Attachment 12 – Operations and Maintenance Plan (Operation Maintenance and Surveillance Manual for Pine Point Tailings Impoundment Area)

The single most important factor in the prevention of incidents is a positive attitude towards safety. Before any task commences, make it a habit to assess the hazards so they can be mitigated and/or controlled. It only takes one at-risk behaviour to result in a serious incident.

Any employee who is asked to participate in an unfamiliar work process must inform his/her supervisor of such before proceeding. Necessary training will then be provided.

OPERATION, MAINTENANCE AND SURVEILLANCE MANUAL FOR PINE POINT TAILINGS IMPOUNDMENT AREA

The review protocol for the Operation, Maintenance and Surveillance (OMS) Manual is shown in Table A-1.

Table A-1: Operation, Maintenance and Surveillance Manual Review Protocol

	Name	Company	Position	Signature	Date
Prepared by	Bjorn Weeks	Golder Associates Ltd.	Engineer of Record		22-FEB-17
Reviewed by	Dana Haggar	Teck Resources Limited	Site Manager		
Approved by	Kathleen Willman	Teck Resources Limited	Manager Engineering and Remediation		

RECORD OF REVISIONS

The OMS Manual should be reviewed on an annual basis and following any significant changes at the site to assess the validity of the content under the prevailing conditions at the time of the review. Revisions to the manual should be undertaken within a reasonable timeframe (within six months) of changes, should updates to the content be required. The version history of the OMS Manual is shown in Table A-2. The last revision of the OMS Manual supersedes all previous versions.

Table A-2: Operation, Maintenance and Surveillance Manual Revision Summary

Revision Number	Details of Revision	Date of Issue	Comment
2017 Version 0	Updated Document by Golder	22 February 2017	■ Update of consequence class for north and west dykes from low to significant. ■ Freeboard calculation updated to include up rush ■ Climate information from 2009 to 2016 updated. ■ Formatted to comply with Teck Guideline (Teck 2014)
2009 Version 0	Updated Document by Golder	19 March 2009	

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1.0 ROLES AND RESPONSIBILITIES

1.1 Formally Assigned

The roles and responsibilities of personnel formally assigned roles in the operation, maintenance, and surveillance of the Pine Point Tailings Impoundment Area (TIA) are defined in Table 1-1.

Table 1-1: Individuals Responsible

Role	Name	Company	Responsibilities	Phone #
Site Manager	Dana Haggar	Teck Resources Limited	complete routine and event-driven/special inspections as outline by surveillance	Office: 1-250-427-8413 Mobile: 250-602-9361
Alternative Contact	Michelle Unger	Teck Resources Limited	contact in the event that site manager cannot be reached	Office: 1-250-427-8422 Mobile: 250-432-5264
Local Consultant	Clell Crook	Maskwa Engineering Limited	assist with routine and event-driven/special maintenance as outlined by maintenance	Office: 1-867-874-2207 Mobile: 867-874-4401
Manager, Engineering and Remediation	Kathleen Willman	Teck Resources Limited	be available for consultation	Office: 1-250-427-8401 Mobile: 1-250-432-9563
Engineer of Record (EoR)	Bjorn Weeks	Golder Associates Ltd.	be available for consultation, complete annual dam safety inspection and submittal, participate in dam safety reviews and risk assessments	Office: 1-604-297-4647 Mobile: 1-604-679-9079

1.2 Organization Chart

An organization chart identifying the individuals indicated in Table 1-1 and their chain of command is presented in Plate 1. Key internal staff (Teck) and external advisors are included.

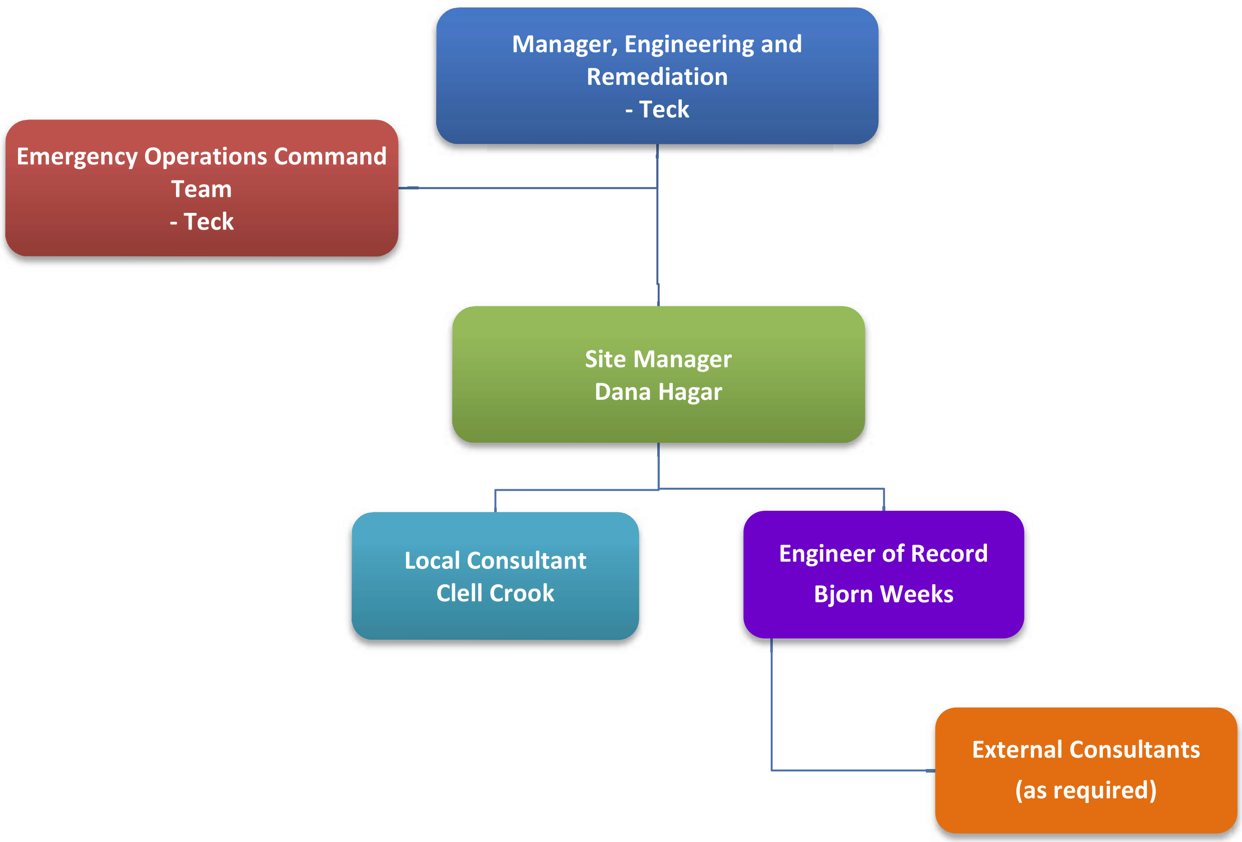

Plate 1: Pine Point TIA Chain of Command

1.3 Responsibilities and Requirements for Competency and Training

Summarizes the minimum knowledge, competency, and training requirements for personnel involved in the operation, maintenance, and surveillance of the Pine Point TIA.

Table 1-2: Required Proficiencies and Training

Roles	Minimum Knowledge and Competency Requirements	Training
Site manager	■ awareness of the responsibilities related to the dykes, their safety, and applicable regulations ■ an understanding of the significance of hazard and risk ■ detailed understanding of Emergency Preparedness and Response Plan (EPRP) in relation to the Pine Point TIA ■ detailed understanding of regulatory requirements for various regulatory bodies in relation to Dam Safety Inspections (DSIs) and Dam Safety Reviews (DSRs)	■ OMS Manual ■ EPRP ■ existing DSI reports ■ existing DSR reports
Caretaker	■ detailed understanding of dam safety regulatory responsibilities ■ detailed understanding of Pine Point TIA operations, maintenance, and surveillance procedures in relation to OMS Manual ■ detailed understanding of EPRP in relation to the Pine Point TIA ■ understanding of dam design principles and construction techniques ■ understanding of abnormal and non-compliance conditions and protocol	■ OMS Manual ■ EPRP
Engineer of Record	■ experience commensurate with the consequence classification and complexity of the facility ■ registration as Professional Engineer in the Northwest Territories ■ detailed understanding of dam safety regulatory responsibilities ■ detailed understanding of design, construction history, as well as applicable standards, criteria, and guidelines	■ OMS Manual ■ EPRP
Teck employees	■ understanding of contents of the OMS Manual ■ knowledge of specific risks as they apply to work areas in and around the pond	■ OMS Manual
Contractors	■ knowledge of specific risks as they apply to work areas in and around the pond	
External consultants	■ experience with specific role relevant to the Pine Point TIA	■ OMS Manual ■ EPRP

OMS = Operation, Maintenance, and Surveillance; EPRP = Emergency Preparedness and Response Plan; DSI = dam safety inspection; DSR = Dam Safety Review; TIA = tailings impoundment area.

1.4 Responsibilities for Managing Change

There are no procedures in place for making changes to the design or operating plans since Pine Point TIA is closed and non-operational.

The OMS Manual and all associated documents shall be kept current with appropriate practices and procedures and, at minimum, be reviewed annually by the required personnel (Table A-1). The site manager will be responsible for ensuring that any changes imposed on the facility or within management are reflected in the OMS Manual, approved, and distributed accordingly.

2.0 FACILITY DESCRIPTION

2.1 Facility Overview

The TIA covers an area approximately 2.5 by 2.8 km in plan, or roughly 700 hectares, and contains approximately 60 million tonnes of zinc-lead tailings. The Pine Point site location is shown in Figure 1. A sketch and plan showing the layout of the TIA are presented in Figure 2. The mine ceased operations in 1988 and the mill buildings and tailings conveyor (trestle) were subsequently dismantled and removed. The only remaining mining installation at the site is the closed TIA.

The TIA is located to the north of the former Pine Point mill site on terrain that slopes gently downward towards the northwest. As a result of this topography the earthfill perimeter dyke system, which retains the tailings and any ponded water, extends fully along the north and west sides of the disposal area, but is required along only a portion of the south and east sides. The facility is described in more detail in Section 2.5, and its construction history is summarized in Section 2.8.

2.1.1 Water and Infrastructure Elevation Benchmarks

A summary of the elevations and benchmarks at the Pine Point ITA are presented in Table 2-1 and Plate 2. These elevations are adopted for determining water management operations at the site.

Table 2-1: Water and Infrastructure Elevations

Levels	Elevation (m)	Comment
Dyke Crest	203.5	Minimum crest elevation on the dyke.
Top of Spillway	202.5	Top and bottom of the concrete wall spillway at the outlet of the polishing pond.
Base of Spillway	199.2	
Culvert Invert Level in Main Pond	200.0	Culvert levels on the Main and Polishing Pond sides of the culvert.
Culvert Invert Level in Polishing Pond	199.9	
Alert Water Level	201.6	The site manager should be informed immediately, and water treatment should start as early as practicable. A site inspection should take place two weeks after the initial alert level was observation.
Maximum Operating Water Level	201.8	The maximum operating pond elevation. Actions to reduce the water level within the pond should commence as a matter of urgency.

