadings are estimated for each constituent by multiplying flow rates and concentrations. Fully mixed concentrations are predicted on an annual basis.

The key facilities included in the model are:

- Tailings Storage Facility (TSF);
- Overburden Dump;
- Main Waste Dump (MWD);
- Main Pit, Aqqaluk Pit and Qanaiyaq Pit;
- Pumpstations and water treatment plants; and
- Mill.

The model contains the following key sheets:

- Inputs for WTP3, measured TSF/Main Pit water elevations, TSF/Main Pit volume-area-elevation data, and catchment delineations;
- Chemical source terms (one sheet for each source);
- GoldSim results, which are used as inputs in the water balance;
- Dashboard, which is the main user interface for the model;
- TSF water balance;
- TSF load balance sheets (one sheet for each parameter);
- WTP1, WTP2, Water Pumpstation and Slurry Pumpstation water and load balances;
- Main Pit, Aqqaluk Pit and Qanaiyaq Pit water and load balances; and
- Water and load balance results.

The model starts on May 01, 2009 to provide a calibration period. It runs beyond closure until 2081, by which time conditions are expected to approach steady state. Annual totals and averages are based on a year from May 01 to April 30. The starting month of May was used to be consistent with the water discharge season, which generally begins in May. Measured data is applied where available up to May 2014.

[1] Sulfate concentrations for certain source terms were determined from ion balances due to previous difficulties laboratories experienced in measuring sources of water with high concentrations of sulfate.

2.2 Summary of Key Updates and Revisions

The initial version of this water and load balance model was created in 2006 to estimate future water quality and water treatment requirements in support of the development of the 2009 Red Dog Mine *Closure and Reclamation Plan*, and to assess potential impacts to hydrology and water quality associated with mining the Aqqaluk deposit. A number of revisions were made over time to incorporate updated flow and chemistry data and to run additional scenarios. Over this same time period, TAK prepared a comprehensive update of the water balance in GoldSim, which is regularly updated and used for ongoing water management at the site.

The revisions made to the model as part of the application process for the renewal of the Integrated Waste Management Permit, *Reclamation and Closure Plan*, and Closure/Post-Closure Cost Estimate includes:

- The water balance flow routing was modified to match the routing in the TAK GoldSim model to reflect current and proposed operations.
- Functionality was added to incorporate results exported from the TAK GoldSim water balance.
- Updated volume-area-elevation data and surveyed water elevations for the TSF and the Main Pit were incorporated.
- The long-term projected precipitation and evaporation were updated based on the historical record and precipitation undercatch predicted by the TAK GoldSim model.
- The assumed values for groundwater inflow to the Main Pit and Red Dog Creek diversion “leakage” to the Mine Sump and Main Pit were revised based on the TAK GoldSim model.
- Sub-models were created for the Water Pumpstation, Slurry Pumpstation, WTP1, WTP2 and each open pit to allow easier management of flow routing scenarios.
- Water treatment scenarios were revised to reflect the current and planned operations, including winter treatment of MWD seepage in the WTP1 and increases in future treatment capacity.
- The predicted MWD concentrations were modified to include a mixture of cover runoff and seepage until the infrastructure is in place to separate the flows (currently assumed to occur in 2020).
- Limitations on discharge to Outfall 001 were incorporated based on minimum TSF pond volumes during operations.
- Future concentrations of TDS and sulfate in the WTP2 effluent were revised to reflect changes in TSF water quality after closure when pond concentrations are predicted to drop below current WTP2 effluent concentrations.
- The load balance was streamlined by combining terms with identical concentrations where possible.
- Where available, source term inputs were updated using measured chemical data.
- Source term inputs for Aqqaluk waste to the Main Pit were revised based on historical concentrations in MWD seepage to simulate concentrations associated with the current fresh waste rock and the expected increase of concentrations over time.

2.3 Model Quality Assurance

Quality analysis of the model included the following procedures:

- The model structure and expressions were reviewed to check for modeling and calculation errors.
- The routing of flows was reviewed for appropriate routing throughout the facilities and to ensure the accounting of all inflows and outflows.
- The water balance model results were compared against the GoldSim results to check for discrepancies.
- Model predictions were compared against monitoring data to ensure predicted results were in line with actual conditions during the calibration period.
- The timing of key changes was checked for accuracy.

2.4 Limitations of the Model

The water and load balance model is intended for internal use by Teck Alaska Incorporated (TAK). Results of the model are provided, however, no conclusions or recommendations have been made. The results of the model are approximate projections. Both the timing and degree of changes in water quality predicted by the model may vary from those observed. The changes the model predicts may occur more slowly than those predicted by the model. Additionally, the precipitation of gypsum throughout the system could result in lower concentrations in the tailings impoundment than the concentrations predicted by the model.

3 Key Inputs and Assumptions

The flow routing and a number of flow inputs were obtained from TAK's GoldSim water balance model[2], including all past and projected production-related flows, TSF seepage, and pumpstation flows. Past water treatment flows are incorporated in the model for the calibration period, while projected flows are based on assumed treatment alternatives and projected capacity. Area-based flows are calculated based on climate data and runoff coefficients from the GoldSim model.

The GoldSim model uses all available metered flows and climate data up to May 2014. A number of modifications were made to the GoldSim model to allow it to be run under constant, average hydrological conditions for future predictions, account for closure and post-closure conditions, and address discrepancies uncovered. Total annual flows were calculated within the GoldSim model using the annual reporting feature, with the start of the reporting year set to May.

The key inputs and assumptions applied in the water and load balance model are described in the following sections.

3.1 Modeling Scenarios

The model allows numerous alternatives for water treatment, reclamation and closure to be simulated. The scenarios presented in this memorandum are base case scenarios reflecting the current plan for future operations and closure. Separate scenarios were evaluated for both the planned closure in 2031 and premature closure in 2015.

[2] File: RedDogTailingsDam_Quantity Only(May212014).gsm

The key assumptions included in the scenarios are summarized below:

- Average hydrological conditions for all future projections;
- Minimum TSF pond volumes imposed during operations;
- Cover efficiency of 75% for all waste rock covers;
- Completion of cover on MWD by 2019;
- Increase in capture efficiency of MWD seepage to 75% by 2019;
- Increase in lime slaking capacity of WTP3 in 2016 and winterization of WTP3 in 2018;
- Increase in water treatment capacity to allow pre-treatment of all MWD seepage captured and Main Pit water in 2025 (2031 closure only); and
- Pre-treatment of TSF reclaim water starting in 2019 (2031 closure only).

3.2 Model Dashboard and Inputs

The water and load balance model includes a dashboard for entering parameters on an annual basis and a table of initial and constant values. The inputs on the dashboard can be varied on an annual basis, which allows multiple scenarios to be modeled. Copies of the table of initial and constant values and the dashboards for the 2015 and 2031 closure scenarios are provided in Appendix B on Table B- 1 through Table B- 3, respectively. Initial values in Table B- 1 are those on May 01, 2009, at the start of the model Water Balance Calculations.

The inflows and outflows are calculated and summed on an annual basis (May 01 to April 30). The pond and pit lake volumes at the end of the year are calculated as follows:

$$End\ of\ Year\ Volume = \text{Start of Year Volume} + \sum \text{Annual Inflows} - \sum \text{Annual Outflows}$$

The following year starts off using the predicted end of year water volume from the previous year, and the above process is repeated.

Predicted water elevations in the TSF pond and the Main Pit lake are calculated from the predicted volumes and volume-elevation data. Tailings and waste rock elevations are estimated from the accumulated volumes and volume-elevation data assuming flat deposition. Pit lake elevations are not predicted for the Aqqaluk Pit or Qanaiyaq Pit due to lack of volume-elevation data.

3.3 Load Balance Calculations

Concentrations in the TSF pond and pit lakes are predicted as follows:

1. Load at the start of the year in the pond/pit lake:

   $$Initial\ Load\ (L_1) = Initial\ Concentration\ \times Initial\ Volume$$

2. Load added to the pond/pit lake for each inflow:

   $$Load\ Added\ (L_2) = \sum [Inflows\ x\ Concentration]$$

3. A new concentration in the pond/pit lake is estimated assuming no flows are removed other than evaporation:

$$Concentration_{NEW} = \frac{Initial\ Load\ (L_1) + Load\ Added(L_2)}{Initial\ Volume\ (V_1) + \sum Inflows\ (V_2)}$$

4. The load removed from the pond/pit lake is assumed to be at the newly calculated concentration:

$$Load\ Removed\ (L_3) = \sum [Outflows\ x\ Concentration_{NEW}]$$

5. The concentration at the end of year is the same as the above calculated concentration:

$$Concentration_{END} = \frac{Initial\ Load\ (L_1) + Load\ Added\ (L_2) - Load\ Removed\ (L_3)}{Initial\ Volume\ (V_1) + \sum Inflows\ (V_2) - \sum Outflows\ (V_3)}$$

Concentrations for the Water Pumpstation and Slurry Pumpstation are predicted using the following equations:

$$Total\ Load\ (L) = \sum [Inflows\ x\ Concentration]$$

$$Concentration = \frac{Load\ (L)}{\sum Inflows\ (V)}$$

Where the units are:

Load in tonnes/year
Inflows, Outflows and Pond Volume in million m^3/year
Concentration in mg/L

3.4 Initial Conditions

3.4.1 Initial Volumes

The TSF water balance starts off using the surveyed pond water elevation and the predicted tailings/waste rock volume from the TAK GoldSim model on May 01, 2009. The Initial area and volume are calculated from the surveyed pond elevation using the volume-elevation curve.

Surveyed water elevations in the Main Pit were not available on the model start date (record starts in 2012). The initial water and waste rock volume in the Main Pit are extracted from the TAK GoldSim model.

Although the initial volumes in the Aqqaluk Pit and Qanaiyaq Pit are assumed to be zero, they are set to values greater than zero for load balance modeling purposes (a volume greater than zero is required to calculate concentrations).

3.4.2 Initial Concentrations

The initial concentrations in the TSF pond at the start of the model are set to the median measured concentrations of TSF reclaim water in 2009. Due to lack of measured parameters, the initial concentrations of water in the Main Pit and Aqqaluk Pit are set such that the predicted end of year and initial concentrations are equal. The initial concentrations in Qanaiyaq Pit are set to zero as the pit does not come online until 2018.

3.5 Climate

3.5.1 Precipitation

Precipitation released was obtained from the GoldSim model. The GoldSim model adjusts daily rainfall and snowfall for undercatch and uses two snowmelt models to estimate snow released to ponds and catchments[3]. Precipitation released is the sum of the incident rainfall and snowmelt.

The precipitation released was based on measured climate data from May 2009 to May 2014. For future predictions, an annual average precipitation of 22.1 inches was applied every year from 2014 to 2081. Average precipitation was considered preferable for the purposes of the load balance because it makes it easier to assess the effects of other variables on the results. The average precipitation was derived by creating a one-year synthetic record based on the average precipitation, wind speed and temperature for each day of the year from the historic record. The synthetic record was run through the GoldSim model to calculate the precipitation released each year.

The TAK GoldSim model was used to assess the effects of variable precipitation on the water balance results for the purposes of tailings management planning. Results of this work are presented in SRK (2014b).

3.5.2 Evaporation

Lake evaporation was extracted from the GoldSim model. It is based on measured pan evaporation up to March 2014 and an average annual value of 7 inches for future predictions.

3.6 Runoff Coefficients

The runoff coefficients from the GoldSim model were applied, which includes coefficients for the Mine Water Diversion (Mine Sump) catchment, Main Pit, seepage collection system, Main Waste Dump (MWD), tailings catchment, tundra and Overburden Dump.

3.7 Catchment Areas

The catchment area delineations applied in the model are those derived in 2006 based on 2004 topography and a layout of the site at closure in 2031. The areas were delineated based on flow directions as well as components of the site that have distinct water chemistries associated with them (i.e. source terms). Areas were estimated on an annual basis for the premature closure and normal closure conditions. For areas that are changing over time, the overall increase or decrease in area was distributed evenly over time up to closure.

The current (2006) and closure layouts are shown on Figure A- 1 and Figure A- 1 (Appendix A), respectively.

The catchment delineations applied in the GoldSim model could not be used for the water and load balance for the following reasons:

- Delineations were made solely by flow direction in the GoldSim model, whereas the load balance requires further delineations based on source terms.

[3] A slightly lower threshold temperature for melting is applied for snowmelt released to ponds

- Separate delineations for Aqqaluk Pit and Qanaiyaq Pit were not made (Aqqaluk Pit was set to 20% of the delineated area of the Main Pit in the GoldSim model).
- The areas were delineated based on 2012 topography and kept constant throughout the modeling period. Changes resulting from mining activity were not included in the GoldSim model.

3.8 Flow Calculations

3.8.1 Area Based Flows

Area-based flows are calculated as follows:

$$Runoff = Catchment\ Area\ x\ Runoff\ Coefficient\ x\ Precipitation\ Released\ to\ Catchment$$

$$Direct\ Precipitation\ to\ Pond = Pond\ Area\ x\ Precipitation\ Released\ to\ Pond$$

$$Pond\ Evaporation = Pond\ Area\ x\ Lake\ Evaporation$$

Pond areas are calculated from the predicted pond elevations and area-elevation curves.

3.8.2 Reclaimed Areas

For areas that are reclaimed, i.e. the Main Waste Dump, waste in the Main Pit and waste in Qanaiyaq Pit, the flows over the cover and seepage are calculated as follows:

$$Flow\ Over\ Cover = \%\ Area\ Covered\ x\ \%\ Cover\ Efficiency\ x\ Total\ Runoff$$

$$Seepage = Total\ Runoff - Flow\ Over\ Cover$$

3.9 Tailings Storage Facility (TSF)

1. **Dam Crest Elevations:** The elevation is set to 970 feet at the start of the model in 2009, with the current elevation of 976 feet in place in 2013. No further raises were assumed under premature closure. For the 2031 closure scenario, the proposed raise to 986 feet is in effect in 2016, and a final raise beyond 986 feet is assumed in 2025 to ensure adequate freeboard.
2. **Freeboard:** 5.3 feet from dam crest or spillway invert elevation (source: assumption from GoldSim model).
3. **Minimum Pond Volume:** A minimum pond volume of 2,000 million gallons is imposed until 2024. From 2025 to closure, the minimum pond volume is decreased in 200 million gallon increments down to 800 million gallons by closure. The minimum pond volume applies when the Mill is operating only (Source: TAK)
4. **Diverted Areas:** Flows from catchment area 9 (west of pond) are assumed to be diverted offsite in a ditch (DD-4) with a diversion efficiency of 75% (source: field flow measurements and professional judgment incorporated into previous water/load balance model).
5. **Volume-Area-Elevation Data/Surveyed Elevations:** Obtained from the GoldSim model. Volume-area-elevation data were calculated by TAK using detailed site topography and ArcGIS to determine the basin volume. Water levels were measured on-site.
6. **Closure Water Cover Depth:** 2-4 feet (source: planned water cover depth from previous water/load balance model).

7. **Flow Routing:**

   - During operations, inflows include catchment runoff, Overburden Stockpile runoff and pumpback, dam seepage pumpback, seepage from the Main Waste Dump, Mine Sump flows, discharge from WTP3, Mill discharge (water and tailings), discharge from the Slurry and Water Pumpstations, grey water[4], water from the Main Pit and waste rock. Outflows include pond evaporation, seepage, reclaim to the Mill, WTP2 and WTP1, waste rock void losses, and water entrained in tailings pores.

   - At closure, the only inflows are catchment flows (with the exception of area 7, which is directed to the Pit), runoff from the north side of the Overburden Stockpile, cover runoff and seepage bypass from the Main Waste Dump, and WTP2 return. Under premature closure, effluent from the WTP3 is discharged to the TSF until 2018. Outflows include pond evaporation, seepage and reclaim to the WTP2.

3.9.1 Seepage and Seepage Pumpback

All seepage from the TSF Main Dam and seepage pumpback flows, both measured and projected, were obtained from the GoldSim model. In the GoldSim model, Main Dam Seepage is estimated based on the difference between measured pumpback flows and runoff to the seepage collection pond. Measured pumpback flows are applied for historical conditions; for future projections, average monthly pumpback flows based on the historical record are applied.

Seepage from the Back Dam is not included in the TAK GoldSim model, and, thus, is not accounted for in the water and load balance. See page pumpback reports to the TSF during operations and to Aqqaluk Pit at closure (or the Main Pit for premature closure).

3.10 Overburden Dump

As in the previous version of the water/load balance model, flows from the Overburden Dump pumpback are based on the runoff generated for the Overburden Dump area rather than the metered flows as the area-based flows are more conservative (on average 1.8 times the metered flows). Pumpback reports to the TSF during operations and Aqqaluk (or Main) Pit at closure.

3.11 Main Waste Dump (MWD)

The MWD is sub-divided into the MWD West, Oxide Dumps East and West[5], and Upper MWD catchment. Key inputs and assumptions include:

1. **Timing of Cover Application:**

   - 2017 – 25% (source: TAK)
   - 2018 – 63% (source: TAK)
   - 2019 – 100% (source: TAK)

2. **Cover Efficiency:** 75% (source: projection from previous water/load balance model. Arithmetic mean from 2008-2013 Oxide Dump monitoring data [O’Kane 2014] is 76%).

[4] Grey water set to zero at closure as in the GoldSim model.
[5] The Oxide Stockpile cover is in place at the start of the model

3. **Cover Runoff:** One year after cover is completed on the MWD (2020), cover runoff is assumed to be separated from seepage and directed to the TSF. Prior to that, cover runoff and seepage are mixed (source: TAK).
4. **Smart Ditch:** Water from the Smart Ditch is diverted away from the MWD surface and routed to the TSF and Pit. The Smart Ditch is not currently modeled.

3.11.1 MWD Collection System

1. 100% of the cover runoff is assumed to be collected, while seepage is collected at the capture efficiency. The flows are fully mixed, and a concentration is calculated for the mixed flow. The term MWD water refers to the combined cover runoff and seepage.
2. **Seepage Escape Rate[6]:** Shown on dashboard, (Table B- 2, Table B- 3):
   - 2009 to 2013: Based on measured flows from the GoldSim model (calculated based on the measured flows captured by the collection system and the estimated yield for the MWD, which indicates an escape rate of roughly 70%)
   - 2014 – 70% (source: TAK)
   - 2015 – 55% (source: TAK)
   - 2017 – 45% (source: TAK)
   - 2019 – 25% (source: TAK)
   - In the previous model, there was a decrease in the seepage escape rate to 5% in 2025. As directed by TAK, the current model does not reflect any further improvements in the capture efficiency.
3. Cover runoff and seepage from the MWD collection system is routed to WTP1, WTP3, and/or Main Pit based on historical data in the GoldSim model up to May 2014. For future predictions, the flows are routed as follows:
   - MWD Collection to WTP1 – 30% of the MWD water that can be collected in a year is assumed to be treated in the WTP1 when the WTP3 is not operational (i.e., in the winter) until 2018. This is based on the percentage of the total flow collected that has been treated in the WTP1 historically. In 2018, when the WTP3 is expected to be winterized, the WTP1 will no longer be used to treat MWD water.
   - MWD Collection to WTP3 – The amount of water that can be collected less the flow to the WTP1 is routed through a WTP3 sub-model, which estimates the amount of water that can be treated based on lime slaking and flow capacities and the number of days the WTP3 is expected to operate (Section 3.16). After 2018, the sub-model is no longer used (assume 100% of MWD water collected is treated in WTP3).
   - MWD Collection to Main Pit – Any excess MWD water that cannot be treated in WTP3 due to capacity limitations (as per the GoldSim model) is routed to the Main Pit. The pit reached its operating water elevation in 2015, above which point excess water from the pit is directed to the Mine Sump. Pumping to the Main Pit is assumed to cease in 2018

[6] Seepage Escape Rate (%) = 100% - Capture Efficiency

when the WTP3 is winterized. Under premature closure conditions, all MWD water collected reports to the Main Pit starting in 2019.

- MWD Collection to Aqqaluk Pit – Under the 2031 closure, all MWD water collected is routed to the Aqqaluk Pit.

4. Seepage bypassing the MWD collection system reports to the TSF at all times.

3.12 Mine Sump (Mine Water Diversion System)

1. **Flow Routing:**
   - Inflows include catchment runoff from area 12 (Slope to north of Camp and Mill), water from the Main and Aqqaluk pits (prior to May 2012) and leakage from the Red Dog Creek Diversion. With the Main Pit flooded, excess water from the pit is assumed to be pumped to the Mine Sump.
   - Water from the Mine Sump is routed to the WTP3 and WTP1 based on the measured flowrates in the GoldSim model up to May 2012. No further treatment is assumed between 2012 and 2024. In 2025, TAK proposes to increase treatment capacity to allow all Mine Sump water to be treated.
2. **Leakage (Seepage) from Red Dog Creek Diversion:**
   - 50 gpm assumed in the GoldSim model[7]. In the previous water/load balance model, this value was calculated based on the difference between the predicted and metered flows and was considerably higher (closer to 150 gpm).

