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FINAL REPORT
DETAILED DESIGN OF DEWATERING DIKES
MEADOWBANK GOLD PROJECT
VOLUME 1

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EXECUTIVE SUMMARY

Meadowbank Mining Corporation (MMC) is preparing an “A Water License” application for submission to the Nunavut Water Board (NWB).

This report presents the detailed design, specifications and drawings suitable for pricing and negotiations with contractors for dewatering dikes at the Meadowbank Gold Project. Dike designs include the East, Bay Zone, and Goose Island Dikes.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX

1.0 INTRODUCTION

The Meadowbank Gold Project is located approximately 70 km north of Baker Lake, Nunavut. Some of the gold ore deposits to be mined are situated adjacent to and beneath Second Portage and Third Portage Lakes. The proposed mining concept includes a series of dewatering dikes to isolate open pit mining activities from these lakes.

This report presents the detailed design for the dewatering dikes in three volumes, including:

Volume 1.:

- Design criteria
- Site conditions
- Results of technical analyses
- Construction techniques
- Long term water handling
- Summary of quantities
- Construction schedule

Volume 2.:

- Specifications
- Drawings

Volume 3.:

- Feasibility Level Design Report

It is expected that the specifications provided with this document will require revision to be consistent with the type of the contract for adopted for construction.

The alignments of major dewatering dikes considered by this report are presented in Drawing 6000-01, and include:

- East Dike – to be constructed prior to mill startup;
- Bay Zone Dike – to be constructed prior to mill startup;
- Goose Island Dike – to be constructed by Year 2 of the mine life.

Other minor dikes are excluded from the scope of this report.

It is proposed to construct the dewatering dikes primarily from materials available on site. The typical dike section includes two parallel rockfill embankments, a till core with downstream filter zone, and a cutoff wall through the till core and foundation soils to the underlying bedrock, and a grout curtain in the bedrock.

The main characteristics of the dikes are included in Table 1.1.

TABLE 1.1: Dike Characteristics

	East Dike	Bay Zone Dike	Goose Island Dike
Maximum Water Depth at cutoff wall (m)	5.8	12.1	20.1
Crest Length at Centreline excluding abutments (m)	840	1,210	1,735
Crest Width (m)	77-93	86-102	82-134
Outer Slopes	1.6 horizontal: 1 vertical	1.6 horizontal: 1 vertical	1.6 horizontal: 1 vertical
Crest Elevation (masl)	136.1	136.1	136.1
Top cutoff elevation (masl)	135.1	135.1	135.1
Area of Soil Bentonite Cutoff Wall (m^2)	5,260	1,780	9,770
Area of Soil cement bentonite cutoff wall (m^2)	-	9,770	10,500
Area of Jet Grout Cutoff wall (m^2)	-	-	7,790

2.0 DESIGN CRITERIA

2.1 Introduction

General criteria for dike location and design include:

- Maintain adequate setback from open pits
- Meet or exceed required safety factors for dam stability
- Minimize water depth and therefore the use of processed construction materials
- Maximize the use of materials available on-site

The design must consider all aspects of constructability, stability, thermal effects, deformation, seepage and resistance to external and internal erosion forces.

2.2 Setback

The distance from the downstream toe of a dike to the open pit crest is the "setback." The purpose of the setback is to isolate the dikes from potential failures occurring through the pit wall at ultimate mining depth, to isolate the dikes and lakes from the effects of blasting, to provide a working area between the pit and the dikes, and to allow for water collection works.

A minimum setback of 70 m was selected based on a review of pit wall stability. A factor of safety of 1.5 is achievable for pit wall stability with respect to the dewatering dikes. Pit wall depressurization will be required for sections of the Goose Island Dike, as described in detail in Golder (2007a).

2.3 Freeboard

The Canadian Dam Association Dam Safety Guidelines states:

- For embankment dams, the freeboard should generally be sufficient to avoid dam (dike) overtopping for 95% of waves created under the specified wind conditions. Wave conditions and set-up due to wind with a 1/1000 Annual Exceedance Probability (AEP) with the reservoir at its maximum normal level, or determined using a "windspeed- total duration" relationship over the expected life of the project. Wave conditions and set-up due to the most severe reasonable wind conditions (1 in 100 year event) for the reservoir at its maximum extreme level based on the selected Inflow Design Flood (IDF) (1 in 10000 year event) (CDA 1999, Section 7.2, p. 7-4).

- Sufficient freeboard shall be provided to accommodate expected settlement of the crest and cracks cause by frost action. (CDA 1999, Section 8.2.1, p. 8-6).

- The freeboard shall be adequate to accommodate the expected settlement, including settlement due to permafrost (CDA 1999, Section 8.4, p. 8-13).

- The freeboard shall be sufficient to accommodate estimated settlements due to earthquake loading (CDA 1999, Section 8.2.7, p. 8-9)

The design freeboard between the traffic way and crest of rockfill embankments and lake surface is a minimum of 2.0 m. Freeboard between the top of the cutoff wall and the lake surface is 1.0 m. Additional freeboard of 1.9 m will be provided by rockfill safety berms during operations.

In addition to freeboard, the upstream slopes of the dam (dikes) and its abutments shall be provided with adequate protection to guard against erosion and possible breaching due to wave and ice action and against burrowing animals such as beaver and muskrat. Failure of the riprap must not result in dam failure (CDA 1999, Section 8.2.5, p. 8-7).

2.4 Crest Width

The dike crest width will depend on:

- Height and hazard category of the dam

- Roadway requirements

- Constructability

The crests of the rockfill embankments will act as haul roads for heavy equipment. Where dike crests are used as haul roads, the crest width should comply with NWT Mine Health and Safety Act and Regulations, or equivalent regulations for Nunavut, for minimum width of haul roads (NWT and Nunavut 1995). For single lane traffic the minimum width is twice the width of the widest haulage vehicle used on the road; for double lane traffic the minimum width is three times the width of the widest haulage vehicle. A shoulder barrier of at least three-quarters the height of the largest tire on any vehicle using the road is required.

The design vehicle used as a basis for sizing the roads is a Caterpillar 777D with a width of 6.05 m, tire diameter of 2.5 m Caterpillar 27.00R49 tire.

Based on NWT Mine Health and Safety Regulations, the minimum width is

- 18.2 m surface for two way traffic,
- 12.1 m surface for one way traffic,
- an additional width for safety berms minimum of 1.9 m height.

The width of the till core at the crest of the dike will be a function of water depth, alignment, and rockfill embankment geometry. A minimum distance of lakebed between the upstream rockfill embankment and downstream granular filter is set at 5 metres.

2.5 Design Earthquake

Canadian Dam Safety Guidelines (CDA 1999) state that dams shall be designed to withstand ground motions associated with the Maximum Design Earthquake Design (MDE) without release of the reservoir. Selection of the MDE is based on the consequence of failure of the dam, shown in Table 2.1.

TABLE 2.1: Classification of Dams in Terms of Consequences of Failure, with Maximum Design Earthquake (after CDA 1999, p.1-12, 5-2)

Consequence Category	Potential for incremental consequences of failure		Maximum Design Earthquake (MDE)
	Loss of Life	Financial	Probabilistically Determined (Annual exceedance Probability)
Very High	Large increase	Excessive Increase	1/10,000
High	Some Increase	Large Increase	1/1,000 to 1/10,000
Low	No Fatalities	Moderate Damages	1/100 to 1/1,000
Very Low	No fatalities	Minor Damages beyond owner's property	

The dewatering dikes fall into the High consequence category. Dike failure could result in loss of life relative to the same earthquake with no dike in place.

The maximum design earthquake (MDE) for the dewatering dikes is the 1 in 10,000 year event.

2.6 Slope Stability

Canadian Dam Association Dam Safety Guidelines for static assessment of slope stability are included in Table 2.2.

TABLE 2.2: Factors of Safety, Static Assessment (CDA 1999, Section 8.2.2, p. 8-5)

Loading Conditions	Minimum Factor-of-Safety	Slope
Steady state seepage with maximum storage pool	1.5	Downstream
Full rapid drawdown	1.2 to 1.3	Upstream
End of construction prior to reservoir filling	1.3	Downstream and Upstream

For pseudo-static conditions a design Factor-of-Safety of 1.1 is adopted here for use with the 1 in 10000 year earthquake event.

CDA (1999, Section 8.4, p.8-13) states that dams (dikes) on permafrost shall meet the same stability requirements as embankment dams, and shall remain stable in spite of large foundation settlements.

2.7 Seepage and Drainage Control

CDA (1999, Section 8.2.3, p. 8-6) states:

"Filters shall be placed between materials where otherwise significant migration of particles by seepage forces would be possible.

The hydraulic gradients in the dam, in foundation abutments and along conduits, shall be low enough to prevent piping and heave in the existing material.

The flow capacity of filters and drains shall be designed to accommodate the maximum anticipated seepage."

Criteria used for filter design included those in Fell et al. (2005), and the U.S. Army Corps (2004). In addition to using established empirical design criteria such as $D_{15}/d_{85} \leq 5$, laboratory evidence of filter performance is also considered for filter gradation design (Eldridge and Gilmer 2002).

2.8 Cutoff Wall

The criteria for cutoff wall design include:

- A low value of hydraulic conductivity to limit seepage quantities to those that can be handled by the pit dewatering system, and

- Erosion resistance to gradients expected during lake dewatering and operation.

Bedrock foundation grouting shall be applied where necessary to control seepage through the bedrock and to control piping of foundation soils into voids in the rock.

3.0 SITE CLIMATE AND HYDROLOGICAL CONDITIONS

The following section describes the climate and hydrological conditions at the Meadowbank site.

3.1 Climate

The project site is located along the southern boundary of the Northern Artic Ecozone in the District of Keewatin. The climate in the Northern Arctic Ecozone is dry and cold, and is described as a polar desert, generally with mean annual precipitation ranging from 100 mm to 200 mm per year. The closest climate station to the Meadowbank site is at Baker Lake, at 64.3°N Latitude and 96.083°W Longitude, approximately 70 km to the south.

Meteorological data has been collected at Meadowbank since 1997. Longer term climate data are available from the regional climate station at Baker Lake. Tables 3.1 and 3.2 summarize the monthly climate data (AMEC, 2005a).

TABLE 3.1: Summary of Monthly Climate Data

Month	Mean Monthly					
	Maximum[1] Air Temperature (°C)	Minimum[1] Air Temperature (°C)	Minimum Relative Humidity (%)	Maximum Relative Humidity (%)	Wind Speed (km/h)	Soil Temperature[1] (°C)
January	-29.1	-35.5	67.1	75.9	16.3	-25.5
February	-27.8	-35.2	66.6	76.5	16.0	-28.1
March	-22.3	-30.5	68.4	81.4	16.9	-24.9
April	-13.3	-22.5	71.3	90.1	17.3	-18.1
May	-3.1	-9.9	75.7	97.2	18.9	-8.0
June	7.6	0.0	62.6	97.2	16.4	2.0
July	16.8	7.2	47.5	94.3	15.1	10.5
August	13.3	6.4	59.2	97.7	18.4	9.3
September	5.7	0.9	70.8	98.6	19.3	3.6
October	-5.0	-10.6	83.1	97.4	21.4	-2.8
November	-14.8	-22.0	80.6	91.1	17.9	-11.7
December	-23.3	-29.9	73.3	82.7	17.7	-19.9

Note. Mean soil temperature is reported by AMEC to be measured at a depth between 0.2 m and 0.3 m below ground surface, but should be confirmed. Installation details such as slope aspect, surficial cover, site drainage, and annual snow cover are not available.
[1] Sources: AMEC (2003, 2005a).

TABLE 3.2: Estimated Average Monthly Temperature & Precipitation Meadowbank Site

Month	Mean [1] Temperature (°C)	Average Precipitation (mm)			Lake Evaporation (mm)
		Rainfall [1]	Snowfall	Total	
January	-32.4	0	11.2	11.2	0
February	-31.7	0	10.5	10.5	0
March	-26.3	0.1	14.6	14.6	0
April	-17.7	2.3	16.7	19.0	0
May	-6.3	9.8	11.3	21.1	0
June	3.7	14.5	3.9	18.4	8.8
July	12.1	36.7	0.0	36.7	99.2
August	9.7	45.5	0.9	46.4	100.4
September	3.4	30.1	8.8	38.9	39.5
October	-7.4	3.5	30.3	33.8	0.1
November	-17.9	0	23.6	23.6	0
December	-25.8	0	15.0	15.0	0

Note. Monthly averages have been rounded. Mean temperatures and rainfall are based on site data (1997 to 2004). Snowfall is based on adjusted Baker Lake data (1946 to 2004) and reported as water equivalent. Adjusted small lake evaporation was estimated from pan evaporation data (2002 to 2004).
[1]Source: AMEC (2003, 2005a, 2005b).

The prevailing winds at Meadowbank (1997 to 2003 data) for both the winter and summer months are from the northwest. A maximum daily wind gust of 83 km/h was recorded on May 21, 2002. Estimates of wave heights on Third Portage Lake during one such event were reportedly on the order of 2 to 3 ft (0.6 m to 0.9 m) based on communication with Cumberland site personnel during 2002.

Meadowbank total annual rainfall averaged 85% of the Baker Lake total over common periods of record. The estimated annual rainfall, snowfall, and precipitation for Meadowbank are 142.6, 148.8 and 292.8 mm, respectively. Estimates of extreme annual rainfall, snowfall and total precipitation at the site are shown in Table 3.3.

TABLE 3.3: Estimates of Extreme Rainfall, Snowfall, and Total Precipitation at Meadowbank Camp

Return Period (Years)	Condition	Rainfall (mm)	Snowfall (cm)	Total Precipitation (mm)
100	Wet	245	265	452
50	Wet	232	252	433
25	Wet	218	237	411
10	Wet	195	212	376
5	Wet	175	189	343
2	Average	139	145	285
5	Dry	108	104	233
10	Dry	93.6	84.4	208
25	Dry	79.2	64.6	183
50	Dry	70.4	52.4	168
100	Dry	62.9	41.8	155

Source: AMEC (2003, 2005a)

The annual precipitation at the site generally falls as rain between June and September while snow falls generally between October and May. However, snowfall may occur at any time of the year. Table 3.4 presents a comparison of annual total precipitation data at Baker Lake and the Meadowbank site (AMEC, 2003).

TABLE 3.4: Comparison of Annual Total Precipitation (1998 to 2003)

Baker Lake				Meadowbank Camp		
Year	Adjusted[1] Rainfall (mm)	Adjusted[1] Snowfall (mm)	Adjusted[1] Total Precipitation (mm)	Adjusted[1] Rainfall (mm)	Estimated Adjusted[1] Snowfall (mm)	Estimated Adjusted[1] Total Precipitation (mm)
1998	250.7	246.5	497.1	210.7	207.2	417.8
1999	251.4	189.1	440.6	243.3	183.0	426.3
2000	152.6	243.8	396.5	142.2	227.2	369.5
2001	158.1	173.9	332.1	117.4	129.2	246.6
2002	236.8	221.5	479.0	181.2	169.5	386.1
2003	147.4	138.9	300.8	120.8	113.9	246.3
Mean	199.5	202.3	407.7	169.3	171.7	348.8

[1]Rainfall, snowfall, and total precipitation values at Baker Lake and at the Meadowbank Camp have been adjusted for undercatch based on undercatch adjustment factors for Baker Lake, as reported by AMEC (2003).

3.1.1 Windspeed Data

There is a long-term Environment Canada meteorological site at Baker Lake, referred to as Baker Lake A. A mean hourly wind rose using the Baker Lake data from 1963 to 2002 was presented in the baseline hydrology report (AMEC, 2003). This wind rose included year round data. Due to winter freeze-up and icing over of the lakes, it is appropriate to use summer winds only.

A mean hourly wind rose using data from May to October for 2002 was also presented in (AMEC 2003) and these data were adopted for the present analysis, assuming that they are representative of a typical open water season. These hourly data were downloaded from Environment Canada (2006). Based upon these data, average hourly wind speeds ranged from 10 to 50 knots (5.1 to 25.7 m/s). Winds from the south occurred about 4.4% of the time, and from the southeast occurred about 11.4%.

The Environment Canada climate normals for Baker Lake indicate that winds blow predominantly from the northwest about 10 months of the year. During June and July, winds blow predominantly from the east and north, respectively.

Maximum hourly windspeeds are available for the Baker Lake A station from the Environment Canada climate normals. Maximum summer winds have typically occurred from the west and the north and have ranged up to 121 km/hr (33.6 m/s). However, the highest hourly average windspeed on record occurred on February 19, 1959 and was from the southeast (124 km/hr or 34.4 m/s).

3.2 Permafrost

The Meadowbank Project is located within the zone of continuous permafrost. The land surface in the project area is underlain by continuous permafrost, while lakes that are deeper than about 2 m will be underlain by a talik, or zone of permanently unfrozen ground. Based on thermal studies carried out to date, the depth of permafrost is estimated to be on the order of 450 m to 550 m. The depth of the active layer ranges from about 1.3 m in areas with soils, up to about 4 m adjacent to lakes. The depth of permafrost and of the active layer will vary based on proximity to lakes, soils thickness, vegetation, climate conditions, and slope direction.

Based on ground conductivity surveys and compilation of regional data, the ground ice content is expected to be low (0% to 10%). Locally on land, ice lenses and ice wedges are present, as indicated by ground conductivity, and by permafrost features such as peat palsas. These areas of local ground ice are generally associated with low lying areas of poor drainage.

Lake ice thicknesses of between 1.5 m and 2.5 m have been encountered during geotechnical investigations in mid to late spring. It is possible that mid-winter ice thickness will be greater; however, no data relating to ice thickness currently exists for the mid-winter period.

Ground temperatures have been monitored at Baker Lake since 1997 as part of the Circumpolar Active Layer Monitoring (CALM) program. Table 3.5 presents ranges in the recorded mean annual ground temperature at an estimated depth of 2 for the Baker Lake CALM station.

TABLE 3.5: Range in Mean Annual Ground Temperature – Baker Lake CALM Site (1998 to 2001)

Site Number	Latitude	Longitude	Elevation (m)	Location (km)	Mean Annual Ground Temperature (2 m depth) (°C)
C20	64° 19.6'N	96° 2.5'W	50	70 km South of Meadowbank	-6.6 to -8.4

The mean annual ground temperatures recorded at the station in Baker Lake are comparable to those estimated at the Meadowbank site (see below). Annual thaw depths at the CALM site are reported in Table 3.6.

TABLE 3.6: Annual Thaw Depth at the Baker Lake CALM Site

Thaw Depth in Centimetres (Baker Lake CALM Site)						
Station	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Baker Lake C20	120	170	174	189	193	207

Thermal studies at the Meadowbank site were initiated during the 1996 summer exploration drilling program, with the installation of two thermistor cables in exploration boreholes drilled on the Third Portage Peninsula. Theses studies have continued with the installation of additional thermistor cables during field investigations in 1997, 1998, 2002, 2003 and 2006.

To date, twenty three thermistor cables have been installed to characterize and monitor the thermal conditions and permafrost at the project site. The thermistors have been located to characterize the thermal regime at the project site both inland (away for the influence of deep lakes), as well as adjacent to the lakes. The thermistors were monitored during periods of time that the camp was open. Generally, data were collected from March through to September.

Thermistor cables were installed at several of the abutments areas of the proposed dewatering dikes. These are:

- Goose Island Dike;
- Bay Zone Dike; and
- East Dike.

The purpose of the installations was to characterize the permafrost directly adjacent to the dike abutments areas. An additional thermistor was installed to provide background data relating to the regional thermal regime and was located a minimum of 500 m from lake bodies. Thermistors were also installed at the various deposits, plant site, tank farm and at the east-west linear feature on the strip of land separating Second Portage Lake from Third Portage Lake. Table 3.7 summarizes thermistor locations and Table 3.8 summarizes the geothermal properties at the dike thermistors.

TABLE 3.7: Summary of Thermistor Locations

Borehole	Ground Slope	Slope Aspect	Offset from Nearest Water Body	Drilling Direction (with respect to shoreline)	Comments
03GT-BZ-1	~1% to 2%	South Facing	30 m	Towards	Third Portage Peninsula
TP97-196	<1%	East Facing	22 m	Towards	Bay Zone Island
03GT-SPEC-F1	5% to 8%	North Facing	200 m	Parallel	Base of North Facing Slope
03GT-GI-7	~9%	East Facing	27 m	Towards	East Shore of South Camp Island in Lee of Slope
03GT-GPIT-2	~1%	West Facing	8 m	Towards	West Shore of Goose Island
03GT-Therm-1	~21%	South Facing	500 m	Vertical	Crest of south facing slope 500 m from nearest small lake, and 1000 m from nearest large lake
GT02-NP-1	~23%	West to Southwest Facing	31 m	Towards	West to Southwest shore of North Portage Deposit
GT02-NP-3	~12%	West Facing	155 m	Away	West shore of North Portage Deposit
03GT-PS-2	<1%	West Facing	330 m	Vertical	Thin felsenmeer and till; bedrock near surface
03GT-PS-3	<1%	-	460 m	Vertical	Thin felsenmeer and till; bedrock near surface
02GT-03	~11%	South Facing	25 m	Towards	Lee of slope; heavy snow accumulation.
02GT-04	~11%	Northeast Facing	33 m	Towards	North shore of Third Portage Deposit area.
03GT-TD-1	~21%	West Facing	30 m	Towards	West Shore of North Portage Deposit

Borehole	Ground Slope	Slope Aspect	Offset from Nearest Water Body	Drilling Direction (with respect to shoreline)	Comments
03GT-TD-5A	~1%	North Facing	40 m	Towards	South Shore Second Portage Lake
03GT-TF-1	<1%	-	250 m	Vertical	Thin felsenmeer and till; bedrock near surface
TP98-261	~5%	East Facing	38 m	Perpendicular	Installed across Bay Fault, beneath water course between Third Portage and Mainland
TP96-154	~7%	West Facing	150 m	Away	Third Portage Deposit Area
TP96-155	~7%	West Facing	105 m	Away	Third Portage Deposit Area
GT02-VLT-2	~8%	East Facing	48 m	Towards	Vault Deposit drilled towards very small lake; small bowl shaped depression
GT03-VLT-4	<1%	East to Southeast Facing	110 m	Towards	Vault Deposit drilled towards Vault Lake
02GT-09	~7%	East Facing	30 m	Towards	Second Portage Lake south shore on outcrop of quartzite, no soil
02GT-10	~9%	Southwest Facing	37 m	Towards	Second Portage Lake north shore
06GT-TD2A	N/A	Lake Bottom	0 m	Vertical	Vibrating Wire Piezometer located under Second Portage Lake at proposed Central Dike location

TABLE 3.8: Summary of Geothermal Properties at Dike Thermistors

Borehole	Location	Vertical Depth of Installation (below ground surface) (m)	Depth of Zero Annual Amplitude (m)	Zero Amplitude Temp. (°C)	Vertical Depth of Active Layer (m)
03GT-BZ-1	Bay Zone	43.1	Insufficient Data	Insufficient Data	Insufficient Data
03GT-GI-7	Goose Island	42.9	Thermistor Data Unreliable		
02-GT03	Southeast Dike North Abutment	22.9	20 - 30	-2.5	3.5
02-GT04	Southeast Dike South Abutment	23.0	20 - 30	-6.5	1.3
02GT-09	West Dike South Abutment	22.1	Indeterminate		3.8
02GT-10	West Dike North Abutment	22.5	20 - 30	-5.5	3.0
03GT-TD5A	Central Dike South Abutment	42.5	Insufficient Data	Insufficient Data	2.8
03GT-TD-1	Central Dike 2nd Portage Abutment	44.2	Insufficient Data	Insufficient Data	1.3
06GT-TD2A	Central Dike Second Portage Lake Bottom	94.96	N/A	N/A	N/A

Note 1. N/A indicates the estimations of certain geothermal properties are Not Applicable due to the proximity of installation to lake body.

Note 2. Insufficient data indicates that insufficient data have been collected to estimate certain geothermal properties, and may indicate that equilibrium conditions have not been reached. Additional data should be collected at the next opportunity.

Note 3. During packer testing of the permafrost/talik interface at borehole 02GT-09, the packer equipment became lodged and subsequently frozen within the borehole. The thermistor cable was folded back on itself and installed to the depth of the frozen equipment. Note 4. Vertical depth of 06GT-TD2A refers to depth below lake bottom.

3.3 Projected Climate Change

The climate change considered in this report follows the worst case “high sensitivity” models described in the latest Intergovernmental Panel on Climate Change (IPCC, 2007). These models predict an increase of 6.4°C to the maximum average air temperature (MAAT) by the year 2100 for a site located at 65°N latitude.

Table 3.9 presents a summary of reported climate change predictions used on a number of northern projects which have been reported in the engineering and scientific literature.

TABLE 3.9: Summary of Reported Climate Change Rates Used in Northern Projects Engineering Studies

Reference	Increase in MAAT by Year 2100 (°C)	Notes
IPCC(2007)	6.4	For site at 65° North Latitude
Hayley (2004)	4.7	Used in design studies for the Inuvik Regional Health Center. Reported as increase of 0.47°C per decade.
Hayley and Cathro (1996)	5.0	Used for Raglan Dam analyses.
Burn (2003)	6.0	For use in the Western Artic for pipeline design projects. Reported as increase of 1.75°C over a 29 year period

3.4 Hydrological Conditions

Maximum and minimum expected lake water elevations are shown in Table 3.10.

TABLE 3.10: Lake Elevation Variations[1]

Return Period	Maximum Water Level (masl)		
	Third Portage Lake	Second Portage Lake	Difference (m)
100 yr wet	134.19	133.39	0.80
10 yr wet	134.14	133.28	0.86
average	134.09	133.17	0.92
10 yr dry	134.03	133.08	0.95
100 yr dry	133.99	132.98	1.0

[1] Source: AMEC 2005a p. 7 and p.11

4.0 GEOLOGICAL AND GEOTECHNICAL CONDITIONS

4.1 Topography and Bathymetry

The general site area consists of low, rolling hills with numerous small lakes. The topography in the immediate vicinity of the main deposits (Third Portage, North Portage, and Goose Island Deposits) is of generally low relief with a range in elevation of about 70 m. Elevations vary from about 133 masl along the Second Portage Lake shoreline and 134 masl along the Third Portage Lake shoreline, to maximum elevations of approximately 200 masl to the northwest of the Portage area deposits.

Bathymetric surveys were conducted by Golder in 2002, 2003 and 2006 for lake areas adjacent to and over the main deposits at Meadowbank. The lake bottom has a similar topography to the adjacent land. Water depths reach a maximum of 38 m in Second Portage Lake. The water depth taken at the cutoff wall of the proposed dike alignments ranges from 0 m to 20 m, with maximum depth along the Goose Island Dike. Typical water depth along the proposed dike alignments is less than 10 m.

4.2 Quaternary Geology

The project area is covered by laterally extensive deposits of glacial till. Glaciofluvial sand and gravel deposits reportedly occur in the three areas: on the north shore of Second Portage Lake, the north shore of the eastern arm of Turn Lake, and to the south of the Vault Deposit. Crysolic soils dominate on land, and lakebed sediment overlies till in the lakes.

4.3 Bedrock Geology

The Meadowbank Project site is underlain by a sequence of Archaean greenstone (ultramafic and mafic flow sequences) and metasedimentary rocks that have undergone polyphase deformation resulting in the superposition of at least two major structural events. Enclosed within the greenstone are volcaniclastic sediments, felsic-to-intermediate flows and tuffs, sediments (greywackes), and oxide iron formations. The sequence also contains sericite schists, which are believed to be altered felsic flows or dikes. The ultramafic rocks are variably altered, containing serpentinite, chlorite, actinolite, and talc. The ore in the Vault deposit is hosted in intermediate volcanic rocks. The ore in the Portage deposit is hosted in iron formation rocks.

There are four main rock types available for dike construction, including iron formation (IF), intermediate volcanic (IV), and ultramafic volcanic (UM) (serpentinized and non-serpentinized), and quartzite (QTZ). All four rock types were observed along proposed dikes alignments during geotechnical investigations performed in 2003 and 2006.

4.4 Geotechnical Conditions

Available geotechnical data for the Meadowbank site are summarized here. Borehole locations are shown in Drawing 6000-02.

4.4.1 Lakebed Sediments

Lakebed sediment samples from the Meadowbank site were provided to Golder's Geotechnical Laboratory in Burnaby, BC from ALS Laboratories. Composite samples were tested for grain size, water content, organic content, and specific gravity.

Organic contents were 6.7%, 6.8% and 16.5%. Water contents for disturbed samples were 306%, 490% and 667%. Liquid Limit of the sediments was 109%, and Plasticity Index was 5.2%.

The Specific Gravity of sediments was 1.69 with organics present, and 2.52 without.

Grain size analysis test results are presented in Figure 4.1, and indicated that the lakebed sediments are primarily sand, silt and clay sized particles. Laboratory data sheets for the 2006-2007 testing are included in Appendix I.

Lakebed Sediments: Strength

Seabed Terminal Impact Newton Gradiometer (STING) tests results for dynamic bearing strength profile of lake sediments from Golder (2007b) are presented in Table 4.1. A 1 m long steel shaft and foot instrumented for vertical acceleration and water pressure measurements are dropped onto the lakebed. Results indicate a limited thickness of soft sediments, underlain by a harder material – typically inferred to be a rocky till or bedrock.

TABLE 4.1: STING Penetrometer Testing Results

Lake	Site Name	Easting	Northing	Thickness Soil (m)	Dynamic Bearing Strength (kPa)
Second Portage	2-A	639416	7213795	0.2	<20
Second Portage	2-B	639345	7213916	0.1	20-50
Second Portage	2-C	638708	7214795	0.2	increasing with depth to 300 kPa
Third Portage	3-A	638312	7212033	0.25	Penetration depths of 0.25 m at 300 kPa
Third Portage	3-B	638641	7213032	0.15	20 - 200
Third Portage	3-C	638799	7212833	0.23	20 - 100

4.4.2 Glaciofluvial Deposits

Occurrences of gravel and sand in boreholes are reported below.

4.4.3 Glacial Till

Observations and thicknesses of on-land and lakebed soils overlying bedrock are summarized in Table I-1 and I-2 in Appendix I. Thickness of soils in boreholes on land varied from 0 m to 5.1 m with an average of 2 m on land. Drilling observations for lakebed soils indicated thickness of 0 m to 18.1 m, with an average of 3.8 m. Drilling observations are summarized in Table I-3 in Appendix I.

Till Gradation

Descriptions of the disturbed soils that have been recovered from beneath the lakes during geotechnical drilling in proximity to the dike alignments generally are cobbles and gravel with traces of sand, silt and clay. Locally, samples of sand have been obtained. Samples of clayey sand material have been recovered using split spoon sampling methods.

Laboratory test data for till gradation are summarized in Table I-4 in Appendix I. The average particle size distribution for the 45 samples of till was 17% gravel, 52% sand, and 31% fines. The till had 25% silt and 6% clay sizes for 42 samples tested by hydrometer analyses. Boulders were noted in 19 of 51 boreholes, summarized from Table I-3 in Appendix I.

Till –Density Related Properties

Values of Specific Gravity for till samples were 2.67, and 2.71.

Till moisture content and Plasticity Indices are presented in Table 4.2.

TABLE 4.2: Till Moisture Content and Plasticity Indices

Borehole	**Sample**	**Moisture content (%)**	**Liquid Limit (%)**	**Plastic Limit (%)**	**Plasticity Index (%)**	**Reference**
02GT-07	3	10.5	16.8	11.3	5.5	Golder 2002b
	5	13.1	15.9	12.7	3.2	
	6	11.1	16.9	13	3.9	
2nd Portage Trenches Area	Till Spoil 1	4.4	15	15.1	Non-plastic	Golder 2006 Lab Testing – Appendix I
	Till Spoil 2	5.7				
	Till Spoil 3	5.9	17.2	16	1.2	
	Till. Grassland 4	14.8	18.8	18	0.8	
	Till Spoil 5	5.3	16.3	15.8	0.5	
	Till Spoil 6 & 7	5				
	Till Spoil 8	4.2				
	Till Spoil 9-10	7				
	Till Spoil 11	10.9	17.5	16.8	0.7	
	Till Spoil 12	8.2	19.4	17.6	1.8	
Average		8.2	17.1	15.1	2.2*	

* calculated for plastic results

Till Strength

A 5.9 m thick deposit of soil with the upper 2.9 m comprising silt, sand and clay was present in Borehole 02GT-07. A 4.2 m thick deposit of till with upper 1.6 m thick comprising clay, silt, sand and gravel was present in Borehole 02GT-08. Standard penetration testing results are presented Table 4.3 (Golder 2002b). Shear strength testing of a composite specimen samples collected from 02GT-07 are presented in Table 4.4.

TABLE 4.3: SPT Blow Counts from Boreholes 02GT-7 and 02GT-08

Sample	Depth Below Ice Surface		SPT Blow Counts (Blows/0.3 m)
	From (m)	To (m)	
02GT-07			
Sa#1	3.60	4.05	15
Sa#2	4.05	4.50	11
Sa#3	4.50	4.95	11
Sa#4	4.95	5.40	35
Sa#5	5.40	5.85	15
Sa#6	5.85	6.30	14
02GT-08			
Sa#1	4.10	4.55	56 (Refusal)
Sa#2	5.25	5.70	94 (Refusal)
Sa#3	6.50	7.10	Shelby Tube Attempted – no recovery
Sa#4	7.10	7.55	29

Strength testing of till samples indicated strength parameters shown in Table 4.4.

TABLE 4.4: Strength Testing for Till

Borehole	Sample	Friction Angle (degrees)	Cohesion (kPa)	Test Type	Reference
02GT-07	3,5,6	32	22	Consolidated Drained Direct Shear	Golder (2002b)
Third Portage Trench	59644, 59645, 59646	37	17	Consolidated Drained Direct Shear	Golder (2002b)
Third Portage Trench	3,6,7	33	0	Undrained Triaxial Test	2006 Laboratory Testing

Till Hydraulic Conductivity and Consolidation Response

Till hydraulic conductivity testing included:

- Borehole 02GT-03 interval El. 132 to 133 masl within bouldery till: $3x10^{-4}$ m/s.
- Borehole 02GT-07 interval El. 126 to 127 masl: $1x10^{-7}$ m/s.
- Laboratory consolidation testing: $2x10^{-9}$ m/s

The laboratory hydraulic conductivity value was derived from progress of consolidation of a large diameter (152 mm diameter) sample of reconstituted fine till. However, the sample was noted to be unsaturated. The same sample had values of m_v from 0.3 to 0.07 at pressures of 0.25 kPa to near 150 kPa. Results are included in Appendix I.

Ice Rich Soils

Observations in 2006 indicated that near surface soils on land flowed when thawed. The behaviour indicates near surface ice contents that are wet of the liquid limit.

4.4.4 Rock

There is a considerable amount of information available for the rock mass at Meadowbank from boreholes drilled at the site. Limited information is available for near surface rock along the dewatering dike alignments. Bed rock elevations are summarized in Table I-3 in Appendix I.

The rock mass is generally of good quality. Rock Quality Designation (RQD), tunnelling parameter Q', and Rock Mass Rating (RMR) are presented for each rock type in Table 4.5 with unconfined compressive strength (UCS) testing results. Discontinuity properties are summarized in Table 4.6.

TABLE 4.5: Summary of Pit Rock Properties

Rock Type	Pit	RQD		UCS (MPa) (Lab Testing)	Q'		RMR (from Q')		mi
		Mean	Median		Mean	Median	Mean	Median	
IF	Goose	97/95*	98/100*	137 to 248	17/32*	21/44*	69/75*	71/78*	20
	Third	92	97	(avg. 175)	14	17	68	69	
	North	93	96		16	16	69	69	
	Vault	89	91		16	14	69	68	
IV	Goose	97/93*	99/100*	51 to 148	18/36*	20/38*	70/76*	71/77	18
	Third	92	97	(avg. 94)	11	12	66	66	
	North	86/92**	91/97**		10/18**	11/12**	65/70**	66/66**	
	Vault	91	98		11	11	66	66	
UMV	Goose	86/81*	92/87*	40 to 92	8/14*	11/16*	63/68*	66/69*	10
	Third	85	92	(avg. 66)	9	14	64	68	
	North	64	73	Serpentinized avg. 32	4	5	56	58	
	Vault	-	-		-	-	-	-	
QTZ	Goose	-	-	70 to 140	-	-	-	-	20
	Third	84	89	(avg. 107)	14	14	68	68	
	North	-	-		-	-	-	-	
	Vault	-	-		-	-	-	-	

*Based on Data Collected by Cumberland/ Golder 2003d **IV/IVCL / IV/IVCS

TABLE 4.6: Summary of Main Discontinuity Properties

Type	Portage & Goose Island Deposits				Vault Deposit		
	Dip	Dip Direction	Average Spacing (m)		Dip	Dip Direction	Average Spacing (m)
Foliation	Dec-72	255-300	0.5 -1.5		21-23	136-164	0.5-0.8
Orthogonal	76-10	067-121	1.4-12		60-70	333-336	2.8-8.1
CJ1	43-79	201-237	2.5 11.4		83-85	197-209	1.7-7.4
CJ2	36-81	025-068	2.5-8.3		80-82	040-053	
CJ3	65-86	125-148	1.2-9.5		-	-	-
CJ4	58 -73	299-340	1.0-7.0		-	-	-
East-dipping	-	-	-		67-81	086-108	3.7-6.1
South-dipping	-	-	-		45-48	174-198	3.7-6.1
Cross	46-63	002-031	0.4-19.4		73	253	4.4
Cross	62-88	341-350			-	-	-
Cross	26-62	170-191			-	-	-
Flat	-	-	-		10-13	330-335	8.3

The Second Portage Fault is located just north of the Third Portage Peninsula area, and trends northwest, parallel to the northwest arm of Second Portage Lake. Its projected surface trace would intersect the proposed Central Dike as well as the East Dewatering Dike. The Second Portage Fault is interpreted as a discrete, narrow focused brittle-ductile fault.

The Third Portage Peninsula is flanked on the west by the north-south trending Bay Zone Fault, which roughly parallels the western shoreline of Third Portage Peninsula and extends northward along the western flank of the North Portage Deposit and south-southeastward between the eastern shore of the Bay Zone Island and the Third Portage Peninsula. A splay trending off the Bay Zone Fault begins south of the narrows separating the Third Portage peninsula from the mainland and trends south along the western side of the Bay Zone Island. Both pass beneath the proposed Bay Zone Dike, but whether one or both pass beneath the Goose Island Dike is unknown. The Bay Zone

Fault is interpreted as a ductile shear, across which stratigraphic continuity is transposed but maintained.

The potential for fault reactivation is considered to be very low. The project area is in a zone of low seismic activity, Seismic Zone '0 '. The Second Portage Fault and Bay Fault are on the order of 1.7 to 1.9 billion years in age (Pehrsson, 2001; Rainbird, 2005). Pehrsson (2005) reports that the structures in the deposit area have not been demonstrably reactivated by orogenic events in the area. McMartin et al. (2005) report that these structures do not localize post-glacial rebound. The potential for fault reactivation is low due to the type, or character, of the faults, the absence of evidence for reactivation despite known tectonism, and the low seismic activity of the area. Consequently, there is a very low risk for potential damage to the dewatering dikes associated with reactivation of the Second Portage Lake Fault.

Bedrock – Hydraulic Conductivity

A summary of bedrock hydraulic conductivity data is shown in Table I-5 in Appendix I. Figure 4.3 plots the same data versus elevation.

Hydraulic conductivity values for boreholes on and adjacent to the alignments of the dewatering dikes are plotted in Drawings 6000-40, 41 and 42.

4.5 Ground Water - Hydrogeology

In areas of continuous permafrost there are two groundwater flow regimes: a shallow groundwater regime located in the active layer near the ground surface, and a deep groundwater regime beneath the permafrost.

4.5.1 Shallow Groundwater Flow Regime

From late spring to late summer, when temperatures are above 0^{o}C, the active layer thaws, creating the shallow groundwater regime. Within the active layer, the water table is expected to be subdued replica of the topographic gradients. Locally, groundwater in the active layer flows to local depressions and ponds that drain or flow directly to Second and Third Portage lakes or flows directly to Second and Third Portage lakes.

Permafrost reduces the hydraulic conductivity of the rock by at least one or two orders of magnitude (Anderson and Morgenstern, 1973; Burt and Williams, 1976). Consequently, hydraulic conductivity in permafrost will be very low compared to unfrozen rock at the Meadowbank site. The shallow groundwater flow regime therefore has negligible hydraulic connection with the groundwater regime located below the deep permafrost except where taliks exist beneath large waterbodies.

4.5.2 Deep Groundwater Flow Regime

In areas of continuous permafrost, the deep groundwater regime is connected by taliks located beneath large lakes. Taliks exist beneath lakes that do not freeze to the bottom in winter. If a lake is large enough, the talik extends down to the deep groundwater regime. At Meadowbank, analyses have predicted that open taliks extending to the deep groundwater regime will occur beneath lakes that do not freeze completely, when the diameter is roughly 570 m or greater for round lakes or the width is at least 320 m for elongated lakes. Based on these analyses, open taliks exist beneath Third and Second Portage lakes, including Second Portage Arm. These analyses also suggest that the talik beneath Vault Lake does not extend to the deep groundwater flow regime because this lake is relatively shallow and much of the lake freezes to the bottom in winter.

The water elevation of lakes with open taliks provides the hydraulic head required to drive deep groundwater flow. The presence of the thick, low permeability permafrost beneath land located between large lakes results in negligible recharge to the deep groundwater flow from these areas. Smaller lakes have isolated, or closed, taliks that do not extend down to the deep groundwater regime and thus do not influence the groundwater flow in the deep regime. Consequently, recharge to the deep groundwater flow regime is limited to the open taliks beneath large lakes. Generally, groundwater will flow from higher elevation lakes to lakes located at lower elevations.

4.6 Seismicity

The Meadowbank Project is located in an area of low seismicity.

Peak horizontal ground accelerations for the Meadowbank site are summarized in Table 4.7.

TABLE 4.7: Peak Horizontal Ground Acceleration for the Meadowbank Site

Return Period of Seismic Event (years)	Peak Horizontal Ground Acceleration (g)
100	0.02
200	0.03
475	0.03
975	0.04
10,000	0.07[D]

Source: 100 to 975 year data from Geological Survey of Canada (2003).
[D] Design event extrapolated from Geological Survey of Canada (2003) data

5.0 DIKE DESIGN

5.1 Design Concept

Typical sections for the dewatering dikes are shown in Drawings 6000-19 to 29. The design concept consists of:

Rockfill Embankments:

- Two parallel rockfill embankments are advanced into the water.
- Crest width of the embankments is 30 m for two way truck traffic, and 20 m for one way truck traffic, including 1.9 m high safety berms. The embankments provide the running surface for the large mine haul trucks during construction.
- Crest elevation for the truck running surface is 136.1 masl.

Filter:

- A granular filter is placed between the rockfill embankments, against the pit-side rockfill embankment, to prevent movement of the finer fraction of the till core into the rockfill.

Till Core

- The space between the granular filter and upstream rockfill embankment is filled with till placed through water. The till core will achieve a relatively low permeability after consolidation and will generally control seepage through the embankment.
- The minimum distance between the pit side filter toe and the lake side rockfill embankment toe is 5 metres to allow cutoff construction.
- A 3 to 5 m surcharge layer of rockfill will be placed to consolidate the till core, then removed. A minimum 1 m thickness of rockfill will be left in place to provide a working platform for cutoff wall construction. The surcharge induced consolidation of the till core backfill will stiffen and strengthen the backfill, which will increase the stability of the slurry supported cutoff trench walls during construction and reduce deformation of the cutoff walls containing cemented material during pit area water drawdown.

Cutoff

- A cutoff wall is constructed through the till core and foundation soils to bedrock.

- Elevation of the top of the cutoff wall is 135.1 masl.

- Cutoff wall technologies include slurry supported trench with soil-bentonite backfill, slurry supported trench with soil-cement-bentonite backfill, and jet grouting. Cutoff walls are discussed in Appendix IV.

Grout Curtain

- A grout curtain will be constructed in the near surface fractured bedrock to control seepage and to prevent piping of the till core and embankment foundation soils into open fractures.

- The contact between the cutoff wall and bedrock will be grouted using a “tube-à-manchette” or sleeve port pipe grouting technique as the bedrock curtain is completed.

A discussion of construction techniques is included in Appendix IV.

5.1.1 Construction Materials

Rockfill

Blasted rock produced by mining operations will be used for dike construction. Maximum gradations of rockfill predicted from blast design are shown in Figure III-1 (Golder 2004a).

Filter

The granular filter will be constructed of IV rock.

Filter gradations were designed on the basis of available grain size data, which are presented in Figure III-2. Waste rock gradations were predicted from blasting design (Golder 2004a) and represent the coarsest expected gradations for UM and IV rock types. The till samples from the Meadowbank site contained 15 to 50% passing the No. 200 or 0.075 mm sieve. Gradations for the filters are presented in Table 5.1, and Figure III-2.

TABLE 5.1: Gradations Limits for Fine and Coarse Filters

US STANDARD SIEVES MAXIMUM SIZE	Size (mm)	Fine Filter % Passing	Coarse Filter % Passing
24"	610		100
12"	305		100-90
6"	152		100-50
3"	76.2	100	92-33
1"	25.4	100-68	44-7
1/2"	12.7	75-56	22-5
#4	4.75	55-40	10-3
#10	2	43-30	
#40	0.425	23-10	
#200	0.075	8-5	

The fine filter gradation is based on the typical gradation of the Zone 2B material in concrete faced rockfill dams. Laboratory testing of this gradation has demonstrated it to be internally stable under high gradients, and able to retain materials with 100% passing the No. 200 sieve (Eldridge and Gilmer 2002). The fine filter will retain the till and lakebed sediments, making it suitable for use in the Dewatering Dikes and the Central Dike. Crushing, screening and washing will most likely be required to produce the fine filter.

The coarse filter was designed based on Fell et al. (2005), and meets filtration criteria against the fine filter zone specification. The coarse filter is designed to be produced by scalping run of mine IV rock of sizes greater than 150 mm diameter. Depending on the crushing and screening plant available on site, processing of run-of-mine rock through the crushing plant may be carried out to reduce material handling requirements.

Till Core Material

Glacial till material will be sorted to remove particles greater than 150 mm, and will contain a minimum of 15 % passing the No. 200 sieve.

Cutoff Wall

For soil-bentonite cutoff trench backfill, a design value of hydraulic conductivity of 10^{-9} m/s was used in analyses presented in this report.

For soil-cement-bentonite mixtures, a design value of 10^{-8} m/s was used in analyses presented in this report.

Laboratory results from hydraulic conductivity testing of trench backfills are presented in Table 5.2, and indicate that low values of hydraulic conductivity will be achievable with the till from the Meadowbank site. Laboratory test data sheets are presented in Appendix I.

TABLE 5.2: Hydraulic Conductivity Test Results – Cutoff Wall Materials

Sample*	Hydraulic Conductivity (m/s)
1.6% bentonite to soil by dry mass, prepared as a slurry, allowed to hydrate, then placed into mould	2×10^{-9}
6% bentonite to soil by dry mass, prepared by mixing dry bentonite powder with dry soil, then adding water	5×10^{-11}
4% bentonite and 4% cement to soil by dry mass, prepared dry, then water added to achieve design slump.	5×10^{-9}

* all specimens prepared from a composite of samples 3, 6 and 7 from 2006 Trench sampling program.

Preparing samples using powdered bentonite rather than hydrated bentonite slurry will increase the hydraulic conductivity of the mixture due to a lack of hydration of the bentonite.

Addition of cement to increase erosion resistance is also noted to increase hydraulic conductivity.

Grout

Cement based grout is used for both curtain grouting, for grouting the cutoff-bedrock contact, and for jet grouting. A typical value of hydraulic conductivity that may be expected from using cement based grout is 10^{-7} m/s. The use of various additives is considered in the specifications.

5.2 Stability Analyses

Computer analyses were conducted to determine the stability of the dewatering dikes. Results are summarized here, with an explanation of methods and assumptions used for the analyses.

5.2.1 Summary

The dikes are relatively low, wide structures that exceed the minimum design criteria factors of safety for stability for:

- pre-drawdown conditions,
- operation conditions with maximum head difference across the dikes,
- pseudo-static earthquake conditions, and
- post closure conditions.

During dumping of the rockfill, the sideslopes of the fill will adjust to the shear strength of the foundation soil. The slopes will be flatter in areas of weaker soils, and steeper in areas of stronger soils. Rapid construction and drawdown will generate pore water pressures in the lakebed soils which may influence the stability of the dikes. Monitoring of pore pressures in foundation soils during dewatering of the pit area will be required to confirm dissipation of pore pressures beneath the downstream rockfill embankment as the water level is lowered.

Methods, assumptions, parameters and model geometries and results of slope stability analyses are presented here.

5.2.2 Methodology and Assumptions

Stability analyses were performed using the GeoSlope SLOPE/W, Version 6.2 computer program for general solution of slope stability by two dimensional limit equilibrium methods.

Drained and undrained analyses were conducted. Pseudo-static analyses were conducted considering the peak ground acceleration of 0.07g, as presented in Section 4.6.

Model Geometry

Two sections were analyzed, based on the steepest and the deepest lakebed bathymetry along the Goose Island Dike alignment. A review of bathymetry did not indicate a critical section with a slope leading down towards the pit. Sections are shown in Appendix III as Figures III-3 and III-4, and listed in Table 5.3.

TABLE 5.3: Sections for Slope Stability Analysis

Description	**Thickness of Lakebed Soils (m)**	**Water Depth at Cut Off Wall (m)**	**Rockfill Embankment Side Slope**
steepest lakebed slopes	8	13	1.6 Horizontal: 1 Vertical
deepest water depth at cutoff wall	8	20	1.6 Horizontal: 1 Vertical

Other model geometry parameters are listed in Table 5.4

TABLE 5.4: Slope Stability Model Geometry

Parameter	**Value**
Range of rockfill embankment sideslopes	1.3 Horizontal: 1 Vertical, to 2.0 Horizontal: 1 Vertical
height of safety berms on roadway	1.9 m
slope of pit wall	1 Horizontal: 1 Vertical
depth of pit	168 m
width of rockfill crest trafficway	13 m or 20 m
distance from rockfill embankment toe to cutoff wall	2.5 m
width of cutoff wall	1 m
setback from pit crest to dike toe	70 m
dike free board	2 m
cutoff free board	1 m
Lake elevation	134.1 masl

The phreatic surface was taken from the seepage analyses.

Material Properties

The soil parameters used in the analysis are listed in Tables 5.5 below.

TABLE 5.5: Material Parameters for Slope Stability Analysis

Material	**Unit Weight**	**Angle of Internal Friction** ϕ'	**Undrained Strength** ***Cu***
	(kN/m^3)	**(degrees)**	**(kPa)**
Till Core	17.2 - 21.4	0 to **32**	45
IV Rockfill - Inner Berm & Filter	18.6 - 21.8	**38** to 40	n/a
IF Rockfill - Outer Berm	18.6 - 25.3	**38** to 40	n/a
UM+Q Rockfill - Surface Treatment	18.6 - 19.8	**38** to 40	n/a
Lakebed Sediments	16 - 17	32	n/a
Lakebed Till	17 - 21.4	22 to 34 (**32**)	30 - 90
Cutoff wall	15.7 - 21.4	30 to 32	30 - 45
Bedrock*	28	40	

* Bedrock typically modeled as infinite strength. Sensitivity analyses used parameters shown, cohesion c = 500 kPa for bedrock. Cohesion c = 0 assumed for all other materials. Base case friction angles shown in bold type.

5.2.3 Results

Results of analyses are presented here and as Figures in Appendix III.

Pre-Drawdown Conditions

Factor of safety for pre-drawdown conditions are illustrated in Figures III-5 to III-8.

The till core will be placed in the wet and it is anticipated that consolidation must occur in order to generate shear strength. The case of low strength till core backfill was analyzed with respect to the overall stability of dikes during construction. For the case where the till core behaves as a heavy fluid with a unit weight of 21.4 kN/m^3 with no strength, or ϕ' = 0, c = 0, the Factors-of-Safety (FoS) are high, as illustrated in Figure III-9.

Figures III-10 and III-11 illustrate influence of the 5 m surcharge load on overall stability. FoS for pseudostatic analysis with surcharge loading are above 1.5.

Dewatering

Results of undrained analyses simulating rapid drawdown of the downstream side are illustrated in Figures III-12 to III-17 in Appendix III. FoS are plotted in Figure III-18. It is noted that the water table is modelled as lower than predicted by seepage modelling to be conservative with respect to the minimum required strength for the lakebed till during drawdown.

Operating Conditions

Upstream and downstream failure modes for standard operating conditions are illustrated in Figures III-19 to III-34 for static and pseudostatic conditions. Results for both static and pseudostatic analyses are above FoS of 1.5.

Post Closure Conditions

Post closure stability of the East Dike indicated values of FoS above 4 for upstream and downstream failure modes, shown in Figure III-35.

Sensitivity Analyses for Stability

Drained friction angle of lakebed till. Results in Figure III-36, indicate that the FoS increases significantly with drained strength of the lakebed till for the critical case of the steepest lakebed section and upstream failure.

Effect of soft sediments: Where lakebed sediments are trapped beneath advancing rockfill during construction, the face of the advancing rockfill will slump and the sideslope will flatten until equilibrium is achieved. The lakebed sediment will then consolidate under the load of the rockfill and gain strength. The expected thickness of sediments is on the order of 0.1 to 0.3 m, based on the Stinger survey, and as such, consolidation of the sediment will occur quickly. Geotechnical investigation of the lake sediments will be carried at to the beginning of construction, as indicated in Section 6.3 to provide additional information on the distribution and strength of the lakebed sediments.

Adaptive Management Strategy**:** For the deep and steeper sections of the Goose Island Dike, which are to be constructed after start-up, if the geotechnical investigation indicates that the thickness and strength of the lakebed sediments will result in the Factor-of-Safety of this section of the dike not meeting the design criteria for stability, the lakebed sediments will be removed from portions of the footprint to increase the stability. The areas of sediment to be removed will be determined based on the results of stability analyses carried out using the design section and the measured strength and thickness of the lakebed sediment.

Effect of Finger Berms as Fish Habitat: The effect of "finger dikes" constructed upstream of the dewatering dikes as fish habitat was not considered in these analyses. Adding rockfill to the upstream face of the dewatering dikes will buttress the dikes and increase the FoS against failure in the upstream direction.

5.3 Seepage

Steady state analyses were performed using the 2D finite element numerical code, Seep/W, to estimate:

1. Flow rate through the dikes.

2. Hydraulic gradients beneath and within the dikes and the potential for internal erosion.

3. The location of the phreatic surface and head lost across the cutoff wall after pit area dewatering.

Sensitivity analyses were performed to determine the influence of hydraulic conductivity, the effect of cracks through the cutoff wall, and the effect of a grout curtain.

5.3.1 Summary of Results

Seepage analyses presented here indicated:

- Seepage into Goose Pit is estimated to be on the order of 450 m^3/day to 2,000 m^3/day over the mine life.

- Seepage into Third Portage Pit is estimated to be on the order of 350 m^3/day to 2,250 m^3/day over the mine life.

- The East Dike has a lake surface at El. 133.1 masl on the east side and at El. 134.1 masl on the west side at closure, which results in an estimated flow of 30 m^3/day through the dike.

- Bedrock grouting will reduce the flows below the dewatering dikes by about 10%.

- Maximum predicted head loss across the cutoff wall at the deep section of the Goose Island Dike is 7.5 metres, including pit depressurization effects.

- Predicted gradients at the toe of downstream till/rockfill contact are low.

5.3.2 Inputs and Assumptions

Model Geometry

Three cross-sections were analyzed, including:

- Shallow Section with 2 m water depth; soil-bentonite cutoff wall, representative of East Dike Section. Shown in Figure III-37 in Appendix III.

- Medium Section with 5.6 m water depth, soil-cement-bentonite cutoff wall; representative of sections of the Bay Zone and Goose Island Dike. Shown in Figure III-38 in Appendix III.

- Deep Section with 20.1 m water depth, jet grout cutoff wall, one way traffic on the downstream rockfill embankment and two-way traffic on the upstream rockfill embankment. Representative of deepest section of Goose Island Dike. Shown in Figure III-39 in Appendix III.

Boundary Conditions

Upstream boundary conditions included lake surface of El. 133.1 masl for the Shallow Section representing the East Dike on Second Portage Lake, and El. 134.1 masl for the Medium and Deep Sections on Third Portage Lake.

Downstream boundaries were set to review nodes along pit and drainage trench walls, and a pressure head equal to zero was applied to the bottom of the downstream toe trench or the base of the pit excavation. For the case of pit wall depressurization at the Goose Island Dike, nodes of pressure equal to zero were placed 90 metres into rock from the pit face. The pit wall depressurization case is conservative, and was meant to represent a "worst case" for drawdown of the water table across the deep section.

To model closure conditions at the East Dike, constant head conditions equal to expected final lake elevations were applied.

Hydraulic Conductivity

Values of hydraulic conductivity used in the analyses are summarized in Table 5.6.

As a worst case scenario for seepage through the bedrock, a zone of more permeable rock extending from bedrock surface to 20 m depth was assumed at the cutoff, and extended horizontally.

TABLE 5.6: Summary of Hydraulic Conductivities

Material	Hydraulic Conductivity Range Observed (m/s)	Hydraulic Conductivity Design Value (m/s)			Source
		Seepage Volume Analyses	Gradient Analyses and Cut off wall Crack/ Gap Analyses	Sensitivity Analyses	
Rockfill/Filter	n/a	10^{-2}	10^{-2}	10^{-2}	Design assumption
Native Till Layer and Till Core Backfill	$3x10^{-4}$ to 10^{-9}	10^{-7}	10^{-5}	10^{-5} and 10^{-7}	estimated range based on grain size, laboratory testing[a]
Lake Bed Sediments	n/a	10^{-7}	10^{-5}	10^{-5} and 10^{-7}	Experience with materials with similar genesis and grain size distribution
Foliated Bedrock (0-20 m depth from bedrock surface))	$1x10^{-4}$ to $3x10^{-9}$	$5X10^{-6}$	$5X10^{-6}$	$5X10^{-6}$	Field investigations [a,b,c,d]
Grouted Bedrock (0- 25 m depth from bedrock surface)	n/a	10^{-7}	10^{-7}	10^{-7}	Design assumption
Low Permeability Bedrock (greater than 20 m depth)	10^{-5} to $8x10^{-9}$	$2X10^{-7}$	$2X10^{-7}$	$2x10^{-7}$	Field investigations [a,b,c,d]
Jet Grout Cut off wall	n/a	10^{-7}	10^{-7}	10^{-7}	Design specification.
Soil-Bentonite Cut off wall	n/a	10^{-9}	10^{-9}	10^{-9}	Design specification.
Soil-cement-bentonite cutoff wall	n/a	10^{-8}	10^{-8}	10^{-8}	Design specification.

[a]Golder 2002b Appendix II, [b]Golder 2003d Appendix II, [c]Golder 2006d Appendix III, [d]No discernable difference in hydraulic conductivity of the various rock types.

5.3.3 Predicted Seepage

Predicted seepage rates are summarized in Table 5.7. Equivalent lengths of dike for each section are shown in Table 5.8. The volume of seepage for the entire dike was based on the summation of the flow rates for each section is shown in Table 5.9.

TABLE 5.7: Predicted Seepage Rates

Section	Water Depth (m)	Flux (l/day/m)			
		At end of Drawdown	Pit Half Open	Pit Open	Closure
Shallow	2	96	946	1081	39
Medium	5.6	232	1009	1122	
Deep	20.1	372	1475	1538	

TABLE 5.8: Summary of Dike Lengths

Dike	Total Alignment Length (m)	Length Medium (m)	Length Deep (m)	Length Shallow (m)
East	830	Not applicable	Not applicable	680
Bay Zone	1200	1200	Not applicable	Not applicable
Goose Island	1720	1420	300	Not applicable

TABLE 5.95: Summary of Seepage Volumes

Dike	Total Seepage Volume (m^3/day)			
	At end of Drawdown	Pit Half Excavated	Pit Fully Excavated	Closure
East Dike	80	820	900	30
Bay Zone Dike	280	1200/670*	1350/740*	
Goose Island Dike	450	1900	2000	

*Bay Zone Dike volumes given for Goose Island Dike not present/present.

5.3.4 Predicted Gradients

Maximum gradient predicted at the contact between foundation till and rockfill was 0.8. Maximum gradients at the cutoff wall are presented in Table 5.10.

TABLE 5.10: Maximum Gradients at Cutoff Wall

Section	Maximum Gradient at Cutoff	Condition
Shallow	2	at the end of drawdown,
Medium	5	at end of drawdown
Deep	8.6	pit fully excavated

5.3.5 Maximum Head Loss Across Cutoff Wall

Post drawdown water tables are illustrated in Figures III-40 to III-42. Water tables for the pit fully excavated are shown in Figures III-43 to III-45. Maximum head loss across the cutoff walls using hydraulic conductivity values of 10^{-5} m/s for lakebed till and till core are presented in Table 5.11. The use of the higher hydraulic conductivity value for the materials surrounding the cutoff wall results in higher head losses across the cutoff wall and less head loss through the foundation and till core.

TABLE 5.11: Maximum Head Loss Across Cutoff Wall

Section	Maximum head loss across cutoff wall (m)
Shallow	5.9
Medium	7.9
Deep	7.5

The maximum expected head loss across the cutoff wall for the Deep Section was smaller than for the medium section due to the shape of the bedrock surface.

It is noted that the water tables used in Stability Analyses in Section 5.2 and deformation models in Section 5.7 assume a much greater head loss across the cutoff wall.

5.3.6 Sensitivity Analyses

Grouting of fractured bedrock is predicted to reduce the flows below the dewatering dikes by 10%, but will be carried out to limit the potential for fine material in the foundation soil being carried into open fractures in the bedrock surface.

Modeling of gaps or cracks in the cutoff wall of the deep section produced maximum gradients of 8 at the cutoff wall. Gaps in the cutoff wall of 0.25 m were simulated at elevations within the till core backfill and within the foundation soil. Simulated cracks in the cutoff wall in deep dike sections did not create gradients higher than cases with no gaps present due to the similarity between hydraulic conductivity of the till and the cutoff.

5.4 Thermal Analyses

Thermal analyses of the interaction between the dewatering dikes and climate were conducted to determine the potential for freeze-thaw deterioration of the dike cutoff walls.