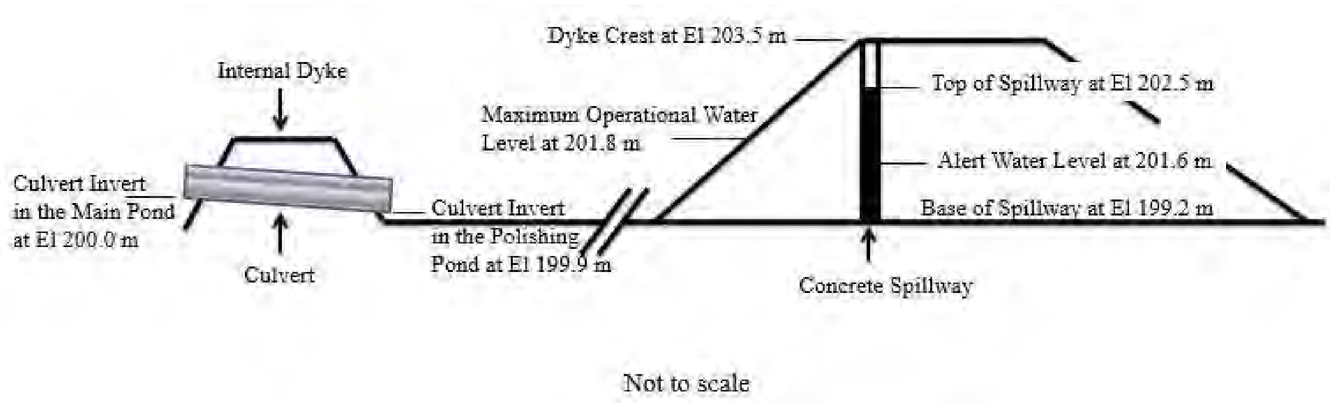

Plate 2: Water and Infrastructure Elevations

2.2 Regulatory Requirements

Applicable codes, guidelines, and regulations governing the Pine Point TIA are listed below:

- Canadian Dam Association (CDA) Dam Safety Guidelines (CDA 2013).
- Application of Dam Safety Guidelines to Mining Dams bulletins (CDA 2014).
- Mining Association of Canada Guidelines (MAC 2011).
- The Type B Water Licence (MV2006L2-0013) issued to Teck Cominco for the Pine Point site by the Mackenzie Valley Land and Water Board (MVLWB 2007) is valid from 29 October 2007 to 28 October 2017. In April, Teck Cominco changed its names to Teck Resources Ltd. (Teck). A copy of this licence is presented in Appendix D.

2.3 Site Reference Data

2.3.1 Grid System and Maps

Pine Point uses UTM NAD 83 Zone 11 map grid. Figure 1 shows the site location map in UTM coordinate system.

2.3.2 Weather

Measurements of temperature, precipitation, snow on the ground, and wind are available from weather stations in the vicinity of Pine Point (Table 2-2). Measurements of temperature and precipitation are also available at Pine Point sporadically from 1953 to 1954 and 1965, and then on a more consistent basis during mining operations from 1975 to 1988. Lake evaporation estimates are sporadically available for Yellowknife (1966 to 1996) and Fort Smith (1966 to 2003), as well as on a continual basis for Pocket Lake from 1994 to 2007 (DIAND 2007).

Table 2-2: Regional Weather Stations

Name[a]	Environment Canada Station Number	Latitude	Longitude	Elevation[c] (m)	Approximate Distance from Site (km)	Period of Record Employed
Pine Point	2203101	60.87° N	114.37° W	224	0	1953 to 1954, 1965, 1975 to 1988
Hay River	2202400	60.84° N	115.78° W	165	75	1953 to 2016
Fort Resolution	2202000	61.18° N	113.69° W	160	50	1953 to 2016
Fort Smith	2202196	60.00° N	111.93° W	183	170	1953 to 2016
Pocket Lake2[b]	NA	62.50° N	114.38° W	NA	180	1994 to 2007
Yellowknife2[c]	2204100	62.47° N	114.45° W	206	180	1966 to 1996

Notes:

(a) See Figure 1 for the location of the stations. Pocket Lake is immediately east of Yellowknife.

(b) Pocket Lake and Yellowknife stations are used only to describe evaporation. Pocket Lake station is operated by the Department of Indian and Northern Development (DIAND 2007).

(c) Approximate elevation of site is 200.0 m.

NA = not available.

Climate measurements at Pine Point correlate well with measurements from the Hay River, Fort Resolution, and Fort Smith weather stations. These stations are affected by the same climatic patterns as Pine Point but have different absolute values due to the distance between sites. A summary of the correlations are presented in Table 2-3 for coinciding observations from different stations on a monthly basis. The square of the correlation coefficients (R^2 values) for temperature are approximately equal to 1. Correlations for rainfall, snowfall, and snow on the ground between Pine Point and the other stations are considered satisfactory for establishing long term data series trends.

Table 2-3: Squared Correlation between Regional Weather Stations

Variable	Squared Correlation between Pine Point and:		
	Hay River	Fort Resolution	Fort Smith
Monthly mean temperature	0.995	0.994	0.994
Monthly rainfall	0.761	0.671	0.581
Monthly snowfall	0.615	0.558	0.554
Monthly snow on the ground	0.494	0.790[a]	0.465

(a) Only three months of coinciding data were available to assess the correlation between stations.

Continuous, long-term time series for temperature and precipitation were estimated for Pine Point based on the available data. These data have been used in the water balance and flood modelling to assist with surface water management of the facility. Data from Pine Point have been used, where available, with data gaps filled with adjusted regional weather station data. Data from Hay River were used preferentially, due to the higher correlation coefficient values with Pine Point. Where Hay River data were not available, data from Fort Resolution and Fort Smith, respectively, were used as secondary and tertiary data sources to complete the data series.

Data from nearby stations, used to fill data gaps, were adjusted based on the differences between coinciding data for Pine Point and the regional weather stations. A constant value was added to regional temperature data, while a weighting factor was applied to regional rainfall and snowfall data (Table 2-4). Precipitation values were also adjusted for "under-catch" factors, which account for:

- wind under-catch and evaporation based on the type of rain gauge used
- gauge-specific wetting losses for individual rain events
- snowfall based on ruler measurements for the period of record to minimize potential discontinuities associated with the introduction of the shielded Nipher snow gauge in the mid-1960s
- snow density corrections based on concurrent ruler and Nipher snow measurements
- quantification of trace snowfall events

Assessments of meteorological records in the Canadian north (Metcalfe et al. 1993) concluded that precipitation amounts are underestimated due to these under-catch factors. Adjustments for the correction of precipitation amounts were proposed by Mekis and Hogg (1999) and applied to northern weather stations. Table 2-4 lists the under-catch factors applied to the weather stations.

Table 2-4: Adjustments to Climate Data

Station	Constant Adjustment on Temperature	Rainfall		Snowfall	
		Weighing Factor	Under-Catch Factor	Weighing Factor	Under-Catch Factor
Pine Point	0.00	1.00	1.12	1.00	1.31
Hay River	+0.02	1.06	1.12	1.82	1.31
Fort Resolution	-0.78	0.80	1.10	0.94	1.13
Fort Smith	-0.12	1.03	1.30	1.30	1.03

Hay River station has the most complete record of snow on the ground. As such, these observations were used without adjustment to describe this climate variable at Pine Point. Linear interpolation between existing data was used to fill gaps in the record.

Hourly wind observations at Hay River were selected and assessed, as it is the closest of the regional weather stations.

The lake evaporation record was the most complete at Fort Smith, and consequently this station was used as the prime source of data for this climate variable at Pine Point. Gaps in the record were filled with data from Yellowknife station from 1966 to 1996 and from Pocket Lake from 1997 and 2007. A factor of 1.075 was applied to data from Fort Smith and of 0.93 to data from Yellowknife and Pocket Lake (these stations are within 10 km of each other). These factors were needed to account for the observed spatial variability between Fort Smith, Yellowknife and Pine Point.

2.3.3 Subsoil Characteristics

The TIA dykes are founded on glacial deposits. The site geology indicates the TIA dykes are underlain by very stiff silty clay with isolated pockets of gravel. Along parts of the dyke alignment, local pockets of peat were encountered. These were not removed in the initial construction phase, but were removed during subsequent dyke crest raises.

2.3.4 Instrumentation

There is no geotechnical instrumentation (piezometers, inclinometers or settlement gauges) in the dykes at the Pine Point TIA. The only monitoring device is a water level gauge at the culvert from the north dyke to the polishing pond.

2.3.5 Surface Water Sampling

A Type B Water Licence was issued by MVLWB to Teck for the Pine Point site (licence number MV2006L2-0013, Appendix D). The licence details a water sampling program (i.e., Surveillance Network Program) that must be implemented for the monitoring of water quality parameter concentrations in the TIA, discharges from the TIA, and at selected locations in the receiving aquatic environment. This sampling program is applicable to both the regulatory requirement of the water licence and the operation, maintenance and surveillance program for the TIA. Data are managed by Teck and submitted as part of the annual report by 31 March of every year to MVLWB.

2.4 Site Conditions

2.4.1 Topography

The TIA is located to the north of the former Pine Point mill site on terrain which slopes downward towards the northwest. The terrain slopes gently for about 13 km towards Great Slave Lake from an approximate elevation of 230 m at the former mill site to an approximate lake elevation of 160 m. Topographic maps (85B15 and 85B16) indicate that the region around the site can be characterized as low gradient terrain.

2.4.2 Geology

The site is situated in a region that lies between the Cordilleran Orogen to the west and the Precambrian Shield to the east and consists of sedimentary strata. Ordovician to Devonian sediments overlay Archean crystalline rocks and Proterozoic sediments (Giroux 2001). Surficial material is composed of a layer of glacial till, gravel, sand, and clay (Fulton 1989; Giroux 2001).

2.4.3 Vegetation and Wildlife

The vegetation in the region is typical of the Taiga Plains Ecozone (Great Slave Lake Plain), where the land cover is composed predominately of wetlands and bog-fen vegetation such as dwarf black spruce, Labrador tea, ericaceous shrubs, and mosses (EC 2005). Jack pine and willows were also observed in the region of the site (Giroux 2001).

Moose, black bear, and deer are rarely observed in the region. The site is south of caribou migration routes and northwest of wood buffalo habitats (Giroux 2001).

2.4.4 Temperature

The long-term monthly temperature range adopted for the site is presented in Table 2-5. July and January are the warmest and coldest months, with mean temperatures of 16.2°C and -23.4°C respectively. Mean monthly temperatures below 0°C are consistently observed from October to April.

Table 2-5: Monthly Temperature Means, Minimums and Maximums

Month	Monthly Minimum (°C)	Monthly Mean (°C)	Monthly Maximum (°C)
January	-28.1	-23.4	-18.7
February	-25.5	-20.0	-14.3
March	-20.3	-14.2	-7.9
April	-8.4	-2.8	3.0
May	0.9	6.4	11.9
June	7.4	13.1	18.7
July	10.9	16.2	21.4
August	8.8	14.0	19.1
September	3.3	7.9	12.5
October	-4.2	-0.4	3.3
November	-16.7	-12.7	-8.6
December	-24.4	-19.9	-15.4
Annual	-28.1	-2.9	21.4

Note: Values derived from site data from 1953 to 2016, with data gaps filled with data from regional weather stations (Hay River, Fort Resolution, and Fort Smith).

2.4.5 Precipitation and Snow on the Ground

The monthly precipitation and snow on the ground averages are presented in Table 2-6. The total average amount of precipitation calculated for the site is 565.0 mm, of which 59% is snowfall (333.2 mm as equivalent rainfall) and 41% is rainfall (231.8 mm). The total average effective precipitation is 461.7 mm, once snow cover loss, due to sublimation and wind redistribution, is accounted for. The snow cover loss at Pine Point (103.3 mm as equivalent rainfall) is estimated to be approximately 31% of the total average snowfall (333.2 mm), which is within the range observed in the Canadian northern regions (Marsh et al. 1994; Pomeroy et al. 1997). The maximum amount of snow on the ground occurs in March and is estimated to be 477.0 mm (as snow). Snowfalls are consistently expected from October to April, and are present in smaller amounts in May, June, and September.

Table 2-6: Monthly Precipitation and Snow on the Ground Averages

Month	Rainfall (mm)	Snowfall (Water Equivalent, mm)[(a)]		Total Precipitation (mm)[(b)]		Snow on the Ground (mm)[(c)]
		Exclusive of Snow Loss[(b)]	Inclusive of Snow Loss[(b)]	Exclusive of Snow Loss[(b)]	Inclusive of Snow Loss[(b)]	
January	0.2	47.2	32.6	47.4	32.8	401.0
February	0.1	38.7	26.7	38.8	26.8	472.0
March	0.2	37.4	25.8	37.7	26.1	477.0
April	4.1	23.9	16.5	28.0	20.6	213.0
May	21.5	7.6	5.2	29.1	26.7	9.0
June	32.0	0.2	0.1	32.2	32.2	0.0
July	55.4	0.0	0.0	55.4	55.4	0.0
August	59.3	0.0	0.0	59.3	59.3	0.0
September	43.8	4.1	2.8	47.9	46.6	1.0
October	13.7	43.6	30.1	57.3	43.8	33.0
November	0.9	79.2	54.6	80.1	55.5	171.0
December	0.7	51.3	35.4	51.9	36.0	297.0
Annual[(d, e)]	231.8	333.2	229.9	565.0	461.7	477.0

(a) The water equivalent of snow assumed based on a relative density of 10% for snowfall.

