2017 Lupin Mine Tailings Containment Area Geotechnical Inspection

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Lupin Mines Incorporated

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Table of Contents

1 INTRODUCTION 1-1

1.1 Project Description 1-2

1.1.1 Location and Access 1-2

1.1.2 History and Current Status 1-3

1.1.3 Site Infrastructure 1-3

1.2 Climate 1-3

1.3 Site Geological Conditions 1-4

1.4 Permafrost and Dam Geotechnical Conditions 1-4

2 TAILINGS CONTAINMENT AREA DAMS 2-1

2.1 Dam Consequence Classifications 2-1

3 2017 TCA INSPECTION 3-1

3.1 General 3-1

3.2 Thermistors 3-1

3.3 TCA Perimeter Dams 3-8

3.4 Internal Dams 3-9

4 RECOMMENDATIONS 4-1

4.1 Mitigation for Dam K Wave Action Toe Erosion 4-4

4.2 Maintenance and Repairs 4-4

4.3 Update of the Dam Safety Inspection Guideline 4-5

5 CLOSURE 5-1

6 REFERENCES 6-1

APPENDIX A PHOTOGRAPH AND INSPECTION LOGS A-1

APPENDIX B INSPECTION LOGS B-1

List of Table

Table 1 CDA Dam Consequence Classification (CDA 2014) 2-2
Table 2 Lupin TCA Dam Consequence Classification 2-1
Table 3 Inspection Observation and Recommendations 4-1

List of Figures

Figure 1 Site Location ..... follows 1-1
Figure 2 Site Overview ..... follows 1-1
Figure 3 Mill Site and Support Facility Plan ..... follows 1-1
Figure 4 Tailings Containment Area ..... follows 1-1
Figure 5 Thermistor Reading for D1A-00-01 3-2
Figure 6 Thermistor Reading for D2-00-2n 3-3
Figure 7 Thermistor Reading for D4-1 3-4
Figure 8 Thermistor Reading for D4-3 3-5
Figure 9 Thermistor Reading for D4-4 3-6
Figure 10 Thermistor Reading for D3D-1 3-7
Figure 11 Thermistor Reading for DK-3 3-8

1 INTRODUCTION

Lupin Mines Incorporated (LMI) retained Norwest Corporation (Norwest) to complete the annual geotechnical dam inspection at the Lupin Mine tailings containment area (TCA). The Lupin Mine site is currently under care and maintenance status and operates under the Nunavut Water License 2AM-LUP1520 (NWB 2015) for LMI. LMI is a wholly-owned indirect subsidiary of Mandalay Resources.

The Lupin Mine is located on the northwest shore of Contwoyto Lake, approximately 400km northeast of Yellowknife, Northwest Territories (Figure 1). The site consists of a mill, camp and support facilities, fuel storage, airstrip, and the TCA (Figure 2). Detailed view of the mill site is provided in Figure 3 and the TCA in Figure 4.

The water license explicitly requires an annual geotechnical inspection to be completed for the TCA perimeter dams, TCA reclamation covers, including a quantitative assessment of any seepage from the TCA (NWB 2015). Norwest has provided a qualified person to conduct the geotechnical inspection to fulfill the requirements listed in Part E, Item 6 of the water license, which stipulates the following:

> "*The tailings containment area shall be constructed, operated and maintained to engineering standards such that:*
>
> a. *A minimum freeboard of 1.0 metre shall be maintained at all times or as recommended by a geotechnical engineer and as approved by the Board in writing;*
> b. *Seepage from the Tailings Containment Area is minimized;*
> c. *Any seepage that occurs is collected and returned immediately to the Tailings Containment Area;*
> d. *Erosion of constructed facilities is addressed immediately;*
> e. *The solids fraction of the mill tailings shall be permanently contained within the Tailings Containment Area or underground as backfill.*
> f. *Implement measures to ensure that the Tailings Containment Area is adequately covered or managed, including the use of approved binding agents, so as to prevent windblown tailings from impacting other areas of the project site;*
> g. *During care and maintenance, inspection shall be carried out on a bi-weekly basis during the freshet (approx. May and June), and monthly during the reminder of the open water period (approx. July – October) of the following:*
>   i. *Collection and return of seepage in Dam 2;*
>   ii. *Water levels in ponds 1 and 2, and cells 3 and 5;*
>   iii. *General surface erosion and anomalies on dams; and,*

iv. *Tension crack in Dam M. If water level in the ponds rise, then inspection shall be carried out bi-weekly during the open water season (approx. May – October);*

v. *Records of these inspection shall be kept for review upon the request of an Inspector, or as otherwise approved by the Board. More frequent inspections shall be performed at the requested of an Inspector.*

vi. *More frequent inspections shall be performed at the requests of an Inspector;*

vii. *An inspection of the Tailings Containment Area shall be carried out annually during ice free, open water condition by a geotechnical Engineer. The Engineer's report shall be submitted to the Board within sixty (60) days following the inspection, and shall include a cover letter from the Licensee outlining an implementation plan to respond to the Engineer's recommendations."*

This report summarizes Norwest's observation of the TCA's condition in 2017 and presents our recommendations. Previous annual inspections, safety reviews, and risk assessments with respect to the TCA made available to Norwest include:

- Inspection Report from 2016 by Norwest Corporation;
- Inspection Report from 2012-2015 by SRK Consulting;
- 2015 Dam Safety Review Report by SRK Consulting; and,
- 2012 TCA Risk Assessment and Water Quality Review by SRK Consulting.

While the annual inspection is carried out to satisfy the license requirements, the format and methodology used are in accordance to the best engineering practice using the Inspection and Maintenance of Dams Safety Guidelines issued by the Province of British Columbia, Water Management Branch (BCWMB 2011) and the Mining Association of Canada (MAC) Guidelines.

1.1 Project Description

1.1.1 Location and Access

The Lupin Mine is only assessible by air or winter road. The air access is serviced by a gravel runway, capable of handling large aircraft such as Hercules C-130 and Boeing 737 jets. Charter flights are typically deployed from Yellowknife for worker rotation and re-supply during the open water seasons. When the mine was in operation, it used the Tibbitt to Contwoyto Winter Road to resupply the mine. This winter road currently ends at the Ekati Diamond Mine and has not been extended to the Lupin Mine since 2005, when the mine went into care and maintenance status.

1.1.2 History and Current Status

Currently the Lupin Mine is in care and maintenance status and licensed accordingly. Mining operation ceased in 2005. Current care and maintenance operations include, but are not limited to, earthwork maintenance, water treatment and discharge as needed, water quality monitoring, and waste management as needed.

1.1.3 Site Infrastructure

The mine site consists of the following main structures: mill site, camp and support facilities, fuel storage, airstrip, and tailings containment area (TCA).