5.4.1 Summary

Thermal analyses indicate an active layer of up to 1.75 m. Without thermal protection, the upper 0.75 m of cutoff walls may be affected by the yearly freeze-thaw cycle. This section of the cutoff wall is within the normal freeboard allowance for the dikes.

5.4.2 Methods & Assumptions

Thermal analyses were performed using a 2D mesh with GeoSlope TEMP/W, Version 6.2.

Two sections were analysed: East Dike and Goose Island Dike, with water depths of 2 and 20 metres, respectively are presented on Figure III-46 and III-47.

The key components of the model are summarized below:

- Second Portage Lake level is El. 133.1 masl;
- Third Portage Lake level is El. 134.1 masl;
- The crest of the embankments is El. 136.1 masl; and

- The cutoff wall is 1 m wide and is constructed to 1 m below the crest of the embankments.

Material Properties

Table 5.12 presents material physical properties, thermal conductivity, and volumetric water content and volumetric heat capacity assumed for thermal analyses. The thermal properties of the materials were primarily defined based on the Johansen equation, and adjusted based on mineralogy and the geotechnical properties of each material, as well reported values from other projects. The basic literature used included; (Geoslope 2004), Johansen (1975), MEND (1998) and Nidal et al. (2000).

TABLE 5.12: Summary of Physical and Thermal Properties of Materials

Material	Moisture Content (%)	Dry Density (Mg/m3)	Porosity (%)	Degree of Saturation (%)	Volumetric Water Content	Thermal Conductivity (W/m-°C)		Volumetric Heat Capacity (MJ/m³-°C)	
						Frozen	Unfrozen	Frozen	Unfrozen
Till Core Saturated	16.6	1869	0.3	100	0.31	2.1	1.6	1.6	2.3
Till Core Unsaturated	11	1869	0.3	66.2	0.11	1.8	1.4	1.5	2
Rockfill upstream - Saturated (inner embankment / outer embankment)	19.0 / 16.0	1865 / 2219	0.3	100	0.355	2.1	1.4	1.6	2.5
Rockfill downstream & Filter – Unsaturated	5	1927	0.355	28.9	0.093	1.7	1.2	1.5	1.8
Soil-Bentonite Mixture - Saturated	16.6	1869	0.3	100	0.31	2.1	1.6	1.6	2.3
Till Foundation	16.6	1869	0.3	100	0.31	2.1	1.6	1.6	2.3
Bedrock	0.5	2710	-	-	0.005	2.8	2.8	2.4	2.4

Boundary Conditions

An estimated ground temperature function was generated from a 6 year climate dataset. The temperature function is presented in Table 5.13 with warmer and colder functions generated for sensitivity analyses.

TABLE 5.13: Ground Surface Temperature Functions

Month	Surface Boundary Condition Ground Temperature (°C)		
	Estimated Normal Yearly Function	Colder Function	Warmer Function
January	-26.3	-29.3	-23.3
February	-25.2	-28.2	-22.2
March	-23.3	-26.3	-20.3
April	-16.6	-19.6	-13.6
May	-6.7	-9.7	-3.7
June	1.4	-1.6	4.4
July	9.8	6.8	12.8
August	10.5	7.5	13.5
September	5.1	2.1	8.1
October	-3.3	-6.3	-0.3
November	-12.8	-15.8	-9.8
December	-19.5	-22.5	-16.5

A steady state analysis was performed for pre-drawdown conditions to generate initial thermal conditions for the transient analysis based on:

- Ground surface temperature: 4°C;
- Ground surface temperature below Lake: 4°C; and
- Deep bedrock temperature: 1°C; (Golder 2006d).

5.4.3 Analyses

Initial transient analysis was performed to determine temperature variation in the dike and foundations during drawdown.

Transient analyses were then run to identify the depth of the active layer through the dike sections for an 8 year period.

5.4.4 Results

Predictions of temperature through the dike sections indicate that portions of the dike profile will freeze, with the depth of freezing increasing each year. The active layer is then defined by the depth of thaw at the surface each year. Figures III-48 and III-49 in Appendix III present the zero isotherm as a function of depth and time for the East Dike and Goose Island Dike sections. Penetration of the active layer into the cutoff wall is summarized in Table 5.14.

TABLE 5.14: Depth of Penetration of Freeze-Thaw Activity in Cutoff Wall

Section location	Drawdown period	Maximum Cut Off Wall Thickness that will Freeze and Thaw (m)
East Dike	Sept.	0.75
	Nov.	0.75
Goose Island Dike	Sept.	0.5
	Nov.	0.6

Sensitivity analyses for the colder year ground temperature function indicated freeze and thaw of 0.1 m less than the estimated normal year. For a warmer year, the freeze and thaw cycle penetrate to the same depth as the estimated normal year.

One meter of rock placed over the East Dike cutoff will prevent active layer penetration into the cutoff wall, as shown in Figure III-50.

5.5 Settlement and Consolidation

5.5.1 Expected Settlements

Settlement was estimated for six locations on the deep section of the Goose Island Dike. Predicted settlements are examined are summarized in Table 5.15, and represent maximum expected settlements for all dewatering dikes.

TABLE 5.15: Predicted Settlements of Dewatering Dikes

Location (Centrelines)	Settlement Prior to Dewatering (m)	Additional Settlement Following Dewatering (m)
upstream embankment rockfill crest El. 136.1 masl.	0.35	0
below upstream rockfill at El. 112 masl, surface of lakebed.	0.35	0
downstream embankment rockfill crest El. 136.1 masl.	0.41	0.17
below downstream embankment rockfill at El. 122 masl, surface of lakebed.	0.24	0.03
till core at crest El. 136.1 masl (above centreline of cutoff wall)	2.5	0.14
cutoff wall at El. 114.5 masl, surface of lakebed	0.28	0.03

5.5.2 Inputs and Assumptions

Material properties used to calculate settlements are shown in Table 5.16.

TABLE 5.16: Material Properties for Settlement Calculations

Material	Specific Gravity, G_s	Void Ratio, e	Dry Unit Weight (kN/m^3)	Saturated Unit Weight (kN/m^3)	Compression Index C_c
Rockfill - Intermediate Volcanics (downstream embankment rockfill)	2.89[A]	0.55	19.2	21.8	Assume 1% settlement
Rockfill - Iron Formation (upstream embankment rockfill)	3.44[A]	0.55	21.7	25.3	Assume 1% settlement
Rockfill– Quartzite and Ultramafics	2.89[A]	0.5	19.8	n/a	Assume 1% settlement
Till Core Backfill	2.71	0.51	20.4[B]	21.4	0.0656[B]
Till Foundation	2.71	0.51	20.4	21.4	0.0656

A. Waste rock geotechnical properties are presented in Table 5.2 of the Mine Waste & Water Management report by Cumberland Resources Ltd. October 2005.
B. Based on 2006 laboratory testing in Appendix I

Settlements are expected to be largest during construction for rockfills and till core backfill, as indicated in Table 5.15.

Magnitude of settlement due to placement of fill and surcharge load will be dependent upon initial condition of both the lakebed till and the till core backfill. Values of pre-drawdown settlement in Table 5.15 should be taken as estimates only. Final elevations are shown in the drawings and settlement will be accounted for during construction by adding material to bring the dike to the design crest elevation.

Till settlement following dewatering is estimated based on measurements of relatively fine till tested in a large diameter consolidation test (presented in Appendix I). Surcharging the till prior to constructing the cutoff wall will reduce the settlement caused by dewatering.

5.5.3 Rate of Consolidation

Lakebed Tills

Consolidation of lakebed tills will occur after placement of the rockfill and till core, and during dewatering. Loading of lakebed tills during rockfill placement may cause an increase in pore water pressure.

Time required for lakebed tills to consolidate or drain excess pore pressures is related to the thickness of the layer, as shown in Table 5.17.

TABLE 5.17: Summary of Consolidation Settlement of Till Core Backfill

Drainage Path (m)	Time to Achieve 95% Consolidation (days)	
	$Cv = 1.2x10^{-3}$ m^2/sec $K1=5x10^{-6} m/s$	$Cv = 2x10^{-5}$ m^2/sec $K2=1x10^{-7} m/s$
10	1.1	65
8	0.7	42
5	0.3	16
3	0.1	6
2.5	0.1	4

Values of coefficient of consolidation, c_v, in Table 5.23 were calculated from assumed hydraulic conductivities, and a value of coefficient of compressibility, $m_v = 4.1x10^{-4}$ m^2/MN derived from 2006 laboratory testing.

Till Core

The till core of the dikes will be placed through water and will be initially loose. Till core materials are expected to settle and generate pore water pressures induced by self-weight loading. Rates of settlement may be taken from Table 5.17, with drainage path dictated by core geometry.

Loading of the till core with a layer of rockfill will be carried out to consolidate the till. A portion of the rockfill will be left on the till surface to create a working platform for installation of the cutoff walls. Consolidation of the till core will increase the density, increase the shear strength and reduce the permeability.

The Goose Island Dike has the deepest section which will require the longest time for the till core to consolidate. The measured magnitude and rate of consolidation of the Bay Zone Dike and East Dike will be used to revise the consolidation estimate for the Goose Island Dike prior to the start of construction of the Goose Island Dike.

5.6 Wave Action and Rip Rap Protection

The design freeboard of 2 m is checked against wave run-up predictions here. Design of wave erosion protection is also presented. For short lived sections of the dikes, including the Goose Island and Bay Zone dikes, a practical approach would be to monitor the effects of storms and repair as necessary.

5.6.1 Wave Hindcast

Wave heights corresponding to the overwater windspeeds were estimated using the simplified procedure in the Coastal Engineering Manual (US Army Corps of Engineers 2006). Preliminary calculations were undertaken using wind durations of 1, 2 and 3 hours and it was determined that waves will be fetch limited, due to the short overwater fetch lengths.

A detailed hindcast to derive wave heights corresponding to different return periods was not undertaken. Rather, wave heights corresponding to the largest recorded windspeeds during the 2002 open water season were calculated. The maximum recorded windspeed of 124 km/hr was also used to hindcast waves from each of the relevant overwater fetches, and these hindcasted waves were used to derive estimates of the potential maximum wave runups. The 1/1,000 year wind event was 83 km/hr, and the design windspeed of 124 km/hr is therefore conservative with respect to expected wave height and run-up.

Fetch lengths and maximum water depths are included in Table 5.24.

TABLE 5.18: Fetch Length and Maximum Water Depth.

Dike	Fetch Direction	Fetch (km)	Maximum water depth at dike (m)
Goose Island Dike	south	2.4 km	3 to 4 m
Goose Island Dike	southeast	2.0 km	30 m
Goose Island Dike	east	1.2 km	30 m
Bay Zone Dike	southeast	2.4 km	10 m
Bay Zone Dike	east	0.3 km	10 m
East Dike	southeast	1.7 km	4 m
East Dike	east	0.75 km	4 m

5.6.2 Wave Runup

Maximum wave runups calculated using the 124 km/hr design wind and values presented in Tables 5.19 and 5.20 are:

- Goose Island Dike 2.1 m.
- Bay Zone Dike 2.0 m
- East Dike is 1.6 m

The proposed elevation of the top of the dikes is 136.1 m, resulting in a freeboard of 2.0 m above the proposed operating level (134.1) for the lake. Considering that the traffic safety berms on the dike shoulders provide an additional 2.0 m of freeboard against wave runup, the present dike crest height is adequate.

Wave runup was estimated using Hughes (2003) assuming rough slopes and is estimated with respect to the still water line (SWL). Sideslopes for the Goose Island, Bay Zone and East Dikes were assumed to be 1.6 Horizontal: 1 Vertical.

The procedure derives estimates of wave runup corresponding to $\boldsymbol{Ru_{2\%}}$, which is defined as the runup exceeded by 2% of the incoming waves. For example, for every 100 waves, 2 of them will result in runup equal to or exceeding this estimate.

The results for each fetch are tabulated in Tables 5.19 and 5.20 below.

TABLE 5.19: Estimated Wave Runup, Third Portage Lake

Dike	Fetch	Wind speed (m/s)	Wave Height Hmo (m)	Wave Period Tp (s)	Runup (m), wrt still water line
Goose Island	S	15.4	0.4	1.9	0.8
		34.4	1.1	2.6	2.1
	SE	13.9	0.3	1.69	0.55
		34.4	1.0	2.44	1.75
	E	15.4	0.3	1.5	0.5
		34.4	0.8	2.1	1.5
Bay Zone	SE	20.6	0.6	2.1	1.1
		34.4	1.1	2.6	2.0
	E	15.4	0.1	0.9	0.1
		34.4	0.4	1.3	0.6

TABLE 5.20: Estimated Wave Runup, Second Portage Lake

Dike	Fetch	Wind speed (m/s)	Wave Height Hmo (m)	Wave Period Tp (s)	Runup (m), wrt still water line
East	SE	20.6	0.5	1.9	0.9
		34.4	0.9	2.3	1.6
	E	15.4	0.2	1.3	0.4
		34.4	0.6	1.8	1.1

5.6.3 Riprap Revetment Design

Revetment design was undertaken for the erosion protection works on the dikes. Revetment was designed using the Coastal Engineering Manual methodology (US Army Corps of Engineers,2006, Part 6-Chapter 5).

The maximum estimated incident wave heights given in Tables 5.19 and 5.20 above, were used to estimate the required riprap sizes for each of the incident fetches. For construction simplicity, it was then assumed that a single revetment would be specified for each of the dikes.

Goose Island and Bay Zone Dikes-Riprap Type 1

M50 = 250 kg, D50 = 520 mm

East Dike-Riprap Type 2

M50= 130 kg, D50 = 420 mm

Normally, riprap is installed at 2 times D50 thick. The estimated particle size distribution for the run-of-mine waste rock meets the requirements for riprap for the dikes. For short lived sections of the dikes, a suitable approach would be to monitor the effects after storms, and repair as necessary.

5.6.4 Wave Rundown

Wave rundown is defined with respect to the still water line and was calculated using the Coastal Engineering Manual (US Army Corps of Engineers, 2006, Part 6-Chapter 5). Wave rundown, or $Rd_{2\%}$, is defined as the rundown exceeded by 2% of the incoming waves. For example, for every 100 waves, 2 of them will result in rundown equal to or exceeding this estimate. The maximum rundown for each of the dikes was calculated using the largest incident waves (refer to Tables 5.25 and 5.26 above) and are as follows:

Goose Island and Bay Zone Dikes
$Rd_{2\%}$ = 1.7 m

East Dike

$Rd_{2\%}$ = 1.4 m

Thus, erosion protection should be implemented at least these distances below the still water line.

5.7 Stress-Deformation

Stress deformation analysis was conducted to estimate the pattern and magnitude of lateral displacements that can be expected during drawdown at the deepest section of Goose Island Dike with a depth of water of 20.1 m. The maximum depth of water at the cutoff wall alignment of the East Dike is 5.8 m and of the Bay Zone Dike is 12.1 m.

5.7.1 Methods and Assumptions

Stress deformation analysis was conducted using SIGMA/W Version 6.20. Mesh geometry was taken from the deep section through the Goose Island Dike and shown in Figure III-51 in Appendix III.

The model was first run to determine the stress state after cutoff placement with a water table at El. 134.1 masl. A body load was applied to generate an in situ stress condition. The stress state generated was used as an input or starting condition for the second step of the analysis.

During the second step the water table was dropped on the downstream side of the cutoff to simulate drawdown. The resulting change in stress generates lateral deformations in the cutoff wall.

Seepage modeling indicates that the maximum head difference across the cutoff wall will be less than 8 metres. While water depth at the cutoff is 20 m, the topography limits head loss across the dike due to ponding of water within the downstream rockfill. To attain a 6 m drawdown, the seepage analysis assumes a high permeability upper bedrock zone cut by a grout curtain, a high permeability lakebed till ($k = 10^{-4}$ m/s), and high permeability till core backfill ($k = 10^{-5}$ m/s).

However, as a worst case, conservative scenario representing complete drawdown of the water table at the cutoff location, the case of a 20 m head loss across the cutoff wall is examined here.

Material properties used for stress analysis are shown in Table 5.21.

TABLE 5.21: Material Properties for Stress/Deformation Analysis

Case:	Young's modulus *E*(MPa)								Unit weight (kN/m^3)	Ko
	1	2	3	4	5	6	7	8		
Till Core	20	20	20	20	40	40	40	40	21.4	0.4
Rockfill	15	15	30	30	15	15	30	30	21.8	0.4
In-situ Till	50	50	50	50	50	50	50	50	21.4	0.5
Jet Grout	100	500	100	500	100	500	100	500	21.4	0.5

Predicted deformations are dependent on assumptions of material properties. Young's moduli have not been determined for materials from the Meadowbank site. However, reasonable assumptions can be made from literature values. Fell et al. (2005) and Marsal (1973) report that rockfills dumped on land typically had values of Young's modulus of 15 to 30 MPa. Fell et al. (2005) related values of Young's modulus for rockfills dumped in 10 m of water of 15 to 19 MPa. The jet grout wall is a cemented product with a value of Young's modulus of between 100 and 500 MPa based on Poh and Wong (2001) and Davie et al. (2003).

The key unknown parameter for deformation analysis of the dewatering dike cutoff is the stiffness of the till core. The till core is expected to deform by two mechanisms, plastic and elastic response.

In order to consolidate the till core material and generate shear strength and stiffness values as assumed in this analysis, the material must be surcharged. A 5 m of rockfill placed across the till core will generate approximately 100 kPa surcharge and will consolidate the till core material prior to excavation of the cutoff wall.

For the purpose of simplifying this analysis, it is assumed that the surcharge will consolidate the till core backfill material. When the surcharge is removed to allow excavation, the till will be in an over consolidated state relative to the stress state prior to dewatering. The strains associated with plastic deformation are assumed to be largely taken up by surcharge loading with 5 metres of rockfill generating 100 kPa. Plastic deformation of the till core backfill due to dewatering is therefore assumed to be small.

Values of the Young's Modulus *E* for till were assumed to be in the range of 20 and 40 MPa were assumed based on USACE (1990) silty material. Non-linear behaviour is expected at higher stress levels.

The Goose Island Dike will be constructed after the East Dike and Bay Zone Dike are completed and dewatering of the Portage Pit area completed. Monitoring of the performance of the Bay Zone and East Dikes during drawdown, and particularly the lateral movement of the cutoff wall in the deepest section of the Bay Zone Dike as measurement with inclinometers will provide till core performance data for calibration and refinement of the deformation model of the deep section of the Goose Island Dike.

5.7.2 Results

Maximum horizontal deflections estimated in the deepest section of the Goose Island Dike from dewatering are less than 0.006 metres, as presented in Figure III-52. Cases included in Figure III-49 refer to a combination of material parameters shown in Table 5.21. Horizontal movements of this magnitude, or an order of magnitude larger as reported for the cutoff wall in the A154 Dike at the Diavik Diamond Mine (Zhou 2004), will not compromise the jet grout cutoff wall.

6.0 CONSTRUCTION AND OPERATION

6.1 Mine Development Plan

Table 6.1 summarizes the proposed development sequence for the Meadowbank Project provided by MMC.

TABLE 6.1: Mine Development Plan

Year	Key Issues
-2 and -1	• Stripping at Third Portage peninsula for construction materials • Construct East Dike and Bay Zone Dikes • Begin constructing Goose Island Dike as construction material becomes available • Lower water level behind East and Bay Zone Dikes • Construct plant site
1	• Commence mining of Portage Pit, south end • Portage Pit water pumped to water sump at process plant • Continue and complete construction of Goose Island Dike. Dewater behind dike. Commence stripping of overburden materials
2	• Commence mining at Goose Island Pit • Portage and Goose Island Pit waters, and plant site and airstrip runoff to be directed to attenuation pond, or pumped to water sump at process plant for use as process water as required before discharge of excess to attenuation pond
3-4	• Portage and Goose Island Pit waters, and plant site runoff waters, pumped to water sump at process plant for monitoring and treatment and use as process water as required before discharge of excess to attenuation pond. • Begin construction of Vault haul road • Construct Vault Dike and dewater Vault Lake
5	• Complete mining of Goose Island Pit, and start abandonment • Goose Island Pit is available for storage of pit water • Pump pit water from Portage Pit to Goose Island Pit for early flooding, water quality monitoring, and in-pit treatment as required. Small quantity to be pumped to the process plant for treatment and use as process water • Begin mining northward at Portage Pit. Selective placement of waste rock into south end of Portage Pit, or into Goose Island Pit. Selective placement of ultramafic rock at Portage RSF for future use during closure. • Commence mining at Vault
6-7	• Continue and complete mining of Portage Pit (north end) • Continue mining of Vault Pit • Continue pumping Portage Pit water to Goose Island Pit lake until Portage Pit is

Year	Key Issues
	mined-out then allow pits to fill • Monitor water quality within flooded pits, treating in-situ as required and/or pumping to process plant for use as process water
8	• Complete mining in Vault • Continue pumping Portage Pit water to Goose Island Pit lake until Portage Pits are mined-out, then allow pits to fill • Monitor water quality within flooded pits treating in-situ as required and/or pumping to process plant for use as process water • Continue Goose Island Pit flooding, monitoring and water treatment; commence Portage Pit flooding, monitoring and water treatment.
9	• Mining complete, start final abandonment and restoration • Commence Vault Pit flooding.

6.2 Materials Balance

The quantities of material available during startup and mine operations are summarized in Appendix II. The table also provides a breakdown of rock type availability.

Table 6.2 summarizes estimates of total volume of water inside the proposed dewatering dikes for Second Portage Lake Arm, Third Portage Lake, and Vault Lake, based on bathymetry carried out at the site in 2002, 2003 and 2006.

TABLE 6.2: Lake Volumes Inside Dewatering Dikes

Location	Lake Section	Volume (Mm^3)
Second Portage Lake Arm (elevation 133.1 masl)	Northwest Basin (run-off pond)	1.9
	Main Basin (Main tailings)	8.3
	East Basin (adjacent to east dike)	3.0
	Total Second Portage Lake Arm within east dewatering dike	13.2
Third Portage Lake – Goose Island Area	Inside Bay Zone dewatering dike	0.5
	Between Bay Zone dike and Goose Island dewatering dikes	2.4
	Total Third Portage Lake – Goose Island Area within dewatering dike	2.9
Vault Lake (elevation 139.4 m masl)	Total Vault Lake within Vault dewatering dike	2.2
Total		18.3

Note. Volume estimates are based on site bathymetry
Source: Golder (2004b), Golder 2006a

6.3 Geotechnical Investigations

Geotechnical investigations for the dewatering dikes are required:

- To confirm the foundation conditions assumed for design,
- To confirm availability of till materials for the dike cores, and
- To confirm the *in situ* condition of the till core material prior to trench construction and drawdown.

Investigations:

1. Prior to placement of fill, the thickness and strength of lakebed sediments and glacial till should be confirmed by drilling investigation.

2. Geotechnical investigations of bedrock underlying dike foundations should include hydraulic conductivity testing of the upper bedrock zone. These investigations may be combined with the bedrock grouting program.

3. Volumes of glacial till available for borrow should be delineated with a systematic investigation program that includes quantifying harvestable percentage of till suitable for dike core construction.

4. Strength and stiffness of the till core backfill must be confirmed prior to cutoff construction. The purpose of the investigation is to confirm that the till core material has sufficient strength for trench stability, and sufficient stiffness for support of cutoff walls during dewatering. Information gathered during construction of the East and Bay Zone Dikes may be used in the design of the deep sections along the Goose Island Dike. Determination of soil strength will be by cone penetration test, (CPT) for till placed in the dike core.

Further monitoring requirements are related in Section 6.5.

6.4 Dike Construction Sequence and Techniques

The general proposed construction sequence consists of:

1. Placement of turbidity barrier

2. Placement of rockfill embankments, filters, and till core

3. Installation of piezometers into lakebed and till core

4. Placement of rockfill surcharge on the till core

5. Excavation of abutments, placement of soil-cement-bentonite

6. Removal of surcharge, geotechnical investigation

7. Construction of the cutoff wall

8. Foundation grouting, and cutoff/bedrock contact grouting

9. Installation of instrumentation within the cutoff wall and dike fills

10. Dewatering

11. Construction of drainage works at dike toe

12. Installation of instrumentation at the downstream toe

Further discussion of the precedent for select construction techniques is provided in Appendix IV

6.4.1 Turbidity Barrier

A sediment control barrier such as a floating or anchored turbidity curtain will be required to minimize the distribution of suspended solids into the lakes during fill placement. Details of the turbidity barrier are given in Specification 1000-10.

6.4.2 Rockfill

The dikes will be constructed by 'bulkheading' the two rockfill embankments, leaving sufficient space between them to subsequently place the till core. 'Bulkheading' consists of dumping rockfill at the advancing end of the active rockfill embankment and then pushing the rockfill over the edge into the water with a bulldozer. This process is shown schematically in Figure 6.1. The crest of each rockfill embankment will be 30 m wide, which is enough to safely accommodate two way haul truck traffic.

The volumetric estimates in this report are based on 1.6 Horizontal :1 Vertical sideslopes on the rockfill embankments. It is likely that during construction the sideslopes of the rockfill will vary. If the sideslopes are steeper than 1.6 Horizontal :1 Vertical, then the overall crest can be narrower, which will reduce the quantities of both the rockfill and the till. Conversely, if the sideslopes are flatter than 1.6 Horizontal :1 Vertical, then it will be necessary to widen the overall crest of the dike in order to maintain the 5 m minimum base width of the till core.

The rockfill will be obtained from open pit mining operations. The approximate construction sequence will be:

1. Trucks with run-of-mine rockfill will advance onto the rockfill embankment, turn near the leading edge and dump onto the platform:

2. The load of rockfill will be pushed by bulldozer into the water. Oversized material should be selectively pushed to the outside of the embankments.

3. IV and IF rockfill types will be placed first to water level. Rockfill placed above water level will be UM and Q.

Typical sections showing rockfill placement are included in Drawings 6000-19 to 29.

6.4.3 Filters

Filter material will require processing to achieve the design gradation. Filters will be produced from IV rockfill obtained from the open pit and placed in a stockpile near the processing plant.

1. The Coarse Filter gradation can be produced by dumping the run-of-mine rockfill through a grizzly with an opening of 150 mm. Alternatively, the contractor may choose to produce the Coarse Filter in the crushing plant to reduce material handling requirements. Processed material will be stockpiled prior to use at the dewatering dikes.

2. The Fine Filter produced will require crushing, screening and possibly washing to achieve the design gradation. Crushing and screening tests using the plant available on site during construction will be required to determine the settings required. Blending of materials produced in the crushing and screening plant may be required. The Fine Filter material will be placed in a stockpile prior to use at the dewatering dikes.

3. Processing to obtain filter materials will be finalized during construction.

4. Coarse Filter material will be loaded from stockpile and hauled to the dike;

5. The lakebed sediments and boulders will be removed from the footprint area of the coarse and fine filters prior to placement of filter materials.

6. The Coarse Filter material will be dumped onto the rockfill platform and placed by bucket to depths that can be reached by the long-reach excavation equipment

or by clamshell for areas beyond the reach of the excavation equipment. End dumping is avoided to limit segregation of the filter material.

7. Coarse Filter is placed first.

8. Fine Filter material will be loaded from stockpile and hauled to the dike;

9. The Fine Filter material will be dumped onto the rockfill platform, avoiding segregation in the pile and then placed by bucket to depths that can be reached by the long-reach excavation equipment or by clamshell for areas beyond the reach of the excavation equipment. End dumping is avoided to limit segregation of the filter material.

10. Quality control procedures must adopted to demonstrate that the thickness of each placed filter zone is between 1 and 1.5 metres perpendicular to the slope.

6.4.4 Till Core

Till for the core will be obtained from open pit pre-stripping operations:

1. Till from the open pit will have the over-size material removed by dumping through a grizzly or farming a stockpile using an excavator. Working with earth materials is common and the final method to remove oversize particles is therefore left up to the contractor;

2. Processed material will be placed in a stockpile;

3. The till will be loaded from stockpile and hauled to the dike;

4. The till will be dumped on the rockfill platform near the advancing crest of the core fill; and

5. The till will be pushed by bulldozer into the water, between the two rockfill shoulders. Boulders in the till will be pushed to the side by the bulldozer.

6. Moisture conditioning will not be required because the till will be placed through water.

6.4.5 Surcharge Loading

A surcharge of 3 to 5 m of rockfill will be placed on the crest to consolidate the till core.

1. Rate of application and total time of application of the surcharge will be governed by pore water pressure response within the till core and foundation soils. The surcharge will be placed in lifts to limit the generation pore water pressures within the till core and foundation soils.

2. The surcharge is removed prior to cutoff construction. A one metre lift of rock is left in place as a working platform.

The condition of the till core after consolidation and surcharge removal will be investigated by cone penetration test (CPT), as described in Section 6.3.

As an ***Adaptive Management Strategy***:

If the till core does not gain sufficient strength, defined by a friction angle of at least 32 degrees, determined by the geotechnical investigation (Section 6.3), then the soil may be compacted by dynamic means, such as heavy tamping e.g. Dumas et al. (1994), NAVFAC (1983). See Appendix IV for a discussion on construction methods.

6.4.6 Abutments

A one metre wide trench is drilled and blasted and excavated to a depth of at least 2 m below bedrock surface to 25 m inland from the water's edge. The trench is back-filled with soil-cement-bentonite. The abutment cutoff does not rely on freezing. However, a rockfill cover of 3 metres will be placed over the abutments to minimize thaw of abutment soils and frost action on the cutoff wall. Grouting in rock at the abutment will be necessarily limited by the presence of frozen ground.

6.4.7 Cutoff

The construction of the cutoff wall will follow removal of surcharge loads and installation of abutment cutoffs. The type of cutoff wall used will depend on water depth. For depths to bedrock of up to 8 m a soil-bentonite slurry trench cutoff will be used. For depths to bedrock between 8 and 14 m a soil-cement-bentonite slurry trench cutoff will be used. For depths greater than 14 m, a jet grout cutoff wall will be used. Interpreted bathymetry along the Dike alignments is shown in Drawings 6000-40 – 42.

A typical soil-bentonite wall construction operation is shown schematically in Figures 6.1 and 6.2. A rockfill working platform, nominally 1 m thick will be left in place along the cutoff wall alignment to facilitate construction equipment movement along the dike.

The basic steps of the construction operation are:

1. Excavate the trench through the till core and foundation soil and 0.5 m into the bedrock or to refusal of the equipment. The excavation will be carried out using a tracked excavator working from the rockfill working platform. The excavated trench material is placed away from the trench to prevent collapse of the sidewall of the trench due to weight of the spoiled material. The trench walls are held stable by the bentonite slurry in the trench.

2. Excavated material is mixed with bentonite slurry to obtain a suitable soil-bentonite mixture. The mixing is usually done with a dozer, in an area away from the excavation activities so that there is no contamination by waste materials.

3. The rockfill working platform is opened by an excavator and the soil-bentonite mixture is pushed into the trench by the dozer. Typically, the angle of repose of the fill in the trench is about 10 Horizontal: 1 Vertical. A 20-m separation is required between the toe of the backfill and the active excavation area, in order to prevent contamination by excavated material. Typically there will be about 100-m length of trench open.

4. As the soil-bentonite backfill is placed into the trench, it displaces the bentonite slurry.

5. For soil-cement-bentonite mixtures, cement is added to the mixture prior to backfilling into the trench.

Jet grouting of the deepest sections of the Goose Island dike will be done from the rockfill working platform over the till core. A single row of overlapping vertical soil-cement columns will be constructed on an estimated spacing of 0.75 m. The column spacing used will be based on the jet grout test program to be carried out at the start of the cutoff wall installation.

Jet grouting involves advancing the drill string to maximum depth and then injecting grout at high pressure into the soil through a rotating nozzle as the nozzle is lifted through the soil. The process breaks up the soil structure completely and mixes the soil and grout to produce a homogeneous material, which solidifies due to cement content. Water-cement-bentonite mixtures may also be used to reduce the permeability of the cutoff wall. Jet grouting may be keyed into bedrock by pre-drilling.

6.4.8 Grouting

The bedrock foundation will be curtain grouted following cutoff construction. Grouting involves drilling a hole in bedrock, pressure testing an interval, and then pumping grout into the formation as required. The total depth of borehole and amount of grout required depend on rock conditions encountered.

The contact between the bedrock and the cutoff wall will be grouted using tube-a-machete pipes installed across the contact between the bedrock and cutoff wall. The grout will fill fractures in the near surface bedrock, and voids that may exist between the cutoff wall and bedrock.

6.4.9 Dewatering

Following dike construction the water within the dike is removed. Dike performance is monitored during drawdown for deformation and pore water pressure response.

6.5 Instrumentation and Monitoring

Geotechnical instrumentation is installed to monitor the behaviour of the dikes and dike foundations during construction, dewatering, and operation.

Instrumentation will provide information on the performance of the fill embankment and foundation and allow comparison with predictions made during the design studies in the deformation, seepage and thermal analyses. Instrumentation will also provide early warning of the development of unexpected pore pressure response to pit blasting, increasing seepage and increasing deformation.

Several types of instruments have been selected to collect the required information, including vibrating wire piezometers, thermistors, and inclinometers.

Instrumentation is summarized in Table 6.3.

TABLE 6.3: Geotechnical Instrumentation Summary

Instrumentation	East Dike (839 m length)	Bayzone Dike (1200 m length)	Goose Island Dike (1720 m length)
Multi-level Piezometer	36	72	84
Thermistor Strings	7	16	9
Slope Inclinometers	3	6	7
Surface Prisms (25m spacing)	33	48	48
Surface Monuments (25m spacing)	33	48	48
Surface Control Monuments	2 (one at each abutment)	3 (one at each abutment and one on land southeast of dike)	2 (one at abutment and one on island south of dike)
Seismographs	2		

6.5.1 Piezometers

Multi-level vibrating wire piezometers will be installed as shown in the Drawings 6000-30 to 32. The piezometers will provide the following information:

During construction:

- Monitoring of dissipation of construction related pore pressures in the foundation soils following fill placement; and
- Monitoring of pore pressure dissipation in the till core following surcharge loading.

During dewatering:

- Measurements of water pressures in the dike foundations to assess performance of the grout curtain ; and
- Measurement of water pressures in the dike core to assess the performance of the cutoff wall and to determine hydraulic gradients across cutoff wall in the foundation materials.

During operations:

- Measure pore pressure response to blasting in the pit;
- Monitor changes in the pore water pressure and hydraulic gradients due to permafrost penetration into the dike fill and foundation and open pit deepening.

6.5.2 Thermistor Strings

Thermistors strings will be installed after cutoff wall construction to monitor the change of thermal conditions within the cutoff wall and dike fills to validate and calibrate the thermal analyses. Thermistors will be installed with the slope inclinometer casings where possible.

Thermistors will be installed as shown on Drawings 6000-30 to 32 and as summarized in Table 6.4.

TABLE 6.4: Summary of Thermistor Strings

Dike	Thermistor String ID	Station	Offset (m) to Cut off wall	Bead Locations	Bedrock Surface El. (masl)	Lake Bed Till Surface El. (masl)	Thermistor String Length (m) from Crest El. 136.1 masl
Goose Island	T1	30+260	0	• First bead at surface • 0.5m, 1.0m, 1.5m, 2.0m, 2.5m, 3.0m, 4.0m, and 5.0m depths for first 5m • 5m spacing afterwards • Last bead embedded 5m into bedrock	122	128	19
	T2	30+540			119	126	22.5
	T3	30+680			106	114	30
	T4	30+840			118	123	18
	T5	31+140			128	132	8
	T6	31+400			120	127	21
	T7	31+500			120	126	21
	T8	31+720		• First bead at surface • 5m spacing for 25m depth	134.1	136.1	25
	T9	25m downchainge of 31+720			134.1	136.1	25
Bay Zone	T10	0+180		• First bead at surface • 0.5m, 1.0m, 1.5m, 2.0m, 2.5m, 3.0m, 4.0m, and 5.0m depths for first 5m • 5m spacing afterwards	132	134	9.5
	T11	0+320			132	134	9.5
	T12	0+520			128	130	13
	T13	0+720			125	129	16
	T14	0+920			120	126	21

Dike	Thermistor String ID	Station	Offset (m) to Cut off wall	Bead Locations	Bedrock Surface El. (masl)	Lake Bed Till Surface El. (masl)	Thermistor String Length (m) from Crest El. 136.1 masl
	T15	1+080		• Last bead embedded 5m into bedrock	125	130	16
	T16	0+520	-22	• First bead at surface • 0.5m, 1.0m, 1.5m, 2.0m, 2.5m, 3.0m, 4.0m, and 5.0m depths	128	130	5
	T17		-15				5
	T18		15				5
	T19	0+920	-22		120	126	5
	T20		-15				5
	T21		15				5
	T22	0+000	0	• First bead at surface • 5m spacing for 25m depth	134.1	136.1	25
	T23	25m upchainage of 0+000			134.1	136.1	25
	T24	1+200			134.1	136.1	25
	T25	25m down chainage of 1+200			134.1	136.1	25
East	T26	60+240		• First bead at surface • 0.5m, 1.0m, 1.5m, 2.0m, 2.5m, 3.0m, 4.0m, and 5.0m depths for first 5m • 5m spacing afterwards • Last bead embedded 5m into bedrock	128.1	130.1	13
	T27	60+440			126.0	128.0	15
	T28	60+700			127.5	129.4	13.5
	T29	60+000		• First bead at surface • 5m spacing for 25m depth	134.1	136.1	25
	T30	25m upchainage of 60+000			134.1	136.1	25
	T31	60+839			134.1	136.1	25
	T32	25m down chainage of 60+839			134.1	136.1	25

6.5.3 Slope Inclinometers

Slope inclinometer casings will be installed within the cutoff walls and the dike fills, and at least 3 m into bedrock, to measure the magnitude and rate of horizontal deformations during dewatering and operations. The locations of the slope inclinometers are shown on Drawings 6000-30 to 32 and as summarized in Table 6.5.

TABLE 6.5: Summary of Slope Inclinometer Locations

Dike	Inclinometer String ID	5m upchainage from Station	Offset (m) to Cut off wall	Bedrock Surface El. (masl)	Lake Bed Till Surface El. (masl)	Inclinometer Casing Length (m) from Crest El. 136.1 masl
Goose Island	S1	30+260	0	122	128	19
	S2	30+540		119	126	22.5
	S3	30+680		106	114	30
	S4	30+840		118	123	18
	S5	31+140		128	132	8
	S6	31+400		120	127	21
	S7	31+500		120	126	21
Bay Zone	S8	0+180		132	134	9.5
	S9	0+320		132	134	9.5
	S10	0+520		128	130	13
	S11	0+720		125	129	16
	S12	0+920		120	126	21
	S13	1+080		125	130	16
East	S14	60+240		128.12	130.12	13
	S15	60+440		125.97	127.97	15
	S16	60+700		127.46	129.40	13.5

Surveys will be performed using a portable probe and readout unit immediately after installation, before dewatering and at intervals during and after dewatering, bottom to top. The top of the inclinometer shall also be surveyed to monitor horizontal deflection.

The results from the deep sections of the Bay Zone Dike will be used to calibrate the deformation model of the deep sections of the Goose Island Dike.

6.5.4 Surface Monuments and Survey Prisms

Survey monuments and survey prisms shall be installed at 25 m intervals along the cutoff wall centerline to measure the vertical and lateral movements associated with fill settlement and foundation soil consolidation during dewatering and operations. Accurate measurements will require the use of high resolution surveying equipment and a network of stable control monuments.

6.5.5 Seismograph

Blast monitoring will be carried out using portable blast monitoring seismographs that will measure both blast induced velocities and accelerations at the crest and/or the toe of the dike. Monitoring stations will consist of a 1m long concrete cylinder cast in the dike fill or foundation soil at locations as shown on Drawing 6000-30.

6.5.6 Automated Data Acquisition System

The proposed instrumentation system includes fifty-six multi-level vibrating wire piezometers and eighteen thermistors. An automatic data acquisition system will be used to collect data from these instruments.

The required system includes three data loggers and will require installation of three instrument shelters at each dike, each data logger being connected with buried cables to a maximum of 20 sensors. The data collected will be downloaded on regular basis to a laptop computer for review and action. Each data logger terminal requires electrical and heating supply to keep the monitoring system at a temperature greater than 0^{o}C.

6.5.7 Monitoring Frequency

Table 6.6 summarizes the routine monitoring program during construction, during dewatering and operations. The frequency of monitoring will depend, to some degree, on the data collected and on the state of operation. The Operating Manual will be required to address the procedures required to change the monitoring frequencies.

TABLE 6.6: Geotechnical Instrumentation Monitoring Frequency

Instrumentation[1]	Monitored By	Reported To	Construction Frequency	Dewatering Frequency	Operations Frequency
Piezometers	• Manually during construction by Contractor • Automatically by Contractor during dewatering; and • Automatically during operations	Construction Manager or Operations Manager and Engineer	Daily	Daily	Weekly
Slope Inclinometers	• Manually by Contractor during construction and during dewatering • Manually by Construction Manager during operations	Construction Manager or Operations Manager and Engineer	Daily	Daily	Weekly changing to Monthly
Thermistors	• Manually during construction by Contractor • Automatically by Contractor during dewatering; and • Automatically during operations	Construction Manager or Operations Manager and Engineer	Weekly	Weekly	Monthly
Surface Monuments and Surface Prisms	• Manually by Contractor during construction and during dewatering • Manually by Construction Manager during operations	Construction Manager or Operations Manager and Engineer	Daily	Daily	Weekly
Seismographs	• Manually by Contractor during construction and during dewatering • Manually by Construction Manager during operations	Construction Manager or Operations Manager and Engineer	During blasting	During blasting	During blasting

[1] All instrumentation shall be monitored at installation

6.6 Water Handling and Seepage Management Plan

Seepage is expected both through the core and foundations of the Dike. A seepage collection trench will be excavated into the till downstream of the Dewatering Dike rockfills. The exact course of drainage will be governed by topography, with seepage reporting to topographic lows. For sections of the dikes built on sloping ground drainage will be expected to travel laterally within the fills and report to the toe as dictated by topography. However, icing within the rockfills may redirect drainage and therefore continuous collection trenches will be excavated downstream of the dikes. Sump location for drainage trenching collection will be selected based on topography observed after dewatering of the pit areas.

7.0 OPPORTUNITIES

Several opportunities for cost savings and performance improvement may become available upon further site investigations and construction trials.

The Goose Island Dike will be the most challenging of the three dikes to be constructed because of the 20 m depth of water along a section of the dike. Significant cost savings related to construction of this dike may be possible by delaying construction of the Goose Dike to later in the mine life. The present mine plan requires that the Goose Island Dike be completed in the second year of operation, which means most of the construction will be carried out during the first year of mining, which provides little time to assess the performance data from the deeper section of the Bay Zone dike. Delaying the Goose Island Dike will also allow more information to be collected on the geologic conditions of the pits, and the interaction of the pits and the dikes. This combined performance and geologic information could be used:

- To adjust (decrease or increase) the required setback distance between the presently planned Goose Island Pit and the Goose Island Dike;
- To optimize the design and construction approach for the Goose Island Dike;
- To investigate the cost implications of revising the pit configuration to allow the dike to be constructed in shallower water; or,
- To investigate the feasibility of extending Goose Island about 100 m to the southeast with till from the Portage Pit so that a stand alone dike is not required in this area. A shallower cutoff through the foundation soil to bedrock could be constructed and tied into the cutoff wall for the sections of dike required.

Another opportunity is to investigate moving the Bay Zone Dike alignment to eliminate the deep water section. The southwest abutment could be moved to the north, which would require changing the plan for mining the south end of the Portage Pit. Alternatively, moving the abutment south would not affect the mine plan but would make a more difficult construction condition for the abutment. Either change would provide a short section in 6 metres of water rather than 12 meters.

CLOSURE

The reader is referred to the "Important Information and Limitations of This Report" which follows the text but forms an integral part of this document.

If you have any questions please do not hesitate to contact us.

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BEW/TLE/lw
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Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, and safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

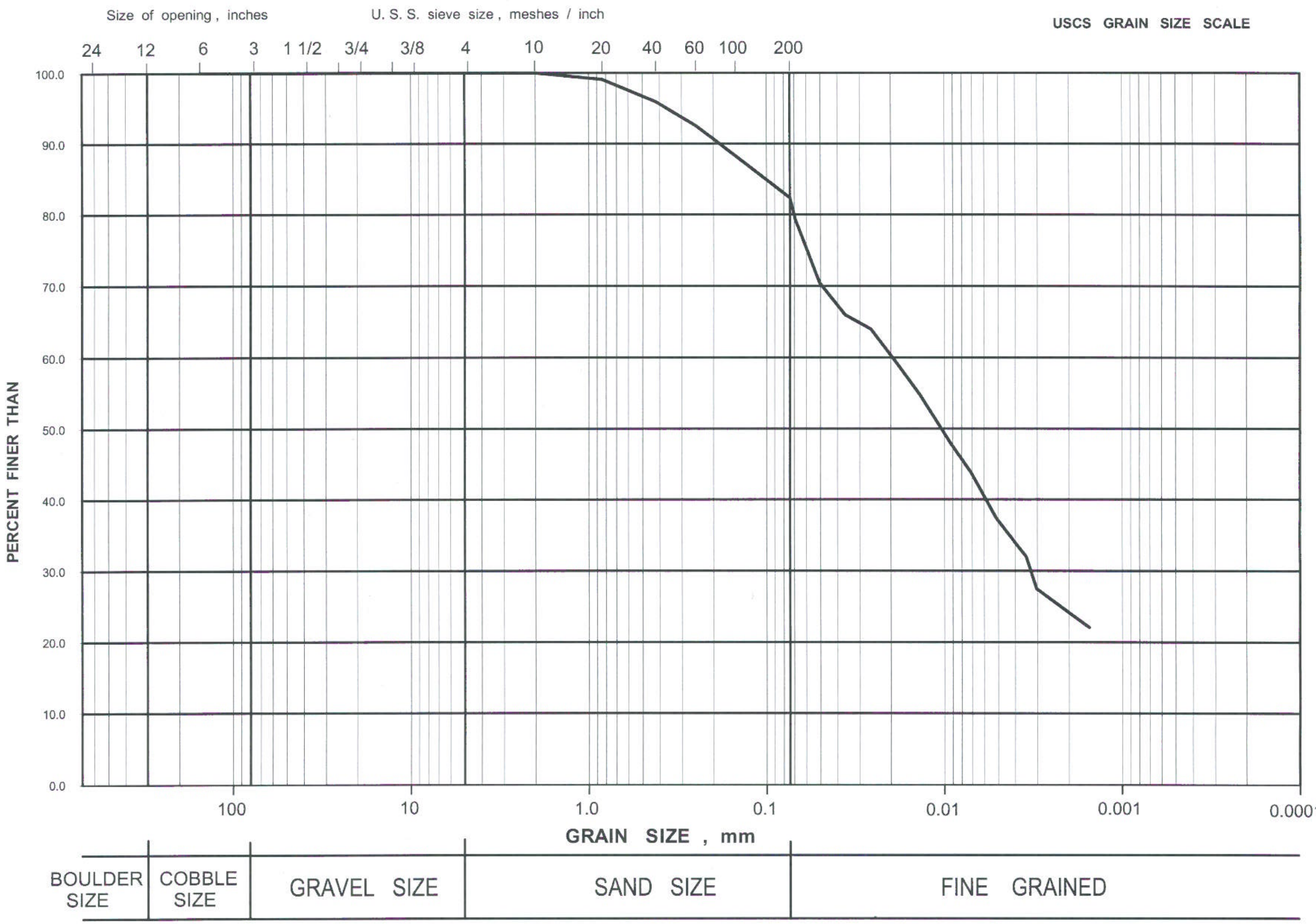
Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client’s expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder’s report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder’s report.

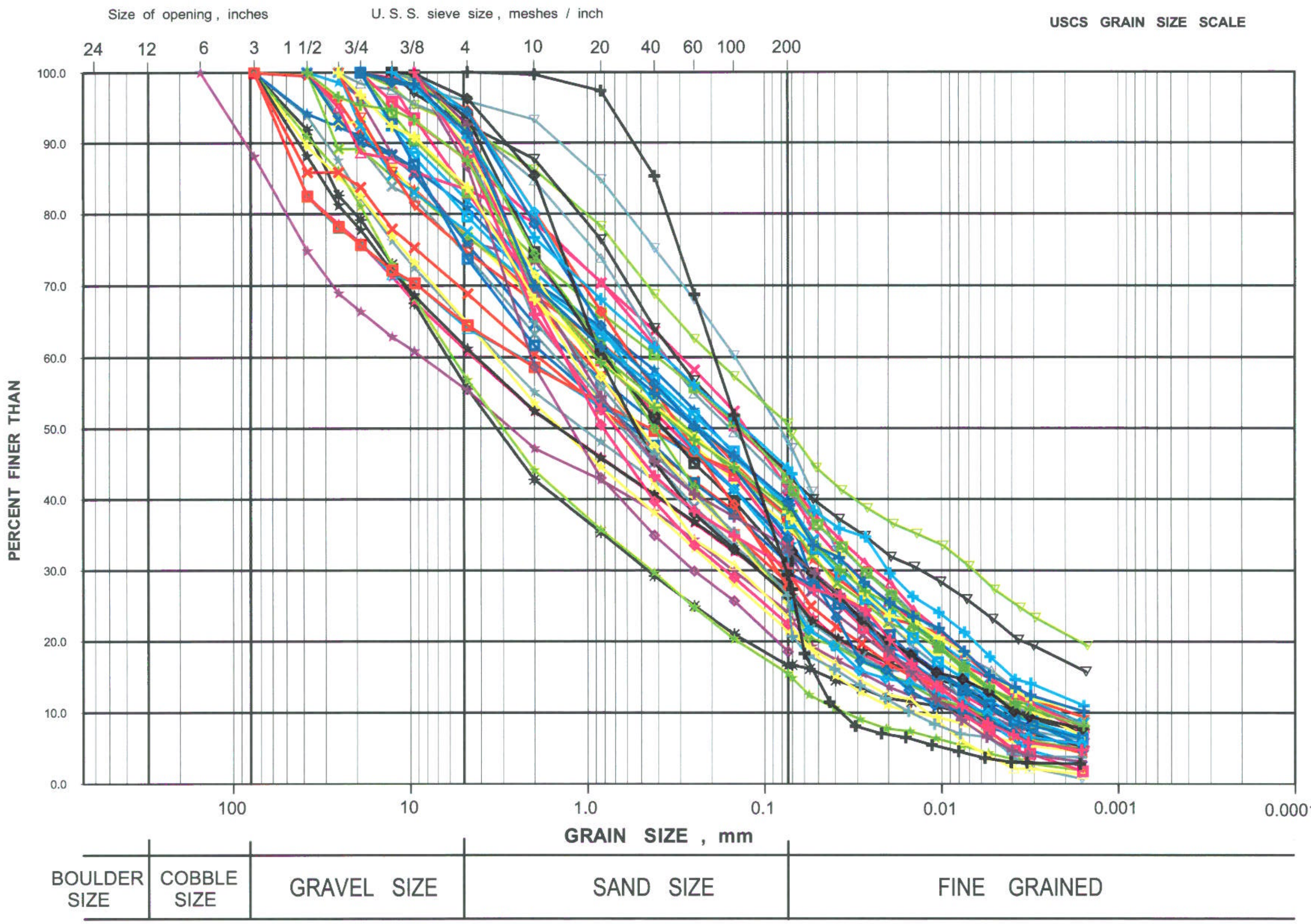
During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder’s report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder’s report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder’s responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.



Project No. 06-1413-081 Drawn TM Reviewed LL Date 03/13/07	Golder Associates	**GRAIN SIZE LAKEBED SEDIMENTS MEADOWBANK GOLD PROJECT, NUNAVUT**	**Figure 4.1**



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Reviewed	BW
Date	03/13/07

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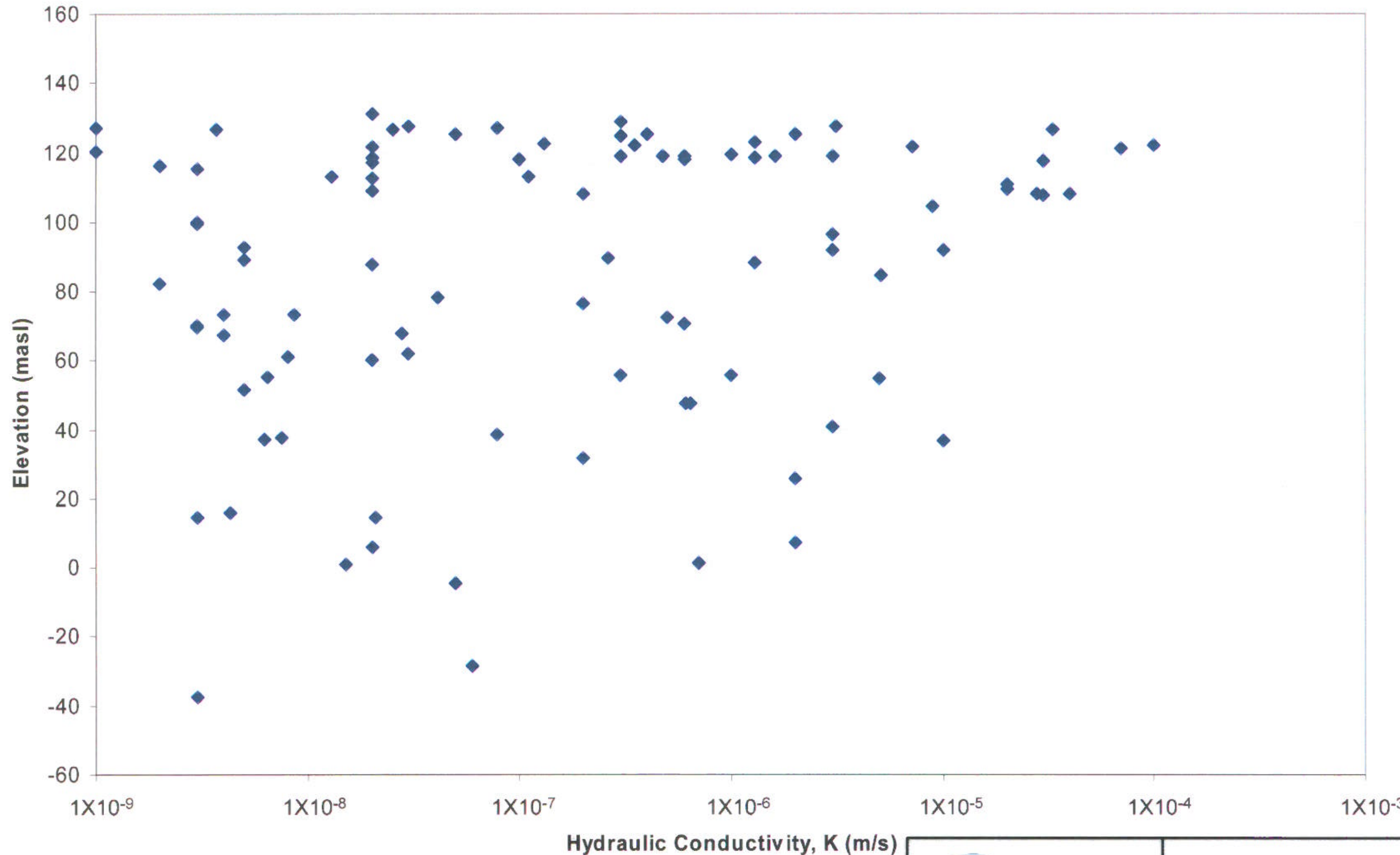
GRAIN SIZE TILL
MEADOWBANK GOLD PROJECT, NUNAVUT

Figure 4.2



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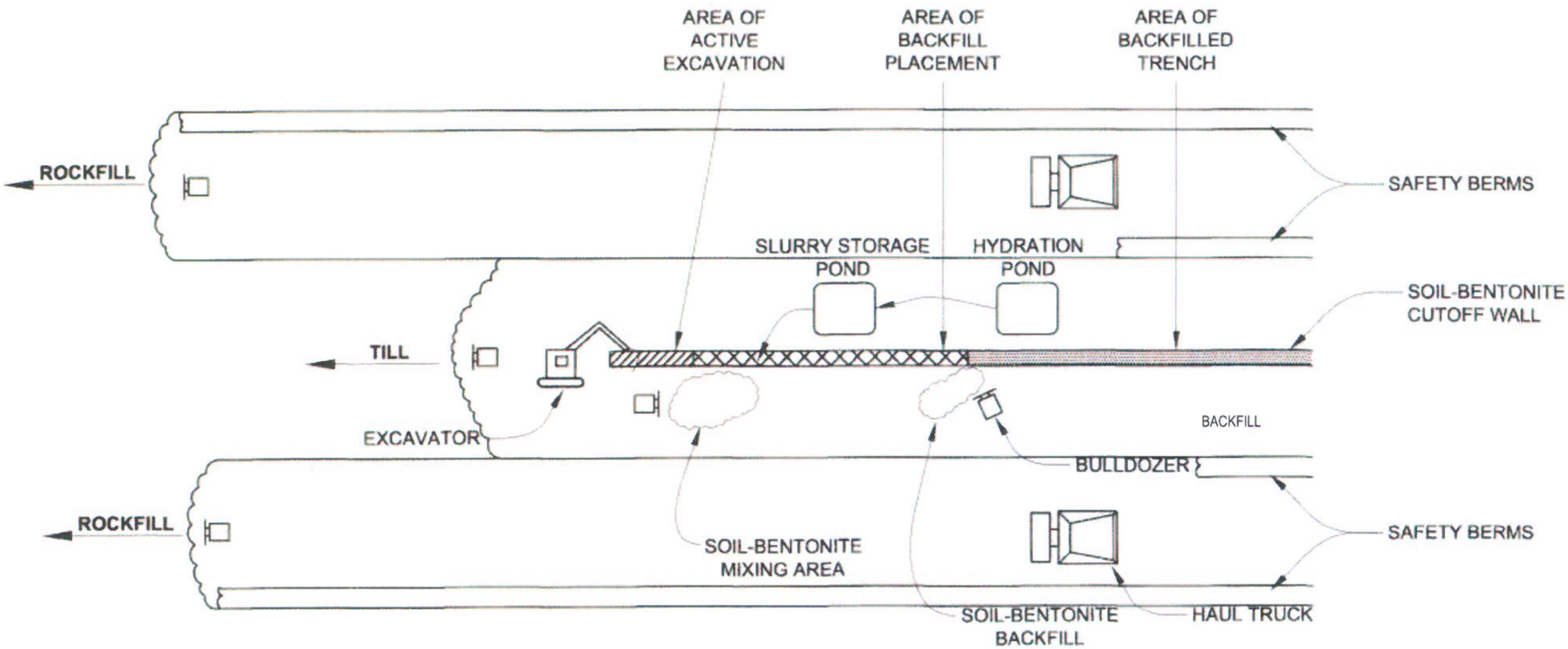
Bedrock Hydraulic Conductivity Versus Elevation Meadowbank Gold Project

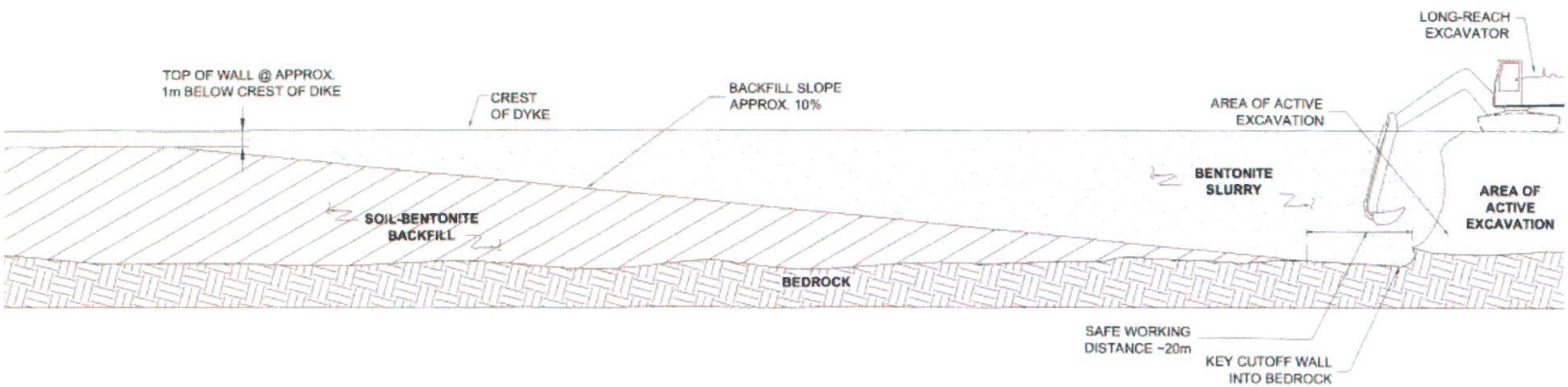
Drawn: TC	App'd:	Date: Feb. 21, 2007	Figure: 4.3

Project No.: 06-1413-089

Revision No.:



PROJECT	MEADOWBANK MINING CORPORATION				
TITLE	SOIL-BENTONITE CUTOFF WALL CONSTRUCTION OPERATION CONCEPTUAL LAYOUT				
Golder Associates	PROJECT No.	06-1413-081		FILE No. ----	
	DESIGN	BW	13MAR07	SCALE NTS	REV.
	CADD	AS	13MAR07	FIGURE 6.1	
	CHECK				
	REVIEW				



PROJECT	**MEADOWBANK MINING CORPORATION**				
TITLE	**SOIL-BENTONITE CUTOFF WALL CONSTRUCTION OPERATION CONCEPTUAL SECTION**				
Golder Associates	PROJECT No.	06-1413-081		FILE No. ----	
	DESIGN	BW	13MAR07	SCALE NTS	REV.
	CADD	AS	13MAR07	**FIGURE 6.2**	
	CHECK				
	REVIEW				