(b) Snow loss accounts for the depletion of snowfall due to sublimation and snow redistribution.

(c) Snow on the ground observations at Hay River available from 1955 to 2016. The values in the table reflect the amount of snow on the ground at the end of the month (as mm of snow).

(d) The annual value for rainfall, snowfall, and total precipitation are the cumulative for of all the months. The annual value for snow on the ground is the maximum monthly mean.

(e) Annual values do not sum exactly due to rounding.

2.4.6 Wind

The average yearly maximum hourly wind in all principal directions, from 1953 to 2016, is presented in Table 2-7. Hourly wind observations at Hay River were used in the assessment of possible wave heights within the TIA, as this was the station closest to Pine Point with the required data.

Table 2-7: Average Yearly Maximum Hourly Wind in All Principal Directions

Direction [(a)]	Wind Speed [(b)] (km/h)
North	42.0
Northeast	37.7
East	37.0
Southeast	36.1
South	39.8
Southwest	38.2
West	44.7
Northwest	50.6

(a) The wind direction indicates the direction from which the wind is blowing.

(b) Values based on data from Hay River from 1953 to 2016.

2.4.7 Evaporation

The average total annual lake evaporation is estimated to be 524 mm. Evaporation occurs from May to September, and the estimated average lake evaporation for these months is presented in Table 2-8. The evaporation values are based on data from 1966 to 2007, and were derived for Pine Point based on data from the surrounding regional weather stations.

Table 2-8: Estimated Average Monthly Lake Evaporation

Month	Monthly Evaporation (mm)	Percentage of Total Evaporation (%)
May	110	21
June	132	25
July	132	25
August	100	19
September	50	10
Total	524	100

Note: Values derived from climate parameters measured at regional weather stations (Fort Smith, Yellowknife, and Pocket Lake).

2.4.8 Permafrost

Pine Point falls within the discontinuous sporadic permafrost zone (Johnston 1981; Heginbottom 1989). Permafrost exists where the ground is at or below 0°C for at least two years continuously. Discontinuous permafrost results when permafrost is present only in certain areas and covers less than 90% of the ground area. Less than 50% coverage of permafrost is called discontinuous sporadic permafrost (NRCC 1988). Site-specific data on the presence or extent of permafrost within the TIA or under the dykes are not available.

2.4.9 Seismicity

According to the 2010 National Building Code of Canada seismic hazard calculator (NRC 2011), peak ground acceleration (PGA) for the Pine Point site is:

- 0.019 g for the 1-in-1,000-year event (5% probability of exceedance in 50 years)
- 0.036 g for the 1-in-2,475-year event (2% probability of exceedance in 50 years)

Seismic hazard in the region of Pine Point mine is ranked as low (NRC 2008).

It is understood that major Precambrian faults run along the East Arm of Great Slave Lake and controlled the distribution of ore bodies which facilitated the discovery of lead-zinc deposits at Pine Point. These lines of weakness in the bedrock, where karstification, dolomitization, and mineralization occurred, are called the Precambrian McDonald–Great Slave Lake fault system (Hannigan 2008).

2.5 Facility Components

2.5.1 Access Roads

The Pine Point property is approximately 800 km north of Edmonton, Alberta, and approximately 10 km south of Great Slave Lake. Access to the site from Hay River is via a 90 km paved road, which is on Crown land. The old haul roads on site mostly remain serviceable and are accessible using light vehicles, skidoos, tractors, and other all-terrain vehicles (Giroux 2001).

2.5.2 Tailings Impoundment Area

The TIA covers an area approximately 2.5 by 2.8 km in plan, or roughly 700 hectares, and contains about 60 million tonnes of zinc-lead tailings. A sketch and plan showing the layout of the TIA are presented in Figure 2.

The TIA is located to the north of the former Pine Point mill site on terrain that slopes gently downward towards the northwest. As a result of this topography the earthfill perimeter dyke system, which retains the tailings and any ponded water, extends fully along the north and west sides of the disposal area, but is required along only a portion of the south and east sides.

The main pond, where surface water runoff accumulates at present, covers the north end of the TIA and its extent varies depending on water elevation.

2.5.3 Dykes

The total length of the dyke system is approximately 8.5 km with a maximum height of approximately 15 m at the northwest corner. The south dyke varies in height from 0 m at the southeast corner of the TIA to 4 m at the southwest corner. The west dyke connects to the south dyke and has a maximum height at the northwest corner of the TIA of 15 m. The north dyke extends from the west dyke to the east dyke, and includes the perimeter dyke enclosing the polishing pond. The north dyke varies from 15 m in height at the connection with the west dyke to 1.0 m in height at the northeast corner of the TIA.

The 1.0 m dyke height continues on the east dyke until the natural ground surface rises above the dyke crest elevation. The east dyke is approximately 200 m long.

Ponded water is typically present on the north side of the TIA, with the pond in contact with the north dyke. Typical sections of the west and north dykes are shown in Figures 3 and 4 respectively. The dam classifications of the dykes are summarized in Section 2.7.1.

A culvert, through the north dyke, connects the main pond and the polishing pond, which is located on the north side of the impoundment. The culvert is fitted with a gate valve which can be used to control the flow from the main pond to the polishing pond.

2.5.4 Polishing Pond

The polishing pond is enclosed by the north dyke and an internal dyke within the TIA, and is used to treat contact water prior to release to the environment. The water exits the facility, after treatment, via a spillway. The spillway consists of a concrete culvert with an internal concrete wall, which acts as a weir to control the elevation at which water exits the facility. Syphons are also situated in the spillway to facilitate the removal of treated water from the polishing pond but are not typically active at other times.

2.6 Regulatory Compliance Points

The Pine Point mine is permitted under Type B Water Licence MV2006L2-0013, a copy of which is presented in Appendix D, which was issued to Teck Cominco by MVLWB (2007). As a requirement of Water Licence MV2006L2-0013, an annual report must be submitted by March 31 of each year. The annual report must include all of the data and information required by the Surveillance Network Program described in the water licence (Section 4.0).

The CDA (2013) Dam Safety Guidelines recommends that a Dam Safety Review (DSR) be conducted once every 10 years for embankments/dykes with a “Significant” dam classification, such as the west and north TIA dykes (Section 2.7.1). The last DSR was conducted in 2010 and included the south, west, and north dykes (SRK 2010).

The next DSR for these dykes should therefore be scheduled for 2020.

2.7 Basis of Design and Design Criteria

2.7.1 Dam Consequence Classification

The TIA is considered to be in the Closure–Active Care phase of mine life (Golder 2016), based on regular monitoring of the dykes and regular treatment and release of water from the facility. The design criteria for the dam therefore follow the CDA (2013) dam classification (Table 2-9).

Table 2-9: Dam Classification in Terms of Consequences of Failure

Dam Class	Population at Risk[(a)]	Incremental Losses		
		Loss of Life [(b)]	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 service
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 transport, 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)

Source: CDA (2013), Table 2-1

(a) 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 temporarily 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 residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

(b) Implications for loss of life:

Unspecified – The appropriate level of safety required 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.

Should the TIA move to the Closure–Passive Care phase, in which the system is considered stable with no water treatment or management of the pond, such that water may be passively released from the system, the design criteria for the dam should be revised based on recommendations by CDA (2014) and Teck (2014).

The dykes at the site are classified as Low to Significant based on the CDA (2013) guidelines. Only the north dyke retains water at any time. The south and west dykes retain only tailings, while the east dyke does not retain water or tailings (it is required only for freeboard). The criteria for classification are evaluated as follows:

- **Population at risk**—None. There is no known permanent population at risk downstream of the site.
- **Loss of life**—There is no possibility of loss of life other than through unforeseeable misadventure.
- **Environmental and cultural values**—A dyke failure would impact the local environment. There is a possibility of minimal short-term loss or deterioration of wildlife habitat as a result of a failure of the south and east dykes. Failure of the north or west dykes present a higher risk due to the impoundment of water, but failure would not lead to a significant loss or deterioration of important wildlife habitat or areas of cultural significance; restoration or compensation for impacts is considered highly possible.
- **Infrastructure and economics**—None. There is no development or infrastructure downstream of the TIA.

Table 2-10: Dam Failure Consequence Classification for the Tailings Impoundment Area Dykes

Dam	Dam Class	Population at Risk	Consequences of Failure		
			Loss of Life	Environment and Cultural Values	Infrastructure and Economics
North Dyke	Significant	none	low to none	low to significant	low to none
East Dyke	Low	none	low to none	low	low to none
West Dyke	Significant	none	low to none	low to significant	low to none
South Dyke	Low	none	low to none	low	low to none

Note: The class assigned to a dam is the highest rank determined among the four attributes (i.e., population at risk, loss of life, environmental and cultural values, and infrastructure and economics).

2.7.2 Design Criteria

The design criteria related to floods and seismic and static stability based on the CDA (2013) guidelines are summarized in Table 2-11:

Table 2-11: Minimum Design Criteria for Pine Point Dykes

Dykes	Dam Class	Annual Exceedance Probability – Floods	Annual Exceedance Probability – Earthquakes	Factors of Safety			
				Static		Pseudo-static	Post-earthquake
				Long Term	Full or Partial Drawdown		
North and west	Significant	between 1/100 and 1/1,000	between 1/100 and 1/1,000	1.5	1.2 to 1.3	1.0	1.2 to 1.3
South and east	Low	1/100	1/100	1.5	1.2 to 1.3	1.0	1.2 to 1.3

Note: Design criteria based on CDA 2013.

CDA (2013) provides two calculations for freeboard; the most critical of the two cases sets the minimum freeboard to be adopted:

- no overtopping by 95% of the waves caused by the most critical wind with a return period of 1,000 years with the pond at its maximum normal operating elevation; or
- no overtopping by 95% of the waves caused by the most critical wind with a return period of 10 years (for Significant consequence structures), with the pond at the maximum level during the passage of the inflow design flood (IDF)

2.7.3 Flood Design

2.7.3.1 Original Design Intent

The original design documents for the dykes are not available.

2.7.3.2 Existing Conditions and Current Design Status

2.7.3.2.1 Storage Capacity of the Tailings Impoundment Area

The storage capacity of the TIA was derived from a topographic survey conducted in November 2008 (Maskwa 2008a). The topographic survey did not include the northeast corner and as such the derived storage capacity represents a conservative estimate, due to underestimation of the impoundment area. Table 2-12 provides the derived storage capacity as a function of water elevation within the TIA.

The ponding volume in Table 2-12 starts at elevation 200.0 m, which corresponds to the upstream, main pond side of the culvert connecting the main pond to the polishing pond (Maskwa 2008b). The ponding volume stops at elevation 203.5 m which corresponds to the minimum elevation of the north dyke.

Table 2-12: Storage Capacity of the Tailings Impoundment Area

Water Elevation (m)	Pond Volume (m^3)
200.0	0
200.1	24,801
200.2	51,504
200.3	80,109
200.4	110,617
200.5	143,028
200.6	177,341
200.7	213,766
200.8	252,512
200.9	293,580
201.0	336,969
201.1	383,021
201.2	432,078
201.3	484,138
201.4	539,203
201.5	597,271
201.6	658,344
201.7	722,711
201.8	790,660
201.9	862,193
202.0	937,308
202.1	1,016,129
202.2	1,098,777
202.3	1,185,251
202.4	1,275,554
202.5	1,369,683
202.6	1,467,639
202.7	1,569,705
202.8	1,676,162
202.9	1,787,010
203.0	1,902,249
203.1	2,022,129
203.2	2,146,897
203.3	2,276,554
203.4	2,411,099
203.5	2,550,328

2.7.3.2.2 Flood Capacity

This section assesses the capacity of the TIA to operate under the following three scenarios:

- extreme daily rainfall occurring when infiltration is possible due to unfrozen/unsaturated soil conditions (likely from June to October)
- extreme daily rainfall occurring when infiltration is negligible due to frozen/saturated soil conditions (possible from April to May)
- extreme annual total precipitation

Events of extreme annual total precipitation and daily rainfall were estimated based on a frequency analysis using the derived precipitation data for Pine Point from 1953 to 2016. The resulting events for representative return periods are given in Table 2-13.

