

YUKON GOVERNMENT

GRUM SULPHIDE CELL COVER, FARO MINE COMPLEX

2016 REVIEW

FINAL REPORT

PROJECT NO.: 0533-017
DATE: March 31, 2017

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Project No.: 0533-017

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Dear Dr. Rainey,

Re: Grum Sulphide Cell Cover, Faro Mine – 2016 Review

Please find attached our final report on the Grum Sulphide Cell Cover (GSC) 2016 Review. The report has been finalized incorporating review comments provided by YG based on our November 29, 2016 draft report.

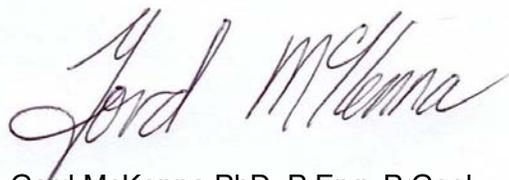
The cover is currently performing as intended. A GSC Maintenance Action Log has been created to track activities and recommended work. The log highlights several action items for 2017. BGC has sent an electronic copy of this action log under separate cover.

Please feel free to contact me anytime with questions or comments.

Yours sincerely,

BGC ENGINEERING INC.

per:



Gord McKenna PhD, P.Eng, P.Geol.
Principal Geotechnical Engineer

EXECUTIVE SUMMARY

The Grum Sulphide Cell (GSC) was constructed at the Grum-Vangorda site near Faro Yukon between 1989 and 1998. A cover system was constructed in 2010 to reduce net percolation and improve surface and groundwater quality. After physically performing poorly in the first freshet, modifications to the covers were constructed in 2011. Since then, the cover has been inspected annually and a report prepared each year documenting the performance of the cover, the surface water drainage system, and the impacts on runoff water quality. This report provides the results for the 2016 GSC Cover System assessment.

In general, the GSC Cover System is performing as intended but maintenance of the cover slopes and benches is recommended for 2017.

A one-day site visit was conducted by Dr Dustin Rainey (of Yukon Government) and Dr Gord McKenna (of BGC) on June 29, 2016. The entire cover and surface water management system were inspected. Observations were compiled in an inspection log along with key photographs.

The performance of the cover is most affected by the climate. The 2015/2016 year was typical of recent years at the Vangorda site but had an early and prolonged snowmelt freshet, conditions favourable to low erosion rates. When this freshet occurred, the slopes and perimeter ditches at the GSC were largely bare, but the benches were drifted in with snow. Based on the observation of some new rilling, it seems likely that due to these snowdrifts, a few of the benches were overtopped during snowmelt. Rainfall during 2015/2016 was typical of the past few years with no events greater than 20 mm per day. The snowfall data is poor and little can be inferred from the dataset.

The Lined Pond and Unlined Pond were actively pumped starting April 1, 2016. Pumping rates were similar to 2014 but much greater than 2015. The Pumping Station V15 pumped similar amounts of water (80,000m³ from April to September 2016) as previous years.

Water quality in the GSC Ponds (Lined and Unlined) was measured in 2016. Limited data indicates the water quality in the Lined Pond was improved compared to 2013 and similar to 2014. (It was not measured in 2015). Only one value of zinc and one value of total suspended solids (TSS) exceeded site Effluent Quality Standards (EQS). The good performance over time makes this pond a candidate for discharge to the environment in 2017. The Unlined Pond has seen improvements in water quality over time, but many samples had elevated zinc. Observed pH values for both ponds remained well above the EQS criteria of >6.5. It is noted that changes in water management have led to the drying out of the Moose Pond in summer.

Revegetation performance of the GSC remains disappointing from an erosion protection point of view – the sparse grasses and shrubs are contributing only marginally to erosion protection, likely due to difficulty in rooting in the very dense Grum Till cover material.

The observations collected during the site visit suggest that the water management system is performing as intended and that water from the cover is being conveyed to the perimeter ditches

and to the Lined Pond where it is pumped back to the Vangorda Pit for future water treatment. There is some ongoing rilling and gullying of the slopes, minor cracking on the 1227 bench, and the three small slumps on the Toe Berm Slope are still somewhat active. It was judged that no maintenance was required in 2016, but that a program of repairs to the rills and benches, sealing of the cracks in the 1227 bench, and revegetation of the slumps should be planned for 2017.

A GSC Maintenance Action Log has been created. Recommendations from past (2012 to 2015) reports has been added along with the recommendations from the 2016 assessment. Completed actions have been noted – the log provides an opportunity to track completion and documentation. The outstanding actions are prioritized. There are no Priority 1 actions (significant issues, concerns, or deficiencies) but numerous Priority 2 (moderate issues, concerns or deficiencies) to address in 2017. Beyond the repairs noted above, other recommendations in the action log include:

- Instrumentation of the GSC Cover to provide information and performance to assess the efficacy of the cover and the water balance – important to the GSC cover performance as well as design of future covers at the Faro Mine Complex.
- Designing and constructing a snowfence trial to capture drifting snow on the slopes, away from benches to reduce drifting and erosion and perhaps enhancing vegetation performance.
- Enhance the density and vigor of the vegetation on the GSC cover to reduce erosion.
- Redesigning the snow survey and snow depth data collection systems.
- Reviewing the water quality management system to collect enough timely samples to make the case for discharge of EQS compliant water to the environment.
- Establishing a reference list and archive of all design, as-built, and monitoring reports.
- Considering reclamation of the rest of the Grum Dump to improve water quality.

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LIMITATIONS

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1.0 INTRODUCTION

As part of the early closure activities at the Faro Mine Complex (FMC) in 2010, Yukon Government (YG) managed the design and construction (by third-party engineers and contractors) of a soil and geosynthetic cover system and related perimeter ditches over the Grum Sulphide Cell (GSC). In May 2011, during spring runoff, significant erosion of the GSC cover occurred and non-compliant water from the GSC was discharged into Vangorda Creek. BGC Engineering Inc (BGC) was retained in July 2011 to review the root causes of this discharge event and several remedial measures were constructed within the cover system (BGC 2012a).

In the original design of the GSC, the runoff water from the cover directly discharged to the environment at the toe of the Grum Dump. Based on the spring 2011 non-compliant discharge event, remedial measures were constructed in fall 2011. These measures included construction of a lined containment pond and an unlined contingency pond to capture surface water from the cover (and some of the unremediated area of the Grum WRD adjacent to the cover), coupled with an active pumping system to transfer contact water into the Vangorda Pit for later treatment. These measures were implemented rapidly in 2011 and intended to reduce the severity of erosion and reduce the potential for sediment- and zinc-laden water discharge into Vangorda Creek during the Spring 2012 Runoff (BGC 2012a). As such, YG accepted active water management from the cover runoff versus the previously expected passive system.

Since remedial measures in 2011, BGC has annually attended the site from 2012 to 2015 to assess the cover performance, following freshet and spring thaw conditions; BGC (2012b; 2013; 2015; 2016) document those results. BGC was requested to attend and document the GSC cover conditions in June 2016. This report documents the freshet conditions, related monitoring information, site observations and recommendations for consideration.

It should be noted that the vegetation performance on the cover is monitored separately (EDI 2016).

1.1. Scope of Work

BGC prepared a proposal dated May 9, 2016, that included the following main tasks:

- Review of information regarding runoff from the cover system (volumes/rates) and photos collected by YG or the site maintenance contractor during 2016 spring freshet.
- Conduct two-day site visit (including travel to and from Whitehorse) by Mr. Jim Cassie, P.Eng. (BGC) to review the condition of the GSC cover and related water management system. The site visit to consist of visual observations and measurements aimed at an assessment of the GSC cover condition (compared to last year) focused on physical stability, water management, and performance of remedial measures since construction in 2011. Unexpectedly, Mr. Cassie was unable to perform the inspection so instead, Dr. Gord McKenna performed the site inspection.

- Prepare a condition and assessment report on the GSC cover and water management system, including a summary of pertinent observations, relevant photographs and recommendations for additional work and monitoring.
- Project management including communications, safety planning, filing and task coordination.
- The scope of work excluded the following aspects:
 - Assessment of long-term closure issues.
 - Evaluation of seepage, net percolation or water balance for the cover.
 - Evaluation of regulatory compliance regarding off-site discharges due to overland flow, channels, pumped discharge, or groundwater seeps.
 - Assessment of landform performance outside the immediate area of the GSC cover system (see Drawing 01).

Authorization to proceed was provided under Engineering Agreement C00034030 between YG and BGC, dated June 21, 2016.

In past years, damage to the cover has necessitated production of a field memo to highlight needed maintenance and repairs during the summer season. The performance of the GSC Cover as observed in the June 2016 visit was adequate so it was agreed with Dr. Rainey of YG that a field memo was not required this year. In particular, the risks associated with the observed defects in the covers were considered to be less than the risk of damage resulting from repair activities, so it was decided that no repairs would be done in 2016 and instead plans would be made for 2017.

2.0 BACKGROUND AND 2016 MONITORING

2.1. Cover background and elements

The Grum Waste Rock Dump was constructed between 1989 and 1998 (Faro Mine Remediation Project 2011). During construction, some of the higher sulphide waste rock was placed in a 28-hectare segregated cell known as the GSC. The boundaries of the cell were poorly defined. SRK (2011) outlines the efforts taken to define the cell boundaries. A cover was installed in 2010 as noted above.

There are no formal performance objectives for the GSC Cover system other than reducing the risk of contaminated water reaching Vangorda Creek. However, Section 4.2 of SRK (2009) outlines the primary design criteria:

- Infiltration [net percolation] less than 0.5% of mean annual precipitation
- Cover should be physically stable
- Uncompacted growth medium thickness of 1 m
- Ditch surrounding the cover sized for 1:100-year storm event.

Background information on the as-built information for the GSC cover are provided in SRK (2011) for the original design and construction. BGC (2012a) provides information for the cover upgrades constructed in 2011.

Major components of the final design from SRK (2011) are as follows:

- Resloping of GSC dump slopes to 5H:1V (or flatter) and establishment of benches at horizontal intervals of 60 to 85 m.
- Construction of a Toe Berm (with clean waste rock) at the base of the GSC cover including geomembrane installation.
- Installation of textured (one side) 60 mil HDPE liner over the resloped GSC surface.
- Placement of 1 m of uncompacted till layer over the liner and Toe Berm.
- Placement of 0.8 m of waste rock over 0.2 m of sand and geotextile over the liner along GSC benches.
- Construction of access ramps and perimeter drainage ditches, including energy dissipation pools and water management structures, to direct surface runoff from the cover to Grum Creek.

As outlined in BGC (2012a), the cover runoff is directed into the GSC Ponds for pumping to the Vangorda Pit (see Drawing 01 of the present report).

The GSC cover directs surface water horizontally from the five benches to the West and East Perimeter Ditches and around the Toe Berm to the Lined Pond (capacity of 8,000 m³), located directly at the toe of the cover. Water from that pond is pumped by pipeline to the Vangorda Pit where it is collected for treatment.

The Unlined Pond (a contingency pond) was created within an existing depression on the waste dump level below the Lined Pond. This pond collects water from two sources; excess water from

the Lined Pond / pumping system (if the inflow is greater than the pumping capacity and the storage is full), and contact water from other (unremediated) dump runoff sources located southwest from the GSC cover and from the access road on the northeast toe of the dump. Water retained in the Unlined Pond is pumped to the Lined Pond.

At higher pond levels in the Unlined Pond, it is also possible that some seepage may occur down the south face of the waste dump as has occurred in previous years.

Seepage and runoff water from the Grum Dump not collected in the ponds is directed down towards the Pumping Station V15 for interception.

2.2. Data provided by YG

YG provided the following documents and spreadsheets to BGC for this assessment:

- 2016 snow survey (TEES 2016)
- Snowmelt pictures April 5, 2016 (DST Consulting Engineers 2016)
- Pumping records for GSC Ponds and Pumping Station V15 (YG spreadsheet)
- Grum Climate Station records (YG spreadsheet)
- Water quality sample laboratory data (YG spreadsheet)
- 2015 GSC Revegetation Draft Report (EDI 2016).

The data has been used in the various assessment herein relative to the cover performance and it is assumed that data is accurate and can be relied upon. BGC has not independently verified these data sources.

2.3. Key 2015/2016 dates

Table 2-1 provides some key dates that are relevant to the 2015/2016 cover performance and monitoring program.