APPENDIX I

SITE DATA SUMMARY TABLES AND 2006- 2007 LABORATORY DATA

TABLE I-1: Summary of On-land Borehole Observations of Soil Overlying Bedrock

Borehole	Ground Surface El. (masl)	Bedrock Surface El. (masl)	Thickness (m)	Description of Soils
02GT-01	131.50	126.40	5.10	Cobbles and gravel
03GT-GI-7	139.35	134.97	4.38	Gravel and cobbles
03GT-PS-1	149.16	147.76	1.40	Boulders and cobbles with silty sand and trace gravel over cobbles with gravel and trace silt
03GT-PS-4	149.33	148.68	0.65	Cobbles and boulders with some gravel
03GT-PS-5	144.68	140.08	4.60	Cobbles and boulders with some angular gravel
03GT-PS-7	149.82	149.37	0.45	Cobbles and boulders with trace gravel and 0.05 m of organics
03GT-PS-9	147.47	146.72	0.75	Cobbles and boulders with trace gravel
03GT-PS-10	148.14	147.49	0.65	Cobbles and boulders with some gravel
03GT-PS-11	149.58	148.88	0.70	Cobbles and boulders with trace gravel
03GT-TD-1	136.41	134.34	2.07	Loose cobbles and round gravel with occasional boulders
03GT-Spec-F1	139.85	138.89	0.97	Cobbles and some angular gravel

TABLE I-2: Summary of Soil Depth and Description for Boreholes Drilled in Lakes

Borehole	Thickness of Soils Encountered (m)	Description
02GT-02A	2.7	Loose, homogenous, wet, dark grey, well graded, clean sand
02GT-02B	3.1	Loose, homogenous, wet, dark grey, well graded, clean sand
02GT-05	1.5	Lake bottom sediments and coarse sand, cobble and gravel
02GT-07	0.45	Loose, yellow silty clay
02GT-08	4.2	Dense yellow clay, silt, sand and gravel over loose gravel and cobbles over loose grey green, white rounded to sub-rounded cobbles, coarse gravel and sand
02GT-11	1.6	Lake bottom sediments and till
03GT-BZ-2	2.16	Loose cobbles and gravel with trace sand
03GT-BZ-3	1.20	Gravel and cobbles
03GT-BZ-5	2.74	Cobbles and boulders with some gravel, trace sandy silt
03GT-BZ-6	4.43	Boulders and cobbles with some gravel, trace sand and silt
03GT-GI-1	3.31	Boulder over cobbles and gravel with trace of clay and sand
03GT-GI-2	3.60	Cobbles and gravel over silty clay with some sand and trace gravel over sandy clay with gravel over sandy clay and gravel with cobbles
03GT-GI-3	1.25	Cobbles and gravel
03GT-GI-4	1.81	Cobble and gravel with trace sand and clay
03GT-GI-5	1.84	Gravel
03GT-GI-6	5.90	Loose cobbles and gravel with trace sand
03GT-GI-8	3.52	Cobbles and boulder with some gravel

Borehole	Thickness of Soils Encountered (m)	Description
03GT-GPIT-1	10.45	Cobbles and gravel
03GT-GPIT-3	14.30	Gravel and cobbles with trace and clay and sand
03GT-GPIT-4	14.94	Cobbles and gravel with trace coarse sand, silty fine grained sand over medium to fine grained sand
03GT-SE-1	4.58	Stiff layered moist light brown and grey greasy silty clay with little gravel over gravel and cobbles
03GT-SE-2	1.54	Cobbles and gravel
03GT-TD-2	5.33	Cobbles and gravel
03GT-TD-3	14.40	Green mud over cobbles and gravel with trace sand and clay
03GT-TD-4	5.84	Cobbles and gravel with trace of sand
03GT-TD-6	18.13	Cobbles and gravel
03GT-Spec-F2	1.61	Gravel
06GT-TD1	10.5	Cored boulders
06GT-TD2	14.4	Fine gravel over boulder and cobbles
06GT-TD3	16.21	Boulder and cobbles with trace of silt, coarse sand to fine gravel over clay silt and sand layer over cobbles

TABLE I-3: Borehole Observations of Bedrock Surface Elevation, Till Surface Elevation, and Boulder Presence

Borehole Number	Bedrock Elevation (masl)	Till Elevation (masl)	Thickness of soils (m)	Boulders Present (Y/N)	Location	Reference
G02-NP-1	136.22	N/A	N/A	N/A	North Portage	Golder (2002b)
GT02-NP-2	127.57	136.87	9.3	Y	North Portage	
GT02-NP-3	142.34	146.84	4.5	Y	North Portage	
G02-TP-01	134.09	N/A	N/A	N/A	3rd Portage	
GT02-TP-2	135.31	N/A	N/A	N/A	3rd Portage	
02GT-07	N/A	4.5 below reference elevation	0.45	N	N/A	
MRC02-01	N/A	at reference elevation	1.8	N	N/A	
MRC02-02	N/A	0.7m below reference elevation	1.52	N	N/A	
MRC02-03	N/A	2.64 m below reference elevation	0.36	N	N/A	
MRC02-04	N/A	at reference elevation	1.2	N	N/A	
MRC02-360	N/A	0.95m below reference elevation	1.05	N	N/A	
MRC02-284	N/A	at reference elevation	0.45	N	N/A	
MRC02-365	N/A	at reference elevation	1.6	N	N/A	
MRC02-362	N/A	at reference elevation	2.1	Y	N/A	
MRC02-04	N/A	1.2m below reference elevation	1.5	Y	N/A	

Borehole Number	Bedrock Elevation (masl)	Till Elevation (masl)	Thickness of soils (m)	Boulders Present (Y/N)	Location	Reference
MRC02-01	N/A	1.8m below reference elevation	1.5	Y	N/A	
MRC02-01	N/A	at reference elevation	1.5	Y	N/A	
MRC02-364	N/A	1.0m below reference elevation	0.1	Y	N/A	
MRC02-366	N/A	at reference elevation	1.4	Y	N/A	
MRC02-363	N/A	1.1m below reference elevation	0.5	Y	N/A	
MRC02-367	N/A	at reference elevation	1.1	Y	N/A	
MRC02-02	N/A	0.7 below reference elevation	1.5	Y	N/A	
MRC02-282	N/A	at reference elevation	0.7	Y	N/A	
MRC02-283	N/A	at reference elevation	0.6	Y	N/A	
MRC02-359	N/A	at reference elevation	1	Y	N/A	
MRC02-361	N/A	at reference elevation	0.8	N	N/A	
02GT-01	126.4	none		N	East Dyke	Golder (2002a)
02GT-02A	125.88	none		N	East Dyke	
02GT-02B	125.48	none		N	East Dyke	
02GT-03	132.74	135.07	2.33	Y	East Dyke	

Borehole Number	Bedrock Elevation (masl)	Till Elevation (masl)	Thickness of soils (m)	Boulders Present (Y/N)	Location	Reference
02GT-04	133.07	136.04	2.97	Y Below 2.75m	East Dyke	
02-GT-05	120.28	none		N	Causeway Alignment, North Hole	
02-GT-07	120.87	126.12	3	Y	West Dyke	
02GT-08	124.3	none		N	West Dyke	
02GT-09	135.58	136.77	1.19	Y	West Dyke	
02GT-10	135.16	136.16	1	Y	West Dyke	
02GT-11	112.88	114.48	1.6	N	Causeway	
03GT-BZ-2	126.34	none		N	Bay Zone	Golder (2003d)
03GT-BZ-3	131.35	none		N	Bay Zone	
03GT-BZ-5	125.59	none		Y	Bay Zone	
03GT-BZ-6	125.4	none		Y	Bay Zone	
03GT-GI-1	129.08	none		Y	Goose Island Dike	
03GT-GI-2	129.49	none		N	Goose Island Dike	
03GT-GI-3	122.2	none		N	Goose Island Dike	
03GT-GI-4	131.58	none		N	Goose Island Dike	
03GT-GI-5	129.74	none		N	Goose Island Dike	
03GT-GI-6	121	none		N	Goose Island Dike	
03GT-GI-7	130.59	none		N	Goose Island Dike	
03GT-GI-8	125.4	none		N	Goose Island Dike	

Borehole Number	Bedrock Elevation (masl)	Till Elevation (masl)	Thickness of soils (m)	Boulders Present (Y/N)	Location	Reference
03GT-GPIT-1	119.481	none		N	Goose Island Pit	
03GT-GPIT-2	132.22	none			Goose Island Pit	
03GT-GPIT-3	115.83	none		N	Goose Island Pit	
03GT-GPIT-4	113.47	none		N	Goose Island Pit	
03GT-PS-1	146.36	none		Y	Plant site	
03GT-PS-2	147.14	none		N	Plant site	
03GT-PS-3	148.05	none		N	Plant site	
03GT-PS-4	148.03	none		N	Plant site	
03GT-PS-5	135.48	none		N	Plant site	
03GT-PS-6	146.63	none		N	Plant site	
03GT-PS-7	148.92	none		Y	Plant site	
03GT-PS-8	143.72	none		N	Plant site	
03GT-PS-9	145.97	none		Y	Plant site	
03GT-PS-10	146.84	none		Y	Plant site	
03GT-PS-11	148.18	none		Y	Plant site	
03GT-SE-1	124.67	none		N	2nd Portage Lake	
03GT-SE-2	131.16	none		N	3rd Portage Lake	
03GT-TD-1	132.27	none		Y	Tailings Dike 2nd Portage abutment	
03GT-TD-2	110.89	none		N	Tailings Dike 2nd Portage	

Borehole Number	Bedrock Elevation (masl)	Till Elevation (masl)	Thickness of soils (m)	Boulders Present (Y/N)	Location	Reference
03GT-TD-3	Below 94.60	none		N	Tailings Dike 2nd Portage	
03GT-TD-4	112.32	none		N	Tailings Dike 2nd Portage	
03GT-TD-6	91.34	none		N	Tailings Dike 2nd Portage	
03GT-Spec-F1	137.93	none		N	Between 2nd and 3rd Port Lakes	
03GT-Spec-F2	125.93	none		N	Between 2nd and 3rd Port Lakes	
06GT-TD1	96.64	N/A		Y	2nd Portage Lake	Golder (2006d)
06GT-TD2	91.21	N/A		Y	2nd Portage Lake	
06GT-TD2A	93.56	N/A		Y	2nd Portage Lake	
06GT-TD3	112.98	N/A		N	2nd Portage Lake	

TABLE I-4: Summary of Till Gradations

Borehole	Depth (m)	% Gravel (>#4)	% Sand (>#200 & <#4)	% Silt (>0.002 mm & <#200)	% Clay (<0.002 mm)	Moisture Content (%)	Reference
Third Portage Trench spoil (59644)	N/A	26	43	24	7	4.4	Golder (2002b)
Third Portage Trench spoil (59645)	N/A	20	41	32	7	4	
Third Portage Trench spoil (59646)	N/A	17	40	37	6	2.7	
MRC02-01-2001	0-1.8	11	60	24	6	3.1	
MRC02-03	2.64-3.0	9	68	22		1.5	
MRC02-04	0-1.2	11	62	23	4	1.4	
MRC02-360	0.95-2.0	7	61	27	5	2.6	
MRC02-284	0-0.45	11	64	21	4	3	
MRC02-365	0-1.6	5	63	24	8	3.6	
MRC02-362	0-2.0	4	70	18	8	4.8	
MRC02-04	1.2-2.7	11	62	23	4	0.8	
MRC02-01-2002	1.8-3.3	12	58	25	5	2.9	
MRC02-01-2003	3.3-4.9	7	59	30	3	0.5	
MRC02-364	1-1.1	6	60	30	5	1.3	
MRC02-366	0-1.4	6	63	24	8	3.7	
MRC02-363	N/A	7	69	18	7	2.8	
MRC02-367	0-1.0	8	65	21	5	3.6	

Borehole	Depth (m)	% Gravel (>#4)	% Sand (>#200 & <#4)	% Silt (>0.002 mm & <#200)	% Clay (<0.002 mm)	Moisture Content (%)	Reference
02GT-02	128.58	3	93	4		16.3	
02GT-07-3	128.12	16	46	27	11	10.5	
02GT-07-4	127.67	12	49	30	9	11.4	
02GT-07-5	127.22	9	46	33	12	13.1	
02GT-07-6	126.79	9	52	29	10	11.1	
02GT-07-7	125.89	0	71	26	3	19.6	
GT02-TP-1	40.291	4	56	34	6	N/A	
Till Spoil 1	N/A	45	37	13	6	4.4	Golder Laboratory Testing 2006
Till Spoil 2	N/A	35	38	20	7	5.7	
Till Spoil 3	N/A	44	31	18	7	5.9	
Till. Grassland 4	N/A	39	33	22	6	14.8	
Till Spoil 5	N/A	23	41	26	10	5.3	
Till Spoil 6 & 7	N/A	34	44	16	6	5	
Till Spoil 8	N/A	43	40	15	2	4.2	
Till Spoil 9-10	N/A	18	46	34	2	7	
Till Spoil 11	N/A	19	42	33	6	10.9	
Till Spoil 12	N/A	39	33	20	8	8.2	
06-1413-034/3000-SA 9	N/A	25	48	18	10	N/A	Sampled Aug-29-06 by Golder, previously unreported
06-1413-034/3000-SA 2	N/A	25	42	27	6	17.2	

Borehole	Depth (m)	% Gravel (>#4)	% Sand (>#200 & <#4)	% Silt (>0.002 mm & <#200)	% Clay (<0.002 mm)	Moisture Content (%)	Reference
051413036-SA1	N/A	18	48	28	6	24.1	Reported in 05-1413-036/4000 – Aug 29 2005 Letter to CRL
051413036-SA2	N/A	13	48	30	9	11.2	
051413036-SA3	N/A	14	48	28	9	23.6	
051413036-SA4	N/A	15	49	28	8	23	
051413036-SA5	N/A	26	45	24	5	11.8	
051413036-SA6	N/A	4	54	33	8	20.5	
CJC04-034-002		36	27	38		N/A	Sept 13 2004 Site Visit Report
CJC04-034-003		15	52	31	2	N/A	
MRC02-151-2472	N/A	6	70	22	2	N/A	

TABLE I-5: Summary of Bedrock Hydraulic Conductivity Test Data

Borehole	Reference Elevation (masl)	Down Hole Depth from ground surface or ice surface		Inclination (degrees)	Azimuth (degrees)	End of Borehole (down the hole depth m)	Vertical Depth		Elevation		Rock Unit	Hydraulic Conductivity (m/s)
		from (m)	to (m)				from (m)	to (m)	from (masl)	to (masl)		
06GT-TD1**	135.1	44.5	67.0	-89.4	-	204.0	44.5	67.0	91	68	Quartzite	$>3x10^{-05}$
	135.1	60.5	83.5	-89.4	-	204.0	60.5	83.5	75	52	Intermediate Volcanic And Quartzite	$>3x10^{-05}$
	135.1	80.5	113.0	-89.4	-	204.0	80.5	113.0	55	22	Quartzite	$5x10^{-06}$
	135.1	98.5	113.0	-89.4	-	204.0	98.5	113.0	37	22	Quartzite	$1x10^{-05}$
	135.1	109.5	144.0	-89.4	-		109.5	144.0	26	-9	Quartzite and Intermediate Volcanic	$2x10^{-06}$
	135.1	139.5	174.0	-89.4	-		139.5	174.0	-4	-39	Quartzite and Wack, Ultra Mafics	$5x10^{-08}$
	135.1	172.5	204.0	-89.4	-		172.5	204.0	-37	-69	Intermediate Volcanic	$3x10^{-09}$
06GT-TD2A	135.1	43.5	60.0	-89.3	-	201.0	43.5	60.0	92	75	Intermediate Volcanic	$3x10^{-06}$
	135.1	58.5	81.0	-89.3	-		58.5	81.0	77	54	Intermediate Volcanic/ Quartzite	$2x10^{-07}$
	135.1	79.5	105.0	-89.3	-		79.5	105.0	56	30	Quartzite, Intermediate Volcanic, Ultra Mafics	$3x10^{-07}$
	135.1	103.5	135.0	-89.3	-		103.5	135.0	32	0	Quartzite	$2x10^{-07}$
	135.1	133.5	164.0	-89.3	-		133.5	164.0	2	-29	Quartzite, 0.3m Sand Seam	$7x10^{-07}$
	135.1	163.5	201.0	-89.3	-		163.5	201.0	-28	-66	Intermediate Volcanic	$6x10^{-08}$
06GT-TD3	135.1	25.5	45.0	-89.6	-	126.0	25.5	45.0	110	90	Intermediate Volcanic	$2x10^{-05}$
	135.1	43.5	66.0	-89.6	-		43.5	66.0	92	69	Intermediate Volcanic	$1x10^{-05}$
	135.1	64.5	81.0	-89.6	-		64.5	81.0	71	54	Intermediate Volcanic, Iron Formation	$6x10^{-07}$
	135.1	79.5	96.0	-89.6	-		79.5	96.0	56	39	Intermediate Volcanic	$1x10^{-06}$
	135.1	94.5	117.0	-89.6	-		94.5	117.0	41	18	Quartzite, Intermediate Volcanic	$3x10^{-06}$
03GT-BZ-2	134	10.9	15.4	-90.0	-	15.4	10.9	15.4	123	119	Intermediate Volcanics	$1.3x10^{-06}$
03GT-BZ-3	134	6.4	9.4	-90.0	-	9.4	6.4	9.4	128	125	Intermediate Volcanics	$3.1x10^{-06}$
03GT-BZ-5	134	8.6	16.1	-90.0	-	16.1	8.6	16.1	125	118	Ultra Mafics	$5x10^{-08}$
03GT-BZ-6	134	11.6	16.1	-90.0	-	16.1	11.6	16.1	122	118	Ultra Mafics	$1.3x10^{-07}$
03GT-GI-1	134	7.6	12.1	-90.0	-	12.1	7.6	12.1	126	122	Intermediate Volcanics	$2.5x10^{-08}$
03GT-GI-2	134	7.5	12.0	-90.0	-	12.0	7.5	12.0	126	122	Intermediate Volcanics	$3.7x10^{-09}$
03GT-GI-3	134	15.4	18.4	-90.0	-	18.4	15.4	18.4	119	116	Intermediate Volcanics	$1.3x10^{-06}$
03GT-GI-5	134	7.6	12.1	-90.0	-	12.1	7.6	12.1	126	122	Ultra Mafics	$3.3x10^{-05}$

Borehole	Reference Elevation (masl)	Down Hole Depth from ground surface or ice surface		Inclination (degrees)	Azimuth (degrees)	End of Borehole (down the hole depth m)	Vertical Depth		Elevation		Rock Unit	Hydraulic Conductivity (m/s)
		from (m)	to (m)				from (m)	to (m)	from (masl)	to (masl)		
03GT-GI-6	134	15.0	18.8	-90.0	-	18.8	15.0	18.8	119	115	Quartzite	$4.7x10^{-07}$
03GT-GPIT-1	132.92	106.8	150.3	-62.0	51.0	150.3	94.3	132.7	39	0	Ultra Mafics	$7.8x10^{-08}$
	132.92	61.8	150.3	-62.0	51.0		54.5	132.7	78	0	Ultra Mafics	$4.1x10^{-08}$
	132.92	22.8	150.3	-62.0	51.0		20.1	132.7	113	0	Ultra Mafics	$1.1x10^{-07}$
03GT-GPIT-3	133.01	22.7	33.2	-61.0	133.0	150.2	19.9	29.1	113	104	Ultra Mafics	$1.3x10^{-08}$
	133.01	97.7	150.2	-61.0	133.0		85.5	131.4	48	2	Iron Formation-Intermediate Volcanics	$6.4x10^{-07}$
	133.01	97.7	150.2	-61.0	133.0		85.5	131.4	48	2	Iron Formation-Intermediate Volcanics	$6.1x10^{-07}$
	133.01	49.7	150.2	-61.0	133.0		43.5	131.4	90	2	Iron Formation-Mafics-Volcanics	$2.6x10^{-07}$
	133.01	28.7	150.2	-61.0	133.0		25.1	131.4	108	2	Iron Formation-Mafics-Volcanics	$2x10^{-07}$
03GT-GPIT-4	129.77	108.7	149.2	-58.0	291.0	149.1	92.2	126.6	38	3	Iron Formation-Mafics	$7.6x10^{-09}$
	129.77	87.7	149.2	-58.0	291.0		74.4	126.6	55	3	Iron Formation-Mafics	$6.5x10^{-09}$
	129.77	66.7	149.2	-58.0	291.0		56.6	126.6	73	3	Iron Formation-Mafics	$8.6x10^{-09}$
	129.77	24.7	149.2	-58.0	291.0		21.0	126.6	109	3	Iron Formation-Mafics	$2x10^{-08}$
03GT-TD-2	133	24.9	29.4	-90.0	-	29.4	24.9	29.4	108	104	Ultra Mafics	$2.8x10^{-05}$
03GT-TD-4	133	24.8	29.3	-90.0	-	29.3	24.8	29.3	108	104	Intermediate Volcanics	$4x10^{-05}$
03GT-TD-6	132.58	47.8	52.3	-90.0	-	52.3	47.8	52.3	85	80	Intermediate Volcanics	$5.1x10^{-06}$
03GT-SE-1	133	11.3	15.8	-90.0	-	15.8	11.3	15.8	122	117	Quartzite	$7.2x10^{-06}$
03GT-SE-2	133	5.8	10.3	-90.0	-	10.3	5.8	10.3	127	123	Intermediate Volcanics	$7.9x10^{-08}$
03GT-SPEC-F2	132.20	15.9	35.4	-58.0	232.0	174.4	13.5	30.0	119	102	Mainly Ultra Mafics	$1.6x10^{-06}$
	132.20	51.9	74.4	-58.0	232.0		44.0	63.1	88	69	Mainly Ultra Mafics	$1.3x10^{-06}$
	132.20	75.9	104.4	-58.0	232.0		64.3	88.5	68	44	Mainly Ultra Mafics	$2.8x10^{-08}$
	132.20	111.9	135.9	-58.0	232.0		94.9	115.2	37	17	Mainly Ultra Mafics	$6.3x10^{-09}$
	132.20	138.9	147.9	-58.0	232.0		117.8	125.4	14	7	Mainly Ultra Mafics	$2.1x10^{-08}$
	132.20	154.9	174.4	-58.0	232.0		131.3	147.9	1	-16	Ultra Mafics-Iron Formation	$1.5x10^{-08}$
	132.20	136.9	174.4	-58.0	232.0		116.1	147.9	16	-16	Ultra Mafics-Iron Formation	$4.3x10^{-09}$
02GT-01	132.5	7.5	9.5	-90.0	-	9.5	7.5	9.5	125	123	Intermediate Volcanic	$2x10^{-06}$
	132.5	7.5	9.5	-90.0	-		7.5	9.5	125	123	Intermediate Volcanic	$4x10^{-07}$
02GT-02	132.48	10.5	12.5	-90.0	-	12.5	10.5	12.5	122	120	Intermediate Volcanic	$3.5x10^{-07}$

Borehole	Reference Elevation (masl)	Down Hole Depth from ground surface or ice surface		Inclination (degrees)	Azimuth (degrees)	End of Borehole (down the hole depth m)	Vertical Depth		Elevation		Rock Unit	Hydraulic Conductivity (m/s)
		from (m)	to (m)				from (m)	to (m)	from (masl)	to (masl)		
02GT-04	136.04	6.5	8.5	-50.3	22.0	30.1	5.1	6.6	131	129	Intermediate Volcanic	2x10^{-08}
	136.04	9.5	17.5	-50.3	22.0		7.4	13.6	129	122	Intermediate Volcanic	3x10^{-07}
	136.04	18.5	29.5	-50.3	22.0		14.4	22.9	122	113	Intermediate Volcanic	2x10^{-08}
02GT-05	132.5	15.0	17.0	-90.0	-	17.0	15.0	17.0	118	116	Intermediate Volcanic	3x10^{-05}
02GT-07	132.621	13.5	15.5	-90.0	-	15.5	13.5	15.5	119	117	Quartzite	1x10^{-06}
02GT-08	132.6	10.5	12.5	-90.0	-	17.0	10.5	12.5	122	120	Intermediate To Felsic Volcaniclasitics	1x10^{-04}
	132.6	11.5	17.0	-90.0	-		11.5	17.0	121	116	Intermediate To Felsic Volcaniclasitics	7x10^{-05}
	132.6	13.5	17.0	-90.0	-		13.5	17.0	119	116	Granite	3x10^{-06}
02GT-09	136.77	24.5	30.5	-48.4	79.0	30.8	18.3	22.8	118	114	Ultra Mafics Volcanic	2x10^{-08}
02GT-10	136.29	15.5	28.0	-48.7	238.0	30.0	11.6	21.0	125	115	Intermediate Volcanic	3x10^{-07}
	136.29	21.5	30.0	-48.7	238.0		16.1	22.5	120	114	Intermediate Volcanic	1x10^{-09}
02GT-11	132.78	25.0	27.0	-90.0	-	27.0	25.0	27.0	108	106	Ultra Mafics Volcanic	3x10^{-05}
	132.78	22.0	27.0	-90.0	-		22.0	27.0	111	106	Ultra Mafics Volcanic	2x10^{-05}
NP02-401	132.91	135.0	158.0	-66.4	113.9	158.0	125.5	144.7	7	-12	Intermediate Volcanic	2x10^{-06}
	132.91	129.0	158.0	-66.4	113.9		118.2	144.7	15	-12	Intermediate Volcanic	3x10^{-09}
	132.91	66.0	158.0	-66.4	113.9		60.5	144.7	72	-12	Intermediate Volcanic	5x10^{-07}
NP02-412	133.24	31.0	39.0	-68.3	109.1	69.0	28.8	36.2	104	97	Ultra Mafics	9x10^{-06}
	133.24	40.0	69.0	-68.3	109.1		37.1	64.1	96	69	Intermediate Volcanic	3x10^{-06}
GT02-NP-1	136.87	25.5	111.0	-59.9	251.0	111.0	21.6	96.0	115	41	Iron Formation/Ultra Mafics/ Intermediate Volcanic	3x10^{-09}
	136.87	55.5	111.0	-59.9	251.0		48.0	96.0	89	41		5x10^{-09}
	136.87	73.5	111.0	-59.9	251.0		63.6	96.0	73	41	Intermediate Volcanic	4x10^{-09}
	136.87	88.5	111.0	-59.9	251.0		76.6	96.0	60	41	Chloritic Intermediate Volcanic	2x10^{-08}

Borehole	Reference Elevation (masl)	Down Hole Depth from ground surface or ice surface		Inclination (degrees)	Azimuth (degrees)	End of Borehole (down the hole depth m)	Vertical Depth		Elevation		Rock Unit	Hydraulic Conductivity (m/s)
		from (m)	to (m)				from (m)	to (m)	from (masl)	to (masl)		
GT02-NP-2	136.87	12.0	16.5	-50.2	292.0	109.5	9.2	12.7	128	124	Mafic	$3x10^{-08}$
	136.87	25.5	30.0	-50.2	292.0		19.6	23.0	117	114	Quartzite/Mafic Volcanic	$2x10^{-08}$
	136.87	31.5	42.0	-50.2	292.0		24.2	32.3	113	105	Ultra Mafics	$2x10^{-08}$
	136.87	64.5	81.0	-50.2	292.0		49.1	62.2	88	75	Ultra Mafics/Fault	$2x10^{-08}$
	136.87	87.0	109.5	-50.2	292.0		66.8	84.1	70	53	Iron Formation/Intermediate Volcanic/ Ultra Mafics	$3x10^{-09}$
	136.87	99.0	109.5	-50.2	292.0		76.0	84.1	61	53	Ultra Mafics	$8x10^{-09}$
TP98-258	133.5	18.5	173.0	-58.0	112.0	173.0	15.7	146.7	118	-13	Intermediate Volcanic-Highly Fractured	$1x10^{-07}$
	133.5	18.5	38.0	-58.0	112.0		15.7	32.2	118	101	Intermediate Volcanic	$6x10^{-07}$
	133.5	39.5	173.0	-58.0	112.0		33.5	146.7	100	-13	Iron Formation	$3x10^{-09}$
	133.5	75.5	173.0	-58.0	112.0		64.0	146.7	70	-13	Ultra Mafics-Bz Fault 82.33 To 88.10	$3x10^{-09}$
	133.5	96.5	173.0	-58.0	112.0		81.8	146.7	52	-13	Ultra Mafics	$5x10^{-09}$
	133.5	150.5	173.0	-58.0	112.0		127.6	146.7	6	-13	Intermediate Volcanic/Iron Formation	$2x10^{-08}$
TP98-261	134.79	9.5	152.0	-56.0	112.0	101.0	7.9	126.0	127	9	Quartzite-Highly Fractured	$1x10^{-09}$
	134.79	22.5	152.0	-56.0	112.0		18.7	126.0	116	9	Intermediate Volcanic/Ultra Mafics	$2x10^{-09}$
	134.79	42.5	152.0	-56.0	112.0		35.2	126.0	100	9	Intermediate Volcanic/Iron Formation	$3x10^{-09}$
	134.79	63.5	152.0	-56.0	112.0		52.6	126.0	82	9	Ultramafics-Bz Fault 73.5 To 76.8	$2x10^{-09}$
	134.79	81.5	152.0	-56.0	112.0		67.6	126.0	67	9	Intermediate Vol./Iron Formation/ Ultra Mafics	$4x10^{-09}$
TP98-265	133.41	18.5	50.0	-52.0	112.0	152.0	14.6	39.4	119	94	Int. Volcanic/Iron Formation-Highly Fractured	$3x10^{-07}$
	133.41	18.5	101.0	-52.0	112.0		14.6	79.6	119	54	Int. Volcanic/Iron Formation-Highly Fractured	$6x10^{-07}$
	133.41	51.5	101.0	-52.0	112.0		40.6	79.6	93	54	Intermediate. Volcanic/Iron Formation	$5x10^{-09}$
	133.41	90.5	101.0	-52.0	112.0		71.3	79.6	62	54	Intermediate. Volcanic/ Ultra Mafics-Bz Fault 92.87 to 93.22	$3x10^{-08}$

** Drilling targeted fault zone

TILL SPECIFIC GRAVITY

SPECIFIC GRAVITY OF SOLIDS

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**Borehole :**	Lake Bed Till
Sch No.	277	**Project :**	Dike Design	**Sample Number :**	1
Lab Work:	SK	**Location:**	Meadowbank Gold Project	**Depth :**	
Test ID:	Test 1			**Date :**	Nov 22 2006

Specific Gravity of Fine Fraction (ASTM D 854-02)

Percentage Passing #4 Sieve		55.5	
Test Number		1	2
Flask Number		1	2
Air Removal Method		Vacuum	Vacuum
Mass of Flask (g)	M_p	179.44	172.65
Mass of Flask + Dry Soil (g)		279.90	273.09
Mass of Dry Soil (g)		100.46	100.44
Mass of Flask + Soil + Water (g)	$M_{\rho ws,t}$	739.30	732.84
Test Temperature (g)	T_t	28.6	29.5
Mass of Flask + Water (g)	$M_{\rho w,t}$	677.05	670.01
Number of Evaporating Dish		1	2
Mass of Dish + Dry Soil (g)		117.45	117.53
Mass of Dish (g)		16.99	17.09
Mass of Oven Dry Soil (g)	M_s	100.46	100.44
Temperature Coefficient	K	0.9979	0.9976
Density of Solids (g/cm^3)	ρ_s	2.63	2.67
Specific Gravity at Test Temperature	G_t	2.64	2.68
Specific Gravity at 20°C	$G_{20°C}$	**2.6**	**2.7**
AVERAGE SPECIFIC GRAVITY		**2.7**	

Specific Gravity of Coarse Fraction (ASTM C 127-88)

Percentage Retained on #4 Sieve		44.5
Mass of Sample in Water (g)	**A**	430.6
Mass of Sample @ SSD (g)	**B**	690.7
Mass of Oven Dryed Sample (g)	**C**	686.5
Bulk G (Oven Dry)	**C/(B-A)**	2.64
Bulk G (SSD)	**B/(B-A)**	2.66
Apparent	**C/(C-A)**	**2.68**
Absorbtion (%)	**(B-C)/C**	0.01

Specific Gravity of Total Sample

COMBINED SPECIFIC GRAVITY	$G_{avg@20°C}$	**2.67**

Remarks:

Method used: Method A Procedure for Moist Specimens

Sample Description:

SPECIFIC GRAVITY OF SOLIDS

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**Borehole :**	Lake Bed Till
Sch No.	277	**Project :**	Dike Design	**Sample Number :**	2
Lab Work:	SK	**Location:**	Meadowbank Gold Project	**Depth :**	
Test ID:	Test 1			**Date :**	

Specific Gravity of Fine Fraction (ASTM D 854-02)

Percentage Passing #4 Sieve		64.7	
Test Number		1	2
Flask Number		1	2
Air Removal Method		Vacuum	Vacuum
Mass of Flask (g)	M_p	179.44	172.65
Mass of Flask + Dry Soil (g)		280.18	278.84
Mass of Dry Soil (g)		100.74	106.19
Mass of Flask + Soil + Water (g)	$M_{pws,t}$	740.60	737.22
Test Temperature (g)	T_t	23.3	23.6
Mass of Flask + Water (g)	$M_{pw,t}$	677.72	670.70
Number of Evaporating Dish		1	2
Mass of Dish + Dry Soil (g)		117.54	123.05
Mass of Dish (g)		16.80	16.86
Mass of Oven Dry Soil (g)	M_s	100.74	106.19
Temperature Coefficient	K	0.9993	0.9992
Density of Solids (g/cm^3)	ρ_s	2.66	2.68
Specific Gravity at Test Temperature	G_t	2.67	2.68
Specific Gravity at 20°C	$G_{20°C}$	**2.7**	**2.7**
AVERAGE SPECIFIC GRAVITY		**2.7**	

Specific Gravity of Coarse Fraction (ASTM C 127-88)

Percentage Retained on #4 Sieve		35.3
Mass of Sample in Water (g)	**A**	523.3
Mass of Sample @ SSD (g)	**B**	821.8
Mass of Oven Dryed Sample (g)	**C**	816.1
Bulk *G* (Oven Dry)	**C/(B-A)**	2.73
Bulk *G* (SSD)	**B/(B-A)**	2.75
Apparent	**C/(C-A)**	**2.79**
Absorbtion (%)	**(B-C)/C**	0.01

Specific Gravity of Total Sample

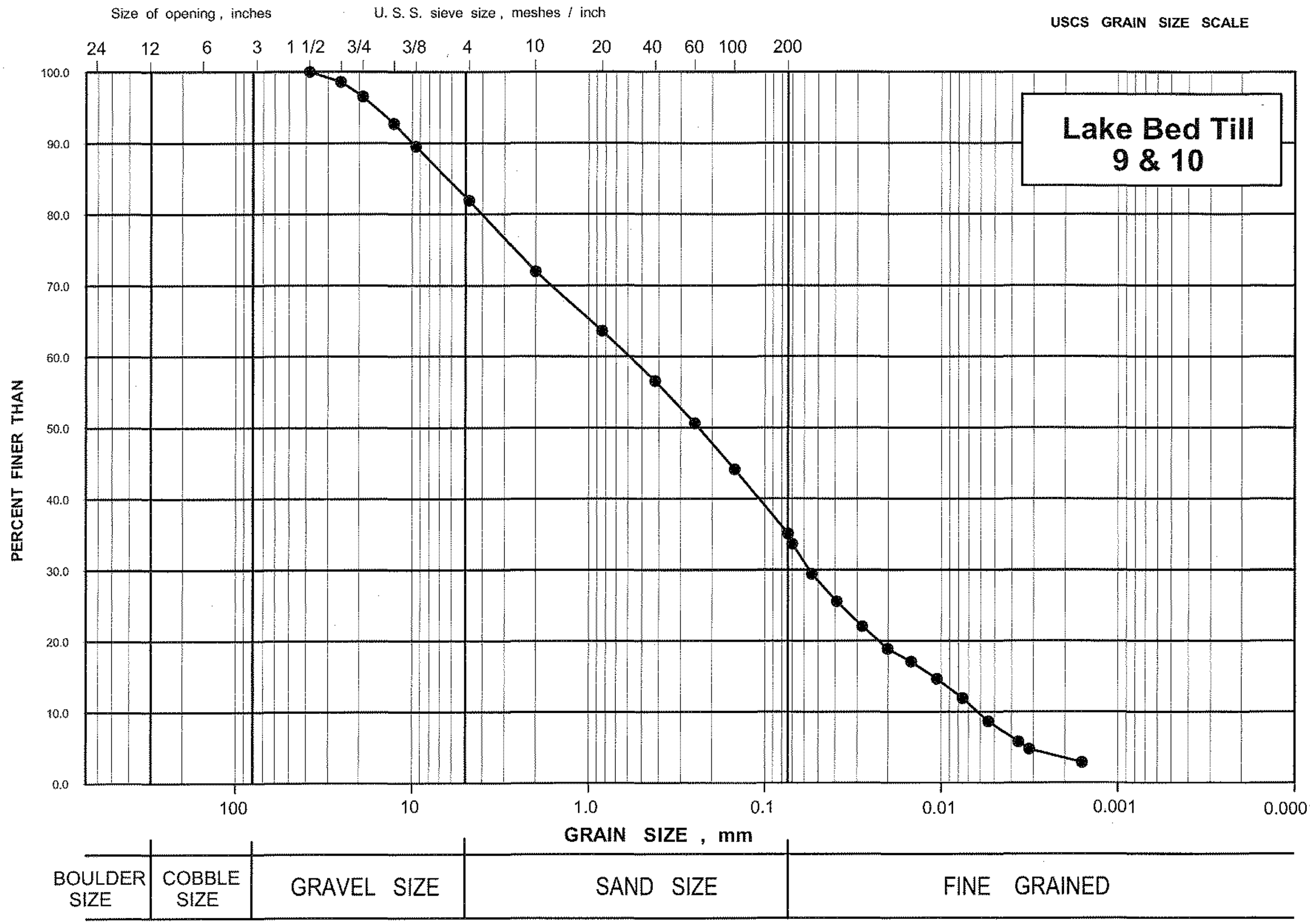
COMBINED SPECIFIC GRAVITY	$G_{avg@20°C}$	**2.71**

Remarks:

Method used: Method A Procedure for Moist Specimens

Sample Description:

TILL GRADATION AND HYDROMETER



Project No. 06-1413-081 Drawn TM Reviewed LL Date 03/09/07	Golder Associates	**GRAIN SIZE DISTRIBUTION** **Meadowbank Mining Corporation** **Meadowbank Gold Project**	**Figure I-1**

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**BH :**	Lake Bed Till
Sch#	277	**Project :**	Dike Design	**Sample :**	9 & 10
Lab Work:	TM	**Location:**	Meadowbank Gold Project		

First Sieving
Total Weight (g) = 13210.9

Hydrometer: (Minus #10)
Before Wash (g) = 50.0
After Wash (g) = 25.9

Residual No. 200 (g) = 0.3
Total minus 200 (g) = 24.4
Gs (assumed) = 2.70

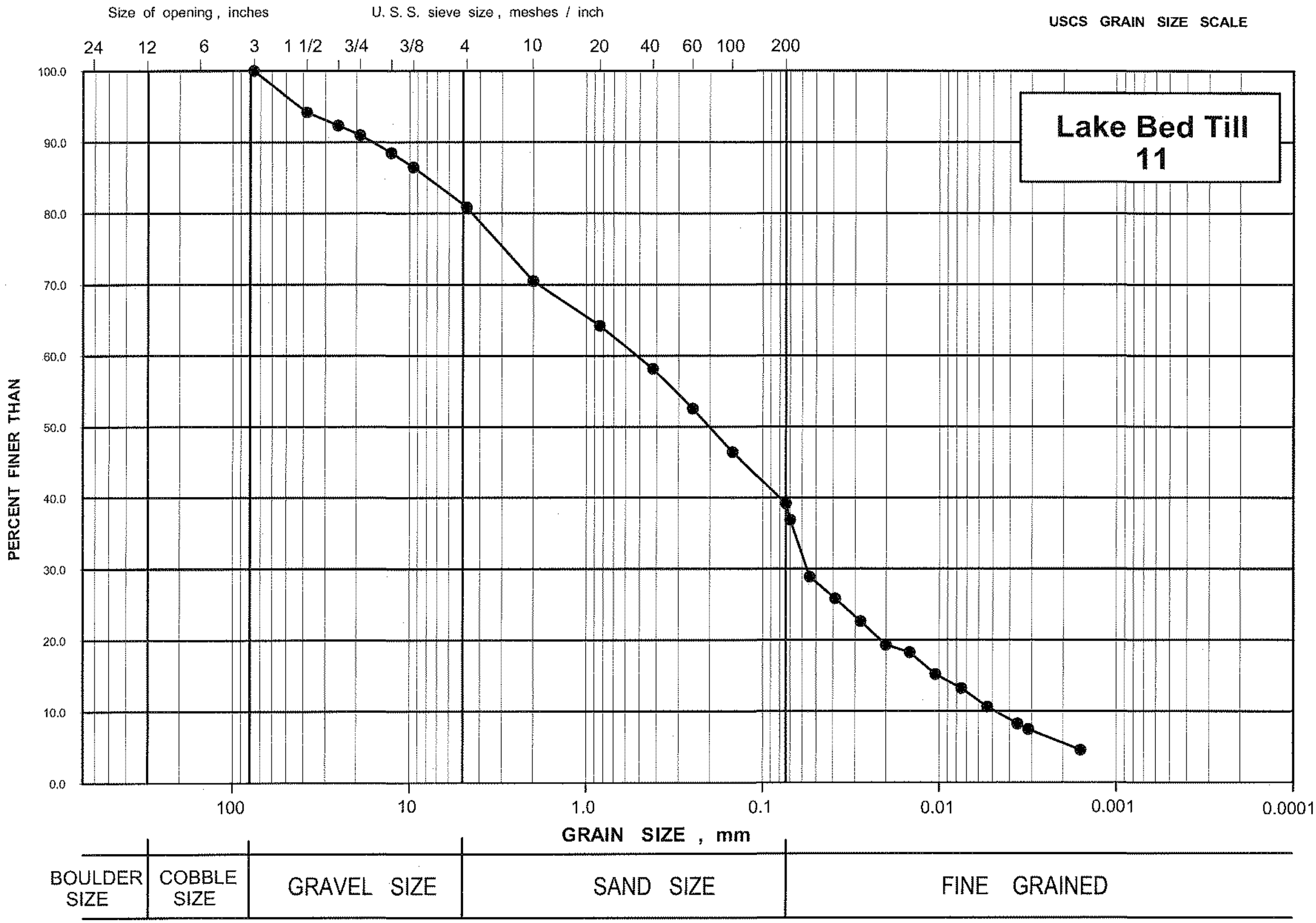
Size (USS)	Weight Retained (g)	Retained (%)	Weight Retained (g)	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"	0.0					**152.4**	**100.0**
3"	0.0					**76.2**	**100.0**
1 1/2"	0.0					**38.1**	**100.0**
1"	185.5	1.4			1.4	**25.4**	**98.6**
3/4"	268.2	2.0			2.0	**19.1**	**96.6**
1/2"	509.4	3.9			3.9	**12.7**	**92.7**
3/8"	423.2	3.2			3.2	**9.52**	**89.5**
#4	1005.7	7.6			7.6	**4.76**	**81.9**
#10	1316.3	10.0			10.0	**2.00**	**71.9**
#20			5.8	11.6	8.3	**0.840**	**63.6**
#40			4.9	9.8	7.0	**0.420**	**56.5**
#60			4.1	8.2	5.9	**0.250**	**50.6**
#100			4.5	9.0	6.5	**0.149**	**44.2**
#200			6.3	12.6	9.1	**0.074**	**35.1**
Pan			24.4	48.8	35.1		

HYDROMETER ANALYSIS

Hydrometer No.: 87024 **Dispersion Method:** Stirring **Dispersion Period (min):**

Comments:

Time (min)	Hydrometer Reading	Temperature (°C)		Composite Correction	Corrected Reading	Diameter (mm)	Percentage Passing
0.5	27.0	19.0		-3.33	23.7	**0.0700**	**33.7**
1	24.0	19.0		-3.33	20.7	**0.0543**	**29.4**
2	21.3	19.0		-3.33	18.0	**0.0391**	**25.6**
4	18.8	19.0		-3.33	15.5	**0.0281**	**22.0**
8	16.6	19.0		-3.33	13.3	**0.0201**	**18.9**
15	15.0	20.0		-3.00	12.0	**0.0148**	**17.1**
30	13.3	20.0		-3.00	10.3	**0.0106**	**14.7**
60	11.2	20.5		-2.83	8.4	**0.0076**	**11.9**
120	8.9	20.5		-2.83	6.1	**0.0054**	**8.6**
270	6.9	20.5		-2.83	4.1	**0.0037**	**5.8**
360	6.0	21.0		-2.67	3.3	**0.0032**	**4.7**
1440	6.0	17.0		-3.99	2.0	**0.0016**	**2.9**



Project No. 06-1413-081
Drawn TM
Reviewed LL
Date 03/09/07

Golder Associates

GRAIN SIZE DISTRIBUTION
Meadowbank Mining Corporation
Meadowbank Gold Project

Figure I-2

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	06-1413-081	Client :	Meadowbank Mining Corporation	BH :	Lake Bed Till
Sch#	277	Project :	Dike Design	Sample :	11
Lab Work:	TM	Location:	Meadowbank Gold Project		

First Sieving
Total Weight (g) = 15616.4

Hydrometer: (Minus #10)
Before Wash (g) = 50.4
After Wash (g) = 23.1

Residual No. 200 (g) = 0.7
Total minus 200 (g) = 28.0
Gs (assumed) = 2.70

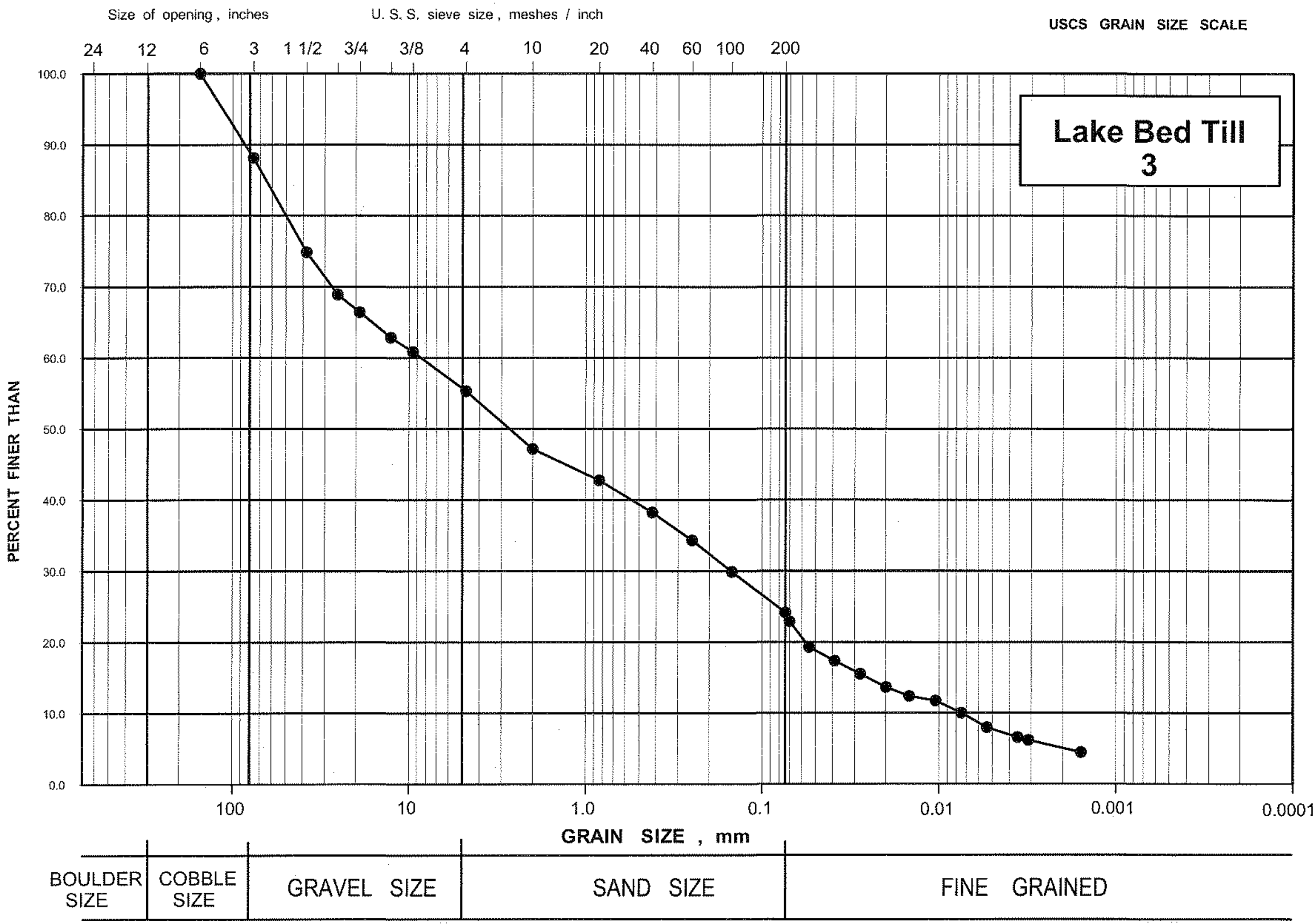
Size (USS)	Weight Retained (g)	Retained (%)	Weight Retained (g)	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"	0.0					**152.4**	**100.0**
3"	0.0					**76.2**	**100.0**
1 1/2"	911.4	5.8			5.8	**38.1**	**94.2**
1"	291.6	1.9			1.9	**25.4**	**92.3**
3/4"	206.9	1.3			1.3	**19.1**	**91.0**
1/2"	388.5	2.5			2.5	**12.7**	**88.5**
3/8"	312.9	2.0			2.0	**9.52**	**86.5**
#4	879.9	5.6			5.6	**4.76**	**80.8**
#10	1620.2	10.4			10.4	**2.00**	**70.5**
#20			4.5	8.9	6.3	**0.840**	**64.2**
#40			4.3	8.5	6.0	**0.420**	**58.2**
#60			4.0	7.9	5.6	**0.250**	**52.6**
#100			4.4	8.7	6.2	**0.149**	**46.4**
#200			5.2	10.3	7.3	**0.074**	**39.2**
Pan			28.0	55.6	39.2		

HYDROMETER ANALYSIS

Hydrometer No.: 87024 **Dispersion Method:** Stirring **Dispersion Period (min):**

Comments:

Time (min)	Hydrometer Reading	Temperature (°C)		Composite Correction	Corrected Reading	Diameter (mm)	Percentage Passing
0.5	30.0	19.0		-3.33	26.7	**0.0700**	**36.9**
1	24.2	19.0		-3.33	20.9	**0.0542**	**28.9**
2	22.0	19.0		-3.33	18.7	**0.0389**	**25.8**
4	19.7	19.0		-3.33	16.4	**0.0279**	**22.6**
8	17.3	19.0		-3.33	14.0	**0.0200**	**19.3**
15	16.2	20.0		-3.00	13.2	**0.0147**	**18.3**
30	14.0	20.0		-3.00	11.0	**0.0105**	**15.2**
60	12.4	20.5		-2.83	9.6	**0.0075**	**13.2**
120	10.5	20.5		-2.83	7.7	**0.0054**	**10.6**
270	8.8	20.5		-2.83	6.0	**0.0036**	**8.2**
360	8.1	21.0		-2.67	5.4	**0.0031**	**7.5**
1440	7.3	17.0		-3.99	3.3	**0.0016**	**4.6**



Project No. 06-1413-081
Drawn TM
Reviewed LL
Date 03/09/07

Golder Associates

GRAIN SIZE DISTRIBUTION
Meadowbank Mining Corporation
Meadowbank Gold Project

Figure I-3

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**BH :**	Lake Bed Till
Sch#	277	**Project :**	Dike Design	**Sample :**	3
Lab Work:	TM	**Location:**	Meadowbank Gold Project		

First Sieving
Total Weight (g) = 11381.4

Hydrometer: (Minus #10)
Before Wash (g) = 50.2
After Wash (g) = 24.9

Residual No. 200 (g) = 0.4
Total minus 200 (g) = 25.7
Gs (assumed) = 2.70

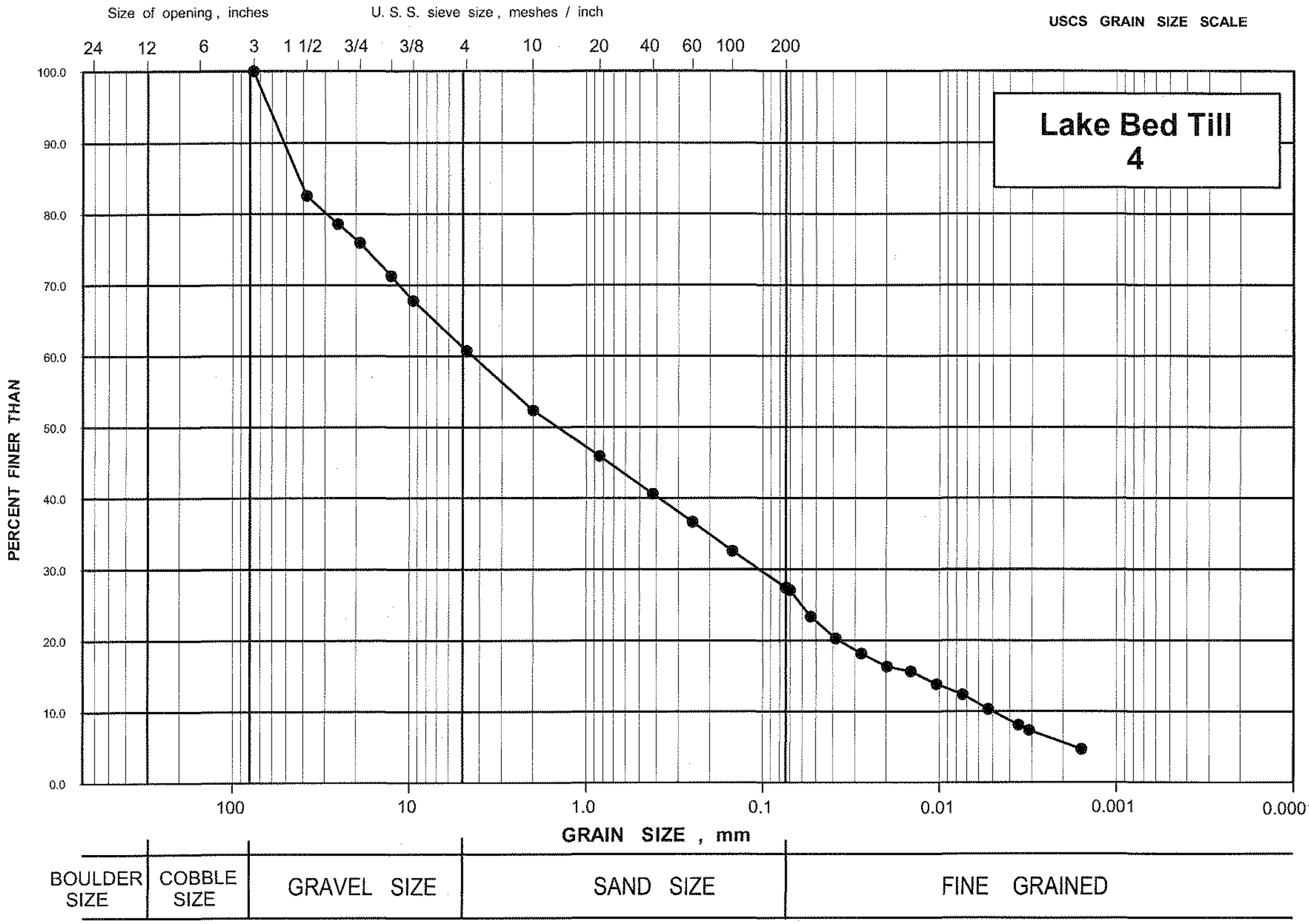
Size (USS)	Weight Retained (g)	Retained (%)	Weight Retained (g)	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"	0.0					**152.4**	**100.0**
3"	1354.0	11.9			11.9	**76.2**	**88.1**
1 1/2"	1510.3	13.3			13.3	**38.1**	**74.8**
1"	672.1	5.9			5.9	**25.4**	**68.9**
3/4"	288.8	2.5			2.5	**19.1**	**66.4**
1/2"	401.9	3.5			3.5	**12.7**	**62.9**
3/8"	230.4	2.0			2.0	**9.52**	**60.8**
#4	627.4	5.5			5.5	**4.76**	**55.3**
#10	926.4	8.1			8.1	**2.00**	**47.2**
#20			4.7	9.4	4.4	**0.840**	**42.8**
#40			4.8	9.6	4.5	**0.420**	**38.3**
#60			4.2	8.4	3.9	**0.250**	**34.3**
#100			4.7	9.4	4.4	**0.149**	**29.9**
#200			6.1	12.2	5.7	**0.074**	**24.2**
Pan			25.7	51.2	24.2		

HYDROMETER ANALYSIS

Hydrometer No.: 87024 **Dispersion Method:** Stirring **Dispersion Period (min):**

Comments:

Time (min)	Hydrometer Reading	Temperature (°C)		Composite Correction	Corrected Reading	Diameter (mm)	Percentage Passing
0.5	28.0	19.0		-3.33	24.7	**0.0700**	**22.9**
1	24.1	19.0		-3.33	20.8	**0.0543**	**19.3**
2	22.0	19.0		-3.33	18.7	**0.0389**	**17.4**
4	20.0	19.0		-3.33	16.7	**0.0279**	**15.5**
8	18.0	19.0		-3.33	14.7	**0.0200**	**13.6**
15	16.3	20.0		-3.00	13.3	**0.0147**	**12.4**
30	15.6	20.0		-3.00	12.6	**0.0104**	**11.7**
60	13.6	20.5		-2.83	10.8	**0.0075**	**10.0**
120	11.4	20.5		-2.83	8.6	**0.0053**	**8.0**
270	9.9	20.5		-2.83	7.1	**0.0036**	**6.6**
360	9.3	21.0		-2.67	6.6	**0.0031**	**6.2**
1440	8.8	17.0		-3.99	4.8	**0.0016**	**4.5**



Project No. 06-1413-081
Drawn TM
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Date 03/09/07

Golder Associates

GRAIN SIZE DISTRIBUTION
Meadowbank Mining Corporation
Meadowbank Gold Project

Figure I-4

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**BH :**	Lake Bed Till
Sch#	277	**Project :**	Dike Design	**Sample :**	4
Lab Work:	TM	**Location:**	Meadowbank Gold Project		

First Sieving
Total Weight (g) = 10768.1

Hydrometer: (Minus #10)
Before Wash (g) = 51.0
After Wash (g) = 24.3

Residual No. 200 (g) = 0.0
Total minus 200 (g) = 26.7
Gs (assumed) = 2.70

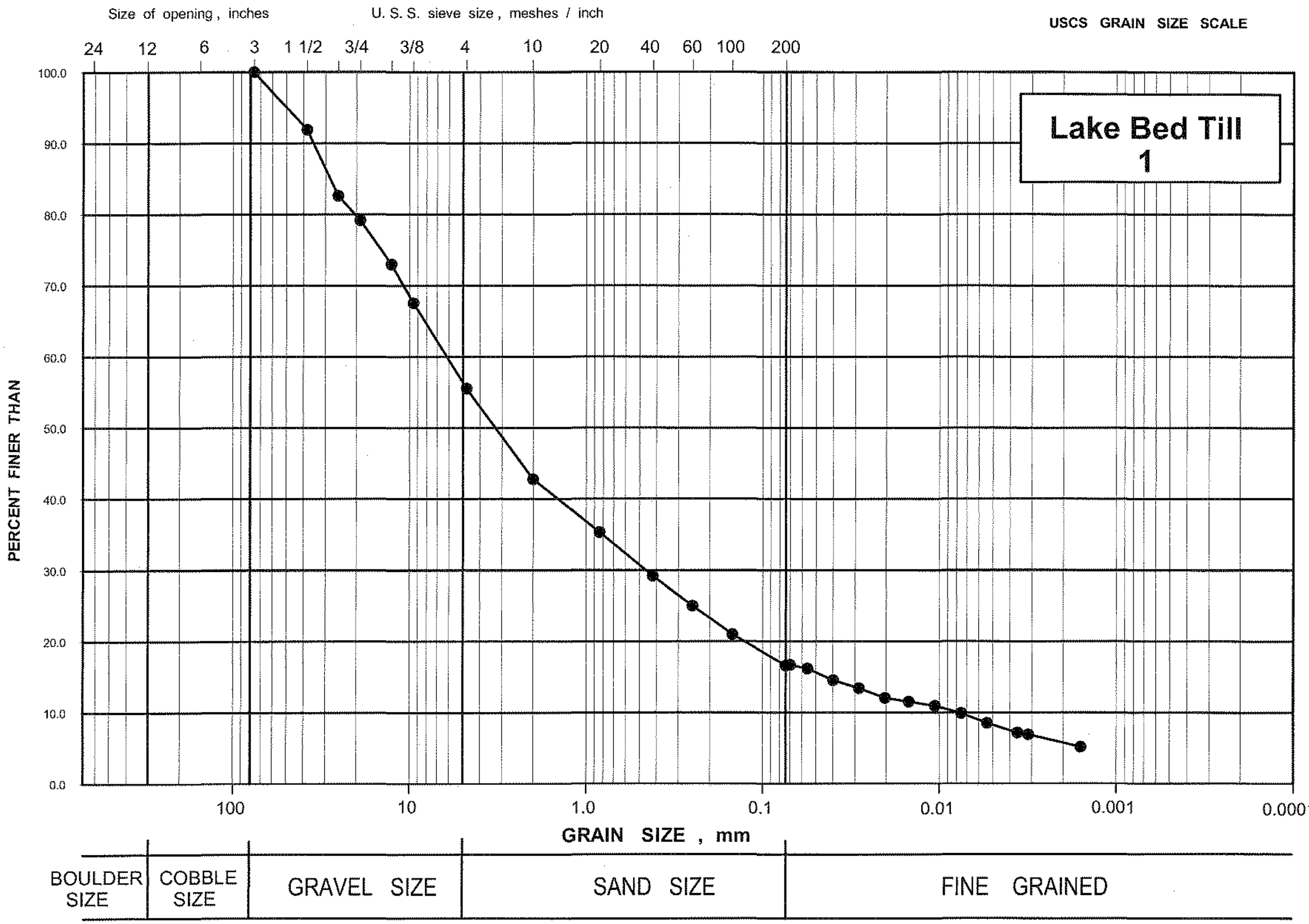
Size (USS)	Weight Retained (g)	Retained (%)	Weight Retained (g)	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"	0.0					**152.4**	**100.0**
3"	0.0					**76.2**	**100.0**
1 1/2"	1881.5	17.5			17.5	**38.1**	**82.5**
1"	425.4	4.0			4.0	**25.4**	**78.6**
3/4"	284.2	2.6			2.6	**19.1**	**75.9**
1/2"	506.1	4.7			4.7	**12.7**	**71.2**
3/8"	372.7	3.5			3.5	**9.52**	**67.8**
#4	756.3	7.0			7.0	**4.76**	**60.8**
#10	901.1	8.4			8.4	**2.00**	**52.4**
#20			6.3	12.4	6.5	**0.840**	**45.9**
#40			5.2	10.2	5.3	**0.420**	**40.6**
#60			3.8	7.5	3.9	**0.250**	**36.7**
#100			4.0	7.8	4.1	**0.149**	**32.6**
#200			5.0	9.8	5.1	**0.074**	**27.4**
Pan			26.7	52.4	27.4		