Table 2-13: Extreme Precipitation Events

Return Period (years)	Extreme Daily Rainfall (mm)	Extreme Annual Total Precipitation (mm)[a]
2	31	458
10	53	610
50	74	707
100	84	742
200	94	775
500	107	815
1,000[b]	**117**	**844**

(a) The amounts of cumulative snowfall and total precipitation account for the depletion of snowfall due to sublimation and snow redistribution.

(b) Design criteria, inflow design flood.

2.7.3.2.2.1 Extreme Annual Daily Rainfall

Flood routing analyses were completed using the Puls method (Watt et al. 1989), to confirm that the TIA can contain the 1-in-100-year and 1-in-1,000-year flood events. These flood events correspond to the lower and upper bound IDF range recommended by CDA (2013) for dams with Significant consequence classifications. (Table 2-11). Flood routing analyses were completed for the 1-in-100-year and 1-in-1,000-year flood events for both unfrozen/unsaturated and frozen/saturated soil conditions.

The following assumptions were used in the flood routing analyses:

- The water elevation in the TIA at the start of the storm is 201.6 m, which corresponds to the maximum observed water level in the TIA before treatment from 1998 to 2016 (Table 6-2).

- The lowest elevation of the internal dyke separating the main pond in the TIA and the polishing pond is assumed to be 202.5 m.
- The polishing pond spillway is assumed to be a broad-crested weir with a width of 2.44 m (Maskwa 2007) and an elevation of 202.5 m.

The results of the flood routing analyses indicate that the water level in the TIA would reach:

- 202.1 m during a 1-in-100-year storm assuming unfrozen/unsaturated soil conditions
- 202.6 m during a 1-in-100-year storm assuming frozen/saturated soil conditions
- 202.4 m during a 1-in-1,000-year storm assuming unfrozen/unsaturated soil conditions
- 202.8 m during a 1-in-1,000-year storm assuming frozen/saturated soil conditions

The predicted water levels are all below the dyke crest elevation of 203.5 m, which indicates that the flood events recommended by CDA (2013), for dams with Significant consequence classifications (Table 2-11), can be contained when the pre-storm water level in the TIA is equal to or lower than 201.6 m.

The flood routing analyses predicted that the polishing pond would discharge into the environment if the soil was frozen/saturated during a 1-in-100-year and 1-in-1,000-year storm, with water levels above the spillway elevation (202.5 m) but below the dyke crest (203.5). This is considered an acceptable management practice during storm events to prevent overtopping of the dyke.

A "YES" in Table 2-14 and Table 2-15 indicate when discharge is likely to occur during storm events with different return periods, for both unfrozen/unsaturated and frozen/saturated ground conditions, based on the pre-storm water level within the TIA.

A "NO" in Table 2-14 and Table 2-15 implies that no discharge through the TIA spillway is expected. A "YES" indicates that discharge through the TIA spillway is expected.

The estimated amount of runoff from unfrozen/unsaturated ground conditions was calculated using the Soil Conservation Service runoff equation and curve numbers (Rawls et al. 1993). A curve number of 81 was selected for unfrozen/unsaturated ground conditions. This was based on the assumption that the catchment consists of 7 km^2 of bare soil (tailings) and 2 km^2 of grassland (area adjacent to tailings). For the frozen/saturated ground scenario, no curve number was selected as infiltration is not assumed to occur in this scenario.

Table 2-14: Tailings Impoundment Area Discharge as a Function of Rainfall Events and Pond Elevations (unfrozen/unsaturated ground)

Return Period (years)	Effective Daily Rainfall (mm)	Rainfall Volume (m^3)	Exceedance of the Spillway Invert Level (202.5 m) Given a Rainfall Event and a Water Elevation (m) in the TIA at the Start of the Event of:										
			200.0	200.9	201.0	201.2	201.5	201.6	201.7	201.9	202.1	202.3	202.5
2	5	40,975	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES
10	17	151,423	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES
50	32	287,237	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES
100	39	353,517	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES
200	47	424,462	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES
500	58	525,418	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES
1,000[(a)]	**67**	**607,238**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**YES**	**YES**	**YES**	**YES**

(a) Design criteria.

Notes: A "NO' implies that no discharge through the TIA spillway is expected. A "YES" indicates that discharge through the TIA spillway is expected.

TIA = tailings impoundment area.

Table 2-15: Tailings Impoundment Area Discharge as a Function of Rainfall Events and Pond Elevations (frozen/saturated ground)

Return Period (years)	Effective Daily Rainfall (mm)	Rainfall Volume (m^3)	Exceedance of the Spillway Invert Level (202.5 m) Given a Rainfall Event and a Water Elevation (m) in the TIA at the Start of the Event of:										
			200.0	200.9	201.0	201.2	201.5	201.6	201.7	201.9	202.1	202.3	202.5
2	31	277,369	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES
10	53	477,792	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES
50	74	668,774	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES
100	84	753,904	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES
200	94	841,633	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES
500	107	962,201	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES
1,000[(a)]	**117**	**1,057,237**	**NO**	**NO**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**

(a) Design criteria.

Notes: A "NO' implies that no discharge through the TIA spillway is expected. A "YES" indicates that discharge through the TIA spillway is expected.

TIA = tailings impoundment area.

The results indicate that discharge is not expected to occur for storms with return periods of up to the 1-in-1,000-years if the water elevation at the start of the storm is:

- Lower or equal to 200.9 m for both unfrozen/unsaturated and frozen/saturated ground conditions.
- At the previously observed maximum TIA water level before treatment (201.6 m) if the ground is unfrozen/unsaturated. Discharge from the TIA is likely to occur if the water level before the storm is at the previously observed maximum water level (201.6 m) and the soil is frozen/saturated.

2.7.3.2.2.2 Extreme Annual Total Precipitation

A flood capacity analysis of the TIA was completed for extreme annual total precipitation events. Table 2-16 indicates the estimated volume of water that the TIA will need to store during extreme annual total precipitation events.

The flood capacity analysis was based on the following:

- The extreme total annual precipitation in Table 2-13.
- The total losses (evaporation, evapotranspiration, and infiltration) are based on the relationship derived in Section 3.5.3 between total precipitation (i.e., rainfall plus snowfall) and total losses. The relationship indicates that ninety-five percent of the total precipitation is lost from the TIA due to total losses.
- A watershed area of approximately 9 km^2.
- The elevation-volume storage capacity relationship of the TIA, Table 2-12, which is based on the November 2008 topographic survey (Maskwa 2008a). The survey did not include the northeast corner of the TIA, and therefore the storage capacity represents a conservative estimate due to underestimation of the impoundment area.

Table 2-16: Flood Capacity Analysis for Extreme Annual Total Precipitation Events

Return Period (years)	Total Annual Precipitation (mm)	Total Annual Losses[(b)] (mm)	Net Annual Precipitation[(c)] (mm)	Net Annual Precipitation Volume[(d)] (m^3)
2	458	437	21	185,902
10	610	582	28	247,599
50	707	675	32	286,971
100	742	709	33	301,178
200	775	740	35	314,573
500	815	778	37	330,809
1,000[(a)]	**844**	**806**	**38**	**342,580**

(a) Design criteria.

(b) Total Annual Losses includes evaporation, evapotranspiration and infiltration.

(c) Net Annual Precipitation is Total Annual Precipitation minus Total Annual Losses.

(d) Net Annual Precipitation Volume is Net Annual Precipitation multiplied by a watershed area of 9 km^2.

When the net precipitation volumes in Table 2-16 are compared with the storage capacity of the TIA (Table 2-12), the results indicate that the TIA has sufficient capacity to store extreme annual total precipitation events with a return period as high as 1,000 years.

2.7.3.2.3 Freeboard

CDA (2013) recommends that the height of the freeboard be sufficiently high enough to prevent overtopping by 95% of the waves caused by the most critical wind in the following two scenarios:

- Scenario 1: Wind return period of 1,000 years with the pond at its maximum normal operating elevation; or
- Scenario 2: Wind return period of 10 years (for Significant consequence structures), with the pond at the maximum level during the passage of the IDF.

The total wave uprush (wind setup plus wave run-up) on the upstream face of the dykes is a function of wind speed and fetch length (i.e., the length of water over which a given wind blows) as formulated by USACE (2006). The hourly wind speeds for the relevant return period were determined through frequency analysis using the wind data from the Hay River station from 1953 to 2016 and are presented in Table 2-17.

Table 2-17: Extreme Hourly Wind Events

Return Period (years)	Wind Directions[a] and Wind Speed (km/h)							
	North	Northeast	East	Southeast	South	Southwest	West	Northwest
2	39.9	37.9	37.1	35.5	39.3	37.8	44.8	51.0
10[b]	**55.4**	**45.0**	**44.0**	**44.7**	**47.4**	**47.2**	**51.5**	**61.1**
50	70.6	48.2	47.5	51.5	53.2	53.2	55.4	66.7
100	77.7	49.1	48.4	54.3	55.5	55.1	56.7	68.6
200	85.1	49.8	49.2	56.9	57.6	56.9	57.9	70.3
500	95.5	50.5	50.1	60.3	60.4	58.9	59.4	72.3
1,000[c]	**104.0**	**50.9**	**50.5**	**62.8**	**62.5**	**60.1**	**60.4**	**73.6**

(a) The wind direction indicates the direction from which the wind is blowing.

(b) Design Criteria for Scenario 2

(c) Design Criteria for Scenario 1

Winds blowing from the north and northwest direction would generate wave movement away from the dikes and were therefore not considered in the assessment of uprush. Wave uprush was estimated for all other directions. The combination of the wind speed and fetch length that resulted in the highest wave uprush is generated by winds blowing from the east.

The input parameters for the two scenarios mentioned above and for an east wind direction were as follows:

- Scenario 1:
  - an operational pond elevation of 201.6 m, which corresponds to the maximum observed TIA pond level before treatment from 1998 to 2016 (Table 6-2)
  - fetch length of 1,700 m for the east wind (50.5 km/h)
- Scenario 2:
  - maximum water level at the passage of the IDF of 202.8 m, which is based on the results of the flood routing for the 1-in-1,000-year flood event when there are frozen/saturated ground conditions (Section 2.7.3.2.2) and the pond was already at a maximum operational level of 201.6
  - fetch lengths of 2,000 m for the southwest wind (44.0 km/h)

The estimated wave uprush heights and corresponding elevations are provided in Table 2-18.

Table 2-18: Wave Uprush Heights and Elevations

Scenario	Wind Return Period (years)	Pond Elevation (m)	East Wind	
			Wave Uprush Height (m)	Wave Uprush Elevation (m)
1	1,000	201.6[(a)]	0.53	202.13
2	10	202.8[(b)]	0.52	203.32

(a) 201.6 is the maximum observed TIA pond level before treatment from 1994 to 2016.

(b) 202.8 m is the maximum pond elevation during the 1-in-1,000-year flood event, assuming frozen/saturated ground conditions and the TIA pond at 201.6 m at the beginning of the storm.

TIA = tailings impoundment area.

Based on the results of the assessment, the following levels have been set:

- an alert level of 201.6 m
- a maximum operational pond level of 201.8 m

The alert level is the elevation at which the site manager should be informed immediately, and water treatment should start as early as practicable. A site inspection should take place two weeks after the initial alert level observation. The maximum operational pond level the maximum level at which the pond level is in compliance with all CDA guidelines for the provision of freeboard to prevent overtopping. At this level, the pond should be able to sustain the 1-in-1,000-year flood event when there are frozen/saturated ground conditions as well as a 1 in 10 year wind without overtopping. At higher levels, there would be a risk of overtopping of the dyke under this combination of circumstances. Once the pond level reaches the maximum operation level actions to reduce the water level within the pond should commence immediately.