Table 2-1. 2015/2016 timeline of events.

| Date | Observation | Comment |
|------------------------------------------------------------|-------------------------------------|-------------------------------------------------------------------------------------------------|
| 2015 Aug 30 | First frost in late summer 2015 | Fairly typical time of year |
| Nov 1 | Sustained sub-zero air temperatures | Perhaps a week or two later than normal. |
| Nov 27 & 28 Jan 27 & 29 2016 Feb 28, Mar 2 | Daily high temperatures above zero | Most years have a similar number of warm days where the daily high temperatures are above zero. |
| Mar 11 | Initial melt of snowpack | Considerable snow may have been lost, much perhaps to sublimation |
| Mar 17 & 18 | Snow survey | Ref: TEES (2016) Considerable snow already lost, benches still drifted in. |

| Date | Observation | Comment |
|-----------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mar 18 to 21 | Precipitation event of 4.1 mm over 4 days | Small, partial rain-on-snow event |
| Mar 25 | Start of major melt, daytime high temperatures rise above zero from this date on | Freshet continues until mid April. |
| Mar 30 to Apr 8 | Precipitation event of 16 mm over 10 days | Modest event |
| Mar 30 to Apr 2 | Overnight low temperatures above zero | Rate of daily snowmelt higher when air temperature remains above freezing at night. |
| Apr 1 | GSC Pond pumping starts | No data on pond elevations were provided. Pumping records available in spreadsheet format to June 30. Ref: Dr Rainey, personal communication, 2017: "No pumping required in July or August. In September, any remaining water in the Unlined and Lined Ponds was pumped to Vangorda Pit and pipelines were drained." "The pond outlets were not active [in 2016.... The] Lined pond outlet has never experienced outflow since pond construction." |
| Apr 5 | Walk-out survey, photos | Ref: DST Consulting Engineers 2016. Little snow on slopes. Little snow in perimeter ditches. Benches still drifted in. Some ponding water. |
| Jun 29 | Annual field inspection | Observations summarized in this report |
| Aug 31 | Grum Till investigation | Ref: IEG (2017) Work for another project that includes field observations at GSC. |
| Nov 18-21 | Climate, pumping, and water quality data provided to BGC by YG | |

2.4. Climate observations

The performance of the GSC Cover is mostly related to the weather, and in particular, the pattern of the spring melt. Daily data has been provided by YG for the Grum Climate Station which is located in a gravel pit to the northeast of the Grum Overburden Dump (approximately 62°15'49" N 133°12'18" W), about 1,300 m northeast of GSC Cover. This climate station was moved to this location in 2010 to facilitate construction of the GSC Cover.

This section provides an overview of the weather at the GSC since 2010 to allow a cursory comparison of the hydrologic (erosional, runoff, and water quality) performance of the cover each year relative to the weather. As noted below, there are no instruments in the cover, and hence the impact of the weather on the temperature and soil moisture conditions in the cover cannot be determined, nor is there a way to estimate net percolation or water balance.

2.4.1. Snow survey

A limited snow survey was conducted on March 17 and 18 (TEES 2016). During the survey, much of the cover was bare. Measurements were taken at 20 sites with snow cover, mostly near the perimeter ditches. The survey indicates snow densities ranges from about 0.23 to 0.37 g/cm³ with an average of 0.33 g/cm³. Snow water equivalent estimates ranged from 5 to 35 cm with an average of 14 cm.

Lacking a map of the snow-covered areas, it is not possible to provide an estimate of snowmelt runoff. A recommendation to design a more detailed snow survey to allow a better snowmelt water balance is included in Section 4.

2.4.2. Air temperature

The data show that spring temperature fluctuations around zero degrees have highly variable patterns each year. The amount and rate of snowmelt will depend on the amount of snow precipitation, snow redistribution, sublimation, spring rainfall, but principally on the rate of temperature increase. Previous observations at site indicate that a sudden rapid rise in temperature with a snowpack leads to large runoff volumes that can lead to elevated rates of cover erosion.

The 2015/2016 winter was slightly warmer than previous years (Figure 2-1). The snowmelt freshet usually occurs in mid-April to early May. The 2016 snowmelt freshet at the GSC occurred somewhat slowly over a period of weeks: there was a week of above-zero mean daily temperatures during the last week of March (Figure 2-2). Mean daily temperatures do not normally exceed zero until into April. Pumping of the GSC Ponds (see Section 2.5) started on April 1 and continued sporadically throughout April. Plates B-1 and B-2 from April 5 indicate much of the snow on the GSC cover was lost, but much was still present on the benches. Mean daily temperature remained above zero after April 9th.

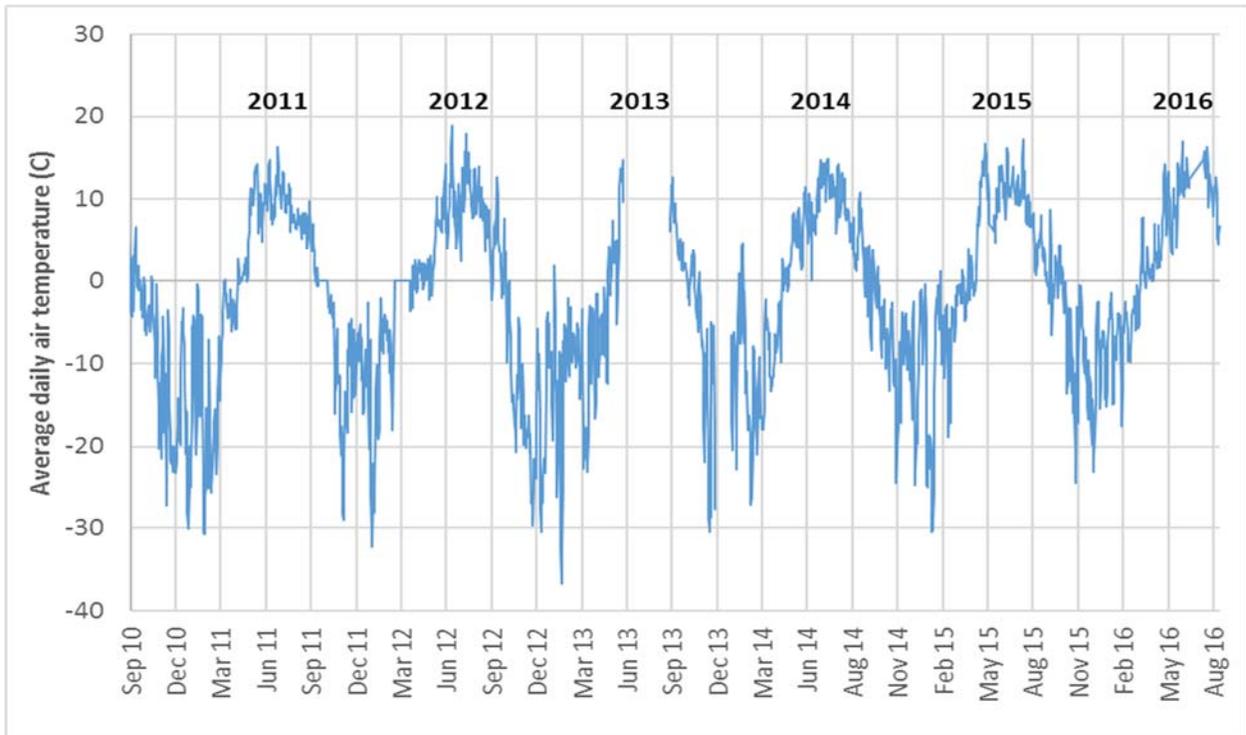


Figure 2-1. Grum Climate Station air temperature data since 2010.

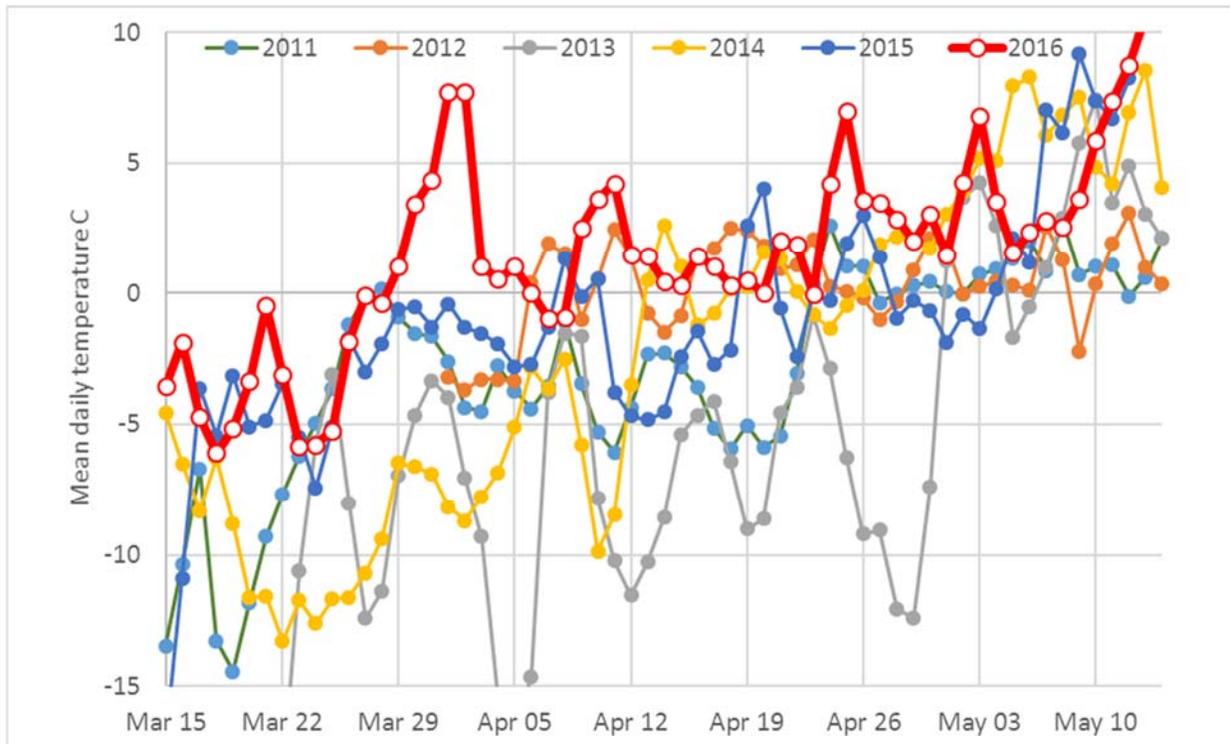


Figure 2-2. Grum Station mean daily air temperatures during spring freshet 2010-2016. Note warm 2016 temperatures in last days of March and first week in April with a rapid rise from March 25 to April 2.

2.4.3. Precipitation

Figure 2-3 shows the daily precipitation measured at the Grum Climate Station from 2010 to 2016. Figure 2-4 shows the same data but only for 2015 / 2016. The data file has not been assessed for data quality. There are numerous days with missing data and the snowfall data appears unreliable and is not plotted.

The data indicate a few modest rainfall events during the past year and frequent small rainfall events, superficially similar to past years with no years that are especially dry or wet.

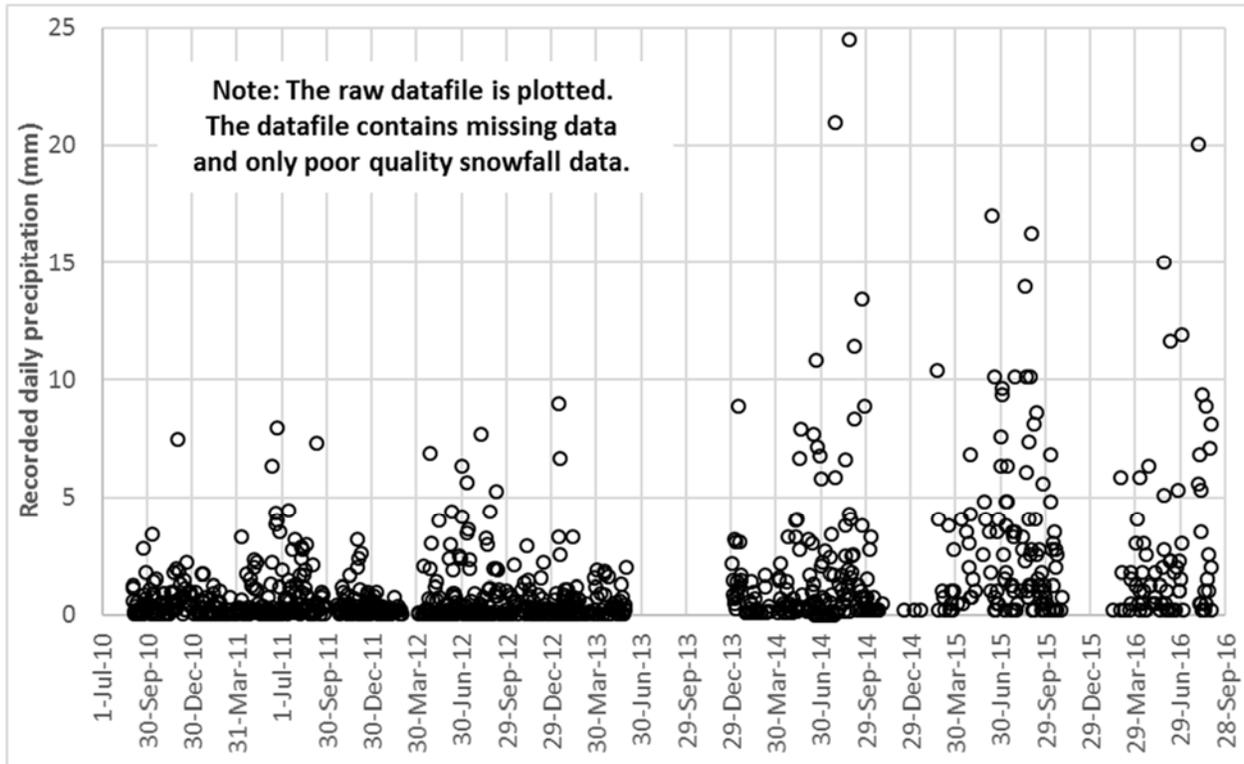


Figure 2-3. Grum Climate Station precipitation data 2010-2016.