HYDROMETER ANALYSIS

Hydrometer No.: 87024 **Dispersion Method:** Stirring **Dispersion Period (min):**

Comments:

Time (min)	Hydrometer Reading	Temperature (°C)		Composite Correction	Corrected Reading	Diameter (mm)	Percentage Passing
0.5	30.0	19.0		-3.33	26.7	**0.0700**	**27.1**
1	26.3	19.0		-3.33	23.0	**0.0534**	**23.3**
2	23.3	19.0		-3.33	20.0	**0.0386**	**20.3**
4	21.2	19.0		-3.33	17.9	**0.0277**	**18.1**
8	19.4	19.0		-3.33	16.1	**0.0198**	**16.3**
15	18.4	20.0		-3.00	15.4	**0.0145**	**15.6**
30	16.6	20.0		-3.00	13.6	**0.0104**	**13.8**
60	15.0	20.5		-2.83	12.2	**0.0074**	**12.4**
120	13.0	20.5		-2.83	10.2	**0.0053**	**10.3**
270	10.8	20.5		-2.83	8.0	**0.0036**	**8.1**
360	9.9	21.0		-2.67	7.2	**0.0031**	**7.3**
1440	8.6	17.0		-3.99	4.6	**0.0016**	**4.7**



Project No. 06-1413-081
Drawn TM
Reviewed LL
Date 03/09/07

Golder Associates

GRAIN SIZE DISTRIBUTION
Meadowbank Mining Corporation
Meadowbank Gold Project

Figure I-5

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**BH :**	Lake Bed Till
Sch#	277	**Project :**	Dike Design	**Sample :**	1
Lab Work:	TM	**Location:**	Meadowbank Gold Project		

First Sieving
Total Weight (g) = 10410.8

Hydrometer: (Minus #10)
Before Wash (g) = 49.5
After Wash (g) = 30.3

Residual No. 200 (g) = 0.0
Total minus 200 (g) = 19.2
Gs = 2.67

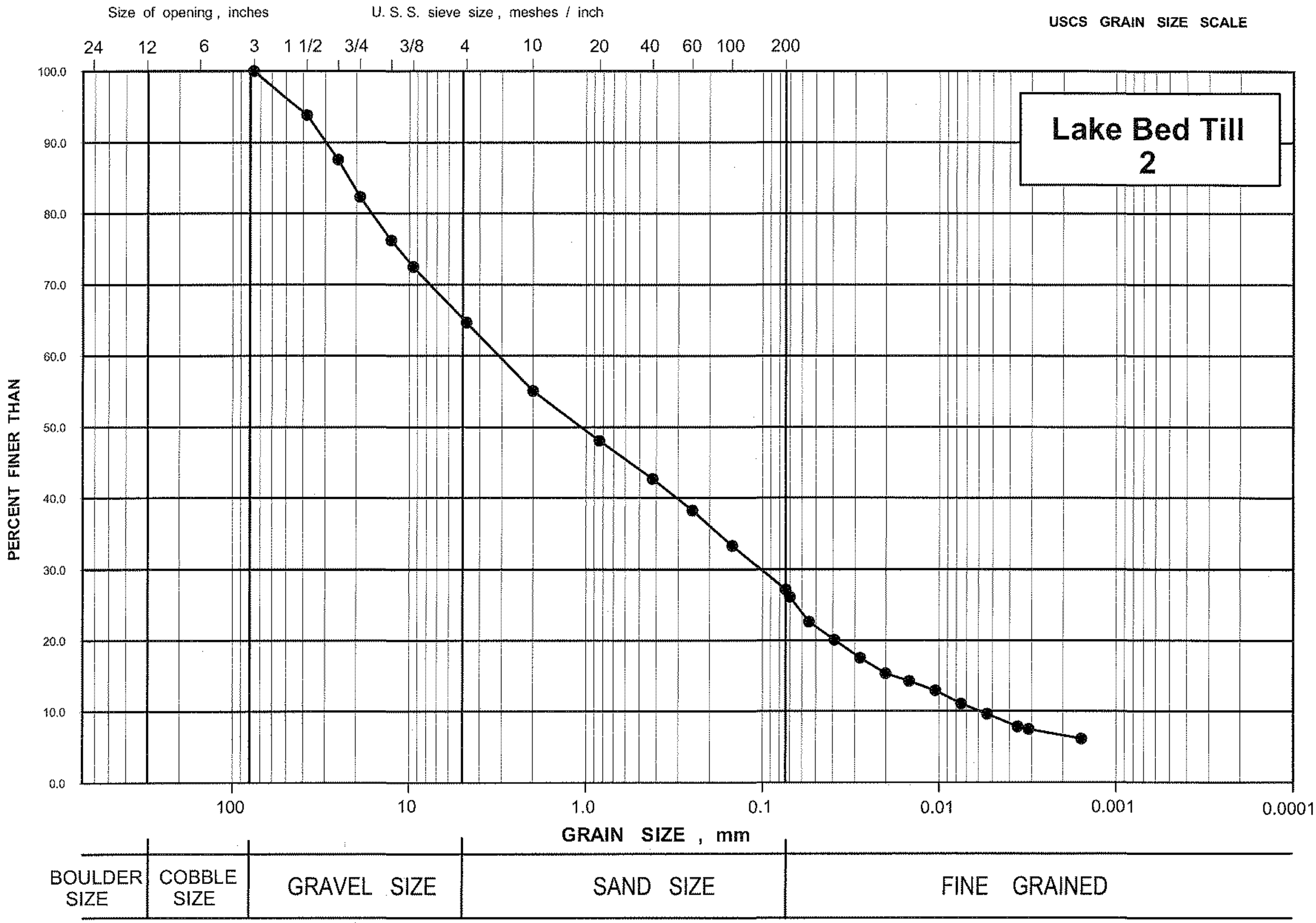
Size (USS)	Weight Retained (g)	Retained (%)	Weight Retained (g)	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"	0.0					**152.4**	**100.0**
3"	0.0					**76.2**	**100.0**
1 1/2"	848.0	8.1			8.1	**38.1**	**91.9**
1"	962.2	9.2			9.2	**25.4**	**82.6**
3/4"	356.7	3.4			3.4	**19.1**	**79.2**
1/2"	646.9	6.2			6.2	**12.7**	**73.0**
3/8"	565.8	5.4			5.4	**9.52**	**67.5**
#4	1249.1	12.0			12.0	**4.76**	**55.5**
#10	1327.6	12.8			12.8	**2.00**	**42.8**
#20			8.6	17.4	7.4	**0.840**	**35.4**
#40			7.1	14.3	6.1	**0.420**	**29.2**
#60			4.9	9.9	4.2	**0.250**	**25.0**
#100			4.6	9.3	4.0	**0.149**	**21.0**
#200			5.1	10.3	4.4	**0.074**	**16.6**
Pan			19.2	38.8	16.6		

HYDROMETER ANALYSIS

Hydrometer No.: 8589 **Dispersion Method:** Stirring **Dispersion Period (min):**

Comments:

Time (min)	Hydrometer Reading	Temperature (°C)		Composite Correction	Corrected Reading	Diameter (mm)	Percentage Passing
0.5	21.7	19.0		-2.30	19.4	**0.0700**	**16.7**
1	21.1	19.0		-2.30	18.8	**0.0558**	**16.2**
2	19.2	19.0		-2.30	16.9	**0.0400**	**14.5**
4	17.9	19.0		-2.30	15.6	**0.0285**	**13.4**
8	16.3	19.0		-2.30	14.0	**0.0203**	**12.0**
15	15.5	20.0		-2.10	13.4	**0.0149**	**11.5**
30	14.8	20.0		-2.10	12.7	**0.0106**	**10.9**
60	13.5	20.5		-2.00	11.5	**0.0075**	**9.9**
120	11.9	20.5		-2.00	9.9	**0.0054**	**8.5**
270	10.3	20.5		-2.00	8.3	**0.0036**	**7.1**
360	9.9	21.0		-1.90	8.0	**0.0031**	**6.9**
1440	8.7	17.0		-2.71	6.0	**0.0016**	**5.2**



Project No. 06-1413-081
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Date 03/09/07

Golder Associates

GRAIN SIZE DISTRIBUTION
Meadowbank Mining Corporation
Meadowbank Gold Project

Figure I-6

PARTICLE SIZE ANALYSIS OF SOILS   ASTM D 422-63

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**BH :**	Lake Bed Till
Sch#	277	**Project :**	Dike Design	**Sample :**	2
Lab Work:	TM	**Location:**	Meadowbank Gold Project		

First Sieving
Total Weight (g) = 11026.2

Hydrometer: (Minus #10)
Before Wash (g) = 49.3
After Wash (g) = 25.0

Residual No. 200 (g) = 0.0
Total minus 200 (g) = 24.3
Gs = 2.71

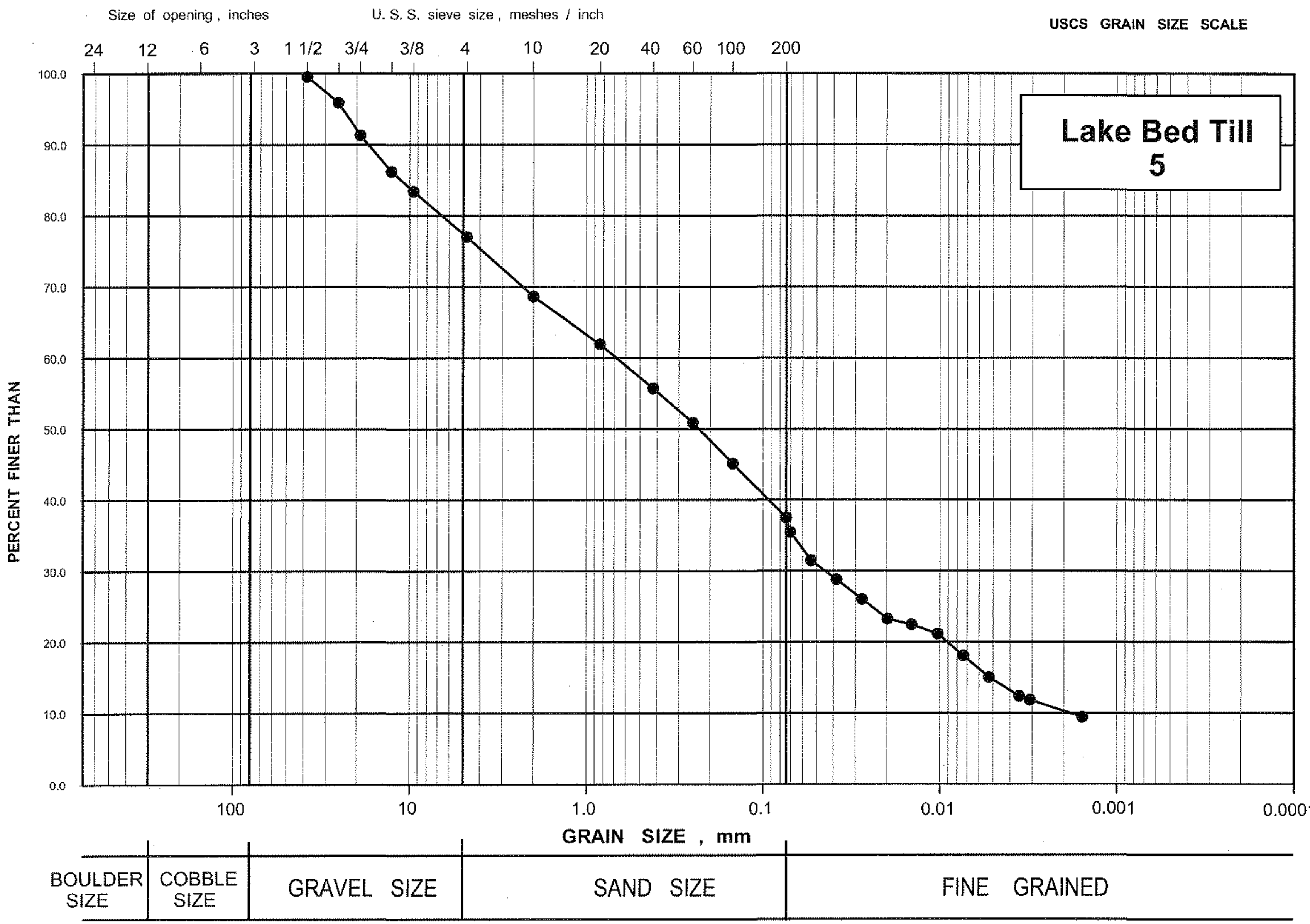
Size (USS)	Weight Retained (g)	Retained (%)	Weight Retained (g)	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"	0.0					**152.4**	**100.0**
3"	0.0					**76.2**	**100.0**
1 1/2"	681.2	6.2			6.2	**38.1**	**93.8**
1"	688.3	6.2			6.2	**25.4**	**87.6**
3/4"	583.1	5.3			5.3	**19.1**	**82.3**
1/2"	671.8	6.1			6.1	**12.7**	**76.2**
3/8"	410.4	3.7			3.7	**9.52**	**72.5**
#4	861.7	7.8			7.8	**4.76**	**64.7**
#10	1054.4	9.6			9.6	**2.00**	**55.1**
#20			6.3	12.8	7.0	**0.840**	**48.1**
#40			4.8	9.7	5.4	**0.420**	**42.7**
#60			4.0	8.1	4.5	**0.250**	**38.2**
#100			4.4	8.9	4.9	**0.149**	**33.3**
#200			5.5	11.2	6.1	**0.074**	**27.2**
Pan			24.3	49.3	27.2		

HYDROMETER ANALYSIS

Hydrometer No.: 8589   **Dispersion Method:** Stirring   **Dispersion Period (min):**

Comments:

Time (min)	Hydrometer Reading	Temperature (°C)		Composite Correction	Corrected Reading	Diameter (mm)	Percentage Passing
0.5	26.0	19.0		-2.30	23.7	**0.0700**	**26.1**
1	22.8	19.0		-2.30	20.5	**0.0546**	**22.6**
2	20.5	19.0		-2.30	18.2	**0.0392**	**20.1**
4	18.2	19.0		-2.30	15.9	**0.0281**	**17.5**
8	16.2	19.0		-2.30	13.9	**0.0201**	**15.3**
15	15.0	20.0		-2.10	12.9	**0.0148**	**14.2**
30	13.8	20.0		-2.10	11.7	**0.0105**	**12.9**
60	12.0	20.5		-2.00	10.0	**0.0075**	**11.0**
120	10.7	20.5		-2.00	8.7	**0.0053**	**9.6**
270	9.1	20.5		-2.00	7.1	**0.0036**	**7.8**
360	8.7	21.0		-1.90	6.8	**0.0031**	**7.5**
1440	8.3	17.0		-2.71	5.6	**0.0016**	**6.2**



Project No. 06-1413-081
Drawn TM
Reviewed LL
Date 03/09/07

Golder Associates

GRAIN SIZE DISTRIBUTION
Meadowbank Mining Corporation
Meadowbank Gold Project

Figure I-7

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**BH :**	Lake Bed Till
Sch#	277	**Project :**	Dike Design	**Sample :**	5
Lab Work:	TM	**Location:**	Meadowbank Gold Project		

First Sieving
Total Weight (g) = 10816.6

Hydrometer: (Minus #10)
Before Wash (g) = 51.1
After Wash (g) = 23.7

Residual No. 200 (g) = 0.5
Total minus 200 (g) = 27.9
Gs (assumed) = 2.70

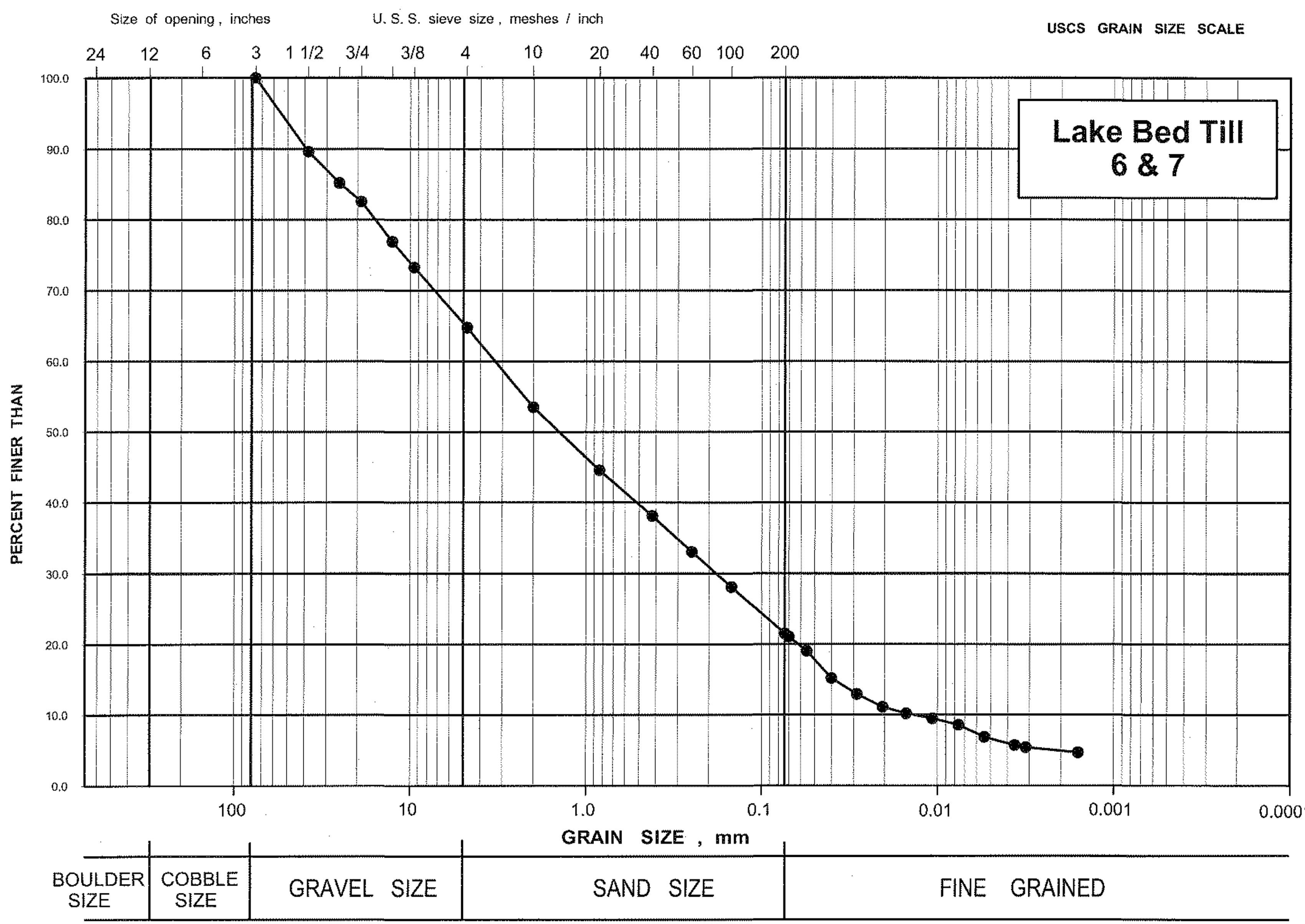
Size (USS)	Weight Retained (g)	Retained (%)	Weight Retained (g)	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"	0.0					**152.4**	**100.0**
3"	0.0					**76.2**	**100.0**
1 1/2"	51.6	0.5			0.5	**38.1**	**99.5**
1"	389.2	3.6			3.6	**25.4**	**95.9**
3/4"	499.5	4.6			4.6	**19.1**	**91.3**
1/2"	551.4	5.1			5.1	**12.7**	**86.2**
3/8"	300.4	2.8			2.8	**9.52**	**83.4**
#4	689.0	6.4			6.4	**4.76**	**77.1**
#10	911.2	8.4			8.4	**2.00**	**68.6**
#20			5.0	9.8	6.7	**0.840**	**61.9**
#40			4.6	9.0	6.2	**0.420**	**55.7**
#60			3.6	7.0	4.8	**0.250**	**50.9**
#100			4.3	8.4	5.8	**0.149**	**45.1**
#200			5.7	11.2	7.7	**0.074**	**37.5**
Pan			27.9	54.6	37.5		

HYDROMETER ANALYSIS

Hydrometer No.: 8589 **Dispersion Method:** Stirring **Dispersion Period (min):**

Comments:

Time (min)	Hydrometer Reading	Temperature (°C)		Composite Correction	Corrected Reading	Diameter (mm)	Percentage Passing
0.5	29.0	19.0		-2.30	26.7	**0.0700**	**35.5**
1	26.0	19.0		-2.30	23.7	**0.0536**	**31.5**
2	24.0	19.0		-2.30	21.7	**0.0384**	**28.8**
4	21.9	19.0		-2.30	19.6	**0.0275**	**26.0**
8	19.8	19.0		-2.30	17.5	**0.0197**	**23.2**
15	19.0	20.0		-2.10	16.9	**0.0145**	**22.4**
30	18.0	20.0		-2.10	15.9	**0.0103**	**21.1**
60	15.6	20.5		-2.00	13.6	**0.0074**	**18.1**
120	13.3	20.5		-2.00	11.3	**0.0053**	**15.0**
270	11.3	20.5		-2.00	9.3	**0.0036**	**12.4**
360	10.8	21.0		-1.90	8.9	**0.0031**	**11.8**
1440	9.8	17.0		-2.71	7.1	**0.0016**	**9.4**



Project No. 06-1413-081
Drawn TM
Reviewed LL
Date 03/09/07

Golder Associates

GRAIN SIZE DISTRIBUTION
Meadowbank Mining Corporation
Meadowbank Gold Project

Figure I-8

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**BH :**	Lake Bed Till
Sch#	277	**Project :**	Dike Design	**Sample :**	6 & 7
Lab Work:	TM	**Location:**	Meadowbank Gold Project		

First Sieving		**Hydrometer: (Minus #10)**			
Total Weight (g) =	16491.9	Before Wash (g) =	52.0	Residual No. 200 (g) =	0.3
		After Wash (g) =	31.4	Total minus 200 (g) =	20.9
				Gs (assumed) =	2.70

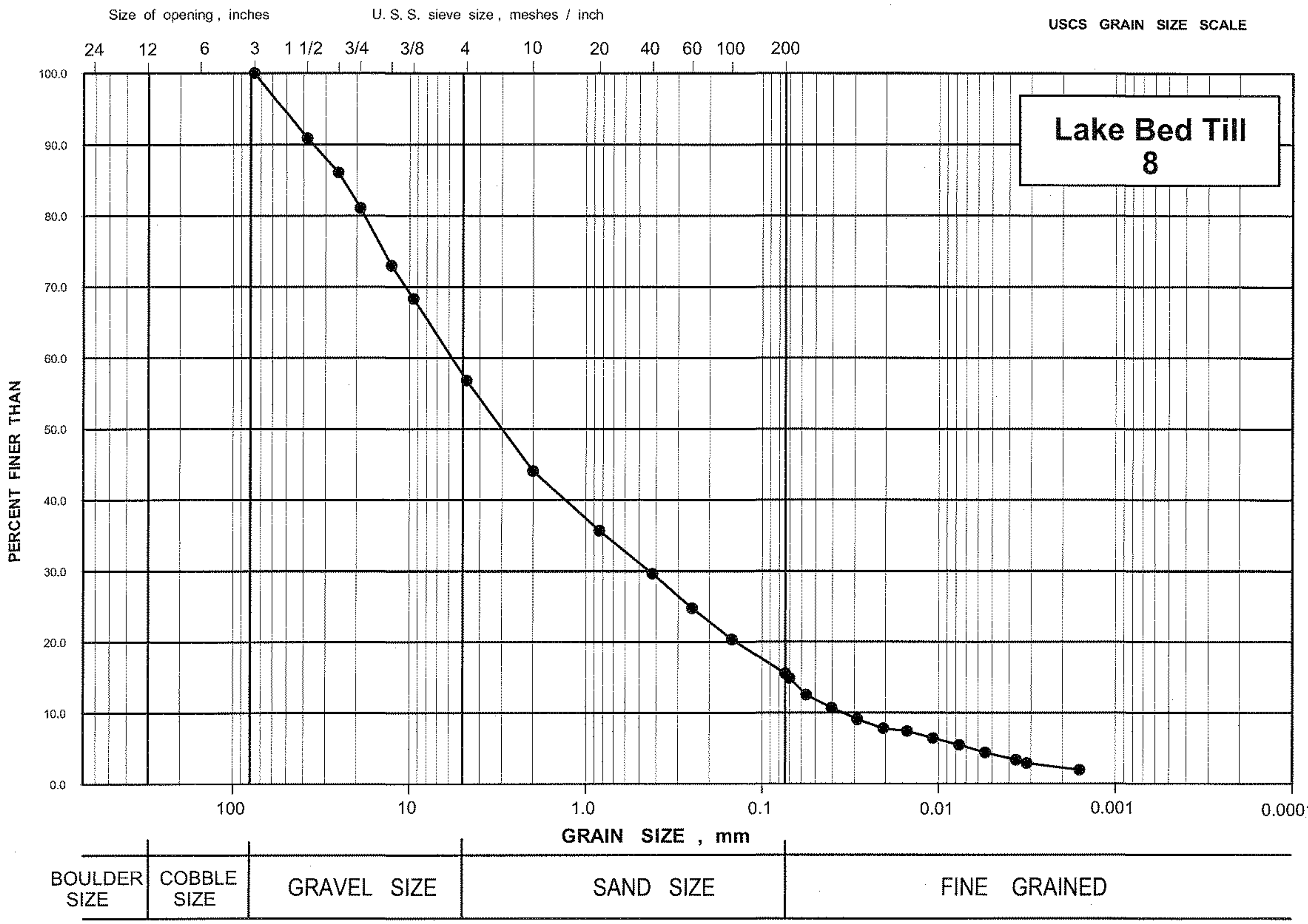
Size (USS)	Weight Retained (g)	Retained (%)	Weight Retained (g)	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"	0.0					**152.4**	**100.0**
3"	0.0					**76.2**	**100.0**
1 1/2"	1718.2	10.4			10.4	**38.1**	**89.6**
1"	721.2	4.4			4.4	**25.4**	**85.2**
3/4"	438.5	2.7			2.7	**19.1**	**82.5**
1/2"	934.6	5.7			5.7	**12.7**	**76.9**
3/8"	599.2	3.6			3.6	**9.52**	**73.2**
#4	1398.0	8.5			8.5	**4.76**	**64.8**
#10	1857.6	11.3			11.3	**2.00**	**53.5**
#20			8.7	16.7	9.0	**0.840**	**44.6**
#40			6.3	12.1	6.5	**0.420**	**38.1**
#60			4.9	9.4	5.0	**0.250**	**33.0**
#100			4.8	9.2	4.9	**0.149**	**28.1**
#200			6.4	12.3	6.6	**0.074**	**21.5**
Pan			20.9	40.2	21.5		

HYDROMETER ANALYSIS

Hydrometer No.: 8589 **Dispersion Method:** Stirring **Dispersion Period (min):**

Comments:

Time (min)	Hydrometer Reading	Temperature (°C)		Composite Correction	Corrected Reading	Diameter (mm)	Percentage Passing
0.5	23.0	19.0		-2.30	20.7	**0.0700**	**21.1**
1	21.0	19.0		-2.30	18.7	**0.0554**	**19.0**
2	17.2	19.0		-2.30	14.9	**0.0401**	**15.2**
4	15.0	19.0		-2.30	12.7	**0.0287**	**12.9**
8	13.2	19.0		-2.30	10.9	**0.0205**	**11.1**
15	12.1	20.0		-2.10	10.0	**0.0151**	**10.2**
30	11.4	20.0		-2.10	9.3	**0.0107**	**9.5**
60	10.4	20.5		-2.00	8.4	**0.0076**	**8.6**
120	8.7	20.5		-2.00	6.7	**0.0054**	**6.8**
270	7.6	20.5		-2.00	5.6	**0.0036**	**5.7**
360	7.2	21.0		-1.90	5.3	**0.0032**	**5.4**
1440	7.3	17.0		-2.71	4.6	**0.0016**	**4.7**



Project No. 06-1413-081
Drawn TM
Reviewed LL
Date 03/09/07

Golder Associates

GRAIN SIZE DISTRIBUTION
Meadowbank Mining Corporation
Meadowbank Gold Project

Figure I-9

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**BH :**	Lake Bed Till
Sch#	277	**Project :**	Dike Design	**Sample :**	8
Lab Work:	TM	**Location:**	Meadowbank Gold Project		

First Sieving
Total Weight (g) = 12741.8

Hydrometer: (Minus #10)
Before Wash (g) = 51.6
After Wash (g) = 34.1

Residual No. 200 (g) = 0.7
Total minus 200 (g) = 18.2
Gs (assumed) = 2.70

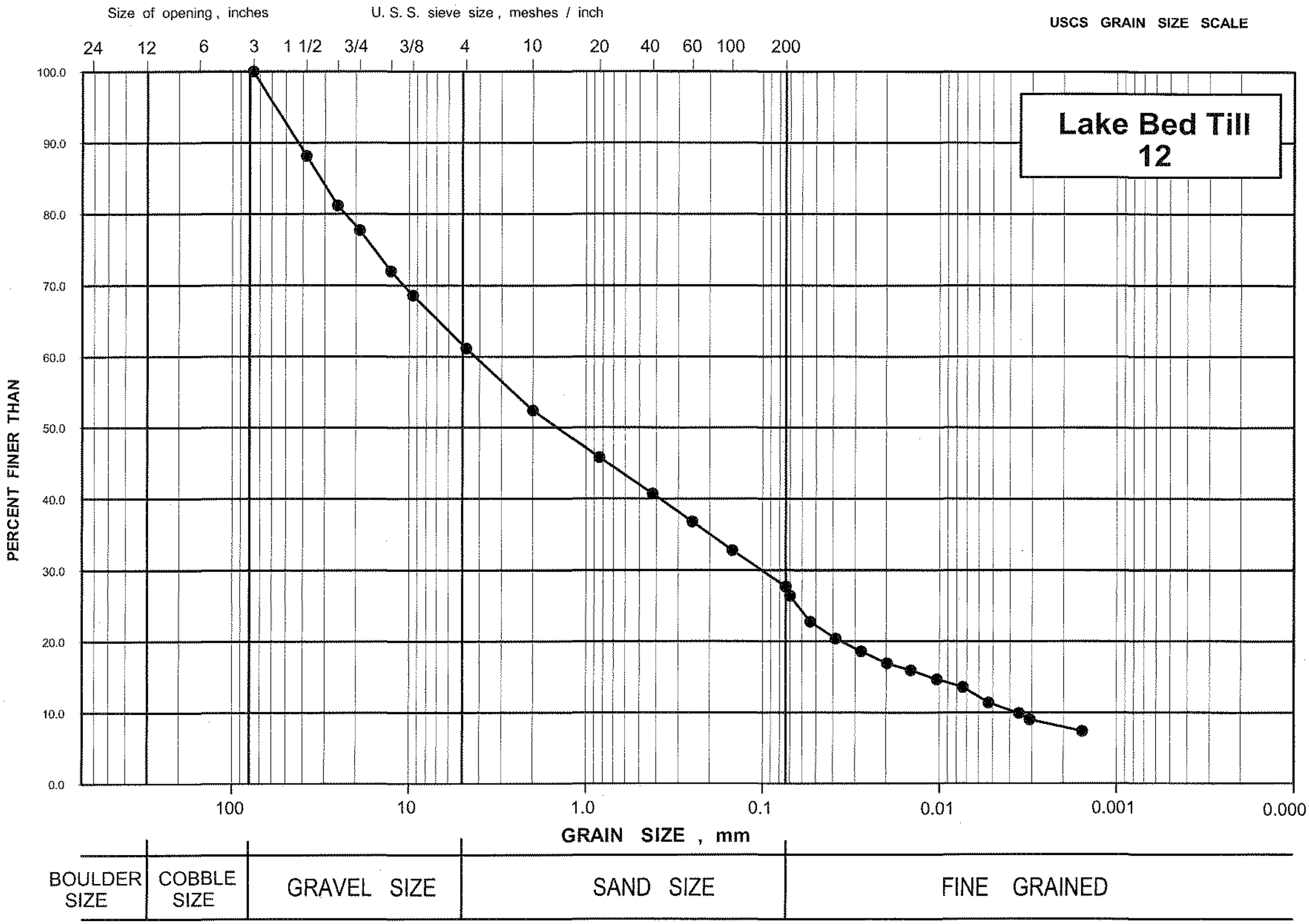
Size (USS)	Weight Retained (g)	Retained (%)	Weight Retained (g)	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"	0.0					**152.4**	**100.0**
3"	0.0					**76.2**	**100.0**
1 1/2"	1160.6	9.1			9.1	**38.1**	**90.9**
1"	609.7	4.8			4.8	**25.4**	**86.1**
3/4"	636.2	5.0			5.0	**19.1**	**81.1**
1/2"	1042.6	8.2			8.2	**12.7**	**72.9**
3/8"	586.1	4.6			4.6	**9.52**	**68.3**
#4	1466.3	11.5			11.5	**4.76**	**56.8**
#10	1621.7	12.7			12.7	**2.00**	**44.1**
#20			9.8	19.0	8.4	**0.840**	**35.7**
#40			7.1	13.8	6.1	**0.420**	**29.7**
#60			5.7	11.0	4.9	**0.250**	**24.8**
#100			5.2	10.1	4.4	**0.149**	**20.3**
#200			5.6	10.9	4.8	**0.074**	**15.6**
Pan			18.2	35.3	15.6		

HYDROMETER ANALYSIS

Hydrometer No.: 87024 **Dispersion Method:** Stirring **Dispersion Period (min):**

Comments:

Time (min)	Hydrometer Reading	Temperature (°C)		Composite Correction	Corrected Reading	Diameter (mm)	Percentage Passing
0.5	21.0	19.0		-3.33	17.7	**0.0700**	**14.9**
1	18.2	19.0		-3.33	14.9	**0.0564**	**12.6**
2	16.0	19.0		-3.33	12.7	**0.0404**	**10.7**
4	14.1	19.0		-3.33	10.8	**0.0289**	**9.1**
8	12.6	19.0		-3.33	9.3	**0.0206**	**7.8**
15	11.8	20.0		-3.00	8.8	**0.0151**	**7.4**
30	10.6	20.0		-3.00	7.6	**0.0107**	**6.4**
60	9.3	20.5		-2.83	6.5	**0.0076**	**5.5**
120	8.0	20.5		-2.83	5.2	**0.0054**	**4.4**
270	6.8	20.5		-2.83	4.0	**0.0037**	**3.4**
360	6.1	21.0		-2.67	3.4	**0.0032**	**2.9**
1440	6.3	17.0		-3.99	2.3	**0.0016**	**1.9**



Project No. 06-1413-081
Drawn TM
Reviewed LL
Date 03/09/07

Golder Associates

GRAIN SIZE DISTRIBUTION
Meadowbank Mining Corporation
Meadowbank Gold Project

Figure I-10

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**BH :**	Lake Bed Till
Sch#	277	**Project :**	Dike Design	**Sample :**	12
Lab Work:	TM	**Location:**	Meadowbank Gold Project		

First Sieving
Total Weight (g) = 16782.5

Hydrometer: (Minus #10)
Before Wash (g) = 52.4
After Wash (g) = 25.2

Residual No. 200 (g) = 0.5
Total minus 200 (g) = 27.7
Gs (assumed) = 2.70

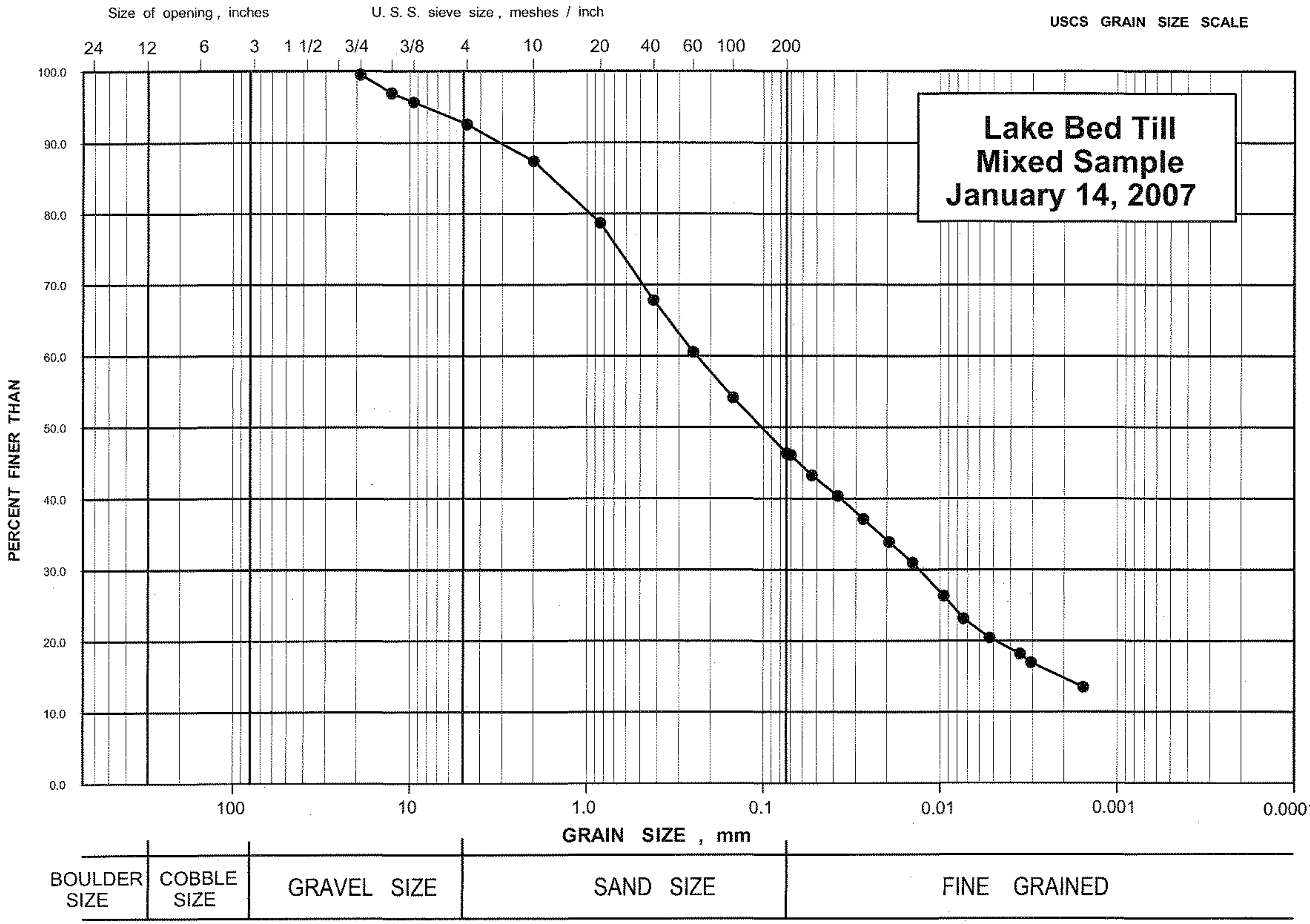
Size (USS)	Weight Retained (g)	Retained (%)	Weight Retained (g)	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"	0.0					**152.4**	**100.0**
3"	0.0					**76.2**	**100.0**
1 1/2"	1992.1	11.9			11.9	**38.1**	**88.1**
1"	1166.2	6.9			6.9	**25.4**	**81.2**
3/4"	578.3	3.4			3.4	**19.1**	**77.7**
1/2"	969.0	5.8			5.8	**12.7**	**72.0**
3/8"	565.8	3.4			3.4	**9.52**	**68.6**
#4	1248.8	7.4			7.4	**4.76**	**61.1**
#10	1466.3	8.7			8.7	**2.00**	**52.4**
#20			6.6	12.6	6.6	**0.840**	**45.8**
#40			5.1	9.7	5.1	**0.420**	**40.7**
#60			3.9	7.4	3.9	**0.250**	**36.8**
#100			4.0	7.6	4.0	**0.149**	**32.8**
#200			5.1	9.7	5.1	**0.074**	**27.7**
Pan			27.7	52.9	27.7		

HYDROMETER ANALYSIS

Hydrometer No.: 8589 **Dispersion Method:** Stirring **Dispersion Period (min):**

Comments:

Time (min)	Hydrometer Reading	Temperature (°C)		Composite Correction	Corrected Reading	Diameter (mm)	Percentage Passing
0.5	29.0	19.0		-2.30	26.7	**0.0700**	**26.4**
1	25.3	19.0		-2.30	23.0	**0.0538**	**22.7**
2	22.9	19.0		-2.30	20.6	**0.0387**	**20.4**
4	21.1	19.0		-2.30	18.8	**0.0277**	**18.6**
8	19.4	19.0		-2.30	17.1	**0.0198**	**16.9**
15	18.2	20.0		-2.10	16.1	**0.0145**	**15.9**
30	16.9	20.0		-2.10	14.8	**0.0104**	**14.6**
60	15.7	20.5		-2.00	13.7	**0.0074**	**13.6**
120	13.5	20.5		-2.00	11.5	**0.0053**	**11.4**
270	12.0	20.5		-2.00	10.0	**0.0036**	**9.9**
360	11.0	21.0		-1.90	9.1	**0.0031**	**9.0**
1440	10.2	17.0		-2.71	7.5	**0.0016**	**7.4**



Project No. 06-1413-081
Drawn TM
Reviewed LL
Date 03/09/07

Golder Associates

GRAIN SIZE DISTRIBUTION
Meadowbank Mining Corporation
Meadowbank Gold Project

Figure I-11

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**Sample :**	Lake Bed Till Mixed Samples
Sch#	288	**Project :**	Dike Design		January 14, 2007
Lab Work:	TM	**Location:**	Meadowbank Gold Project		

First Sieving
Total Weight (g) = 3840.3

Hydrometer: (Minus #10)
Before Wash (g) = 48.1
After Wash (g) = 22.7

Residual No. 200 (g) = 0.1
Total minus 200 (g) = 25.5
Gs (assumed) = 2.70

Size (USS)	Weight Retained (g)	Retained (%)	Weight Retained (g)	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"	0.0					**152.4**	**100.0**
3"	0.0					**76.2**	**100.0**
1 1/2"	0.0					**38.1**	**100.0**
1"	0.0					**25.4**	**100.0**
3/4"	17.8	0.5			0.5	**19.1**	**99.5**
1/2"	99.1	2.6			2.6	**12.7**	**97.0**
3/8"	48.8	1.3			1.3	**9.52**	**95.7**
#4	120.9	3.1			3.1	**4.76**	**92.5**
#10	196.6	5.1			5.1	**2.00**	**87.4**
#20			4.8	10.0	8.7	**0.840**	**78.7**
#40			6.0	12.5	10.9	**0.420**	**67.8**
#60			4.0	8.3	7.3	**0.250**	**60.5**
#100			3.5	7.3	6.4	**0.149**	**54.2**
#200			4.3	8.9	7.8	**0.074**	**46.3**
Pan			25.5	53.0	46.3		

HYDROMETER ANALYSIS

Hydrometer No.: 87024 **Dispersion Method:** Stirring **Dispersion Period (min):**

Comments:

Time (min)	Hydrometer Reading	Temperature (°C)		Composite Correction	Corrected Reading	Diameter (mm)	Percentage Passing
0.5	28.0	22.0		-2.34	25.7	**0.0700**	**46.1**
1	26.4	22.0		-2.34	24.1	**0.0531**	**43.2**
2	24.8	22.0		-2.34	22.5	**0.0380**	**40.4**
4	23.0	22.0		-2.34	20.7	**0.0272**	**37.1**
8	21.2	22.0		-2.34	18.9	**0.0194**	**33.9**
15	19.6	22.0		-2.34	17.3	**0.0143**	**31.0**
35	17.0	22.0		-2.34	14.7	**0.0095**	**26.4**
60	15.2	22.0		-2.34	12.9	**0.0074**	**23.1**
120	13.7	22.0		-2.34	11.4	**0.0053**	**20.4**
270	12.3	22.5		-2.17	10.1	**0.0035**	**18.2**
360	11.6	22.5		-2.17	9.4	**0.0031**	**16.9**
1440	10.5	20.0		-3.00	7.5	**0.0016**	**13.5**

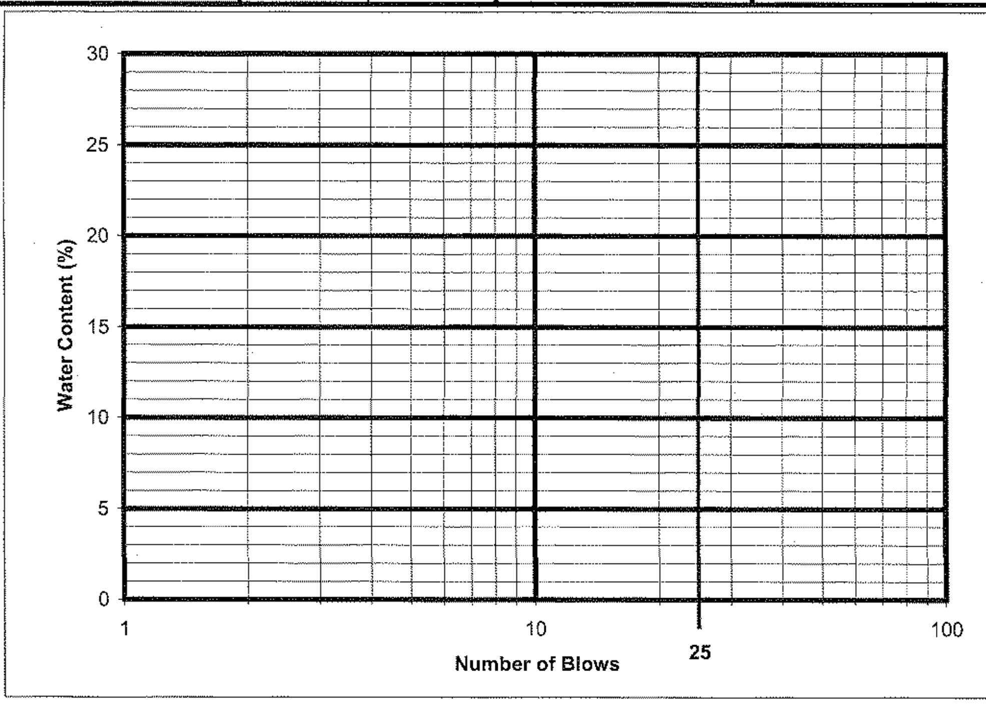
TILL ATTERBERG LIMITS

Project # 06-1413-081 Tech : TM

Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4318-93

TYPE OF TEST	LL	LL	LL	LL		W% Nat.
CONTAINER NUMBER						
NUMBER OF BLOWS						
MASS WET SOIL + TARE						15848.80
MASS DRY SOIL + TARE						14909.60
MASS OF WATER						939.20
MASS OF CONTAINER						1472.60
MASS OF DRY SOIL						13437.0
WATER CONTENT W (%)						7.0

TYPE OF TEST	PL	PL	BOREHOLE NO.	Lake Bed Till
CONTAINER NUMBER			SAMPLE	9 & 10
MASS WET SOIL + TARE			DEPTH	
MASS DRY SOIL + TARE			LIQUID LIMIT (%)	NA
MASS OF WATER			PLASTIC LIMIT (%)	NA
MASS OF CONTAINER			PLASTICITY INDEX (%)	NA
MASS OF DRY SOIL			W% Natural (%)	7.0
WATER CONTENT W (%)			LIQUIDITY INDEX	NA



SAMPLE DESCRIPTION : Non Plastic Result
Could not achieve 25 blows

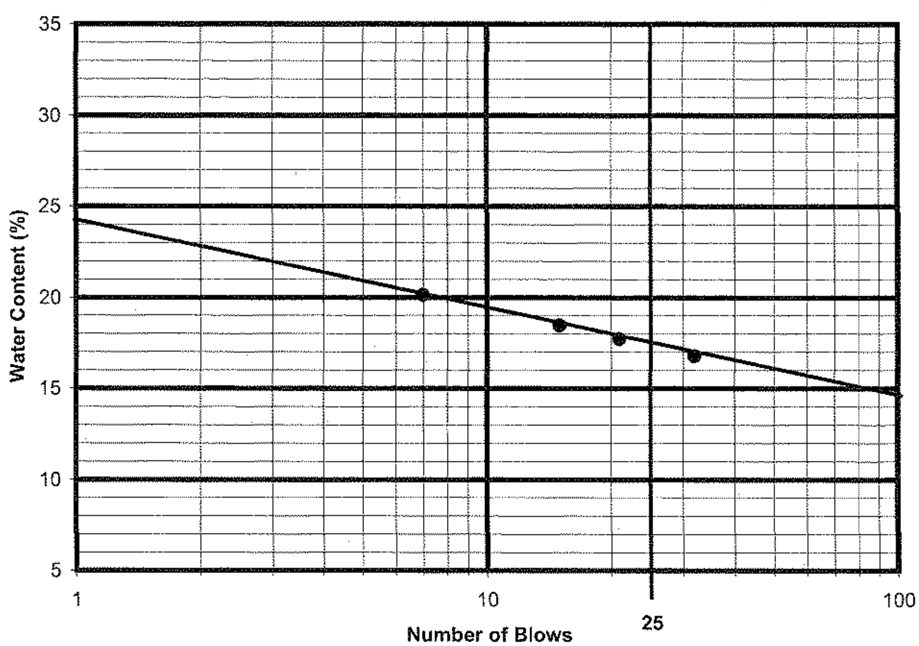
Meadowbank Mining Corporation
Meadowbank Gold Project

Project # 06-1413-081 Tech : TM

Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4318-93

TYPE OF TEST	LL	LL	LL	LL		W% Nat.
CONTAINER NUMBER						
NUMBER OF BLOWS	7	15	21	32		
MASS WET SOIL + TARE	45.93	50.04	43.27	47.60		18746.30
MASS DRY SOIL + TARE	43.05	47.06	40.95	44.88		17042.30
MASS OF WATER	2.88	2.98	2.32	2.72		1704.00
MASS OF CONTAINER	28.73	30.89	27.85	28.66		1425.90
MASS OF DRY SOIL	14.32	16.17	13.10	16.22		15616.4
WATER CONTENT W (%)	20.1	18.4	17.7	16.8		10.9

TYPE OF TEST	PL	PL	BOREHOLE NO.	Lake Bed Till
CONTAINER NUMBER			SAMPLE	11
MASS WET SOIL + TARE	36.56	19.18	DEPTH	
MASS DRY SOIL + TARE	35.45	18.21	LIQUID LIMIT (%)	17.5
MASS OF WATER	1.11	0.97	PLASTIC LIMIT (%)	16.8
MASS OF CONTAINER	28.66	12.57	PLASTICITY INDEX (%)	0.7
MASS OF DRY SOIL	6.79	5.64	W% Natural (%)	10.9
WATER CONTENT W (%)	16.3	17.2	LIQUIDITY INDEX	-8.06



SAMPLE DESCRIPTION : CL

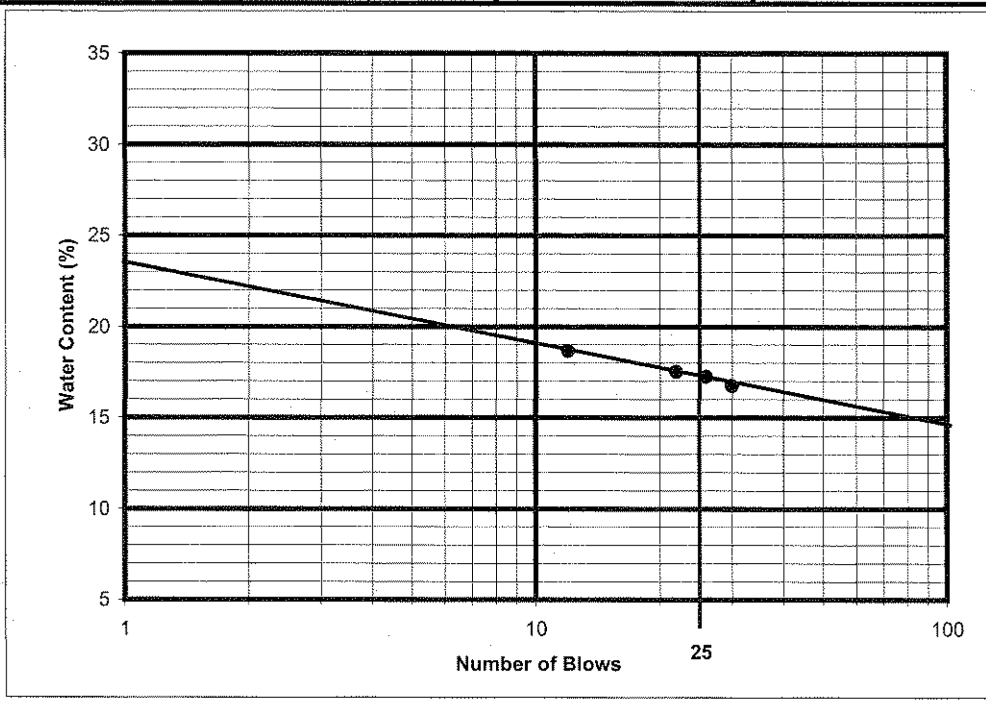
Meadowbank Mining Corporation
Meadowbank Gold Project

Project # 06-1413-081 Tech : TM

Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4318-93

TYPE OF TEST	LL	LL	LL	LL		W% Nat.
CONTAINER NUMBER						
NUMBER OF BLOWS	30	26	22	12		
MASS WET SOIL + TARE	43.57	51.84	46.59	50.31		13376.30
MASS DRY SOIL + TARE	41.39	48.76	43.92	46.92		12704.80
MASS OF WATER	2.18	3.08	2.67	3.39		671.50
MASS OF CONTAINER	28.36	30.88	28.67	28.75		1269.60
MASS OF DRY SOIL	13.03	17.88	15.25	18.17		11435.2
WATER CONTENT W (%)	16.7	17.2	17.5	18.7		5.9

TYPE OF TEST	PL	PL	BOREHOLE NO.	Lake Bed Till
CONTAINER NUMBER			SAMPLE	3
MASS WET SOIL + TARE	38.72	40.86	DEPTH	
MASS DRY SOIL + TARE	37.25	39.43	LIQUID LIMIT (%)	17.2
MASS OF WATER	1.47	1.43	PLASTIC LIMIT (%)	16.0
MASS OF CONTAINER	27.97	30.57	PLASTICITY INDEX (%)	1.2
MASS OF DRY SOIL	9.28	8.86	W% Natural (%)	5.9
WATER CONTENT W (%)	15.8	16.1	LIQUIDITY INDEX	-8.36



SAMPLE DESCRIPTION : CL

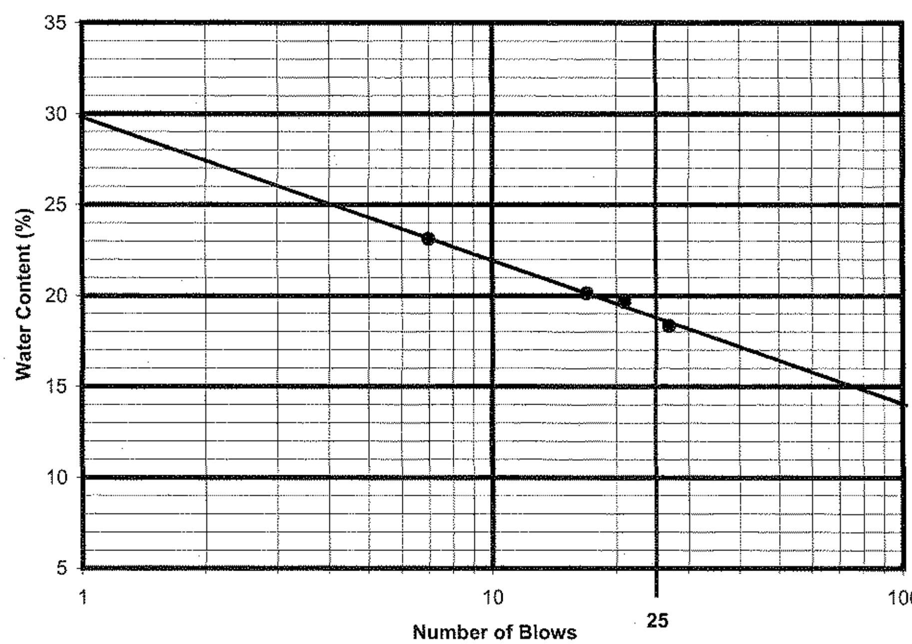
Meadowbank Mining Corporation
Meadowbank Gold Project

Project # 06-1413-081 Tech : TM

Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4318-93

TYPE OF TEST	LL	LL	LL	LL		W% Nat.
CONTAINER NUMBER						
NUMBER OF BLOWS	7	17	21	27		
MASS WET SOIL + TARE	44.13	43.24	46.86	47.16		13779.60
MASS DRY SOIL + TARE	41.27	40.70	43.86	44.26		12164.40
MASS OF WATER	2.86	2.54	3.00	2.90		1615.20
MASS OF CONTAINER	28.89	28.07	28.58	28.41		1269.60
MASS OF DRY SOIL	12.38	12.63	15.28	15.85		10894.8
WATER CONTENT W (%)	23.1	20.1	19.6	18.3		14.8

TYPE OF TEST	PL	PL	BOREHOLE NO.	Lake Bed Till
CONTAINER NUMBER			SAMPLE	4
MASS WET SOIL + TARE	42.47	40.03	DEPTH	
MASS DRY SOIL + TARE	40.56	38.37	LIQUID LIMIT (%)	18.8
MASS OF WATER	1.91	1.66	PLASTIC LIMIT (%)	18.0
MASS OF CONTAINER	29.95	29.17	PLASTICITY INDEX (%)	0.8
MASS OF DRY SOIL	10.61	9.20	W% Natural (%)	14.8
WATER CONTENT W (%)	18.0	18.0	LIQUIDITY INDEX	-4.11



SAMPLE DESCRIPTION : CL

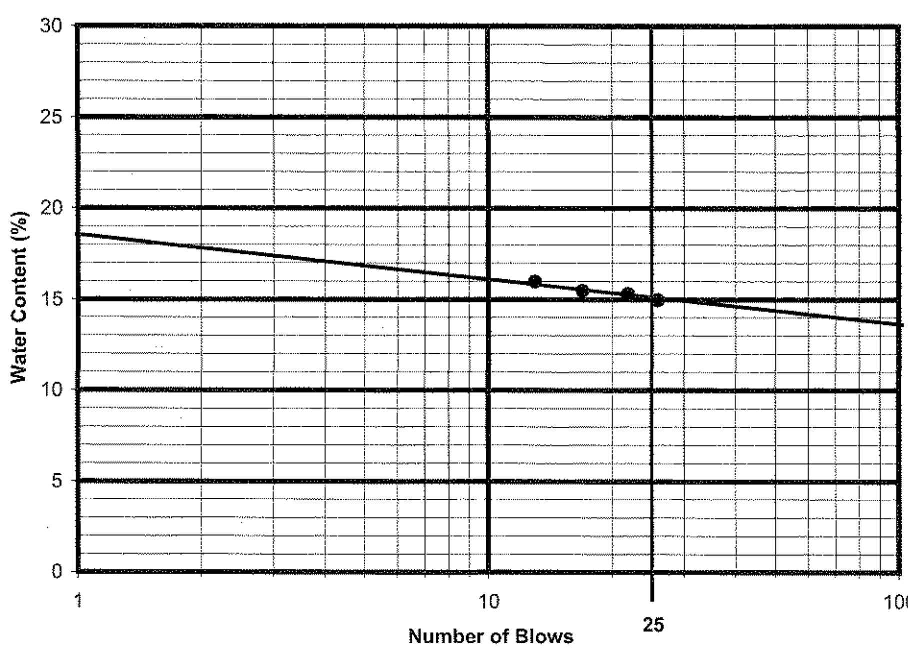
Meadowbank Mining Corporation
Meadowbank Gold Project

Project # 06-1413-081 Tech : TM

Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4318-93

TYPE OF TEST	LL	LL	LL	LL		W% Nat.
CONTAINER NUMBER						
NUMBER OF BLOWS	26	22	17	13		
MASS WET SOIL + TARE	28.97	46.92	44.32	50.34		12396.00
MASS DRY SOIL + TARE	26.86	44.50	42.06	47.34		11936.70
MASS OF WATER	2.11	2.42	2.26	3.00		459.30
MASS OF CONTAINER	12.76	28.67	27.42	28.53		1492.00
MASS OF DRY SOIL	14.10	15.83	14.64	18.81		10444.7
WATER CONTENT W (%)	15.0	15.3	15.4	15.9		4.4

TYPE OF TEST	PL	PL	BOREHOLE NO.	Lake Bed Till
CONTAINER NUMBER			SAMPLE	1
MASS WET SOIL + TARE	31.27	38.04	DEPTH	
MASS DRY SOIL + TARE	30.27	36.81	LIQUID LIMIT (%)	15.0
MASS OF WATER	1.00	1.23	PLASTIC LIMIT (%)	15.1
MASS OF CONTAINER	23.68	28.65	PLASTICITY INDEX (%)	---
MASS OF DRY SOIL	6.59	8.16	W% Natural (%)	4.4
WATER CONTENT W (%)	15.2	15.1	LIQUIDITY INDEX	---