- The mill site included an underground hoist and wheelhouse, ball mill, concentrator, and a paste backfill plant (now decommissioned).
- The camp and support facilities included multiple wings of accommodations for workers, an office building, recreation facilities, cool and warm storage, generators, sewage lagoons and dams, and waste management facilities. Gravel roads are in place to connect the facilities.
- Fuel storage includes the main tank farm that contains diesel fuel for annual operation, along with fuel for aircraft. Fuel is pumped to a satellite tank farm as needed for equipment fueling and power generation to minimize the risk of spillage and accidents from using the large fuel tanks at the main farm.
- The airstrip is a gravel runway that can accommodate aircraft up to the size of a Boeing 737 jet.
- The TCA consists of a number of frozen core dams that provide a closed system for tailings and water treatment. Tailings are contained in a number of cells and progressive reclamation is ongoing and has now been completed at several cells. Water treatment is carried out using Pond 1 as a holding pond for effluent, treating the water in a plant, and then using Pond 2 as a polishing pond to allow the solids to precipitate prior to discharge to the environment. Details of the TCA configuration are described in Section 2 of this report.

1.2 Climate

Norwest evaluated the climate data from an automated weather station known as Lupin (CWIJ) available in the Weather Underground database (WU 2016). Intermittent climate data is also available from the Environment Canada database under station Lupin CS Climate ID 230N002. The evaluation was done from May 2005 to April 2017. The evaluation results indicate the station reported an annual mean temperature of -13°C. The average winter temperature, from October to April, was around -21°C. The average summer temperature, from May to September, was around 8°C. Annual total precipitation was averaged to be around 592mm, where the data does not differentiate between snow and rain. The mean wind direction was south-southeast, with average wind speed of 16km/h and high of 50km/h.

1.3 Site Geological Conditions

The Lupin Mine is located in the Archean metaturbidite sequence of the Contwoyto Formation. The rocks have been subjected to both regional and contact metamorphism, including deformations and intrusions.

The area was glaciated and experienced isostatic rebound after the melt. The glaciers and runoff from the melt washed out the erodible soils and formed lakes in low lying areas. The easily erodible glaciolacustrine and glacio-fluvial sands were reworked and displaced by the meltwater and resulted in the outcrops present with thin soil veneers, abandoned beaches and esker formations (Kinross 2005). Where bedrock is not present at the surface, the overburden typically consists of coarse grained glacial till which is intermittently covered by glaciolacustrine and glacial-fluvial deposits. The till is a silty sand with gravel and boulders, with low plasticity and ice depending on the depth.

1.4 Permafrost and Dam Geotechnical Conditions

The site is within a continuous permafrost region. The active layer is observed to be variable between the depth of 1m to 3m based on available data. During operation, scheduled monitoring was completed of all instrumentation, recording water levels, water quality and production volumes. This monitoring program was reduced accordingly during the care and maintenance period and is now carried out when work is being done on site. Thermistors are installed in several dams and in the tailings cover to monitor their performance. Some of the thermistors are no longer functional or damaged beyond repair. The remaining thermistors are read at least once annually during the geotechnical inspection and more often when site access allows. The thermistor readings indicate that permafrost remains within the dams and reclaimed tailings, and the readings are consistent with historical variation and limits.

2 TAILINGS CONTAINMENT AREA DAMS

The tailings produced are primarily comprised of amphibole and quartz, which accounts for 80% of the volume. Pyrrhotite and arsenopyrite make up an additional 17%. The tailings have been shown through various studies to have potential for acid generation (Kinross 2005). All of the tailings are contained within the TCA.

The Lupin Mine TCA consists of eight (8) perimeter dams and nine (9) internal dams. The perimeter dams are Dam 1A, 1B, 1C, and Dams 2 through 6. The internal dams are Dam 3a through 3e, Dams J through N, and the Divider Dykes. Combinations of the perimeter dams and internal dams form Tailings Cell 1 through 5 for containment. As the progressive reclamation is being completed, some of the internal dams (3a, 3b, 3c, 3e) are incorporated into the cover and are no longer considered as individual dams. Currently, Cells 1 and 2 are completely reclaimed, while Cell 3 is approximately 80% covered and Cell 5 is approximately 70% covered. About 84% of the entire tailings area is reclaimed with at least 1m of sand/gravel cover. No new tailings have been produced since 2005 when the site went into care and maintenance status.

All dams are constructed from esker sand and gravels, with the perimeter dams incorporating a geosynthetics liner for seepage control. All the perimeter dams are designed as frozen core dams founded on permafrost. Generally, the perimeter dams range in height from 1 to 8 metres. The internal dam heights range from 6 to 12 metres.

The care and maintenance procedures for water management, direct runoff and seepage from Cell 3 into Cell 4. The water in Cell 4 then flows through the Divider Dykes either though the control structure or seepage into Pond 1. Cell 5 runoff is pumped directly into Pond 1. Pond 1 water level is managed by siphoning water into Pond 2. Water treatment is carried out by treating the water in-situ in Pond 2, by adding lime to raise the pH. Precipitates from this treatment are deposited in Pond 2. The treated water in Pond 2 is siphoned into the environment in accordance with the Water License requirements (NWB 2015). Pond 2 does not have any flood overflow structures, such as a spillway or a control gate, to manage the water level. All discharge is retained and restricted until water quality meets the discharge requirement outlined in the Water License (NWB 2015).

2.1 Dam Consequence Classifications

Norwest utilized the Canadian Dam Association Guidelines (CDA 2014) to classify the consequence classification of each dam. The CDA consequence classification is shown in Table 1.

The dam consequence classification of the dams based on Norwest's 2017 inspection is outlined in Table 2. Norwest's consequence classifications are in line with the classifications outlined in the 2015 Dam Safety Review (SRK 2015).

An emergency preparedness plan (EPP) is noted by the DSR (SRK 2015) to be in place and deemed appropriate for care and maintenance status. Norwest did not review the EPP. Due to the lack of transportable tailings, permanent population, or infrastructure downstream of the perimeter dams, a detailed inundation study is deemed non-applicable.

Table 1
CDA Dam Consequence Classification (CDA 2014)

Dam Class	Population at Risk(1)	Incremental Losses		
		Loss of Life(2)	Environmental and Cultural Values	Infrastructure and Economics
Low	None	0	Minimal short-term loss; No long-term loss	Low economic losses Area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	Significant loss or deterioration of important fish or wildlife habitat Restoration or compensation in kind highly possible	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very High	Permanent	100 or fewer	Significant loss or deterioration of critical fish or wildlife habitat Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g. highway, industrial facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Major loss of critical fish or wildlife habitat Restoration or compensation in kind impossible	Extreme losses affecting critical infrastructure or services (e.g. hospital, major industrial complex, major storage facilities for dangerous substances)

Note 1. Definition for population at risk:
None - There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.
Temporary - People are only temporary in the dam-breach inundation zone (e.g. seasonal cottage use, passing through on transportation routes, participating in recreational activities). **Permanent** - The population at risk is ordinarily located in the dam-breach inundation zone (e.g. as permanent resident); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimate of potential loss life (to assist in decision-making if the appropriate analysis is carried out).
Note 2. Implication for loss of life:
Unspecified - The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

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Table 2
Lupin TCA Dam Consequence Classification