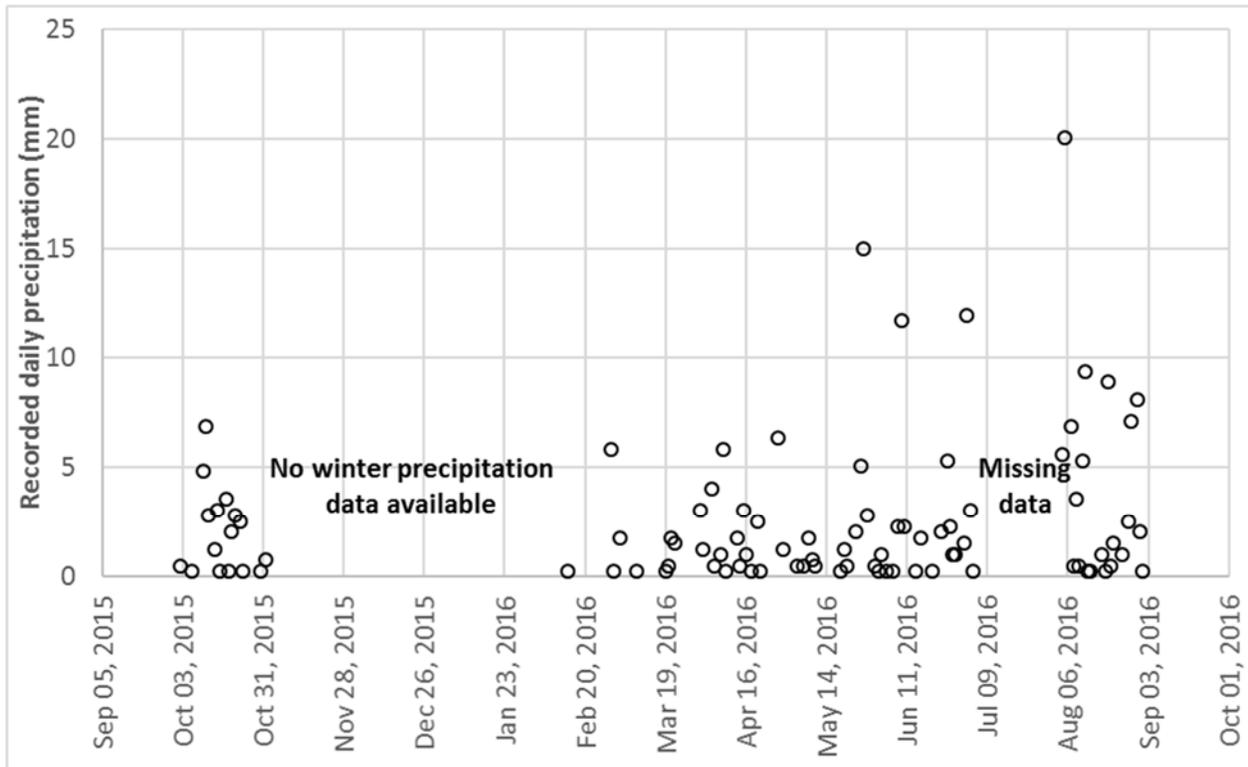


Figure 2-4. Grum Climate Station precipitation data 2015-2016.

Future assessments would benefit from a reconciliation of the raw Grum Climate precipitation data and production of a continuous record based on interpolation of missing values and extrapolation of data from other climate stations on site and in the region.

Snowfall and snowpack data from the raw datafiles is presently unreliable. Visual evidence confirms considerable snowfall redistribution on the GSC due to winds, with bare areas on slopes and drifts on benches. The present quality of the data does not permit an attempt at a water balance for the cover.

2.5. Pumping quantities

Figures 2-5 and 2-6 presents the recorded quantities of water pumped from the GSC Ponds and from the Pumping Station V15.

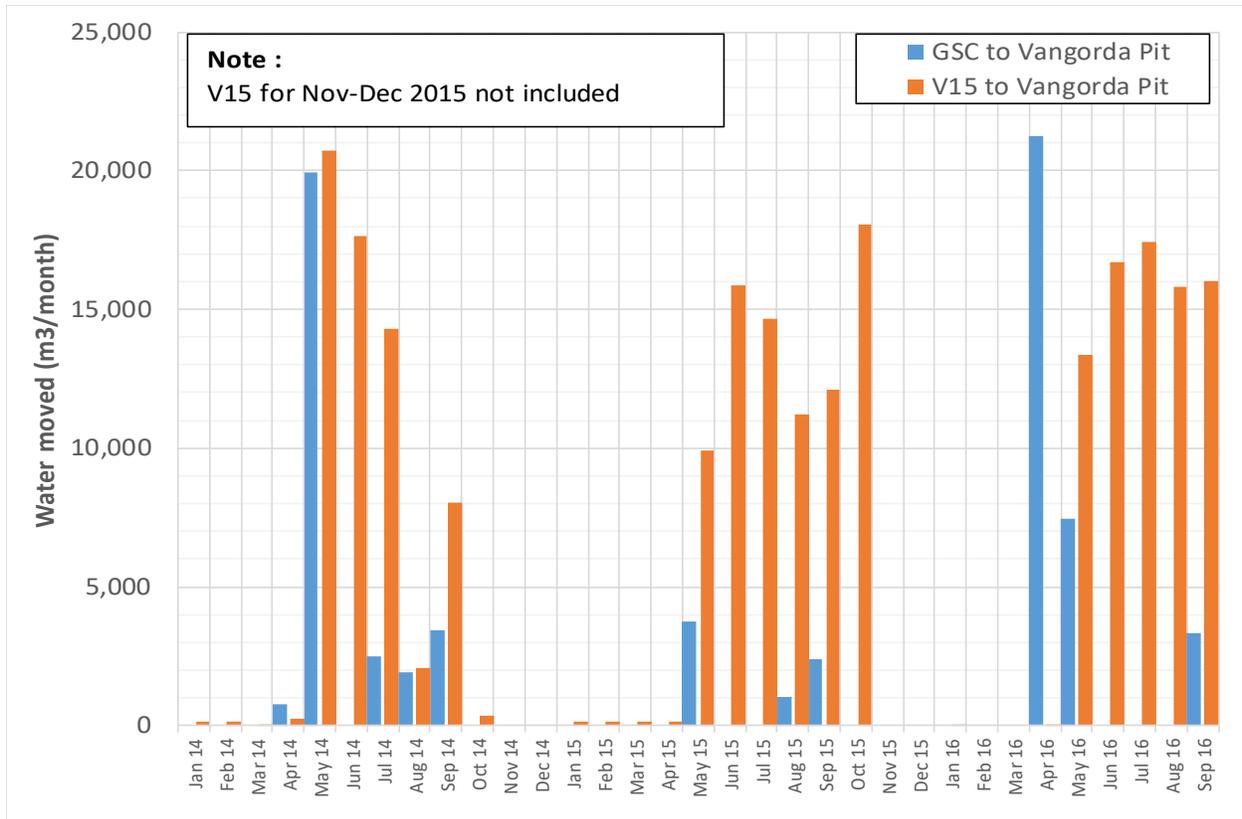


Figure 2-5. Monthly pumping at GSC Lined Pond and Pumping Station V15 (2014-2016).

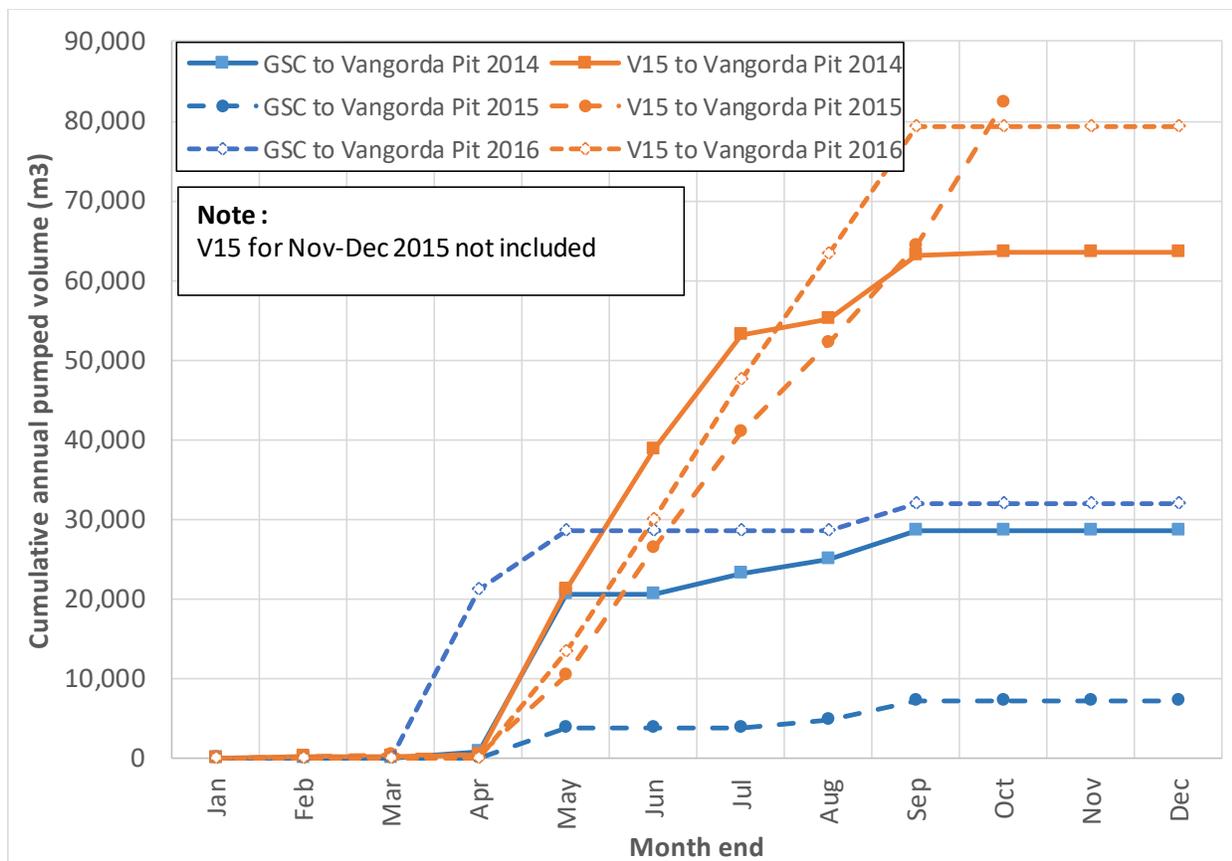


Figure 2-6. Cumulative pumping at GSC Lined Pond and Pumping Station V15 (2014-2016)

As noted in Section 2.4.2, the pumping from the GSC Ponds started April 1 (earlier than in past years). The total flows pumped in the spring of 2016 are similar to that of 2014 but much greater than 2015 (Figure 2-6). The flow quantity equivalent reporting to the GSC Ponds from the nominal 28 ha surface watershed is about 100 mm for 2014 and 2016 but only about 25 mm in 2015.

Cumulative volumes pumped from the Pumping Station V15 have ranged from about 60,000 to 80,000 m³ per year.

2.6. Water quality

BGC (2015) reviews the available water quality data at the water seepage and water quality stations against the site’s Effluent Quality Standards (EQS), as listed below:

- Dissolved zinc (< 0.5 mg/L)
- Dissolved sulphate (n/a)
- Total suspended solids (TSS) (< 15 mg/L)
- pH (> 6.5).

In 2016, samples from the GSC Ponds and Pumping Station V15 were collected and analyzed for water chemistry. YG provided BGC with a raw spreadsheet with water quality data. The GSC Ponds were tested for pH, total suspended solids (TSS), and total zinc. Pumping Station V15

waters were tested for pH, sulphate and TSS and some samples were tested for a broader suite of metals. Figure 2-7 and 2-8 present the data graphically. Note, no GSC Pond water quality data was collected in 2015.