2.7.4 Seismic and Static Stability

2.7.4.1 Foundation Conditions

There is no known documentation of site investigation that may have been conducted prior to construction of the dykes. Conditions have been inferred from the site geology, which indicates the TIA dykes are underlain by very stiff silty clay with isolated pockets of gravel. Soil units under the clay and gravel are unknown. Along parts of the dyke alignment, local pockets of peat were encountered during construction. These were not removed in the initial construction phase, but were removed during subsequent dyke crest raises.

2.7.4.2 Embankment Fill Materials

The initial perimeter dyke was developed with silt-clay and without a downstream gravel blanket. The clay material for the dyke construction was obtained from borrow pits to the west of the TIA (these pits are now flooded). The sand and gravel needed for the dyke extensions were obtained from borrow pits to the southwest or east of the TIA.

The available information suggests that:

- The north and west dykes were developed with a clay zone on the pond side to act as a low permeability zone, and a downstream shell was built with sand and gravel to maintain a low phreatic surface through the dykes. Dyke raises for the north and west dykes were constructed using downstream construction methods and included a downstream gravel toe zone which was overlain at the top of the dyke section by a 1 to 2 m thick layer of local silt or silty clay. Typical sections of the west and north dyke are shown in Figures 3 and 4 respectively.
- A very limited clay zone was developed on the pond side of the south dyke, with the bulk of the dyke developed with sand and gravel. The south dyke was not designed or built to retain water, only tailings.
- The east dyke was not developed with a clay upstream or pond side low permeable zone.

2.7.4.3 Original Design Intent

Original design documents for the dykes are not available.

2.7.4.4 Existing Conditions and Current Design Status

The 1981 stability review indicated that:

- The north dyke had a global static stability Factor of Safety of 1.8 because of the existing toe berm. The dyke was noted to have a Factor of Safety of 1.4 for a shallow slumping failure of the upper surface of the downstream slope, but this was not deemed to represent a critical surface, provided any slumping of the slope was repaired.
- The west dyke had a global static stability Factor of Safety of 1.4 with no toe berm. The subsequent dyke raise included a toe berm which raised the static Factor of Safety to 1.5.

The 1981 stability review did not calculate a seismic Factor of Safety against failure for the dykes as the 1980 Building Code specified a very low seismic risk for the site. As part of the 2010 DSR (SRK 2010), an independent slope stability analysis was completed for the north and west dykes under pseudo-static conditions. This analyse used a horizontal PGA of 0.059 g, based on the 2005 National Building Code seismic hazard calculator (NRC 2005) for the 1-in-2,475-year event. The analysis indicated:

- Upstream and downstream Factors of Safety of 1.3 for the north dyke.
- Upstream and downstream Factors of Safety of 1.3 and 1.1 respectively for the west dyke, assuming there is no peat beneath the west dyke. The Factors of Safety reduce to 1.1 and 0.9 if a 0.3 m thick layer of peat beneath the dyke is assumed.

The National Building Code has been updated since the 2010 DSR, and the 2010 National Building Code seismic hazard calculator (NRC 2011) indicates a PGA for this site of 0.019 g for the 1-in-1,000-year event (5% probability of exceedance in 50 years), and 0.036 g for the 1-in-2,475-year event (2% probability of exceedance in 50 years). These revised values are lower than the PGA used in the 2010 DSR, and therefore a higher Factor of Safety for pseudo-static analysis can be expected. This should be confirmed as part of the next DSR in 2020.

2.7.5 Geometry

2.7.5.1 Original Design Intent

Original design documents for the dykes are not available.

2.7.5.2 Existing Conditions and Current Design Status

The geometry of the dykes is summarized in Table 2-19. Typical sections of the west dyke and north dyke are shown in Figures 3 and 4 respectively.

Table 2-19: Tailings Impoundment Area Current Dyke Geometry

Dyke	Downstream Slopes	Upstream Slopes	Crest Width (m)	Embankment Height (m)
North	2 horizontal to 1 vertical	2 horizontal to 1 vertical	4 to 5	1 to 15
West	2 horizontal to 1 vertical	steeper than 2 horizontal to 1 vertical, but are now buried or supported by tailings	4 to 5	4 to 15
South	2 horizontal to 1 vertical	1.5 horizontal to 1 vertical	generally 3.5 m wide with several narrower sections	0 to 4
East	unknown	unknown	unknown	up to 1

2.7.6 Dam Breach and Inundation Study

No dam breach and inundation study has been completed for the Pine Point TIA.

2.7.7 Design Criteria Summary

Table 2-20 summarizes the design criteria for the TIA.

Table 2-20: Tailings Impoundment Area Closure–Active Care and Design Criteria

Design Feature	Criteria	Source	Original Assessment	Updated Assessment	Meets Criteria	Comments
Dam safety inspection	required to be completed annually	CDA (2013, 2014)	NA	in progress	Y	
Dam Safety Review	required to be completed every 10 years	CDA (2013, 2014)	NA	SRK 2010	Y	
Emergency Preparedness and Response Plan	NA	CDA (2013, 2014)	NA	in progress	Y	
OMS Manual	NA	CDA (2013, 2014)	NA	OMS Manual (2017)	Y	
Freeboard	two calculations for freeboard with the more critical of the two cases setting the minimum freeboard	CDA (2013, 2014)	NA	OMS Manual (2017)	Y	
Inflow design flood	between 1/100 and 1/1,000 year return period	CDA (2013, 2014)	NA	OMS Manual (2017)	Y	
Earthquake design ground motion	between 1/100 and 1/1,000 year return period	CDA (2013, 2014)	NA	SRK 2010	Y	PGA of 0.056 g used, which is higher than the updated 2010 NBCC PGA for 1-in-1,000-year event of 0.019 g.
Factory of Safety	long term static – 1.5	CDA (2013, 2014)	NA	SRK 2010	Y	post-earthquake condition not analysed
	pseudo-static – 1.0	CDA (2013, 2014)	NA	SRK 2010	Y	
	post-earthquake – 1.2	CDA (2013, 2014)	NA	required	out of date	

OMS = operation, maintenance and surveillance; PGA = peak horizontal ground acceleration; NA = not available; NBCC = National Building Code of Canada.

2.8 Construction History

Mine construction started in 1962 and mining operations in 1964. The initial perimeter dyke was developed with silt-clay and without a downstream gravel blanket. The clay material for the dyke construction was obtained from borrow pits to the west of the TIA (these pits are now flooded). The sand and gravel needed for dyke raising were obtained from borrow pits to the southwest or east of the TIA. The tailings dykes were raised and extended in several stages during the life of the mine as required to contain the increasing volume of mill tailings. The last three crest level increases to the dykes were as follows:

- **1976**—The crest of the north dyke was raised to elevation 203.5 m above mean sea level or some 2.1 m above the previous crest. Also, the dyke was extended eastward to the northeast corner of the pond. Construction of a segment of the east dyke was also carried out.
- **1981**—During the summer of 1981, the west and south dykes were raised and the south dyke extended eastwards.
- **1987**—The height of the perimeter dykes was again raised in July and August 1987 to provide additional tailings storage. Fill was added to the south, west, and a portion of the north dyke at this time. The increase in height of the dyke was generally 1 m or less.

2.9 Training Requirements

Teck site inspectors are required to have completed the following training courses:

- Inspection & Maintenance of Dams, Dam Safety Guidelines, Province of British Columbia Waste Management Branch, Version 2, March 2011.

2.10 Documentation and Document Control

Teck has set up procedures for the retention of information. Once a document has been revised, the version number is updated, at which time the revised procedure is flagged as necessary training to all applicable employees.

Historical reports on the Pine Point TIA and reports from external consultants conducting work on the Pine Point TIA are kept by Teck at its administrative office and electronically on its server in Kimberley, BC, as follows.

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3.0 OPERATIONS

3.1 Objectives

The objective of this section is to define operating standards and procedures in accordance with design criteria, regulatory requirements, company policies, and best operating practices.

3.2 Tailings Transport and Deposition

Pine Point is a closed site, and there is no ongoing tailings transport and deposition.

3.3 Equipment Operating Instructions

Pine Point is a closed site, and equipment operations at Pine Point only relate to water management at the TIA. Refer to Section 3.5 for surface water management operating instructions.

3.4 Dam and Impoundment Raising

Pine Point is a closed site, and no raises to the dam are undertaken or planned at this time.

3.5 Surface Water Management and Water Balance

3.5.1 Water Release

The following operational practices should be applied to the TIA:

- The polishing pond should be operated as instructed in the Water Treatment Manual (Teck Cominco 2008) when water treatment is implemented. The applicability of this document should be reviewed on a regular basis and updated if required. The release of treated water must be controlled to maximize retention time in the polishing pond, which will allow the reaction of constituents such as zinc in the water with the lime solution employed in the treatment process.
- Water treatment should proceed until no water can be conveyed through the culvert between the main and polishing ponds by gravity flow, which would occur when water elevation reaches elevation 200.0 m.
- Visits to site for general inspections (Section 4.3.1) should be made at least three times per year during the open water period, namely during spring (April to May), summer (June to August), and fall (September to October) to determine compliance with the alert level (201.6 m) and maximum operational water level (201.8 m).
- A general inspection should also be undertaken after extreme weather events as noted by the monitoring program (Section 4.3.8). If water elevation is observed at or above the alert level (201.6 m) during any visit, the site manager should be informed immediately and water treatment should start as early as practicable. Another inspection should be scheduled two weeks later. If water elevation is observed below 201.6 m, water treatment should be initiated in July, per standard operating practice.
- Instructions provided in the Contingency Manual (Appendix C) should be followed in the event of the discharge of untreated water.

A flow chart diagram summarizing the operational and climate monitoring practices for water releases, and a diagram of infrastructure elevation benchmarks is attached in Appendix A.

3.5.2 Water Treatment

The Water Treatment Manual (Teck Cominco 2008) must be consulted for details of operational practices for water treatment. Only a brief description of these practices is given in this section.

Water treatment on site consists of a lime solution, prepared in a slurry tank, which is fed with a peristaltic pump to the water flowing in the culvert connecting the main pond to the polishing pond. The amount of lime used is estimated from the historical records of treated water discharge and the water elevation in the TIA. Historical consumption of lime indicates that an average amount of 0.17 kg of lime should be used for every 1 m^3 of released water.

During the water treatment period, the following tasks are undertaken daily:

- Activate power to the treatment facility.
- Prepare the lime solution in the slurry tank by mixing lime and water to achieve a slurry density of 17% solids.
- Generate a water flow in the polishing pond by opening the culvert.
- Feed the lime solution to the water in the culvert by activating the peristaltic pump.
- Adjust the pump speed to achieve a desired pH in the water of 10.9 (see Teck Cominco 2008, Appendix E5, for table of pump speed versus water flow).
- At the end of the day, stop the flow (i.e., close the culvert and spillway gate) and turn off the power to the treatment facility.

The constituents in the water, such as zinc, precipitate out to form solids that settle to the bottom of the polishing pond under low velocity (high retention time). These solids form a sludge which is dredged periodically to preserve the capacity, and therefore the retention time, of the polishing pond. The dredged material is removed from the polishing pond and placed within the TIA footprint.

3.5.3 Water Balance

The water balance for the TIA describes the yearly amount of water released from the facility as the sum of rainfall and snowfall, minus sublimation and snow redistribution, evaporation and evapotranspiration, and infiltration. An annual water balance was performed for the TIA (Table 3-1), from 1993 to 2016, to estimate total losses from evaporation, evapotranspiration, and infiltration. The following assumptions were considered in the water balance:

- Rainfall and snowfall are based on derived precipitations for Pine Point from 1993 to 2016.
- Sublimation and snow redistribution reduces snowfall values by 31%.
- Infiltration occurs over the whole watershed area, which includes the TIA.