Dam		Consequence Classification	Rationale
Perimeter Dams	1A	Significant	Release of water that might not meet discharge criteria into the environment
	1B	Significant	Release of water that might not meet discharge criteria into the environment
	1C	Significant	Release of water that might not meet discharge criteria into the environment
	2	Significant	Release of water that might not meet discharge criteria into the environment
	3	Low	No free-standing water; Stable reclaimed tailings with very limited impact consequence upon failure
	4	Significant	Release of water that might not meet discharge criteria into the environment
	5	Low	No free-standing water; Stable reclaimed tailings with very limited impact consequence upon failure
	6	Low	No free-standing water; Stable reclaimed tailings with very limited impact consequence upon failure
Internal Dams	3D	Low	Any release of effluent or tailings are contained within the TCA
	J	Low	Any release of effluent or tailings are contained within the TCA
	K	Low	Any release of effluent or tailings are contained within the TCA
	L	Low	Any release of effluent or tailings are contained within the TCA
	M	Low	Any release of effluent or tailings are contained within the TCA
	N	Low	Any release of effluent or tailings are contained within the TCA
	Divider Dykes	Low	Any release of effluent or tailings are contained within the TCA

3 2017 TCA INSPECTION

3.1 General

Mr. Alvin Tong, PEng., a Senior Geotechnical Engineer with Norwest, conducted the geotechnical inspection on the 24th to 30th of August 2017. Detailed visual inspection was completed on all TCA components, along with readings of instrumentation. Mr. John LaBrie, representative of LMI, was on site for communication and organization, but did not accompany Norwest on the inspection.

The weather during inspection was cool and overcast with periods of sunshine. Detailed inspection and photograph logs are provided in Appendix A. The inspection logs are provided in Appendix B.

The general observations indicated that the perimeter dams are in stable condition. The divider dykes and Dam K should be considered for maintenance and repairs and Norwest communicated this to Mr. LaBrie on site. Pond 2 water level was raised slightly compared to last year's level with a freeboard upwards of 3m at the perimeter dams. The water level in Cell 5 continues to be lowered by pumping to Pond 1 to facilitate repair and allow placement of cover over the tailings.

Since the inspection in August, LMI continues to cover the tailings in Cell 5. Monitoring is being carried out on the water level in Cell 4 to ensure the freeboard is maintained and the condition of the divider dykes is satisfactory.

3.2 Thermistors

Thermistors were installed in the TCA between 1995 and 2004 to monitor the performance of the dams and tailings covers. From the existing records, there were thirteen thermistors installed in the dams, but only seven of them are currently functional. Of the seven functioning thermistors, five are in the perimeter dams and two are in the internal dams. There are an additional seven thermistors installed in the reclaimed tailings cover, but three of them do not have calibration data on record to evaluate the results. This report focuses on the thermistor readings from dams, using the thermistor readings from the cover for reference and comparison.

The thermistors were read monthly during operation up until 2006, and then read semi-annually during care and maintenance. Not all the functioning thermistors were read consistently throughout the care and maintenance period. To provide a point of reference in this report, selected data series between August and September, from year 2010 to 2017, are shown for comparison, while maximum values are calculated from the entire series from the first available records to 2017.

For the perimeter dams, the five functional thermistors are less than 20m deep. The five thermistor readings are shown in Figures 5 to 9. The data suggests the 2017 readings are within the historical variations, taking into account annual climatic variations and time of reading. Generally, the active layer (thaw zone) ranges from 2m to 3m depth, as interpolated by the 0°C gradient line. The largest historical variation in the given data set is approximately 2.2°C (between -2.5°C and -4.7°C) in Dam 2 (D2-00-02n) at the depth of 6m.