SAMPLE DESCRIPTION : Non Plastic Result

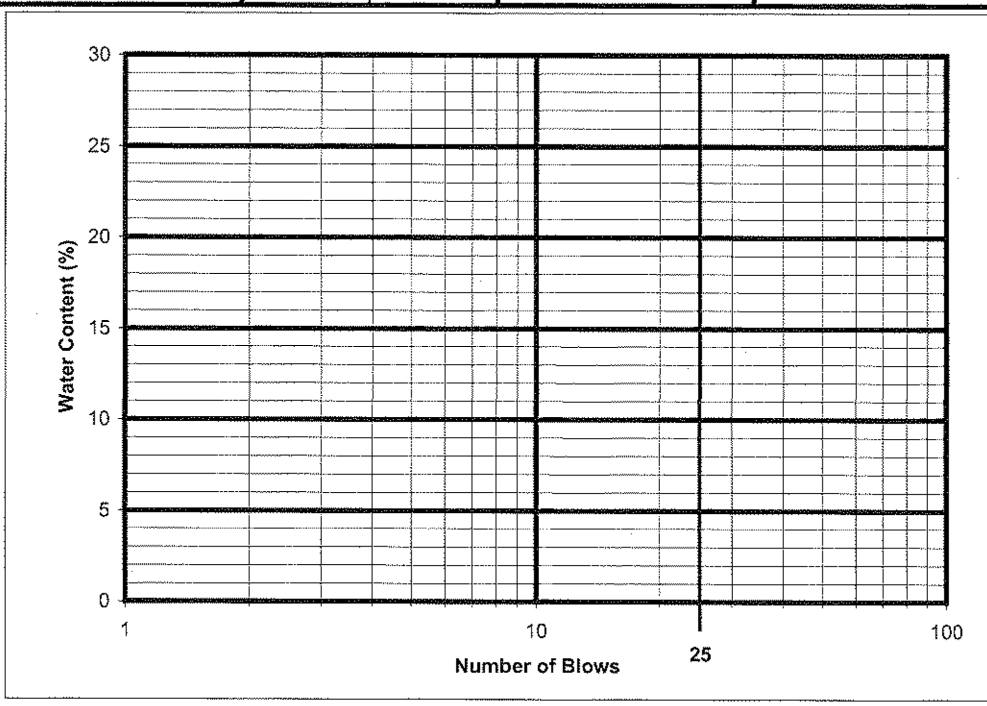
Meadowbank Mining Corporation
Meadowbank Gold Project

Project # 06-1413-081 Tech : TM

Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4318-93

TYPE OF TEST	LL	LL	LL	LL		W% Nat.
CONTAINER NUMBER						
NUMBER OF BLOWS						
MASS WET SOIL + TARE						12923.40
MASS DRY SOIL + TARE						12295.40
MASS OF WATER						628.00
MASS OF CONTAINER						1234.60
MASS OF DRY SOIL						11060.8
WATER CONTENT W (%)						5.7

TYPE OF TEST	PL	PL	BOREHOLE NO.	Lake Bed Till
CONTAINER NUMBER			SAMPLE	2
MASS WET SOIL + TARE			DEPTH	
MASS DRY SOIL + TARE			LIQUID LIMIT (%)	NA
MASS OF WATER			PLASTIC LIMIT (%)	NA
MASS OF CONTAINER			PLASTICITY INDEX (%)	NA
MASS OF DRY SOIL			W% Natural (%)	5.7
WATER CONTENT W (%)			LIQUIDITY INDEX	NA



SAMPLE DESCRIPTION : Non Plastic Result
Could not achieve 25 blows

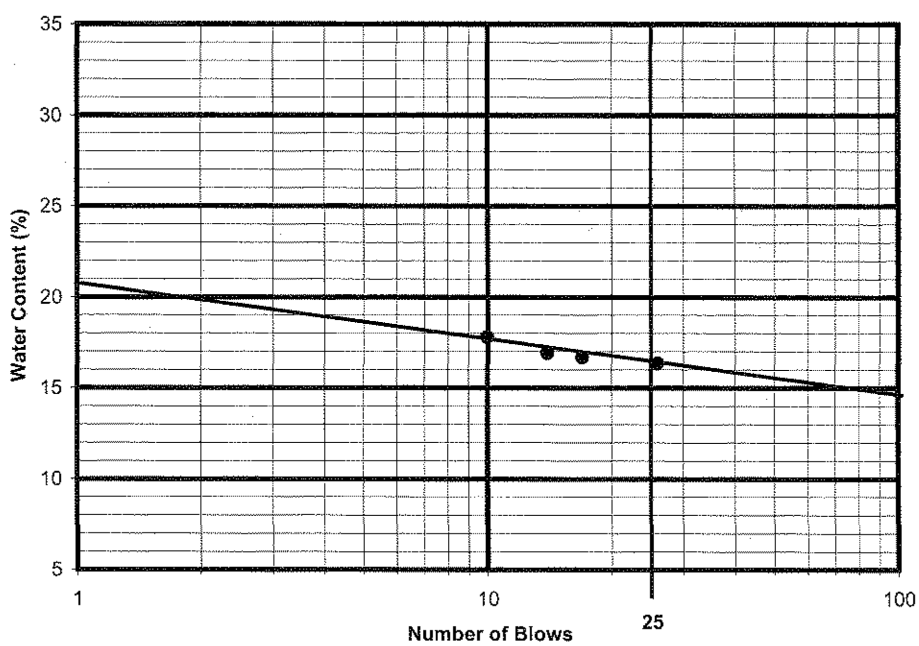
Meadowbank Mining Corporation
Meadowbank Gold Project

Project # 06-1413-081 Tech : TM

Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4318-93

TYPE OF TEST	LL	LL	LL	LL		W% Nat.
CONTAINER NUMBER						
NUMBER OF BLOWS	26	17	14	10		
MASS WET SOIL + TARE	16.96	21.93	19.36	19.59		12648.00
MASS DRY SOIL + TARE	14.79	19.01	16.78	16.86		12072.40
MASS OF WATER	2.17	2.92	2.58	2.73		575.60
MASS OF CONTAINER	1.50	1.49	1.51	1.50		1230.10
MASS OF DRY SOIL	13.29	17.52	15.27	15.36		10842.3
WATER CONTENT W (%)	16.3	16.7	16.9	17.8		5.3

TYPE OF TEST	PL	PL	BOREHOLE NO.	Lake Bed Till
CONTAINER NUMBER			SAMPLE	5
MASS WET SOIL + TARE	11.61	9.40	DEPTH	
MASS DRY SOIL + TARE	10.26	8.32	LIQUID LIMIT (%)	16.3
MASS OF WATER	1.35	1.08	PLASTIC LIMIT (%)	15.8
MASS OF CONTAINER	1.54	1.60	PLASTICITY INDEX (%)	0.5
MASS OF DRY SOIL	8.72	6.72	W% Natural (%)	5.3
WATER CONTENT W (%)	15.5	16.1	LIQUIDITY INDEX	-20.00



SAMPLE DESCRIPTION : CL

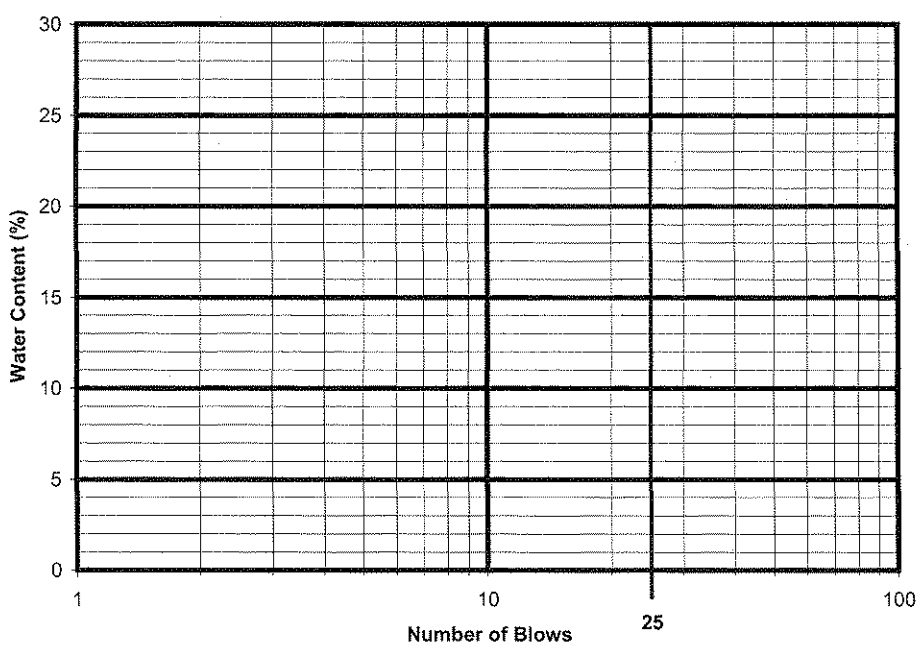
Meadowbank Mining Corporation
Meadowbank Gold Project

Project # 06-1413-081 Tech : TM

Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4318-93

TYPE OF TEST	LL	LL	LL	LL		W% Nat.
CONTAINER NUMBER						
NUMBER OF BLOWS						
MASS WET SOIL + TARE						18496.00
MASS DRY SOIL + TARE						17672.50
MASS OF WATER						823.50
MASS OF CONTAINER						1134.70
MASS OF DRY SOIL						16537.8
WATER CONTENT W (%)						5.0

TYPE OF TEST	PL	PL	BOREHOLE NO.	Lake Bed Till
CONTAINER NUMBER			SAMPLE	6 & 7
MASS WET SOIL + TARE			DEPTH	
MASS DRY SOIL + TARE			LIQUID LIMIT (%)	NA
MASS OF WATER			PLASTIC LIMIT (%)	NA
MASS OF CONTAINER			PLASTICITY INDEX (%)	NA
MASS OF DRY SOIL			W% Natural (%)	5.0
WATER CONTENT W (%)			LIQUIDITY INDEX	NA



SAMPLE DESCRIPTION : Non Plastic Result
Could not achieve 25 blows

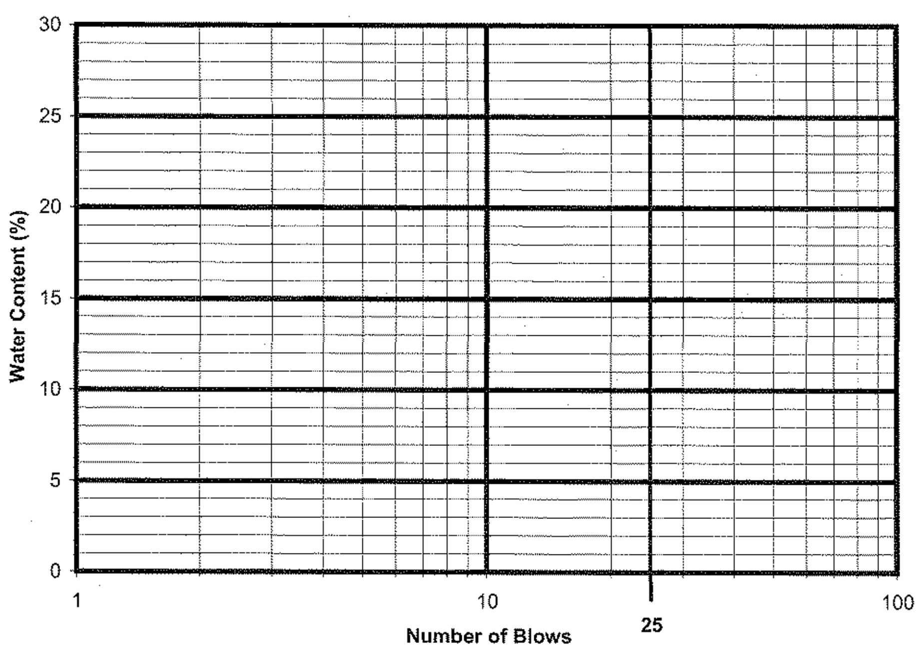
Meadowbank Mining Corporation
Meadowbank Gold Project

Project # 06-1413-081 Tech : TM

Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4318-93

TYPE OF TEST	LL	LL	LL	LL		W% Nat.
CONTAINER NUMBER						
NUMBER OF BLOWS						
MASS WET SOIL + TARE						14752.30
MASS DRY SOIL + TARE						14213.90
MASS OF WATER						538.40
MASS OF CONTAINER						1425.90
MASS OF DRY SOIL						12788.0
WATER CONTENT W (%)						4.2

TYPE OF TEST	PL	PL	BOREHOLE NO.	Lake Bed Till
CONTAINER NUMBER			SAMPLE	8
MASS WET SOIL + TARE			DEPTH	
MASS DRY SOIL + TARE			LIQUID LIMIT (%)	NA
MASS OF WATER			PLASTIC LIMIT (%)	NA
MASS OF CONTAINER			PLASTICITY INDEX (%)	NA
MASS OF DRY SOIL			W% Natural (%)	4.2
WATER CONTENT W (%)			LIQUIDITY INDEX	NA



SAMPLE DESCRIPTION : Non Plastic Result
Could not achieve 25 blows

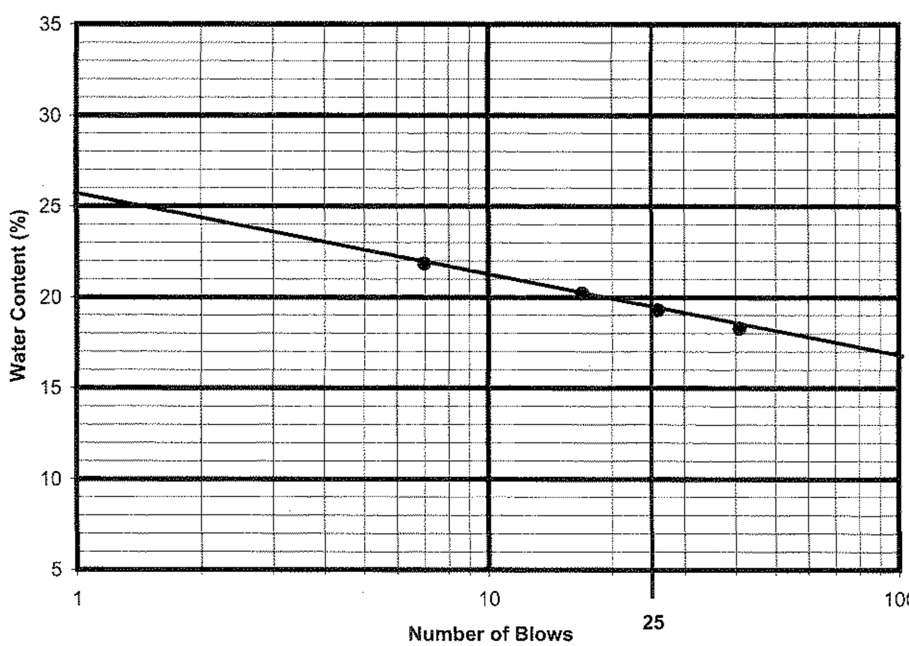
Meadowbank Mining Corporation
Meadowbank Gold Project

Project # 06-1413-081 Tech : TM

Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4318-93

TYPE OF TEST	LL	LL	LL	LL		W% Nat.
CONTAINER NUMBER						
NUMBER OF BLOWS	7	17	26	41		
MASS WET SOIL + TARE	46.50	46.20	45.36	46.10		19462.20
MASS DRY SOIL + TARE	43.34	43.47	42.62	43.31		18083.10
MASS OF WATER	3.16	2.73	2.74	2.79		1379.10
MASS OF CONTAINER	28.87	29.95	28.42	28.05		1218.20
MASS OF DRY SOIL	14.47	13.52	14.20	15.26		16864.9
WATER CONTENT W (%)	21.8	20.2	19.3	18.3		8.2

TYPE OF TEST	PL	PL	BOREHOLE NO.	Lake Bed Till
CONTAINER NUMBER			SAMPLE	12
MASS WET SOIL + TARE	36.42	37.44	DEPTH	
MASS DRY SOIL + TARE	35.44	36.11	LIQUID LIMIT (%)	19.4
MASS OF WATER	0.98	1.33	PLASTIC LIMIT (%)	17.6
MASS OF CONTAINER	29.85	28.57	PLASTICITY INDEX (%)	1.8
MASS OF DRY SOIL	5.59	7.54	W% Natural (%)	8.2
WATER CONTENT W (%)	17.5	17.6	LIQUIDITY INDEX	-5.18



SAMPLE DESCRIPTION : CL

Meadowbank Mining Corporation
Meadowbank Gold Project

TILL WATER CONTENT

Project Number : 06-1413-081 Tech : TM

Laboratory Determination of Water Content of Soil and Rock
ASTM D 2216-92

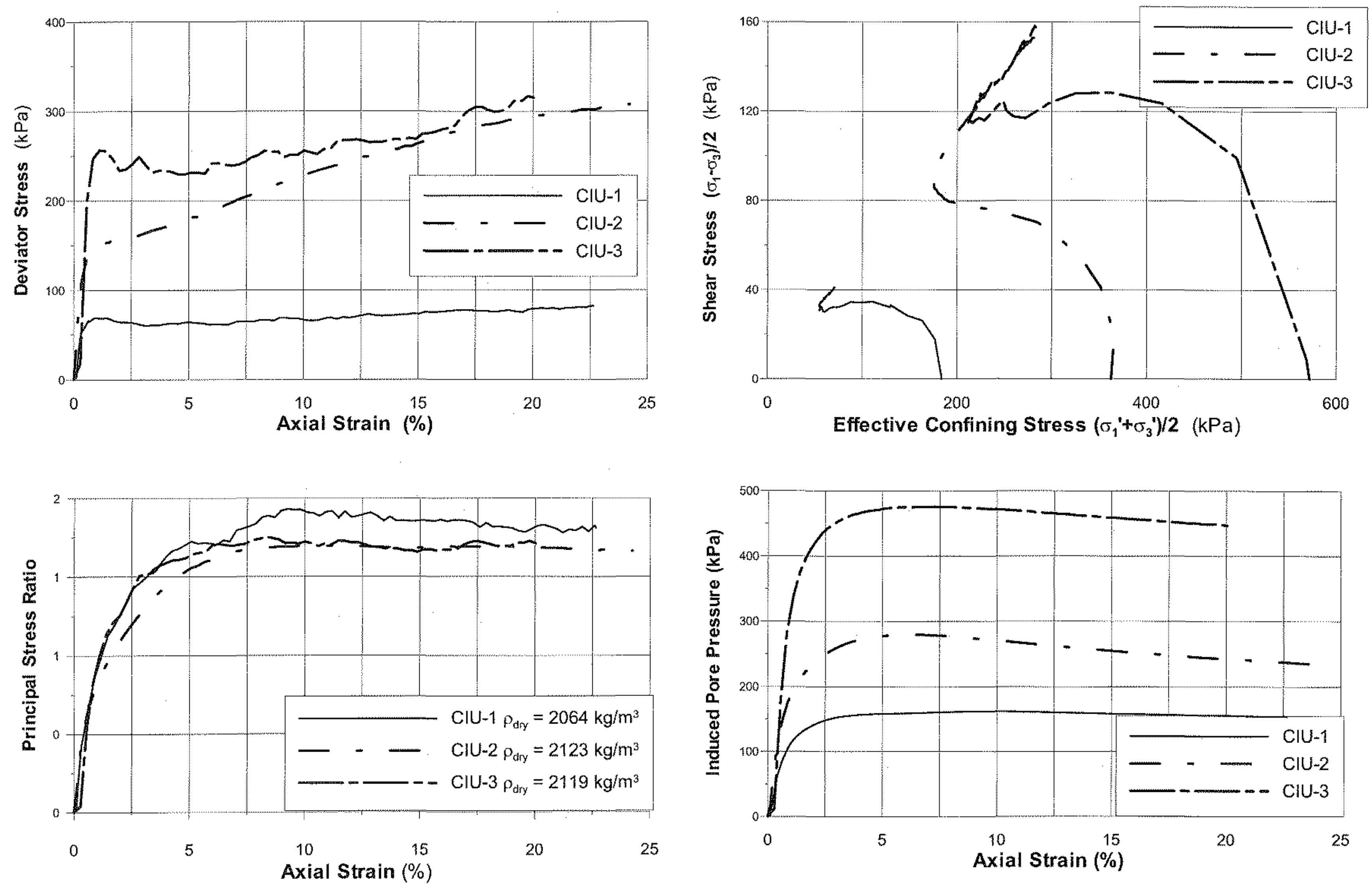
Borehole	Till Spoil	Till Spoil	Till	Till, Grassland	Till Spoil	Till Spoil
Sample Number	1	2	3	4	5	6 & 7
Depth (m)						
CONTAINER NUMBER						
MASS WET SOIL + TARE	12396.0	12923.4	13376.3	13779.6	12648.0	18496.0
MASS DRY SOIL + TARE	11936.7	12295.4	12704.8	12164.4	12072.4	17672.5
MASS OF WATER	459.3	628.0	671.5	1615.2	575.6	823.5
MASS OF CONTAINER	1492.0	1234.6	1269.6	1216.8	1230.1	1134.7
MASS OF DRY SOIL	10444.7	11060.8	11435.2	10947.6	10842.3	16537.8
Water Content W (%)	4.4	5.7	5.9	14.8	5.3	5.0

Borehole	Till Spoil			Till, Trenches		
Sample Number	8	9 & 10	11	12		
Depth (m)						
CONTAINER NUMBER						
MASS WET SOIL + TARE	14752.3	15848.8	18746.3	19462.2		
MASS DRY SOIL + TARE	14213.9	14909.6	17042.3	18083.1		
MASS OF WATER	538.4	939.2	1704.0	1379.1		
MASS OF CONTAINER	1425.9	1472.6	1425.9	1218.2		
MASS OF DRY SOIL	12788.0	13437.0	15616.4	16864.9		
Water Content W (%)	4.2	7.0	10.9	8.2		

Borehole						
Sample Number						
Depth (m)						
CONTAINER NUMBER						
MASS WET SOIL + TARE						
MASS DRY SOIL + TARE						
MASS OF WATER						
MASS OF CONTAINER						
MASS OF DRY SOIL						
Water Content W (%)						

Meadowbank Mining Corporation
Meadowbank Gold Project

TILL TRIAXIAL



Golder Associates	Project No. 06-1413-081 Drawn AS Reviewed Date 03/09/07	**CONSOLIDATED ISOTROPIC UNDRAINED TRIAXIAL TEST** **TILL SAMPLES 3, 6 AND 7 COMPOSITE** **Meadowbank Mining Corporation** **Meadowbank Gold Project**	**Figure I-12**

Undrained Triaxial Compression Test

Project No. :	06-1413-081/5000	**Client :**	Meadowbank Mining Corporation	**Location :**	
Sch No.		**Project :**	Dike Design	**Type :**	Lake Bed Till
Lab Work:	ROB	**Location:**	Meadowbank Gold Project	**Depth :**	
Test ID:	CIU - 1				

Equipment

Machine:	Trautwein
Chamber:	C2
Load Cell:	206856
Axial DCDT:	LP-175
Cell Pressure:	PS-3118
Back Pressure:	PS-3125
Pore Pressure:	PS-2232

Specimen Geometry

	Initial	Final
Height (mm) =	128.13	98.13
Diameter (mm) =	73.05	83.05
Area (cm^2) =	41.91	54.17
Volume (cm^3) =	537.02	537.02

Phase Relationships

	Initial	Final
e =	0.32	0.32
ρ_{sat} (kg/m^3) =	2308	2308
ρ_{dry} (kg/m^3) =	2064	2064
Gs =	2.73	

Strength Results

q_{MAX} (kPa) :	82.2
Strain @ =	22.63
η_{MAX} =	1.54
Strain @ =	9.25
B Value	0.96
Target Mean Effective Stress (kPa)	183.55

Axial Strain (%)	Load (kN)	ΔU (kPa)	Cell Pressure (kPa)	Pore Pressure (kPa)	A_c (cm^2)	σ_1' (kPa)	σ_3' (kPa)	p' (kPa)	q (kPa)	Stress ratio η
0.00	0.00	0.00	955.98	772.4	41.9	183.6	183.6	183.6	0.0	0.00
0.11	0.01	0.92	955.55	773.3	42.0	185.0	182.2	183.1	2.8	0.02
0.22	0.15	23.72	955.42	796.1	42.0	194.7	159.3	171.1	35.4	0.21
0.32	0.22	46.31	955.86	818.7	42.0	189.6	137.1	154.6	52.5	0.34
0.44	0.24	63.63	955.68	836.1	42.1	176.4	119.6	138.6	56.8	0.41
0.63	0.28	86.38	955.85	858.8	42.2	163.0	97.0	119.0	66.0	0.55
0.63	0.27	86.21	955.75	858.6	42.2	161.5	97.1	118.6	64.4	0.54
0.91	0.29	106.71	955.63	879.1	42.3	145.7	76.5	99.6	69.2	0.70
1.18	0.29	119.71	955.53	892.1	42.4	131.8	63.4	86.2	68.4	0.79
1.46	0.29	129.23	955.37	901.7	42.5	122.7	53.7	76.7	69.0	0.90
1.74	0.28	135.89	955.52	908.3	42.7	113.1	47.2	69.2	65.9	0.95
2.03	0.27	141.34	955.57	913.8	42.8	106.0	41.8	63.2	64.2	1.02
2.30	0.28	145.24	955.67	917.7	42.9	102.2	38.0	59.4	64.2	1.08
2.57	0.27	148.61	955.42	921.0	43.0	97.9	34.4	55.6	63.6	1.14
2.87	0.27	150.98	955.44	923.4	43.2	93.7	32.0	52.6	61.7	1.17
3.14	0.26	152.87	955.40	925.3	43.3	90.2	30.1	50.1	60.1	1.20
3.41	0.26	154.13	955.44	926.6	43.4	89.7	28.9	49.2	60.8	1.24
3.69	0.26	155.52	955.91	928.0	43.5	88.7	28.0	48.2	60.7	1.26
3.97	0.27	156.01	955.50	928.4	43.6	89.2	27.1	47.8	62.1	1.30
4.25	0.27	156.88	955.48	929.3	43.8	88.8	26.2	47.1	62.7	1.33
4.54	0.27	157.34	955.45	929.8	43.9	88.1	25.7	46.5	62.5	1.34
4.79	0.28	157.57	955.63	930.0	44.0	89.5	25.6	46.9	63.8	1.36
5.08	0.28	157.87	955.44	930.3	44.2	89.4	25.1	46.6	64.2	1.38
5.36	0.28	157.92	955.53	930.3	44.3	88.6	25.2	46.3	63.4	1.37
5.63	0.28	158.24	955.52	930.7	44.4	87.8	24.8	45.8	62.9	1.37
5.91	0.27	158.60	955.42	931.0	44.5	85.9	24.4	44.9	61.5	1.37
6.19	0.28	158.66	955.85	931.1	44.7	86.6	24.8	45.4	61.9	1.36
6.47	0.28	158.99	955.32	931.4	44.8	85.6	23.9	44.5	61.7	1.39
6.74	0.28	159.35	955.81	931.8	44.9	85.5	24.0	44.5	61.4	1.38
7.02	0.29	159.70	955.46	932.1	45.1	87.6	23.3	44.8	64.3	1.44
7.30	0.29	160.27	955.98	932.7	45.2	88.2	23.3	44.9	64.9	1.44
7.57	0.29	160.58	955.91	933.0	45.3	87.7	22.9	44.5	64.8	1.46
7.86	0.29	160.61	955.56	933.0	45.5	87.3	22.5	44.1	64.8	1.47
8.13	0.30	161.09	955.63	933.5	45.6	88.6	22.1	44.3	66.5	1.50
8.42	0.30	161.11	955.41	933.5	45.8	88.4	21.9	44.1	66.6	1.51
8.70	0.30	161.50	955.72	933.9	45.9	87.4	21.8	43.7	65.6	1.50
8.96	0.32	161.28	955.54	933.7	46.0	90.6	21.8	44.7	68.7	1.54
9.25	0.32	161.89	955.89	934.3	46.2	90.3	21.6	44.5	68.7	1.54
9.54	0.32	161.80	955.72	934.2	46.3	89.6	21.5	44.2	68.1	1.54
9.80	0.32	161.92	955.77	934.3	46.5	89.4	21.4	44.1	68.0	1.54
10.08	0.31	161.99	955.63	934.4	46.6	87.3	21.2	43.2	66.1	1.53
10.36	0.31	161.78	955.46	934.2	46.8	87.1	21.3	43.2	65.8	1.52
10.64	0.31	161.31	955.48	933.7	46.9	87.8	21.7	43.8	66.0	1.51
10.91	0.32	161.40	955.59	933.8	47.0	89.8	21.8	44.4	68.0	1.53
11.18	0.33	160.94	955.39	933.4	47.2	91.2	22.0	45.1	69.2	1.53
11.47	0.32	160.58	955.45	933.0	47.3	89.9	22.5	44.9	67.4	1.50
11.73	0.33	160.78	955.43	933.2	47.5	91.9	22.2	45.5	69.7	1.53
12.03	0.33	160.40	955.73	932.8	47.6	91.9	22.9	45.9	69.0	1.50
12.30	0.34	160.17	955.69	932.6	47.8	93.3	23.1	46.5	70.2	1.51
12.57	0.34	159.98	955.68	932.4	47.9	94.8	23.3	47.1	71.6	1.52
12.85	0.35	159.68	955.55	932.1	48.1	96.5	23.4	47.8	73.0	1.53
13.14	0.35	159.47	955.53	931.9	48.3	95.5	23.6	47.6	71.8	1.51
13.42	0.34	159.33	955.97	931.8	48.4	95.4	24.2	47.9	71.2	1.48
13.70	0.35	158.95	955.09	931.4	48.6	95.4	23.7	47.6	71.7	1.51
13.97	0.35	158.72	955.55	931.1	48.7	96.2	24.4	48.4	71.8	1.49

Axial Strain (%)	Load (kN)	ΔU (kPa)	Cell Pressure (kPa)	Pore Pressure (kPa)	A_c (cm^2)	σ_1' (kPa)	σ_3' (kPa)	p' (kPa)	q (kPa)	Stress ratio η		
14.25	0.35	158.60	955.66	931.0	48.9	97.2	24.6	48.8	72.6	1.49		
14.52	0.36	158.40	955.60	930.8	49.0	97.6	24.8	49.0	72.8	1.48		
14.80	0.36	158.04	955.58	930.5	49.2	98.8	25.1	49.7	73.7	1.48		
15.07	0.36	158.09	955.39	930.5	49.4	98.3	24.9	49.4	73.4	1.49		
15.36	0.37	157.71	955.81	930.1	49.5	101.4	25.7	50.9	75.7	1.49		
15.63	0.37	157.41	955.47	929.8	49.7	100.9	25.6	50.7	75.2	1.48		
15.91	0.38	157.56	955.50	930.0	49.8	101.2	25.5	50.8	75.7	1.49		
16.18	0.38	157.12	955.49	929.5	50.0	102.0	25.9	51.3	76.0	1.48		
16.47	0.39	156.98	955.46	929.4	50.2	103.1	26.1	51.7	77.0	1.49		
16.75	0.39	156.94	955.55	929.4	50.3	103.6	26.2	52.0	77.4	1.49		
17.03	0.39	156.75	955.53	929.2	50.5	103.9	26.4	52.2	77.5	1.49		
17.32	0.39	156.49	955.52	928.9	50.7	103.9	26.6	52.4	77.3	1.48		
17.59	0.39	156.15	955.75	928.6	50.9	103.7	27.2	52.7	76.5	1.45		
17.87	0.39	156.47	955.42	928.9	51.0	103.5	26.5	52.2	77.0	1.48		
18.15	0.39	156.20	955.63	928.6	51.2	103.2	27.0	52.4	76.2	1.45		
18.43	0.39	155.76	954.92	928.2	51.4	102.4	26.7	52.0	75.7	1.46		
18.70	0.40	155.86	955.54	928.3	51.6	104.1	27.3	52.9	76.8	1.45		
18.98	0.40	155.55	955.64	928.0	51.7	105.2	27.7	53.5	77.5	1.45		
19.27	0.39	155.55	955.61	928.0	51.9	103.6	27.6	53.0	76.0	1.43		
19.56	0.39	155.30	955.32	927.7	52.1	102.7	27.6	52.6	75.1	1.43		
19.83	0.41	155.31	955.99	927.7	52.3	106.9	28.3	54.5	78.6	1.44		
20.10	0.41	155.16	955.41	927.6	52.5	106.8	27.8	54.1	79.0	1.46		
20.37	0.42	155.00	955.28	927.4	52.6	107.6	27.9	54.5	79.8	1.47		
20.65	0.42	154.76	955.27	927.2	52.8	107.5	28.1	54.5	79.4	1.46		
20.92	0.42	154.31	955.34	926.7	53.0	108.3	28.6	55.2	79.7	1.44		
21.20	0.42	154.28	955.70	926.7	53.2	107.6	29.0	55.2	78.6	1.42		
21.50	0.43	154.28	955.53	926.7	53.4	108.8	28.8	55.5	80.0	1.44		
21.77	0.43	154.17	955.70	926.6	53.6	109.2	29.1	55.8	80.1	1.44		
22.04	0.44	154.33	955.47	926.8	53.8	109.8	28.7	55.7	81.0	1.45		
22.31	0.43	153.67	955.59	926.1	54.0	110.1	29.5	56.4	80.6	1.43		
22.58	0.44	154.01	955.29	926.4	54.1	110.9	28.9	56.2	82.1	1.46		
22.83	0.45	153.84	955.53	926.3	54.2	111.4	29.3	56.7	82.2	1.45		

Undrained Triaxial Compression Test

Project No. :	06-1413-081/5000	**Client :**	Meadowbank Mining Corporation	**Location :**	
Sch No.		**Project :**	Dike Design	**Type :**	Lake Bed Till
Lab Work:	ROB	**Location:**	Meadowbank Gold Project	**Depth :**	
Test ID:	CIU - 2				

Equipment

Machine:	Trautwein
Chamber:	C1
Load Cell:	205859
Axial DCDT:	LP-175
Cell Pressure:	PS-3118
Back Pressure:	PS-3125
Pore Pressure:	PS-2232

Specimen Geometry

	Initial	Final
Height (mm) =	118.39	89.72
Diameter (mm) =	69.53	79.87
Area (cm^2) =	37.97	50.10
Volume (cm^3) =	449.50	449.50

Phase Relationships

	Initial	Final
e =	**0.29**	**0.29**
ρ_{sat} (kg/m^3) =	**2345**	**2345**
ρ_{dry} (kg/m^3) =	**2123**	**2123**
Gs =	2.73	

Strength Results

q_{MAX} (kPa)	308.2
Strain @ =	23.80
η_{MAX} =	1.36
Strain @ =	11.10
B Value	0.96
Target Mean Effective Stress (kPa)	362.69

Axial Strain (%)	Load (kN)	ΔU (kPa)	Cell Pressure (kPa)	Pore Pressure (kPa)	A_c (cm^2)	σ_1' (kPa)	σ_3' (kPa)	p' (kPa)	q (kPa)	Stress ratio η		
0.00	0.00	0.00	1090.60	727.9	38.0	362.7	362.7	362.7	0.0	0.00		
0.11	0.14	15.48	1090.64	743.4	38.0	385.0	347.3	359.8	37.7	0.10		
0.21	0.31	52.34	1090.84	780.3	38.0	392.8	310.6	338.0	82.2	0.24		
0.32	0.41	85.55	1090.50	813.5	38.1	385.4	277.0	313.2	108.3	0.35		
0.44	0.47	112.21	1090.52	840.1	38.1	373.4	250.4	291.4	123.0	0.42		
0.55	0.51	133.35	1090.57	861.3	38.2	364.0	229.3	274.2	134.7	0.49		
0.66	0.54	150.02	1090.67	877.9	38.2	353.5	212.7	259.7	140.8	0.54		
0.77	0.55	163.57	1090.76	891.5	38.3	343.0	199.3	247.2	143.7	0.58		
0.87	0.56	175.27	1090.64	903.2	38.3	333.8	187.5	236.2	146.3	0.62		
0.99	0.57	184.74	1090.64	912.7	38.3	326.7	178.0	227.6	148.7	0.65		
1.10	0.58	193.31	1090.76	921.2	38.4	321.3	169.5	220.1	151.8	0.69		
1.21	0.58	200.38	1090.68	928.3	38.4	313.5	162.4	212.8	151.2	0.71		
1.32	0.59	207.02	1090.60	934.9	38.5	308.4	155.7	206.6	152.8	0.74		
1.43	0.59	213.10	1090.82	941.0	38.5	303.1	149.8	200.9	153.3	0.76		
1.53	0.59	218.41	1090.79	946.3	38.6	298.2	144.5	195.7	153.7	0.79		
1.65	0.60	223.08	1090.69	951.0	38.6	294.9	139.7	191.4	155.2	0.81		
1.77	0.60	227.69	1090.83	955.6	38.7	289.6	135.2	186.7	154.4	0.83		
1.88	0.60	231.52	1090.49	959.4	38.7	286.0	131.1	182.7	155.0	0.85		
1.98	0.61	235.05	1090.50	963.0	38.7	284.4	127.5	179.8	156.9	0.87		
2.10	0.61	238.98	1090.64	966.9	38.8	281.1	123.7	176.2	157.4	0.89		
2.21	0.61	242.07	1090.50	970.0	38.8	278.9	120.5	173.3	158.3	0.91		
2.31	0.61	244.83	1090.48	972.7	38.9	275.9	117.7	170.4	158.1	0.93		
2.58	0.62	251.60	1090.63	979.5	39.0	270.6	111.1	164.3	159.5	0.97		
2.85	0.63	256.86	1090.60	984.8	39.1	267.4	105.8	159.7	161.6	1.01		
3.13	0.64	261.45	1090.67	989.4	39.2	265.7	101.3	156.1	164.4	1.05		
3.40	0.65	265.47	1090.61	993.4	39.3	263.4	97.2	152.6	166.2	1.09		
3.69	0.67	268.71	1090.70	996.6	39.4	263.0	94.1	150.4	168.9	1.12		
3.96	0.67	271.36	1090.39	999.3	39.5	261.7	91.1	148.0	170.5	1.15		
4.22	0.68	273.60	1090.61	1001.5	39.6	261.8	89.1	146.6	172.7	1.18		
4.51	0.70	275.30	1090.78	1003.2	39.8	263.7	87.6	146.3	176.1	1.20		
4.78	0.71	276.48	1090.74	1004.4	39.9	264.5	86.4	145.7	178.1	1.22		
5.07	0.73	277.64	1090.82	1005.6	40.0	266.7	85.3	145.8	181.5	1.24		
5.33	0.73	278.39	1090.57	1006.3	40.1	266.0	84.3	144.9	181.8	1.25		
5.60	0.74	279.02	1090.64	1006.9	40.2	268.8	83.7	145.4	185.1	1.27		
5.88	0.76	279.06	1090.55	1007.0	40.3	271.3	83.6	146.1	187.7	1.28		
6.15	0.77	279.50	1090.93	1007.4	40.5	274.4	83.5	147.1	190.8	1.30		
6.43	0.78	279.23	1090.62	1007.1	40.6	276.6	83.5	147.9	193.2	1.31		
6.71	0.80	279.42	1090.66	1007.3	40.7	279.9	83.3	148.8	196.5	1.32		
6.98	0.81	278.78	1090.45	1006.7	40.8	282.9	83.8	150.1	199.1	1.33		
7.25	0.83	278.36	1090.63	1006.3	40.9	286.7	84.4	151.8	202.3	1.33		
7.52	0.84	278.09	1090.65	1006.0	41.1	288.9	84.6	152.7	204.3	1.34		
7.79	0.85	277.46	1090.68	1005.4	41.2	292.1	85.3	154.2	206.8	1.34		
8.08	0.87	276.50	1090.30	1004.4	41.3	296.1	85.9	156.0	210.2	1.35		
8.36	0.88	275.92	1090.67	1003.8	41.4	299.1	86.8	157.6	212.3	1.35		
8.62	0.89	274.92	1090.51	1002.8	41.6	302.5	87.7	159.3	214.8	1.35		
8.91	0.91	274.19	1090.72	1002.1	41.7	307.0	88.6	161.4	218.4	1.35		
9.18	0.92	273.26	1090.77	1001.2	41.8	309.7	89.6	163.0	220.1	1.35		
9.44	0.93	272.25	1090.70	1000.2	41.9	313.4	90.5	164.8	222.8	1.35		
9.73	0.95	271.25	1090.59	999.2	42.1	317.6	91.4	166.8	226.1	1.36		
10.00	0.96	270.42	1090.85	998.3	42.2	320.2	92.5	168.4	227.6	1.35		
10.28	0.98	269.63	1090.72	997.5	42.3	323.7	93.2	170.0	230.5	1.36		
10.56	0.99	268.71	1090.55	996.6	42.5	326.5	93.9	171.4	232.5	1.36		
10.83	1.00	267.67	1090.67	995.6	42.6	329.9	95.1	173.4	234.8	1.35		
11.10	1.01	266.86	1090.52	994.8	42.7	332.9	95.7	174.8	237.1	1.36		
11.38	1.02	265.93	1090.57	993.8	42.8	335.7	96.7	176.4	239.0	1.35		

Axial Strain (%)	Load (kN)	ΔU (kPa)	Cell Pressure (kPa)	Pore Pressure (kPa)	A_c (cm^2)	σ_1' (kPa)	σ_3' (kPa)	p' (kPa)	q (kPa)	Stress ratio η		
11.66	1.04	264.86	1090.68	992.8	43.0	339.1	97.9	178.3	241.1	1.35		
11.95	1.05	264.07	1090.60	992.0	43.1	341.4	98.6	179.5	242.7	1.35		
12.22	1.06	263.16	1090.69	991.1	43.3	345.5	99.6	181.6	245.9	1.35		
12.48	1.08	262.55	1091.04	990.5	43.4	348.8	100.6	183.3	248.2	1.35		
12.76	1.08	261.54	1090.59	989.5	43.5	350.1	101.1	184.1	249.0	1.35		
13.03	1.10	260.58	1090.57	988.5	43.7	353.1	102.1	185.8	251.1	1.35		
13.32	1.11	259.61	1090.49	987.5	43.8	355.9	103.0	187.3	252.9	1.35		
13.60	1.12	258.67	1090.67	986.6	43.9	359.2	104.1	189.1	255.1	1.35		
13.86	1.13	257.84	1090.55	985.8	44.1	361.6	104.8	190.4	256.8	1.35		
14.14	1.14	257.22	1090.61	985.1	44.2	363.0	105.5	191.3	257.5	1.35		
14.41	1.16	256.42	1090.65	984.3	44.4	367.0	106.3	193.2	260.7	1.35		
14.69	1.16	255.58	1090.17	983.5	44.5	367.3	106.7	193.5	260.6	1.35		
14.98	1.18	254.71	1090.50	982.6	44.7	371.4	107.9	195.7	263.5	1.35		
15.24	1.19	253.92	1090.44	981.8	44.8	374.2	108.6	197.1	265.6	1.35		
15.51	1.20	253.23	1090.54	981.1	44.9	375.6	109.4	198.1	266.2	1.34		
15.79	1.21	252.51	1090.52	980.4	45.1	377.9	110.1	199.4	267.8	1.34		
16.07	1.22	251.81	1090.54	979.7	45.2	381.0	110.8	200.9	270.1	1.34		
16.35	1.25	251.11	1090.64	979.0	45.4	387.0	111.6	203.4	275.4	1.35		
16.63	1.26	250.22	1090.70	978.1	45.5	388.9	112.6	204.7	276.3	1.35		
16.88	1.27	249.76	1090.50	977.7	45.7	391.2	112.8	205.6	278.4	1.35		
17.17	1.28	249.04	1090.55	976.9	45.8	393.2	113.6	206.8	279.6	1.35		
17.46	1.29	248.45	1090.44	976.4	46.0	395.4	114.1	207.8	281.3	1.35		
17.72	1.31	247.83	1090.48	975.7	46.1	397.8	114.7	209.1	283.0	1.35		
18.00	1.32	247.12	1090.68	975.0	46.3	400.5	115.6	210.6	284.9	1.35		
18.28	1.33	246.52	1090.63	974.4	46.5	401.5	116.2	211.3	285.3	1.35		
18.55	1.34	245.75	1090.43	973.7	46.6	403.5	116.8	212.3	286.8	1.35		
18.82	1.35	245.24	1090.63	973.2	46.8	406.2	117.5	213.7	288.7	1.35		
19.09	1.36	244.48	1090.63	972.4	46.9	408.9	118.2	215.1	290.6	1.35		
19.37	1.37	243.77	1090.56	971.7	47.1	410.0	118.9	215.9	291.1	1.35		
19.65	1.39	243.30	1090.83	971.2	47.3	412.8	119.6	217.3	293.1	1.35		
19.92	1.40	242.73	1090.66	970.6	47.4	414.2	120.0	218.1	294.2	1.35		
20.20	1.40	242.04	1090.38	969.9	47.6	415.6	120.4	218.8	295.2	1.35		
20.49	1.41	241.68	1090.57	969.6	47.8	416.6	121.0	219.5	295.7	1.35		
20.76	1.42	241.08	1090.64	969.0	47.9	418.7	121.6	220.7	297.1	1.35		
21.03	1.43	240.75	1090.72	968.7	48.1	420.2	122.1	221.4	298.1	1.35		
21.32	1.44	239.90	1090.56	967.8	48.3	421.9	122.7	222.5	299.1	1.34		
21.58	1.45	239.52	1090.95	967.4	48.4	422.7	123.5	223.2	299.1	1.34		
21.87	1.46	238.84	1090.68	966.8	48.6	424.2	123.9	224.0	300.2	1.34		
22.15	1.47	238.53	1090.93	966.4	48.8	426.3	124.5	225.1	301.8	1.34		
22.42	1.48	237.89	1090.88	965.8	48.9	427.0	125.1	225.7	302.0	1.34		
22.70	1.48	237.08	1090.70	965.0	49.1	427.4	125.7	226.3	301.7	1.33		
22.96	1.50	236.64	1090.55	964.5	49.3	430.0	126.0	227.3	304.0	1.34		
23.24	1.51	236.19	1090.62	964.1	49.5	431.7	126.5	228.2	305.2	1.34		
23.52	1.52	235.29	1090.53	963.2	49.6	432.9	127.3	229.2	305.6	1.33		
23.80	1.54	234.96	1090.52	962.9	49.8	435.9	127.6	230.4	308.2	1.34		
24.06	1.54	234.68	1090.80	962.6	50.0	435.4	128.2	230.6	307.2	1.33		
24.22	1.54	234.15	1090.76	962.1	50.1	436.1	128.7	231.2	307.4	1.33		

Undrained Triaxial Compression Test

Project No. :	06-1413-081/5000	**Client :**	Meadowbank Mining Corporation	**Location :**	
Sch No.		**Project :**	Dike Design	**Type :**	Lake Bed Till
Lab Work:	ROB	**Location:**	Meadowbank Gold Project	**Depth :**	
Test ID:	CIU - 3				

Equipment

Machine:	Trautwein
Chamber:	C1
Load Cell:	194249
Axial DCDT:	LP-175
Cell Pressure:	PS-3118
Back Pressure:	PS-3128
Pore Pressure:	PS-2232

Specimen Geometry

	Initial	Final
Height (mm) =	121.90	97.49
Diameter (mm) =	67.74	75.75
Area (cm^2) =	36.04	45.07
Volume (cm^3) =	439.36	439.36

Phase Relationships

	Initial	Final
e =	**0.29**	**0.29**
ρ_{sat} (kg/m^3) =	**2343**	**2343**
ρ_{dry} (kg/m^3) =	**2119**	**2119**
Gs =	2.73	

Strength Results

q_{MAX} (kPa)	316.2
Strain @ =	19.77
η_{MAX} =	1.40
Strain @ =	8.29
B Value	0.99
Target Mean Effective Stress (kPa)	572.02

Axial Strain (%)	Load (kN)	ΔU (kPa)	Cell Pressure (kPa)	Pore Pressure (kPa)	A_c (cm^2)	σ_1' (kPa)	σ_3' (kPa)	p' (kPa)	q (kPa)	Stress ratio η		
0.00	0.00	0.00	1440.36	868.3	36.0	572.0	572.0	572.0	0.0	0.00		
0.29	0.06	11.52	1439.64	879.9	36.1	577.6	559.8	565.7	17.9	0.03		
0.56	0.72	176.32	1440.34	1044.7	36.2	594.0	395.7	461.8	198.3	0.43		
0.82	0.90	279.87	1440.11	1148.2	36.3	539.0	291.9	374.3	247.1	0.66		
1.11	0.93	338.28	1440.42	1206.6	36.4	490.2	233.8	319.3	256.4	0.80		
1.39	0.93	374.53	1439.59	1242.9	36.6	452.2	196.7	281.9	255.5	0.91		
1.68	0.90	398.77	1439.93	1267.1	36.7	419.6	172.8	255.1	246.8	0.97		
1.97	0.86	416.28	1439.90	1284.6	36.8	388.8	155.3	233.1	233.6	1.00		
2.25	0.87	430.26	1440.30	1298.6	36.9	376.8	141.7	220.1	235.1	1.07		
2.53	0.89	440.69	1440.43	1309.0	37.0	372.0	131.4	211.6	240.6	1.14		
2.83	0.92	447.89	1439.99	1316.2	37.1	373.0	123.8	206.8	249.2	1.21		
3.12	0.89	454.39	1440.23	1322.7	37.2	357.5	117.5	197.5	240.0	1.22		
3.40	0.86	459.20	1440.18	1327.5	37.3	344.1	112.6	189.8	231.5	1.22		
3.70	0.87	463.33	1439.82	1331.7	37.4	341.6	108.1	186.0	233.4	1.26		
3.98	0.88	465.83	1440.04	1334.2	37.5	339.6	105.9	183.8	233.7	1.27		
4.28	0.87	468.42	1440.04	1336.8	37.7	335.2	103.3	180.6	231.9	1.28		
4.55	0.87	469.76	1439.79	1338.1	37.8	331.0	101.7	178.1	229.3	1.29		
4.85	0.87	471.19	1440.06	1339.5	37.9	329.9	100.5	177.0	229.3	1.30		
5.14	0.88	473.07	1440.22	1341.4	38.0	330.1	98.8	175.9	231.3	1.31		
5.43	0.88	473.98	1440.14	1342.3	38.1	329.1	97.8	174.9	231.3	1.32		
5.71	0.88	474.84	1439.79	1343.2	38.2	326.6	96.6	173.3	230.0	1.33		
5.99	0.93	474.99	1440.35	1343.3	38.3	338.6	97.0	177.5	241.6	1.36		
6.28	0.93	475.14	1439.93	1343.5	38.5	338.5	96.4	177.1	242.0	1.37		
6.58	0.93	475.54	1440.27	1343.9	38.6	336.6	96.4	176.4	240.2	1.36		
6.86	0.93	475.74	1440.51	1344.1	38.7	335.8	96.4	176.2	239.3	1.36		
7.16	0.93	475.63	1440.12	1344.0	38.8	336.1	96.1	176.1	240.0	1.36		
7.44	0.95	475.30	1440.34	1343.6	38.9	339.6	96.7	177.7	242.9	1.37		
7.72	0.97	475.61	1440.14	1344.0	39.1	344.2	96.2	178.9	248.1	1.39		
8.01	0.98	475.53	1440.50	1343.9	39.2	347.1	96.6	180.1	250.5	1.39		
8.29	1.00	475.00	1440.40	1343.3	39.3	352.6	97.1	182.2	255.5	1.40		
8.58	1.00	474.57	1440.16	1342.9	39.4	351.6	97.3	182.0	254.4	1.40		
8.88	1.01	473.64	1440.35	1342.0	39.6	352.8	98.4	183.2	254.4	1.39		
9.15	0.99	473.52	1440.31	1341.9	39.7	346.7	98.5	181.2	248.3	1.37		
9.45	1.00	473.08	1440.70	1341.4	39.8	350.4	99.3	183.0	251.1	1.37		
9.73	1.00	472.17	1440.14	1340.5	39.9	350.3	99.6	183.2	250.7	1.37		
10.02	1.02	471.66	1440.29	1340.0	40.1	355.9	100.3	185.5	255.6	1.38		
10.31	1.02	471.36	1440.44	1339.7	40.2	354.4	100.7	185.3	253.7	1.37		
10.59	1.01	470.32	1440.52	1338.7	40.3	353.6	101.9	185.8	251.7	1.35		
10.88	1.04	469.79	1440.39	1338.1	40.4	359.4	102.3	188.0	257.1	1.37		
11.17	1.05	468.97	1440.34	1337.3	40.6	360.8	103.0	188.9	257.8	1.36		
11.45	1.08	468.39	1440.26	1336.7	40.7	369.1	103.5	192.1	265.6	1.38		
11.72	1.09	467.16	1439.75	1335.5	40.8	371.1	104.3	193.2	266.9	1.38		
12.02	1.09	466.28	1439.95	1334.6	41.0	372.4	105.3	194.3	267.0	1.37		
12.31	1.10	466.02	1440.06	1334.4	41.1	373.5	105.7	195.0	267.8	1.37		
12.59	1.10	465.11	1439.93	1333.4	41.2	372.9	106.5	195.3	266.4	1.36		
12.87	1.10	464.46	1440.16	1332.8	41.4	372.1	107.4	195.6	264.7	1.35		
13.16	1.10	463.99	1440.00	1332.3	41.5	372.9	107.7	196.1	265.2	1.35		
13.45	1.10	462.50	1439.79	1330.8	41.6	373.9	108.9	197.3	264.9	1.34		
13.75	1.12	461.84	1440.19	1330.2	41.8	377.6	110.0	199.2	267.6	1.34		
14.03	1.12	461.31	1440.08	1329.7	41.9	378.7	110.4	199.9	268.3	1.34		
14.31	1.12	460.46	1440.02	1328.8	42.1	378.5	111.2	200.3	267.3	1.33		
14.61	1.14	459.94	1440.39	1328.3	42.2	381.6	112.1	201.9	269.5	1.33		
14.90	1.14	458.65	1440.02	1327.0	42.4	381.2	113.0	202.4	268.2	1.32		
15.17	1.16	458.82	1440.46	1327.2	42.5	387.0	113.3	204.5	273.7	1.34		
15.47	1.17	458.12	1440.09	1326.5	42.6	388.7	113.6	205.3	275.0	1.34		

Axial Strain (%)	Load (kN)	ΔU (kPa)	Cell Pressure (kPa)	Pore Pressure (kPa)	A_c (cm^2)	σ_1' (kPa)	σ_3' (kPa)	p' (kPa)	q (kPa)	Stress ratio η		
15.75	1.18	456.97	1440.87	1325.3	42.8	392.0	115.6	207.7	276.5	1.33		
16.04	1.20	456.22	1440.16	1324.6	42.9	394.9	115.6	208.7	279.3	1.34		
16.33	1.21	455.49	1440.15	1323.8	43.1	396.8	116.3	209.8	280.5	1.34		
16.61	1.23	455.07	1440.35	1323.4	43.2	400.7	116.9	211.5	283.7	1.34		
16.91	1.28	454.46	1440.55	1322.8	43.4	411.7	117.7	215.7	294.0	1.36		
17.19	1.31	453.44	1439.99	1321.8	43.5	418.8	118.2	218.4	300.6	1.38		
17.47	1.33	453.03	1440.13	1321.4	43.7	423.0	118.8	220.2	304.2	1.38		
17.77	1.34	451.69	1440.18	1320.0	43.8	424.8	120.1	221.7	304.7	1.37		
18.04	1.32	451.43	1439.90	1319.8	44.0	421.3	120.1	220.5	301.2	1.37		
18.34	1.32	450.59	1439.90	1318.9	44.1	420.1	121.0	220.7	299.1	1.36		
18.64	1.33	450.63	1440.11	1319.0	44.3	421.3	121.1	221.2	300.2	1.36		
18.91	1.35	449.33	1440.71	1317.7	44.4	427.1	123.0	224.4	304.1	1.36		
19.21	1.39	448.96	1440.29	1317.3	44.6	434.6	123.0	226.9	311.6	1.37		
19.50	1.39	448.88	1440.14	1317.2	44.8	433.9	122.9	226.6	311.0	1.37		
19.77	1.42	448.30	1440.13	1316.6	44.9	439.7	123.5	228.9	316.2	1.38		
20.03	1.42	446.66	1439.96	1315.0	45.1	439.8	125.0	229.9	314.8	1.37		

TILL CONSOLIDATION

One-Dimensional Consolidation Properties of Soils of Soils - ASTM D 2436 - 96

Project No. :	06-1413-081/4000	**Client :**	Meadowbank Mining Corporation	**Borehole:**	
Sch No.		**Project :**	Dike Design	**Sample:**	Lake Bed Till
Lab Work:	ROB/LL	**Location:**	Meadowbank Gold Project	**Depth :**	

Equipment

Machine:	Sigma-1
Mach No.	Station 1
Ring No.	Large
Lever Arm Ratio	0.0
Drainage:	Double-sided

Specimen Geometry

	Initial	Final
Height (mm) =	71.21	62.15
Diameter (mm) =	152.40	152.40
Area (cm^2) =	182.41	182.41
Volume (cm^3) =	1298.93	1133.65

Phase Relationships

	Initial	Final
Wet Wt (g) =	2701.80	2566.60
Dry Wt (g) =	2305.10	2305.10
w (%) =	**17.21**	**11.34**
e =	**0.54**	**0.34**
ρ_{wet} (kg/m^3) =	**2080**	**2264**
ρ_{dry} (kg/m^3) =	**1775**	**2033**
S (%) =	**87.3**	**90.4**

Remarks

ASTM Method:	B - Constant Time Increment
Method for Cv :	Casagrande
H_{avg} :	Half the specimen height
Time Increment:	

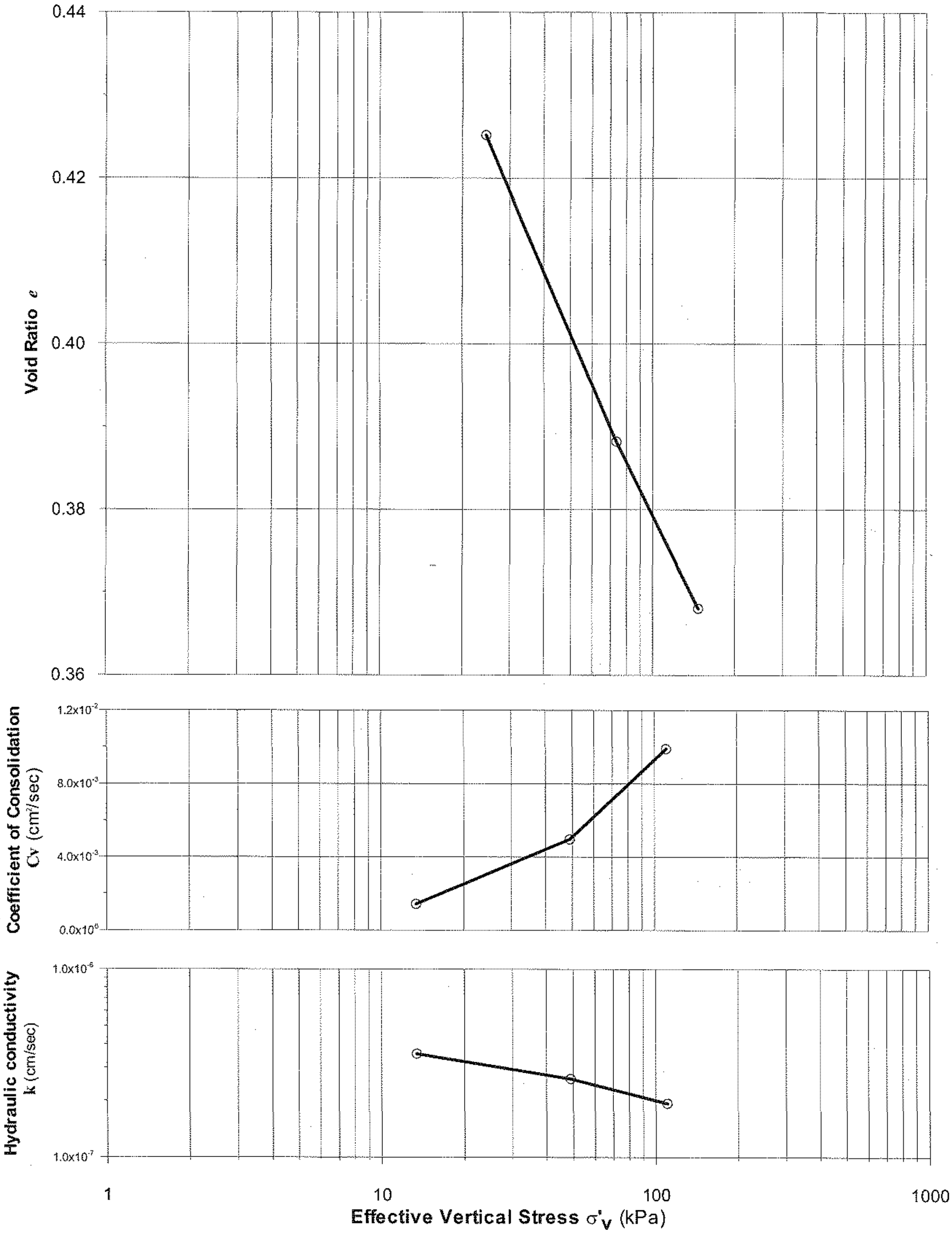
Sample Properties

G_s =	2.73	Calculated
H_s (mm) =	46.29	

Stress (kPa)	ΔH (mm)	**Corrected** d_f (mm)	ε Σ ΔH / Ho (%)	H-H_s (mm)	e (H-H_s)/H_s	**Stress** $_{avg}$ (kPa)	e_{avg}	H_{avg} (mm)	**t 50** (min)	Cv (cm^2/sec)	k (cm/sec)
2.3	1.49	69.75	2.05	23.46	**0.51**						
24.5	4.25	65.97	7.36	19.68	**0.43**	**13.4**	**0.47**	67.86	105.000	**1.4E-03**	**3.5E-07**
73.5	2.01	64.26	9.76	17.97	**0.39**	**49.0**	**0.41**	65.11	28.000	**5.0E-03**	**2.6E-07**
147.0	1.11	63.32	11.07	17.04	**0.37**	**110.2**	**0.38**	63.79	13.500	**9.9E-03**	**1.9E-07**

Comments:

Sample Description :



Golder Associates	Project No. 06-1413-081 Drawn ROB Reviewed LL Date 01/09/07	**ONE-DIMENSIONAL CONSOLIDATION LABORATORY TEST RESULTS OF TILL** **Meadowbank Mining Corporation** **Meadowbank Gold Project**	**Figure I-13**