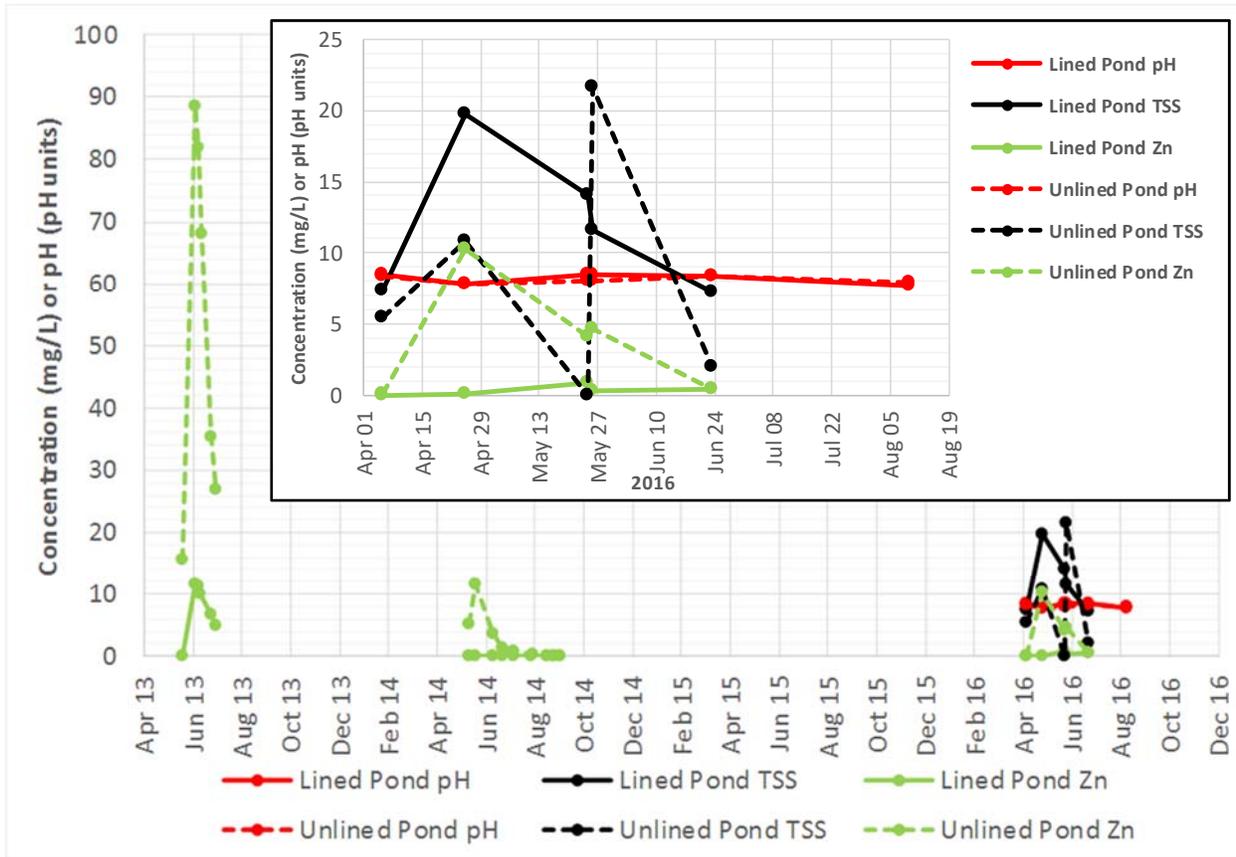


Figure 2-7. Water quality data for GSC Lined and Unlined Ponds.

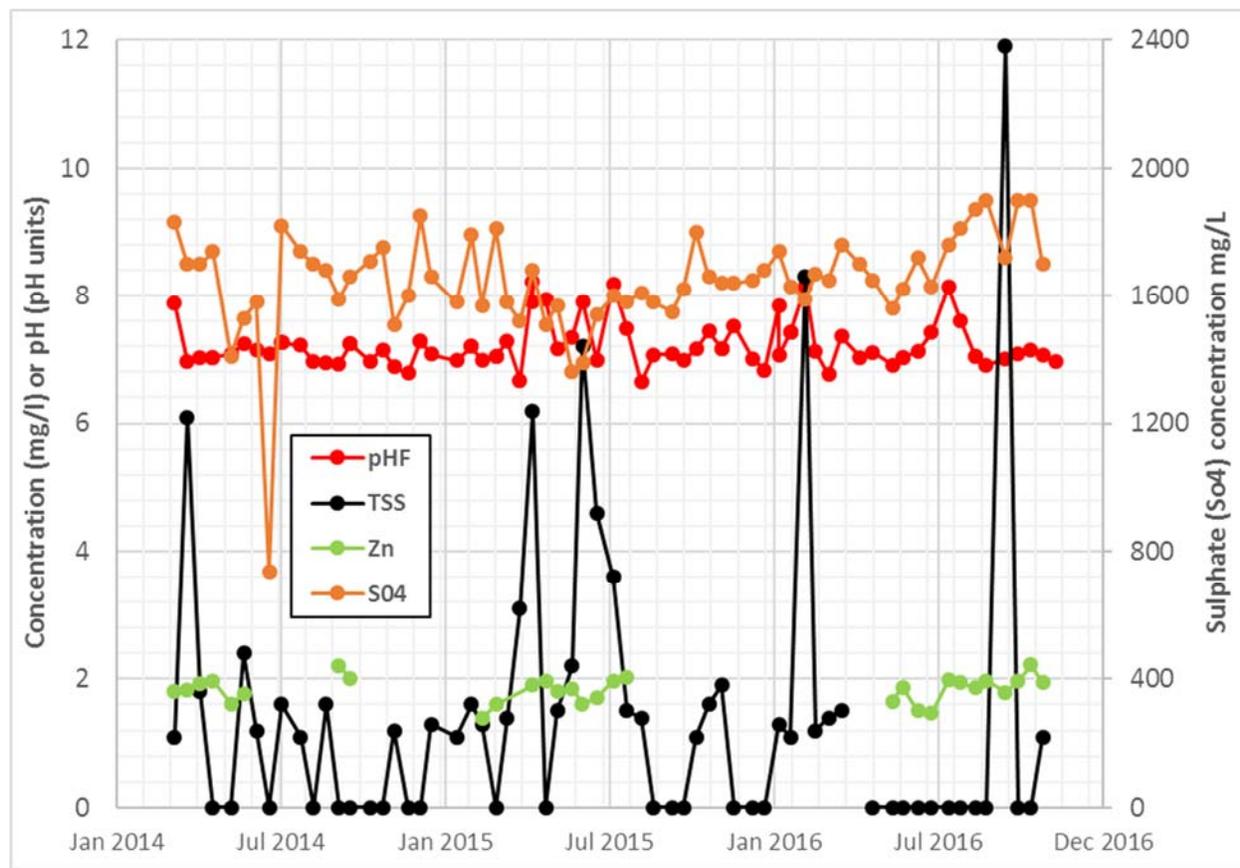


Figure 2-8. Select water quality data for Pumping Station V15 (zero for TSS indicates below 1 ppm detection limit)

GSC Ponds:

- Zinc concentrations in the Lined Pond in 2016 ranged from 0.034 to 0.86 mg/L; one value (May 24) exceeded of the EQS but a sample the following day was below the EQS. The zinc concentration in the Unlined Pond ranged from 0.066 to 10.2 mg/L; three of five values exceeded the EQS. The values are similar to 2014, and below those in 2013.
- Sulphate concentrations in the Lined and Unlined Ponds were not measured.
- TSS in the Lined Pond ranged from 7 to 20 mg/L with only one exceedance of the EQS (April 25). The TSS in the Unlined Pond ranged from 2 to 22 with only one exceedance of the EQS (May 25).
- The pH in the Lined and Unlined Ponds ranged from 7.7 to 8.5 which meets the EQS.

With the exception of the two measurements, the Lined Pond met the EQS targets.

The Pumping Station V15 (2016 data):

- The zinc concentration ranged from 1.47 to 2.22 mg/L – all values exceeded the EQS.
- Sulphate concentrations ranged from 740 to 1900 mg/L. There appears to be a slight upward trend in 2015 and 2016.
- TSS values were highly variable and ranged from 1 to 12 mg/L which meets EQS.

- The pH values are also variable but constrained between the range from 7.3 to 8.4 which meets the EQS.

The 2016 zinc levels in the Pumping Station V15 samples show a reduction from the 2 to 2.5 mg/L in 2014 but are still in excess of the EQS. The 2015/2016 data for sulphate, TSS and pH appear to be similar to previous years. Other metals were also measured in the Pumping Station V15 water quality samples in 2015 and 2016.

As noted in the 2015 GSC inspection report (BGC 2016), the GSC Cover System seems to have made a positive contribution to reducing the zinc concentrations in runoff water to the Lined Pond and this water should be considered for discharge when all water quality parameters meet the EQS. If more samples are taken throughout the open-water season, the case for discharge will be stronger.

Water reporting to the Pumping System V15 (mostly seepage) remains elevated in zinc and needs to be continued to be monitored and pumped to the Vangorda Pit for eventual treatment.

2.7. Revegetation review

Based on the revegetation field trials work up to the end of 2015, the draft EDI (2016) report concludes the following:

- Overall vegetation cover for the site increased from 8% in 2013 to 60% in 2015 mostly due to establishment of fire moss.
- Vegetation cover appears to be reaching a level to effectively control erosion and stabilize slopes and, combined with the site preparation method, the site appears to be quite stable.

The report goes on to recommend continuation of the testing and monitoring program though the ultimate purposes of this continued testing should be clarified.

IEG (2017) provides modified sand-cone density measurement and vegetation cover description at several sites on the GSC, as part of a reconnaissance investigation into the performance of Grum Till fill as a growth medium. Based on this work and visual observations at the site, it appears likely that the invading native plants from the nearby natural areas will eventually stabilize the slopes. This process though, is likely to take many decades at the GSC, due mostly to the adverse rooting conditions caused by the high density of the cover materials (preliminary field information indicates a bulk density close to 100% Standard Proctor maximum dry density which is a limiting factor with respect to rooting).

There is an opportunity to evaluate the role of vegetation in reducing the risk of erosion of the slopes and to reduce maintenance costs (see Section 4). It is noted that some of the engineering observations regarding resistance to erosion are somewhat at odds with the draft EDI (2016) report (see Section 3.10 below). Section 4 provides a recommendation to review the performance of the vegetation relative to erosion protection for the cover.

3.0 2016 SITE VISIT

The GSC site inspection was conducted on June 29, 2016 by Dr. Gord McKenna, P.Eng., P.Geol., of BGC and Dr. Dustin Rainey, P.Geo. of YG. Conditions for the inspection were nearly ideal. The weather was mostly cloudy with some rain showers. The temperature was about 15°C. There was no standing water on the cover areas, except in the collection ponds at the toe. There was no snow on site.

At locations selected for specific observation, coordinates were recorded with a hand-held GPS device and observations were recorded in a field book (see Appendix A for the inspection log) and photographs were taken with a digital camera (see Appendix B).

Results from this work and previous actions were distilled into a new “GSC Cover System Maintenance Action Log” (as provided in Appendix C and summarized in Section 4).

The tour started with taking overview photographs from the Grum Overburden Dump (camera location 62°15'36.24"N 133°12'41.98"W) then the Vangorda Dump (62°14'42.40"N 133°12'9.94"W), as shown on Plates B-3 and B-4. The 2016 photos show little change from 2015.

The cover inspection began at the top of the Grum Dump, followed by working down the cover, zig-zagging along the benches, working down to the Toe Berm. Drawing 01 shows the path followed and the stations where observations were made.

As indicated earlier, additional observations were collected during another site visit to GSC cover on August 31, 2016 by Gord McKenna of BGC with Justin Straker and Trevor Baker of Integral Ecology Group (IEG). The objective of that site visit was to examine the density of the Grum Till that used as a cover on GSC (SRK 2011) and its impact of this density on vegetation performance. IEG (2017) provides the results of that work. During that visit, no changes in GSC cover performance from the June 2016 inspection were noted, except that the vegetation cover was reaching the end of the growing season and had yellowed significantly as would be expected. This inspection report extracts a few related highlights from the August visit.

3.1. Run on control ditch

There is an upper run-on control ditch and surface water control berm on the Grump Dump plateau (Plate B-5) at the top of the cover which is modest but working as intended. Some areas, especially to the south, have only modest relief but are also working effectively. The East and West Perimeter Ditches (Section 3.7) also serve as run-on controls.

3.2. Vegetation performance

The agronomic vegetation is partially helping to limit surface erosion on slopes but grass and shrubs are still sparse in most areas, even after six growing seasons (see Plate B-6). Areas above the phyllite drains have less dense materials (IEG 2017) and show somewhat better vegetation cover and growth. Some volunteer bushes and trees are starting to invade most areas of the cover. The benches remain largely unvegetated, but some plants are starting to invade in some

bench areas. There is typically a stripe of lush vegetation on the upslope side of the benches, likely due to a combination of wetter conditions and less dense cover materials.

3.3. Damage from equipment

In previous inspections, damage from earthmoving equipment was noted. The ruts and damage to vegetation have either been repaired or have partially self-revegetated prior to the 2016 inspection. Plate B-7 shows an example of a previously damaged area.

3.4. Bench channels

The bench channels on the 1284, 1272, 1258, 1244 and 1227 Benches generally performed well in 2016 (aside from the snowdrifts noted below) and are discharging water into the East and West Perimeter Ditches.

Cracking (see Plates B-8 and B-9) was noted in two locations on the 1227 Bench. The cracks ranged from 10 to 25 m long, with 1 to 2 cm aperture with no vertical offset. There was no visible distress in the slope immediately downslope of the cracks, though the downslope areas appeared slightly wetter than most other areas of the cover. The mechanism for the crack is unclear; they may perhaps be due to freeze-thaw or wetting-drying expansion. The cracks were not present during the 2015 inspection. See Section 4 regarding recommendations to seal these cracks in 2017.