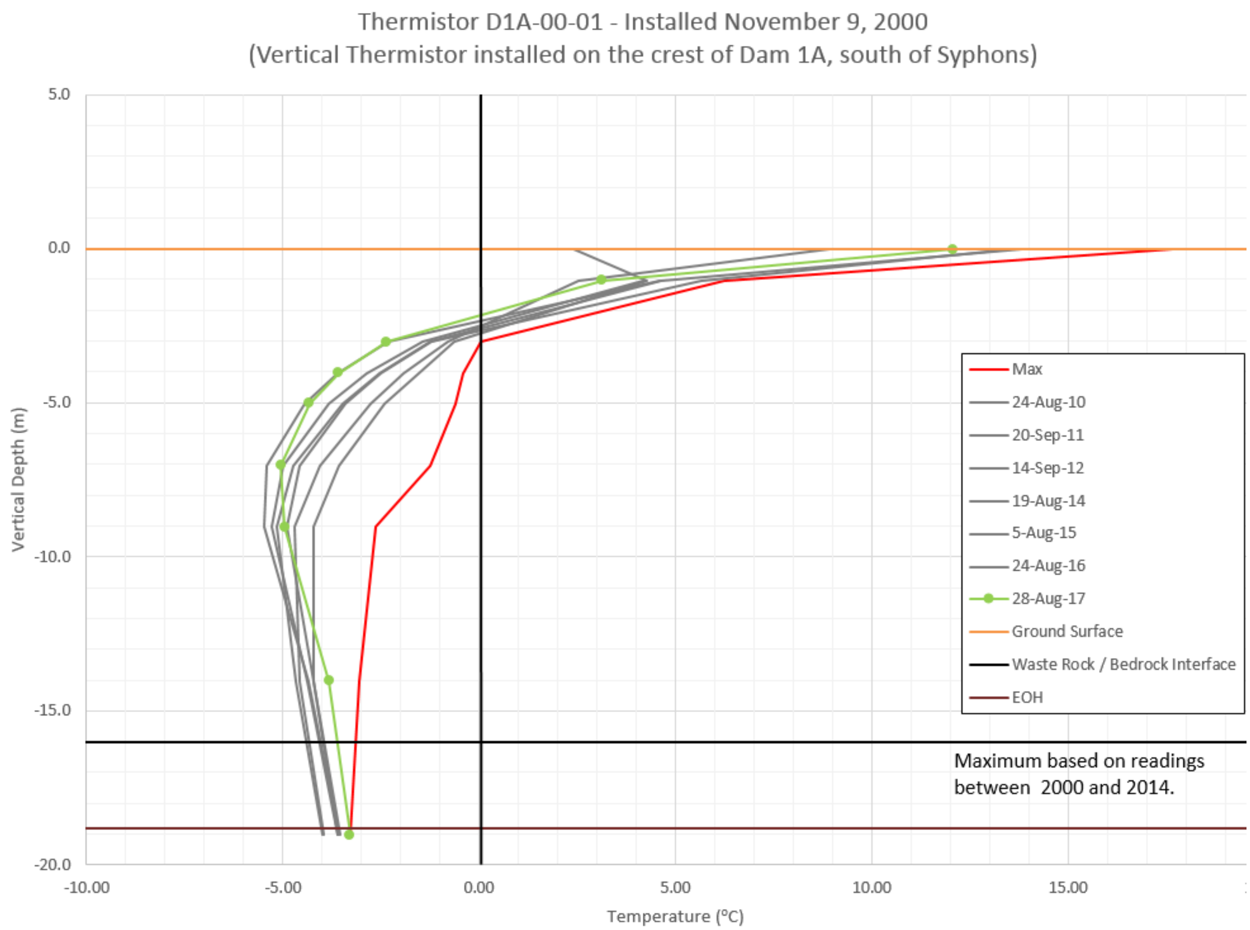

Figure 5: Thermistor Reading for D1A-00-01

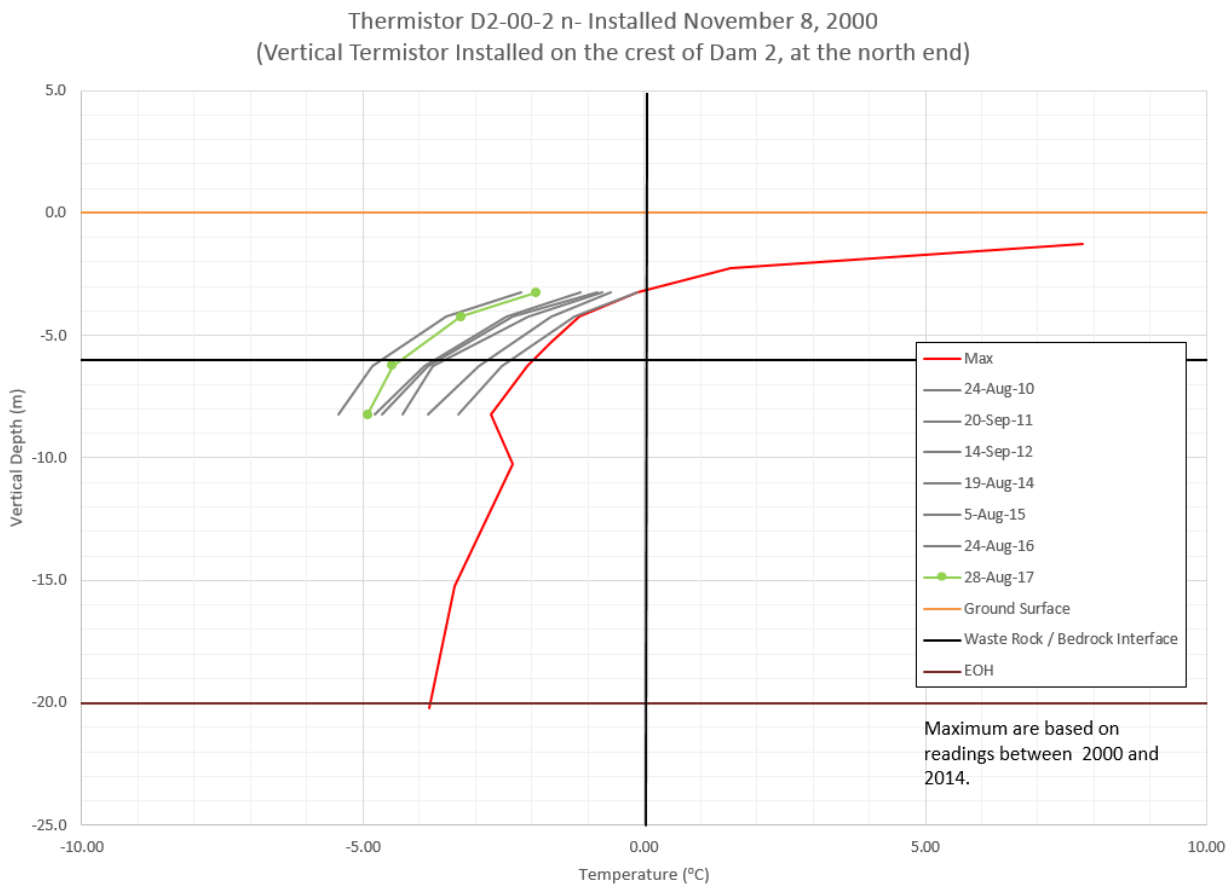

Figure 6 Thermistor Reading for D2-00-2n

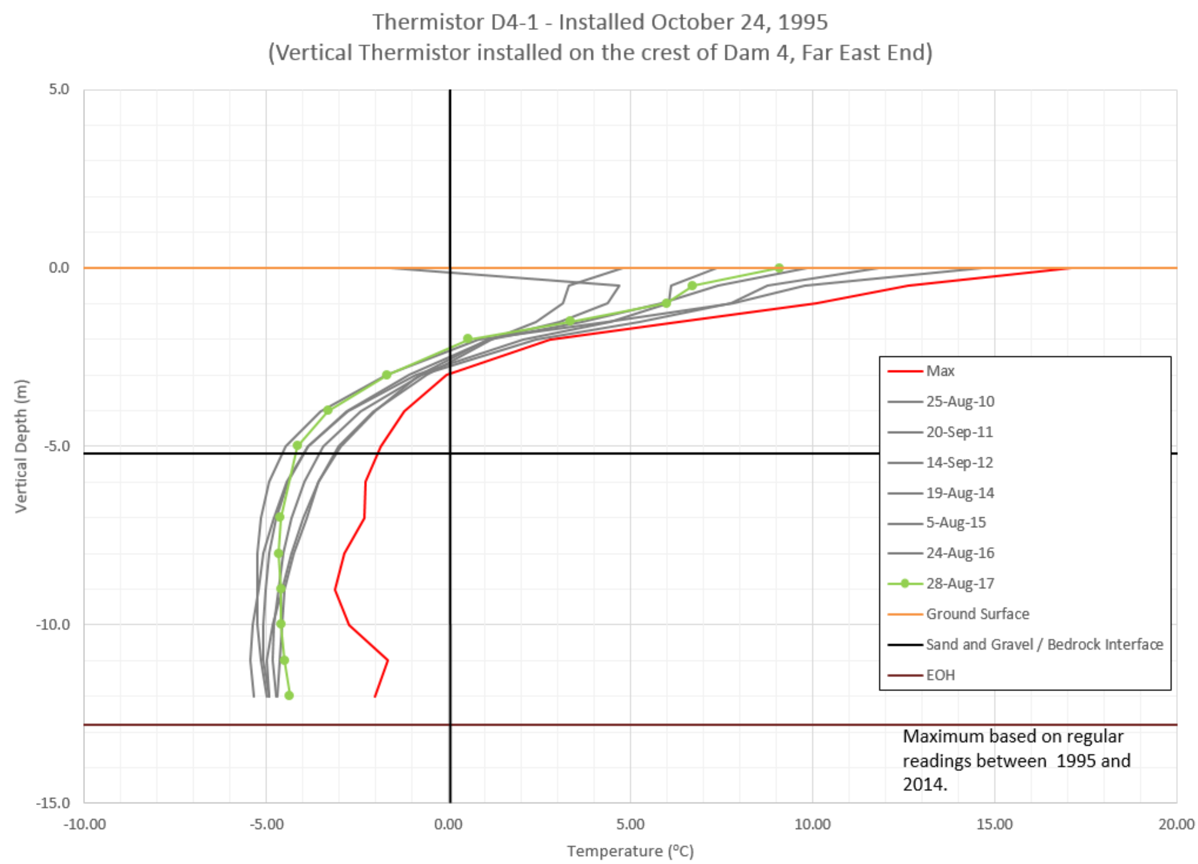

Figure 7 Thermistor Reading for D4-1

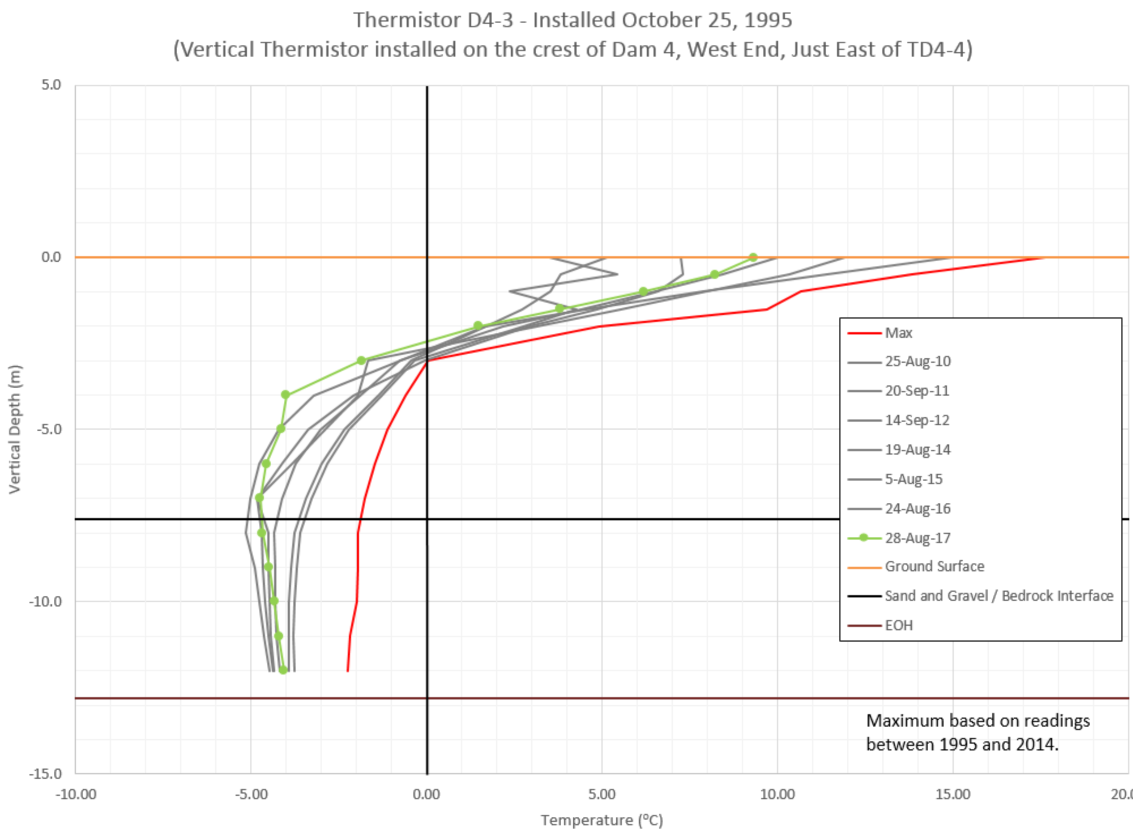

Figure 8 Thermistor Reading for D4-3

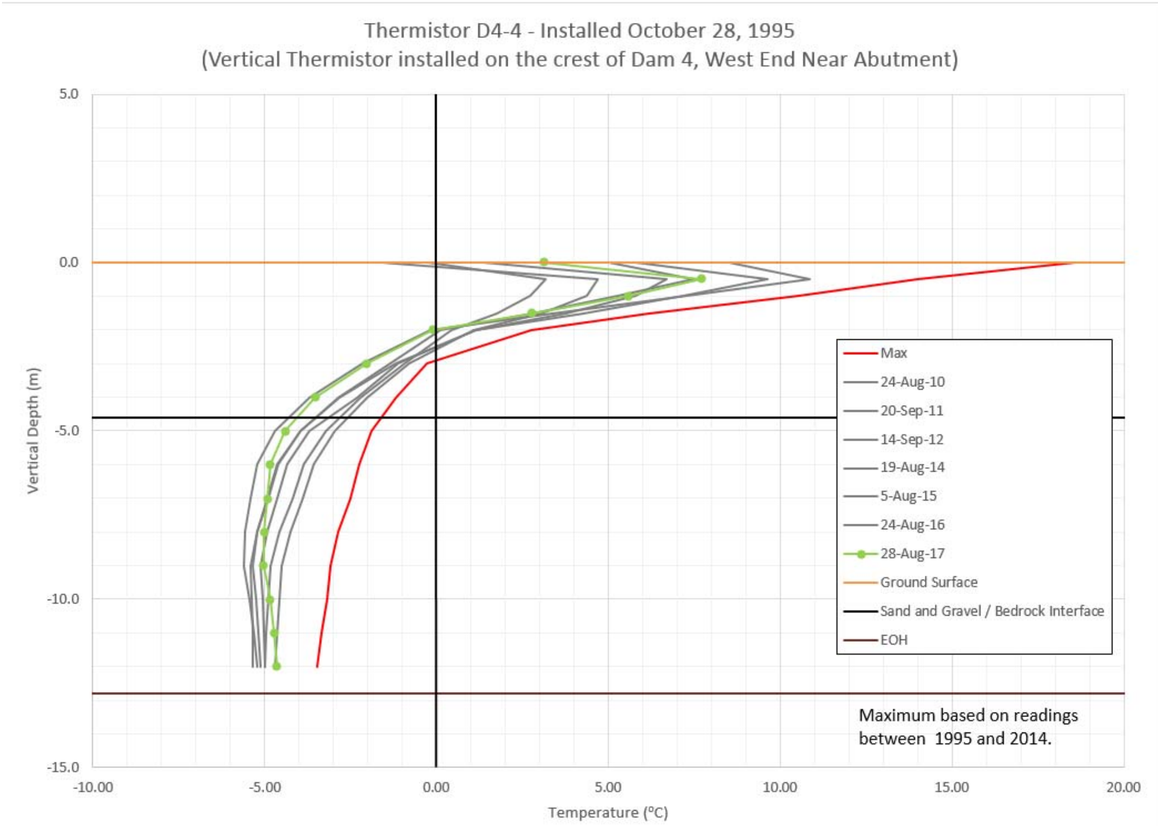

Figure 9 Thermistor Reading for D4-4

For the internal dams, the two functional thermistors are also less than 20m deep. These were not monitored as rigorously as the ones installed in the perimeter dams, and only have recent data between 2014 and 2017. The two thermistors readings are shown in Figure 10 and Figure 11. The active layer is observed to be between 2m to 3m, as interpolated by the 0°C gradient line. The variations between the data set are less than 2°C and generally occur below the historical maximum.