3.13 Main Pit

1. **Timing of Cover Application on Waste in Pit:**
   - 2031 Closure - 25% covered in 2027; 100% covered in 2033
   - 2015 Closure – 100% covered in 2020
2. **Cover Efficiency:** 75% (source: projection from previous water/load balance model. Arithmetic mean from 2008-2013 Oxide Dump monitoring data [O'Kane 2014] is 76%).
3. **Cover Runoff:** Flow over the cover and seepage from the waste in the Main Pit are fully mixed within the Pit (source: assumption from previous model).
4. **Groundwater Inflow:** 200 gpm based on the GoldSim model. Based on discussions with site personnel, this value was derived from discrepancies between predicted and measured elevations in the Pit. A value of 50 gpm was used in the previous water and load balance based on guidance from Jeff Weaver, a former consultant for TAK. Limited information was available to develop this estimate at the time. The revised value is a considerable increase. However, the previous water and load balance applied a correction for discrepancies between the predicted and metered Mine Sump flows of approximately 150 gpm, which

[7] In the GoldSim model, a single flow of 50 gpm reports to the Mine Sump as part of the Main Pit inflows prior to May 2012. After May 2012, two flows of 50 gpm each are included – one to the Mine Sump and a second to the Main Pit. The water and load balance assumes these flows are added to the Mine Sump and Main Pit at all times for consistency.

included both inflows from the Main Pit and water from the Red Dog Creek Diversion. Consequently, the overall corrections are similar.

5. **Flow Routing:**

   - Inflows to the Main Pit throughout the mine life and post-closure include direct precipitation[8], pit wall runoff, Main Pit waste rock seepage, Hilltop Creek, leakage from the Red Dog Creek Diversion, and groundwater.
   - An additional inflow was included during the high precipitation events in 2013 to simulate flooding of the Red Dog Diversion, which is assumed to be at background runoff concentrations (source: inflow extracted from GoldSim model, based on observations and measurements by TAK). Pumping from the Water Pumpstation was also added in 2012 and 2013 (source: flowrates extracted from GoldSim model, based on flows measured and projected by TAK for the 2012/2013 season). The flow was routed directly to the Main Pit as in the GoldSim model. However, the actual flow was pumped to the Mine Sump first and then to the Main Pit.
   - Dewatering flows from Aqqaluk and Qanaiyaq Pits are routed to the Main Pit during operations. This continues after the Main Pit is flooded, which is consistent with the GoldSim model. Based on discussions with site staff, this may be required due to the current pumping configurations.
   - Under premature closure conditions, flows from Aqqaluk Pit, TSF catchment area 7, Overburden Stockpile and TSF seepage pumpback, MWD seepage from the collection system and Mine Sump catchment are routed to the Main Pit.
   - Outflows include pit lake evaporation (modeled under premature closure only – see footnote 8) and waste rock void losses. Excess water was routed to the Mine Sump until May 2012. No outflows are modeled from May 2012 until the Pit is flooded.
   - Once the Pit is flooded, excess water is directed to the Mine Sump (source: TAK). The model assumes this water will be treated starting in 2025 when TAK proposes to increase water treatment capacity.
   - Under premature closure, excess water from the Main Pit is treated in a new treatment plant, WTP4[9]. WTP4 return[10] is sent back to the Main Pit. Under 2031 closure, excess water is routed to Aqqaluk Pit.

3.14 Aqqaluk Pit

1. **Area Contributions:**

   - The Aqqaluk Pit and buffer zone are assumed to be at their ultimate plan areas by 2013, with the pit wall source term applied to the pit area starting in 2011. When the pit is flooded, the flooded area is subtracted from the pit wall area.

[8] Modeled under premature closure only. Modeling direct precipitation removes an area that is disturbed and/or covered with waste, which is less conservative than retaining the loadings from the disturbed /waste areas.
[9] WTP4 is the name used to refer to the post-closure water treatment plant for modeling purposes. The design of this plant is to be determined. It may consist of a reconfiguration of existing plants or an entirely new plant.
[10] WTP4 return is the amount not discharged based on the return ratio assumed (see Section (3.19.4)

2. **Flow Routing:**
   - Inflows throughout the mine life and post-closure include direct precipitation, pit wall runoff, and groundwater.
   - Under the 2031 closure, flows from the Main Pit, TSF catchment area 7, Overburden Dump and TSF seepage pumpback, MWD seepage (from collection system), and Mine Sump catchment are routed to Aqqaluk Pit.
   - Outflows include pit lake evaporation. Excess water (pit dewatering) was routed to the Mine Sump until May 2012 and to the Main Pit from 2012 until closure.
   - Under premature closure, excess water from Aqqaluk Pit is routed to the Main Pit. Under 2031 closure, excess water is treated in WTP4. WTP4 return is sent back to the Pit.
3. **Pit Flooding:** Under the 2031 closure scenario, the Aqqaluk Pit is expected to be flooded approximately five years after closure. Under premature closure, the pit is assumed to be dewatered.
4. **Groundwater Inflow:** 50 gpm beginning in 2018 (source: projection from previous water/load balance model, based on guidance from Geomatrix Consultants).

3.15 Qanaiyaq Pit[11]

1. **Timing of Cover Application on Waste in Pit:**
   - 50% covered in 2031; 100% covered in 2032
2. **Cover Efficiency:** 75% (source: projection from previous water/load balance model. Arithmetic mean from 2008-2013 Oxide Dump monitoring data [O'Kane 2014] is 76%).
3. **Area Contributions:**
   - Qanaiyaq Pit is assumed to be at its ultimate plan area, with the pit wall source term applied to the full pit area, starting in 2018. As the pit is backfilled (2023-2030), the pit area is converted to waste rock area based on a linear increase in area over time.
4. **Flow Routing:**
   - Inflows include pit wall runoff and waste rock seepage. Excess water reports to the Main Pit from when the Qanaiyaq Pit comes online in 2018 until closure as pit dewatering or seepage via Hilltop Creek (source: TAK). The pit wall area is reduced from the start of backfill and goes to zero by closure, while the backfill area is gradually increased until it occupies the full pit area.
   - The Pit is assumed to not hold water due to fractured rock (source: TAK). Once dewatering ceases, any water entering Qanaiyaq Pit reports to the Main Pit as seepage.
   - At closure, flow over the cover is routed to the TSF the year cover application begins. Seepage is directed to the Main Pit via Hilltop Creek (source: TAK).

[11] The Qanaiyaq Pit is not modeled under premature closure

3.16 Mill Flows

Mill inflows and outflows (measured and projected), including consolidated tailings (volume tailings occupy in the TSF, including pore water), freshwater, water in ore, reclaim water, and water in the concentrate are obtained from the GoldSim model. Waste rock deposited in the TSF is also obtained from estimates in the GoldSim model and added to the tailings solids.

In the TAK GoldSim model, there is approximately 1 billion gallons of water per year reclaimed from the TSF to the Process Water Tank (PWT) in excess of the Mill demand. The excess is routed to the Water Pumpstation.

3.17 Water Consumption

Freshwater, potable water, and other water uses, both measured and projected, are obtained from the GoldSim model.

3.18 Pumpstations

Sub-models were created for the Slurry and Water Pumpstations to estimate concentrations of the outflows as follows:

1. **Slurry Pumpstation:** Inflows include water from WTP1 and WTP2. Outflow goes to the TSF.
2. **Water Pumpstation:**
   - Inflows include backwash from the Sand Filter, effluent from WTP1 and WTP2, and overflow from the Process Water Tank. Water is routed to the Sand Filter based on the demand, and the excess reports to the TSF. In 2012 and 2013, water was also pumped to the Main Pit due to limitations on discharge (source: measurements incorporated into GoldSim model).
   - For the purposes of modeling, the resulting chemistry is estimated assuming all the inflows are fully mixed. In practice, excess from the Process Water Tank is routed directly back to the TSF and not mixed with water to be discharged.

3.19 Water Treatment

3.19.1 WTP1

1. Inflows to the WTP1 during operations include water from the MWD collection system, Mine Sump, TSF, and WTP2. Flows were extracted from the GoldSim model up to May 2014, which are based on metered flows. Future predictions are made as follows:
   - MWD to WTP1: flows prior to the winterization of the WTP3 are based on the amount of water expected to be collected in the winter. This is assumed to be zero in 2018 once the WTP3 is winterized.
   - Mine Sump to WTP1: no future inflows to the WTP1 are modeled.
   - TSF to WTP1: flows prior to the onset of pre-treatment of Mill reclaim are obtained from the GoldSim model (based on historical flows). Once pre-treatment of reclaim water is simulated in 2019, there is no additional treatment of TSF water in the WTP1 over and above Mill reclaim.

- WTP2 to WTP1: flows are obtained from the GoldSim model (based on historical flows).

2. Outflows from the WTP1 include underflow to the Slurry Pumpstation, obtained from GoldSim (measured and projected), and excess water to the Water Pumpstation.
3. WTP1 is assumed to cease operation at closure under the 2031 scenario (source: previous water/load balance model). Under premature closure, WTP1 is used to treat MWD cover runoff/seepage during the winters of 2015 to 2017. TAK may consider using WTP1 after closure to remove loading from the TSF pond and/or supplement discharge.

3.19.2 WTP2

1. Historical inflows to WTP2 from the TSF are obtained from the TAK GoldSim model. For future predictions, the maximum of the GoldSim input or the inflow required to ensure the sand filter demand is met is applied. Any excess water not required for discharge is routed back to the TSF from the Water Pumpstation.
2. Outflows include water to WTP1, underflow to the Slurry Pumpstation and excess to the Water Pumpstation.
3. After closure, the inflow to the WTP2 from the TSF is equal to 1.1 times the required discharge. Return from the plant reports to the TSF (source: assumption from previous water/load balance model).

3.19.3 WTP3

1. Measured flows treated in the WTP3 are applied in the model up to May 2014 (from the GoldSim model).
2. For future predictions up to 2017, a sub-model was created to simulate the WTP3 performance. The amount of MWD seepage and Mine Sump flows that can be treated are estimated based on lime slaking and flow capacities, and number of days of anticipated treatment (the latter is based on historical data). MWD seepage is given first priority of treatment (source: previous water/load balance model).
3. Once the WTP3 is proposed to be winterized in 2018, it is assumed it can treat all MWD seepage collected.
4. The WTP3 or other treatment capacity is proposed to be increased in 2025, at which time it is assumed there will be sufficient capacity to treat all MWD seepage captured and Mine Sump (i.e. Main Pit) water.
5. **Lime Slaking Capacity:**
    - 2009 to 2015: 70 tonnes/day (source: assumption from previous water/load balance model)
    - 2016 to 2024: 174 tonnes/day (source: TAK)
    - 2025 to closure: As needed to treat all MWD seepage collected and Mine Sump water (source: TAK)
6. **Flow Capacity:**
    - 2009 to 2024: 1,500 gpm (source: assumption from previous water/load balance model).

- 2025 to closure: As needed to treat all MWD seepage collected and Mine Sump water (source: TAK)

7. The WTP3 is assumed to cease operation at closure under the 2031 closure scenario. For premature closure, the WTP3 is used to treat MWD water until 2019 (source: TAK).

3.19.4 WTP4

1. WTP4 is the name used to refer to the post-closure treatment plant for modeling purposes. The design of this plant is to be determined. It may consist of a reconfiguration of existing plants or an entirely new plant.
2. WTP4 treats water from the Main Pit under premature closure or Aqqaluk Pit under the 2031 closure (source: assumption from previous water/load balance model).
3. The inflow to the WTP4 is 1.1 times the required discharge from the Pit, and the return from the plant is sent back to the Pit (source: assumption from previous water/load balance model).

3.19.5 Discharge to Outfall 001

1. Discharge to Outfall 001 is obtained from the GoldSim model from 2009 to May 2014, which is based on measured discharge.
2. **Future Discharge Rates:**
   - 2014 to 2016: 1.244 billion gallons (source: TAK)
   - 2017 to 2018: 1.396 billion gallons (source: TAK)
   - 2019 to closure: 1.55 billion gallons maximum with restrictions imposed to maintain the minimum TSF pond volumes (source: TAK)
   - Post-Closure: Equivalent to the net inflows to the site once the 2-foot water cover is achieved (source: planned discharge rate from previous water/load balance model). The combined discharge from WTP2 and WTP4 is assumed to be limited to 1.55 billion gallons at all times. The discharge is not increased beyond 1.55 billion gallons or allowed above the volume required to maintain the minimum TSF pond volumes.

3.19.6 WTP Sludge

Water treatment sludge is not included in the water balance model (source: previous water/load balance model).

3.20 Source Terms

The source term inputs are provided in Table B- 4, (Appendix B). The inputs are based on monitoring data provided by TAK. In cases where the chemistry did not appear to be changing over time, the median was derived from long-term data and/or years with the best quality data. Where annual trends were observed, median values were calculated for each year the data was available (e.g. tailings discharge water, reclaim water, MWD seepage, Mine Sump, Outfall 001 discharge, and seepage pumpback). The annual values were based on the period from May 01 to April 30 for consistency with the water balance model.

Although concentrations in the tailings discharge and reclaim water have been increasing over time, data from the waste rock stockpiles and pit sump suggest that concentrations in these areas are starting to stabilize. For this reason, future concentrations from waste rock and pit wall sources were assumed to remain at current levels. However, the model includes functionality to simulate increased concentrations.

Two of the source terms require some additional explanation, as follows:

- WTP2 Effluent and Return Source Terms:
  - Under post-closure conditions, the concentrations of TDS and sulfate in the TSF pond are predicted to decrease below those in the current WTP2 effluent and discharge. Consequently, the TDS and sulfate source terms for WTP2 effluent and return were modified such that the minimum of the predicted TSF pond concentrations or current WTP2 effluent concentrations are applied for future projections.
- Tailings Discharge Water Source Term:
  - TAK requested that the pre-treatment of reclaim water in the WTP1 be simulated starting in 2019. In order to model this, the number of days of pre-treatment is set in the Dashboard. It was assumed that during treatment, the concentrations of most tailings discharge parameters would be similar to those in 2005 when reclaim water was being pre-treated. The projected pre-treated concentrations of parameters (with the exception of sulfate, TDS, calcium and magnesium) are calculated using the following equation:

$$\frac{[2005\ Conc. \times Treatment\ Days] + [(365\ Days - Treatment\ Days) \times Current\ Conc.]}{365\ Days}$$

  - Concentrations of sulfate, TDS, calcium and magnesium are assumed to be at current concentrations to reflect build-up of TDS in the tailings water. Current concentrations were estimated from the last two years of measured data to be conservative as concentrations in 2013 were lower than in the previous two years.
  - The model assumes 80 days of treatment of TSF reclaim in the WTP1, which is the equivalent number of days of treatment based on the WTP1 capacity of approximately 500 MGals/year.

4 Model Results and Calibration

4.1 Water Balance

The predicted flows throughout the key facilities at the mine are illustrated during operations in Year 2014 on Figure A- 3 (Appendix A). Predicted post-closure flows are shown in Year 2037 under the 2031 and 2015 closure in Figure A- 4 and Figure A- 5, respectively.

Table 1 provides a summary of predicted inflows to the TSF and pits during operations in Years 2014 and 2019, and after closure in Year 2037.

Table 1: Predicted Flows during Operations and Closure

Description	Flows (MGals/year)					
	Operations		2031 Closure		2015 Closure	
	TSF Pond		TSF Pond	Aqqaluk Pit	TSF Pond	Main Pit
Inflows	**Year 2014**	**Year 2019**	**Year 2037**		**Year 2037**	
Precipitation on Pond	363	387	391		323	
Runoff from "Background" Areas	312	289	249	33	310	34
Overburden Stockpile	50	50	18	32	18	32
Main Waste to Pond/Pit	123	10	130	30	150	35
Mine Sump to Pond/Pit	41	726		41		41
Mill Discharge Water to Pond	2,715	2,187				
Grey Water	91	91				
Return from Pumpstations / WTP	1930	1531	26	105	28	102
WTP3 Effluent	41	149				
Dam Seepage Pumpback	452	446		445		445
Pit Inflows	0	0	18[12]	477	0	445
Total Water Inflow	**6117**	**5867**	**831**	**1162**	**830**	**1133**
Outflows						
Process Water to Mill	3460	3303				
Flow to Water Treatment[13]	2358	1913	285	1152	305	1124
Sand Filter Deficit	0	0				
Main Dam Seepage	431	424	422		422	
Water Held in Tailings Pores	261	210				
Waste Rock Void Loss	0	0				
Evaporation from Pond/Pit Lake	116	122	124	10	102	9
Total Water Outflow	**6625**	**5972**	**831**	**1162**	**830**	**1133**
Net Water Inflow (Outflow)	**-510**	**-105**	**0**	**0**	**0**	**0**
Discharge to Outfall 001	***1244***	***1550***	***259***	***1047***	***277***	***1022***

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

The Main Pit began flooding in May 2012 and reached its operating elevation of 840 ft amsl in May 2015. In Year 2014, all pit flows are being stored in the Main Pit and there are no pit inflows to the TSF. In contrast, in Year 2019 the Main Pit is flooded, and all excess pit water is assumed to report to the TSF via the Mine Sump. Additionally, waste rock is being added to the flooded Main Pit, which results in a displacement of water from the pit to the Mine Sump (and ultimately the TSF). This leads to a predicted increase in Mine Sump flows of nearly 700 MGals/year from

[12] This flow is the cover runoff from the Qanaiyaq Pit Dump.
[13] Flow to water treatment does not include pre-treatment of reclaim water for the Mill in the WTP1.

2014 to 2019. Projected production-related flows decrease from 2014 to 2019, whereas the discharge rate is anticipated to increase over the same time period.

After closure, the inflows to the impoundment decrease substantially due to shutdown of the Mill and the pumping of contaminated flows to the Aqqaluk Pit (or Main Pit under premature closure). The total inflow to the TSF is reduced from over 6,000 MGals/year during operations to less than 1,000 MGals/year after closure. The net inflow to the pits is just over 1,000 MGals/year after closure. Differences in post-closure flows under the 2015 and 2031 closure include:

- Differences in TSF area-related flows due to a lower water elevation under premature closure (associated with a lower tailings elevation). A lower water elevation results in lower direct precipitation on the pond combined with higher runoff inflows;
- Slightly higher inflows to the pits under the 2031 closure due to the addition of groundwater inflow to Aqqaluk Pit, which is assumed to begin in 2018, and seepage inflows to the Main Pit from Qanaiyaq Pit (cover runoff reports to the TSF); and
- Lower predicted MWD seepage under the 2031 closure due to the allocation of a portion of the MWD area to the Qanaiyaq Pit.

4.1.1 TSF Volumes and Elevations

The TAK GoldSim model is recommended for projecting the timing of dam raises. To support the updated *Tailings and TSF Water Management Plan* (2016c), SRK ran the TAK Goldsim model under variable hydrological conditions for 1,000 probabilistic realizations to estimate a range of possible dates when the water elevation may encroach on the freeboard for the 986-foot dam. The results indicated predicted dates between 2020 and 2027, with the mean date in the fall of 2025. TAK will need to verify the assumptions and results (SRK 2014b).

In the water and load balance model, a 1,000-foot dam crest was entered arbitrarily as the final dam raise where needed to address freeboard requirements. Future dam crest elevations and raise timing will need to be determined through detailed engineering, which is outside the scope of this evaluation.

4.1.2 Predicted Discharge to Outfall 001

The predicted annual discharge rates to Outfall 001 under average hydrological conditions for the two closure scenarios are shown in Table 2. The model assumes the combined discharge of TSF and pit water cannot exceed the target discharge rates provided by TAK (Section 3.19.5). The predicted long-term, steady discharge rates are achieved by 2030 under premature closure and by 2036 under 2031 closure. For comparison, TAK reported 1.352 million gallons of discharge in 2014 and 1.145 million gallons of discharge in 2015, an average of 1.249 million gallons per year.