- The effects of evaporation, evapotranspiration and infiltration are combined into a single term called total losses.
- Evaporation only occurs in the main pond, which constitutes only a small percentage of the total watershed area of the TIA. Evapotranspiration affects the remaining area of the watershed (i.e., land area). Estimation of the respective amount of evapotranspiration and infiltration cannot be supported with direct observations, however, a previous study concluded that evapotranspiration is greater than precipitation at the location of Pine Point mine (Golder 1996).
- The documented volume of water released (Table 6-2) was converted into an equivalent water depth for use in this water balance. This was calculated by dividing the documented volume of water released by the watershed area of the TIA (approximately 9 km^2). The equivalent water depth is termed Net Water Released in Table 3-1.

Table 3-1: Water Balance in the Main Pond

Year	Rainfall (mm)	Snowfall [(a)] (mm)	Total Losses [(b)] (mm)	Net Water Released (mm)
1993/4	158	201	314	45
1994/5	108	253	278	83
1995/6	168	115	252	31
1996/7	344	142	468	18
1997/8	275	145	401	19
1998/9	336	184	498	22
1999/0	201	118	310	9
2000/1	252	249	463	38
2001/2	392	282	634	40
2002/3	223	213	409	27
2003/4	174	244	396	22
2004/5	226	274	491	9
2005/6	283	201	457	27
2006/7	272	332	590	14
2007/8	198	380	562	16
2008/9	364	463	801	26
2009/10	220	427	620	27
2010/11	325	354	658	21
2011/12	168	508	649	27
2012/13	223	673	869	27
2013/14	195	321	491	25
2014/15	250	295	537	8
2015/16	354	342	660	36

(a) The snowfall amounts in the table are adjusted to account for sublimation and snow redistribution.

(b) Total losses consist of the effects of evaporation, evapotranspiration and infiltration.

The water balance results (Table 3-1) indicate that water had been released every year since 1993, and that there is a strong linear relationship between the values of total precipitation (i.e., rainfall plus snowfall) and total losses (Plate 3). The square of the correlation coefficient (R^2 value, or the coefficient of determination) for these two variables is 0.987 (Plate 3). This relationship indicates that 95% of total precipitation is removed from the basin as total losses. Consequently, the water released from the TIA constitutes approximately 5% of the total precipitation.

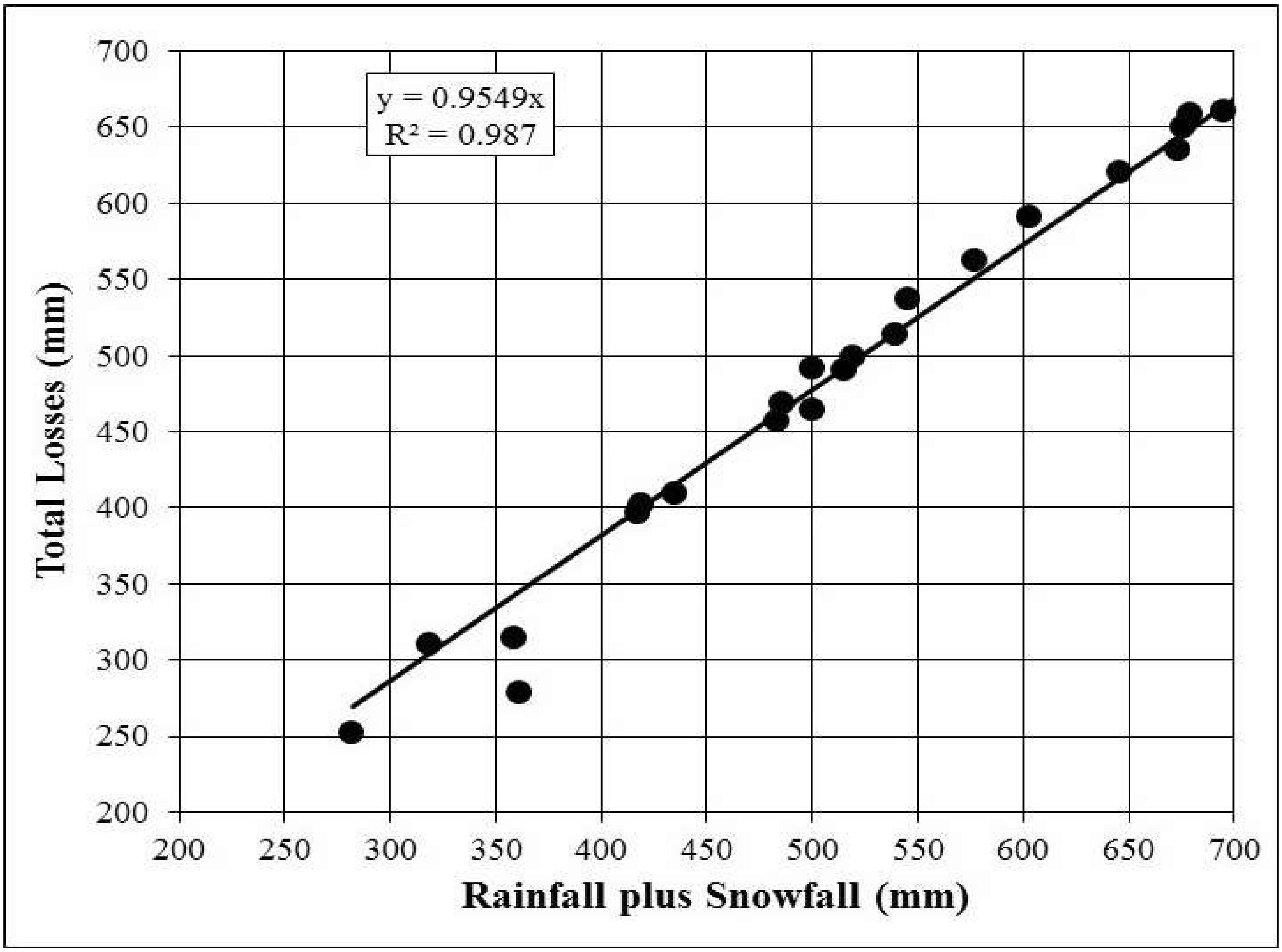

Plate 3: Relation between Total Losses and Total Precipitation (rainfall plus snowfall)

3.6 Environmental Protection

Refer to section 3.5.1 and 3.5.2 for surface water release and treatment operating instructions.

3.7 Safety and Security

The site currently does not have access restriction. It is a remote site, which historically has had little unauthorized access.

3.8 Change Management

The site manager will be responsible for ensuring that any changes at the facility or within management is reflected in the OMS Manual and subsequently reviewed, approved, and distributed accordingly.

3.9 Documentation

The OMS Manual and all associated documents shall be kept current with appropriate practices and procedures and at minimum, reviewed annually by the required personnel (Table A-1).

3.10 Reporting

Records of yearly water releases, lime consumption for water treatment, and water elevations in the main pond at the start and end of the treatment phase are to be kept.

4.0 SURVEILLANCE

4.1 Objectives

A surveillance program is implemented to assess the current performance of a facility relative to its intended design parameters.

The objective of the surveillance program is to provide confirmation of the adequate performance of the facility, including containment, stability, and operational function by observing, measuring, and recording data relative to potential failure modes.

4.2 Surveillance Parameters

4.2.1 Identify Potential Failure Modes

The following represent the different failure modes applicable to the Pine Point TIA:

- overtopping
- instability
- piping

4.2.2 Visual Parameters

Table 4-1 outlines the different failure modes applicable to the Pine Point TIA and visual observations which may indicate potential failure.

Table 4-1: Failure Modes and Identification

Failure Mode	Conditions to Identify Potential Failure Mode
Overtopping	■ water elevation ■ meteorological event
Instability	■ cracking ■ settlement ■ bulging ■ seepage ■ erosion ■ seismic event
Piping	■ seepage ■ wet spots downstream of dam toe ■ sinkholes, depressions

4.2.3 Instrumentation Installation Details

There is no geotechnical instrumentation (piezometers, inclinometers or settlement gauges) in the dykes at the Pine Point mine.

A water level gauge is present at the culvert from the north dyke to the polishing pond, for the monitoring of pond water levels.

4.2.4 Instrumentation Parameters and Thresholds

Details of the operation benchmark and warning elevations for the water level gauge, present at the culvert from the north dyke to the polishing pond, are presented in Section2.1.1.

4.2.5 Sampling and Testing Location Details

The Type B Water Licence issued by MVLWB to Teck for the Pine Point site (licence number MV2006L2-0013, Appendix D) details a water sampling program (i.e., Surveillance Network Program) that must be implemented. Reference should be made to the Water Licence for the details of sampling and testing locations.

4.2.6 Sampling and Testing Parameters and Thresholds

The Type B Water Licence issued by MVLWB to Teck for the Pine Point site (licence number MV2006L2-0013, Appendix D) details a water sampling program (i.e., Surveillance Network Program) that must be implemented. Reference should be made to the Water Licence for the details of sampling and testing locations.

4.3 Surveillance Procedures

4.3.1 Defined Frequency, Schedule, and Procedures

A program of regular periodic surveillance is required to ensure that the TIA is performing adequately and that any problems are detected so that the necessary corrective actions can be implemented in a timely manner. Site inspections will be conducted as per the following frequencies:

- General inspections of the TIA are to occur each spring (April to May), summer (June to August), and fall (September to October).
- Geotechnical inspections of the dykes are to be arranged each summer; and following any extreme weather or seismic events (i.e., extreme wind, rainfall or earthquakes).
- DSRs are to be conducted every 10 years.

The general inspections are the responsibility of any personal visiting the site. The general inspection in spring (April to May) is to be scheduled no later than two weeks after a period of two weeks with air temperatures above 0°C, and no later than 31 May of each year, ideally prior to or during the spring freshet period. The site is also to be inspected during the summer, and prior to start of the winter period to gauge the water management needs.

The geotechnical inspections are the responsibility of the geotechnical specialist, and a geotechnical inspection is to be conducted at least once a year.

An independent DSR should be undertaken by an external consultant or third party.

The site manager is responsible for the implementation of all visits conduced on site.

4.3.2 Visual Monitoring

General inspection forms are attached in Appendix B. The general inspections involve a brief assessment of the TIA and should cover the tasks noted below:

- observation of compliance with the main pond alert level (201.6 m) and maximum operational pond level (201.8 m)
- general characterization of the dyke crests
- observation of any evidence of significant slope instability, sloughing or slides
- observation and recording of deterioration and damage to the access roads to confirm yearly site access; deterioration or damage to the access roads include:
    - any indications of instability (e.g., potholes, slumping, or cracks) in the road or the supporting fills below the road; and
    - any accumulations of debris or other materials on the road or paths.

If seepage is observed through the dykes, the seepage should be inspected. If the seepage flow is “clear,” small local collection ditches and/or retention pools should be developed to allow monitoring of the flows to the existing surface water management system. If the seepage flow is “cloudy,” the geotechnical specialist or EoR should be informed and a site visit arranged. In addition, measures should be started to develop and construct a gravel filter zone in the area of the seepage to minimize the loss of dyke material. These water management actions would be built on the downstream side of the dykes at the site of the seepages.

The geotechnical inspections of the dyke should provide an assessment of both the upstream and downstream faces of the TIA dykes. The tasks for the upstream slope inspection entail observations of:

- any water ponding against the face
- any indication of cracking on the face
- any distortion or displacement of the face

The tasks for the downstream slope inspection include observing the following:

- any indication of cracking of the dam fill
- any areas of local subsidence of the dam fill
- any areas of water ponding
- any areas of accumulation of fines or other unsuitable materials
- any areas of vegetation growth

4.3.3 Survey and Bathymetry

A topographic survey of the tailings facility at the location of the main pond will be made every 10 years or if observations during previous site visits indicate significant changes in the topography of the TIA. The survey will be used to recalibrate the water storage capacity of the main pond and include a check on the north dyke crest elevations.

The last survey of the Pine Point TIA was completed in November 2008 (Maskwa 2008a). No bathymetry has been completed for the TIA.