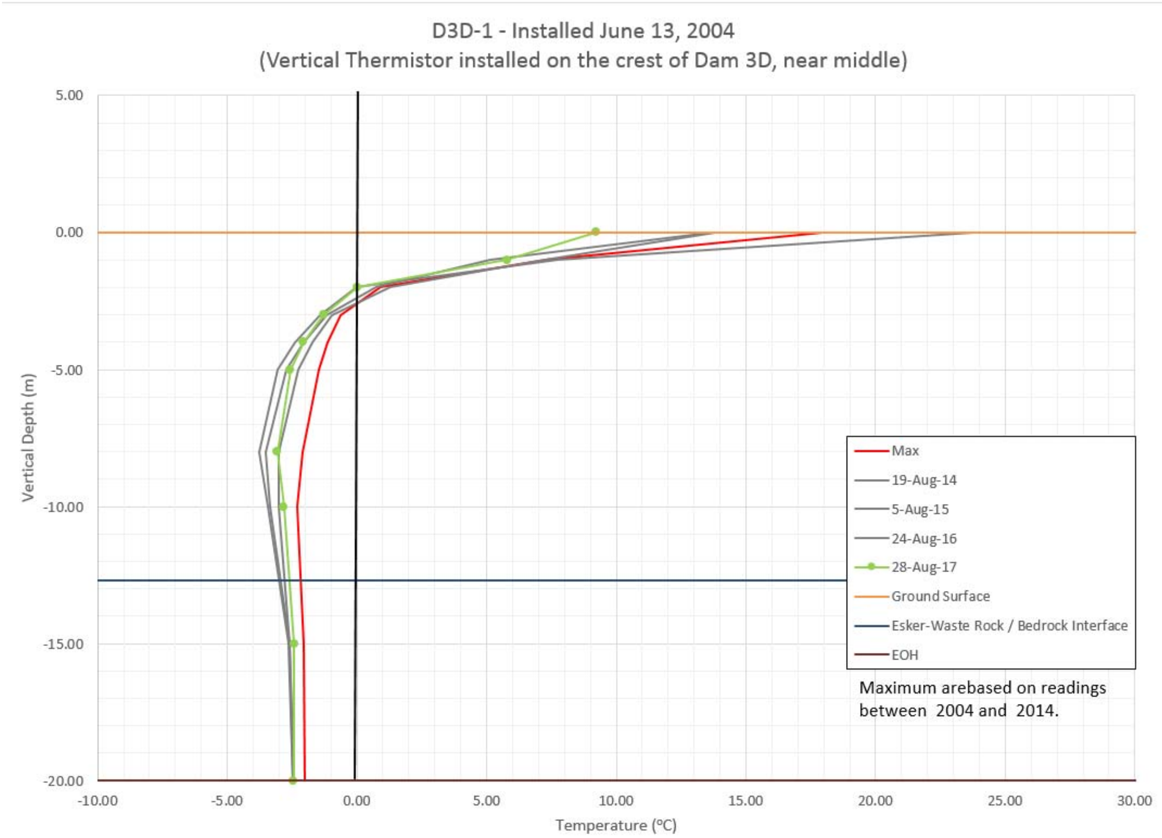

Figure 10: Thermistor Reading for D3D-1

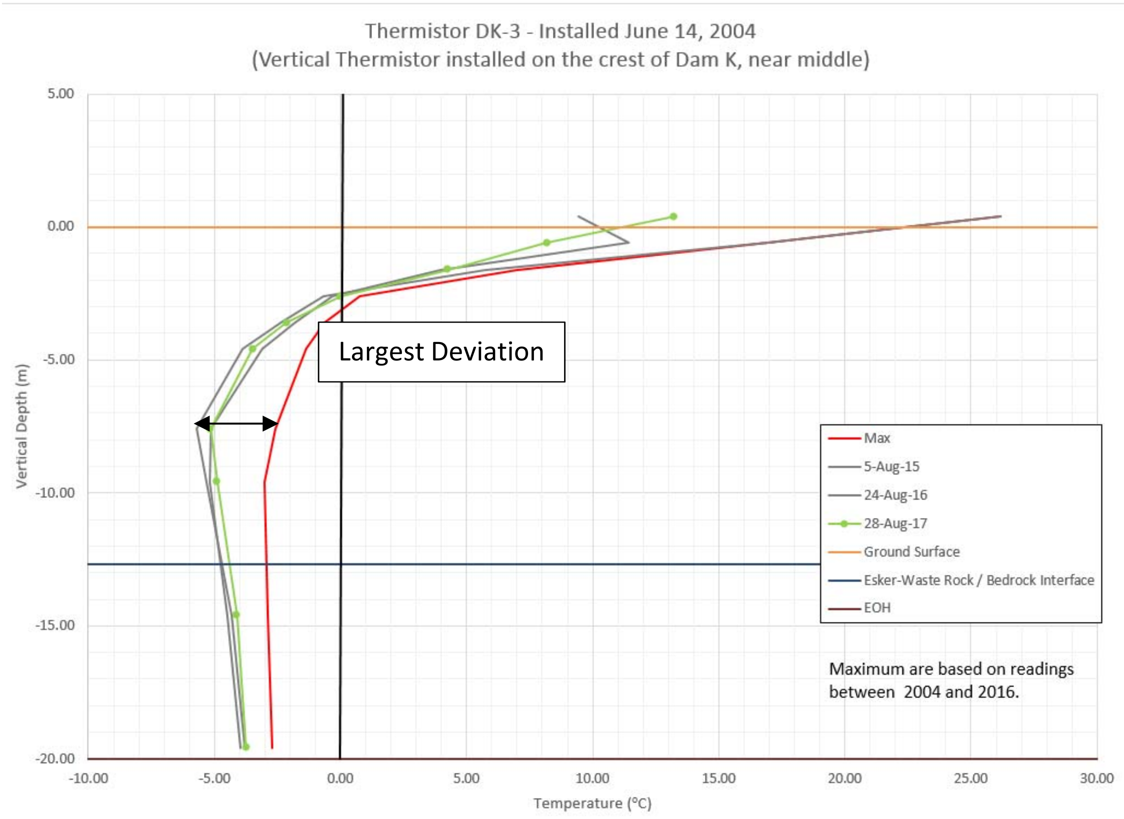

Figure 11 Thermistor Reading for DK-3

Readings from the four thermistors in the tailings cover are not presented in this report. The results are comparable to the readings from the dams. All the observed large temperature deviations remained below 0°C and well below the active layer. The observed active layer depths remain within the site recorded data and information provided by national research (Penner 1983). The thermistor readings indicated that the frozen cores within the monitored dams are frozen below the active layer and are performing well within the regional climate disparities.

3.3 TCA Perimeter Dams

The perimeter dams (Dam 1A through Dam 6) were observed to be in stable condition, although some erosion was observed on dam slopes from either surface runoff or wave action below the high water mark (HWM). While most of the surface erosion was observed to be minor, repair work should be considered on the downstream face of Dam 1A (Photo 1 to 3). The rest of the dams should be monitored and repaired as needed, to prevent the erosion from becoming worse and creating preferential surface flow paths.

Previous annual inspections found seepage from the northern toe buttress of Dam 2 into the seepage collection pond adjacent to Dam 2 Lake. This seepage was observed in 2017 at less than

1L/min, similar to the flowrates observed since 2012 (Photo 10). The seepage was collected and periodically pumped back into Pond 2. Historically, seepage was observed in the western buttress of Dam 4 into Ferguson Lake dating back to 2011. This seepage was not observed in 2016 and was not found in the previous four years.