Table 2: Predicted Discharge to Outfall 001 – 2015 and 2031 Closure

Year	Predicted Discharge to Outfall 001 (MGals/year)					
	2015 Closure			2031 Closure		
	TSF Water	Pit Water	Total Discharge	TSF Water	Pit Water	Total Discharge
2014	1244	0	1244	1244	0	1244
2015	504	740	1244	1244	0	1244
2016	257	987	1244	1244	0	1244
2017	409	987	1396	1396	0	1396
2018	409	987	1396	1396	0	1396
2019	388	1162	1550	1550	0	1550
2020	528	1022	1550	1550	0	1550
2021	528	1022	1550	1550	0	1550
2022	528	1022	1550	1550	0	1550
2023	527	1023	1550	1550	0	1550
2024	528	1022	1550	1550	0	1550
2025	528	1022	1550	1550	0	1550
2026	528	1022	1550	1550	0	1550
2027	527	1023	1550	1550	0	1550
2028	528	1022	1550	1507	0	1507
2029	326	1022	1347	1488	0	1488
2030	277	1022	1299	1550	0	1550
2031	276	1023	1299	615	0	615
2032	277	1022	1299	259	0	259
2033	277	1022	1299	259	0	259
2034	277	1022	1299	259	0	259
2035	276	1023	1299	258	301	559
2036	277	1022	1299	259	1047	1306

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

4.1.3 Water Balance Calibration

The predicted and surveyed TSF and Main Pit water at the end of each year between 2009 and 2014 are shown on Figure A- 6 and Figure A- 7, respectively. The weekly surveyed elevations are also provided for reference.

The differences between the predicted and surveyed water levels in the TSF range from 0.5 feet to 1.8 feet. For the Main Pit, the differences between the predicted and surveyed water levels are greater, ranging from 3 feet to 17 feet. The recorded elevations for the Main Pit provided by TAK appear to be estimated prior to 2012; therefore, the differences prior to that date are uncertain. The Main Pit water balance under-predicts water elevations in the last two years. The differences between the measured and predicted Main Pit elevations are relatively small in comparison to the elevation changes that take place over a year during pit flooding, which could exceed 100 feet.

4.2 Load Balance

Load balances were created for the TSF, Main Pit, Aqqaluk Pit, Qanaiyaq Pit, and pumpstations under the 2015 and 2031 closure scenarios, assuming long-term average climate conditions for future predictions.

4.2.1 Site Loading Distributions

Predicted Operational Loadings

The predicted zinc and TDS loadings to the pits and TSF, which are the two sources of water treated for discharge, are shown during operations in Year 2014 on Figure A- 8 and Figure A- 9, respectively. Distributions of these loadings are illustrated in a pie chart during operations in Years 2014 and 2030 on Figure A- 10 and Figure A- 11.

Based on the results, during operations, the top contributors to loadings at mine site are seepage from the MWD, Mill discharge, pit wall runoff, seepage from waste rock in the pits and TSF dam seepage. As mine development progresses, the loadings from waste rock seepage in the pits increase. At the end of operations, this source is predicted to be the largest contributor of zinc and TDS loadings. Once the covers in the Main Pit are applied, the contribution from in-pit waste rock seepage decreases, as described in the following section.

Predicted Post-Closure Loadings

The predicted post-closure zinc and TDS loadings under the 2031 and 2015 closure scenarios are provided on Figure A- 12 through Figure A- 15. The distribution of post-closure zinc and TDS loadings are provided in Figure A- 16 and Figure A- 17.

After closure, the largest contributor to zinc and TDS loadings in the TSF is MWD seepage bypassing the collection system. The other main sources of loadings, i.e. pit wall runoff and seepage from waste rock in the pits, TSF dam and MWD, are collected in the pit.

From a site-wide perspective, under the 2031 closure, the four main sources of loadings – pit wall runoff, waste rock seepage in the pits, MWD seepage and TSF dam seepage – are split relatively equally, each contributing between 20% and 30% to the overall loadings. Under premature closure, there is less waste rock deposition in the pits, and the in-pit waste rock seepage contribution drops to roughly 5%, with the remaining loading contributions contributing slightly higher percentages.

4.2.2 TSF Pond Concentrations

The beginning of year predicted concentrations of zinc, calculated sulfate, TDS, cadmium and calculated acidity in the TSF over time are provided on Figure A- 18 through Figure A- 22. The predicted concentrations are shown for both the 2015 and 2031 closure scenarios, along with the annual median measured reclaim water concentrations.

Load Balance Calibration

Figure A- 18 through Figure A- 22 show the predicted TSF pond concentrations at the beginning of the year and the annual median measured reclaim water concentrations. The model appears to predict concentrations close to those measured in the TSF pond, but consistently over-predicts concentrations in 2013 for all parameters. The measured reclaim water indicates a decrease in concentrations from 2012 to 2013, whereas the model indicates an increase over the same time period.

Predicted Operational Concentrations

The concentrations in the TSF pond under the 2015 and 2031 closure are identical until premature closure in 2015.

Under the planned 2031 closure, there are no significant loading increases between 2013 and 2015. At the same time, there is more water treated than required for discharge. The excess treated water is routed back to the TSF, resulting in a slight decrease in predicted concentrations during this time period. The Main Pit began filling with water in 2012 and reached its operating elevation of 840 feet amsl in May 2015, which leads to predicted increases of all parameters in the TSF. TAK has proposed various measures to reduce concentrations over time, including the increase in WTP3 lime slaking capacity and capture efficiency of MWD seepage, along with the pre-treatment of reclaim water starting in 2019. The treatment of reclaim results in a significant reduction effect in all parameters with the exception of calculated sulfate and TDS. The next large decrease is predicted in 2025 when treatment of Main Pit water is assumed to begin.

Predicted Closure Concentrations

The concentrations of all parameters modeled in the TSF Pond are predicted to increase after closure under the premature closure scenario. Once premature closure begins, the TSF concentrations are driven by the MWD seepage bypassing the collection system. All other high loading contributors are assumed to be pumped to the Main Pit. Once the MWD cover construction begins, which is assumed to take place between 2017 and 2019, and the capture efficiency is increased to 75% in 2019, the concentrations of all parameters in the TSF pond begin to decrease.

At closure in 2031, the concentrations of all parameters in the TSF decrease. The spike in concentrations predicted under premature closure is not predicted at closure in 2031 due to the MWD being fully covered and the capture efficiency is increased to 75% by the time closure occurs under the 2031 closure scenario. As the MWD seepage bypass is now the largest contributor to loadings in the TSF, any additional improvements in seepage collection would be anticipated to produce a significant improvement in TSF water quality.

The long-term post-closure concentrations of all parameters approach similar values for the 2015 and 2031 closure scenarios, as shown in Table 3. The differences in concentrations are caused primarily by MWD seepage bypass loadings. Under 2031 closure, a portion of the MWD is allocated to Qanaiyaq Pit, which removes this contribution to the TSF (other than cover runoff from the pit, which is assigned Overburden Stockpile runoff concentrations).

Table 3: Predicted Long-Term TSF Pond Concentrations[14]

Closure Scenario	Predicted Post-Closure Concentration in TSF Pond (mg/L)				
	Zinc	Calculated Sulfate	TDS	Cadmium	Calculated Acidity
2031	170	913	1,489	1.0	645
2015	191	993	1,622	1.1	725

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

4.2.3 Post-Closure Pit Water Concentrations and Loadings

The long-term post-closure concentrations of parameters modeled in Aqqaluk Pit and Main Pit for the 2015 and 2031 closure scenarios are shown in Table 5. Concentrations are slightly lower

[14] Model results from Year 2081

under the 2031 closure as Aqqaluk Pit is modeled as flooded, which removes a portion of the pit wall loadings.

Table 4: Predicted Long-Term Pit Water Concentrations[14]

Closure Scenario	Predicted Post-Closure Concentration in Pit Water (mg/L)				
	Zinc	Calculated Sulfate	TDS	Cadmium	Calculated Acidity
2031 – Aqqaluk Pit	1,329	5,418	9,004	21	4,128
2015 – Main Pit	1,409	5,648	9,371	22	4,228

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

The calculated acidity for the pits and water treatment over time are shown on Figure A- 23 and Figure A- 24 for the 2031 and 2015 closure scenarios, respectively.

For the 2015 closure scenario, the loadings to the Main Pit (Figure A- 24) drop in the first few years after closure when additional capacity is added to WTP3 and MWD seepage is treated rather than being routed to the Pit. The loadings increase in 2019 when MWD seepage is no longer treated in the WTP3 and it begins being routed to the Main Pit. The loadings drop again as the covers on the MWD and waste in the Main Pit are completed. The loadings from the waste in the Main Pit subsequently increase somewhat with the assumed increased seepage concentrations due to aging of the waste rock (assumed to follow the same historical pattern as MWD rock).

Under 2031 closure, the loadings to Aqqaluk Pit drop in 2035 as the pit floods (Figure A- 23). The loading to the Main Pit drops after closure due to the completion of the cover on the waste in the pit. The gradual decrease in the total loading to Aqqaluk Pit is associated with the inflows from the Main Pit. Concentrations in the Main Pit decrease over time as the pit reaches steady state due to the decrease in loadings from the waste in the pit (as a result of the cover application). Water treatment begins in 2035 when Aqqaluk Pit is predicted to be flooded.

4.2.4 Water Treatment Loadings

The predicted long-term loadings to water treatment from the TSF and pits under the 2031 and 2015 closure scenarios are provided in Table 5.

As noted in the previous section, the loadings to the TSF are slightly lower under 2031 closure due to a portion of the MWD area being allocated to Qanaiyaq Pit, The predicted loadings from Qanaiyaq Pit are minimal as the pit is assumed to be fully backfilled and covered at closure.

The pit loadings are also lower under 2031 closure due primarily to the predicted Aqqaluk Pit loadings. Aqqaluk Pit is modeled at its full plan area under both closure scenarios by 2013. For 2031 closure, the pit is assumed to begin flooding after closure, and the flooded area is removed from the pit wall area, which reduces pit wall loadings. Under premature closure, Aqqaluk Pit is assumed to be dewatered indefinitely due to limited storage capacity. Consequently, the pit wall loadings are predicted to be higher under premature closure as the full pit area is modeled at pit wall concentrations.

Table 5: Predicted Long-Term Loadings to Water Treatment[14]

Source of Inflow to WTP	Long-Term Post-Closure Loadings to Water Treatment (tonnes/year)				
	Zinc	Calculated Sulfate	TDS	Cadmium	Calculated Acidity
2031 Closure					
TSF Water	184	991	1,617	1.1	700
Pit Water	5,788	23,593	39,206	90	17,975
2015 Closure					
TSF Water	222	1,152	1,882	1.3	841
Pit Water	5,989	24,003	39,820	93	17,969

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

5 References

O'Kane Consultants Inc., 2014. Teck Resources – Red Dog Mine Oxide Stockpile Full-Scale Cover System 2012-13 Annual Performance Monitoring Report. Report No. 694/6-01. Prepared for Teck Alaska, Inc., April 2014

TAK, 2014. GoldSim Model: "RedDogTailingsDam_Quantity Only(May212014).gsm".

SRK, 2014a. Memorandum: "Red Dog Water and Load Balance – Key Inputs and Assumptions", August 02, 2014.

SRK, 2014b. Memorandum: "Red Dog Water and Load Balance – Water Balance Results under Variable Climate Conditions", TBD, 2014.

SRK, 2016c. SRK Tailings and Water Management Plan.

SRK appreciates the opportunity to work with TAK on the Red Dog project. Please contact me at (604) 601-8405 with comments or questions on this document.

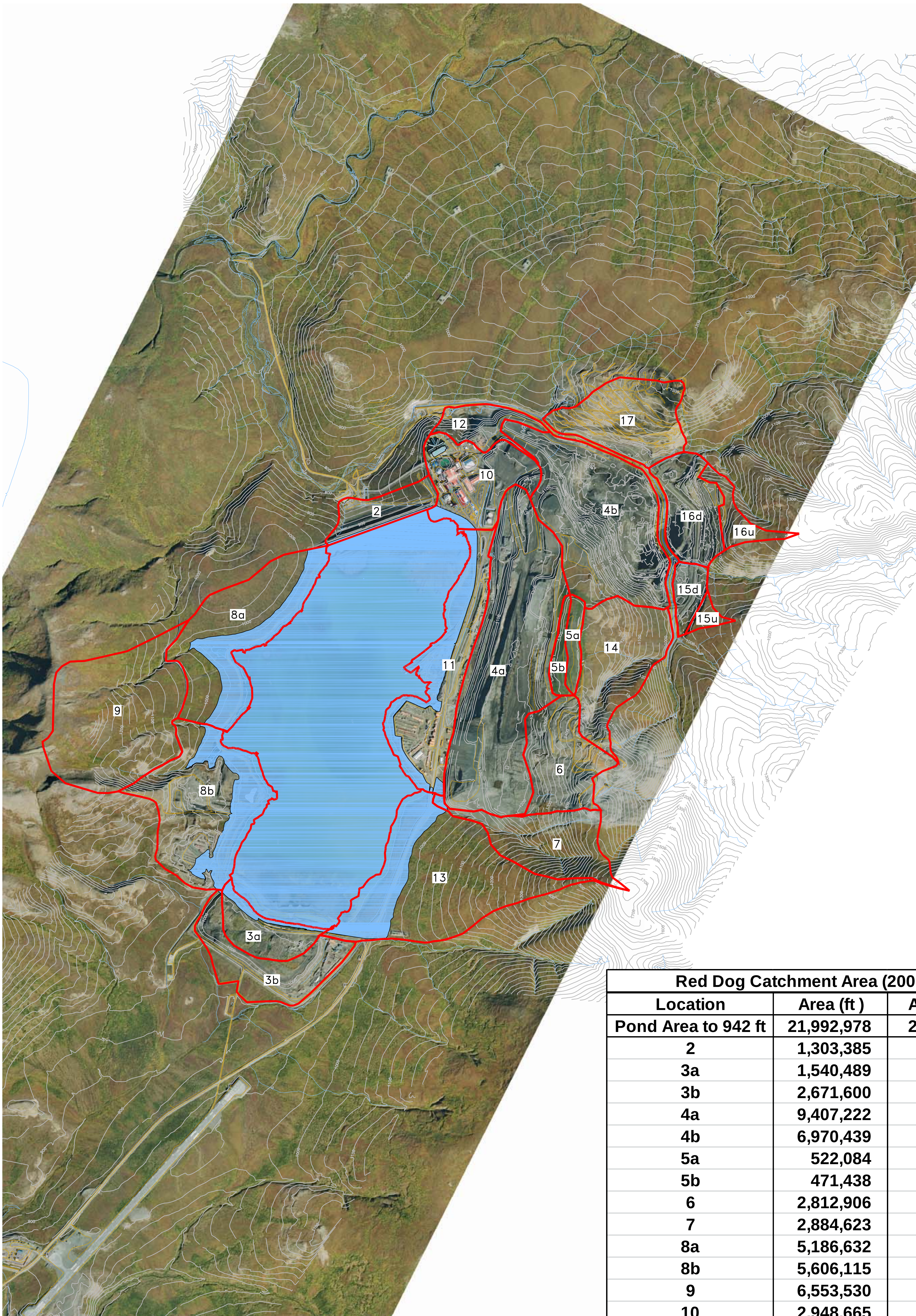
Regards,
SRK Consulting (Canada) Inc.

Kelly Sexsmith, MS. PGeo
Principal Consultant, Environmental Geochemistry

For

Kathleen Willman, PEng
Senior Consultant

Appendix A: Figures



Red Dog Catchment Area (2006)		
Location	**Area (ft)**	**Area (m)**
Pond Area to 942 ft	**21,992,978**	**2,043,000**
2	**1,303,385**	**121,000**
3a	**1,540,489**	**143,000**
3b	**2,671,600**	**248,000**
4a	**9,407,222**	**874,000**
4b	**6,970,439**	**648,000**
5a	**522,084**	**49,000**
5b	**471,438**	**44,000**
6	**2,812,906**	**261,000**
7	**2,884,623**	**268,000**
8a	**5,186,632**	**482,000**
8b	**5,606,115**	**521,000**
9	**6,553,530**	**609,000**
10	**2,948,665**	**274,000**
11	**4,502,813**	**418,000**
12	**1,152,357**	**107,000**
13	**7,127,118**	**662,000**
14	**3,573,318**	**332,000**
15	**985,009**	**92,000**
16	**3,024,347**	**281,000**
17	**3,160,360**	**294,000**

0 500 1000

1"=1000 FEET

Red Dog Mine

REVISIONS		
REV.	DESCRIPTION	DATE

FILE NAME: Figures A-1 and A-2.dwg

DESIGN: KSS
DRAWN: KSS/IJC
REVIEWED: KSS
APPROVED: KSS

IF THE ABOVE BAR DOES NOT MEASURE 1 INCH, THE DRAWING SCALE IS ALTERED

PREPARED BY: srk consulting

PROJECT:

RED DOG MINE
FUTURE PREDICTIONS OF FLOW AND CHEMISTRY

DRAWING TITLE:

CATCHMENTS AREAS
2006 SITE CONDITIONS

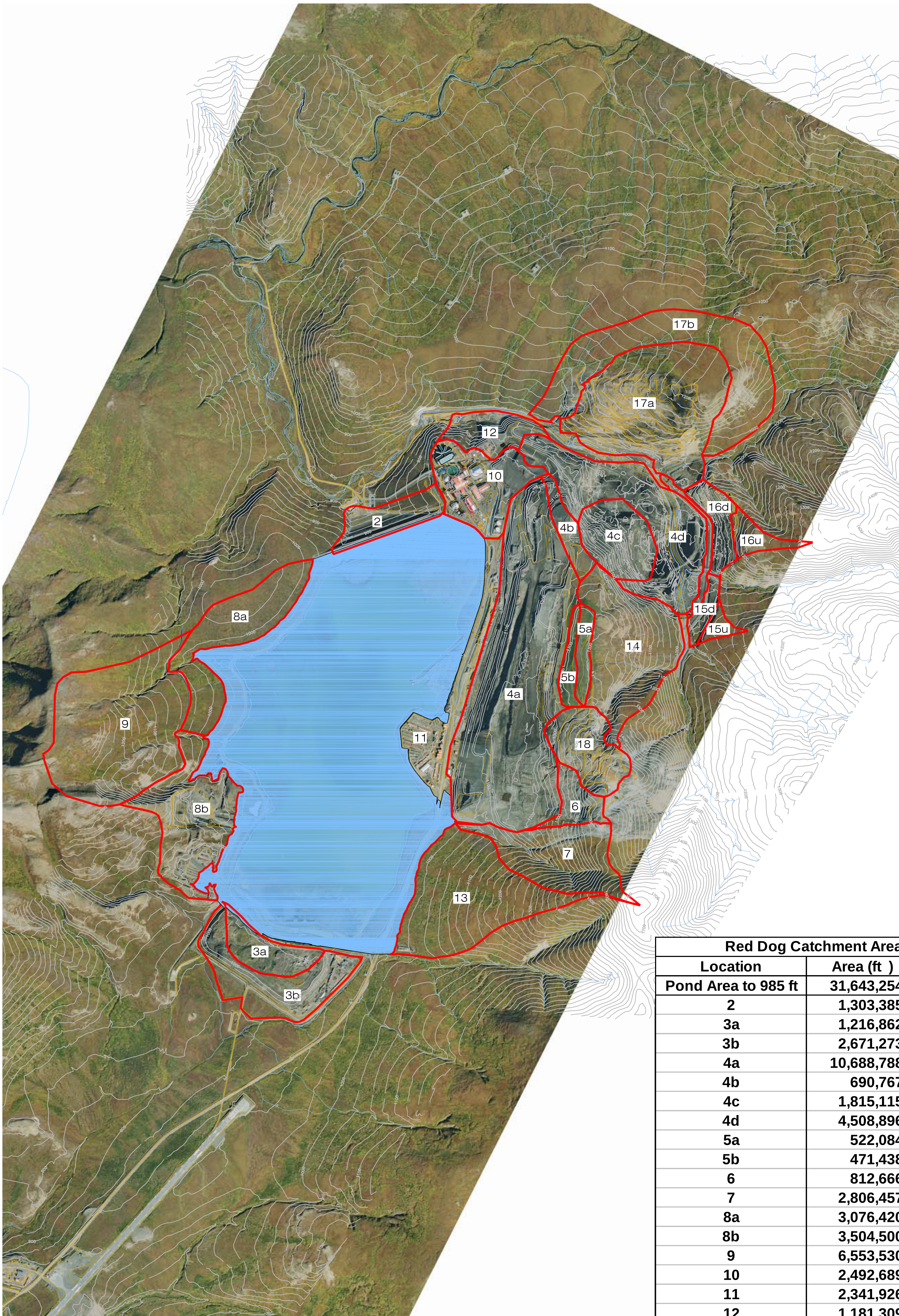
DATE: OCTOBER 2014

REVISION: ---

SRK PROJECT NO.: 329100.030

DRAWING NO.: A-1

P:\Teck Alaska - Red_Dog\329100.030 IWMP\329100.030 IWMP\040_AutoCAD_GIS\Water and Tailings Figures\Figures A-1 and A-2.dwg