4.3.4 Instrumentation Measurements

The water level at the gauge will be recorded during each site inspection and as per standard procedure during the water treatment period (Teck Cominco 2008). The most accurate water elevations would be obtained when no flow is conveyed through the culvert or spillways. It is therefore preferable that the culvert gate valve be shut when a water level is recorded.

4.3.5 Sampling and Testing

The Type B Water Licence issued by MVLWB to Teck for the Pine Point site (licence number MV2006L2-0013, Appendix D) is valid from 29 October 2007 to 28 October 2017. The licence details a water sampling program (i.e., Surveillance Network Program) that must be implemented for the monitoring of water quality parameter concentrations in the TIA, discharges from the TIA and at select locations in the receiving aquatic environment. This sampling program is applicable to both the regulatory requirement of the water licence and the operation, maintenance and surveillance program for the TIA.

Sample collection, preservation, and analyses should be conducted in accordance with methods prescribed in the most up to date edition of *Standard Methods for the Examination of Water and Wastewater* (APHA 2012), or equivalent. The site manager is responsible for selecting an approved laboratory where the samples will be analyzed. The site manager is also responsible for reviewing the quality assurance and quality control (QA/QC) plan for the laboratory and planning for a QA/QC procedure (i.e., collecting split and blank samples) within the sampling program for Pine Point. The sampling program, laboratory selection, and QA/QC must be accepted by an analyst from MVLWB.

The water management/treatment operator is responsible of conducting the water sampling program. As a support to that program, this person must also undertake the following tasks:

- record the daily and annual volume of water discharged from the polishing pond to the aquatic environment
- record the water level in the main pond three times a year in conjunction with the water samples performed in the TIA (spring, summer, and fall)

4.3.6 Weather Stations

Reference should be made to Table 2-2 (Section 2.3.2) for a list of weather stations near Pine Point.

Observations of air temperature, rainfall and snowfall are available publicly for Hay River. These observations can be obtained from Environment Canada (https://www.canada.ca/en/services/environment/weather.html). Hourly and daily temperature as well as daily precipitation records are available for download in Excel compatible files (i.e., CSV files). The data should be compiled and processed by the site manager or an assigned member of their staff. The processing should include applying the rainfall and snowfall weighting and under-catch factors that are identified in Table 2-4 to the data from Hay River to determine precipitation at Pine Point. All the downloaded data should be summarized each year by the site manager or designate to determine the cumulative or total precipitation on a yearly basis at the TIA. The information will assist in determining trends to assist with the oversight of the water management system. At present, these data are reviewed annually and reported as part of the annual DSI.

In anticipation of extreme events, the site manager should subscribe to the Weather Network weather alert service (http://www.theweathernetwork.com/) or similar, and check the Environment Canada website for public weather alerts (http://weather.gc.ca/warnings/index_e.html) on a regular basis.

Rainfall data at Hay River should be collected from Environment Canada following any heavy rainfall warning issued between April and September. Environment Canada defines heavy rainfall as 7 mm per hour or more.

If total rainfall during any five days exceeds 50 mm, which is equivalent to a 10-year daily rainfall event (Table 2-13), an inspection should be scheduled as soon as practical. This procedure is included in the flow chart diagram showing operational and climate monitoring practices for water releases in Appendix A.

4.3.7 Triggers for Change of Operations

The Pine Point TIA is not in operation.

Ongoing surveillance is intended to detect any unusual conditions that could signify potential issues with the site, as described in Section 4.2 of this document. If any unusual conditions are observed, the site manger must be informed immediately. Depending on the nature and severity of the condition observed, the EoR may be contacted or the EPRP may be initiated. The decision to execute the EPRP shall only be made once an incident exists (i.e., possible failure or failure of a dyke) and there is a serious risk to facilities and/or downstream stakeholders.

4.3.8 Event-Driven Procedures

In addition to the routine and periodic inspections, special inspections may be required during (if possible) and after unusual or significant seismic or climatic events. Significant climatic events include heavy rainfall and spring freshet floods.

Teck staff should carry out the special inspections after significant events, and the EoR should be notified. If there are any concerns with areas of the dyke, then the site manager would arrange to bring in the EoR for further inspections and review.

4.3.9 Data Collection, Analysis, and Documentation

Inspection reports and water quality results are maintained by Teck at its administrative office, and electronically on its server, in Kimberley, BC.

4.3.10 Periodic Inspections and Review

4.3.10.1 Annual Dam Safety Inspection

A comprehensive review of the Pine Point TIA and its management should be undertaken annually by the EoR or designate. This review shall be submitted to MVLWB.

The inspection shall consist of a geotechnical assessment of the conditions of the dykes, spillways, and would typically be conducted following the freshet period.

Inspection reports are stored by Teck at its administrative office, and electronically on its server, in Kimberley, BC.

4.3.10.2 Dam Safety Review

The Canadian Dam Association Dam Safety Guidelines (CDA 2013) recommends that a DSR be conducted once every 10 years for embankments/dykes with a ‘Significant’ dam classification, such as the west and north TIA dykes. The last DSR was conducted in 2010 (SRK 2010). The next DSR for these dykes is therefore scheduled for 2020.

All dam safety review reports are stored by Teck at its administrative office, and electronically on its server, in Kimberley, BC.

5.0 MAINTENANCE

5.1 Objectives

Facility maintenance is important to the safe operation of the TIA and the effective management of the ponded water. It is the responsibility of the site manager to ensure that the TIA is properly maintained.

The objectives of the maintenance program are to:

- identify and describe critical parts of the facility
- address routine, predictive/preventative, and event-driven maintenance
- address operating and surveillance observations for all components of the facility

5.2 Inventory of Components Requiring Maintenance

The following components of the Pine Point TIA may require maintenance over the facility's lifetime:

- access
- dykes
- culverts
- spillways

5.3 Maintenance Schedule and Triggers

The TIA should be subject to a regular maintenance program.

The site manager for Pine Point should have sufficient personnel or access to a contractor in close proximity to the site to perform necessary repairs to the TIA infrastructure. These repairs would be planned tasks to address issues identified during the regular inspections (Section 4.3.1) or inspections due to extreme weather or reported sudden change in TIA conditions.

Contractors in Hay River who have experience with earthworks and who could be contacted are:

- Carter Industries Ltd., 40 Studney Drive, phone: 867-874-6574
- Rowe's Construction, 25 Studney Drive, phone: 867-874-3243

5.4 Maintenance Parameters

There are no maintenance parameters.

5.5 Routine and Preventative Maintenance

5.5.1 Access

The access road to the site of the TIA is on Crown land; however, any observed road deterioration or damage during site visits should be recorded. If it is noted that it is necessary to carry out a maintenance program, this will require coordination with MVLWB to confirm access to the TIA site. The maintenance program may normally include regrading of the gravel site access roads as needed. It is not anticipated that extensive work would be required.

5.5.2 Dykes

Maintenance work required on the dyke structures to control seepage and erosion should be carried out as needed and comprise the following activities:

- Regrade dyke crests and replace granular road surfacing material to maintain crest design profiles.
- Replace and regrade fill materials lost on the downstream face and road surface (such as may be eroded by rainfall runoff).
- Replace and regrade fill materials lost on the pond side slope and regrade the adjacent road.

  Ongoing removal of vegetation is required to protect dyke integrity, in particular to prevent the growth of larger trees and the damage to the dykes that could occur in the event of treefall. Any tree on the dykes with a trunk diameter greater than 100 mm should be cut within 50 mm of the ground surface. Any vegetation on the north and west dykes with a trunk/stem diameter larger than 20 mm should be cut to within 50 mm of the ground surface. If herbicide is to be used to control vegetation, all trees with a diameter greater than 20 mm are to be cut off within 50 mm of the ground surface prior to herbicide application.

5.5.3 Culvert

The conveying capacity of the culvert connecting the main pond to the polishing pond must be maintained. The culvert should be kept clean of any blockages from soil material or vegetation. The valve should also be maintained in an operable condition.

5.5.4 Spillway

In order to maintain the efficiency of the spillway, the following activities should be undertaken:

- The conveying capacity of the spillway must be maintained. The spillway should be kept clean of any blockages from soil material or vegetation.
- A reserve of clay should be on site to fill the clay plug at the spillway, if needed, to minimize seepage.

5.6 Event-Driven Maintenance

After a special inspection due to an event-driven inspection, event-driven maintenance may be required. The maintenance should be completed as soon as possible.

5.7 Documentation

Maintenance records and summaries are maintained by Teck at its administrative office and electronically on its server in Kimberley, BC.

6.0 REPORTING AND COMMUNICATION

6.1 Communications

Contacts for the Pine Point operation are listed in Table 6-1.

Table 6-1: Pine Point Contacts

Name	Contact Number
Dana Haggar (site manager)	Office: 250-427-8413 Mobile: 250-602-9361
Michelle Unger (alternate)	Office: 250-427-8422 Mobile: 250-432-5264

6.2 Operations Reporting

Records of yearly water releases, lime consumption for water treatment, and water elevations in the main pond at the start and end of water releases are to be kept. The totals from 1994 to 2016 are provided in Table 6-2.

Table 6-2: Lime Consumption and Water Levels at the Tailings Impoundment Area

Year	Lime Consumption (tonnes)	Volume of Water Releases (m^3)	Water Level in the TIA at the Start of Water Releases (m)	Water Level in the TIA at the End of Water Releases (m)
1994	17.0	410,000	NA	NA
1995	65.0	748,000	NA	NA
1996	44.0	274,000	NA	NA
1997	NA	164,164	NA	NA
1998	NA	162,661	202.0	200.3
1999	NA	196,381	201.2	200.5
2000	NA	86,917	200.7	200.4
2001	95.0	336,648	201.6	200.3
2002	89.9	359,173	201.6	200.6
2003	66.5	237,494	201.3	200.3
2004	43.0	197,931	201.1	200.3
2005	23.0	86,457	200.8	200.4
2006	46.0	244,791	201.3	200.3
2007	29.0	122,374	201.0	200.3
2008	27.1	139,000	201.1	200.5
2009	50.5	240,000	201.4	200.4
2010	42.2	237,700	201.4	200.4
2011	25.8	190,000	201.2	200.4
2012	20.0	240,617	201.1	200.3

Year	Lime Consumption (tonnes)	Volume of Water Releases (m^3)	Water Level in the TIA at the Start of Water Releases (m)	Water Level in the TIA at the End of Water Releases (m)
2013	20.0	240,486	201.1	200.4
2014	20.0	226,954	201.1	200.3
2015	12.0	79,088	201.0	200.4
2016	28.0	320,124	201.4	200.4

TIA = tailings impoundment area; NA = not available.

6.3 Surveillance Reporting

Surveillance reporting must be completed as follows:

- three times a year (spring, summer, and fall) for general inspections
- annually for the geotechnical DSI
- every 10 years for a DSR
- any time a special inspection due to extreme weather is carried out

A list of the general inspections from 1990 to 2016 are shown in Table 6-3.

Table 6-3: List of General Inspections

Year	Month
1990	May
1992	May
1994	June
1996	June
1998	June
2000	July
2002	July
2004	July
2005	July
2006	July
2007	July & October
2008	August
2009	May & October
2010	May, July & October
2011	May, July & October
2012	May, August & October

Year	Month
2013	May, July & October
2014	May, July & October
2015	May, July & October
2016	May, July & October

It is the responsibility of:

- any personnel visiting the site to report (i.e., letter or electronic mail) to the site manager within a day any observed issues that require immediate maintenance or repair
- any personnel visiting the site to report (i.e., letter or electronic mail) to the site manager within one week any other observed issues that require maintenance or repair
- the geotechnical specialist to prepare a memorandum for each geotechnical inspection, describing the observation made during the visits on site
- the water management/treatment operator to prepare summary tables summarizing water volume discharged to the aquatic environment and transferred to the polishing pond from the TIA, water level in the TIA, volume of lime used, and water quality sampling results

Observations made during general and geotechnical inspections must be catalogued in field books. Photocopies of the used pages of the field books should be made for safekeeping. Copies of field notes or field books should be stored at the project office location when not in use.