The benches are perhaps the most vulnerable part of the cover system and are prone to blockage by sediment fans and especially snow drifts. Plate B-10 shows a wavy pattern on the Toe Berm Toe Road at GPS 523 that is the result of lateral flow along the bench around the toe of snow drifts. Fines have been stripped away and other material deposited along this small channel. The greatest cause of erosion to date has been where such flowing water overtops the bench, and starts to downcut forming one or more rills, then a gully, to form immediately downslope of bench. The regrading efforts of 2011 have been beneficial here to reduce the vulnerability but overflow and erosion are still occurring.

3.5. Rilling and gulying on slopes

Numerous areas of minor rilling and gulying were observed in many isolated areas of the GSC cover. As noted above, most are due to water flowing over the downstream crest of the benches. Once the rill has started, there are only a few cases where the vegetation is limiting further erosion. The locations are noted Table A-1 and the ones recommended for repair in 2017 are included in Table C-1 (Appendix C).

Plates B-11 through B-14 provide examples of the rills noted during the inspection. The plates show some self-armoring by larger clasts, but in most areas, this has yet to develop to the extent where downcutting is arrested (or even slowed). Vegetation is not generally establishing much in the erosion channels but some is invading the depositional fans. Rill erosion also leads to sediment deposition on the bench surfaces, potentially blocking lateral flows. There are several small gullies that flow into the West Perimeter Ditch as noted in Table C-1.

3.6. Slumps

There are three small slumps on the oversteepened slope below the Toe Berm (GPS 529) that had been previously identified in 2014. Vegetation patterns indicate they are showing minor continued movement, but with no new cracks. The slumps are indicative of the oversteepened slope and at least in one case, the failure may be related to excess pore-water pressure on the liner. Plate B-15 shows two of the slumps.

3.7. Perimeter Ditches, Lined Pond, and Unlined Pond

The East and West Perimeter Ditches are performing well, carrying water from the benches to the Dissipation Pools which feed the Lined Pond. There is no evidence of blockage or erosion of these channels.

Plates B-16 through B-18 show examples of the perimeter ditches and the two dissipation pools. No evidence of blockage, erosion, or significant sediment accumulation was observed.

The Lined Pond (see Plate B-19) had been pumped down and there was a pump ready to take any new water to the Vangorda Pit. The safety fence around the Lined Pond has fallen from its posts. The liner has no obvious damage and the lined outlet shows no sign of blockage or erosion.

The Unlined Pond and its outlet are unengineered facilities and their geotechnical evaluation is outside the scope of the GSC Cover inspection. The pump had been removed (see Plate B-20).

Plate B-21 show the outlet Unlined Pond outlet. Though unengineered, the Unlined Pond system is currently working as intended as a contingency measure.

As also noted above, Dr Rainey (personal communication 2017) reports that the Lined Pond has never seen flow and that the Unlined Pond has not seen flow since spring 2013

3.8. Pumping Station V15

The Pumping Station V15 appeared to be in good working order and operating in “low flow” mode (only the smallest of the pumps were operating), as shown in Plates B-22 and B-23.

3.9. Moose Pond

During the past year, water input flow for the Moose Pond (downstream from Pumping Station V15) was cut off and the area recently drained. The area is underlain by soft wet mud and natural vegetation is starting to invade, as shown on Plate B-24. According to Dr Rainey (personal communication, 2017), the seepage interception system intercepts summer flow, but incomplete winterization means the system cannot run in the winter and winter seepage enters Moose Pond. This area is presently no longer part of the surface water drainage system from GSC, but the seep locations on the downstream side (adjacent to Vangorda Creek) are being monitored (according to Dr Rainey, as mentioned during the site tour).

3.10. Summary of site visit observations

The cover system performed as intended in 2016 but the following specific aspects are noted:

- Grass growth is sparse (though slowly improving) and provides only limited erosion protection. The role of the thin layer of moss, which forms much of the vegetative cover (EDI 2016), for erosion protection is unclear. It likely provides some raindrop erosion protection, but only modest protection from erosion from overland flow as it lacks sufficient rooting.
- Slopes are prone to erosion caused by rilling and gullying, leading to fan development. Rills without ongoing maintenance or suitable vegetation establishment may form into channels. In extreme cases, the liner may be exposed if there is excessive erosion forming deep channels / gullies.
- Lateral benches are prone to overtopping during snowmelt due to snow drifts blocking lateral flow.
- The oversteepened Toe Berm Slope is prone to slumps, likely due to the steep nature of material and possibly due to localized pore-water pressure build up in the dump or cover materials. No instrumentation exists in the cover to monitor this potential mechanism.
- The perimeter ditches (downslope channels), the dissipation pools, and the Lined Pond are in satisfactory condition.
- The pumping systems from the Lined Pond and the Unlined Pond are active and working along with the access roads. Similarly, the Pumping Station V15 appears to be operating as intended, at least in the summer.

Comparing the 2016 GSC Cover System field performance to the original SRK (2009) design objectives as listed in Section 2.1:

- The infiltration (net percolation) through the cover has not been measured and cannot be estimated using the present monitoring system.
- The cover is only marginally physically stable; it is prone to rill and gully erosion, there are tension cracks on the 1227 Bench, there is some slumping on the Toe Berm Slope, and the cover requires physical maintenance most years.
- The growth medium is present, but was placed very dense -- grasses and shrubs are having difficulty in rooting and erosion protection from the plants is less than would normally be expected.
- The Bench Channels are vulnerable to blockage by snow drifts and spilling of water that leads to rills and gullies occurs most years, leading to maintenance.
- The Perimeter Ditches, Dissipation Pools, and the Lined Pond and Unlined Ponds are performing as intended. Contaminated surface water from the cover area is being collected and pumped back to the Vangorda Pit. Additional contaminated water is being intercepted by the Pumping Station V15 and also pumped back to the Vangorda Pit.

4.0 RECOMMENDATIONS

New to this year's inspection report, Table C-1 (see Appendix C) compiles the recommendations from previous GSC Cover inspections, along with those from the 2016 inspection visit, into a single table to provide better tracking of completed, outstanding, and new actions. It is recommended that YG work with the care and maintenance contractor and BGC to maintain this table and document the field maintenance and repairs. Action items are based on BGC inspections (featured in 2016 and inspection previous reports back until 2012).

The action as were assigned priorities as follows:

- Priority 1: Significant issue, concern or deficiency observed or opportunity noted. High risk of major compromise to cover system, landform, or water quality issue downstream. Urgent attention required. Repair this year. Monitor performance of repairs and properly document.
- Priority 2: Moderate issue, concern or deficiency observed or opportunity noted. Moderate risk. Repair during next cover rehabilitation program. Monitor annually and reassess.

There are no items in Table C-1 classified as #1 or "Significant issues". However, the large number of action items in the #2 or "Moderate issues", some of which are several years old, others that are new in 2016. Following from this accumulation of issues, BGC recommends that YG plan for a field maintenance program in 2017. BGC recommends that after the spring inspection, that the action log be updated and that YG and BGC work together to develop a work plan to address as many of the outstanding issues as practical in early summer 2017.

As also shown in Table C-1, there are a few significant projects that BGC recommends be considered for summer 2017, as follows:

- Instrumenting of the GSC Cover to provide information on its performance and water balance and as importantly, important lessons for design of the Faro covers (and eventually other covers at the Grum Vangorda site).
- Designing and constructing a new snowfence pilot to trap snow on the cover away from the benches to help reduce rilling and erosion during snowmelt. If successful, additional snowfences could be added to the other mid slope areas. Winter monitoring would be required to confirm the efficacy of this pilot test. If successful, fences would be installed on other berms and future covers elsewhere at FMC. Tabler (1991) provides background on snowfence design, installation, and maintenance.
- Working with BGC and others, assess the efficacy of improving the density and vigor of the vegetation on the GSC to reduce erosion. This would involve seeding and fertilizing areas with poor vegetation performance and the slumps on the Toe Berm Slope. It may be more cost effective and allow a greater risk reduction to simply seed and fertilize most or all areas of the cover. Such an approach would reduce the erosion potential of the slope, potentially saving maintenance costs and helping to ensure ongoing good erosion and water management performance.

- Review the design of the snow survey data collection for the GSC to make it more useful for water balance calculations and to streamline data management.
- Review and streamline the water-quality management system (especially the sampling/testing frequency) for the GSC Ponds and the Pumping Station V15, to allow a more robust case for discharging suitable water from the Lined Pond.
- Install signage that indicate that access/work in the GSC requires permission from the site operator (to reduce the likelihood of damage to the cover by equipment), and install signage indicating the bench names and the names of other cover facilities to facilitate communication and simplify reporting.
- Establish a reference list and archive for all design and as-built drawings and reports and all monitoring reports for the GSC cover.
- Consider reclamation and landform design the rest of the Grum Dump to reduce net percolation and associated acid rock drainage from this landform.

5.0 CLOSURE

We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC ENGINEERING INC.

per:

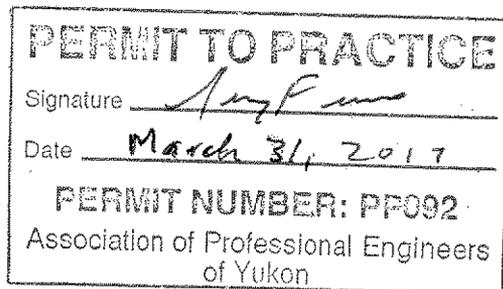


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GM/JWC/gc/ky



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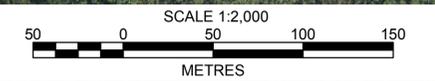
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DRAWINGS



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THIS BAR MEASURES 100 mm AT FULL SIZE. ALL SCALES REFERENCED TO FULL SIZE.



THIS DRAWING MAY HAVE BEEN REDUCED OR ENLARGED.
ALL FRACTIONAL SCALE NOTATIONS INDICATED ARE
BASED ON ORIGINAL FORMAT DRAWINGS.

LEGEND
● OBSERVATION/GPS POINT
 — GPS INSPECTION TRACK

- NOTES:**
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
 2. THIS DRAWING MUST BE READ IN CONJUNCTION WITH BGC'S REPORT TITLED "GRUM SULPHIDE CELL COVER INSPECTION" DATED MARCH 30, 2017.
 3. BASE IMAGERY DATA PROVIDED BY YUKON ENGINEERING SERVICES (YES), DATED 2014.
 4. PROJECTION IS NAD83 UTM ZONE 8N.
 5. FIELD OBSERVATIONS MADE BY GORD MCKENNA (BGC) AND DUSTIN RAINEY (YG) ON JUNE 29, 2016.
 6. NOTE THAT DOWNSTREAM SEEPAGE COLLECTION FACILITIES AT V15 NOT SHOWN -- SEE REPORT FOR LOCATION.

7. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

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| SCALE: | 1:2,000 |
| DATE: | MARCH 30 2017 |
| DRAWN: | IL |
| CHECKED: | GM |
| APPROVED: | JWC |

BGC ENGINEERING INC.
 AN APPLIED EARTH SCIENCES COMPANY

CLIENT:
 GOVERNMENT OF YUKON

| | |
|-------------------------------------------------|----------|
| PROJECT: GRUM SULPHIDE CELL COVER INSPECTION | |
| TITLE: FIELD OBSERVATIONS JUNE 29, 2016 | |
| PROJECT No.: | DWG No.: |
| 0533017 | 01 |

APPENDIX A

FIELD INSPECTION NOTES JUNE 29, 2016

Table A-1. Field inspection notes June 29, 2016.