Red Dog Catchment Area (2031)		
Location	Area (ft)	Area (m)
Pond Area to 985 ft	31,643,254	2,939,754
2	1,303,385	121,000
3a	1,216,862	113,050
3b	2,671,273	248,169
4a	10,688,788	993,021
4b	690,767	64,174
4c	1,815,115	168,624
4d	4,508,896	418,876
5a	522,084	48,503
5b	471,438	43,798
6	812,666	75,499
7	2,806,457	260,728
8a	3,076,420	285,809
8b	3,504,500	325,579
9	6,553,530	608,843
10	2,492,689	231,578
11	2,341,926	217,572
12	1,181,309	109,747
13	4,833,881	449,082
14	4,117,179	382,498
15d	413,076	38,376
15u	277,345	25,766
16d	885,823	82,296
16u	570,476	52,999
17a	6,048,744	561,947
17b	4,769,989	443,146
18	1,810,324	168,185

0 500 1000
1"=1000 FEET

Red Dog Mine

REVISIONS		
REV.	DESCRIPTION	DATE

FILE NAME: Figures A-1 and A-2.dwg

DESIGN: KSS
DRAWN: KSS/IJC
REVIEWED: KSS
APPROVED: KSS

IF THE ABOVE BAR DOES NOT MEASURE 1 INCH, THE DRAWING SCALE IS ALTERED

PREPARED BY: srk consulting

PROJECT:
RED DOG MINE
FUTURE PREDICTIONS OF FLOW AND CHEMISTRY

DRAWING TITLE:
CATCHMENTS AREAS
SITE CONDITIONS AT CLOSURE

DATE: OCTOBER 2014
REVISION: ---
DRAWING NO.: A-2
SRK PROJECT NO.: 329100.030

P:\Teck Alaska - Red_Dog\329100.030 IWMP\329100.030 IWMP\040_AutoCAD_GIS\Water and Tailings Figures\Figures A-1 and A-2.dwg