The observed freeboard at the perimeter dams was more than 3m. This exceeds the minimum requirement of 1m freeboard as stated in the water license. Dam 1B, 1C, Dam 5 and Dam 6 do not have water on the upstream face of the dams.

3.4 Internal Dams

All of the internal dams have some erosion on their slopes, associated with either surface runoff or wave action at the HWM. Dam 3D also has some crest erosion from the surface runoff. Dam J (Photo 27 and 29) and Dam L (Photo 35) both have wave action erosion at the HWM that has reduced their crest widths. Maintenance should be considered to repair the erosion on the slopes of Dam 3D, Dam J and Dam L.

Dam K has experienced considerable undercutting at the toe from Pond 2 wave action (Photo 30 to 32). The erosion has not yet migrated upwards to develop sloughing and cracks. The eroded toe section is currently susceptible to erosion due to a raised water level. This area should be closely monitored for physical change and rising water level, and repair is recommended (see Table 3).

Maintenance and repair of the tension cracks were completed on Dam M. The repair was completed by constructing buttresses in front of the compromised areas, and sealing the cracks to limit infiltration into the core of the dam. The buttress was to be built up to 2/3 height of the dam in lifts of 1m with compacted esker sand and gravel at a slope of approximately 2H:1V. Compaction of the buttress was done with vehicle traffic. The toe of the buttress was armored with large boulders as riprap protection. The tension cracks on the crest were removed by excavation to 1m and replacement with compacted sand and gravel to limit infiltration. The western abutment is approximately 100m long, measured from the Dam N abutment, and the eastern abutment is approximately 150m long, measured from the Dam J abutment. The repairs were completed to mitigate the risks associated with the tension cracks and the over steepened slopes due to undercutting.

Dam N was observed to be in stable condition, but with only 0.5m freeboard between it and Pond 2 (Photo 40). This was communicated with LMI site personnel, and the need to increase the freeboard to 1m to meet water license requirement was highlighted. Dam N and its contents were submerged in previous years and this did not appear to have had any adverse impact on its geotechnical stability. The reduced freeboard does not create any geotechnical and environmental concerns as Dam N and its contents are contained within Pond 2.

The northern section of the divider dykes at the east end of Cell 4 is in poor condition, while the southern section has been repaired. Signs of erosion, cracks, and sloughing were noted on the upstream and downstream sides of both dykes (Photo 43 to 44). Deformations have created an uneven crest and reduced its width to around 2m in some areas. The south divider dyke has experienced sufficient sloughing to create a low spot with a freeboard of around 1m. The slopes of the dykes vary between 2H:1V to 1H:1V in some areas.

4 RECOMMENDATIONS

Table 3 summarizes the observations and recommendations from the 2017 inspection, together with the findings from the 2016 inspection for comparison.

Table 3
Inspection Observation and Recommendations

Inspection Item	2017 Inspection			2016 Inspection	
	Estimated Freeboard (m)	Observation	Recommendations	Observations	Recommendations
Perimeter Dams					
Dam 1A	3.7	Minor erosion on slopes with some deep erosion gullies	Repair deep erosion gullies.	Historical minor erosion on slopes with some deep erosion gullies	Repair deep erosion gullies.
Dam 1B	N/A[(1)]	Minor erosion in the slopes.	Surface maintenance, e.g. grading and backfilling.	Historical minor erosion in the slopes. One animal burrow noted.	Surface maintenance, e.g. grading and backfilling. Monitor burrow activities.
Dam 1C	N/A[(1)]	Minor erosion in the slopes.	Surface maintenance e.g. grading and backfilling.	Historical minor erosion in the slopes.	Surface maintenance e.g. grading and backfilling.
Dam 2	3.8	Minor erosion in the slopes. Seepage at northern abutment estimated at 1L/min. Seepage was collected and pumped back into Pond 2.	Surface maintenance e.g. grading and backfilling. Monitor the seepage and pump back into Pond 2 as necessary.	Historical minor erosion in the slopes. Seepage at northern abutment estimated at 0.5L/min. Seepage was collected and pumped back into Pond 2.	Surface maintenance e.g. grading and backfilling. Monitor the seepage and pump back into Pond 2 as necessary.
Dam 3	No water is impounded by this dam	Minor erosion in the downstream slope.	Surface maintenance e.g. grading and backfilling.	Repair done in 2015 on the eroded section of the dam crest by converting the gully into an armored channel. No new erosion was found in 2016. Historical erosion in the downstream slope.	Monitor the performance of the new armored channel for erosion and flow arounds.

Inspection Item	2017 Inspection			2016 Inspection	
	Estimated Freeboard (m)	Observation	Recommendations	Observations	Recommendations
Dam 4	3.6	Minor erosions in the slopes. Historical exposed geogrid at the east abutment in similar condition as observed previously.	Surface maintenance e.g. grading and backfilling. Monitor the exposed geogrid for changes and deformations.	Historical minor erosions in the slopes. Historical exposed geogrid at the east abutment.	Surface maintenance e.g. grading and backfilling. Monitor the exposed geogrid for changes and deformations.
Dam 5	N/A(1)	Minor erosion in the slopes.	Surface maintenance e.g. grading and backfilling.	Historical minor erosion in the slopes.	Surface maintenance e.g. grading and backfilling.
Dam 6	N/A(1)	Ponding in a natural low at the south abutment. Erosion gullies in the downstream slope.	Surface maintenance e.g. grading and backfilling. Monitor the ponded water level in the south abutment.	Ponding in a natural low at the south abutment. Historical erosion gullies in the downstream slope.	Surface maintenance e.g. grading and backfilling. Monitor the ponded water level in the south abutment.
Internal Dams					
Dam 3D	No water is impounded by this dam	Minor erosion in the slopes.	Surface and slope maintenance e.g. grading and backfilling.	Historical minor erosion in the slopes.	Surface and slope maintenance e.g. grading and backfilling.
Dam J	1.1(2)	Erosion gullies on slopes. Over steepened slope due to erosion and reduced crest width in some sections.	Repair the eroded slope and crest with compacted sand and gravel.	Historical erosion gullies on slopes. Over steepened slope due to erosion and reduced crest width.	Repair the eroded slope and crest with compacted sand and gravel.
Dam K	N/A(1)	Erosion at HWM and erosion gullies in the downstream crest. Near vertical slope at the eroded toe.	Repair the eroded gullies at the crest and toe, and armor the slope up to the HWM with boulders to limit further erosion. Monitor the crest for cracks and sloughing until repairs are completed. Repair should be done while the Pond 2 water level is lower for access.	Erosion at HWM and historical erosion gullies in the downstream crest. Near vertical slope at the eroded toe. No animal burrows were observed.	Repair the eroded gullies at the crest and toe, and armor the slope up to the HWM with boulders to limit further erosion. Monitor the crest for cracks and sloughing until repairs are completed.
Dam L	1.5(2)	Erosion in the crest and slopes.	Repair the eroded slope and armor the toe for protection.	Erosion in the crest and slopes.	Repair the eroded slope and armor the toe for protection.