| Time / GPS Location | General location | Field notes and observations (recommended actions have been included in the GSC Action Item List – see Appendix C) |
|------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>June 29, 2016 11:12 GPS 480</p> <p>Coords 0592860m 6904435m 4216ft</p> | <p>Grum Overburden Dump plateau, repeat photography site</p> | <p>Photostop and overlook from top of Grum Overburden Dump. Park truck and walk about 50m.</p> <ul style="list-style-type: none"> • Occupied same site as last year's photo • To find the exact spot as last year's photo, in camera viewfinder, lined up small power pole with rocky triangular area where power road meets main haul road • Good view of ponds at toe of cover • Good view of Grum Sulphide Cell Cover • Revegetation trial plots clearly visible, darker green • Mostly cloudy, very light breeze, rain in vicinity, not hampering inspection. |
| <p>11:44 GPS 481</p> <p>Coords 0593369 6902782 3889ft</p> | <p>Vangorda Dump plateau, repeat photography site</p> | <p>Photostop and overlook from bubble dump area of Vangorda Dump plateau. Park truck and walk 50m along cat track.</p> <ul style="list-style-type: none"> • Occupied same site as last year's photo • Orange snowfence visible around Lined Pond, Godwin pump to left side |
| <p>12:15pm GPS 482</p> | <p>GSC Upper Plateau, upper NW corner of cover area</p> | <ul style="list-style-type: none"> • The Run-On Water Control Berm and Ditch across top of plateau to prevent run-on is in good condition, little to no erosion ② Add signage to reclaimed areas to indicate: "Reclaimed area, no access to equipment without permit." Consider adding to orientation to keep out of reclaimed areas. |
| <p>14:43 GPS 483</p> | <p>Top of west access road</p> | <p>Shallow cross-ditch (water bar) across road</p> <ul style="list-style-type: none"> • Performing as intended, but very little relief, could overtop. • Continue to monitor |
| <p>12:47 GPS 484</p> | | <p>Un-revegetated repair</p> <ul style="list-style-type: none"> • Vegetation moving into area very slowly • Downslope, dozer cat tracks are visible • 10% vegetation cover estimated • Some rilling • Rilling starts within 1 to 2 m of crest • Continue to monitor |
| <p>13:00 GPS 485</p> | <p>Top slope Key Trench Bench (highest bench)</p> | <ul style="list-style-type: none"> • Some mosses visible • 0.05m high by 0.15m wide ridges parallel to bench with little growth on them • This is the anchor trench bench for the geomembrane in the cover. • Rills parallel along bench • Tipped out bench performing well – no erosion |
| <p>13:06 GPS 486</p> | <p>Just above 1284 Bench</p> | <ul style="list-style-type: none"> • Fair vegetation performance (even coverage, no erosion) |

| Time / GPS Location | General location | Field notes and observations (recommended actions have been included in the GSC Action Item List – see Appendix C) |
|---------------------|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 13:07 GPS 487 | Minor downslope rill in slope inflection | <p>Mossy stripe down slope</p> <ul style="list-style-type: none"> • Some geofabric pieces exposed • This is a phyllite drain – created with 0.5m deep excavation, clean phyllite fill • Good moss cover, more shrubs • Erosion rill next to drain. • Rills appear to be new. • Continue to monitor. |
| 13:14 GPS 489 | 1284 Bench | <ul style="list-style-type: none"> • Some sediment collection in channel, good grass+ moss growth in channel • Cat tracks across bench, appears somewhat repaired, performing well. • Small ledge 0.5m above bench, lots of moss and lush vegetation |
| 13:20 GPS 490 | 1284 Bench | <p>Grasses on benches</p> <ul style="list-style-type: none"> • Wet green grasses on slope just upslope of the bench • Some grass starting to grow on the bench |
| 13:22 GPS 491 | 1284 Bench | <p>Rounded benches:</p> <ul style="list-style-type: none"> • Here, and many locations on the benches, the downstream edge of the bench is rounded, increasing the risk of overtopping of the benches by ponded water or just loss of a bit of water down the slope – a cause of some rilling. • Continue to monitor. |
| 13:27 GPS 493 | Midslope | <p>Small depression</p> <ul style="list-style-type: none"> • Was this perhaps the location of a mired dozer during construction? • Growing well. |
| 13:26 GPS 494 | 1284 Bench | <p>Phyllite drain (base of drain)</p> <ul style="list-style-type: none"> • Minor old erosion rill and fan. Inactive? • Performing well. |
| 13:30 GPS 495 | East end of 1284 Bench | <p>This is the tie in to the East Perimeter Ditch – a rip-rapped downslope collection ditch.</p> <ul style="list-style-type: none"> • Fill had been placed into the ditch to facilitate access for a dozer for the last set of repairs. • Not fully cleaned out but 0.5 to 0.8m of relief in Perimeter Ditch remains. • Likely to wash out in big flow. • Use this location for access for 2017 repairs. |
| 13:35 GPS 496 | East end of 1284 Bench | <p>Small (4x4m) area of denser vegetation.</p> <ul style="list-style-type: none"> • Dense grass and some fireweed |
| 13:40 GPS 497 | East end of 1272 Bench | <p>Tie in between bench channel and East Perimeter Ditch</p> <ul style="list-style-type: none"> • Good performance • 75 to 150mm diameter angular rip rap |
| 13:43 GPS 498 | East end of 1272 Bench, just downslope of bench | <p>Strip of denser vegetation - EDI vegetation trial</p> <ul style="list-style-type: none"> • EDI 34-0-0 written on post |
| 13:40 GPS 499 | East end of 1272 Bench | <p>Tie in between bench and ditch</p> <ul style="list-style-type: none"> • North end beam 4 good performance • Riprap side ditch 3-6" dia • Tie in performing well • Break in slope above bench just like upper bench |
| 13:48 GPS 499 | B1F2 Trial Test Plots | <p>Trial plots</p> <ul style="list-style-type: none"> • 30-40% cover with grass, not much moss • Seems like nitrogen fertilizer is improving vegetation performance |

| Time / GPS Location | General location | Field notes and observations (recommended actions have been included in the GSC Action Item List – see Appendix C) |
|---------------------|----------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 13:58 GPS 500 | 1272 Bench | Shrubs and grasses invading the bench, natural ingress. |
| 14:05 GPS 501 | Slope 2 just above west end of 1272 Bench, near West Perimeter Ditch | Area of erosion rills on slope <ul style="list-style-type: none"> • Half-dozen erosion rills, each 5m long x 0.15m deep • Vegetation appears to be invading rills slowly. • Continue to monitor. |
| 14:10 GPS 502 | West end of 1272 Bench at West Perimeter Ditch | The tie in between the Perimeter Ditch and the bench channel is irregular <ul style="list-style-type: none"> • There is a risk that water coming down the ditch could deflect onto the bench which would cause gullyng. • Continue to monitor. |
| 14:15 GPS 503 | West Perimeter Ditch downslope of 1272 Bench | Curvy dozer tracks mid slope noted <ul style="list-style-type: none"> • Not a problem. |
| 14:18 GPS 504 | West end 1258 Bench | Snowfence location trial. <ul style="list-style-type: none"> • The snowfence is much too porous to trap snow. • Poor location of fence – would trap snow on bench. <ul style="list-style-type: none"> ② Remove snowfence and the posts. ② Consider a new snowfence trial with long fences midslope above and below 1258 bench |
| | | Small rill (almost a gully) <ul style="list-style-type: none"> • 20m long x 0.4m wide x 0.3m deep • Some vegetation trying to grow in rill, but appears active. • To fix, would need to cut off source of water on bench. Would be a couple cubic metres of fill to fill in the rill if needed and then would require revegetation. • Appears to be new since 2015. <ul style="list-style-type: none"> ② Repair in 2017 |
| 14:40 GPS 505 | 1258 Bench | Bulldozer Track <ul style="list-style-type: none"> • Area had been damaged and had been marked for fix up in previous inspection. • Appears to have been raked and revegetated, very nicely repaired. • Now appears as two parallel strips with slightly less and shorter vegetation. • No action required. |
| 14:47 GPS 506 | | Diagonal rock drain from slope above terminates on this bench. <ul style="list-style-type: none"> • A bit denser vegetation over drain, a few more shrubs. • No erosion. Some fabric exposed. |
| 14:52 GPS 507 | | Another vegetation trial strip growing better than surrounding area. <ul style="list-style-type: none"> • 34-0-0 marked on post. |
| 14:53 GPS 508 | East end of 1258 Bench | Good tie in of bench with green grass in channel and Perimeter Ditch. <ul style="list-style-type: none"> • No issues |
| 14:57 GPS 509 | East end of 1244 Bench | Good tie in end of bench where bench channel meets East Perimeter Ditch <ul style="list-style-type: none"> • No issues • The ditch turns the corner here, there is a good road bench that provides containment. • There are some dozer tracks on the bench that may lead to erosion <ul style="list-style-type: none"> ② Repair dozer tracks on bench in 2017 |

| Time / GPS Location | General location | Field notes and observations (recommended actions have been included in the GSC Action Item List – see Appendix C) |
|---------------------|----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15:03 GPS 510 | 1244 Bench | Bench in minor distress. <ul style="list-style-type: none"> • 50 to 80m long x 4m wide area (240m²) on bench (outer edge). Rutted by equipment in the past. • May cause additional rilling through ponding of water. <p>② Repair in 2017</p> |
| 15:05 GPS 511 | 1244 Bench | Rill erosion below bench <ul style="list-style-type: none"> • 15m long x 0.4m wide, 0.05 to 0.25m deep, slightly sinuous • Caused by overtopping of bench, probably due to snowmelt, fed by channel above bench • Continue to monitor • Recommended for repair previously (#2015-09) <p>② Repair in 2017</p> |
| 15:10 GPS 512 | Upslope from 1244 Bench | Zone of red rust / oxidized zone / red staining on cover <ul style="list-style-type: none"> • 3m x 4m in size • No vegetation • 10m up from road (planview distance) • There is an EDS fertilizer trial stake here • Appears to be an area of waste rock that is oxidizing. • No erosion, but a weak zone in the cover due to lack of vegetation. • Continue to monitor |
| 15:16 GPS 513 | Upslope from 1244 Bench | Rilling above road, small silt fan in ditch <ul style="list-style-type: none"> • 2 rills, upslope • Left rill (west) is 30 to 40m long x 0.15m wide x 0.05m deep • Right rill (east) is 30 to 40m long x 0.3m wide x 0.15m deep • Resulting fan <1m³ of material • Previously recommended for repair (#2015-13) <p>② Repair in 2017</p> |
| 15:23 GPS 514 | Upslope from 1244 Bench | Old healed rill / channel above bench <ul style="list-style-type: none"> • 1.5m wide x 0.1m deep • Darker vegetation, appears inactive • Continue to monitor |
| 15:26 GPS 515 | West end of 1244 Bench | 4 to 5 minor rills upslope of bench at west end <ul style="list-style-type: none"> • Rills are each 10m long x 0.1m wide x 0.05m deep • Silt/sand fan in bench channel is < 1m³ • Continue to monitor <p>② Repair in 2017</p> |
| 15:31 GPS 516 | Midslope between 1244 and 1227 Benches | Rill downslope of 1244 bench <ul style="list-style-type: none"> • 25m long x 0.20m wide x 0.15m deep • Adjacent to gravel channel with fabric exposed. • Continue to monitor |
| 15:35 GPS 517 | West end 1227 Bench | Small rill with a small fan, very minor <ul style="list-style-type: none"> • 10m long x 0.1m wide x 0.05m deep • Rill is larger downslope but seems to be inactive / self-healed. • 50m long x 0.3m wide x 0.1m deep • Continue to monitor |

| Time / GPS Location | General location | Field notes and observations (recommended actions have been included in the GSC Action Item List – see Appendix C) |
|----------------------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15:40 GPS 518 | 1227 Bench | Crack in road <ul style="list-style-type: none"> • 25m long, 1 to 2 cm wide, 5cm deep. • Part of an arcuate scarp • A few holes that hint at piping into the crack • No offset or drop of the scarp • No expression on the downslope area, but a bit wetter. • May be a bit of sliding on liner or settlement / moisture cracking. <p>② Seal this crack in 2017.</p> |
| 15:45 GPS 519 | 1227 Bench | Area with minor rills below bench <ul style="list-style-type: none"> • Minor • Partially overgrown, in active. Runs down to next bench |
| 15:50 GPS 520 | 1227 Bench | Minor cracks in road (similar to GPS 518) <ul style="list-style-type: none"> • 2 to 3 arcuate cracks, • 10m long • No other signs of slope instability downslope (or upslope) <p>② Seal cracks in 2017.</p> |
| 15:57 GPS 521 | East end of Toe Berm Bench | On the Toe Berm Toe Road <ul style="list-style-type: none"> • Good performance • Slope below measured at 28° (2H:1V was the design for this area, steepened from 3H:1V elsewhere due to room constraints • Vegetation performance looks better than one slopes above |
| 16:04 GPS 522 | Toe Berm Bench | Bigger rills - developing for years on upstream side of bench road <ul style="list-style-type: none"> • 0.4m wide x 0.1m deep, extend upslope a fair distance • Fan on road is 5m radius, perhaps 5m³ in volume <p>② Re-evaluate in 2017, repair if needed (grade to remove source water, regrade rills, remove fan, revegetate).</p> |
| 16:12 GPS 523 | Toe Berm Bench | Gully downslope of bench <ul style="list-style-type: none"> • 50m long x 2.0m wide x 0.9m deep • 0.05 to 0.3m diameter rock is self-armoring • Headcut 2m into road, probably caused by snowdrifts pushing laterally flowing water over crest. • Gully is too shallow to intersect the liner • Snow drift zigzag fines winnowing visible in photos <p>② Re-evaluate in 2017, repair if needed (grade to remove source water, regrade rills, remove fan, revegetate).</p> |
| 16:20 GPS 524,525 | Gulley field on slope above Toe Berm Bench next to West Perimeter Ditch | Gully adjacent to Perimeter Ditch <ul style="list-style-type: none"> • 1.0m wide x 0.15m deep • Too rainy for a photo • A few tributary rills, some vegetation in rills but minor • Slope is 4H:1V have over steepened from 5H: 1V in construction • Caused by drifted snow- during melt would be largely solved by 0.3m high berm • Perimeter Ditch performing well • No photos of gully field. <p>② Repair in 2017</p> |
| 16:30 GPS 526 | West Dissipation Pool | Muddy rocky pond at bottom of slope. <ul style="list-style-type: none"> • Looks good, performing as intended. |