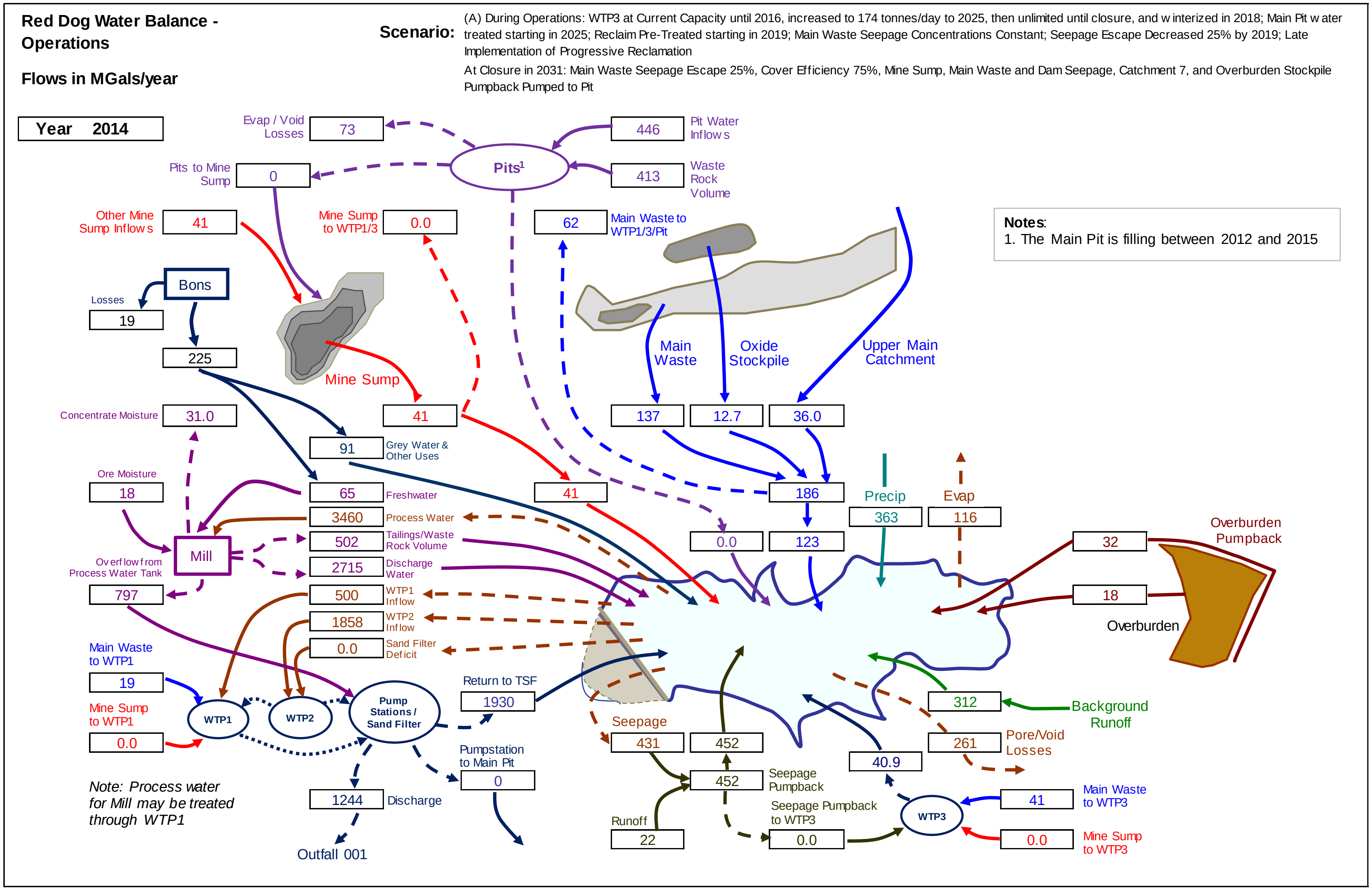


Figure A- 3: Operational Water Balance – Year 2014

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

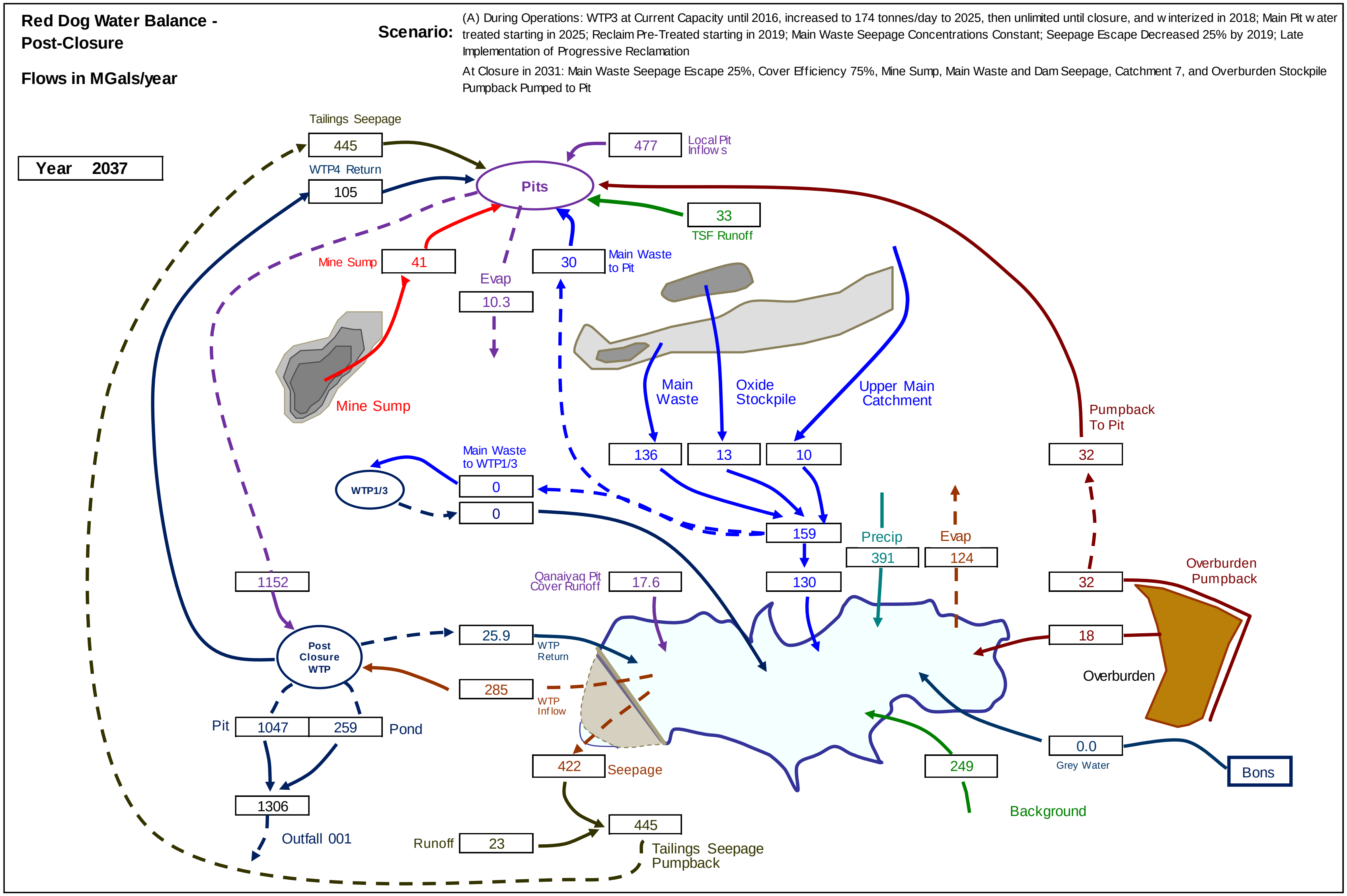


Figure A- 4: Post-Closure Water Balance for 2031 Closure – Year 2037

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

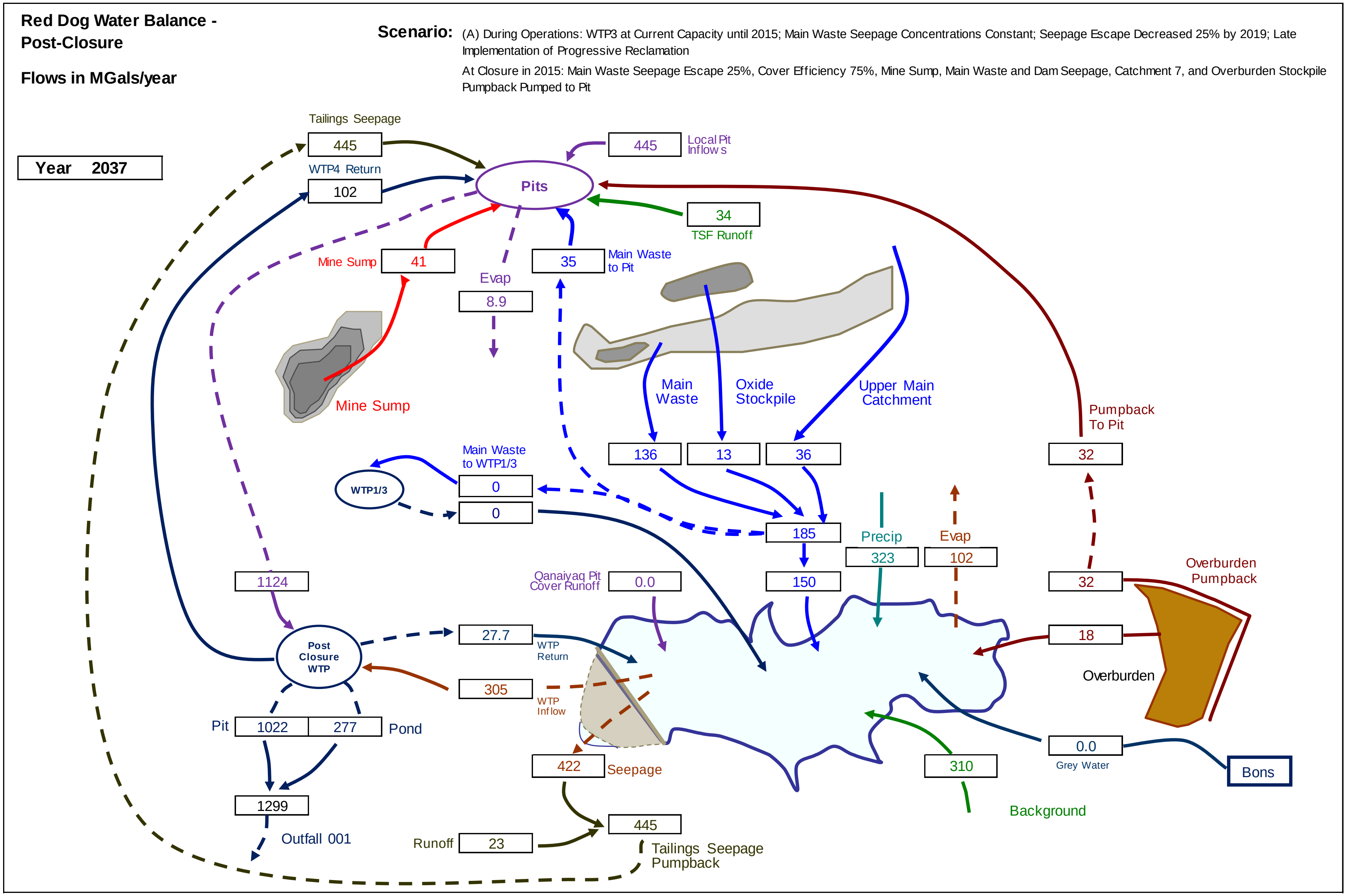


Figure A- 5: Post-Closure Water Balance for 2015 Closure – Year 2037

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

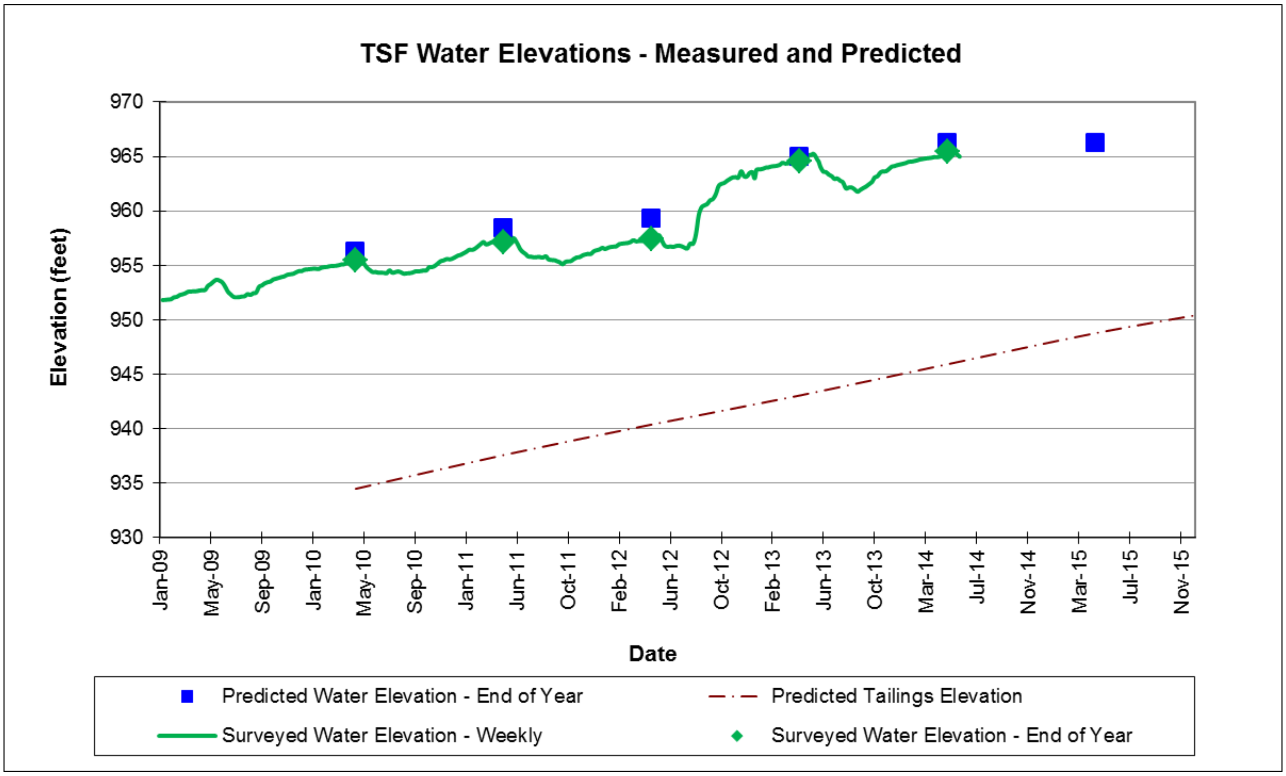


Figure A- 6: Comparison of Measured and Predicted TSF Elevations

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

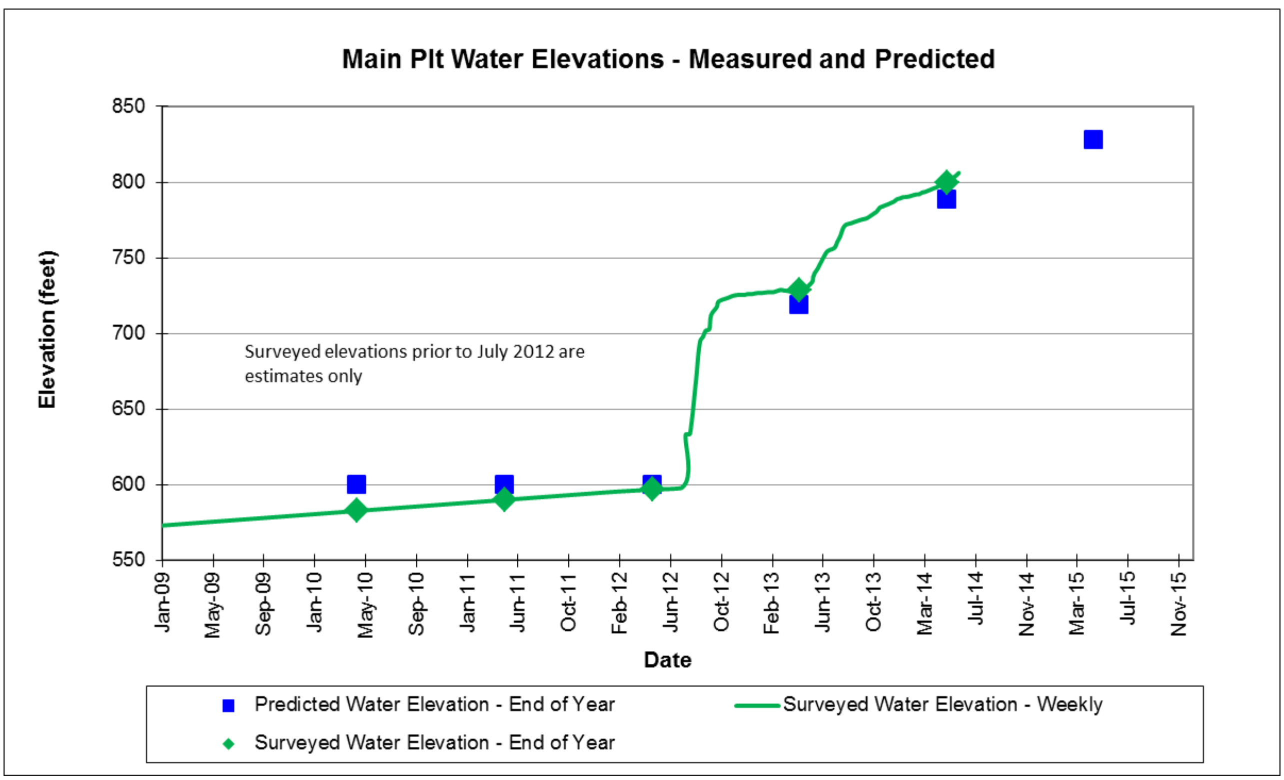


Figure A- 7: Comparison of Measured and Predicted Main Pit Water Elevations

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

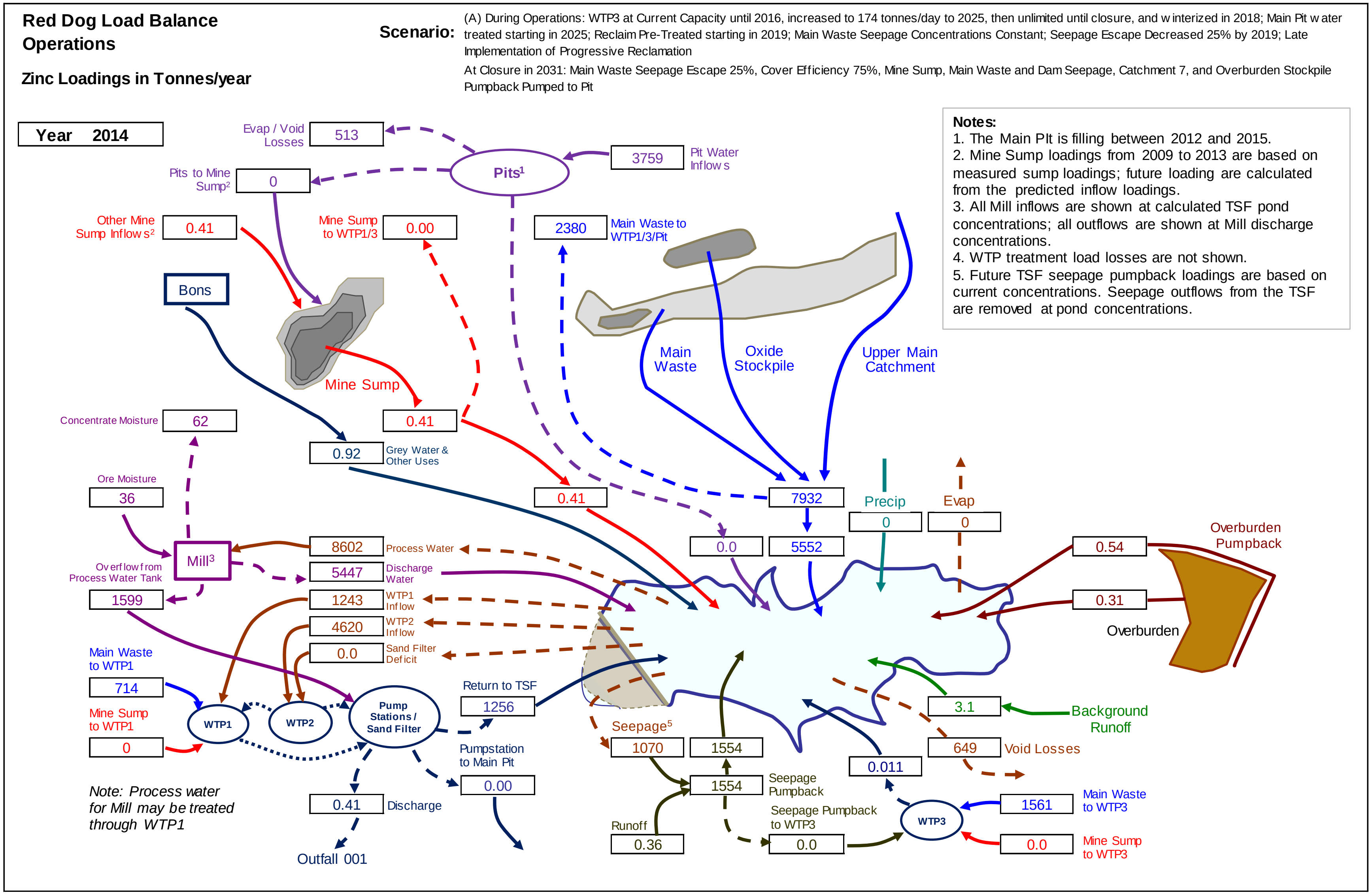


Figure A- 8: Operational Zinc Load Balance – Year 2014

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

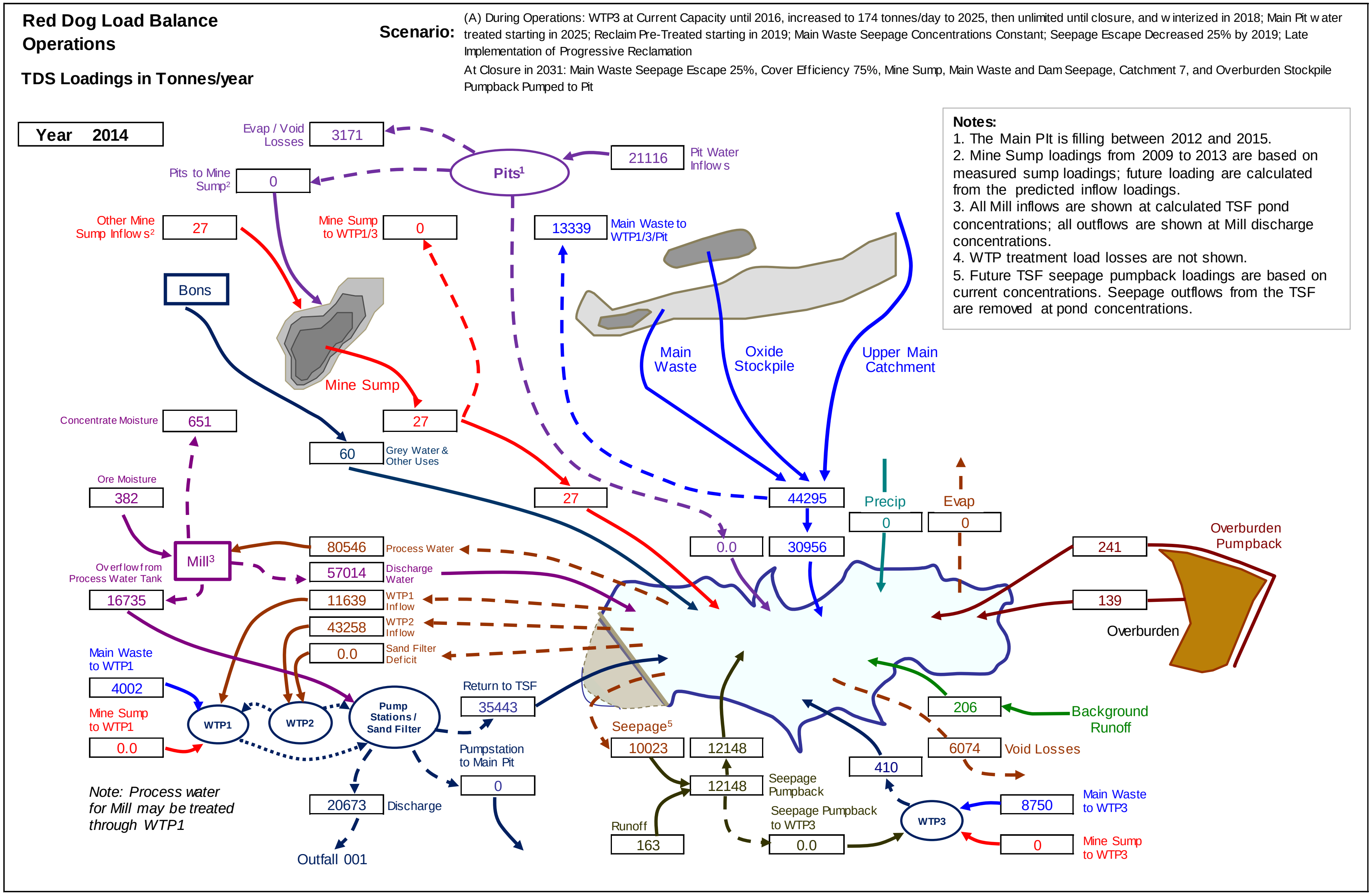
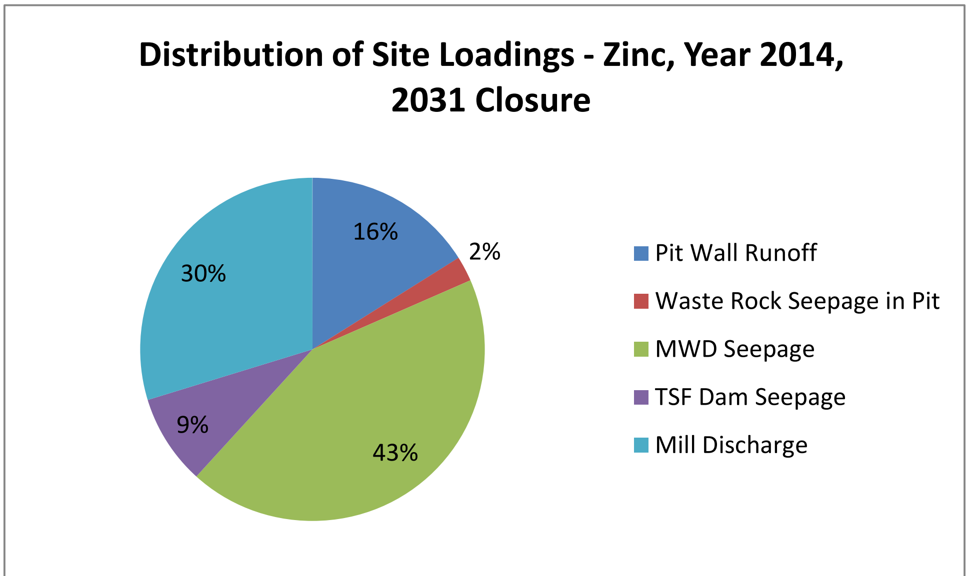


