



Waste Rock Management Plan

Red Dog Mine, Alaska, USA

Teck Alaska Incorporated



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September 2018

Record of Revisions

Date of Revision	Section/Table Figure	Description
9/14/18	Figure 2	Removed reclamation schedule
9/14/18	Figure 1	Updated dump and stockpile location map
9/14/18	Misc. sections	Removed Okane references
9/14/18	Sec 2.8 and Table 1	Added PAC dump
9/14/18	Sec 2.9 and Table 1	Added Main Waste Dump Extension

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Appendix A: Segregation Plan for Cover Material at the Red Dog Mine, Alaska (SRK 2016c)

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 and follow conditions set forth in this Plan..

2 Current Status and Construction Plan for Waste Rock Dumps

2.1 Overview

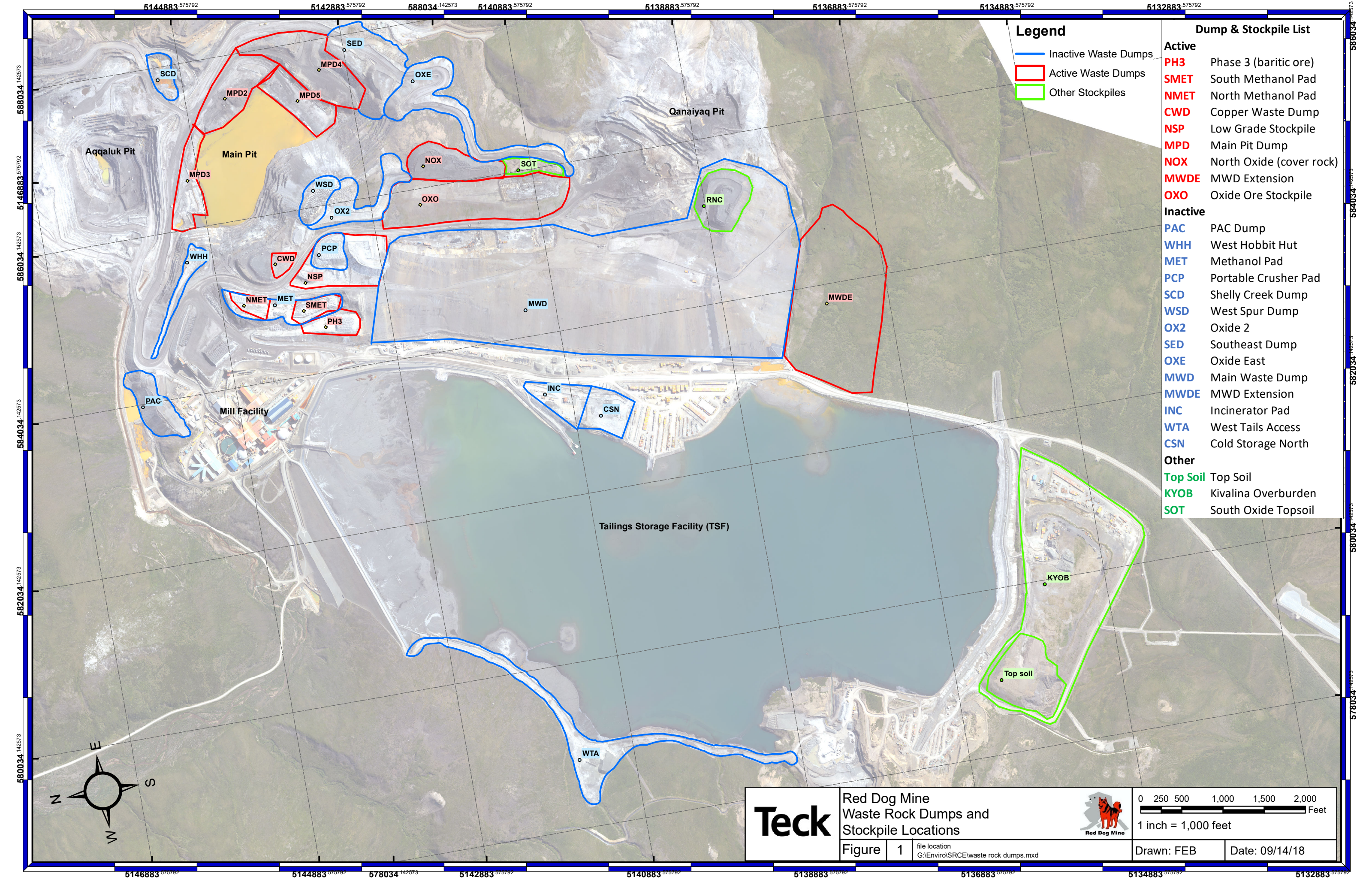
Waste rock dumps are used to dispose of waste rock that is not expected to have economic value before the end of the mine life. There are multiple waste rock dumps and low-grade stockpiles at the Mine (Figure 1), and there are plans to backfill the Qanaiyaq Pit with waste rock. Brief descriptions of 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.