Inspection Item	2017 Inspection			2016 Inspection	
	Estimated Freeboard (m)	Observation	Recommendations	Observations	Recommendations
			Monitor the water level in Cell 3 and manage as necessary.		Monitor the water level in Cell 3 and manage as necessary.
Dam M	2.5[(2)]	Tension cracks have been excavated and backfilled, and over steepened slopes have been buttressed and armored at the toe.	Monitor the repair for erosion and settlements.	Cell 5 is mostly dewatered for risk mitigation and cover construction. Repairs are completed on the tension cracks and sloughing noted in previous inspection. Compacted sand and gravel buttresses, armored with boulders are built below the cracks. The cracks are excavated down to 1m and replaced with compacted sand and gravel to limit seepage into the core.	Join the repairs to form a continuous buttress by connecting the western and eastern buttresses. Monitor the repair for settlement, erosion, deformations.
Dam N	0.5[(2)]	Minor wave action erosion at HWM.	Monitor the water level behind Dam N and manage it as necessary to yield minimum 1m freeboard.	Minor wave action erosion at HWM.	Monitor the water level behind Dam N and manage it as necessary to yield minimum 1m freeboard.
Divider Dykes	0.4[(2)]	Erosion, sloughing and cracks along upstream and downstream of the northern portion of the dyke. Uneven crest level and reduced crest width.	Repair has been done to the southern section of the dyke. Complete similar repair to the northern section	Erosion, sloughing and cracks along upstream and downstream of the dykes. Uneven crest level and reduced crest width.	Repair the dyke to original design with compacted sand and gravel. Monitor the water level in Cell 4 and manage as necessary to yield minimum 1m freeboard.

Notes: 1. Water is not adjacent to the dam to determine available freeboard.

2. Freeboard at the lowest point of the dam and below the minimum requirement stated in the Water License (NWB 2015).

4.1 Mitigation for Dam K Wave Action Toe Erosion

The Dam K toe has significant erosion below the HWM from the wave action in Pond 2. The erosion has undercut the toe of the dam and created near vertical slopes in several areas. The undercutting makes the dam susceptible to instability such as sloughing and cracks. To mitigate these risks, Norwest recommends that LMI maintain the water level in Pond 2 as low as practicable to limit further erosion. The crest and slopes of the dam should be inspected for any deformation such as cracks, sloughs, scars, or settlement. Maintenance and repair should be completed to replace the eroded material with compacted sand and gravel armored with boulders/riprap for wave protection. All the work should be endorsed by the Engineer-of-Record prior to commencement.

The water level in Pond 2 has raised since the inspection in 2016. It is likely that the pond water will need to be lowered to allow for the repair access. LMI should consider timing and planning of the repair work to coincide with the water treatment activity.

4.2 Maintenance and Repairs

Of the repairs and maintenance recommended in Table 3, the following repairs should be prioritized:

1. Monitor the condition of the southern section of the Divider Dykes. Repair the northern section of the Divider Dykes with compacted sand and gravel to restore the original design configuration, including side slopes, a leveled crest and armoring up to the HWM, as directed by the Engineer-of-Record.
2. Monitor the condition of Dam K. Repair the eroded toe at Dam K with compacted sand and gravel to restore the original design configuration and armor the repaired toe with boulders/riprap for wave protection.
3. Monitor the water level behind Dam N and lower the water level to maintain a minimum 1m freeboard and prevent localized erosion of dam crest.

After the completion of the priority repairs, LMI should consider carrying out the following repairs:

- Monitor the seepage at Dam 2 and manage it as necessary by pumping the seepage back into Pond 2.
- LMI is currently monitoring and managing the water in Cell 5 as part of the cover construction work. This monitoring and water management should continue to prevent damage to newly repaired Dam M.
- General repairs on surface and slope erosion at the HWM.

- Monitor the performance of the completed repair at Dam N for cracks, settlement, sloughs, sinkholes, erosion and other deformation.

All observations and records from monitoring should be included in the annual inspection report, and sent to a qualified person and the Engineer-of-Record for review.

4.3 Update of the Dam Safety Inspection Guideline

Prior to 2014, Dam 3D, Dam L and Dam N were not included in the annual inspections. Due to the to change in 2014 Canadian Dam Association Guidelines (CDA 2014) that state any structure impounding liquefiable contents, such as unfrozen tailings, should be considered a dam, these dams have now been included in the annual dam safety inspection until the tailings behind these dams are confirmed to be non-liquefiable. The functioning thermistors within the tailings cover suggest the active layer is between 2m to 3m, and material beneath 3m is below 0°C. There is currently insufficient data and evidence to determine if the tailings beneath the cover, and above the permafrost, are non-liquefiable. Until such information is available, these dams need to be incorporated in to the annual inspection.

Should LMI wish to declassify Dam 3D, Dam L and Dam N as regulated dams according to the CDA guidelines, additional test work should be considered to confirm the tailings beneath the cover are non-liquefiable.

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5 CLOSURE

This report has been prepared by Norwest for Lupin Mines Incorporated (LMI). The text contained herein presents documentation of the 2017 inspection carried out by Norwest with respect to the safe operation of the Lupin Mine, located in Nunavut, Canada. This report represents the opinion of Norwest based on information provided by LMI and observations made during limited site visits.

All the information contained herein has been interpreted by Alvin Tong, PEng., and has been reviewed by Tim Peterson, P.Eng.

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6 REFERENCES

Canadian Dam Association (CDA) 2014. Technical Bulletin, Application of Dam Safety Guidelines to Mining Dams, 2014.

Norwest Corporation. (Norwest 2016) 2017 Lupin Mine Tailings Containment Area Geotechnical Inspection. Prepared for Lupin Mine Incorporated, October 2016.

SRK Consulting Ltd. (SRK) 2016. Lupin Mine Tailings Management Facility 2015 Dam Safety Review. Prepared for Lupin Mine Incorporated, January 2016.

SRK Consulting Ltd. (SRK) 2015. 2015 Annual Geotechnical Inspection – Lupin Mine Tailings Containment Area, Nunavut. Prepared for Lupin Mines Incorporated, October 2015.

Nunavut Water Board (NWB) 2015. Nunavut Water License 2AM-LUP1520, issued to Lupin Mines Incorporated, May 2015.

SRK Consulting Ltd. (SRK) 2012. Lupin Mine Site 2012 Geotechnical Inspection Follow-up Risk Assessment and Water Quality Review. Prepared for Lupin Mines Incorporated, 2012.

Weather Underground (WU) 2016. San Francisco (CA): Weather Underground, Inc. Accessed August, 2016. Available from https://www.wunderground.com/cgi-bin/findweather/hdfForecast?query=lupin.

Province of British Columbia, Water Management Branch (BCWMB) 2011. Dam Safety Guidelines, Inspection & Maintenance of Dams. Prepared by Dam Safety Section. ISBN 0-7726-3520-X. March 2016.

Kinross Gold Corporation (Kinross) 2006. Final Abandonment and Restoration Plan and 2006 Response to Technical Review Comments – Lupin Mine. Prepared for Nunavut Water Board, 2006.

Penner, E. and Crawford, C.B., 1983. Frost Action and Foundations, published as DBR paper no. 1090 of the Division of Building Research, National Research Council of Canada, March 1983.

Appendix A
Photograph and Inspection Logs

Appendix B
Inspection Logs