Figure A- 9: Operational TDS Load Balance – Year 2014

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm



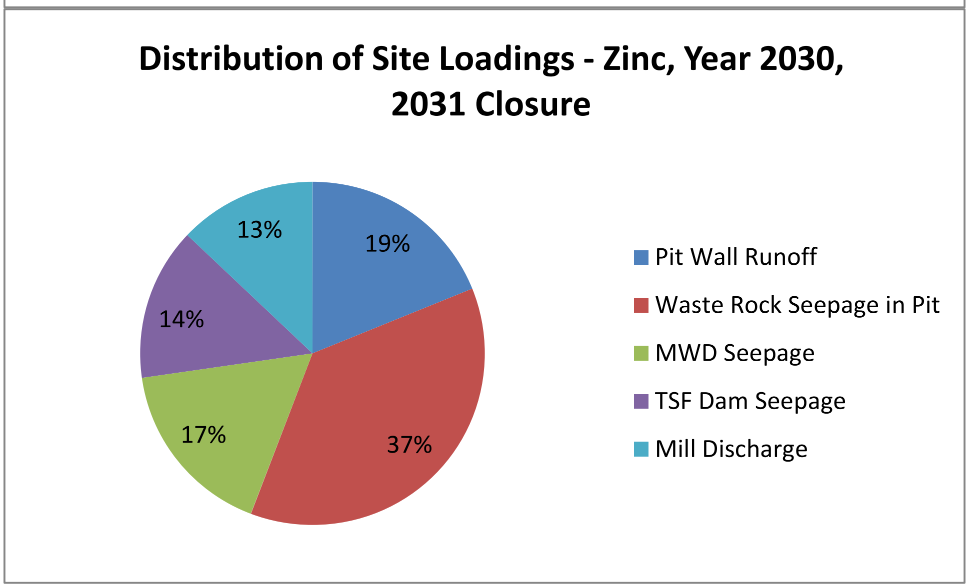


Figure A- 10: Distribution of Zinc Loadings During Operations

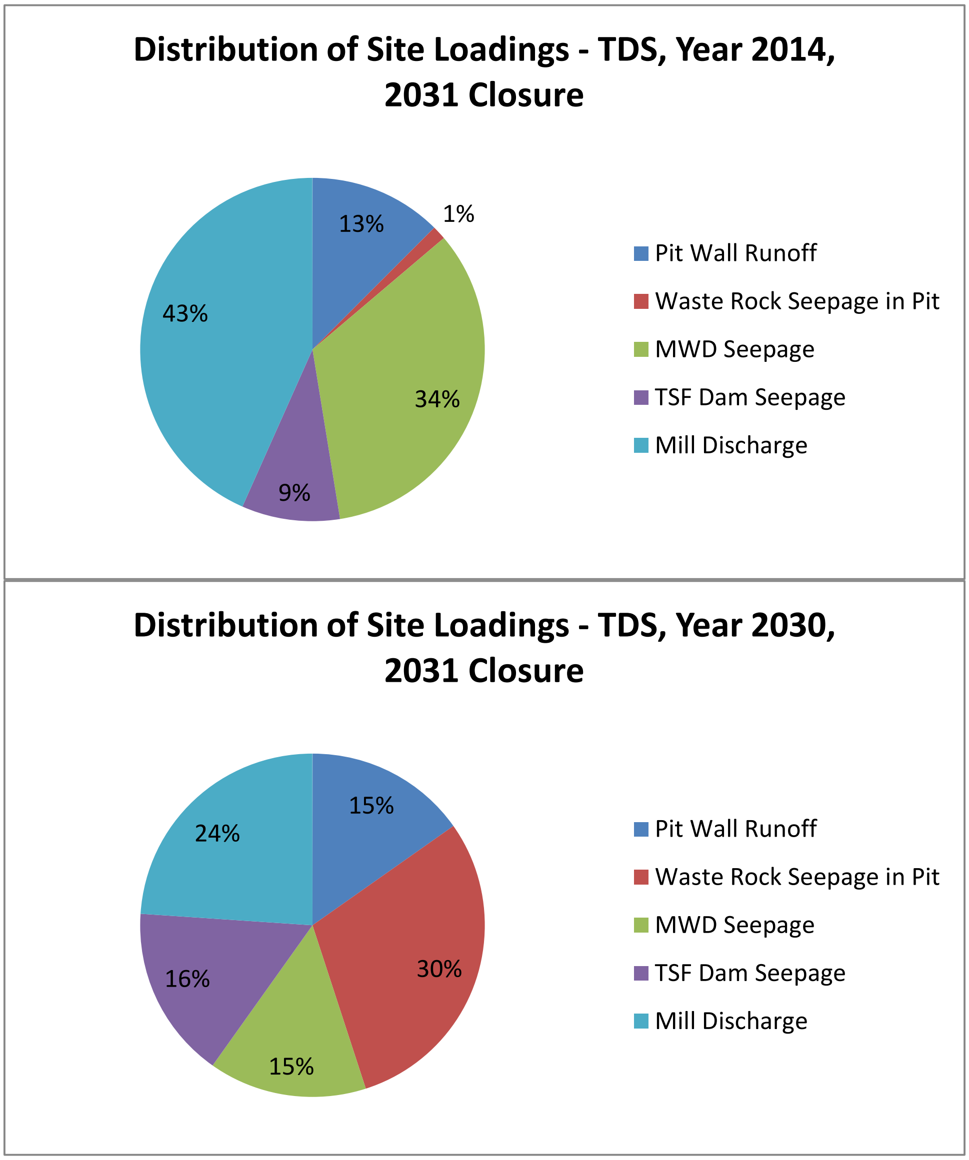


Figure A- 11: Distribution of TDS Loadings During Operations

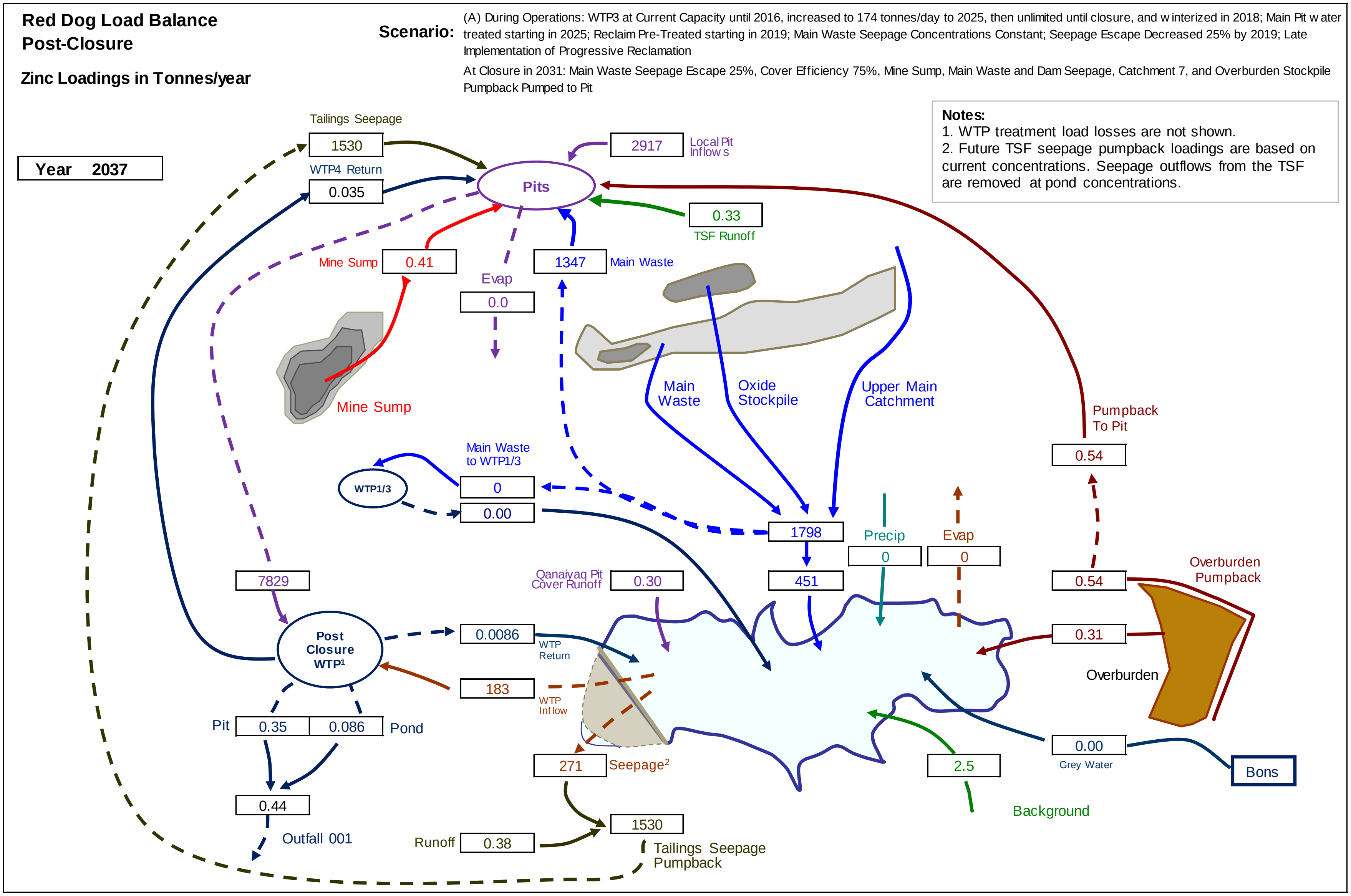


Figure A- 12: Post-Closure Zinc Load Balance for 2031 Closure – Year 2037

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

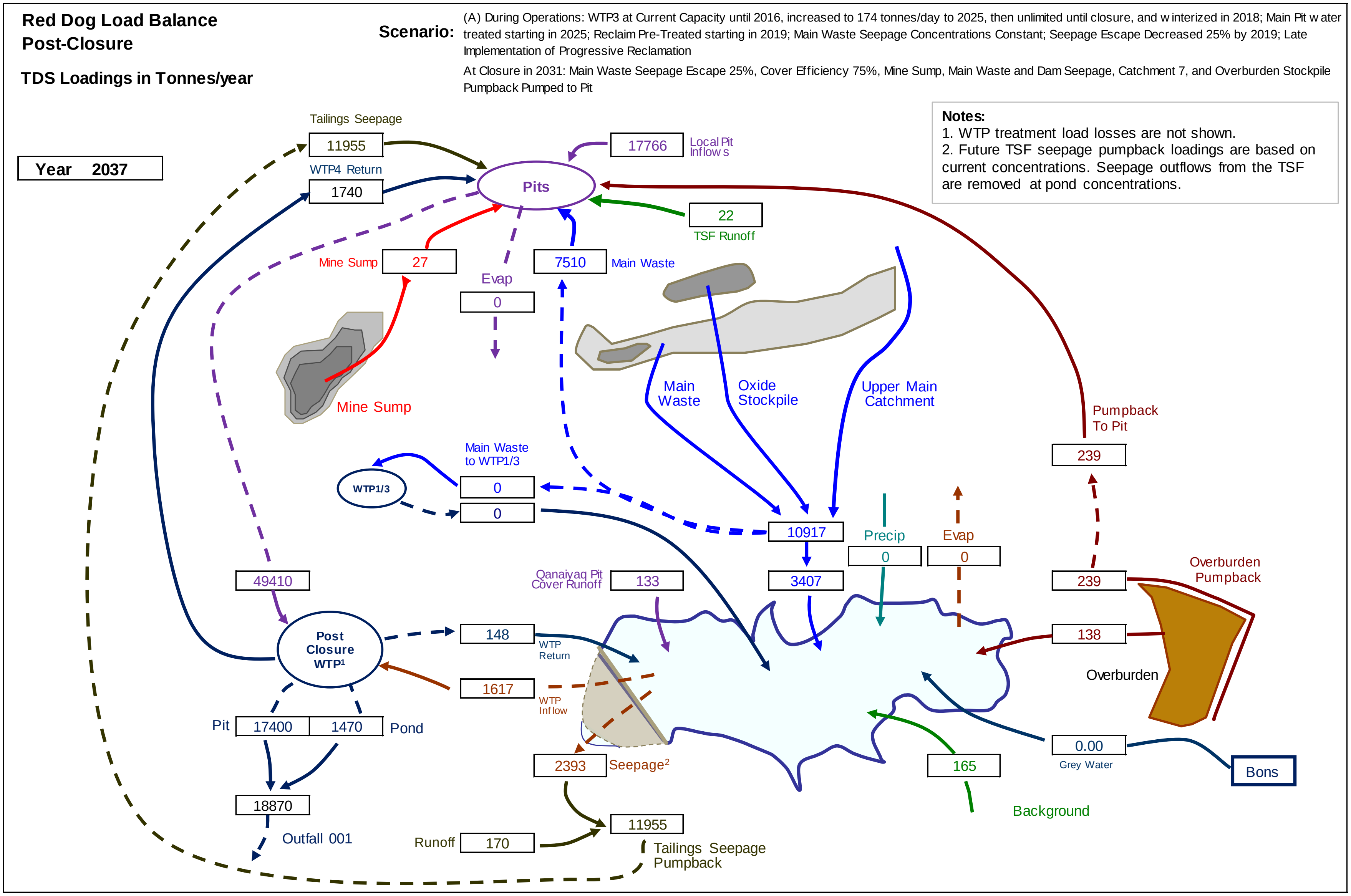


Figure A- 13: Post-Closure TDS Load Balance for 2031 Closure – Year 2037

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

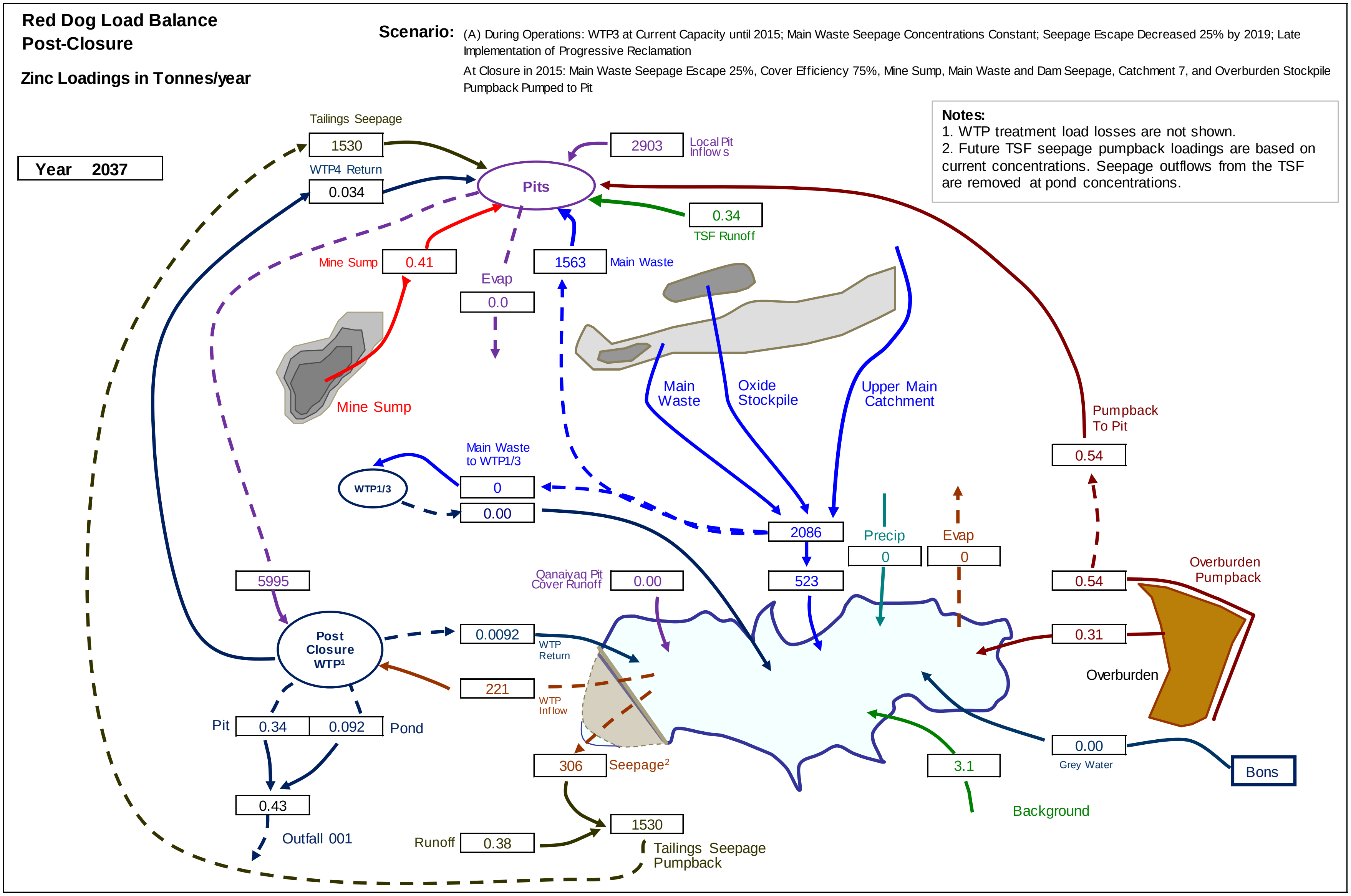


Figure A- 14: Post-Closure Zinc Load Balance for 2015 Closure – Year 2037

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

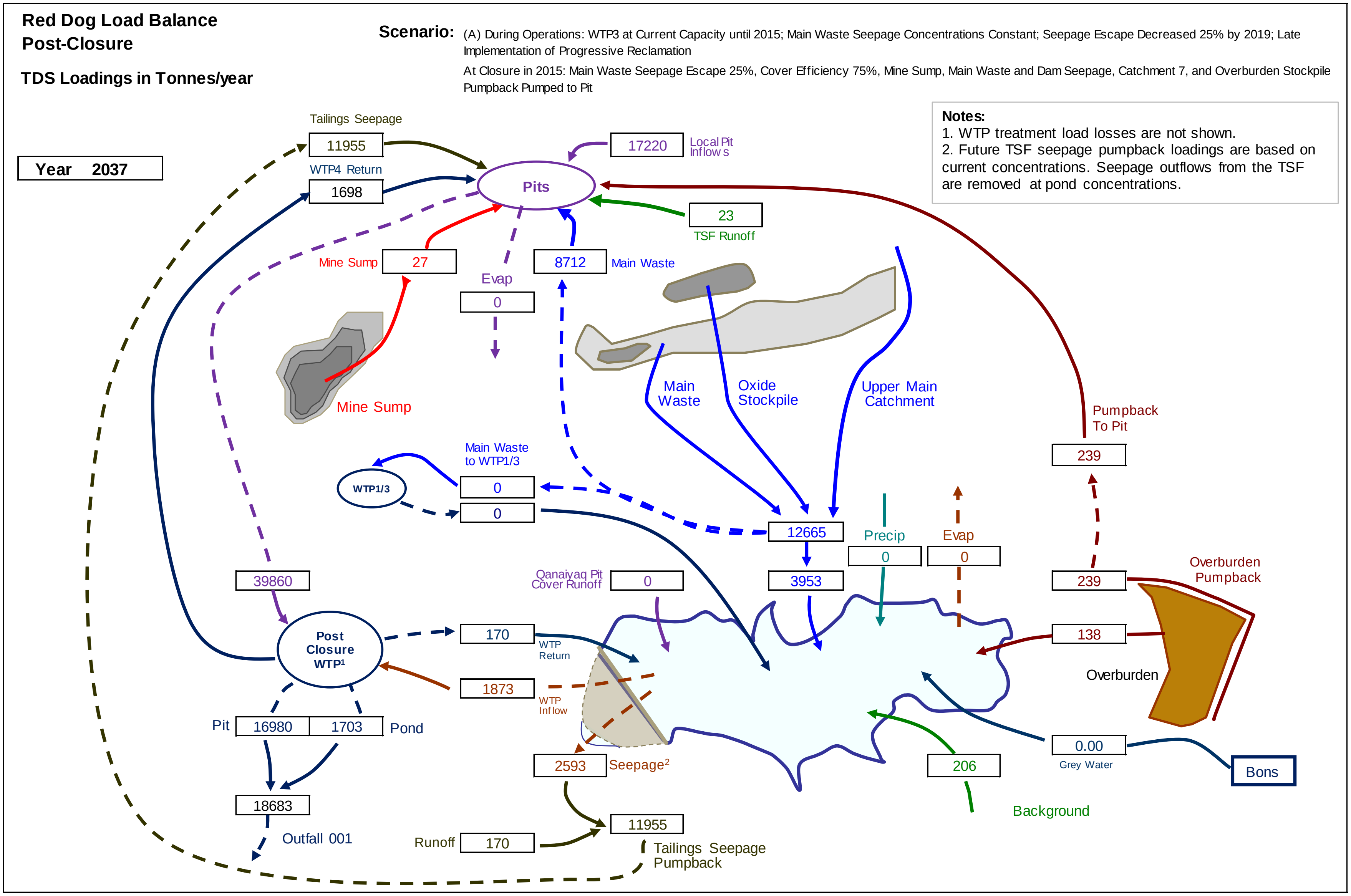


Figure A- 15: Post-Closure TDS Load Balance for 2015 Closure – Year 2037

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

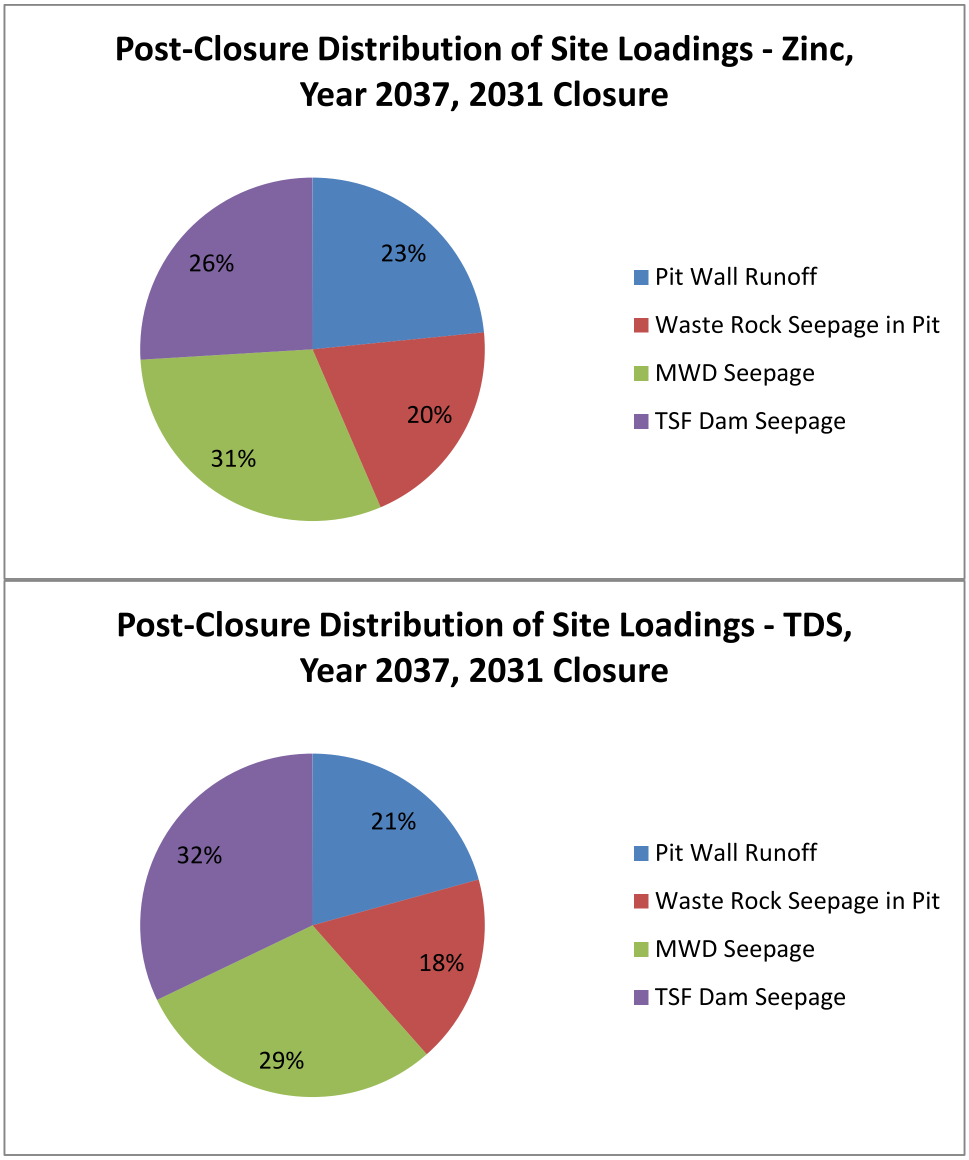
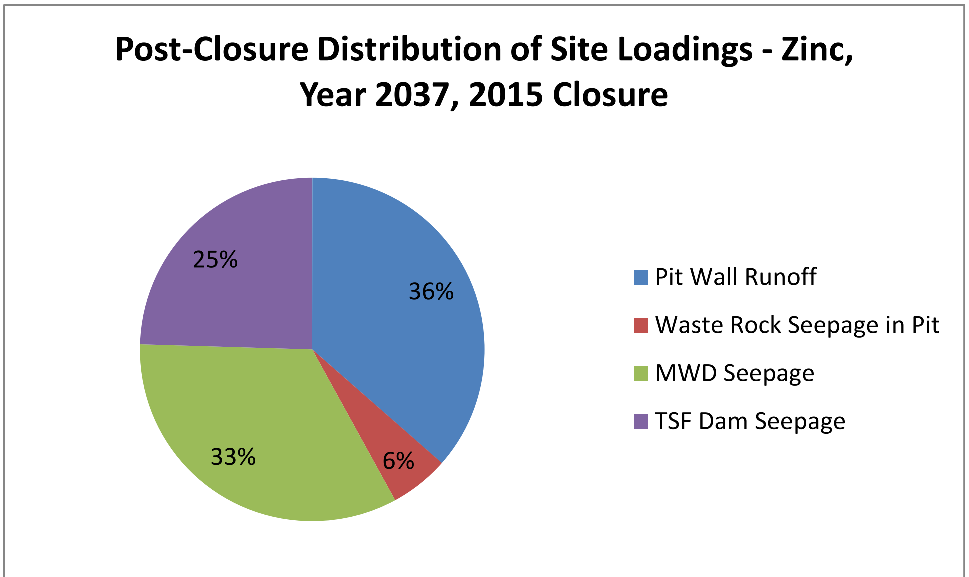


Figure A- 16: Distribution of Post-Closure Zinc and TDS Loadings – 2031 Closure



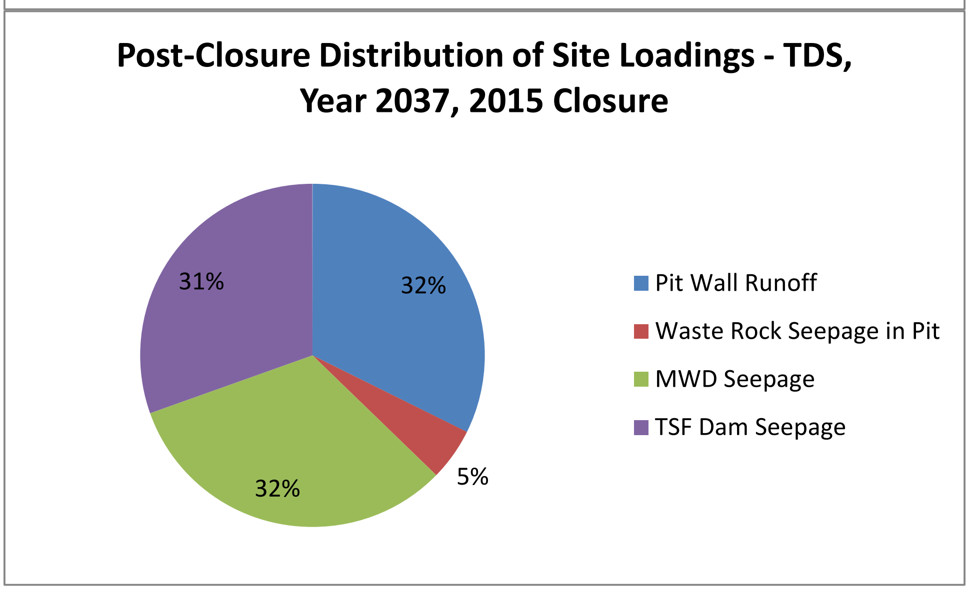


Figure A- 17: Distribution of Post-Closure Zinc and TDS Loadings – 2015 Closure

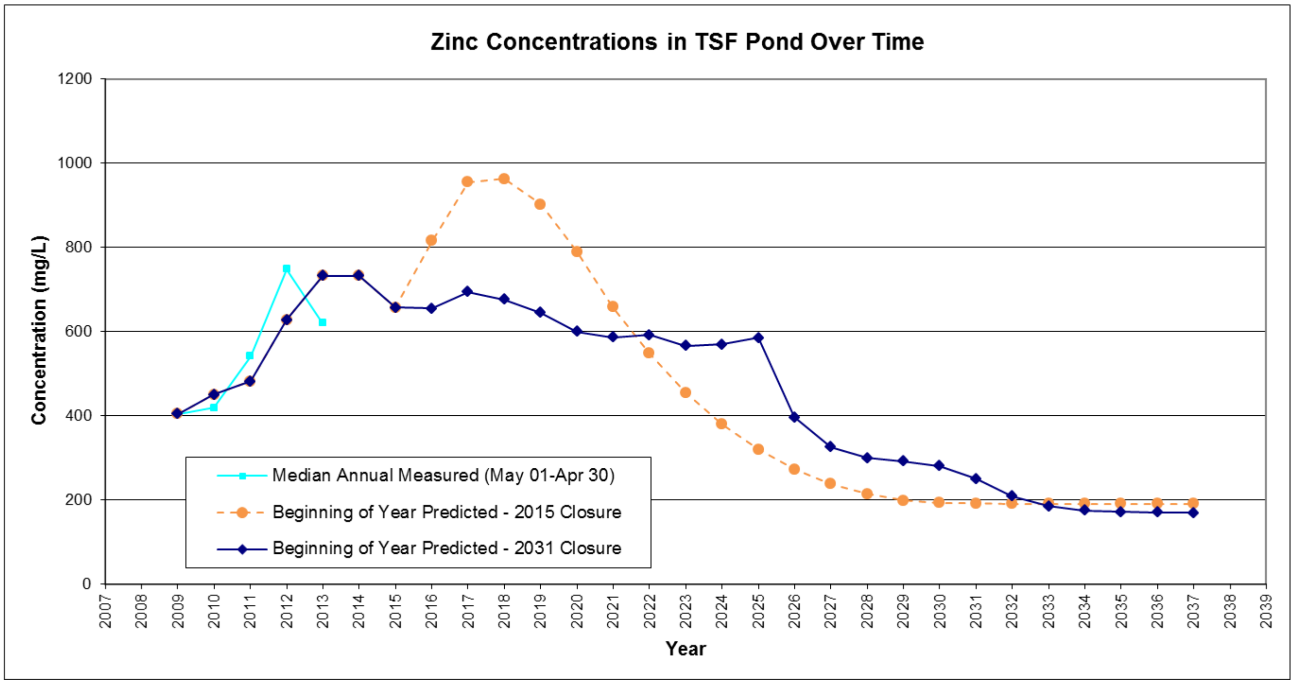


Figure A- 18: Predicted and Measured Zinc Concentrations in TSF Pond Over Time

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

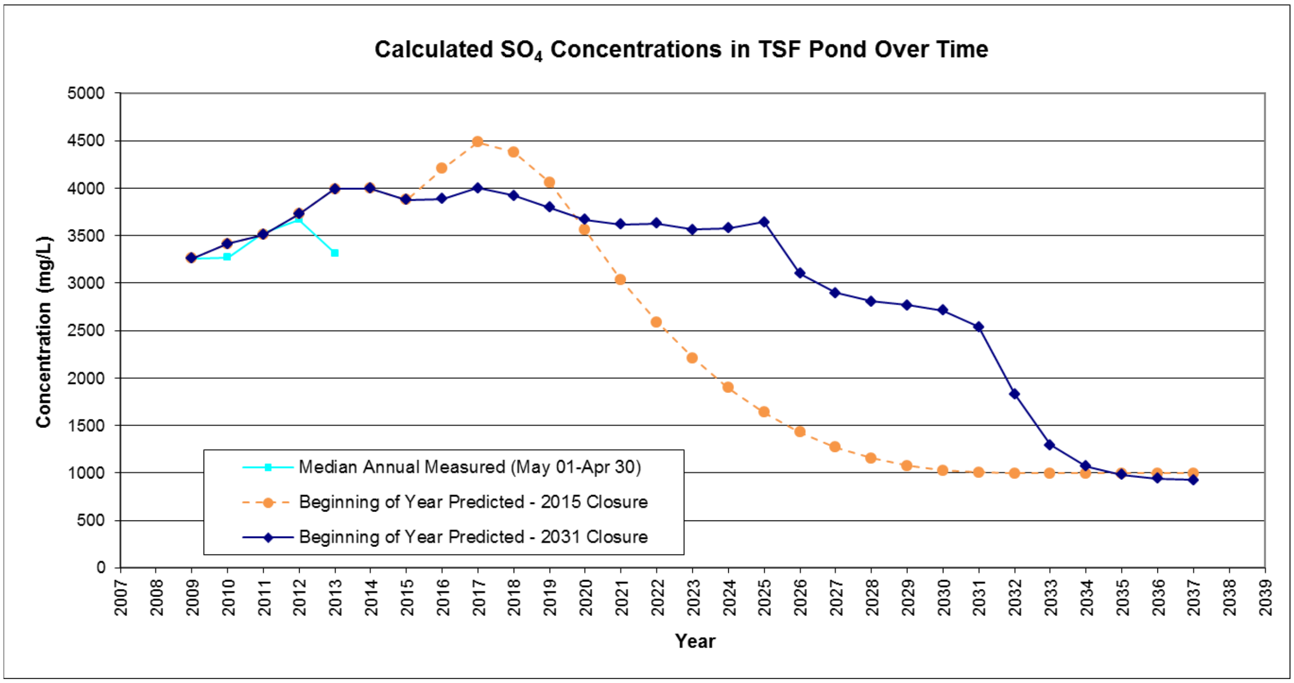


Figure A- 19: Predicted and Measured Calculated Sulfate Concentrations in TSF Pond Over Time