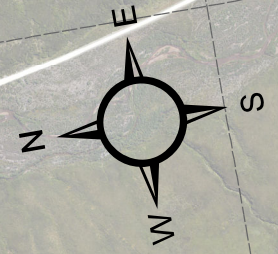


Legend

- Inactive Waste Dumps
- Active Waste Dumps
- Other Stockpiles

Dump & Stockpile List

- Active**
- PH3** Phase 3 (baritic ore)
 - SMET** South Methanol Pad
 - NMET** North Methanol Pad
 - CWD** Copper Waste Dump
 - NSP** Low Grade Stockpile
 - MPD** Main Pit Dump
 - NOX** North Oxide (cover rock)
 - MWDE** MWD Extension
 - OXO** Oxide Ore Stockpile
- Inactive**
- PAC** PAC Dump
 - WHH** West Hobbit Hut
 - MET** Methanol Pad
 - PCP** Portable Crusher Pad
 - SCD** Shelly Creek Dump
 - WSD** West Spur Dump
 - OX2** Oxide 2
 - SED** Southeast Dump
 - OXE** Oxide East
 - MWD** Main Waste Dump
 - MWDE** MWD Extension
 - INC** Incinerator Pad
 - WTA** West Tails Access
 - CSN** Cold Storage North
- Other**
- Top Soil** Top Soil
 - KYOB** Kivalina Overburden
 - SOT** South Oxide Topsoil



Red Dog Mine
Waste Rock Dumps and
Stockpile Locations



0 250 500 1,000 1,500 2,000
Feet

1 inch = 1,000 feet

Figure 1

file location
G:\EnvirosRCE\waste rock dumps.mxd

Drawn: FEB

Date: 09/14/18

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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).
Kivalina 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. 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.
PAC Dump	Contains waste rock accumulated from mining the Aqqaluk Pit, currently serves
Low Grade Ore Stockpiles	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.
Main Waste Dump Extension	Waste rock from the Aqqaluk and Qanaiyaq pits may be place here if needed, Currently not in use

2.3 Kivalina Overburden Dump

The Kivalina 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 Kivalina 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 Dumps (MPD) in 2012 and will continue to use this dump through the remaining mine life. The MPD will also receive waste from Phase I of the Qanaiyaq Pit.. 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 re-sloped surface to be composed of engineered 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 was previously used for a trials test for an earthen compacted cover. The dump is currently being used to store Qanaiyaq material for future processing. .

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. Waste rock placed in Qanaiyaq Pit Dump will be segregated according to Table 3, with the exception that waste rock will not be placed under water, as no groundwater is expected in Qanaiyaq Pit.

2.7 Low Grade Ore Stockpiles

The Low Grade Ore Stockpiles, located north of the MWD, contain 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.

2.8 PAC Dump

The PAC dump located north of the crushers was added to provide an additional storage / laydown area near the mill. The dump remained active from 2015 thru 2017 and is now graded and compacted. No further waste rock placement is expected at this dump.

2.9 Main Waste Dump Extension

The Main Waste Dump Extension is a planned and approved dump location for both Aqqaluk and Qanaiyaq waste rock. Currently this area is not being used.

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.

- Completed or ongoing activities
 - A 16-acre geosynthetic cover pilot test for the MWD was constructed during 2017. Performance monitoring is ongoing and expected to last thru 2019. Should the pilot test performance monitoring prove favorable, TAK will engage with interested stakeholders and propose a modification to the *Reclamation and Closure Plan (RCP)* in the next 5-year renewal cycle (2021) or submit an amendment to the existing RCP.
- Planned Activities
 - If TAK decides to move forward with a geosynthetic cover, a formalized design work plan would be submitted to ADEC and ADNR for review and approval prior to any work commencing. Based on construction experience learned from the cover pilot test approximately 20-30 acres would be completed each year (earliest 2020 start date) with the project expected to last a few years. 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.

4 Waste Rock Classification and Segregation

TAK has developed procedures 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:

$$\text{Self-Heating Capacity Risk Region} = 3.41744 + (\%Pb - \%sPb) / 0.866 \times (-0.33539 + 0.03897 \times \%Zn / 0.671) - 0.81502 \times \text{Log}((\%Ba / 0.5886) / (\%Fe / 0.4654)).$$

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.

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.
- 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 Material. SRK Consulting (U.S.), Inc.
- TAK . Red Dog Mine Waste Rock Management Procedures, Rev. 6, Qualtrax Document No. 2231. Teck Alaska Incorporated.
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- 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