LAKE BED SEDIMENTS SPECIFIC GRAVITY

SPECIFIC GRAVITY OF SOLIDS

Project No. :	06-1413-089	**Client :**	Meadowbank Mining Corporation	**Sample Number :**	WAL-1 & TPS-1
Sch No.	13	**Project :**	Dike Design	**Date :**	25/01/2007
Lab Work:	TM	**Location:**	Meadowbank Gold Project		

Specific Gravity of Fine Fraction (ASTM D 854-02)

Percentage Passing #4 Sieve		100	
Test Number		1	2
Flask Number		1	1
Air Removal Method		Vacuum	Vacuum
Mass of Flask (g)	M_p	179.42	179.42
Mass of Flask + Dry Soil (g)		213.12	212.61
Mass of Dry Soil (g)		33.70	33.19
Mass of Flask + Soil + Water (g)	$M_{pws,t}$	698.66	698.11
Test Temperature (g)	T_t	18.0	18.0
Mass of Flask + Water (g)	$M_{pw,t}$	678.22	678.22
Number of Evaporating Dish			
Mass of Dish + Dry Soil (g)		33.70	33.19
Mass of Dish (g)		0.00	0.00
Mass of Oven Dry Soil (g)	M_s	33.70	33.19
Temperature Coefficient	K	1.0004	1.0004
Density of Solids (g/cm^3)	ρ_s	2.54	2.50
Specific Gravity at Test Temperature	G_t	2.55	2.50
Specific Gravity at 20ºC	$G_{20°C}$	**2.55**	**2.50**
AVERAGE SPECIFIC GRAVITY		**2.52**	

Specific Gravity of Coarse Fraction (ASTM C 127-88)

Percentage Retained on #4 Sieve		0
Mass of Sample in Water (g)	**A**	
Mass of Sample @ SSD (g)	**B**	
Mass of Oven Dryed Sample (g)	**C**	
Bulk G (Oven Dry)	**C/(B-A)**	
Bulk G (SSD)	**B/(B-A)**	
Apparent	**C/(C-A)**	
Absorbtion (%)	**(B-C)/C**	

Specific Gravity of Total Sample

COMBINED SPECIFIC GRAVITY	$G_{avg@20°C}$	**2.52**

Remarks:

Method used: Method A Procedure for Moist Specimens

Sample Description:

SPECIFIC GRAVITY OF SOLIDS

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**Sample :**	TPN-1
Sch No.	288	**Project :**	Dike Design		INUG-1
Lab Work:	TM	**Location:**	Meadowbank Gold Project		SP-1 Sed
Test ID:	Test 1			**Date :**	07/12/2006

Specific Gravity of Fine Fraction (ASTM D 854-02)

Percentage Passing #4 Sieve		100	
Test Number		1	2
Flask Number		1	1
Air Removal Method		Vacuum	Vacuum
Mass of Flask (g)	M_p	179.44	179.44
Mass of Flask + Dry Soil (g)		245.01	245.29
Mass of Dry Soil (g)		97.32	97.23
Mass of Flask + Soil + Water (g)	$M_{pws,t}$	716.96	718.55
Test Temperature (g)	T_t	18.0	18.0
Mass of Flask + Water (g)	$M_{pw,t}$	678.14	678.22
Number of Evaporating Dish			
Mass of Dish + Dry Soil (g)		97.32	97.23
Mass of Dish (g)		0.00	0.00
Mass of Oven Dry Soil (g)	M_s	97.32	97.23
Temperature Coefficient	K	1.0002	1.0004
Density of Solids (g/cm^3)	ρ_s	1.66	1.71
Specific Gravity at Test Temperature	G_t	1.67	1.71
Specific Gravity at 20°C	$G_{20°C}$	**1.67**	**1.71**
AVERAGE SPECIFIC GRAVITY		**1.69**	

Specific Gravity of Coarse Fraction (ASTM C 127-88)

Percentage Retained on #4 Sieve		0
Mass of Sample in Water (g)	**A**	
Mass of Sample @ SSD (g)	**B**	
Mass of Oven Dryed Sample (g)	**C**	
Bulk G (Oven Dry)	**C/(B-A)**	
Bulk G (SSD)	**B/(B-A)**	
Apparent	**C/(C-A)**	
Absorbtion (%)	**(B-C)/C**	

Specific Gravity of Total Sample

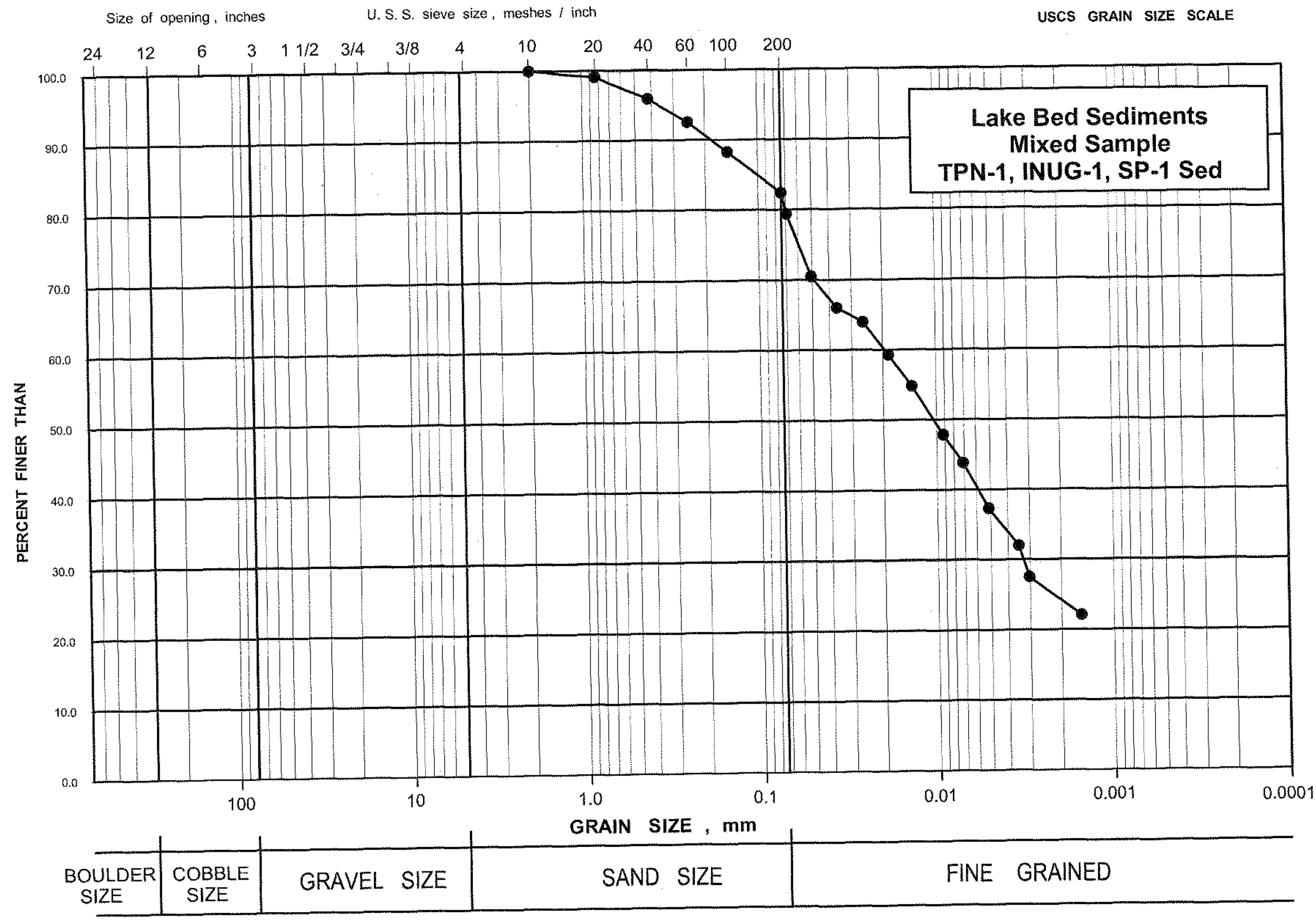
COMBINED SPECIFIC GRAVITY	$G_{avg@20°C}$	**1.69**

Remarks:

Method used: Method A Procedure for Moist Specimens

Sample Description:

LAKE BED SEDIMENTS GRADATION AND HYDROMETER



Project No. 06-1411-042 Drawn PK Reviewed LL Date 03/09/07	Golder Associates	**GRAIN SIZE DISTRIBUTION** **Meadowbank Mining Corporation** **Meadowbank Gold Project**

Figure I-14

PARTICLE SIZE ANALYSIS OF SOILS ASTM D 422-63

Project No. :	06-1413-081	**Client :**	Meadowbank Mining Corporation	**Sample :**	TPN-1
Sch#	288	**Project :**	Dike Design		INUG-1
Lab Work:	TM	**Location:**	Meadowbank Gold Project		SP-1 Sed

First Sieving
Total Weight (g) = 44.2

Hydrometer: (Minus #10)
Before Wash (g) = 44.2
After Wash (g) = 8.2

Residual No. 200 (g) = 0.4
Total minus 200 (g) = 36.4
Gs (assumed) = 2.70

Size (USS)	Weight Retained (g)	Retained (%)	Weight Retained (g)	Retained (%)	% Retained Total	Diameter (mm)	% Passing
							100.0
6"	0.0					**152.4**	**100.0**
3"	0.0					**76.2**	**100.0**
1 1/2"	0.0					**38.1**	**100.0**
1"	0.0					**25.4**	**100.0**
3/4"	0.0					**19.1**	**100.0**
1/2"	0.0					**12.7**	**100.0**
3/8"	0.0					**9.52**	**100.0**
#4	0.0					**4.76**	**100.0**
#10	0.0					**2.00**	**100.0**
#20			0.4	0.9	0.9	**0.840**	**99.1**
#40			1.4	3.2	3.2	**0.420**	**95.9**
#60			1.5	3.4	3.4	**0.250**	**92.5**
#100			1.9	4.3	4.3	**0.149**	**88.2**
#200			2.6	5.9	5.9	**0.074**	**82.4**
Pan			36.4	82.4	82.4		

HYDROMETER ANALYSIS

Hydrometer No.: 8589 **Dispersion Method:** Stirring **Dispersion Period (min):**

Comments:

Time (min)	Hydrometer Reading	Temperature (°C)		Composite Correction	Corrected Reading	Diameter (mm)	Percentage Passing
0.5	38.0	18.0		-2.51	35.5	**0.0693**	**79.4**
1	34.0	18.0		-2.51	31.5	**0.0506**	**70.5**
2	32.0	18.0		-2.51	29.5	**0.0363**	**66.0**
4	31.1	18.0		-2.51	28.6	**0.0259**	**64.0**
8	29.0	18.0		-2.51	26.5	**0.0186**	**59.3**
15	27.0	18.0		-2.51	24.5	**0.0138**	**54.8**
35	23.9	18.0		-2.51	21.4	**0.0092**	**47.9**
60	22.0	18.5		-2.41	19.6	**0.0071**	**43.8**
120	19.1	18.5		-2.41	16.7	**0.0051**	**37.3**
270	16.6	19.0		-2.30	14.3	**0.0035**	**32.0**
360	14.6	19.0		-2.30	12.3	**0.0030**	**27.5**
1440	13.0	15.0		-3.12	9.9	**0.0015**	**22.1**

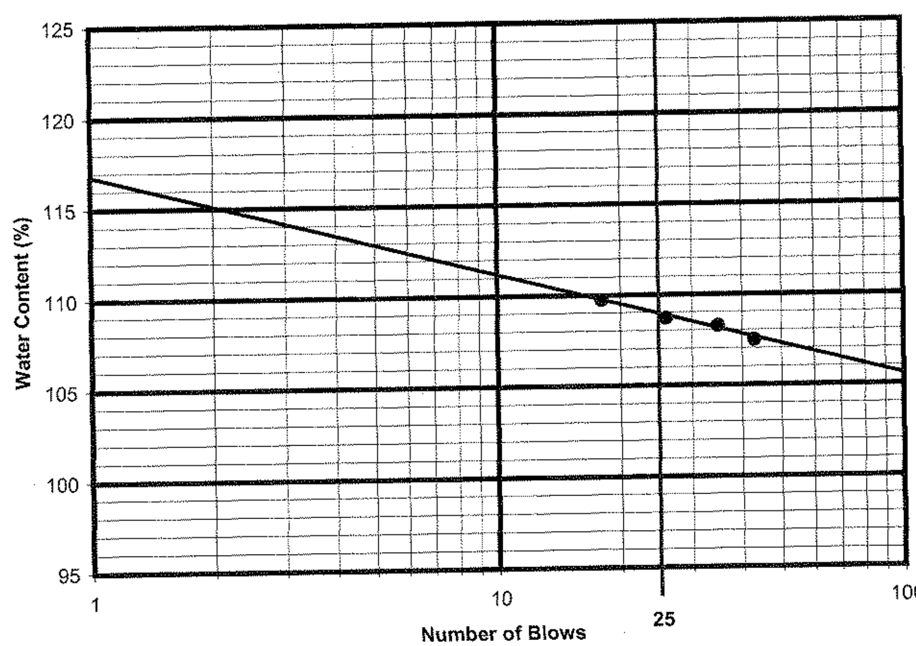
LAKE BED SEDIMENTS ATTERBERG LIMITS

Project # 06-1413-081 Tech : TM

Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D 4318-93

TYPE OF TEST	LL	LL	LL	LL		W% Nat.
CONTAINER NUMBER						
NUMBER OF BLOWS	43	18	35	26		
MASS WET SOIL + TARE	35.45	30.39	35.48	35.09		491.90
MASS DRY SOIL + TARE	31.69	27.00	32.59	31.58		401.60
MASS OF WATER	3.76	3.39	2.89	3.51		90.30
MASS OF CONTAINER	28.19	23.91	29.92	28.35		372.10
MASS OF DRY SOIL	3.50	3.09	2.67	3.23		29.5
WATER CONTENT W (%)	107.4	109.7	108.2	108.7		306.1

TYPE OF TEST	PL	PL	SAMPLE	TPE-1 Sed
CONTAINER NUMBER				
MASS WET SOIL + TARE	31.65	33.57		
MASS DRY SOIL + TARE	29.62	31.78	LIQUID LIMIT (%)	108.9
MASS OF WATER	2.03	1.79	PLASTIC LIMIT (%)	103.2
MASS OF CONTAINER	27.67	30.03	PLASTICITY INDEX (%)	5.7
MASS OF DRY SOIL	1.95	1.75	W% Natural (%)	306.1
WATER CONTENT W (%)	104.1	102.3	LIQUIDITY INDEX	35.56



SAMPLE DESCRIPTION : OH

Meadowbank Mining Corporation
Meadowbank Gold Project

LAKE BED SEDIMENTS WATER CONTENT

Project Number : 06-1413-089 Tech : TM

Laboratory Determination of Water Content of Soil and Rock
ASTM D 2216-92

Borehole						
Sample Number	**WAL-1**		**TPS-1**			
Depth (m)						
CONTAINER NUMBER						
MASS WET SOIL + TARE	232.1		267.6			
MASS DRY SOIL + TARE	125.4		147.0			
MASS OF WATER	106.7		120.6			
MASS OF CONTAINER	109.4		122.4			
MASS OF DRY SOIL	16.0		24.6			
Water Content W (%)	**666.9**		**490.2**			

Borehole						
Sample Number						
Depth (m)						
CONTAINER NUMBER						
MASS WET SOIL + TARE						
MASS DRY SOIL + TARE						
MASS OF WATER						
MASS OF CONTAINER						
MASS OF DRY SOIL						
Water Content W (%)						

Borehole						
Sample Number						
Depth (m)						
CONTAINER NUMBER						
MASS WET SOIL + TARE						
MASS DRY SOIL + TARE						
MASS OF WATER						
MASS OF CONTAINER						
MASS OF DRY SOIL						
Water Content W (%)						

Meadowbank Mining Corporation
Meadowbank Gold Project

LAKE BED SEDIMENTS ORGANIC CONTENT

Project Number : 06-1413-089 Tech : TM

Moisture, Ash and Organic Matter of Peat and Other Organic Soils
ASTM D 2974-87 Method C

Borehole						
Sample Number	Combined TPS-1 & WAL-1					
Depth (m)						
Tare Number						
Mass of Soil @ 105^0 C + Tare	90.83					
Mass Soil @ 440^0 C + Tare	84.30					
Mass of Organics	6.53					
Mass of Tare	51.14					
Mass of soil @ 105^0 C	39.69					
Organic Content (%)	**16.45**					

Borehole						
Sample Number						
Depth (m)						
Tare Number						
Mass of Soil @ 105^0 C + Tare						
Mass Soil @ 440^0 C + Tare						
Mass of Organics						
Mass of Tare						
Mass of soil @ 105^0 C						
Organic Content (%)						

Borehole						
Sample Number						
Depth (m)						
Tare Number						
Mass of Soil @ 105^0 C + Tare						
Mass Soil @ 440^0 C + Tare						
Mass of Organics						
Mass of Tare						
Mass of soil @ 105^0 C						
Organic Content (%)						

Recommended Standard Furnace Time @ 440^0 C for Different Soil Types

Sandy Soils	1 Hr
Clay Soils	2 Hr
Organic Soils	3 Hr
Peat	4 Hr

Meadowbank Mining Corporation
Meadowbank Gold Project

Project Number : 06-1413-081 Tech : TM

Moisture, Ash and Organic Matter of Peat and Other Organic Soils
ASTM D 2974-87 Method C

Borehole						
Sample Number	TE-1 Sed	TE-1 Sed				
Depth (m)						
Tare Number						
Mass of Soil @ 105^0 C + Tare	41.87	43.05				
Mass Soil @ 440^0 C + Tare	40.88	42.03				
Mass of Organics	0.99	1.02				
Mass of Tare	27.28	27.78				
Mass of soil @ 105^0 C	14.59	15.27				
Organic Content (%)	**6.79**	**6.68**				

Borehole						
Sample Number						
Depth (m)						
Tare Number						
Mass of Soil @ 105^0 C + Tare						
Mass Soil @ 440^0 C + Tare						
Mass of Organics						
Mass of Tare						
Mass of soil @ 105^0 C						
Organic Content (%)						

Borehole						
Sample Number						
Depth (m)						
Tare Number						
Mass of Soil @ 105^0 C + Tare						
Mass Soil @ 440^0 C + Tare						
Mass of Organics						
Mass of Tare						
Mass of soil @ 105^0 C						
Organic Content (%)						

Recommended Standard Furnace Time @ 440^0 C for Different Soil Types

Sandy Soils	1 Hr
Clay Soils	2 Hr
Organic Soils	3 Hr
Peat	4 Hr

Meadowbank Mining Corporation
Meadowbank Gold Project

SLURRY TRENCH BACKFILL PERMEABILITY TESTS

Permeability of Granular Soils (Falling Head)
ASTM D 2434-68 (1993)

Project #	06-1413-081 Phase 4000 Task 4100	Sample: Cutoff Wall Slurry Mixtures	Panel No. 3
Client	Meadowbank Mining Corporation	Bentonite: 6%	Cell No. 3
Project	Dike Design	Composite sample from 06-1413-034 Sa-3,6	Sch No. 288
Location	Meadowbank Gold Project		

Dimensions - Initial

D_o	10.25	cm
H_o	8.71	cm
A_o	82.53	cm^2
V_o	719.1	cm^3

Dimensions - After Consolidation

δH_c	0.76	cm
H_c	7.95	cm
V_c	656.5	cm^3

	Initial	Final	
Wet Wt	1473.1	1513.6	g
Dry Wt	1241.1	1241.1	g
w	18.7	22.0	
ρ_{dry}	1726	1890	Kg/M^3
e	0.66	0.51	
G_s	2.86	2.86	assumed
Saturation	104.2	122.4	%

Method of sample preparation
6% bentonite added to dry soil
water added to make it into a thick slurry blend
Final blend spooned into mould

Distance between manometers
L_{man} = 13.5 cm
$a_{standpipe}$ = 0.291 cm^2

Permeability Test (Falling Head)

Test	Manometers			Head		Time		Gradient		Temp	
No.	h_1	h_2	p_{bottom}	h_1	h_2	δt	$\log(h_1/h_2)$	h_{avg}/H_c	Temp	Correction	k_{20}
	cm	cm	kPa	cm	cc	min			C_{deg}	R_t	cm/s
1	39.2	39.0	7.6	130.0	129.8	100	0.0007	16.3	25.0	0.9988	**7.2E-09**
2	39.2	35.1	7.6	130.0	125.9	1160	0.0139	16.1	25.2	0.9988	**1.3E-08**
3	39.2	33.4	7.6	130.0	124.2	2675	0.0198	16.0	25.2	0.9988	**8.0E-09**
4	39.2	32.5	7.6	130.0	123.3	3880	0.0230	15.9	25.2	0.9988	**6.4E-09**
5	39.2	30.3	7.6	130.0	121.1	5250	0.0308	15.8	25.4	0.9997	**6.3E-09**
6	39.2	29.4	7.6	130.0	120.2	6685	0.0340	15.7	25.4	0.9997	**5.5E-09**
7	39.2	27.0	7.6	130.0	117.8	8165	0.0428	15.6	25.4	0.9997	**5.6E-09**
8	39.2	26.4	7.6	130.0	117.2	9630	0.0450	15.5	25.4	0.9997	**5.0E-09**
9	39.2	21.9	7.6	130.0	112.7	11150	0.0620	15.3	25.4	0.9997	**6.0E-09**
10	39.2	19.9	7.6	130.0	110.7	12590	0.0698	15.1	25.4	0.9997	**6.0E-09**
11	39.2	18.4	7.6	130.0	109.2	13945	0.0757	15.0	25.4	0.9997	**5.8E-09**
12	39.2	16.9	7.6	130.0	107.7	19710	0.0817	14.9	25.4	0.9997	**4.5E-09**
13	39.2	13.0	7.6	130.0	103.8	21625	0.0977	14.7	25.4	0.9997	**4.9E-09**
										Average k_{20} =	**6.5E-09**

Remarks :

Minus 19 mm material
σ_v' = 88 kPa

1 psi = 70.305 cm of H_2O
1 psi = 6.895 kPa
1 kPa = 10.20 cm of H_2O

Falling Head Permeability Test
$k_{20} = (2.303*(a*L)*(\log(h_1/h_2)*k_t)/(A*t)$

Permeability of Granular Soils (Falling Head)
ASTM D 2434-68 (1993)

Project #	06-1413-081 Phase 4000 Task 4100	Sample	Cutoff Wall Slurry Mixtures
Client	Meadowbank Mining Corporation	Bentonite	1.6%
Project	Dike Design	Composite sample from 06-1413-034 Sa-3,6	
Location	Meadowbank Gold Project		

Panel No. 1
Cell No. 1
Sch No. 288

Dimensions - Initial

D_o	10.25	cm
H_o	7.90	cm
A_o	82.44	cm^2
V_o	651.4	cm^3

Dimensions - After Consolidation

δH_c	0.80	cm
H_c	7.10	cm
V_c	585.2	cm^3

	Initial	Final	
Wet Wt	1344.3	1285.4	g
Dry Wt	1156.9	1156.9	g
w	16.2	11.1	
ρ_{dry}	1776	1977	Kg/M^3
e	0.61	0.45	
G_s	2.86	2.86	assumed
Saturation	103.7	71.1	%

Method of sample preparation
8% bentonite slurry mixed with dried till soil
Soil adjusted to an estimated slump of 105mm
Blend ended up with 1.6% bentonite content.
Final blend poured into mould.

Distance between manometers
L_{man} = 15.4 cm
$a_{standpipe}$ = 0.291 cm^2

Permeability Test (Falling Head)

Test	Manometers			Head		Time		Gradient		Temp	
No.	h_1	h_2	p_{bottom}	h_1	h_2	δt	$\log(h_1/h_2)$	h_{avg}/H_c	Temp	Correction	k_{20}
	cm	cm	kPa	cm	cc	min			C_{deg}	R_t	cm/s
1	38.7	37.6	22.1	279.1	278.0	5	0.0017	39.2	22.0	0.9988	**3.3E-07**
2	38.7	34.3	22.1	279.1	274.6	30	0.0070	39.0	22.0	0.9988	**2.2E-07**
3	38.7	29.7	22.1	279.1	270.1	60	0.0142	38.7	22.0	0.9988	**2.3E-07**
4	38.7	21.7	22.1	279.1	262.0	120	0.0274	38.1	22.0	0.9988	**2.2E-07**
5	38.7	16.8	22.1	279.1	257.2	155	0.0355	37.8	22.0	0.9997	**2.2E-07**
6	38.7	10.5	22.1	279.1	250.9	203	0.0463	37.3	22.0	0.9997	**2.2E-07**
7	38.7	5.3	22.1	279.1	245.6	240	0.0554	37.0	22.0	0.9997	**2.2E-07**
8	38.7	2.5	22.1	279.1	242.9	265	0.0603	36.8	22.0	0.9997	**2.2E-07**

Average k_{20} = 2.4E-07

Remarks :

Final sample weights, wet and dry, reflect a loss of fines during testing. Only filter paper was used at top and stone and paper at bottom.
Sample consists of minus 19 mm material.

σ_v' = 88 kPa

1 psi = 70.305 cm of H_2O
1 psi = 6.895 kPa
1 kPa = 10.20 cm of H_2O

Falling Head Permeability Test
$k_{20} = (2.303*(a*L)*(\log(h_1/h_2)*k_t)/(A*t)$

Permeability of Granular Soils (Falling Head)
ASTM D 2434-68 (1993)

Project # 06-1413-081 Phase 4000 Task 4100	Sample Cutoff Wall Slurry Mixtures	Panel No. 3	
Client Meadowbank Mining Corporation	Bentonite 4%	Cell No. 3	
Project Dike Design	Cement 4%	Sch No. 288	
Location Meadowbank Gold Project	Composite sample from 06-1413-034 Sa-3,6 and 7		

Dimensions - Initial				Initial	Final		
D_o	10.38	cm	Wet Wt	1260.6	1253.6	g	**Method of sample preparation**
H_o	7.54	cm	Dry Wt	1045.1	1045.1	g	4% cement & 4% bentonite added to dry soil
A_o	84.62	cm^2	w	20.6	20.0		water added to make it into a thick slurry blend
V_o	638.4	cm^3	ρ_{dry}	1637	1665	Kg/M^3	Final blend spooned into mould.
Dimensions - After Consolidation			e	0.62	0.59		Curing time 2 days.(Before testing).
δH_c	0.12	cm	G_s	2.65	2.65	assumed	Visually estimated slump of 110mm.
H_c	7.42	cm	Saturation	92.3	89.3	%	**Distance between manometers**
V_c	627.8	cm^3					L_{man} = 13.6 cm
							$a_{standpipe}$ = 0.291 cm^2

Permeability Test (Falling Head)

Test	Manometers			Head		Time		Gradient		Temp	
No.	h_1	h_2	p_{bottom}	h_1	h_2	δt	$\log(h_1/h_2)$	h_{avg}/H_c	Temp	Correction	k_{20}
	cm	cm	kPa	cm	cc	min			C_{deg}	R_t	cm/s
1	38.1	35.4	6.9	122.0	119.3	13	0.0097	16.3	22.2	0.9988	**7.3E-07**
2	38.1	27.9	6.9	122.0	111.8	43	0.0379	15.8	22.2	0.9988	**8.6E-07**
3	38.1	22.4	6.9	122.0	106.3	75	0.0598	15.4	22.2	0.9988	**7.8E-07**
4	38.1	18.1	6.9	122.0	102.0	109	0.0780	15.1	22.2	0.9988	**7.0E-07**
5	38.1	14.4	6.9	122.0	98.3	144	0.0938	14.8	22.2	0.9997	**6.4E-07**
6	38.1	12.2	6.9	122.0	96.1	169	0.1036	14.7	22.2	0.9997	**6.0E-07**
7	38.1	7.4	6.9	122.0	91.3	219	0.1259	14.4	22.2	0.9997	**5.6E-07**
8	38.1	5.2	6.9	122.0	89.1	250	0.1367	14.2	22.2	0.9997	**5.4E-07**
										Average k_{20} =	**6.8E-07**

Remarks :

Minus 19 mm material
σ_v' = 88 kPa

1 psi = 70.305 cm of H_2O
1 psi = 6.895 kPa
1 kPa = 10.20 cm of H_2O

Falling Head Permeability Test
$k_{20} = (2.303*(a*L)*(\log(h_1/h_2)*k_t)/(A*t)$

APPENDIX II

MATERIAL BALANCE
REVISED MINING SEQUENCE
MARCH 2007

MEADOWBANK GOLD PROJECT
MATERIALS BALANCE

	Estimate of Required Material Quantities by Year (m3)											
	-2	-1	1	2	3	4	5	6	7	8	9	TOTAL
Overburden												
East Dike	72,090	-	-	-	-	-	-	-	-	-	-	72,090
Second Portage Causeway	-	-	-	-	-	-	-	-	-	-	-	-
Bay Zone Dike	-	145,034	-	-	-	-	-	-	-	-	-	145,034
Second Portage Tailings Dike	-	45,000	-	91,740	-	-	35,750	-	-	-	-	172,490
Central Dike Full Cut-off (if required)	-	201,532	-	-	-	-	-	-	-	-	-	201,532
Stormwater Dike	-	-	-	-	-	-	-	-	-	-	-	-
Goose Island Dike	-	-	433,593	-	-	-	-	-	-	-	-	433,593
Vault Dike	-	-	-	-	6,600	-	-	-	-	-	-	6,600
Tailings Containment Berms	-	-	-	-	16,522	-	-	-	-	-	-	16,522
Total Volume Required for Dike	72,090	391,566	433,593	91,740	23,122	-	35,750	-	-	-	-	1,047,861
Road to ANFO Storage	-	-	-	-	-	-	-	-	-	-	-	-
Plant Roads	-	-	-	-	-	-	-	-	-	-	-	-
Vault Haul Road	-	-	-	-	-	-	-	-	-	-	-	-
Airstrip	-	-	-	-	-	-	-	-	-	-	-	-
Mill Foundations	-	-	-	-	-	-	-	-	-	-	-	-
Total Volume Required for Construction	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL OVERBURDEN REQUIRED	72,090	391,566	433,593	91,740	23,122	0	35,750	0	0	0	0	1,047,861
TOTAL OVERBURDEN AVAILABLE[2]	367,000	714,941	1,217,941	1,791,235	0	1,266,118	33,372	0	0	0	0	5,390,607
SURPLUS (DEFICIT)	294,910	323,375	784,348	1,699,495	(-23,122)	1,266,118	(-2,378)	0	0	0	0	4,342,746
UM+QZ												-
East Dike (Surfacing)	-	-	192,587	-	-	-	-	-	-	-	-	192,587
East Causeway (Surfacing)	-	-	-	-	-	-	-	-	-	-	-	-
Bay Zone Dike (Surfacing	-	-	186,303	-	-	-	-	-	-	-	-	186,303
Cental Dike (Surfacing)	-	51,364		233,801	-	-	318,417	-	-	-	-	603,582
South Saddle Dam					540,184							
Goose Island Dike (Surfacing)	-	-	-	273,409	-	-	-	-	-	-	-	273,409
Vault Dike (Surfacing)	-	-	-	-	-	-	6,760	-	-	-	-	6,760
Tailings Containment Berms (Surfacing)	-	-	-	-	-	-	-	-	-	-	-	-
Finger Dikes (Surfacing)	-	-	-	-	39,200	78,400	39,200	39,200	-	-	-	196,000
Total Volume Required for Dikes	-	51,364	378,890	507,210	579,384	78,400	364,377	39,200	-	-	-	1,998,825
Stockpiling Capping Material for Portage Dump	-	-	-	660,000	660,000	-	-	-	-	-	-	1,320,000
Stockpiling Capping Material for Vault Dump	-	-	-	-	-	-	-	-	-	-	-	-
Stockpiling Capping Material for Tailings Pond	-	-	-	1,450,000	1,450,000	-	-	-	-	-	-	2,900,000
Total Capping Volume Required	-	-	-	2,110,000	2,110,000	-	-	-	-	-	-	4,220,000
Road to ANFO Storage (Capping)	-	25,349	-	-	-	-	-	-	-	-	-	25,349
Plant Roads (Capping)	-	34,644	-	-	-	-	-	-	-	-	-	34,644
Vault Haul Road (Capping)	-	-	-	36,000	-	-	-	-	-	-	-	36,000
Airstrip	-	-	-	-	-	-	-	-	-	-	-	-
Mill Foundations	20,000	20,000	-	-	-	-	-	-	-	-	-	40,000
Total Volume Required for Construction	20,000	79,993	-	36,000	-	-	-	-	-	-	-	135,993
									0			
TOTAL UM+QZ REQUIRED	20,000	131,357	378,890	2,653,210	2,689,384	78,400	364,377	39,200	0	0	0	6,354,819
TOTAL UM+QZ AVAILABLE[2]	123,290	279,607	3,522,355	7,583,302	6,599,308	4,050,175	1,438,513	281,587	0	0	0	23,878,136
SURPLUS (DEFICIT)	103,290	148,250	3,143,465	4,930,092	3,909,924	3,971,775	1,074,135	242,387	0	0	0	17,523,318
IV												
East Dike (Construction)	100,332	-	-	-	-	-	-	-	-	-	-	100,332
East Causeway (Construction)	-	-	-	-	-	-	-	-	-	-	-	-
Bay Zone Dike (Construction)	-	206,147	-	-	-	-	-	-	-	-	-	206,147
Central Dike (Construction)	-	213,583	-	763,327	-	-	15,168	-	-	-	-	992,078
North Saddle Dam (Construction)	-	511,381	-	-	-	-	-	-	-	-	-	511,381
Goose Island Dike (Construction)	-	-	439,837	-	-	-	-	-	-	-	-	439,837
Vault Dike (Construction)[1]	-	-	-	-	-	-	12,380	-	-	-	-	12,380
Tailings Containment Berms (Construction)	-	-	-	-	71,640	-	-	-	-	-	-	71,640
Finger Dikes (Construction)	-	-	-	-	-	-	-	-	-	-	-	-
Total Volume Required for Dikes	100,332	931,111	439,837	763,327	71,640	-	27,548	-	-	-	-	2,333,795
Road to ANFO Storage	-	75,000	-	-	-	-	-	-	-	-	-	75,000
Plant Roads	-	103,932	-	-	-	-	-	-	-	-	-	103,932
Vault Haul Road	-	-	-	356,450	-	-	-	-	-	-	-	356,450
Airstrip	-	18,700	-	-	-	-	-	-	-	-	-	18,700
Mill Foundations	60,000	60,000	-	-	-	-	-	-	-	-	-	120,000
Total Volume Required for Construction	60,000	257,632	-	356,450	-	-	-	-	-	-	-	674,082
												-
TOTAL IV REQUIRED	160,332	1,188,743	439,837	1,119,777	71,640	0	27,548	0	0	0	0	3,007,877
TOTAL IV AVAILABLE[2]	239,784	392,234	3,446,746	3,956,876	2,508,588	1,800,654	834,349	203,287	0	0	0	13,382,517
SURPLUS (DEFICIT)	79,452	(-796,510)	3,006,909	2,837,099	2,436,948	1,800,654	806,801	203,287	0	0	0	10,374,639
IF												-
East Dike (Construction)	146,859	-	-	-	-	-	-	-	-	-	-	146,859
East Dike Extension	275,080	-	-	-	-	-	-	-	-	-	-	275,080
Finger Dike Extension	-	-	-	-	258,621	517,242	258,621	258,621	-	-	-	1,293,104
NNLP HC Mounts (M1, M2, M3, M4, M5, M6)	-	-	-	-	-	-	34,182	-	-	-	-	34,182
East Causeway (Construction)	-	-	-	-	-	-	-	-	-	-	-	-
Bay Zone Dike (Construction)	-	245,210	-	-	-	-	-	-	-	-	-	245,210
Tailings Dike (Construction)	-	-	-	-	-	-	-	-	-	-	-	-
Stormwater Dike (Construction)	-	277,250	-	-	-	-	-	-	-	-	-	277,250
Goose Island Dike (Construction)	-	-	886,534	-	-	-	-	-	-	-	-	886,534
Vault Dike (Construction)	-	-	-	-	-	-	-	-	-	-	-	-
Tailings Containment Berms (Construction)	-	-	-	-	-	-	-	-	-	-	-	-
Finger Dikes (Construction)	-	-	-	-	420343.4	840686.8	791343.4	49343.4	-	-	-	2,101,717
Total Volume Required for Dike	421,939	522,460	886,534	-	678,964	1,357,928	1,084,146	307,964	-	-	-	5,259,936
Road	-	-	-	-	-	-	-	-	-	-	-	-
Plant Roads	-	-	-	-	-	-	-	-	-	-	-	-
Vault Haul Road	-	-	-	-	-	-	-	-	-	-	-	-
Airstrip	-	-	-	-	-	-	-	-	-	-	-	-
Mill Foundations	-	-	-	-	-	-	-	-	-	-	-	-
Total Volume Required for Construction	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL IRON FM. REQUIRED	421,939	522,460	886,534	0	678,964	1,357,928	1,084,146	307,964	0	0	0	5,259,936
TOTAL IRON FM. AVAILABLE[2]	217,225	830,122	5,956,608	2,025,875	1,745,133	4,407,913	2,469,286	308,533	0	0	0	17,960,695
SURPLUS (DEFICIT)	(-204,714)	307,662	5,070,074	2,025,875	1,066,168	3,049,985	1,385,140	569	0	0	0	12,700,759
WASTE MATERIALS BALANCE												
WASTE REQUIREMENTS[3]	674,361	2,234,127	2,138,854	3,864,727	3,463,110	1,436,328	1,511,821	347,164	0	0	0	15,670,493
WASTE ROCK PRODUCTION[2]	947,299	2,216,904	14,143,650	15,357,288	10,853,028	13,496,428	12,506,512	11,613,545	9,262,245	5,566,085	547,297	96,510,281

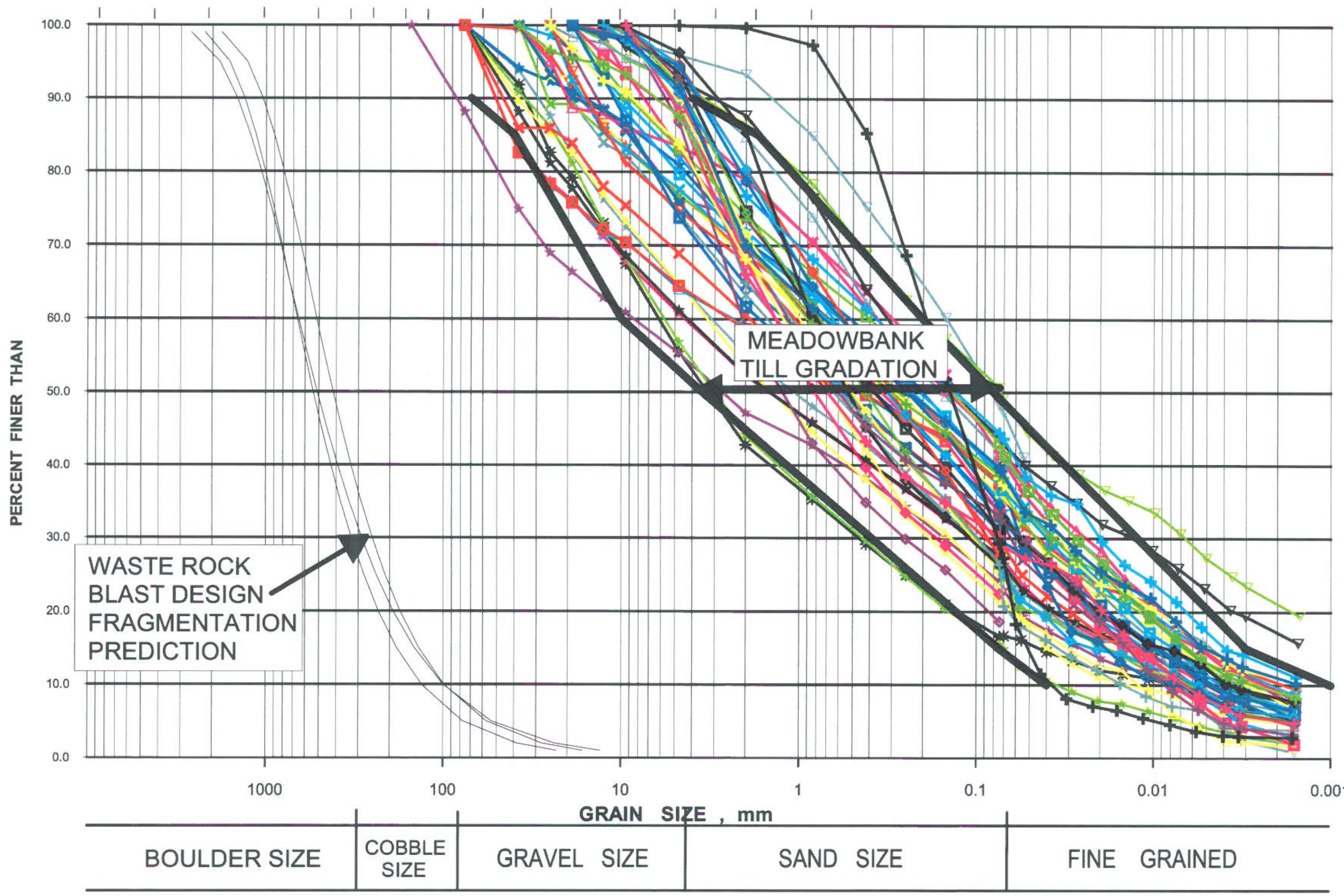
MINED VOLUMES[2]	Year - 2	Year -1	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Total
PORTAGE AREA[2]												
Intermediate Volcanic (m3)	239,784	392,234	3,446,746	1,198,329	885,436	1,224,598	797,091	203,287	0	0	0	8,387,504
Ultramafic (m3)	123,290	257,178	3,510,979	2,247,242	2,401,272	2,479,555	1,404,847	281,587	0	0	0	12,705,949
Iron Formation (m3)	217,225	830,122	5,956,608	1,254,465	1,149,964	3,811,261	2,349,923	308,533	0	0	0	15,878,101
Quartzite (m3)	0	22,429	11,376	0	0	427,153	30,817	0	0	0	0	491,776
Overburden (m3)	367,000	714,941	1,217,941	0	0	1,266,118	33,372	0	0	0	0	3,599,372
Total Waste (m3)	947,299	2,216,904	14,143,650	4,700,035	4,436,672	9,208,685	4,616,050	793,407	0	0	0	41,062,701
GOOSE AREA[2]												
Intermediate Volcanic (m3)	0	0	0	2,758,547	1,623,152	576,056	37,258	0	0	0	0	4,995,013
Ultramafic (m3)	0	0	0	4,283,136	3,922,954	1,143,466	2,848	0	0	0	0	9,352,405
Iron Formation (m3)	0	0	0	771,410	595,168	596,653	119,363	0	0	0	0	2,082,594
Quartzite (m3)	0	0	0	1,052,924	275,082	0	0	0	0	0	0	1,328,006
Overburden (m3)	0	0	0	1,791,235	0	0	0	0	0	0	0	1,791,235
Total Waste (m3)	0	0	0	10,657,253	6,416,356	2,316,174	159,470	0	0	0	0	19,549,253
VAULT AREA[2]												
Intermediate Volcanic (m3)	0	0	0	0	0	1,971,569	7,730,992	10,820,138	9,262,245	5,566,085	547,297	35,898,326
Ultramafic (m3)	0	0	0	0	0	0	0	0	0	0	0	0
Iron Formation (m3)	0	0	0	0	0	0	0	0	0	0	0	0
Quartzite (m3)	0	0	0	0	0	0	0	0	0	0	0	0
Overburden (m3)	0	0	0	0	0	0	0	0	0	0	0	0
Total Waste (m3)	0	0	0	0	0	1,971,569	7,730,992	10,820,138	9,262,245	5,566,085	547,297	35,898,326

Notes:
1. All construction material will come from the Portage and Goose Pits, except for the Vault Dike construction material which will come from the Vault Pit.
2. Mined Volumes (m^3) converted from Mined Tonnages using density: 1.9 tonnes/m^3 (IV, IF, UM+QTZ) and 1.7 tonnes/m^3 (overburden)

Material balance based on mined tonnages provided by AMEC 2005b
O:\Active_2006\1413\06-1413-081 - Meadowbank Dewatering Dikes\Phase 6000 Design Report\Final Report\Appendix II Materials Balance 2007\Materials Balance Final 2007.xls

Minor variations in estimates of material quantities may result from rounding errors and variations in assumptions.

APPENDIX III
RESULTS OF TECHNICAL ANALYSES

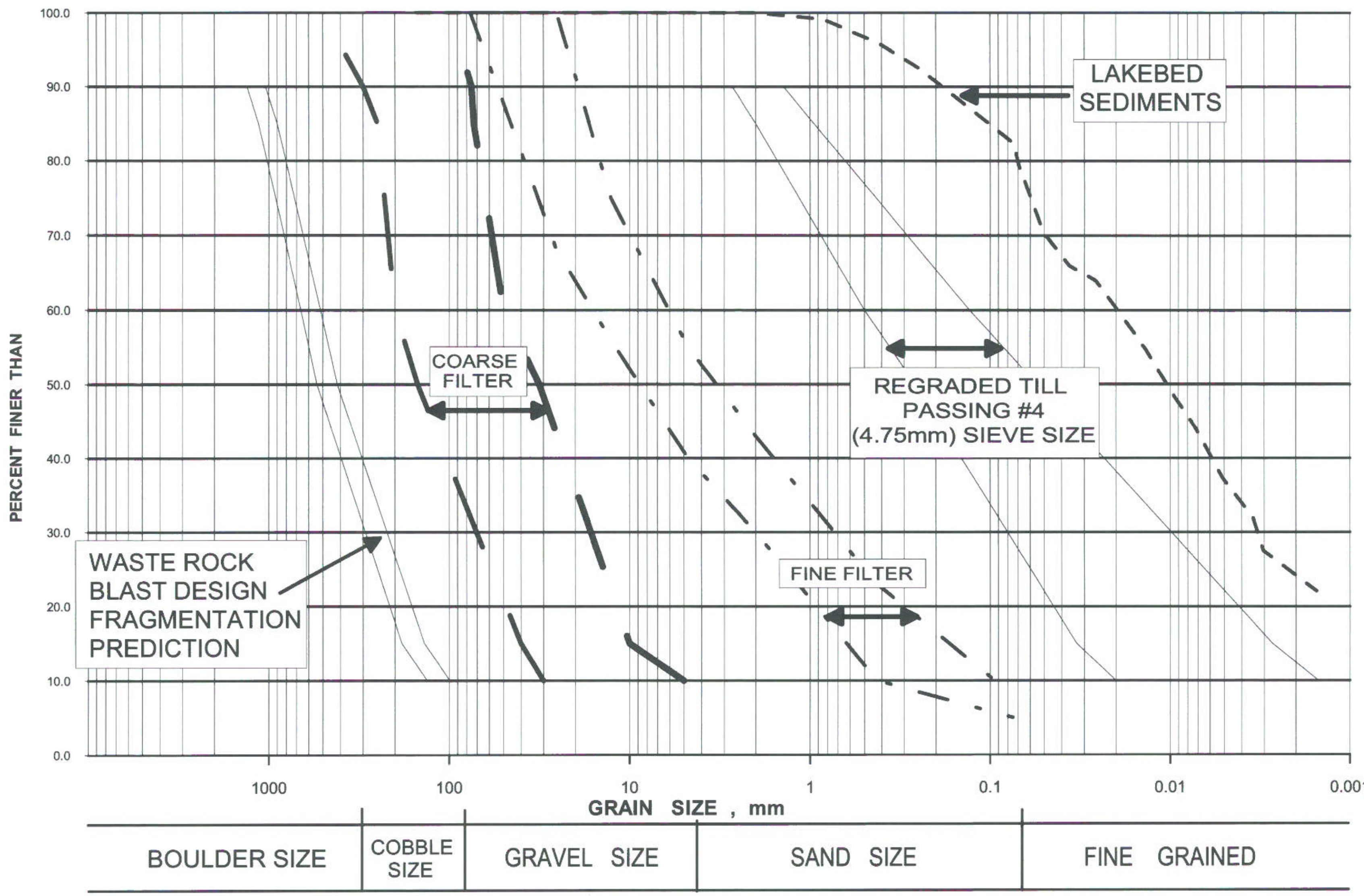


Project No. 06-1413-081
Drawn PK
Reviewed BW
Date 03/08/07

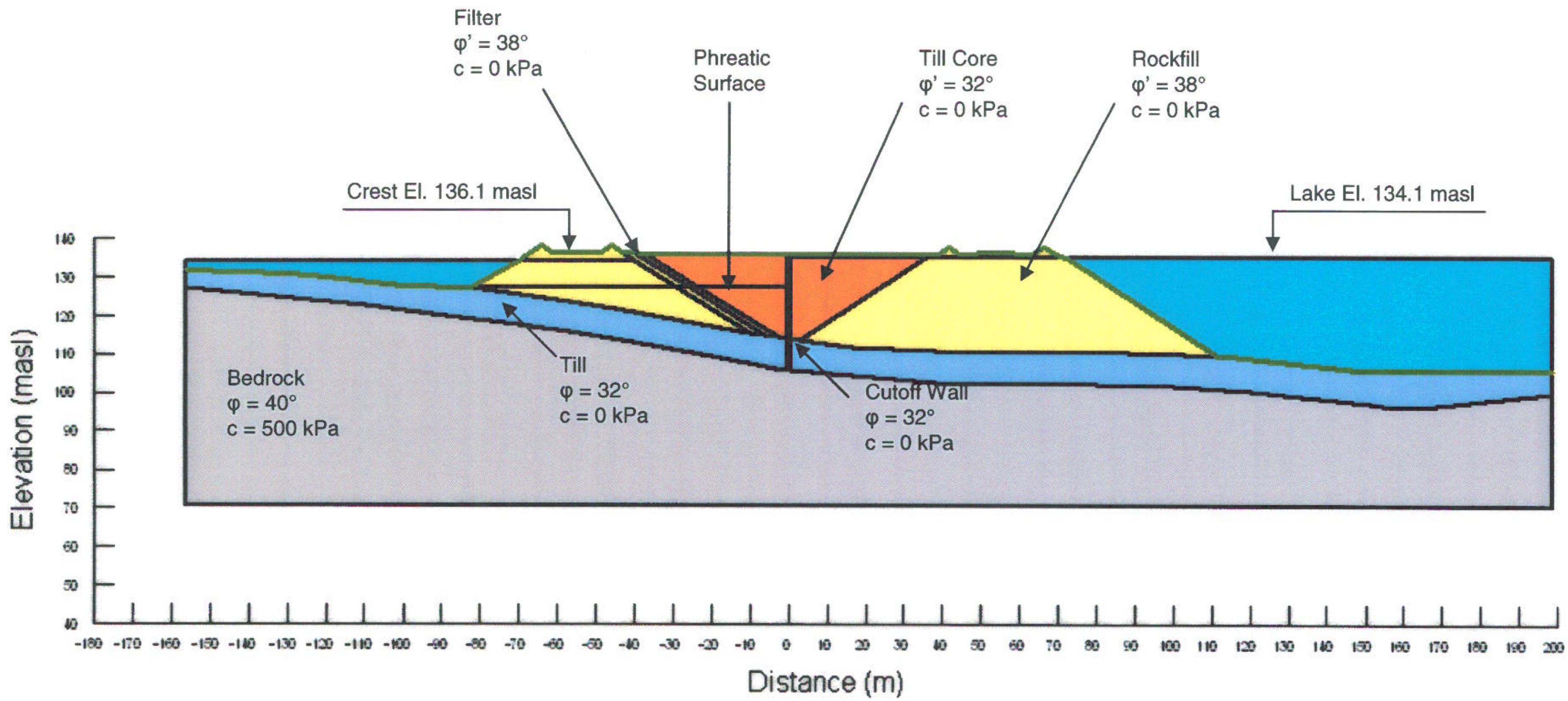
Golder Associates

GRAIN SIZE FOR FILTER DESIGN
MEADOWBANK GOLD PROJECT, NUNAVUT

Figure III-1



Project No. 06-1413-081 Drawn KD Reviewed BW Date 03/08/07	Golder Associates	**GRAIN SIZE COARSE AND FINE FILTERS MEADOWBANK GOLD PROJECT, NUNAVUT**	**Figure III-2**



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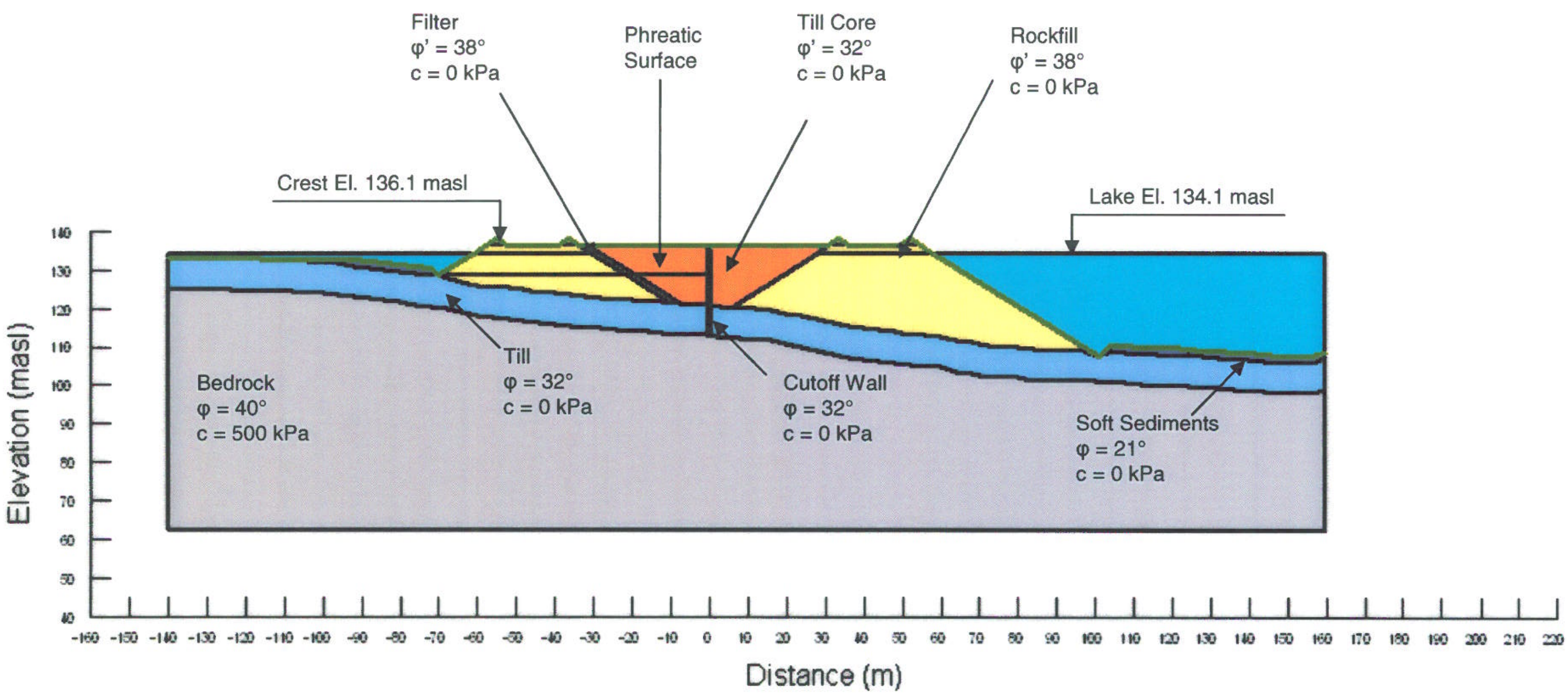
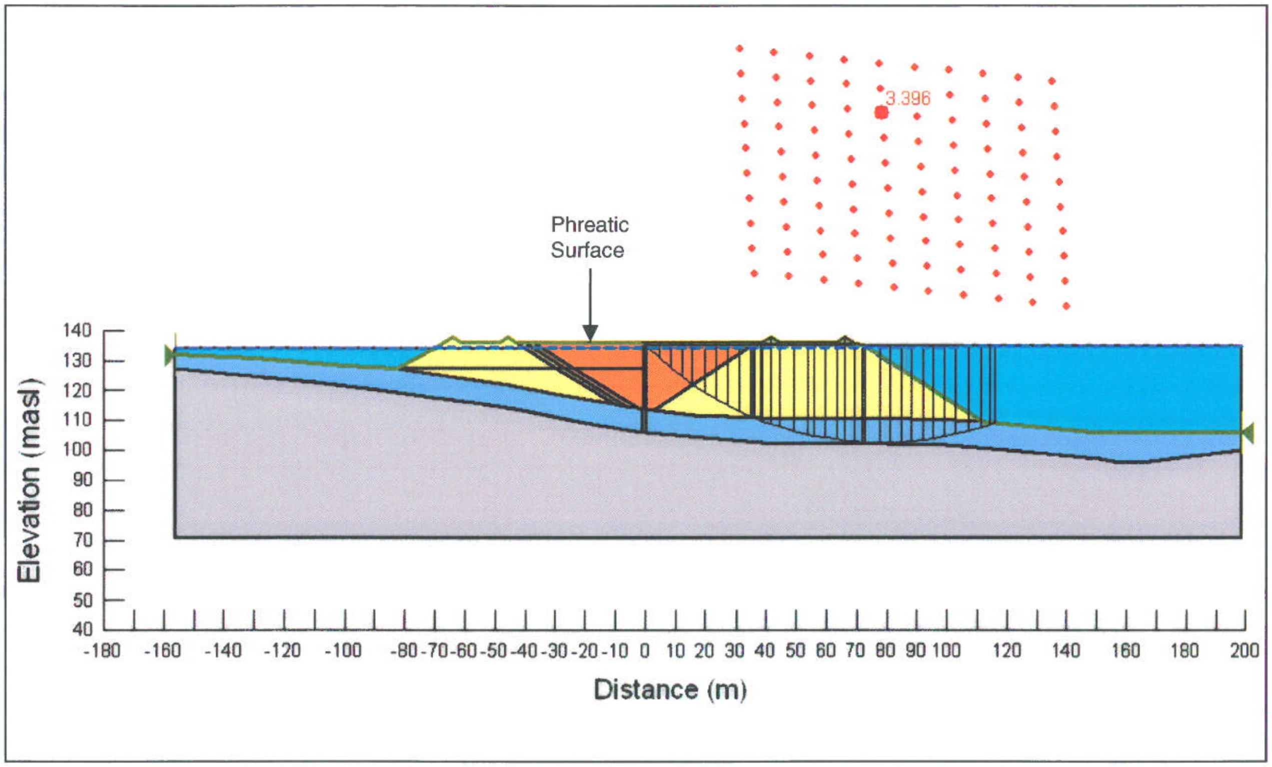
Meadowbank Gold Project
06-1413-081

Figure III-3
Deep Section
Stability Analysis



Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-4
Steep Section
Stability Analysis



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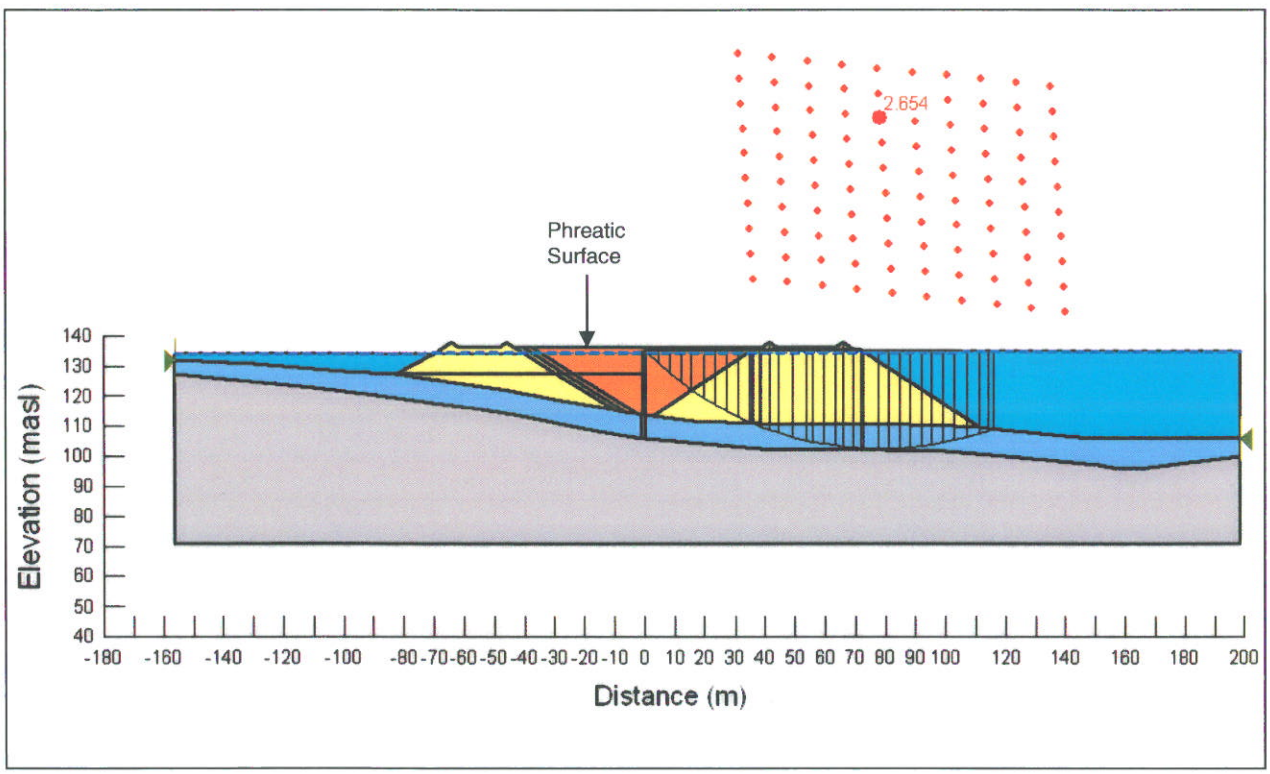