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

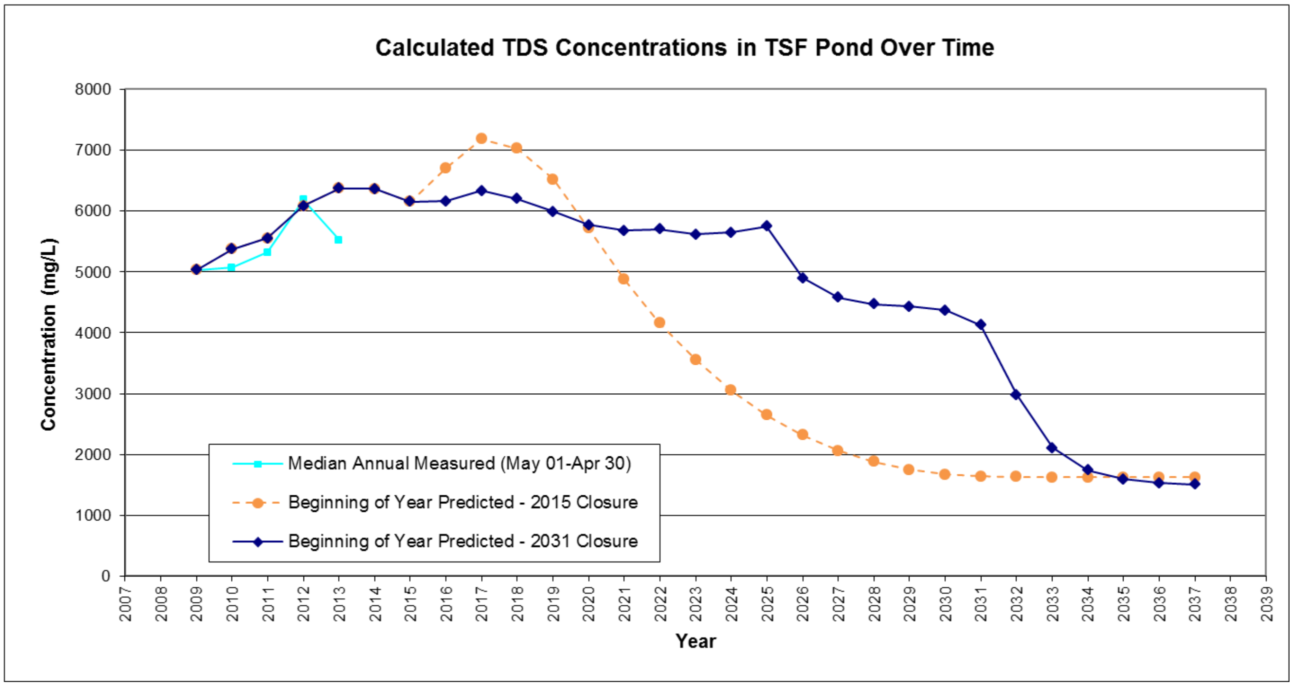


Figure A- 20: Predicted and Measured TDS Concentrations in TSF Pond Over Time

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

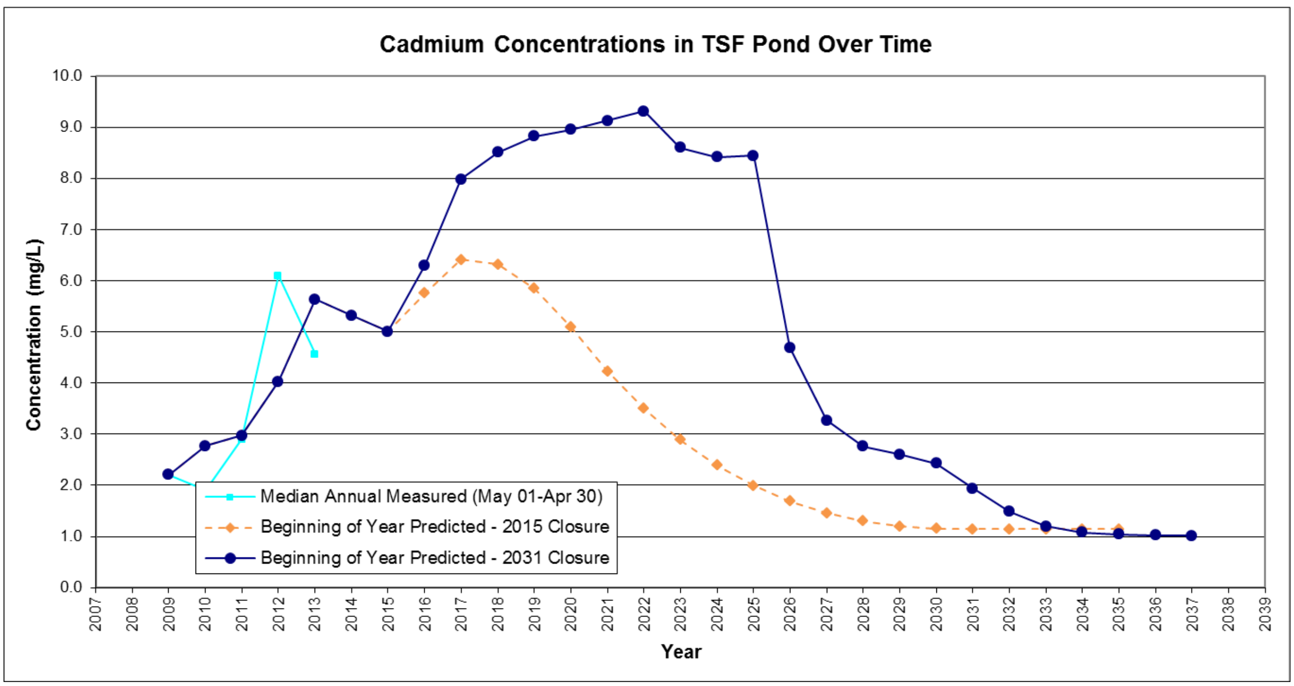


Figure A- 21: Predicted and Measured Cadmium Concentrations in TSF Pond Over Time

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

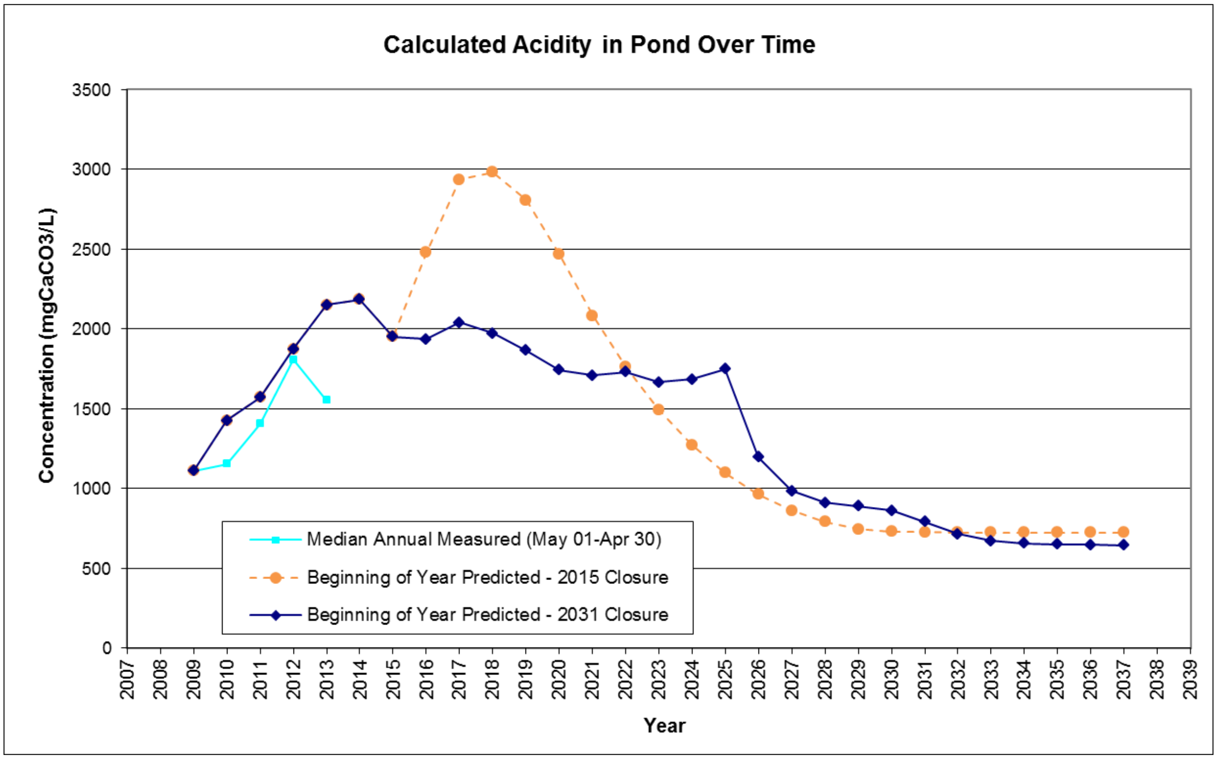


Figure A- 22: Predicted and Measured Calculated Acidity Concentrations in TSF Pond Over Time

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

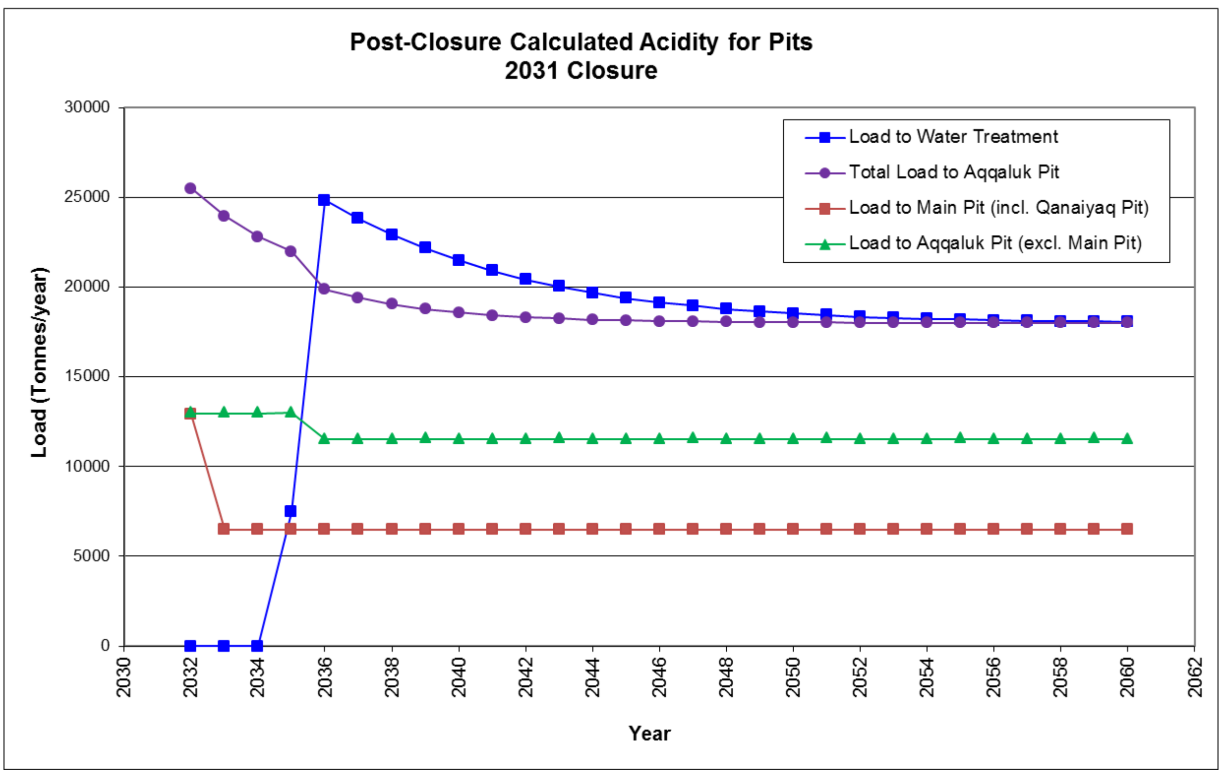


Figure A- 23: Post-Closure Calculated Acidity for Pits – 2031 Closure

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

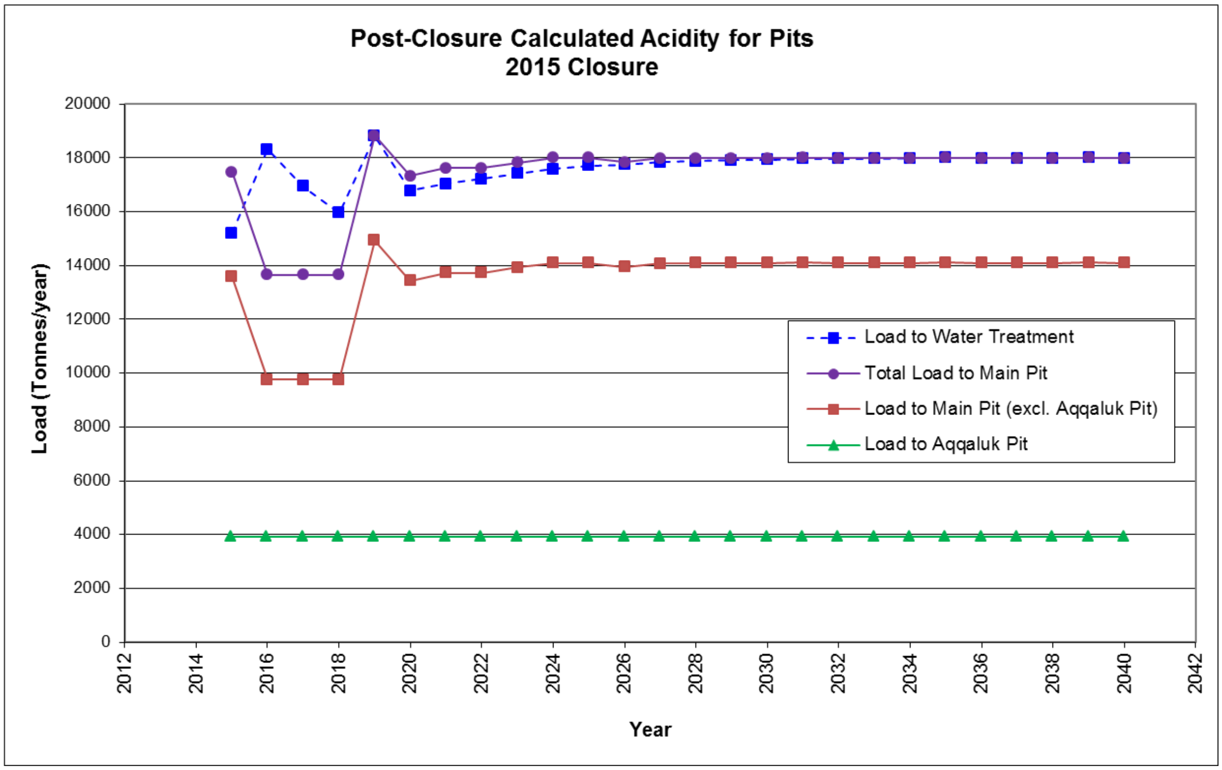


Figure A- 24: Post-Closure Calculated Acidity for Pits – 2015 Closure

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

Appendix B: Source Term Tables

Table B- 1: Table of Initial and Constant Values

Input Parameters	Source of Data	Units	Value
Initial Tailings Pond Level (based on surveyed water level)	GoldSim	feet	953.1
Initial Accumulated Tailings / Waste Rock Volume in Tailings Pond	GoldSim	MGals	6041
Estimated % of MWD Seepage Captured to WTP1	GoldSim	%	30%
Percent of Discharge for Sand Filter Backwash	GoldSim	%	3.1%
Start Date of Flooding Main Pit	GoldSim	date	5/1/2012
Initial Main Pit Volume	GoldSim	MGals	164
Initial Main Pit Solids Volume	GoldSim	MGals	0
Maximum Main Pit Volume	GoldSim	MGals	3240[15]
Initial Aqqaluk Pit Volume	Assumed value[16]	MGals	10
Maximum Aqqaluk Pit Volume – 2031 Closure	SRK volume calculations at 845 feet	MGals	4997[17]
Maximum Aqqaluk Pit Volume – 2015 Closure	SRK volume calculations at 845 feet	MGals	353
Premature Closure Year	TAK/SRK	YYYY	2015
Normal Closure Year	TAK 2014 LOM Plan	YYYY	2031
Qanaiyaq Pit Online - Dewatered to Main Pit	TAK 2014 LOM Plan	YYYY	2018
Qanaiyaq Pit Backfill Begins	TAK 2014 LOM Plan	YYYY	2023
Qanaiyaq Pit Backfill Ends	TAK 2014 LOM Plan	YYYY	2031

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

[15] Maximum volume and freeboard for Main Pit to be verified by TAK.
[16] Aqqaluk Pit is assumed to be empty at start of model. Initial value of 10 MGals is applied to allow concentration calculations.
[17] Maximum volume and freeboard for Aqqaluk Pit to be verified by TAK.