| Time / GPS Location | General location | Field notes and observations (recommended actions have been included in the GSC Action Item List – see Appendix C) |
|---------------------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16:34 GPS 527 | Access road at toe of cover | <p>Big erosion gully</p> <ul style="list-style-type: none"> • 1.0m wide by 1.0m deep gully below road • Intentional – caused by gap in safety berm in road, designed to allow road to drain • Severe erosion, cutting into road a little, maintenance issue. • Noted various areas of rilling at toe of toe berm as walked the site, minor, nothing more noted. • Recommended for repair previously (#2015-11) <p>② Repair in 2017 by regrading road berm to limit further access to water and further erosion.</p> |
| 16:40 GPS 528 | Lined Pond | <p>Lined Pond, outlet, fence, pump</p> <ul style="list-style-type: none"> • Appears to be in good shape, outlet open • Pumped down to minimum level • Large pump at west end, ready to go • Wildlife fence in disrepair, no longer functional, pipe from pump is laying on part of fence. <p>② Repair fence restore its functionality.</p> |
| 16:44 GPS 529 | Toe Berm Toe near Lined Pond | <p>Three small slumps where toeberm slope is oversteepened</p> <ul style="list-style-type: none"> • Slope at 2H:1V is a bit too steep for the fill on the liner. • Look no worse than last year • Lowest slump (westernmost) <ul style="list-style-type: none"> ○ 2m above toe of slope ○ 2m diameter. ○ 0.3m-0.6m downslope movement. ○ Some vegetation. Looks like seepage port (where seepage exits the face) • Middle slump <ul style="list-style-type: none"> ○ More difficult to see ○ Appears 10m wide (across) and 5m long (downslope). ○ Small scarps ○ Some vegetation, better vegetation growth below and too the sides ○ Likely influenced by moisture • Eastern (right) slump <ul style="list-style-type: none"> ○ Similar to middle slump, similar elevation • Repaired gully between middle and eastern slump performing well. (Appeared to be filled and seeded). • Performance indicates that 2H:1V is likely too steep for future designs with similar materials. Performance may improve with denser vegetation. <p>② Revegetate slumps in 2017. Install piezometers to monitor pore-water pressure changes with time.</p> |
| 16:46 GPS 530 | Lower Dissipation Pond | <p>Small sump/ pond</p> <ul style="list-style-type: none"> • 3m diameter • Good performance • Water field conductivity 1260 µs/cm (fresh water) • Slope above has two repaired gullies • Performing as intended. |
| 16:56 GPS 531 | Lined Pond | <p>Lined Pond and outlet</p> <ul style="list-style-type: none"> • Outlet of Lined Pond in good shape. • Slope below is rough • Pond is very low (has been pumped down) • Performing as intended. |

| Time / GPS Location | General location | Field notes and observations (recommended actions have been included in the GSC Action Item List – see Appendix C) |
|---------------------|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 16:58 GPS 532 | Unlined Pond (contingency storage) | Unlined Pond <ul style="list-style-type: none"> • Pond is low • No pump in place, pump has been removed • No photos in the rain for this site. Overview shown in Photo 957. • Performing as intended. |
| 17:06 GPS 533 | Unlined Pond | Unengineered outlet <ul style="list-style-type: none"> • Outlet could be damaged or fail during large flow event. |
| 17:17 GPS 534 | Pumping Station V15 | Pump back station about 350m from Lined Pond <ul style="list-style-type: none"> • Operating in low-flow mode (small pumps running, big pumps on standby). • Good access. All the roads around are very good. • Confluence of 3 streams, • Water conductivity 1800 to 2200 $\mu\text{S}/\text{cm}$, 8°C. (slightly saline water) • Visited small pond just upstream, old swamp, clear water; becoming overgrown • Performing as intended. |
| 17:38 GPS 535 | Moose Pond | Previously used sump <ul style="list-style-type: none"> • Water source cut off, completely drained, no longer used (stopped meeting discharge criteria when cover failed) • Soft mud located at base of old pond • Some horsetail vegetation coming in from east messy • Walked to ridge to overlook Vangorda Creek. Lots of downed trees. Old seepage ports being monitored for water quality. • No action required. |
| 17:45 | | Leave GSC Area |

APPENDIX B
FIELD INSPECTION PHOTOS JUNE 29, 2016

LIST OF PLATES

- Plate B-1. April 5 observations showing relatively bare slopes and drifted in benches (DST 2016)
- Plate B-2. April 5 observations showing West Perimeter Ditch and West Dissipation Pool relatively free from snow (DST 2016).
- Plate B-3. Repeat photography for GSC as viewed from Grum Overburden Stockpile (GPS 480). Upper photo is May 26, 2015. Bottom photo is June 29, 2016.
- Plate B-4. Repeat photography for GSC as viewed from Vangorda Waste Rock Dump (GPS 481). Upper photo is May 26, 2015. Bottom photo is June 29, 2016.
- Plate B-5. Upper run-on diversion berm and ditch/swale (GPS 483)
- Plate B-6. Sparse vegetation and rilling of cover materials below the 1244 bench (GPS 515)
- Plate B-7. Damage due to equipment tracks (from a previous year) below the 1258 Bench. (GPS 505).
- Plate B-8. New cracking on the 1227 Bench (GPS 518).
- Plate B-9. New cracking on the 1227 Bench (GPS 518).
- Plate B-10. Remnants of a channel skirting a recent snow drift are visible in this photo on the Toe Berm bench (GPS 523). The photo has been enhanced to show the channel more clearly. This site will require repairs to a gully below and grading of the bench.
- Plate B-11. Rilling above 1284 Bench (GPS 487). These active rills appear to be new since 2015 inspection.
- Plate B-12. Rilling below the 1258 Bench. GPS (504). The photo illustrates some rock armoring but little vegetative armoring of the rill. They appear to be new since 2015.
- Plate B-13. Rilling below the 1244 Bench. (GPS 515). Rills are each 10 m long x 0.1 m wide x 0.05 m deep and appear to be new since 2015 inspection.
- Plate B-14. Rilling with fan deposition onto the Toe Berm Bench. This fan deposition, if left unchecked, could block flow in the lateral berm channel (GPS 522). Noted in action log for repair of gully and removal of fans.
- Plate B-15. Two of the slumps on the Toe Berm Slope (GPS 529) Movements of the lower slump are due to the oversteepened slope and possibly excess pore-water pressures at the liner. Vegetation patterns indicate the slump is still active.
- Plate B-16. West Perimeter Ditch (GPS 525) showing good performance. Looking upslope from near 1227 Bench.

- Plate B-17. East Perimeter Ditch at Bench 1284 (GPS 495). No signs of blockage or flow channelization.
- Plate B-18. Dissipation pools at base of perimeter ditches (A: East Dissipation Pool, GPS 530; B: West Dissipation Pool. (GPS 526).
- Plate B-19. Lined Pond (GPS 528). The liner is intact, and the pump at the ready, but the orange safety fence for wildlife entry is of need of repair.
- Plate B-20. Unlined Pond (GPS 532). The pump has been removed.
- Plate B-21. Unlined Pond outlet channel. (GPS 533)
- Plate B-22. Pumping station V15. (GPS 534)
- Plate B-23. Ditches and pumps at the Pumping Station V15 (GPS 534). The two high-flow pumps are sitting idle above the creek bed during this low-flow period.
- Plate B-24. The Moose Pond became dry after its water source was cut off. The base is muddy; some vegetation is invading. (GPS 535)



Plate B-1. April 5 observations showing relatively bare slopes and drifted in benches (DST 2016)

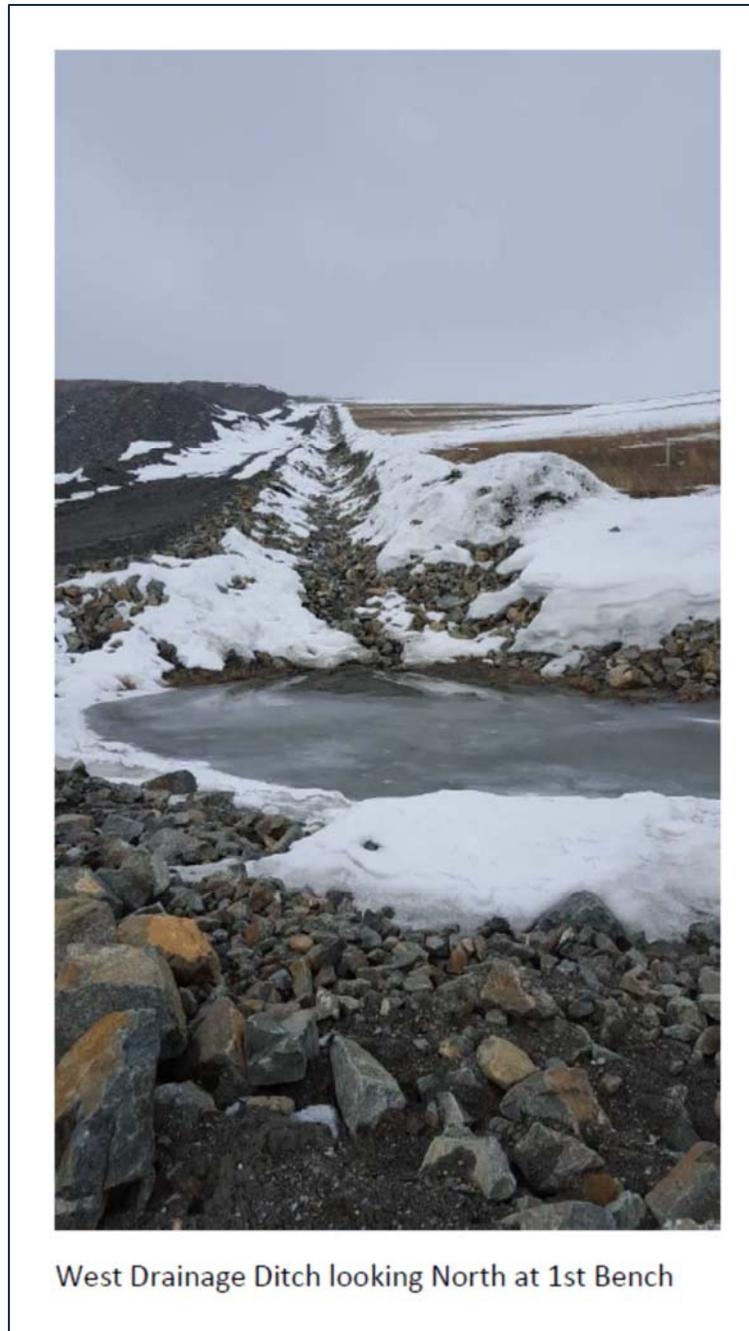


Plate B-2. April 5 observations showing West Perimeter Ditch and West Dissipation Pool relatively free from snow (DST 2016).



Plate B-3. Repeat photography for GSC as viewed from Grum Overburden Stockpile (GPS 480). Upper photo is May 26, 2015. Bottom photo is June 29, 2016.



Plate B-4. Repeat photography for GSC as viewed from Vangorda Waste Rock Dump (GPS 481). Upper photo is May 26, 2015. Bottom photo is June 29, 2016.



Plate B-5. Upper run-on diversion berm and ditch/swale (GPS 483).

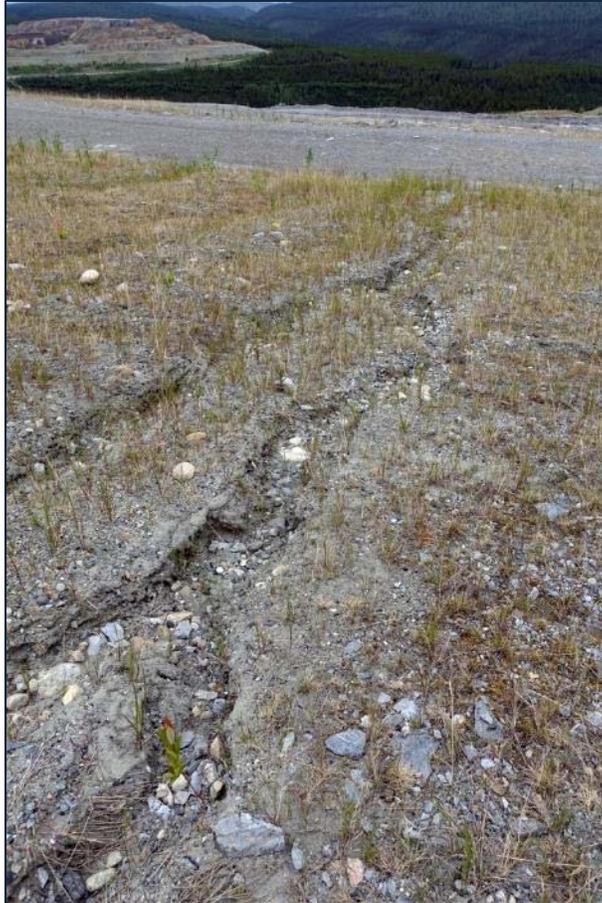


Plate B-6. Sparse vegetation and rilling of cover materials below the 1244 bench (GPS 515).