Pseudostatic a=0.035 g

Figure III-5
SLOPE/W Analysis
Deep Section, Pre-drawdown
Upstream Failure

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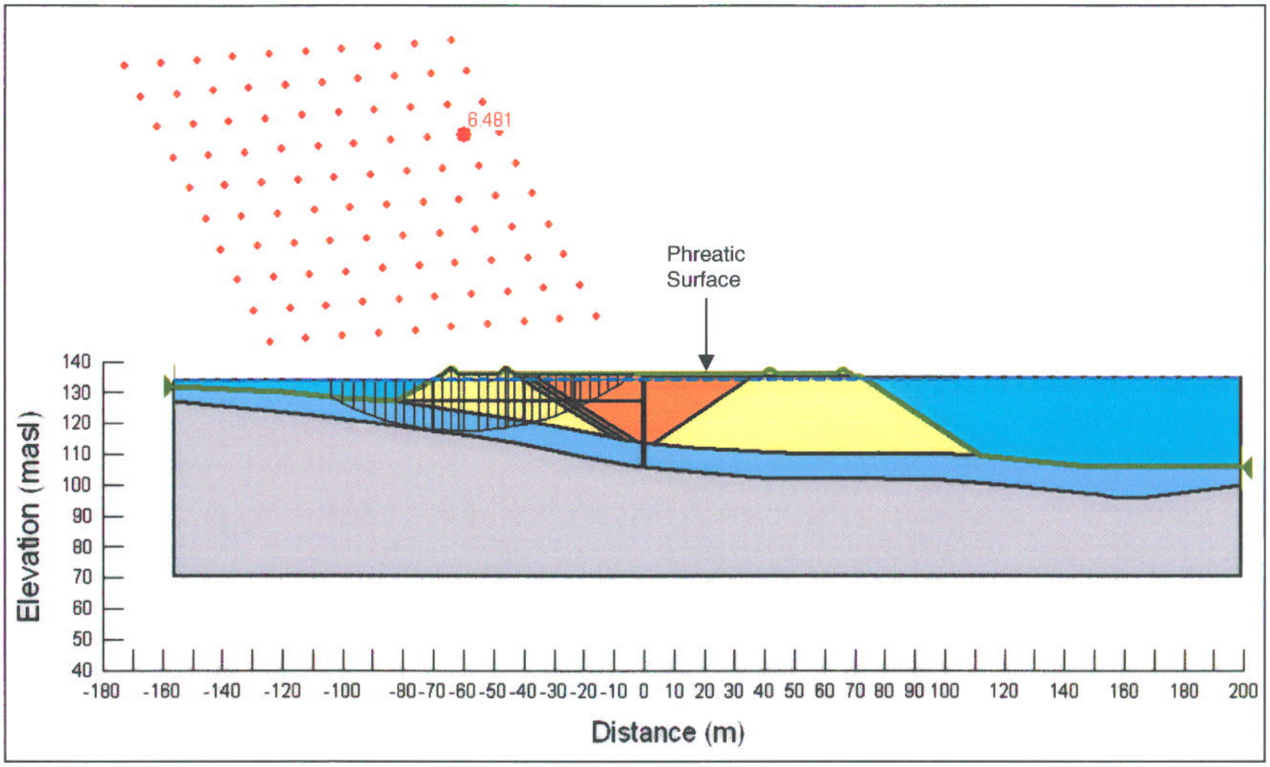
06-1413-081



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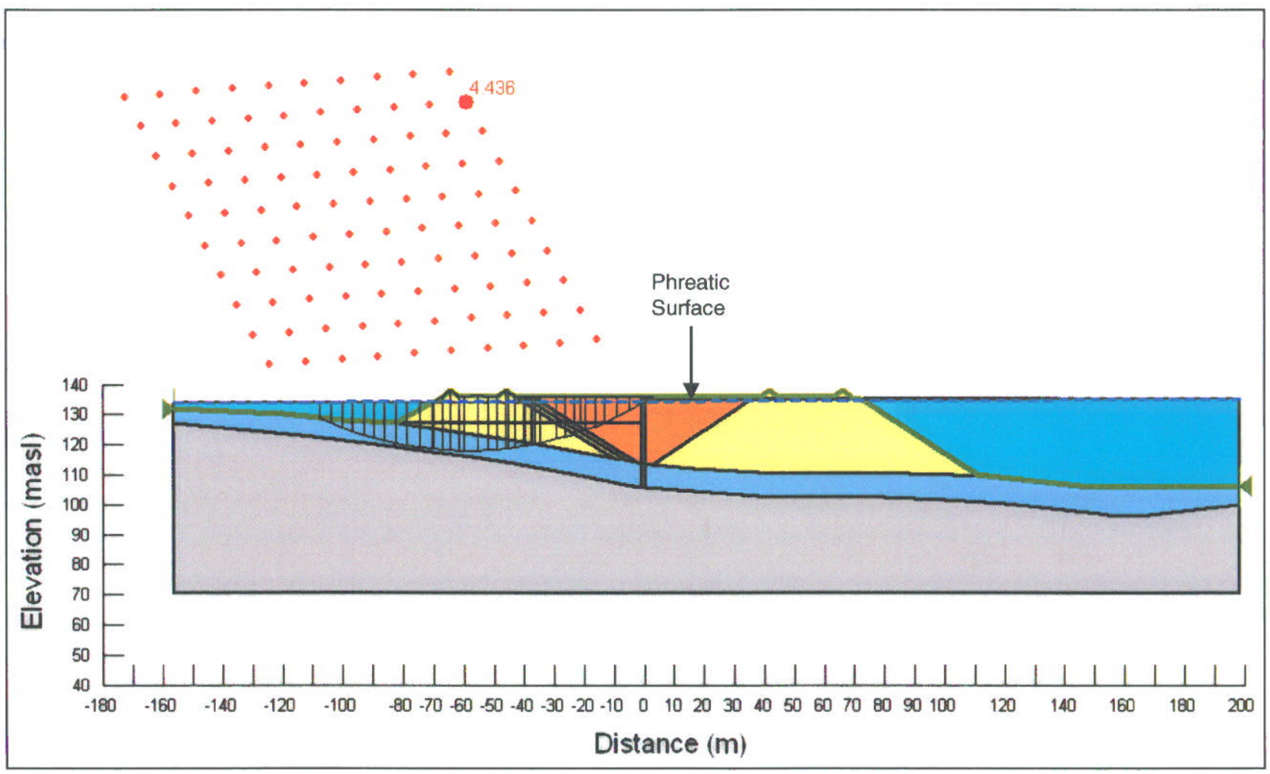
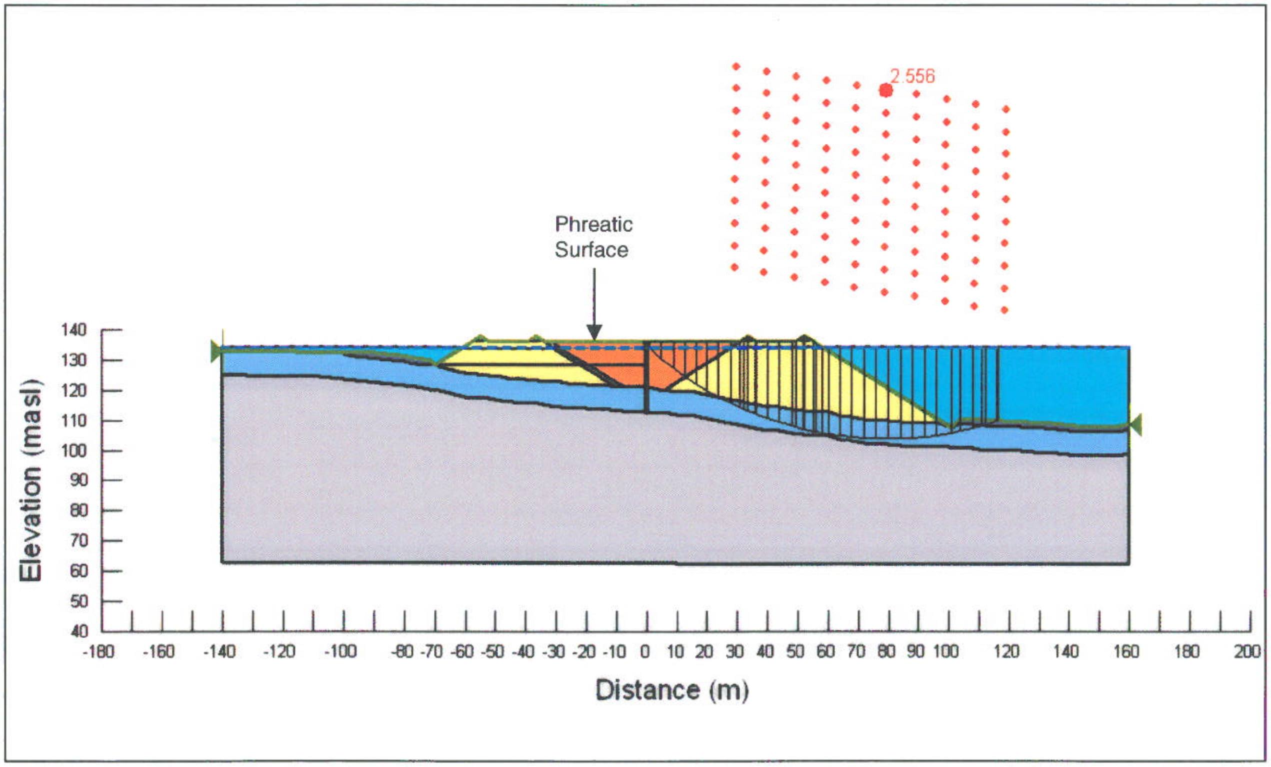


Pseudostatic a=0.035 g

Figure III-6
SLOPE/W Analysis
Deep Section, Pre-drawdown
Downstream Failure

Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081



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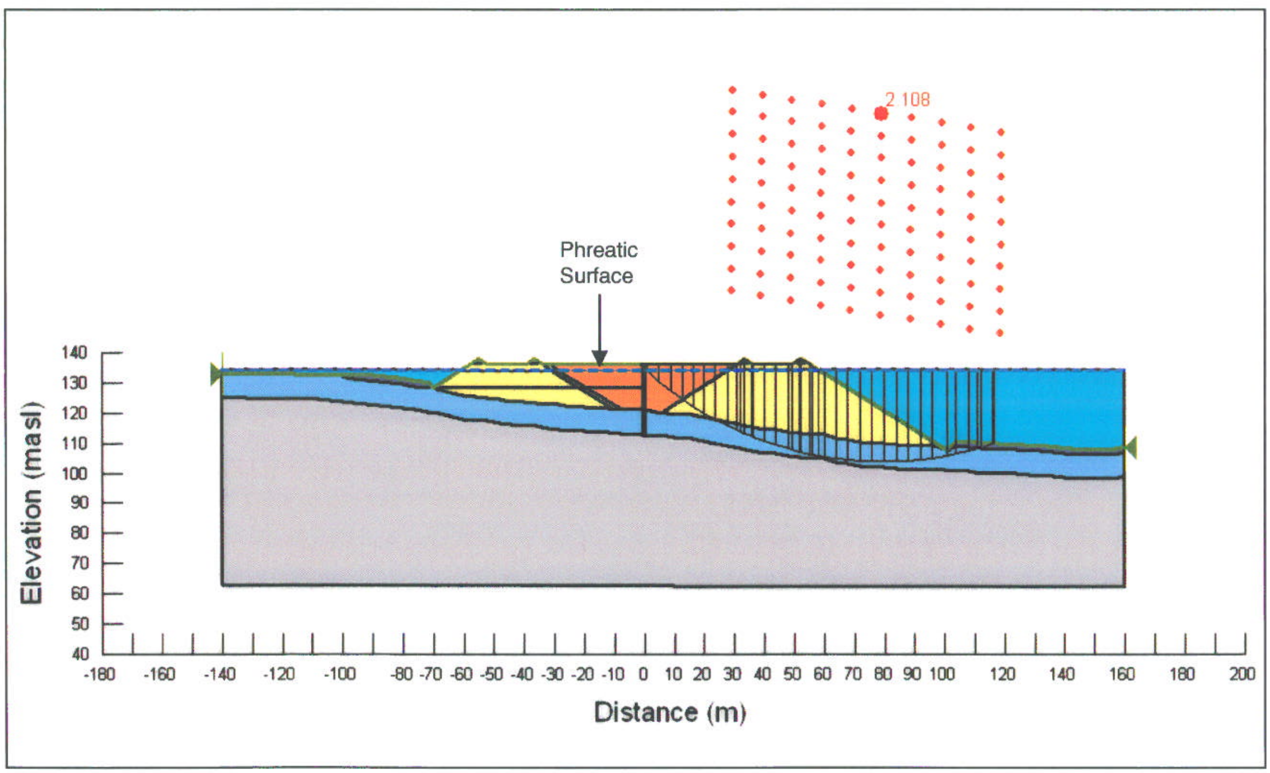
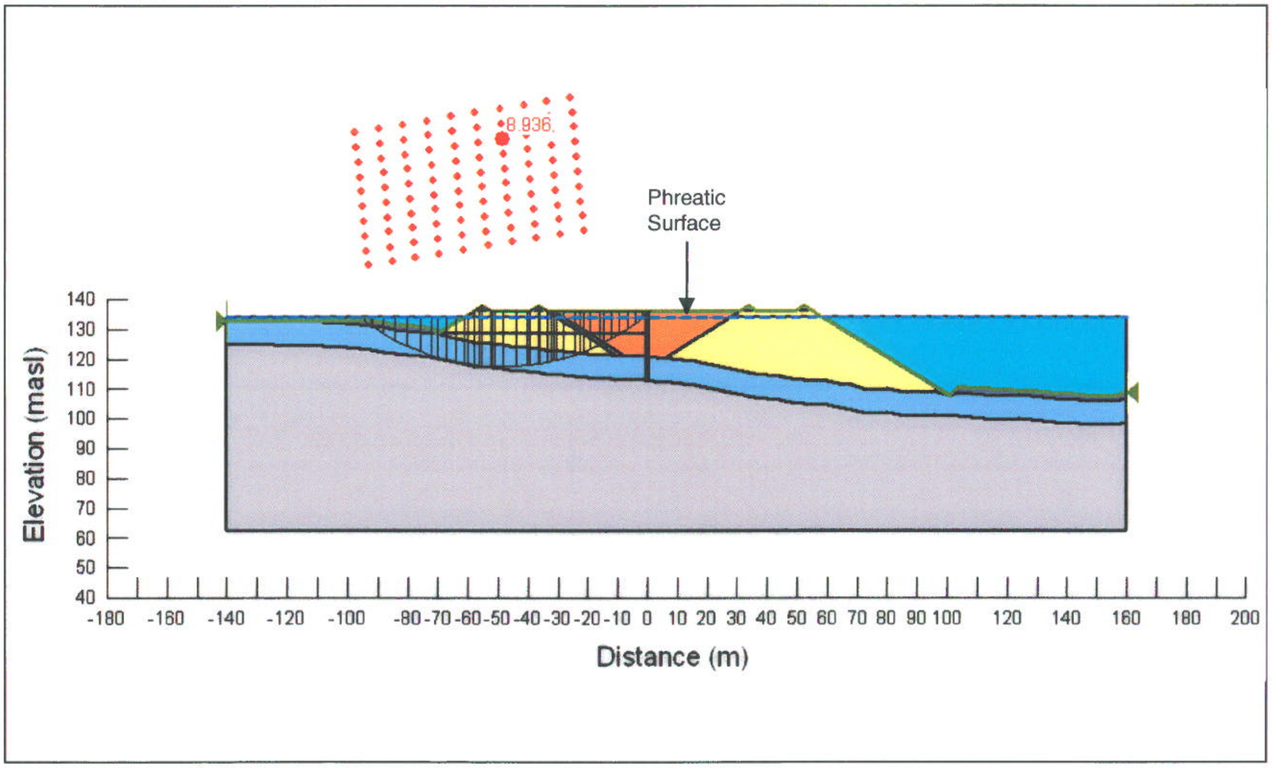


Pseudostatic a=0.035 g

Figure III-7
SLOPE/W Analysis
Steep Section, Pre-drawdown
Upstream Failure



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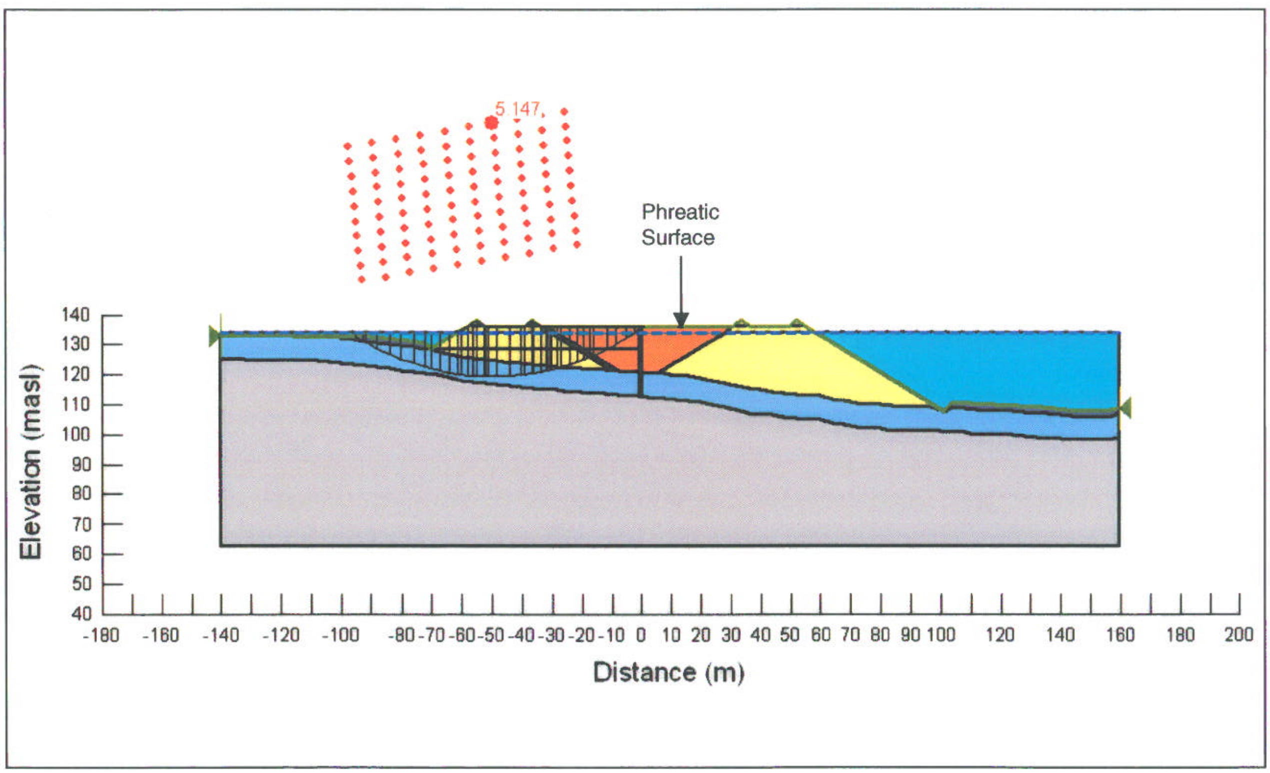

Pseudostatic a=0.035 g

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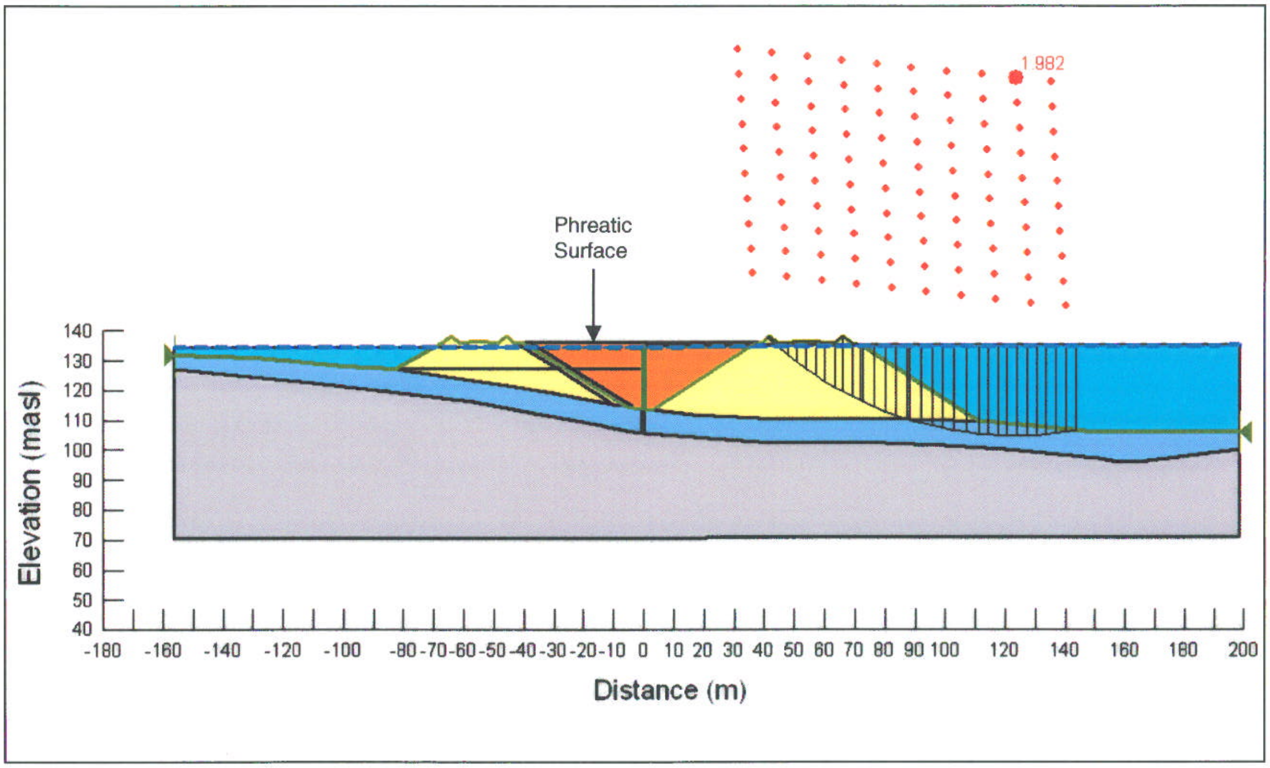
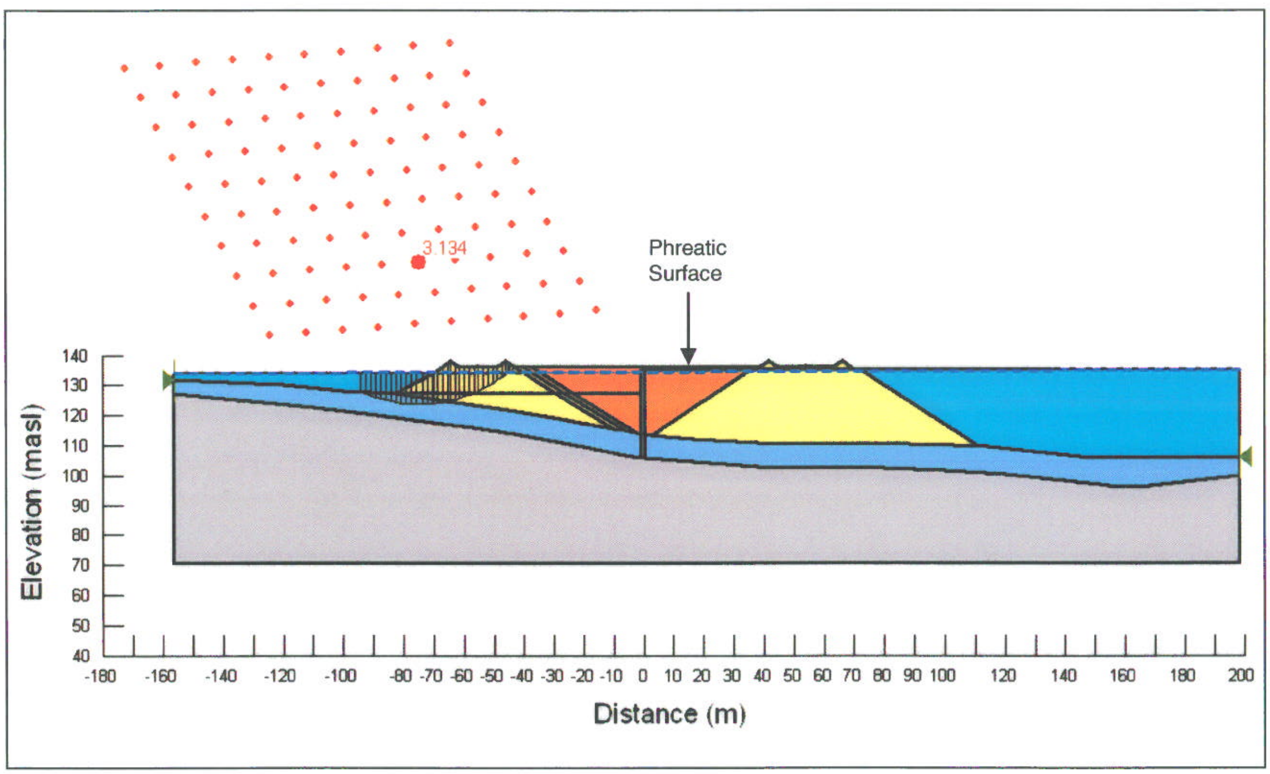
Meadowbank Gold Project
06-1413-081

Figure III-8
SLOPE/W Analysis
Steep Section, Pre-drawdown
Downstream Failure



Upstream



Downstream

Figure III-9
SLOPE/W Analysis
Deep Section, Pre-Drawdown
Low Strength of Till Core φ≤1, C=0 kPa

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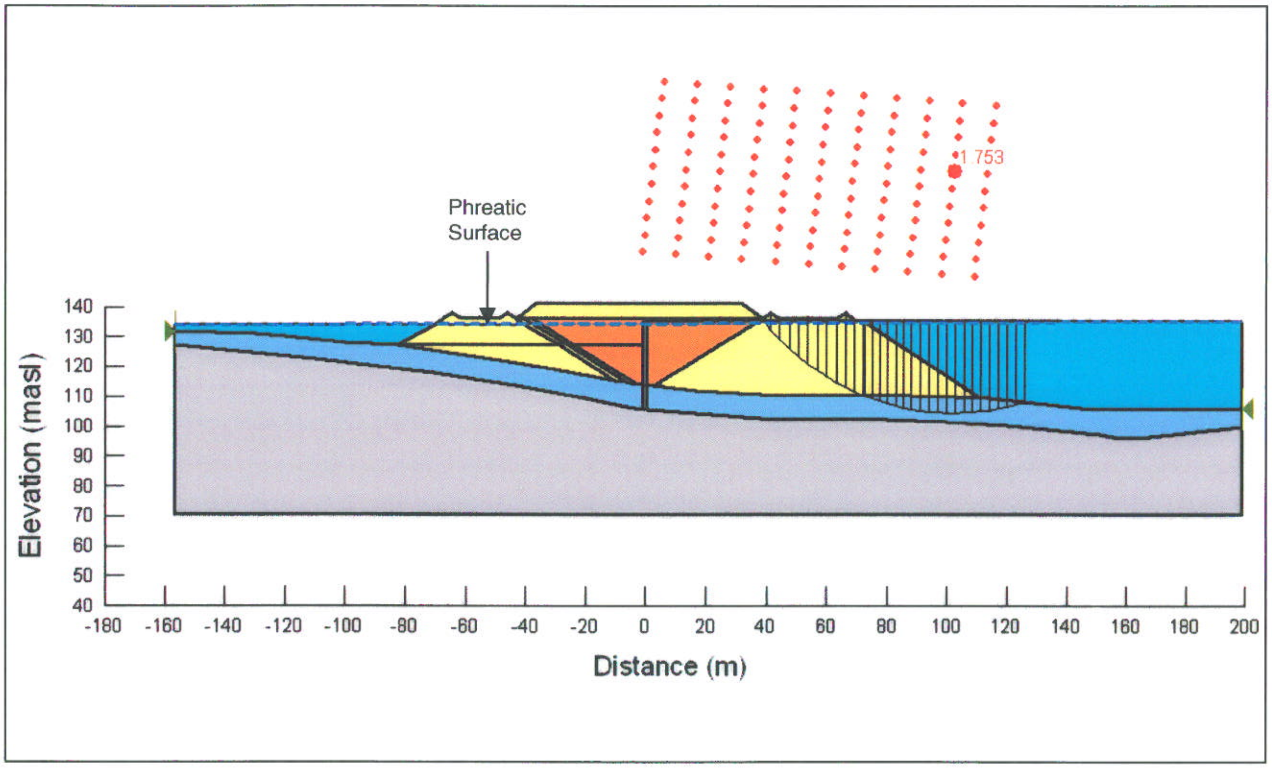
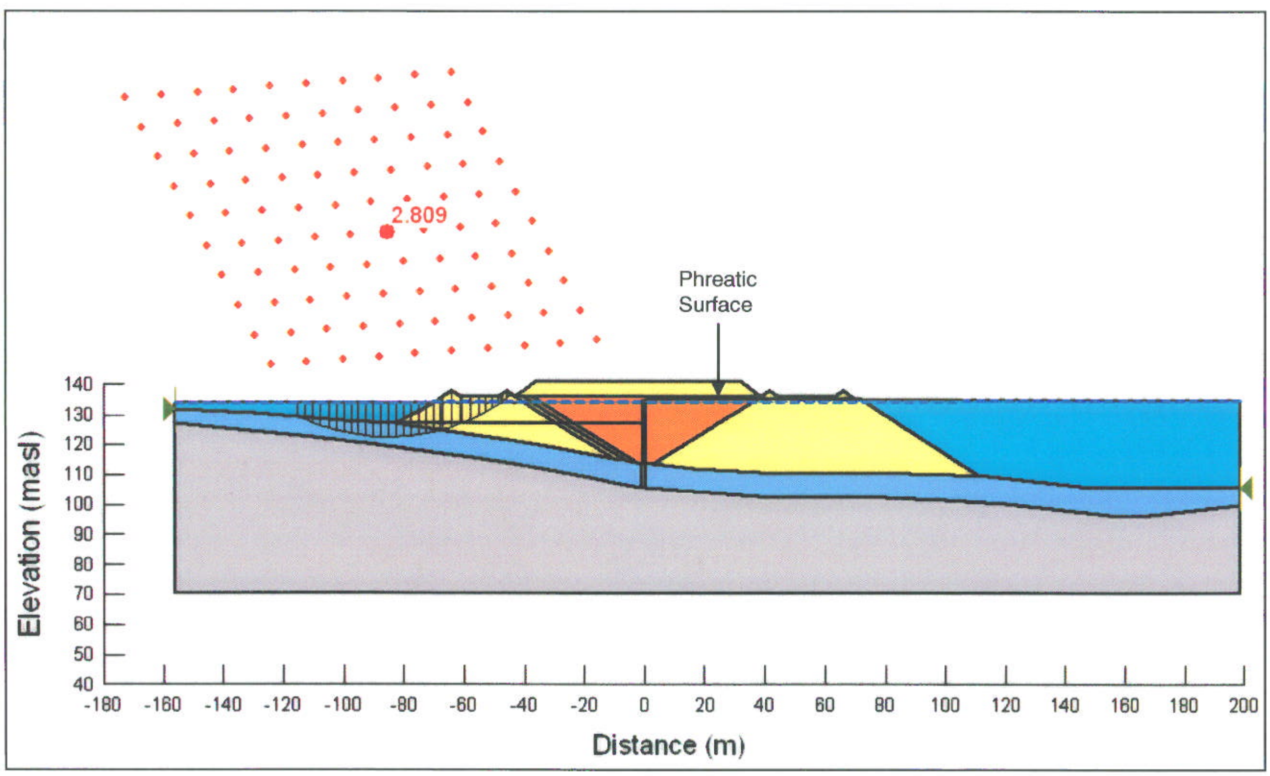
06-1413-081



Upstream



Downstream

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Meadowbank Gold Project
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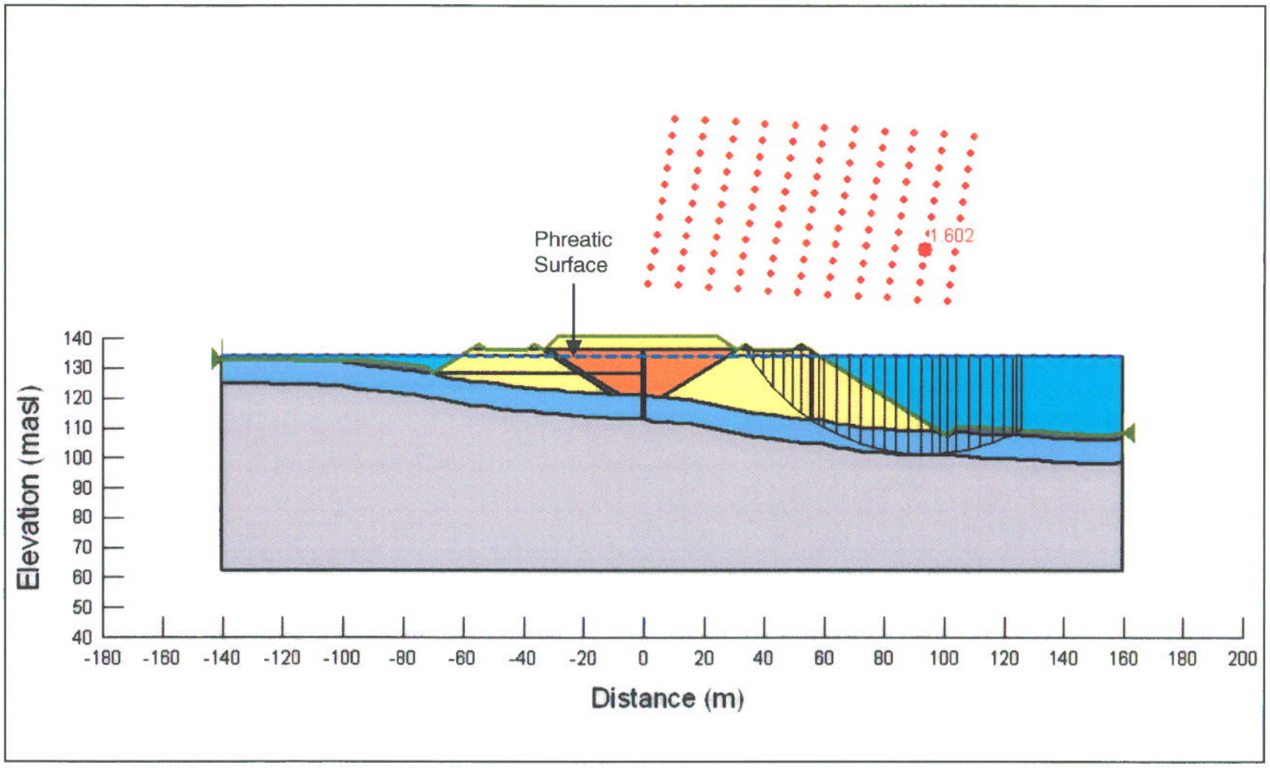
Figure III-10
SLOPE/W Analysis
Deep Section
Pseudostatic
5m Rockfill Cover



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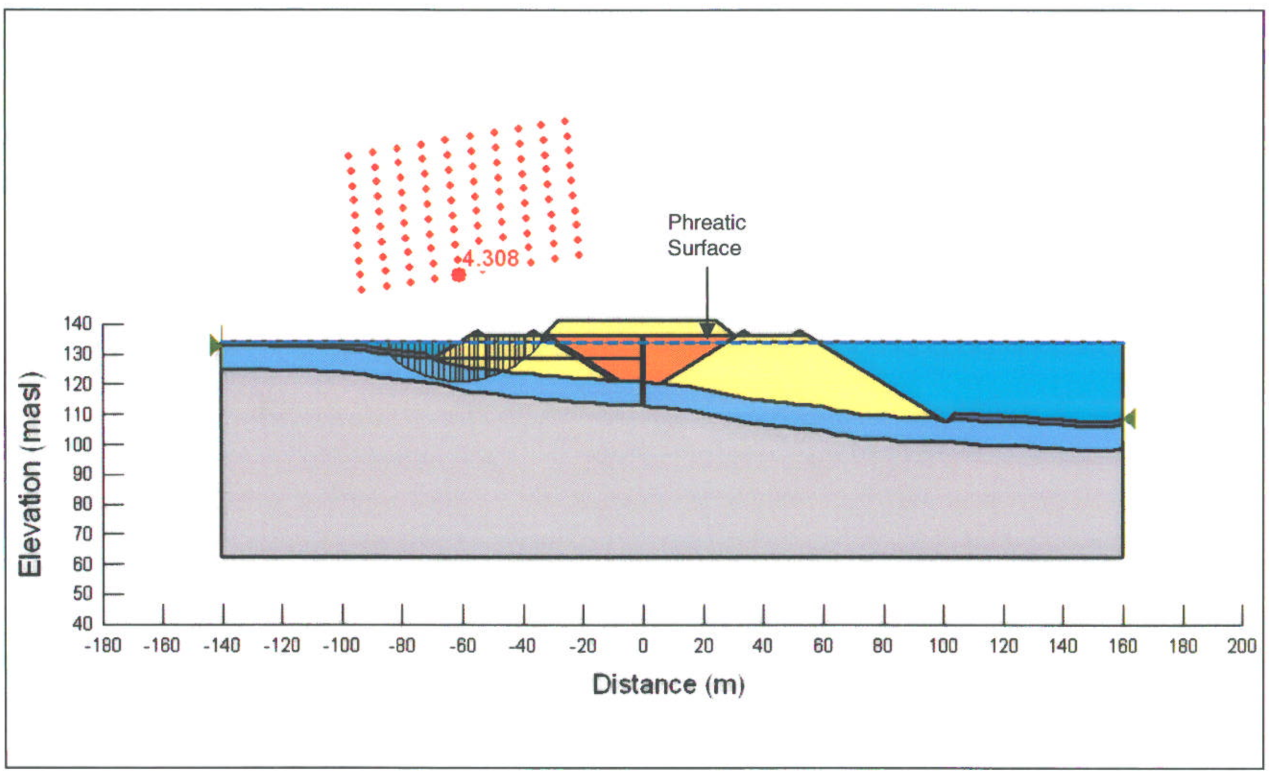
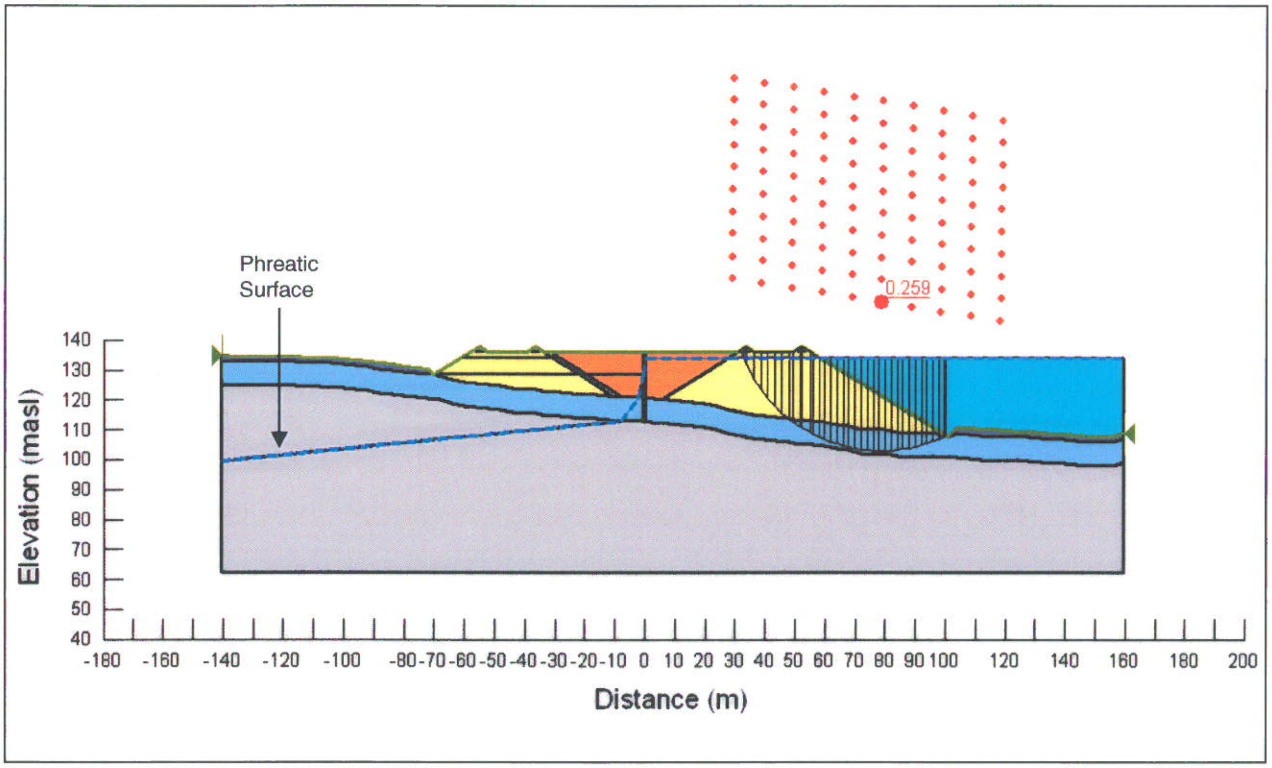


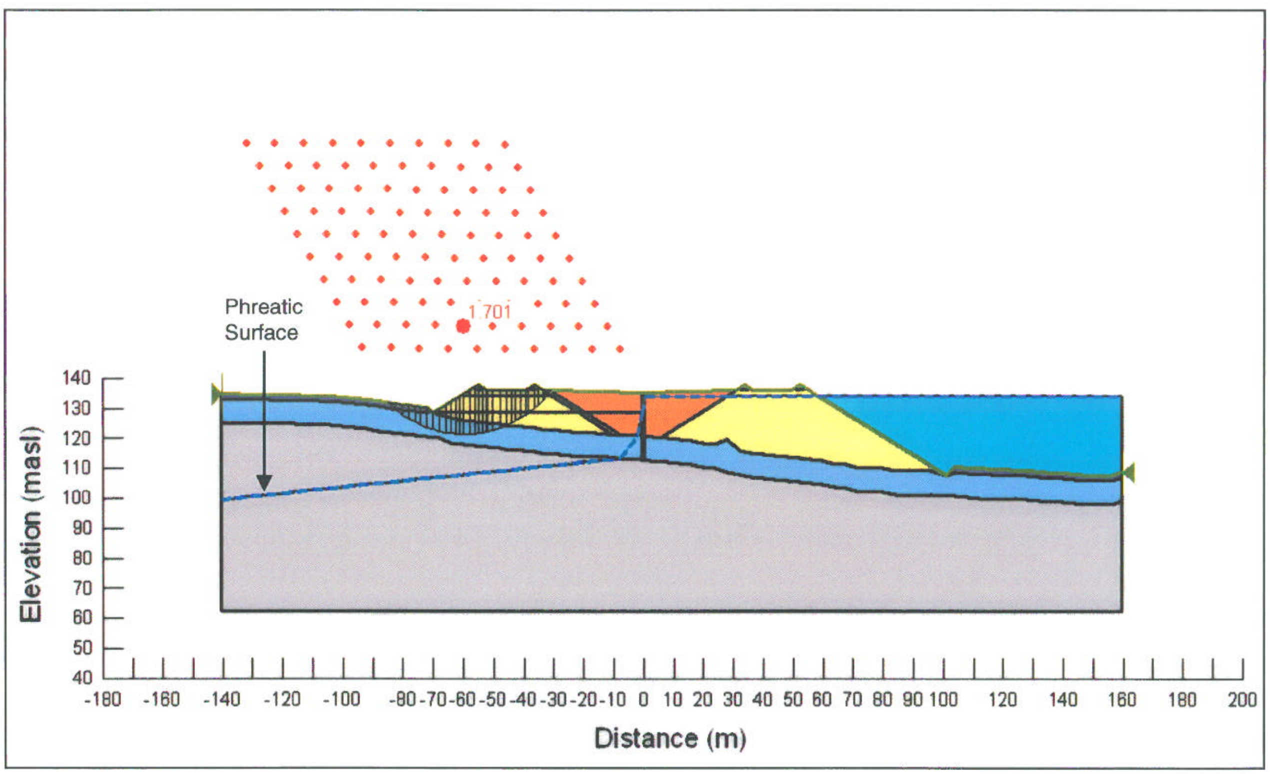
Downstream

Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-11
SLOPE/W Analysis
Steep Section
Pseudostatic
5m Rockfill Cover



Upstream



Downstream

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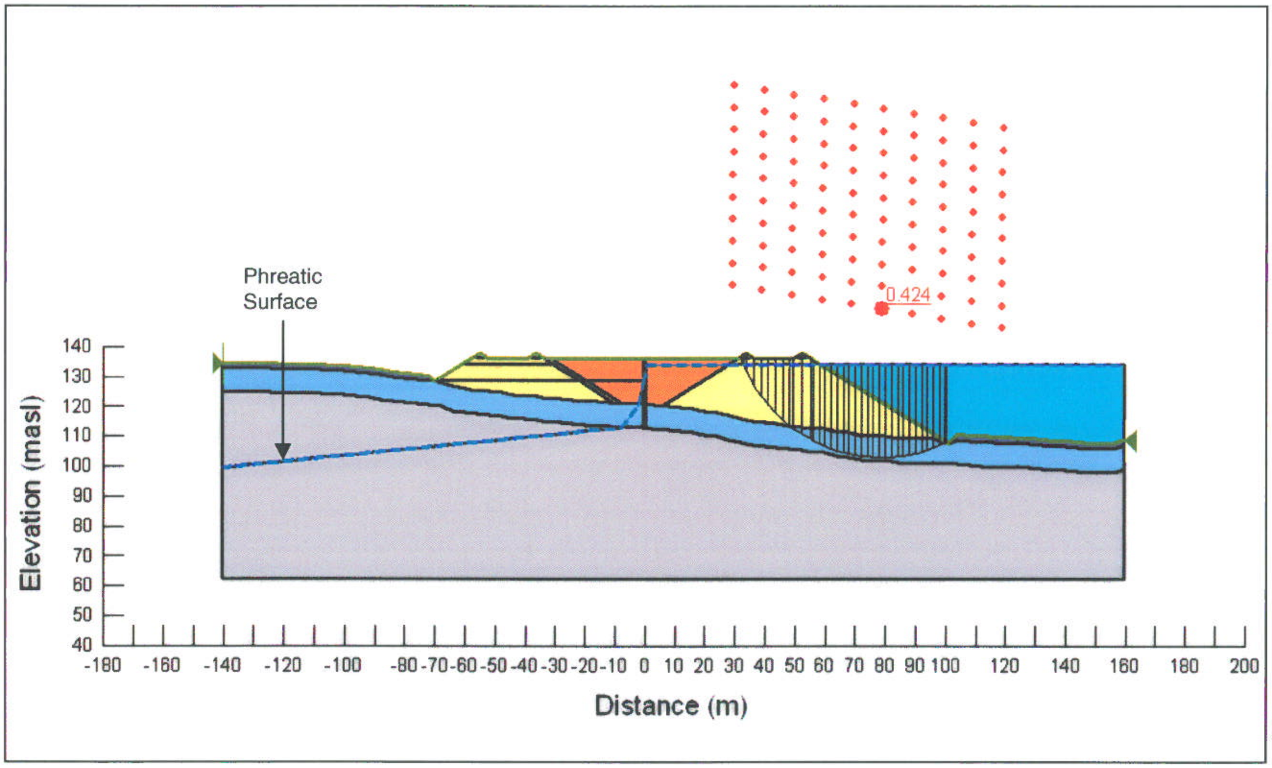
Figure III-12
SLOPE/W Undrained Analysis
Steep Section with low water table
Undrained Strength Lakebed Till 10 kPa



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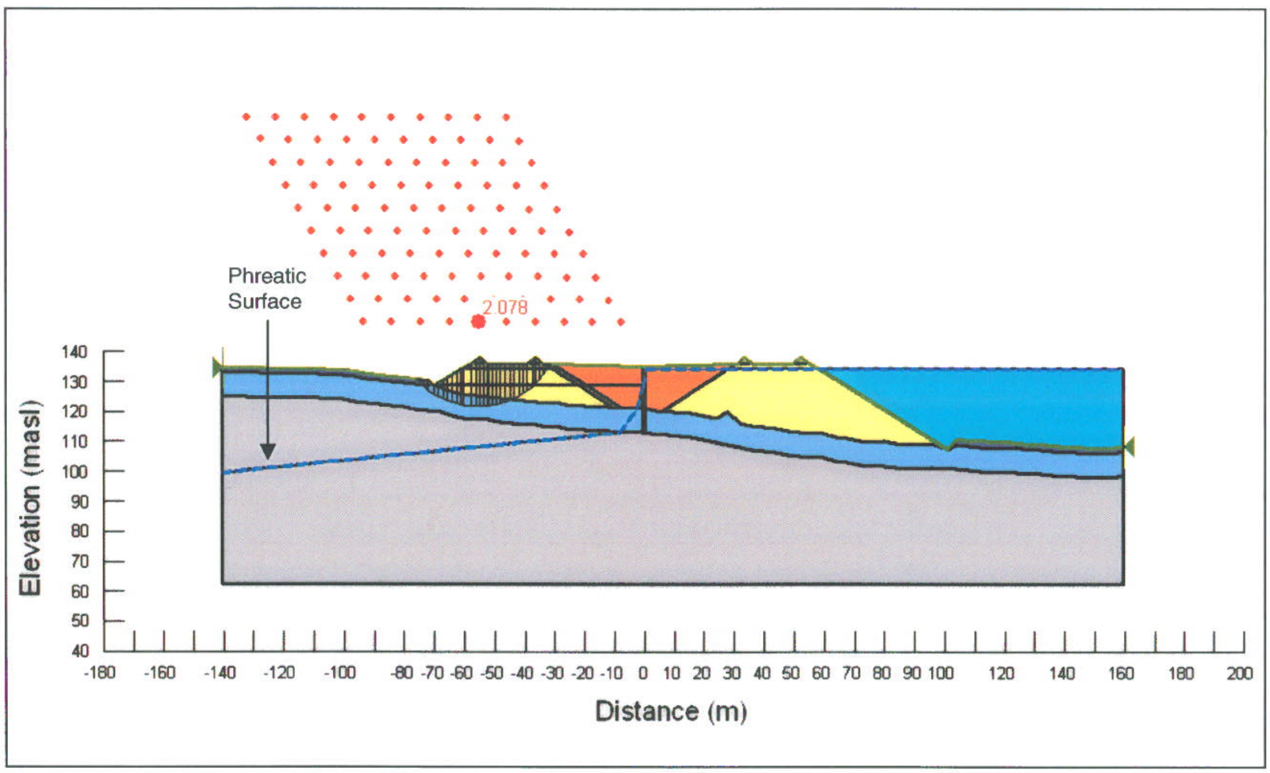

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Meadowbank Gold Project
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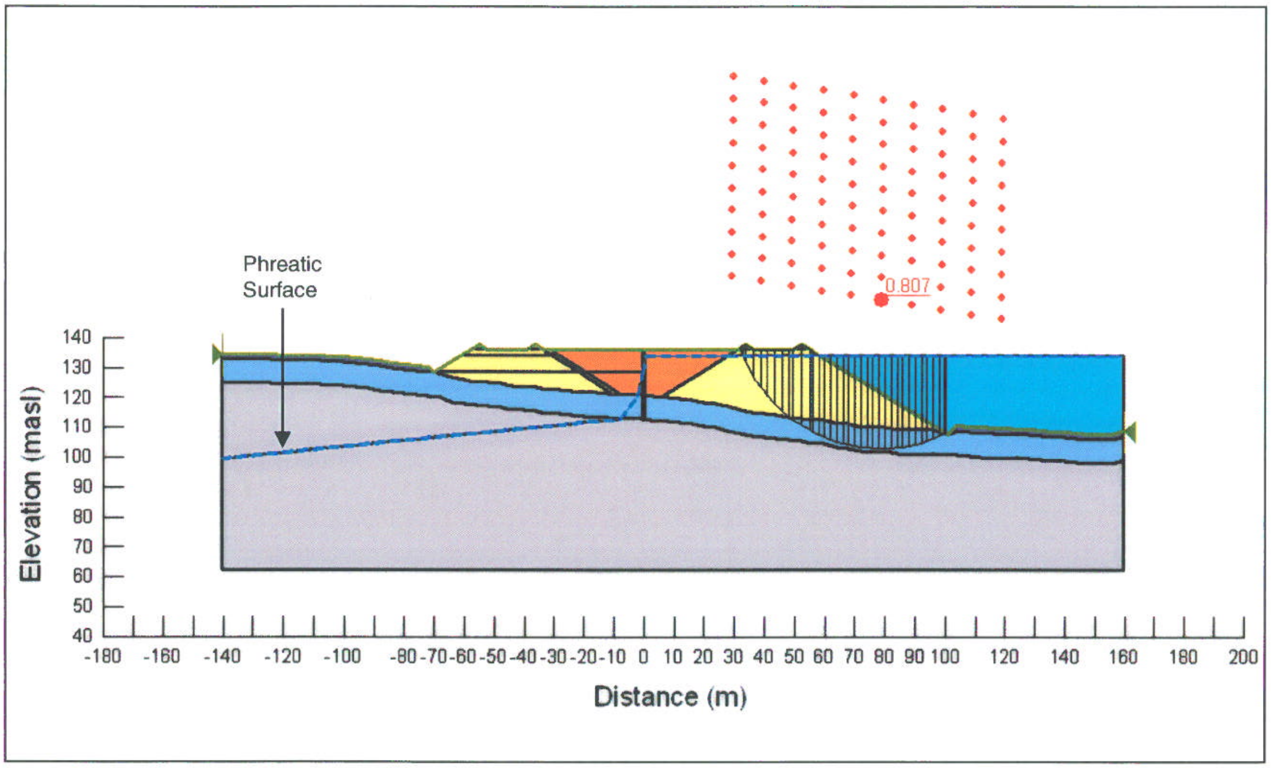
Figure III-13
SLOPE/W Undrained Analysis
Steep Section with low water table
Undrained Strength Lakebed Till 20 kPa



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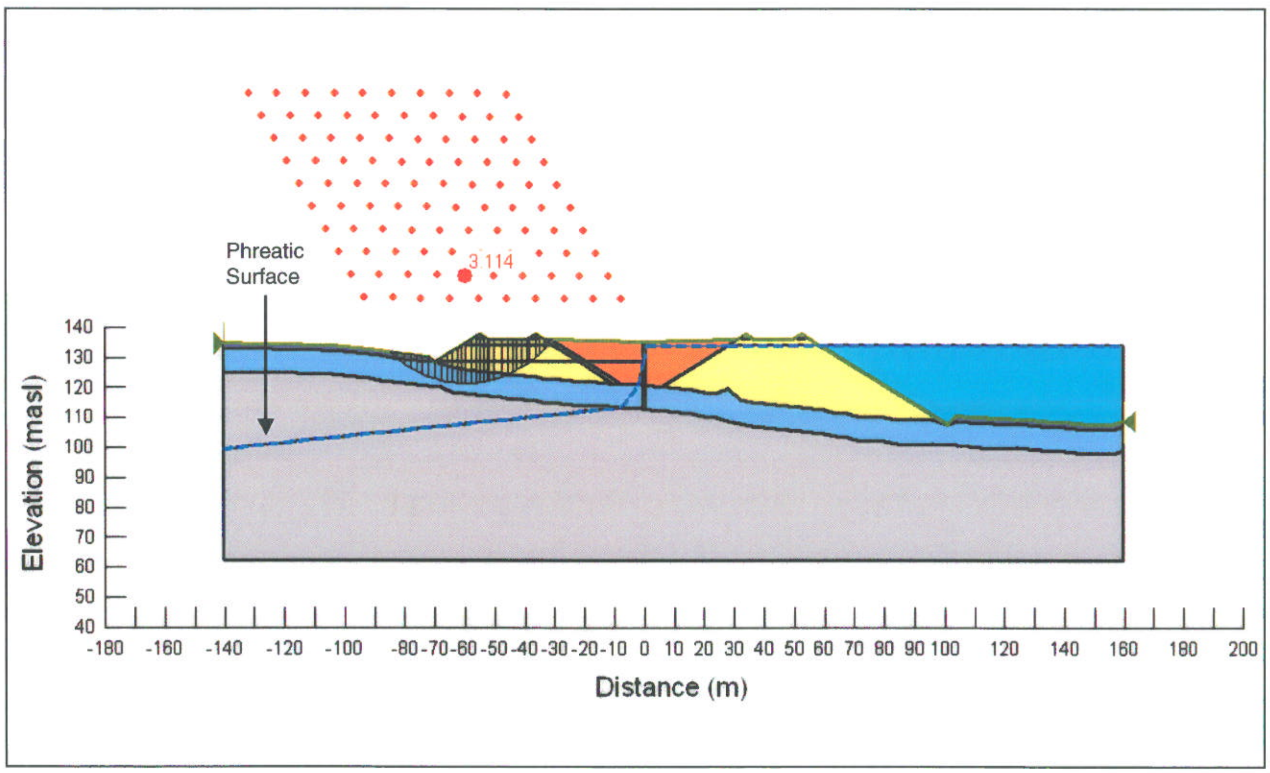

Downstream

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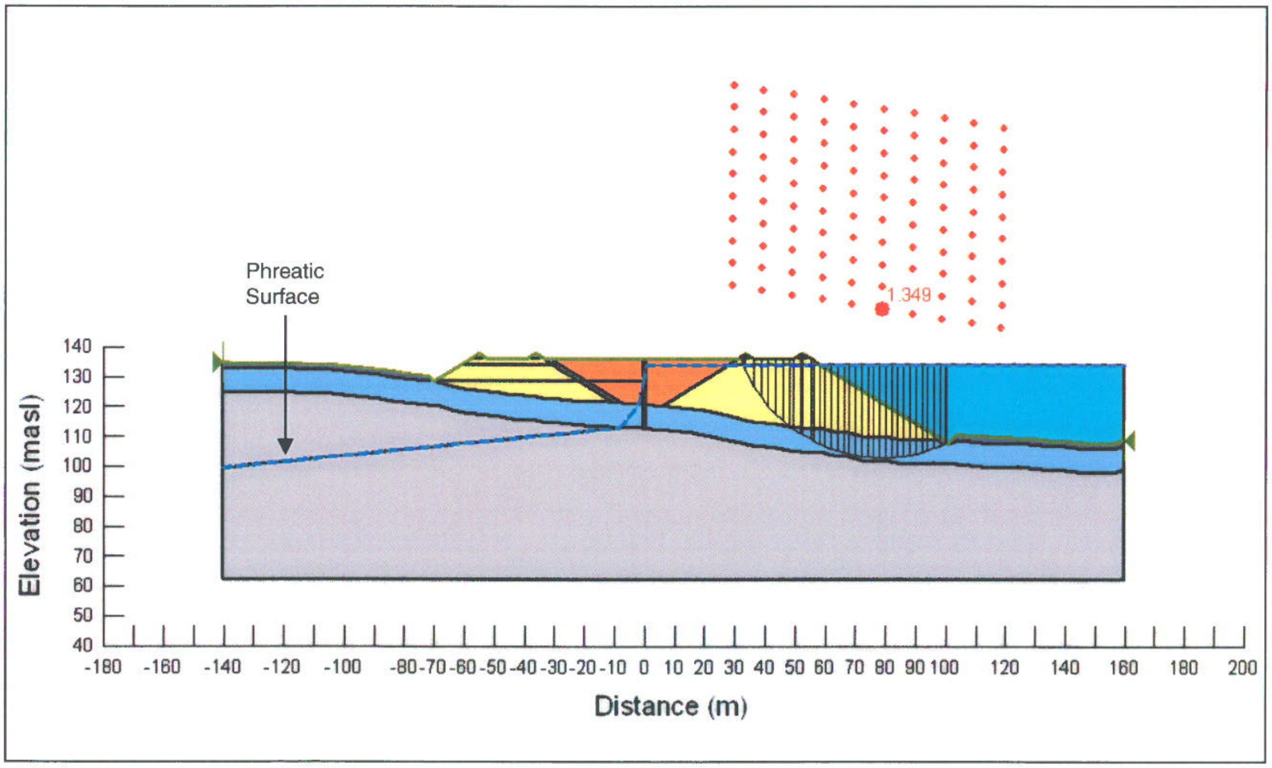
Meadowbank Gold Project
06-1413-081

Figure III-14
SLOPE/W Undrained Analysis
Steep Section with low water table
Undrained Strength Lakebed Till 50 kPa



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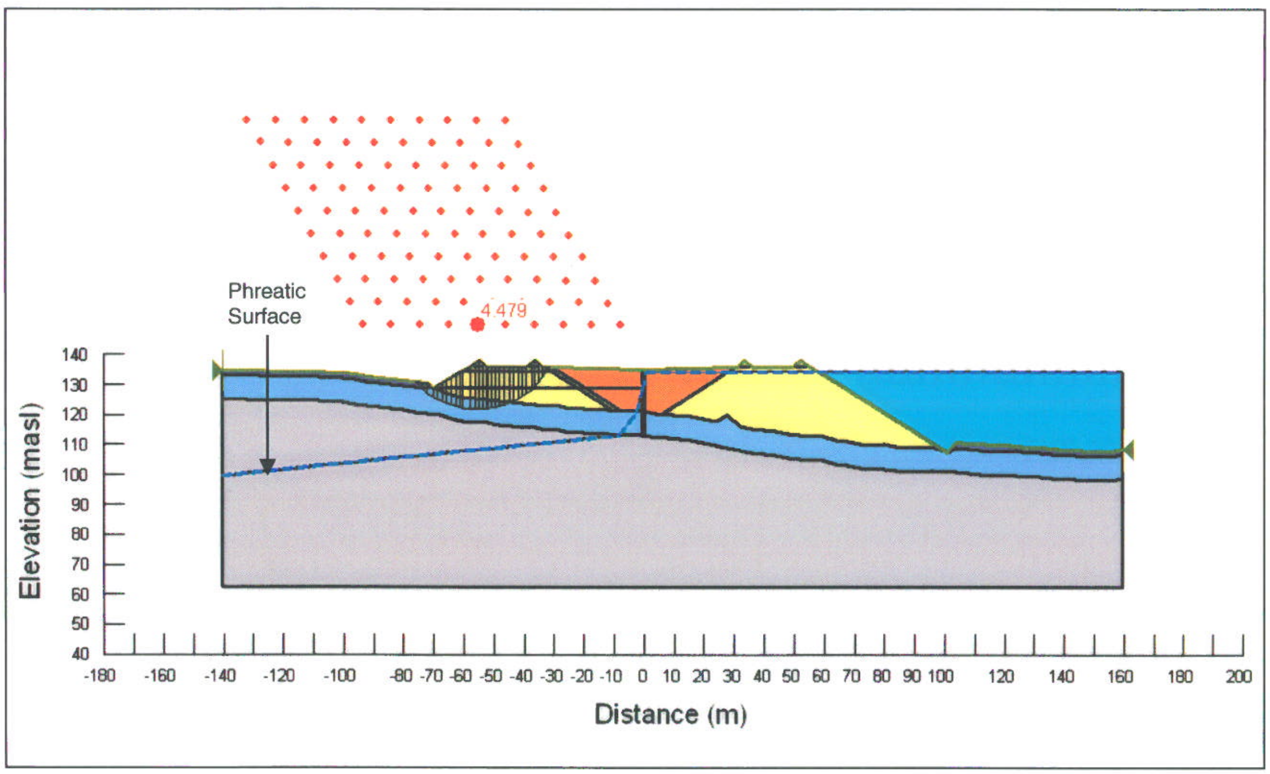