Table B- 2: Dashboard Parameters – 2031 Closure

Parameter	Units	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Precipitation - Avg of 22.1 in/yr constant	inches/year	21.4	15.0	20.9	37.2	34.6	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1
Discharge to Outfall 001 Criteria:																										
Outfall 001 Discharge from WTP2 (pond w ater)	MGals/yr	936.1	796.2	1294.0	311.0	1308.0	1244.0	1244.0	1244.0	1396.0	1396.0	1550.0	1550.0	1550.0	1550.0	1550.0	1550.0	1550.0	1550.0	1550.0	1507.2	1488.3	1550.0	615.0	259.2	259.4
Outfall 001 Discharge from WTP4 (pit w ater)	MGals/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Annual Water Inflow to Pond	MGals/yr	1061.2	717.0	1018.5	991.9	1073.2	736.9	1146.9	1437.5	1433.2	1442.9	1444.6	1449.3	1435.5	1259.8	1259.0	1258.9	1259.9	1261.0	1260.3	1260.1	1288.3	1369.3	249.2	259.2	259.4
Water Cover = 2 - 4 feet	feet	21.7	20.8	18.9	21.9	20.3	17.4	16.7	17.3	17.2	17.2	16.4	15.7	15.0	13.5	12.0	10.6	9.2	7.8	6.4	5.3	4.4	3.6	2.0	2.0	2.0
Minimum Free Water Volume	MGals	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	1800	1600	1400	1200	1000	800	300	300	300
End of Year Free Water Volume >= Minimum Volume	MGals	3744	3665	3389	4070	3835	3328	3231	3425	3462	3509	3403	3303	3188	2898	2607	2316	2026	1737	1447	1200	1000	819	453	453	453
End of Year Water Elevation	feet	956.2	958.4	959.3	965.0	966.2	966.2	967.8	970.8	972.8	974.9	976.2	977.6	978.8	979.3	979.8	980.2	980.6	981.1	981.5	982.1	982.7	982.6	981.0	981.0	981.0
End of Year Tailings Elevation	feet	934.5	937.6	940.4	943.1	945.9	948.8	951.2	953.5	955.6	957.7	959.9	961.9	963.9	965.8	967.7	969.6	971.5	973.3	975.1	976.8	978.3	979.0	979.0	979.0	979.0
Dam Crest Elevation Criteria:																										
Dam Crest Elevation[1]	feet	970	970	970	970	976	976	976	986	986	986	986	986	986	986	986	986	986	1000	1000	1000	1000	1000	1000	1000	1000
Freeboard = 5.3 feet minimum[2]	feet	13.8	11.6	10.7	5.0	9.8	9.8	8.2	15.2	13.2	11.1	9.8	8.4	7.2	6.7	6.2	5.8	5.4	15.9	15.5	14.9	14.3	14.4	16.0	16.0	16.0
Main Waste/Oxide Stockpile Options:																										
Percentage of Main Waste Dump Covered	%	0%	0%	0%	0%	0%	0%	0%	0%	25%	63%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Percentage of Oxide Stockpile Covered	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Cover Efficiency - Main Waste / Oxide Stockpiles	%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
MWD Seepage Escape Rate	%	88%	89%	85%	69%	71%	70%	55%	55%	45%	45%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
MWD Seepage to Pit, WTP1/3 or Tailings? Pit)		WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	Pit	Pit	Pit
Cover Runoff to WTP1/3, Tailings or Pit?		WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings
Main Pit Options:																										
Percentage of Waste Rock Covered	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	25%	25%	25%	25%	25%	25%	100%
Cover Efficiency - Waste Rock in Pit	%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Pit Wall Runoff Concentrations Current or Increasing?		Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current
Groundw ater Inflow	MGals/yr	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
Flow s to Mine Sump, Tailings, Aqqaluk Pit or WTP4? (begins flooding in 5/2012)		Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Aqqaluk Pit	Aqqaluk Pit	Aqqaluk Pit
Aqqaluk Pit Options:																										
Pit Area Set to Stormw ater Runoff or Pit Wall Concentrations?		Runoff	Runoff	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall
Pit Wall Runoff Concentrations Current or Increasing?		Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current
Allow Pit to Flood?	Yes/No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes
Groundw ater Inflow	MGals/yr	0	0	0	0	0	0	0	0	0	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Qanaiyaq Pit Options: (2031 Closure Only)																										
Percentage of Waste Rock Covered	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	100%	100%
Cover Efficiency - Waste Rock in Pit	%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Pit Area Set to Stormw ater Runoff or Pit Wall Concentrations?		Runoff	Runoff	Runoff	Runoff	Runoff	Runoff	Runoff	Runoff	Runoff	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall
Pit Wall Runoff Concentrations Current or Increasing?		Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current
Direction of Flows:																										
Runoff from TSF Catchment 7 Pumped to Pit or Tailings?		Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Pit	Pit	Pit
Overburden Stockpile Pumpback Pumped to Pit or Tailings?		Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Pit	Pit	Pit
Mine Sump Pumped to Pit, WTP1/3 or Tailings?		WTP1/3	WTP1/3	WTP1/3	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	Pit	Pit	Pit
Dam Seepage Pumped to Pit or Tailings?		Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Pit	Pit	Pit
Water Treatment Options:																										
WTP3 Flow Capacity (Current at 1500 gpm)		Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	N/A	N/A
WTP3 Lime Slaking Capacity	Tonnes/day	70	70	70	70	70	70	70	174	174	174	174	174	174	174	174	174	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	N/A	N/A
WTP3 Operation - Seasonal or Year-Round?		Seasonal	Seasonal	Seasonal	Seasonal	Seasonal	Seasonal	Seasonal	Seasonal	Seasonal	Year-Round	Year-Round	Year-Round	Year-Round	Year-Round	Year-Round	Year-Round	Year-Round	Year-Round	Year-Round	Year-Round	Year-Round	Year-Round	Year-Round	N/A	N/A
WTP2 Treatment Ratio (Inflow/Discharge) - 2031 Closure		Based on GoldSim Model																						1.1	1.1	1.1
WTP4 Treatment Ratio (Inflow/Discharge)		N/A																						1.1	1.1	1.1
WTP4 Return Flow to Pit or Tailings?		N/A																						Pit	Pit	Pit
Number of Days of Treatment of Reclaim Water to Mill	Days	0	0	0	0	0	0	0	0	0	0	80	80	80	80	80	80	80	80	80	80	80	80	0	0	0

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

Notes: 1. The 1000-foot dam crest is an option TAK is considering to address the potential need for an increase above the 986-foot dam crest prior to 2031. The spillway would be located at 997 feet.

2. Freeboard = depth from water level to dam crest or spillway; proposed final spillway elevation of 997 feet

Table B- 3: Dashboard Parameters – 2015 Closure

Parameter	Units	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Precipitation - Avg of 22.1 in/yr constant	inches/year	21.4	15.0	20.9	37.2	34.6	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1	22.1
Discharge to Outfall 001 Criteria:																										
Outfall 001 Discharge from WTP2 (pond w ater)	Mgals/yr	936.1	796.2	1294.0	311.0	1308.0	1244.0	504.1	256.9	408.9	408.9	388.3	528.2	528.2	528.2	527.0	528.2	528.2	528.2	527.0	528.2	325.7	277.2	276.1	277.2	277.3
Outfall 001 Discharge from WTP4 (pit w ater)	MGals/yr	0.0	0.0	0.0	0.0	0.0	0.0	739.9	987.1	987.1	987.1	1161.7	1021.8	1021.8	1021.8	1023.0	1021.8	1021.8	1021.8	1023.0	1021.8	1021.8	1021.8	1023.0	1021.8	1021.8
Annual Water Inflow to Pond	MGals/yr	1061.2	717.0	1018.5	991.9	1073.2	736.9	283.8	305.6	305.6	305.8	131.4	271.9	272.6	273.1	272.5	274.2	274.9	275.3	274.7	276.5	277.2	277.2	276.1	277.2	277.3
Water Cover = 2 - 4 feet	feet	21.7	20.8	18.9	21.9	20.3	17.4	16.3	16.6	16.1	15.6	14.3	13.0	11.7	10.4	9.0	7.7	6.4	5.0	3.6	2.3	2.0	2.0	2.0	2.0	2.0
Minimum Free Water Volume	MGals	2000	2000	2000	2000	2000	2000	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
End of Year Free Water Volume >= Minimum Volume	MGals	3744	3665	3389	4070	3835	3328	3108	3157	3053	2950	2693	2437	2181	1926	1672	1417	1164	911	659	407	359	359	359	359	359
End of Year Water Elevation	feet	956.2	958.4	959.3	965.0	966.2	966.2	965.1	965.4	964.9	964.3	963.1	961.8	960.5	959.2	957.8	956.5	955.2	953.8	952.4	951.1	950.8	950.8	950.8	950.8	950.8
End of Year Tailings Elevation	feet	934.5	937.6	940.4	943.1	945.9	948.8	948.8	948.8	948.8	948.8	948.8	948.8	948.8	948.8	948.8	948.8	948.8	948.8	948.8	948.8	948.8	948.8	948.8	948.8	948.8
Dam Crest Elevation Criteria:																										
Dam Crest Elevation[1]	feet	970	970	970	970	976	976	976	976	976	976	976	976	976	976	976	976	976	976	976	976	976	976	976	976	976
Freeboard = 5.3 feet minimum[2]	feet	13.8	11.6	10.7	5.0	9.8	9.8	10.9	10.6	11.1	11.7	12.9	14.2	15.5	16.8	18.2	19.5	20.8	22.2	23.6	24.9	25.2	25.2	25.2	25.2	25.2
Main Waste/Oxide Stockpile Options:																										
Percentage of Main Waste Dump Covered	%	0%	0%	0%	0%	0%	0%	0%	0%	25%	63%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Percentage of Oxide Stockpile Covered	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Cover Efficiency - Main Waste / Oxide Stockpiles	%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
MWD Seepage Escape Rate	%	88%	89%	85%	69%	71%	70%	55%	55%	45%	45%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
MWD Seepage to Pit, WTP1/3 or Tailings? Pit)		WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit
Cover Runoff to WTP1/3, Tailings or Pit?		WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	WTP1/3	Pit	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Tailings
Main Pit Options:																										
Percentage of Waste Rock Covered	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Cover Efficiency - Waste Rock in Pit	%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Pit Wall Runoff Concentrations Current or Increasing?		Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current
Groundw ater Inflow	MGals/yr	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105	105
Flow s to Mine Sump, Tailings, Aqqaluk Pit or WTP4? (begins flooding in 5/2012)		Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	Mine Sump	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4	WTP4
Aqqaluk Pit Options:																										
Pit Area Set to Stormw ater Runoff or Pit Wall Concentrations?		Runoff	Runoff	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall
Pit Wall Runoff Concentrations Current or Increasing?		Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current
Allow Pit to Flood?	Yes/No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Groundw ater Inflow	MGals/yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Qanaiyaq Pit Options: (2031 Closure Only)																										
Percentage of Waste Rock Covered	%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	50%	100%	100%
Cover Efficiency - Waste Rock in Pit	%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Pit Area Set to Stormw ater Runoff or Pit Wall Concentrations?		Runoff	Runoff	Runoff	Runoff	Runoff	Runoff	Runoff	Runoff	Runoff	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall	Pit Wall
Pit Wall Runoff Concentrations Current or Increasing?		Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Current
Direction of Flows:																										
Runoff from TSF Catchment 7 Pumped to Pit or Tailings?		Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit
Overburden Stockpile Pumpback Pumped to Pit or Tailings?		Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit
Mine Sump Pumped to Pit, WTP1/3 or Tailings?		WTP1/3	WTP1/3	WTP1/3	Tailings	Tailings	Tailings	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit
Dam Seepage Pumped to Pit or Tailings?		Tailings	Tailings	Tailings	Tailings	Tailings	Tailings	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit
Water Treatment Options:																										
WTP3 Flow Capacity (Current at 1500 gpm)		Current	Current	Current	Current	Current	Current	Current	Current	Current	Current	Unlimited	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WTP3 Lime Slaking Capacity	Tonnes/day	70	70	70	70	70	70	70	174	174	174	174	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WTP3 Operation - Seasonal or Year-Round?		Seasonal	Seasonal	Seasonal	Seasonal	Seasonal	Seasonal	Seasonal	Seasonal	Seasonal	Year-Round	Year-Round	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WTP2 Treatment Ratio (Inflow /Discharge) - 2015 Closure		Based on GoldSim Model						1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
WTP4 Treatment Ratio (Inflow /Discharge)		N/A						1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
WTP4 Return Flow to Pit or Tailings?		N/A						Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit	Pit
Number of Days of Treatment of Reclaim Water to Mill	Days	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

Table B- 4: Source Term Inputs

Source Term	Data Source/Comments	Parameter (mg/L)				
		TDS	Calc. SO4	Cd	Zn	Calc. Acidity
Constant Sources (median of source data)						
Aqqaluk Stormwater	Aqqaluk Stormwatergroundwater.xls	210	133	0.31	21	74
Background Runoff	Station 140 1998-2004; Acidity = 10 as per D. Hockley	175	85	0.02	2.7	29
Hilltop Creek	Set to Background Runoff	175	85	0.02	2.7	29
Evaporation	Zero concentrations (i.e. no loading)	0	0	0	0	0
Overburden Stockpile	Median of East and West Sump concentrations from 2006-2007	1,997	1,255	0.01	4.5	498
Pit Walls	Aqqaluk_Pit_Water_Quality kss20080602.xls	27,709	17,258	87	4,965	13,101
Pit Walls Increase	Aqqaluk_Pit_Water_Quality kss20080602.xls	33,523	20,058	172	6,088	16,941
Pit Groundwater	Aqqaluk Drill Site #2, 09/08/2005	5,800	3,590	90	694	3,423
Precipitation	Zero concentrations for all parameters except acidity	0	0	0	0	10
Tailings Beach	Zero concentrations for all parameters except acidity	0	0	0	0	10
Aqqaluk Waste						
2009-2020	Historical MWD concentrations shifted forward	21,963	17,226	52	5,576	14,527
2021		42,756	27,178	79	8,711	24,771
2022		42,756	27,178	79	8,711	24,771
2023		53,791	34,034	88	10,306	31,136
2024		61,900	40,889	98	11,900	37,507
2025		60,900	41,063	102	12,000	37,580
2026		60,900	32,963	83	11,100	32,233
2027		62,100	40,596	92	12,300	36,648
2028-2081		66,350	40,766	71	11,900	37,320
MWD Seepage						
2009	WTP3 influent concentrations	61,900	40,889	98	11,900	37,507
2010		60,900	41,063	102	12,000	37,580
2011		60,900	32,963	83	11,100	32,233
2012		62,100	40,596	92	12,300	36,648
2013-2081		66,350	40,766	71	11,900	37,320

Source Term	Data Source/Comments	Parameter (mg/L)				
		TDS	Calc. SO4	Cd	Zn	Calc. Acidity
Mine Sump						
2009	Measured Mine Sump concentrations	6,690	4,364	9	946	3,189
2010		8,210	5,610	13	1,310	4,410
2011		8,240	4,528	11	1,220	3,570
2012		7,690	4,327	9	1,060	3,160
2013		4,500	2,933	5	495	1,375
2014-2081		Calculated from load balance				
WTP1 Discharge						
2009	Outfall 001 concentrations	4,355	2,339	0.0002	0.068	253
2010		4,355	2,339	0.0002	0.068	253
2011		4,360	2,801	0.0002	0.064	262
2012		4,350	2,743	0.0005	0.050	232
2013-Closure		4,390	3,008	0.0003	0.088	179
WTP2 Return						
2009	Outfall 001 concentrations	4,355	2,339	0.0002	0.068	253
2010		4,355	2,339	0.0002	0.068	253
2011		4,360	2,801	0.0002	0.064	262
2012		4,350	2,743	0.0005	0.050	232
2013		4,390	3,008	0.0003	0.088	179
2014-2030		4,390	3,008	0.0003	0.088	179
2031-2081	Predicted TSF pond TDS and SO_4 concentrations; Outfall 001 concentrations for other parameters (previous year's values applied to avoid circular references)	4,289	2,680	0.0003	0.088	179
WTP2 Effluent						
2009	Outfall 001 concentrations	4,355	2,339	0.0002	0.068	253
2010		4,355	2,339	0.0002	0.068	253
2011		4,360	2,801	0.0002	0.064	262
2012		4,350	2,743	0.0005	0.050	232
2013		4,390	3,008	0.0003	0.088	179
2014-2029		4,390	3,008	0.0003	0.088	179
2030-2081	Predicted TSF pond TDS and SO4 concentrations; Outfall 001 concentrations for other parameters	4,289	2,680	0.0003	0.088	179

Source Term	Data Source/Comments	Parameter (mg/L)				
		TDS	Calc. SO4	Cd	Zn	Calc. Acidity
WTP3 Effluent						
2009	WTP3 effluent concentrations	3,785	2,537	0	0	46
2010		3,785	2,537	0	0	46
2011		2,910	1,985	0	0	36
2012		2,840	1,854	0	0	36
2013-closure		2,649	1,648	0	0	5
WTP4 Return and Effluent						
2009	Outfall 001 concentrations	4,355	2,339	0.0002	0.068	253
2010		4,355	2,339	0.0002	0.068	253
2011		4,360	2,801	0.0002	0.064	262
2012		4,350	2,743	0.0005	0.050	232
2013-2081		4,390	3,008	0.0003	0.088	179
TSF Seepage Pumpback						
2009	Seepage pumpback concentrations	5,500	3,613	1.2	531	1,834
2010		6,010	4,009	1.3	630	2,153
2011		6,690	4,258	2.1	821	2,596
2012		6,680	4,180	2.4	860	2,461
2013-2081		7,100	3,950	3.7	909	2,633
TSF Reclaim Water						
2009	TSF reclaim water concentrations	5,030	3,261	2	404	1,111
2010		5,070	3,269	2	420	1,152
2011		5,320	3,526	3	542	1,404
2012		6,180	3,666	6	748	1,806
2013-2081		5,525	3,317	5	621	1,551

Source Term	Data Source/Comments	Parameter (mg/L)				
		TDS	Calc. SO4	Cd	Zn	Calc. Acidity
Tailings Discharge Water						
2009	Tailings discharge concentrations. Future concentrations of most parameters except SO4, TDS, Ca and Mg include functionality to model pre-treatment of reclaim water in WTP1 based on assumption that concentrations pre-2006 reflect pre-treatment. Future concentrations without pre-treatment and concentrations of SO4, TDS, Ca and Mg are based on average of last two years of data	4,675	3,160	0.6	298	925
2010		4,910	3,131	0.7	326	996
2011		5,715	3,565	3.5	606	1,468
2012		5,935	3,718	7.0	564	1,453
2013		5,160	3,324	4.8	497	1,302
2014		5,548	3,521	5.9	530	1,377
2015		5,548	3,521	5.9	530	1,377
2016		5,548	3,521	5.9	530	1,377
2017		5,548	3,521	5.9	530	1,377
2018		5,548	3,521	5.9	530	1,377
2019-Closure		5,548	3,521	1.3	86	592

Source: \\Van-svr0.van.na.srk.ad\projects\01_SITES\Red_Dog\329100_030_Closure\Task 3_Water&Load\Revised Load Balance\Full Update\ Red Dog Load Balance_Avg Precip_Update_329100.030_rev68.xlsm

Appendix F : Requirements for Hazardous Waste Accumulation Areas

Requirements for Hazardous Waste Accumulation Areas

RCRA 40 CFR Reference	Description	SQG	LQG
262.34(a)(2)	Containers must be clearly marked with the accumulation start in a way that is visible for inspection.	Yes	Yes
262.34(a)(3)	Containers must be clearly labeled with the words, "Hazardous Waste."	Yes	Yes
265 Subpart C – Preparedness and Prevention			
265.31	Maintenance and Operation of Facility	Yes	Yes
235.32	Required Equipment	Yes	Yes
265.33	Testing and Maintenance of Equipment	Yes	Yes
265.34	Access to Communications or Alarm System	Yes	Yes
265.35	Required Aisle Space	Yes	Yes
265.37	Arrangements with Local Authorities	Yes	Yes
265 Subpart D – Contingency Plan and Emergency Procedures			
265.51	Purpose and Implementation of Contingency Plan	No	Yes
265.52	Content of Contingency Plan	No	Yes
265.53	Copies of Contingency Plan	No	Yes
265.54	Amendment of Contingency Plan	No	Yes
265.55	Emergency Coordinator	See 262.34(d)(5)	Yes
265.56	Emergency Procedures	See 262.34(d)(5)	Yes
265 Subpart I – Use and Management of Containers			
265.171	Condition of Containers	Yes	Yes
265.172	Compatibility of Waste With Container	Yes	Yes
265.173	Management of Containers	Yes	Yes
265.174	Inspections (at least weekly)	Yes	Yes
265.176	Special Requirements for Ignitable or Reactive Waste	No	Yes
265.177	Special Requirements for Incompatible Wastes	Yes	Yes
265.178	Air Emission Standards	No	Yes
265 Subpart AA – Air Emission Standards for Process Vents		No	Yes
265 Subpart BB – Air Emission Standards for Equipment Leaks		No	Yes
265 Subpart CC – Air Emission Standards for Tanks, Surface Impoundments and Containers		No	Yes
265.111	Closure Performance Standard	No	Yes
265.114	Disposal or Decontamination of Equipment, Structures, and Soils	No	Yes
265.16	Personnel Training (includes specific requirements, such as annual refresher and maintenance of training records)	See 262.34(d)(5)	Yes
262.34(d)(5)(i)	Emergency Coordinator on premises or on call responsible for coordinating emergency response measures	Yes	See Subpart D
262.34(d)(5)(ii)	Posting of Emergency Information	Yes	See Subpart D
262.34(d)(5)(iii)	Personnel Training	Yes	See 265.16
262.34(d)(5)(iv)	Emergency Response Procedures	Yes	See Subpart D