As a requirement of the water licence (MVLWB 2007; Appendix D), an annual report must be submitted by 31 March of every year. The reports must include all of the data and information required by the Surveillance Network Program described in the water licence (Section 4.3). It is the responsibility of the site manager to prepare these annual reports, which would include the summary tables prepared by the water management/treatment operator. The Pine Point site manager is responsible to submit copies to MVLWB and any other agencies. The site manager would also prepare quarterly activity reports for Teck.

The site manager is also responsible for the preparation of the DSR report, which must be produced every 10 years. The content of the report should meet the requirements provided in the latest Dam Safety Guidelines published by the Canadian Dam Association, Currently CDA 2013.

Hard copies of all documents produced in the reporting process are to be stored at the project safe keeping location. All electronic documents are to be saved on a safe computer or network drive. All documents will be retained for a period of time defined in Teck 2014.

6.4 Maintenance Reporting

It is the responsibility of the water management/treatment operator to maintain and keep updated an electronic database cataloguing all quantitative data collected on site, including:

- water volume discharged to the aquatic environment from the polishing pond
- water level in the TIA
- quantity (in tonnes) of lime used
- water quality sampling results

The database should be saved on a network drive. All documents will be retained for the period of time defined in Teck 2014.

Maintenance records and summaries must be completed immediately after works are carried out and maintained on Teck's Kimberley, BC server.

6.5 Annual Operation, Maintenance and Surveillance Manual Review and Update

Revisions to the OMS Manual are made, as and when required, by re-issuing a complete section, table, or appendix so that the outdated section, table, or appendix can be removed and replaced. The official electronic copy of the OMS Manual is also updated at the same time and will be the primary reference document.

The version history of the OMS Manual is shown in Table 6-4. The last revision of the OMS Manual supersedes all previous versions.

Table 6-4: Operation, Maintenance and Surveillance Manual Revision Summary

Revision Number	Details of Revision	Date of Issue	Comment
2017 Version 0	Updated Document by Golder	20 February 2017	■ Change of consequence class for north and west dykes from low to significant. ■ Freeboard calculation updated to include up rush ■ Climate information from 2009 to 2016 updated. ■ Formatted to comply with Teck Guideline (Teck 2014)
2009 Version 0	Updated Document by Golder	19 March 2009	

The personnel responsible for the review of the OMS Manual is shown in Table 6-5.

Table 6-5: Operation, Maintenance and Surveillance Manual Review Protocol

Name	Company	Position
Bjorn Weeks	Golder Associates Ltd.	Engineer of Record
Dana Haggar	Teck Resources Limited	Site Manager
Kathleen Willman	Teck Resources Limited	Manager, Engineering and Remediation

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PROJECT	
TECK PINE POINT, NT	
TITLE	
GENERAL LOCATION OF PINE POINT MINE SITE	

	PROJECT No.		1656451	FILE No. 1656457-1400-001
Golder Associates	DESIGN	MS	2017-01-31	SCALE NTS
	CADD	JY	2017-01-31	**FIGURE 1**
	CHECK	MW	2017-02-20	
	REVIEW	BW	2017-02-20	

DRAWING DATE: 04-Feb-09 COREL FILE: N:\Bur-Graphics\Projects\2007\1413\07-1413-0068\Drafting\4000\FIGURE 2.cdr

REFERENCE

BASE PLAN PROVIDED BY TECK COMINCO
CAD FILE: PINE_POINT_01.MXD
DATED: OCTOBER 14, 2006

PROJECT

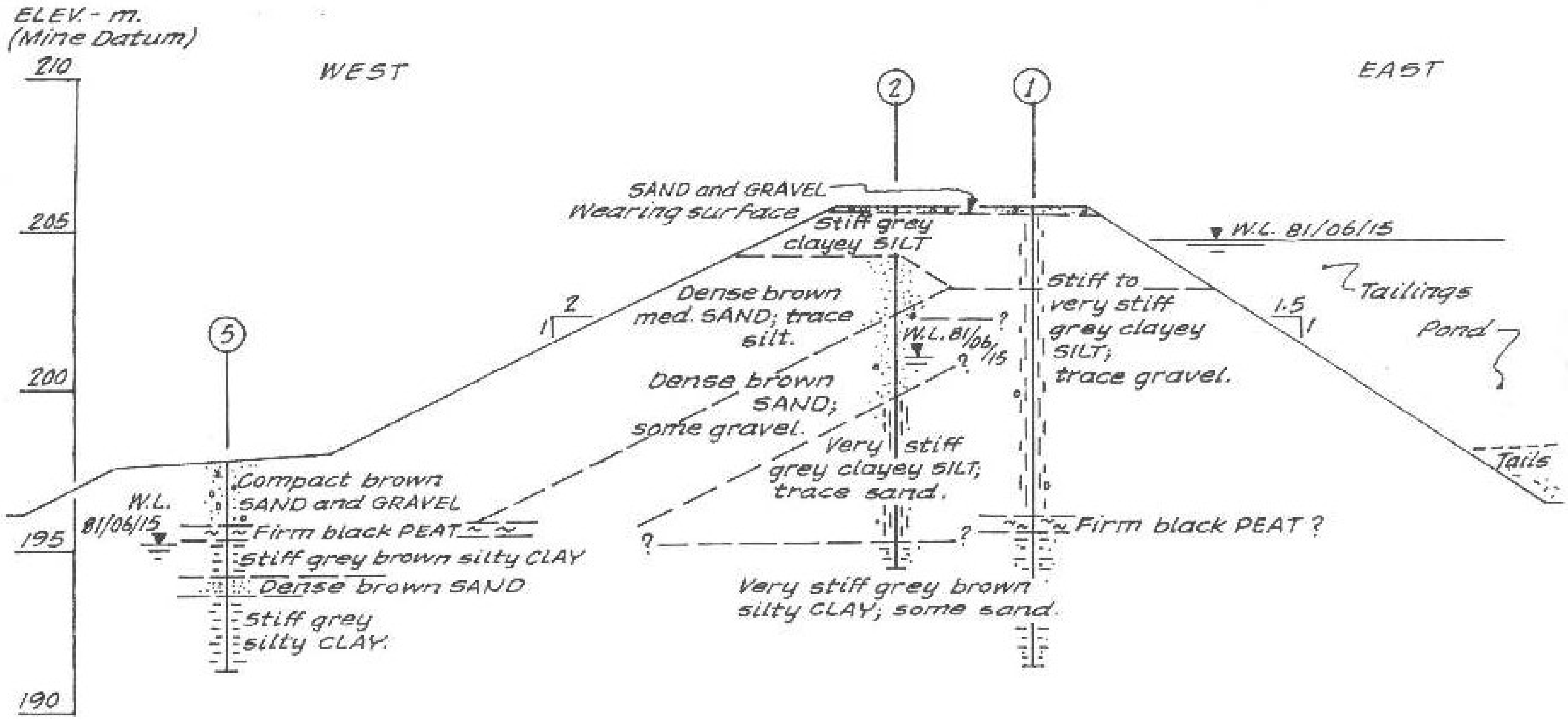
TECK
PINE POINT, NT

TITLE

TAILINGS IMPOUNDEMENT AREA

Golder Associates

PROJECT No.		1656457	FILE No.	1656457-1400-001
DESIGN	JH	30JAN09	SCALE AS SHOWN	REV.
CADD	GG	30JAN09	FIGURE 2	
CHECK	MW	20FEB17		
REVIEW	BW	20FEB17		



SCALE 1 : 200

LEGEND

Location of Borehole

NOTE

1. Section partially inferred from construction records.
2. Black peat removed from under toe berm of west dyke south of Sta. 35+00.

PROJECT	TECK PINE POINT, NT			
TITLE	TYPICAL SECTION WEST DYKE			
PROJECT No.		1656457	FILE No.	1656457-1400-001
DESIGN	JH	07OCT08	SCALE	REV.
CADD	SS	07OCT08	FIGURE 3	
CHECK	JH	07OCT08		
REVIEW	BW	20FEB17		

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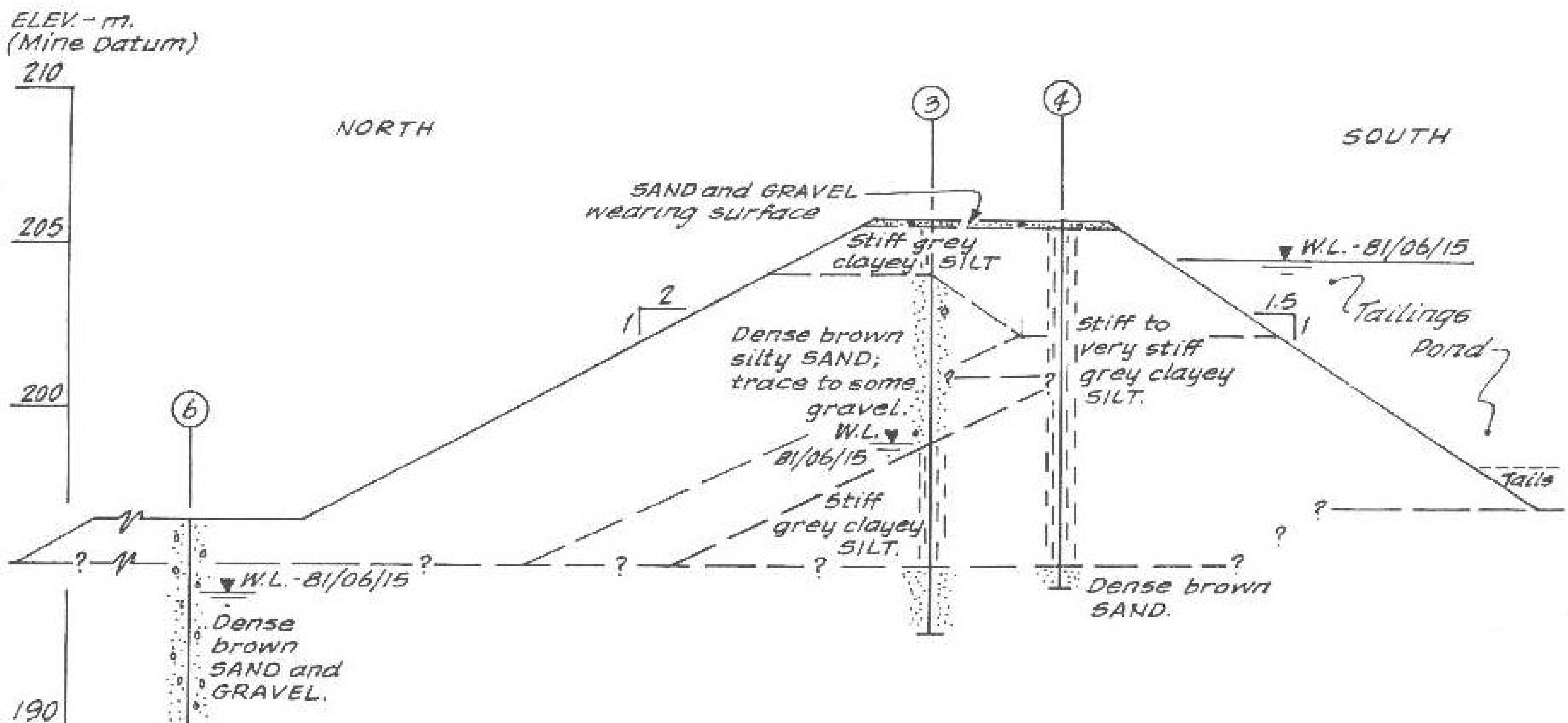
DRAWING DATE: 04-Feb-09 COREL FILE: N:\Bur-Graphics\Projects\2007\1413\07-1413-0068\Drafting\4000\FIGURE 3_4.cdr



SCALE 1 : 200

LEGEND

(6) Location of Borehole

NOTE

1. Section partially inferred from construction records.

PROJECT
TECK
PINE POINT, NT

TITLE
TYPICAL SECTION
NORTH DYKE

Golder Associates

PROJECT No.		1656457	FILE No.	1656457-1400-001
DESIGN	JH	07OCT08	SCALE	REV.
CADD	SS	07OCT08	**FIGURE 4**	
CHECK	JH	07OCT08		
REVIEW	BW	20FEB17		