Plate B-7. Damage due to equipment tracks (from a previous year) below the 1258 Bench. (GPS 505).



Plate B-8. New cracking on the 1227 Bench (GPS 518).



Plate B-9. New cracking on the 1227 Bench (GPS 518).



Plate B-10. Remnants of a channel skirting a recent snow drift are visible in this photo on the Toe Berm bench (GPS 523). The photo has been enhanced to show the channel more clearly. This site will require repairs to a gully below and grading of the bench.



Plate B-11. Rilling above 1284 Bench (GPS 487). These active rills appear to be new since 2015 inspection.



Plate B-12. Rilling below the 1258 Bench. GPS (504). The photo illustrates some rock armoring but little vegetative armoring of the rill. They appear to be new since 2015.



Plate B-13. Rilling below the 1244 Bench. (GPS 515). Rills are each 10 m long x 0.1 m wide x 0.05 m deep and appear to be new since 2015 inspection.



Plate B-14. Rilling with fan deposition onto the Toe Berm Bench. This fan deposition, if left unchecked, could block flow in the lateral berm channel (GPS 522). Noted in action log for repair of gully and removal of fans.



Plate B-15. Two of the slumps on the Toe Berm Slope (GPS 529) Movements of the lower slump are due to the oversteepened slope and possibly excess pore-water pressures at the liner. Vegetation patterns indicate the slump is still active.

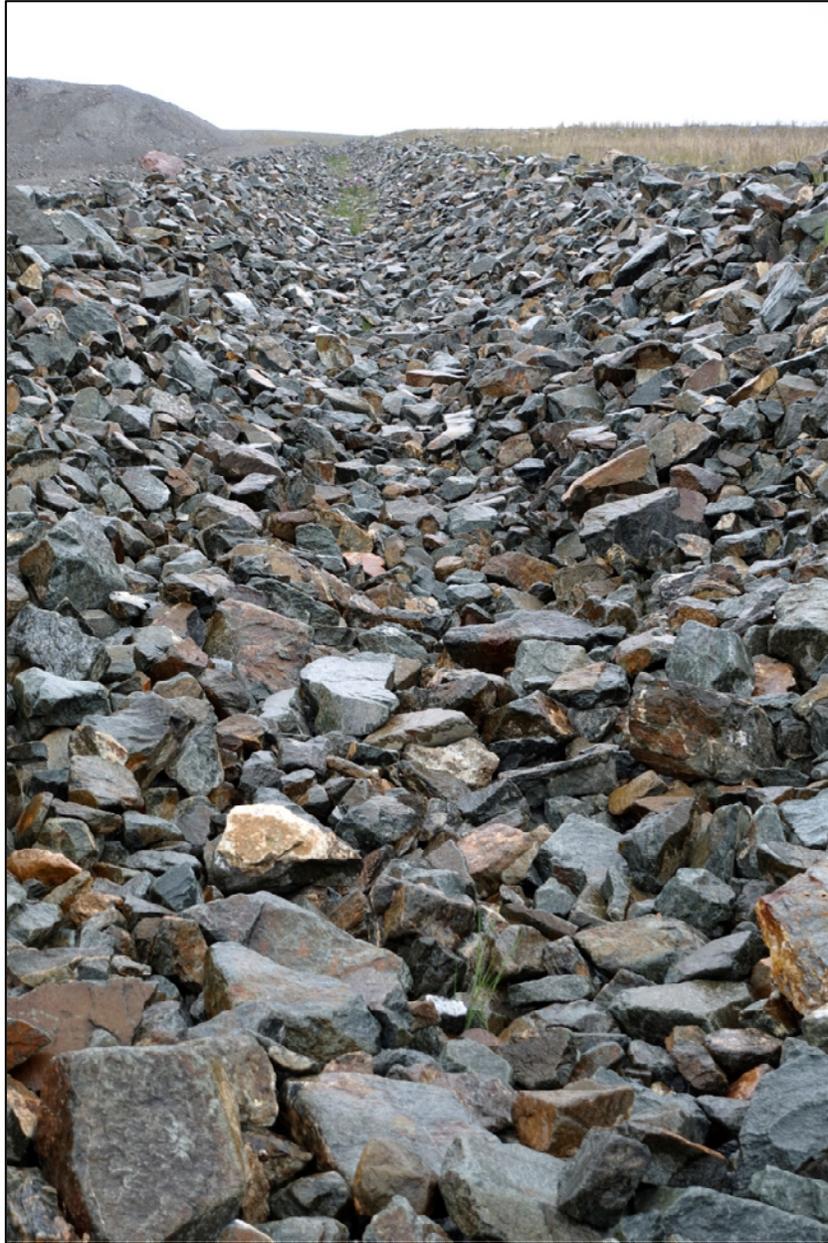


Plate B-16. West Perimeter Ditch (GPS 525) showing good performance. Looking upslope from near 1227 Bench.



Plate B-17. East Perimeter Ditch at Bench 1284 (GPS 495). No signs of blockage or flow channelization.



Plate B-18. Dissipation pools at base of perimeter ditches (A: East Dissipation Pool, GPS 530; B: West Dissipation Pool, GPS 526).



Plate B-19. Lined Pond (GPS 528). The liner is intact, and the pump at the ready, but the orange safety fence for wildlife entry is of need of repair.



Plate B-20. Unlined Pond (GPS 532). The pump has been removed.



Plate B-21. Unlined Pond outlet channel (GPS 533)



Plate B-22. Pumping station V15. (GPS 534).



Plate B-23. Ditches and pumps at the Pumping Station V15 (GPS 534). The two high-flow pumps are sitting idle above the creek bed during this low-flow period.



Plate B-24. The Moose Pond became dry after its water source was cut off. The base is muddy; some vegetation is invading. (GPS 535).

APPENDIX C

GRUM SULPHIDE CELL MAINTENANCE ACTION LOG

Table C-1. Grum Sulphide Cell Maintenance Action Log

| Action item # | Recommendation | Priority (see legend at bottom) | Recommendation date | Description of activity undertaken | Date completed | Comment |
|---------------|----------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------|-----------------------------------------------------------------|--------------------------------|-------------------------------|
| 2012 | | | | | | |
| 2012-01 | Install permanent perimeter safety fence around Lined Pond | - | Jan 2012 | | Completed | Snowfence installed. |
| 2012-02 | Install snowfence trial | - | Jan 2012 | | Completed | No as-builts provided to BGC. |
| 2012-03 | Install pump and pipeline system to pump from Lined Pond to Vangorda Pit | - | Jan 2012 | | Completed | |
| 2012-04 | Instrument the cover system and develop a water balance for prediction of future performance and future cover design | 2 | Jan 2012 | | | |
| 2013 | | | | | | |
| 2013-01 | Remove slough from West and East Perimeter Ditches | - | June 2013 | | Completed | No as-builts provided to BGC. |
| 2013-02 | Repair rills and gullies on cover | - | June 2013 | | Completed | |
| 2013-03 | Create water bar and extend Run-un Ditch on plateau | - | June 2013 | | Completed | |
| 2013-04 | Hydroseed bare areas | - | June 2013 | | Completed | |
| 2014 | | | | | | |
| 2014-01 | Repair gullies at West Perimeter Ditch | 2 | May 2014 | | | |
| 2014-02 | Repair rills and gullies on cover | - | May 2014 | | Completed | No as-builts provided to BGC. |
| 2014-03 | Reclaim the rest of the waste dump landform | 2 | May 2014 | | | |
| 2015 | | | | | | |
| 2015-01 | Regrade excavator tracks on 1284 Bench | - | May 2015 | Unclear extent of any repairs vs natural ingress of vegetation. | Acceptable performance in 2016 | No as-builts provided to BGC. |
| 2015-02 | Regrade excavator tracks on 1258 Bench | - | May 2015 | | Acceptable performance in 2016 | |
| 2015-03 | Regrade excavator tracks on 1244 Bench | - | May 2015 | | Acceptable performance in 2016 | |
| 2015-04 | Repair dozer tracks on slope between 1244 and 1258 Benches | - | May 2015 | | Acceptable performance in 2016 | |
| 2015-05 | Repair dozer tracks on slope between 1227 and 1244 Benches (near East Perimeter Ditch) | - | May 2015 | | Acceptable performance in 2016 | |
| 2015-06 | Repair and revegetate loose ditch spoil above 1244 Bench | - | May 2015 | | Acceptable performance in 2016 | |

| Action item # | Recommendation | Priority (see legend at bottom) | Recommendation date | Description of activity undertaken | Date completed | Comment |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------|------------------------------------|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| 2015-07 | Remove soil backfill and replace rip rap in East Perimeter Ditch at 1244 Bench | | May 2015 | | Acceptable performance in 2016 | |
| 2015-08 | Establish procedure to prevent equipment from entering cover area during snowmelt to prevent damage to benches and slopes. | 2 | May 2015 | | | Also, add this notice to mine orientation and standard operating procedure. |
| 2015-09 | Regrade top of gully between 1227 and 1244 Benches N 6903988 E 592319 | 2 | May 2015 | | | Site GPS 511 in 2016 inspection. |
| 2015-10 | Regrade top of gully between Toe Berm Toe Road and 1227 Bench N 6903928 E 592387 | - | May 2015 | | Acceptable performance in 2016 | No as-builts provided to BGC. |
| 2015-11 | Regrade top of gully below Toe Berm Toe Road N 6903652 E 592265 | 2 | May 2015 | | | Site GPS 527 in 2016 inspection. |
| 2015-12 | Regrade top of gully below 1244 Bench N 6903846 E 592106 | 2 | May 2015 | | | Site GPS 513 in 2016 inspection |
| 2015-13 | Repair gully on West Access Ramp N 6903964 E 591886 | 2 | May 2015 | | | |
| 2015-14 | Create a more permanent water management system at the toe of the dump aimed at long-term closure. | 2 | May 2015 | | | |
| 2016 | | | | | | |
| 2016-01 | Add signage on access roads to remind people and equipment to avoid disturbing reclaimed areas. | 2 | Dec 2016 | | | |
| 2016-02 | Add signage marking the 1284, 1272, 1258, 1244 and 1227 Benches and Toe Berm Toe Road to aid in inspection and maintenance activities. | 2 | Dec 2016 | | | |
| 2016-03 | Evaluate option to reseed and fertilize areas of underperforming vegetation or reseed and fertilize broad areas of dump in 2017. | 2 | Dec 2016 | | | Establishing better vegetation will reduce risk and may be enough to limit the need for more expensive earthwork fixes in future years. |
| 2016-04 | Establish a reference list and archive for all design and as-built drawings and reports and all monitoring reports for the GSC cover. | 2 | Dec 2016 | | | These will be important for demonstrating long-term performance, for learnings for other covers, and in support of future maintenance and repairs. |

| Action item # | Recommendation | Priority (see legend at bottom) | Recommendation date | Description of activity undertaken | Date completed | Comment |
|---------------|------------------------------------------------------------------|---------------------------------|---------------------|------------------------------------|----------------|-----------------------------------------------------------------------------------------|
| 2016-05 | Remove existing snowfence on 1258 Bench. GPS 504 | 2 | Dec 2016 | | | |
| 2016-06 | Conduct formal snowfence trial on two slopes in 2017. | 2 | Dec 2016 | | | Opportunity for installation this fall for next spring. |
| 2016-07 | Regrade 1244 Bench to remove ruts near crest. GPS 510 | 2 | Dec 2016 | | | |
| 2016-08 | Repair cracks in road. 1227 Bench. GPS 518/520 | 2 | Dec 2016 | | | |
| 2016-09 | Revegetated three slumps on Toe Berm Slope. | 2 | Dec 2016 | | | |
| 2016-10 | Repair rill field and fans upslope of Toe Berm Bench. GPS 522 | 2 | Dec 2016 | | | |
| 2016-11 | Repair gully. Downslope of Toe Berm Bench. GPS 523 | 2 | Dec 2016 | | | |
| 2016-12 | Repair gully. Upslope of Toe Berm Bench. GPS 524, 525 | 2 | Dec 2016 | | | |
| 2016-13 | Repair wildlife control fence around Lined Pond. GPS 528 | 2 | Dec 2016 | | | Consider permanent chain-link fence as a replacement. Pipeline will need to be shifted. |
| 2016-14 | Repair rill GPS 504 | 2 | Dec 2016 | | | Near existing snowfence trial |
| 2016-16 | Regrade equipment damage (track ruts) on 1244 Bench GPS 509 | 2 | Dec 2016 | | | Small job for a bobcat working on the bench. |
| 2016-17 | Repair rill field west end of 1244 Bench GPS 515 | 2 | Dec 2016 | | | |
| KEY | | | | | | |

ACTION PRIORITY

1 Significant issue, concern or deficiency observed or opportunity noted. High risk of major compromise to cover system, landform, or water quality issue downstream. Urgent attention required. Repair this year. Monitor performance of repairs and properly document.

2 Moderate issue, concern or deficiency observed or opportunity noted. Moderate risk. Repair during next cover rehabilitation program. Monitor annually and reassess.

Action items are based on BGC inspections (featured in 2016 and inspection previous reports back until 2012).