Downstream

Figure III-15
SLOPE/W Undrained Analysis
Steep Section with low water table
Undrained Strength Lakebed Till 100 kPa

Meadowbank Mining Corporation
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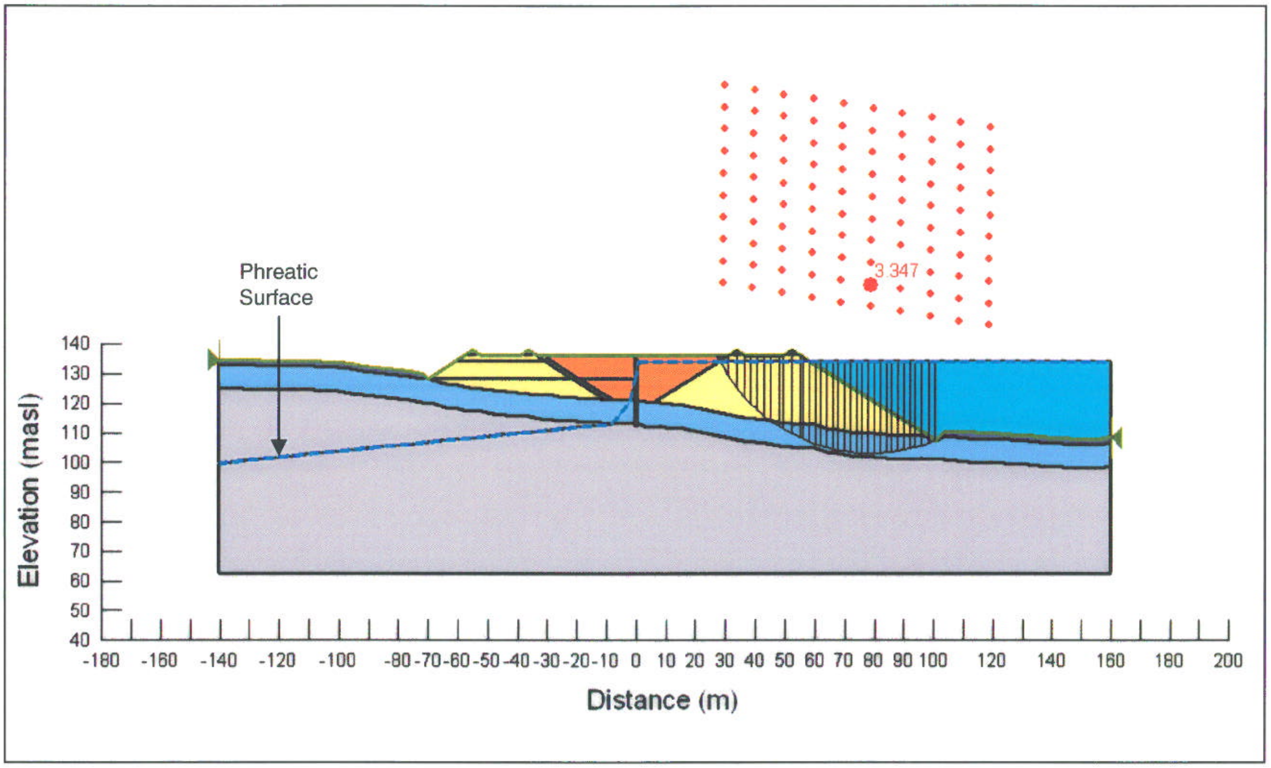

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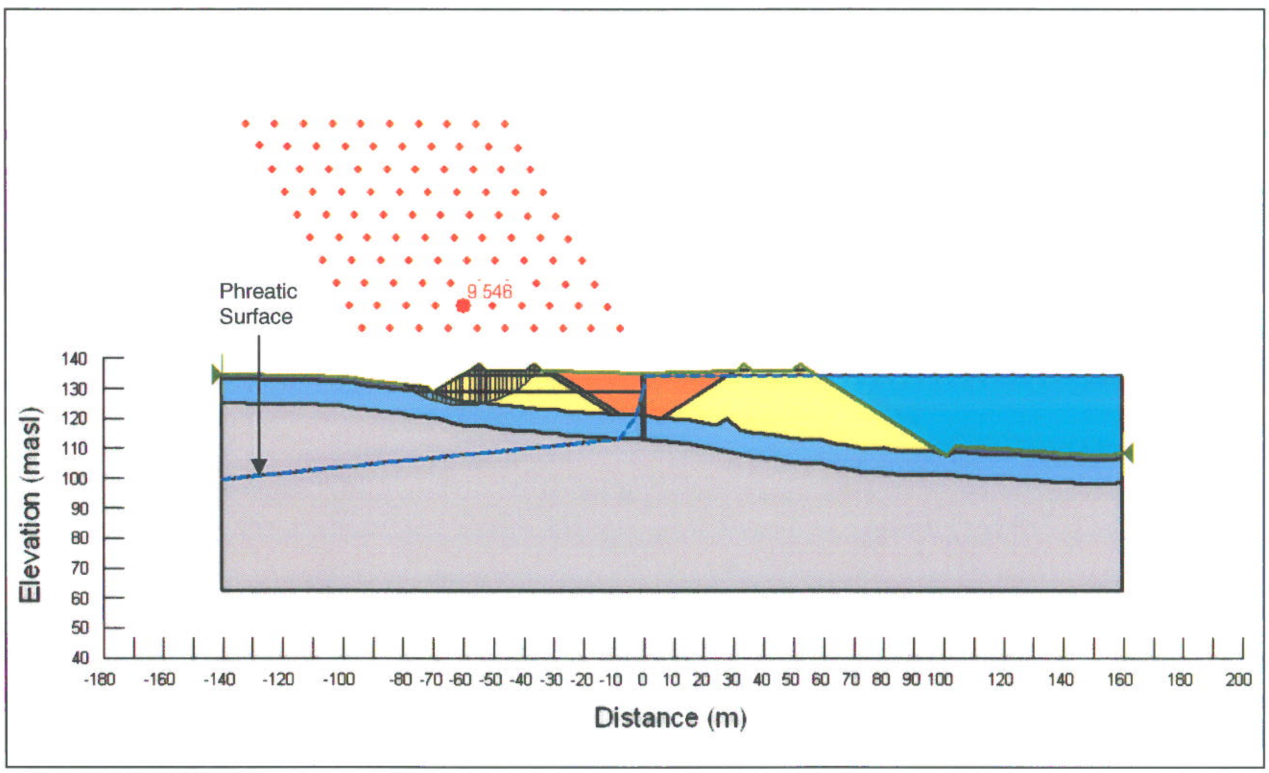

Downstream

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Meadowbank Gold Project
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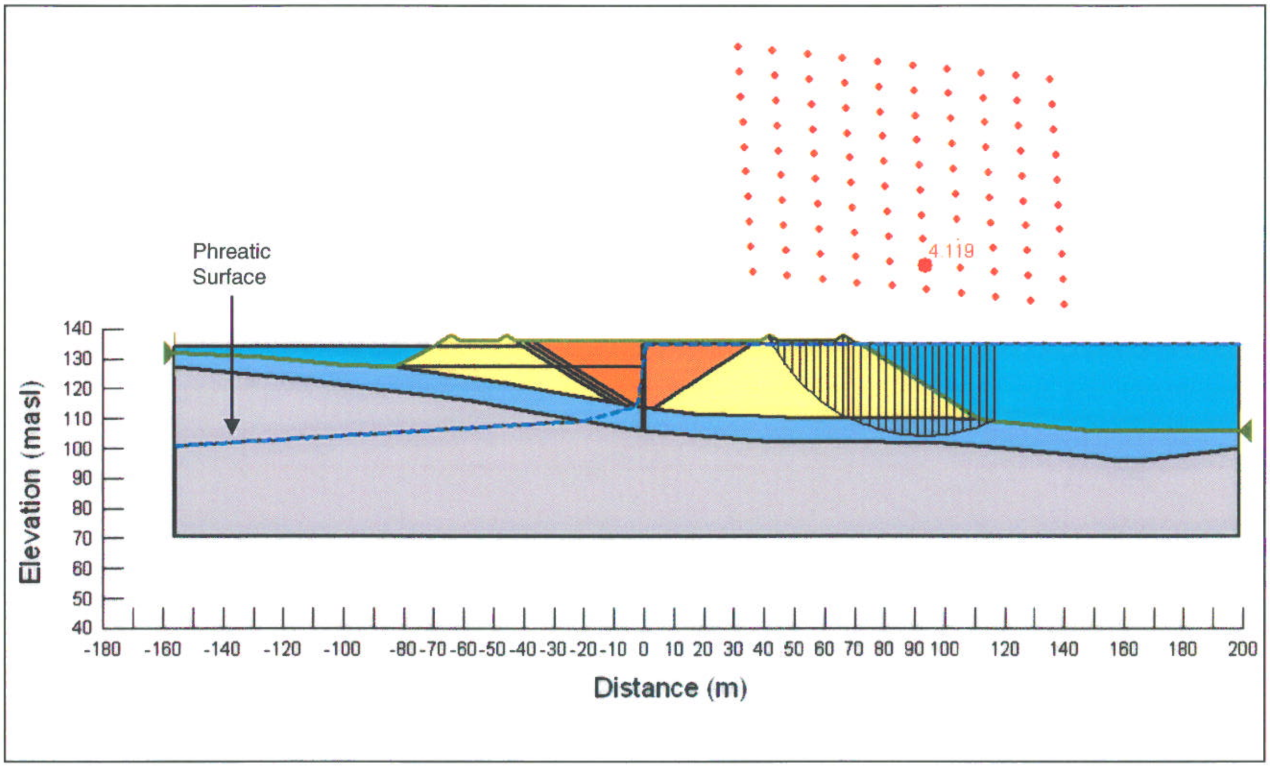
Figure III-16
SLOPE/W Undrained Analysis
Steep Section with low water table
Undrained Strength Lakebed Till 300 kPa



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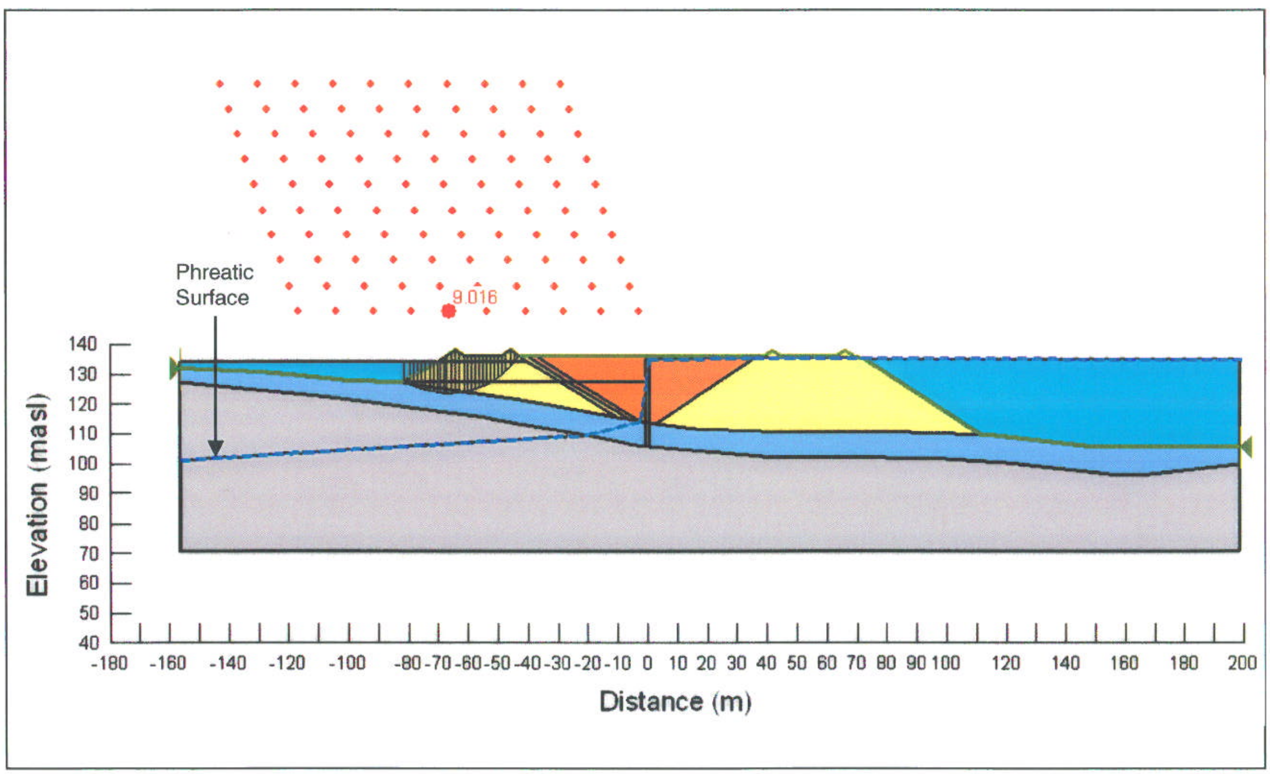

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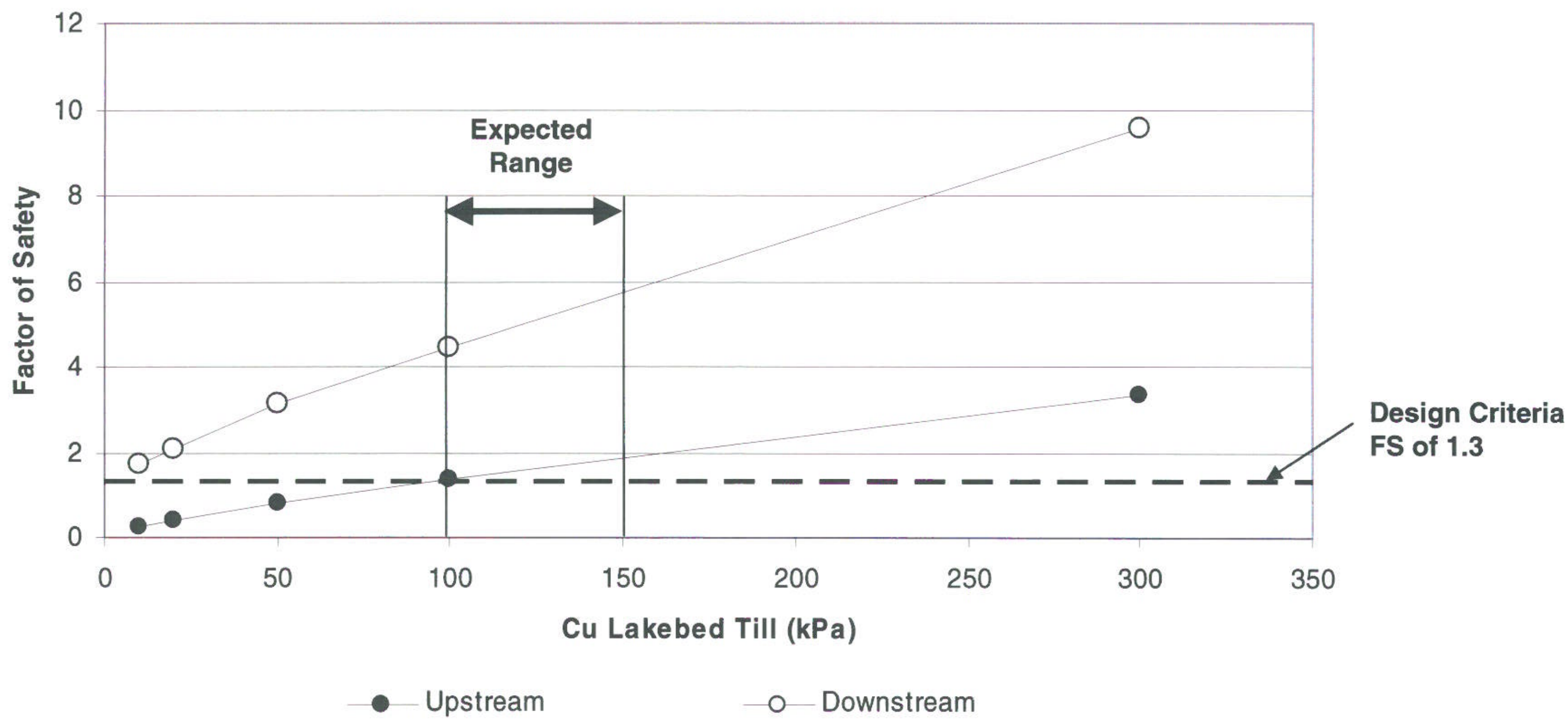
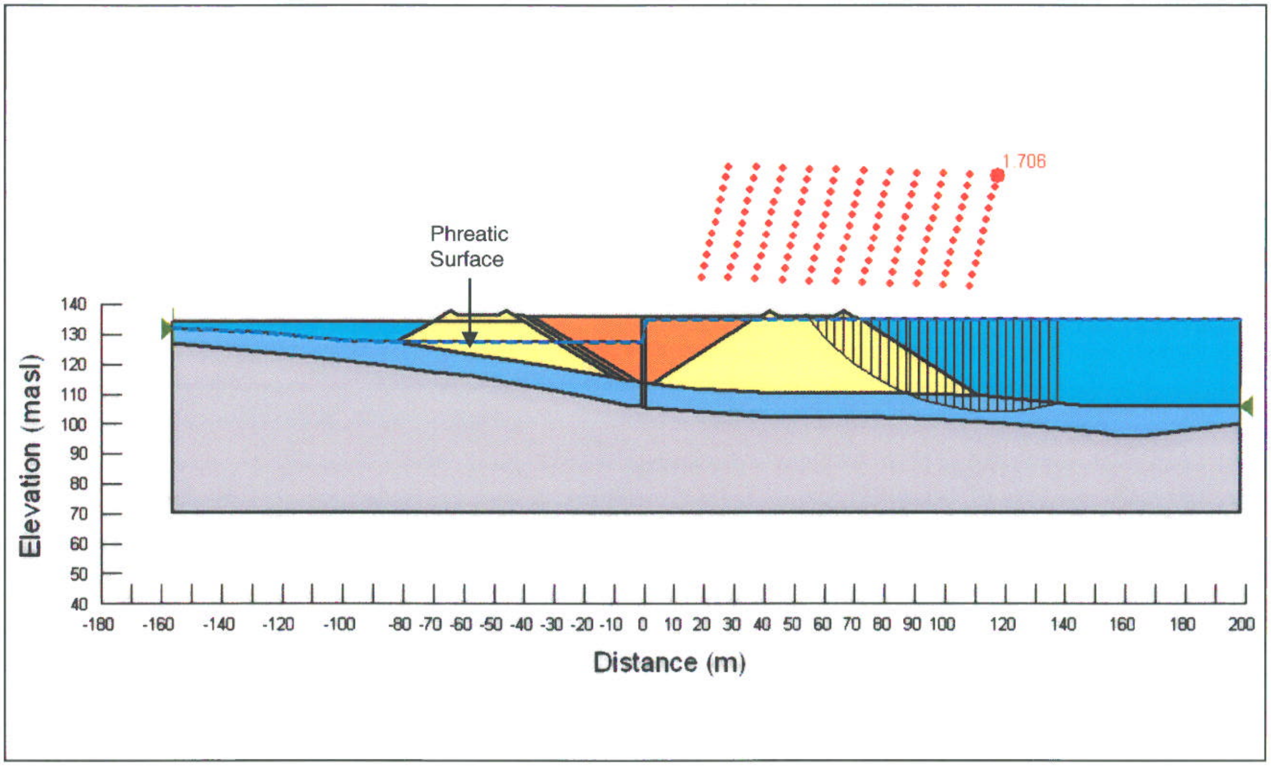
Figure III-17
SLOPE/W Undrained Analysis
Deep Section with low water table
Undrained Strength Lakebed Till 300 kPa



Golder Associates

Factor of Safety versus Undrained Strength
Meadowbank Mining Corporation
Meadowbank Gold Project

Drawn: KD	App'd:	Date: Mar. 09, 2007	Figure: **III-18**



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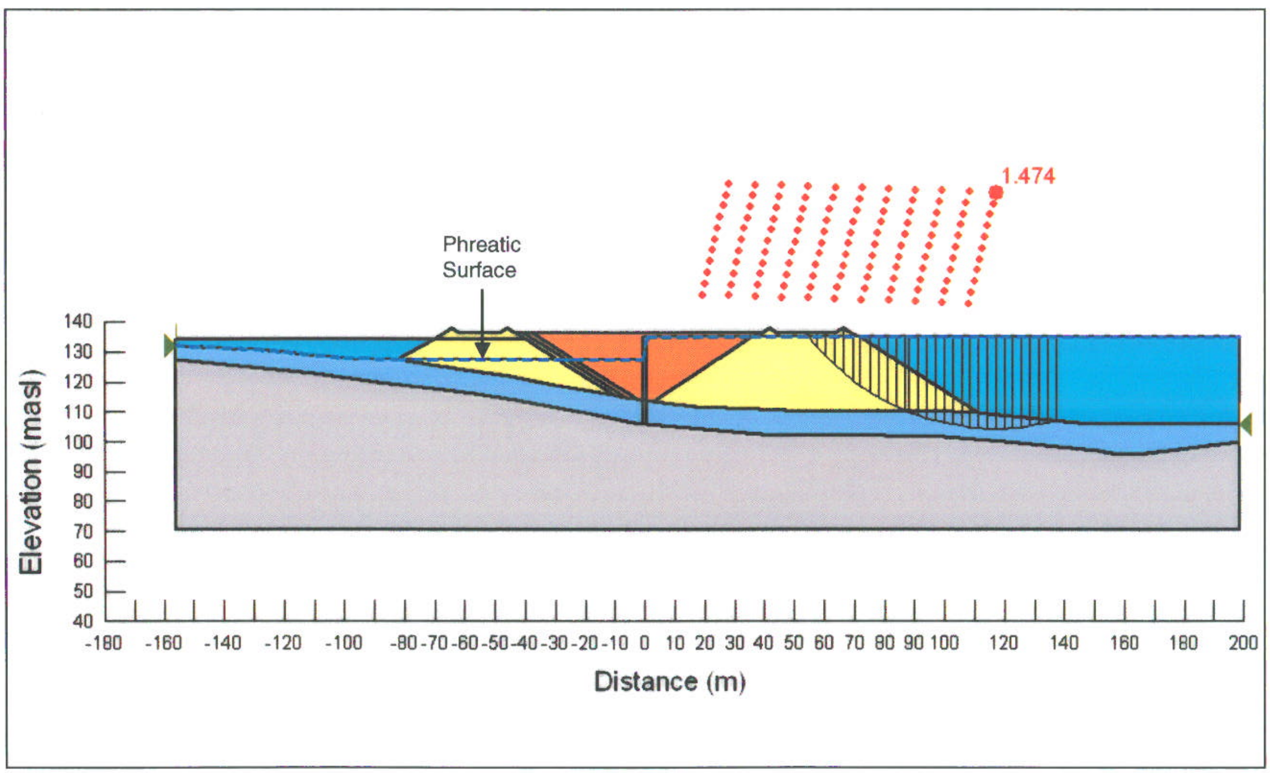
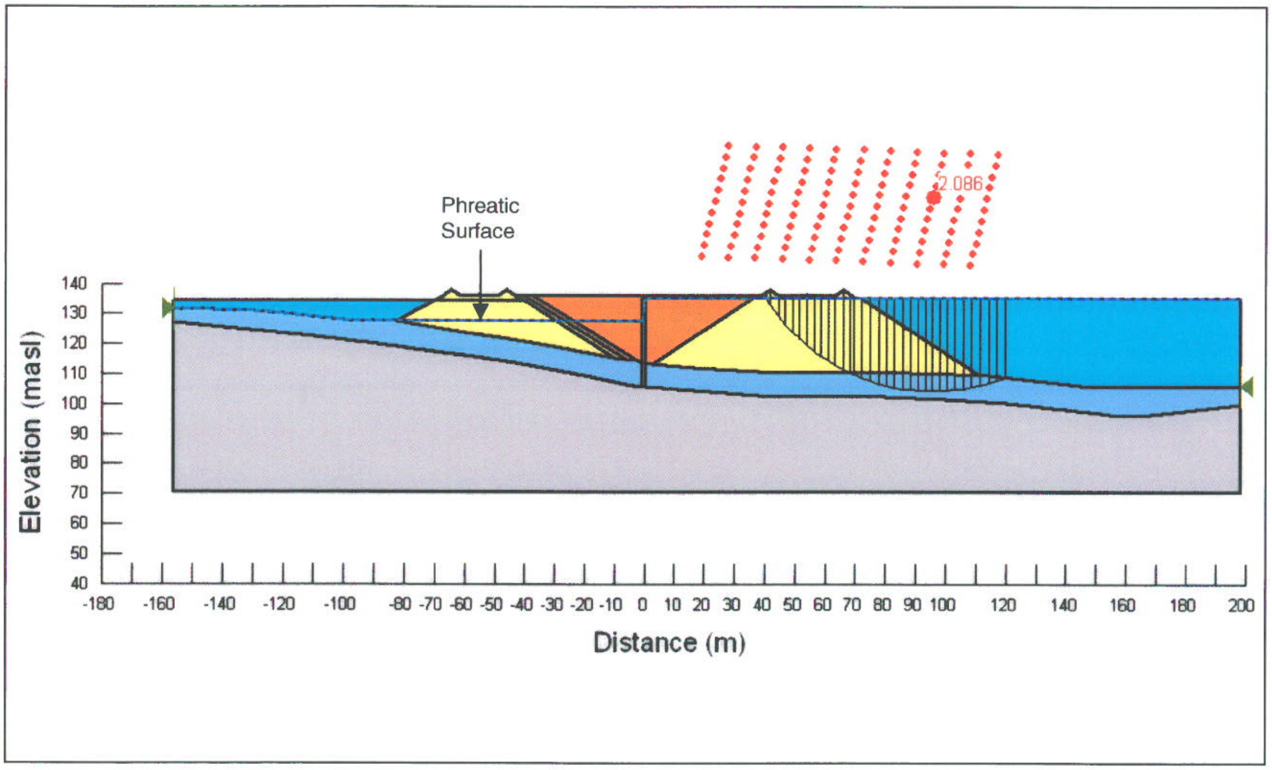


Pseudostatic a=0.035 g

Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-19
SLOPE/W Analysis
Deep Section, Post Drawdown
Upstream Failure



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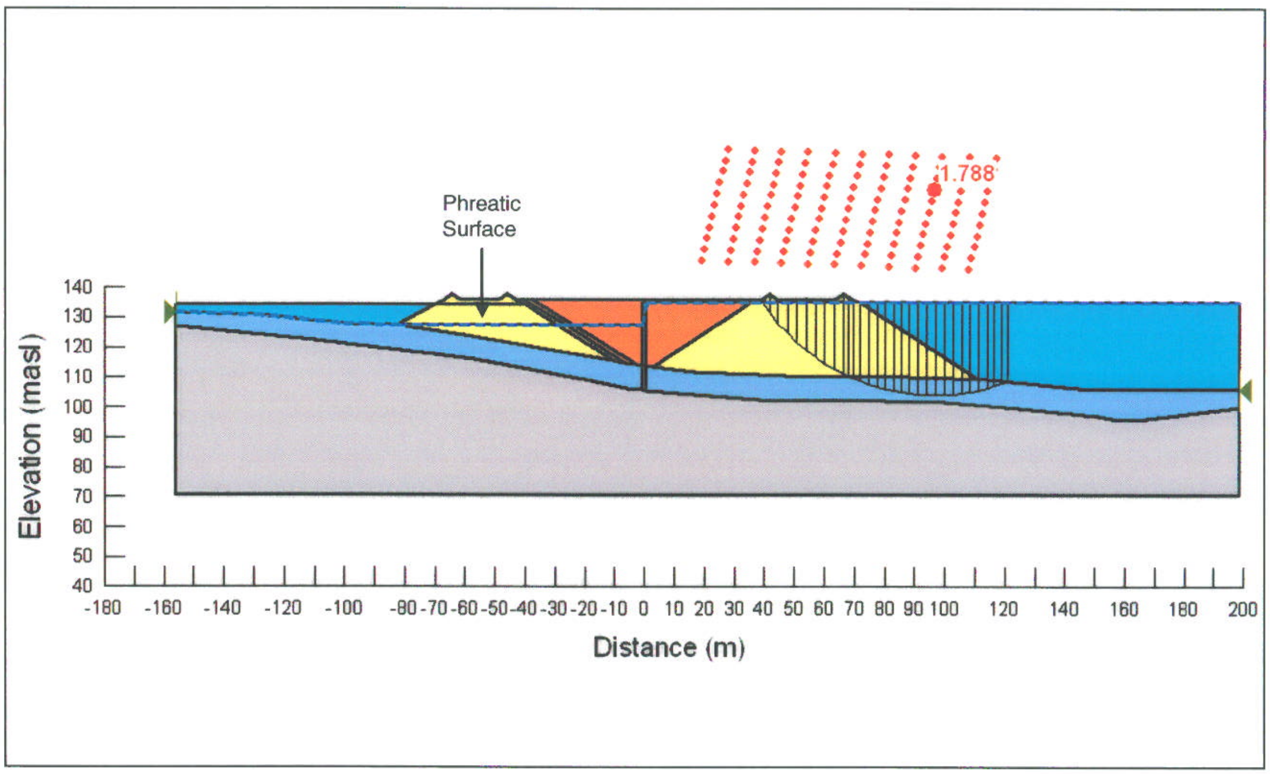
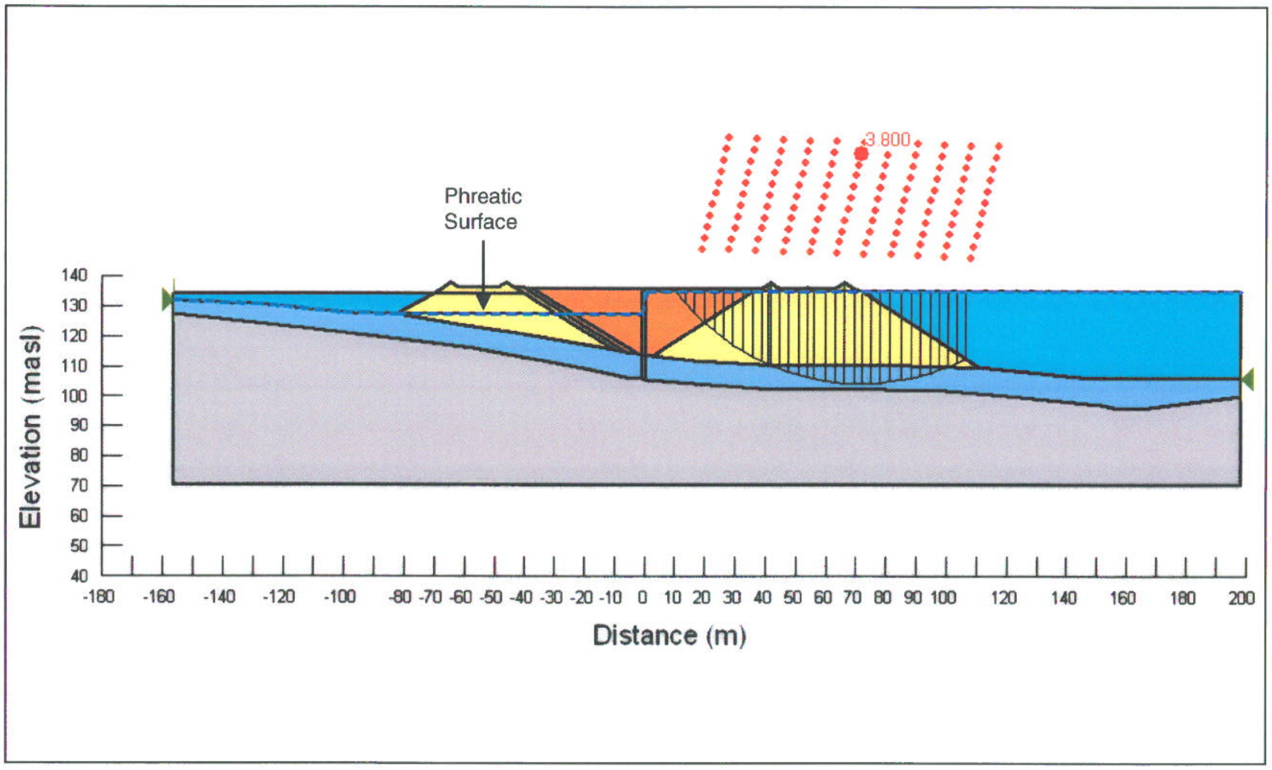


Pseudostatic a=0.035 g

Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-20
SLOPE/W Analysis
Deep Section, Post Drawdown
Upstream Failure



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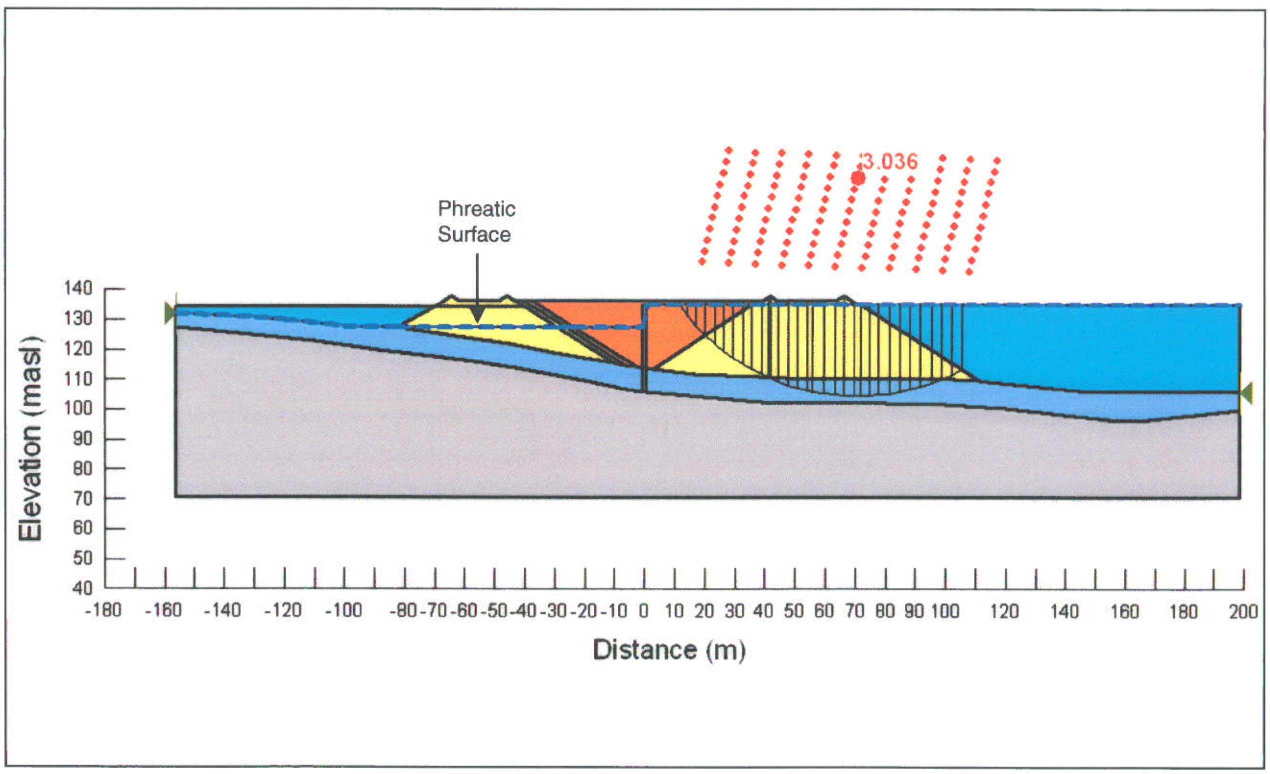

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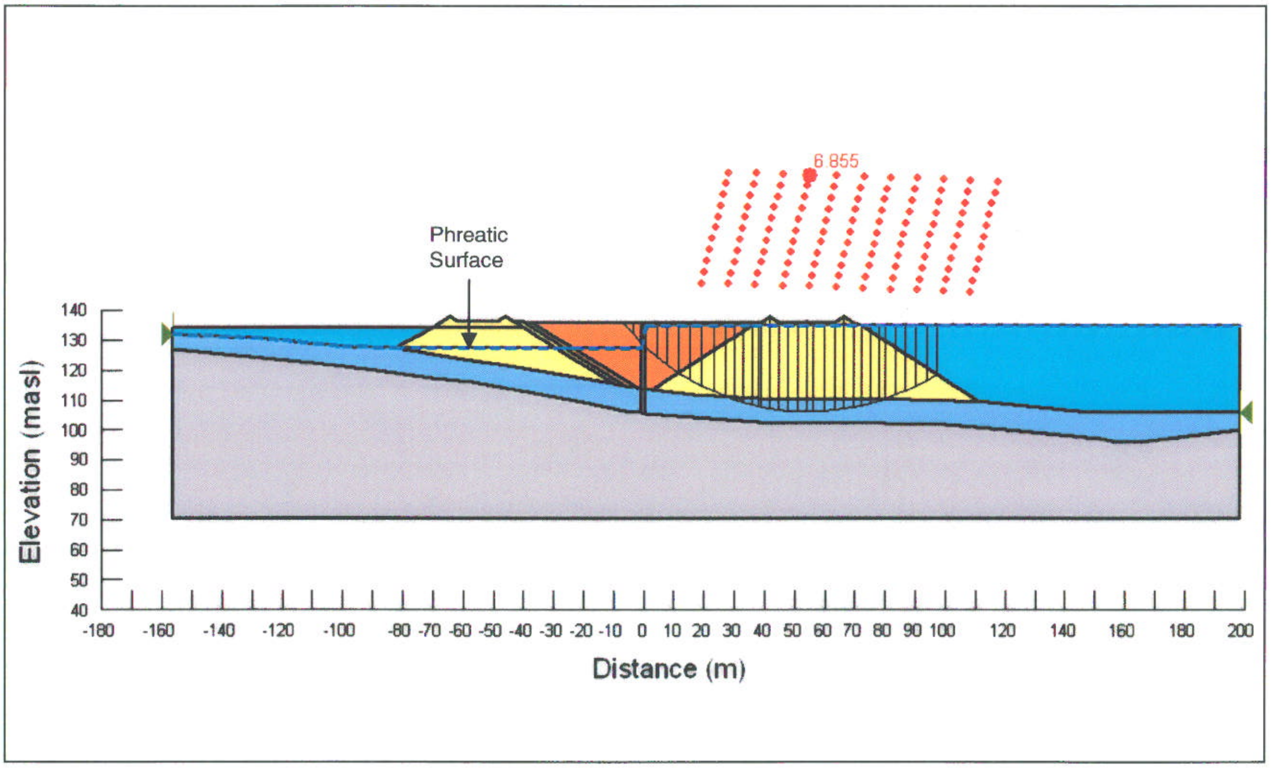
Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-21
SLOPE/W Analysis
Deep Section, Post Drawdown
Upstream Failure



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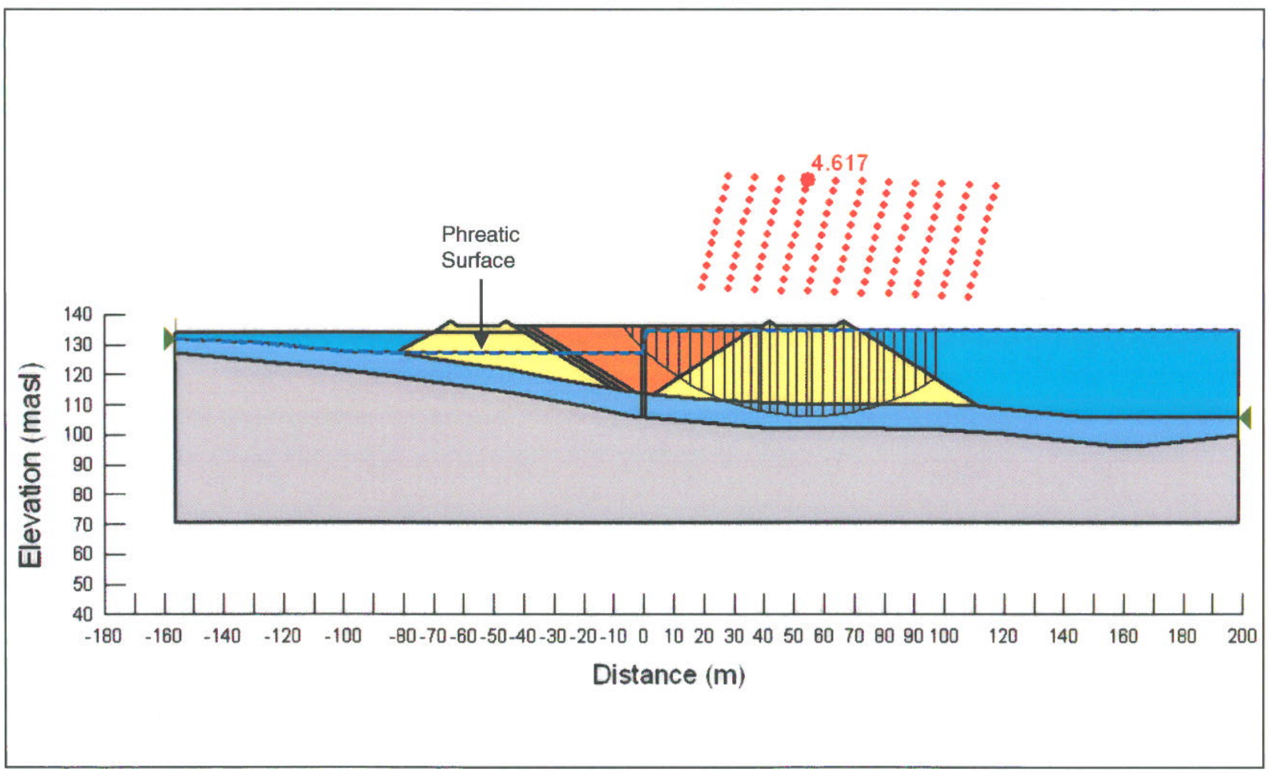

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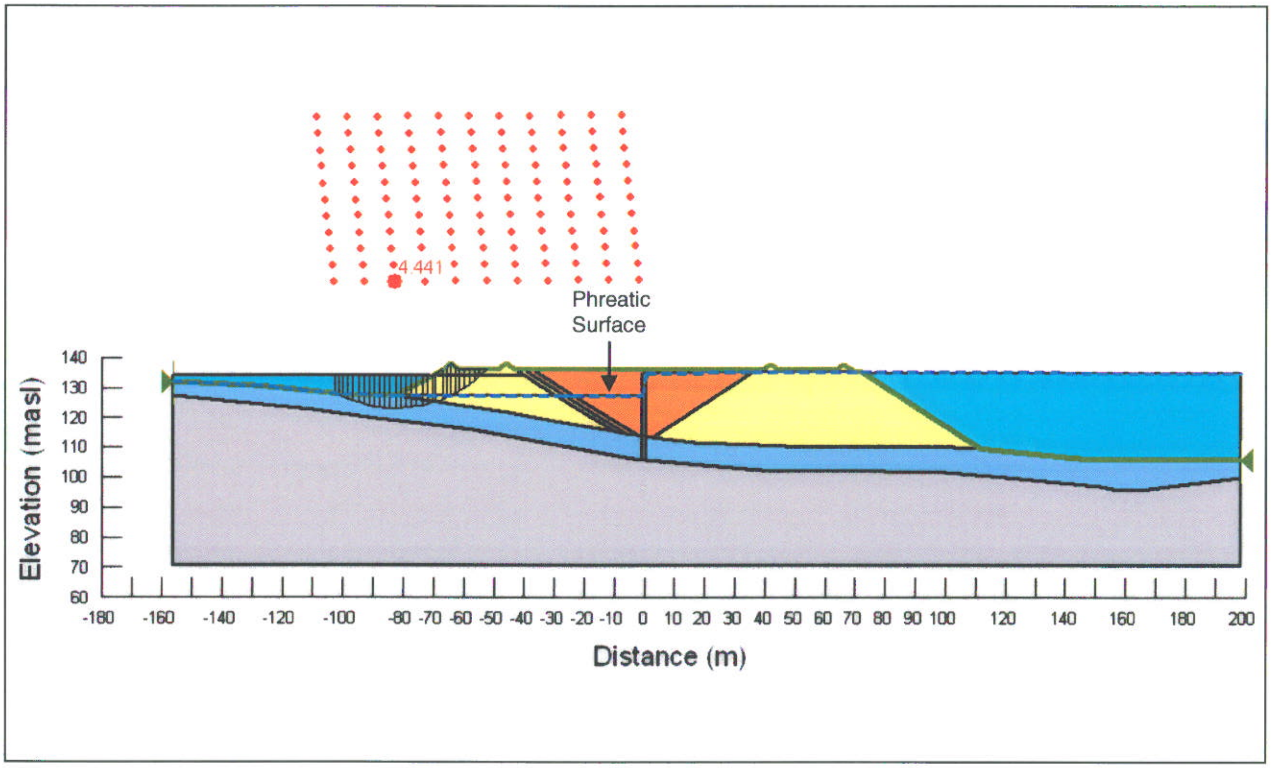
Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-22
SLOPE/W Analysis
Deep Section, Post Drawdown
Upstream Failure



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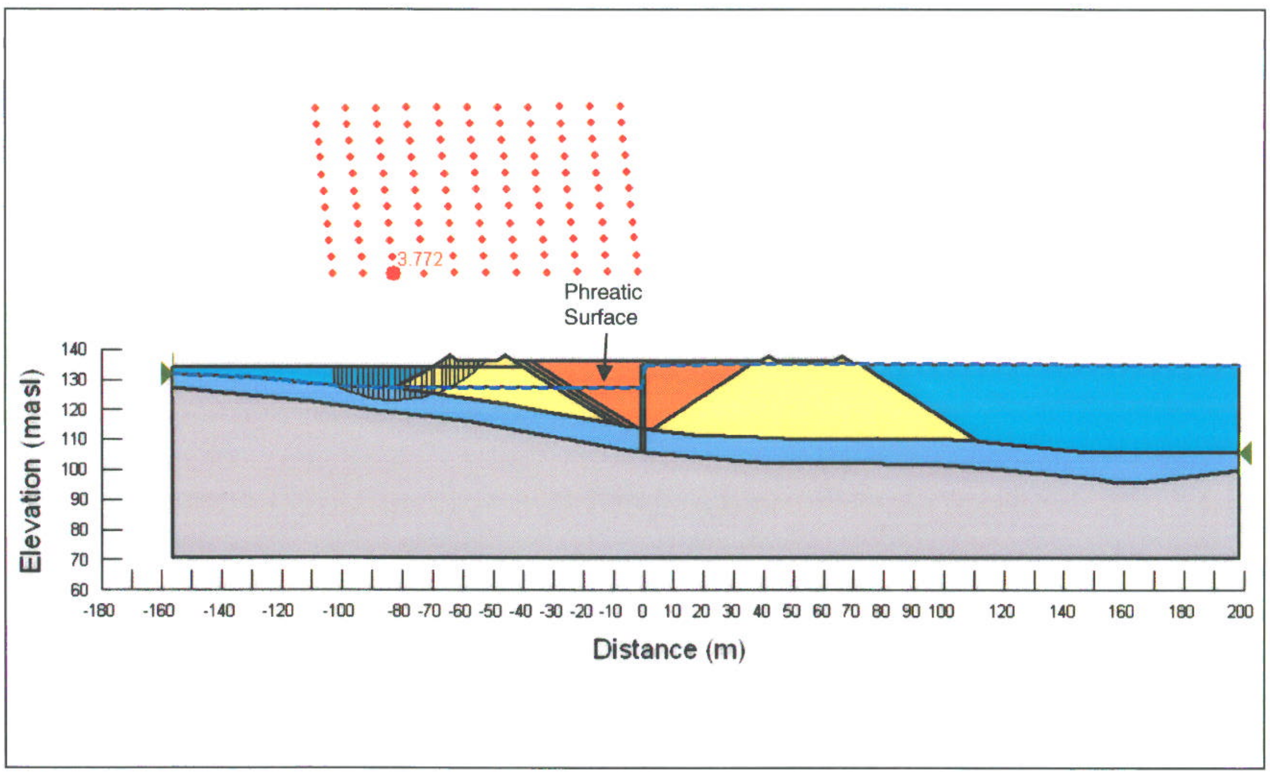

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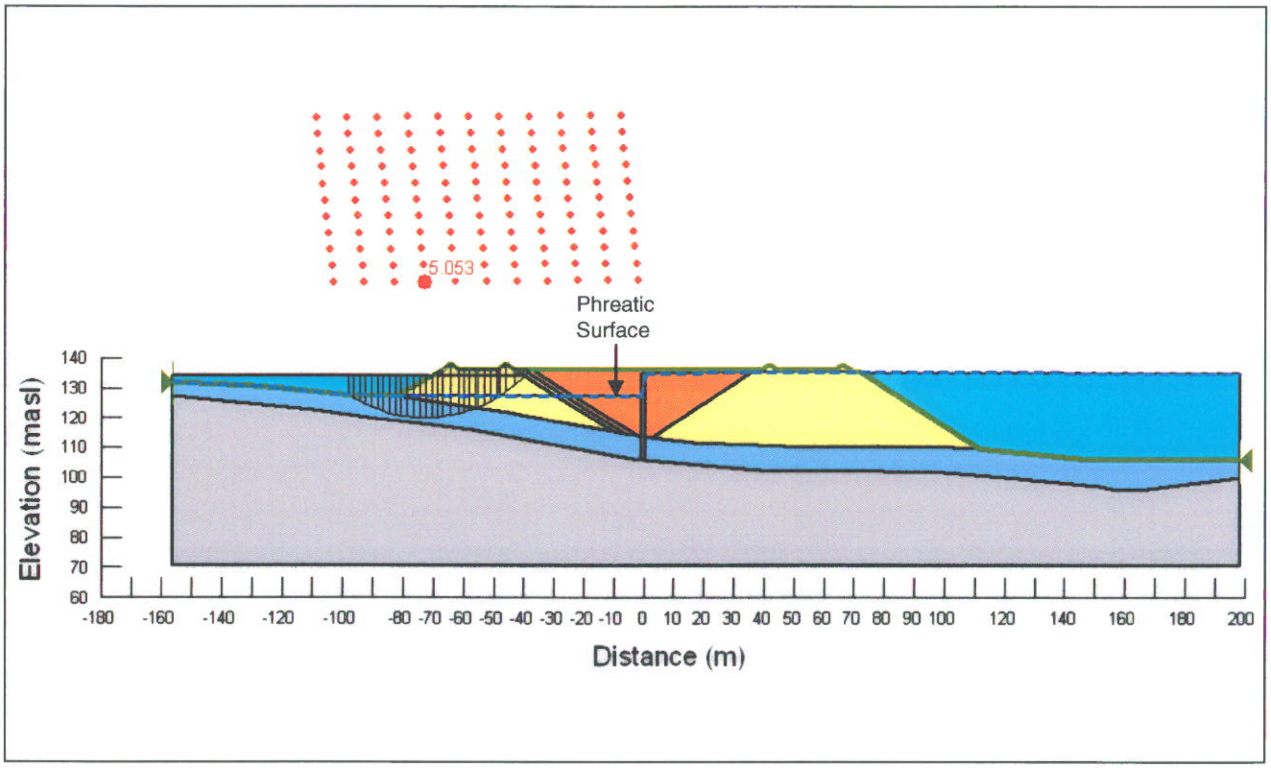
Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-23
SLOPE/W Analysis
Deep Section, Post Drawdown
Downstream Failure



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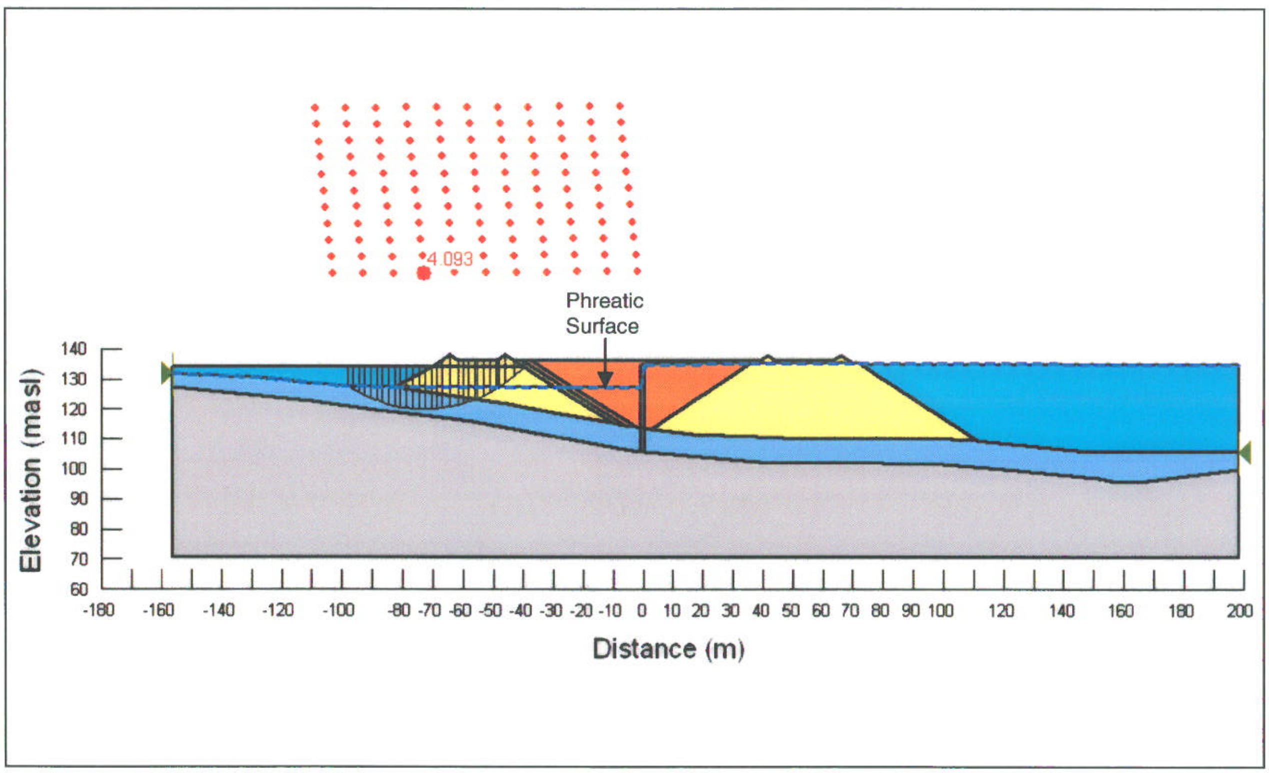
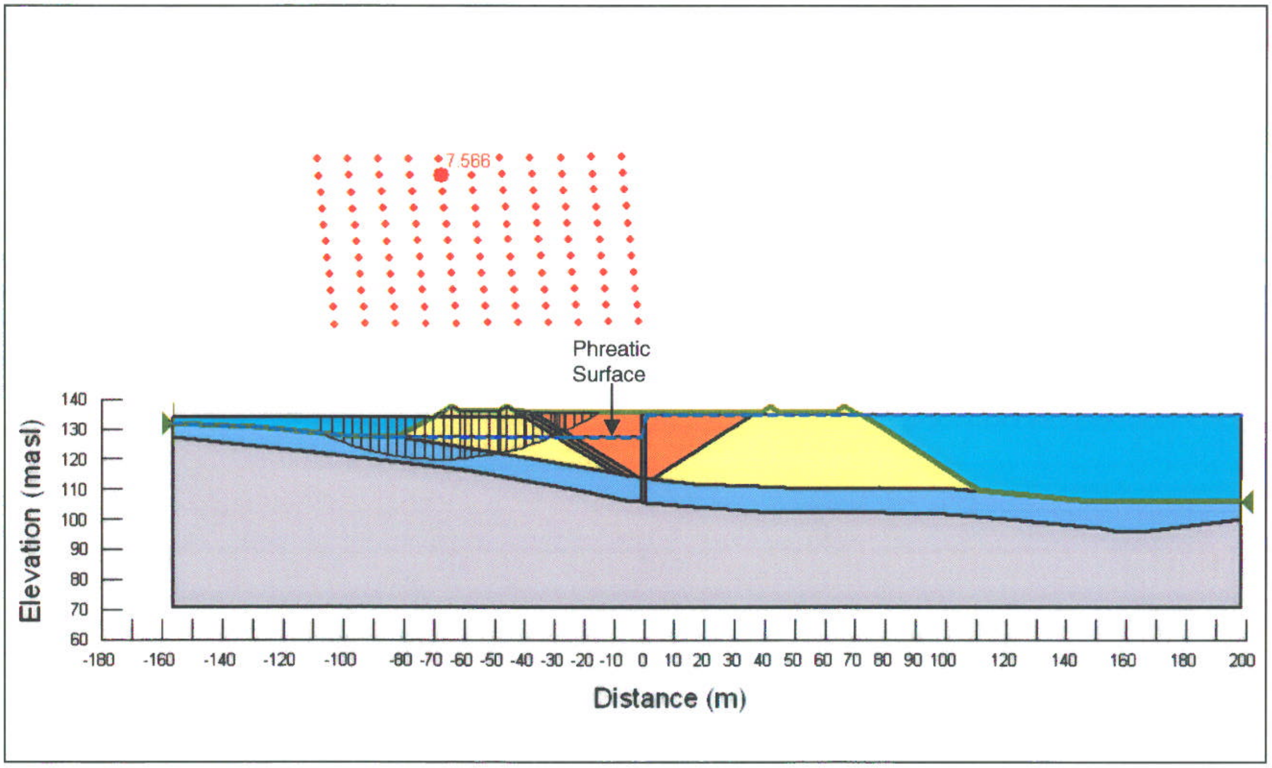


Pseudostatic a=0.035 g

Figure III-24
SLOPE/W Analysis
Deep Section, Post Drawdown
Downstream Failure

Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081



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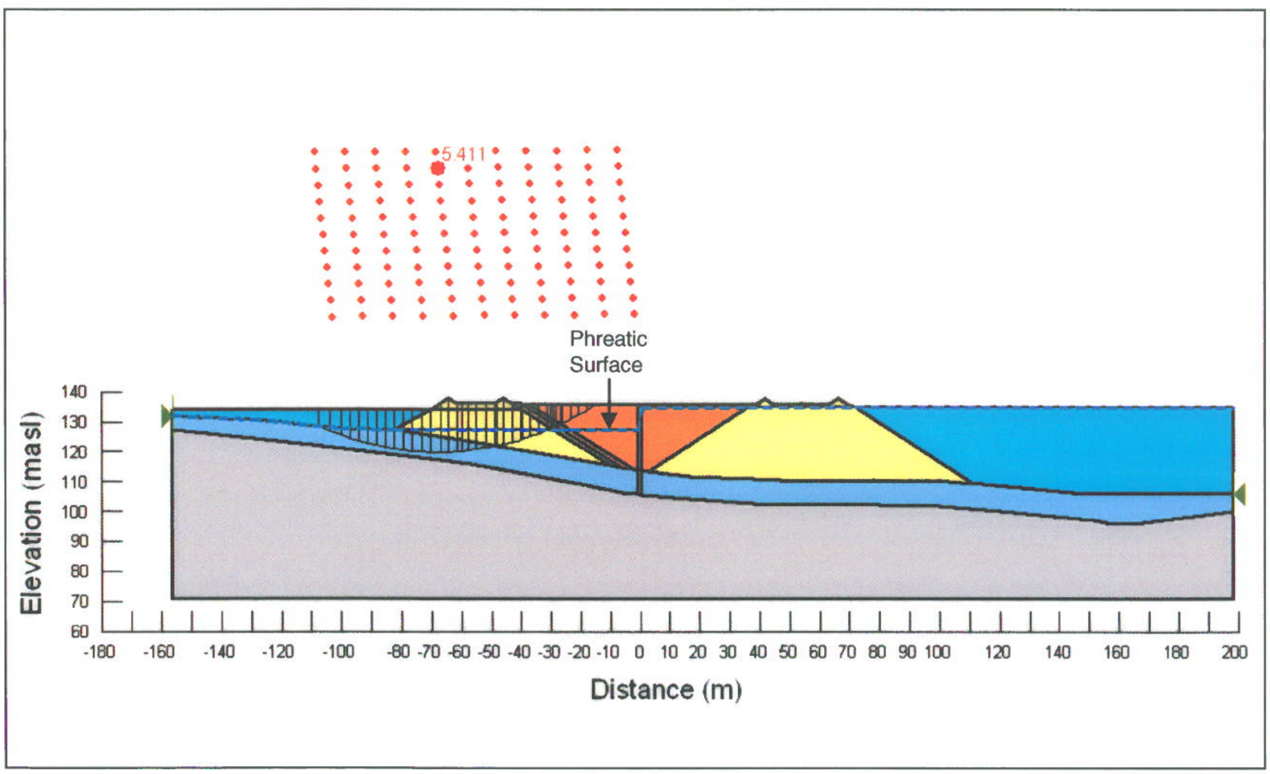
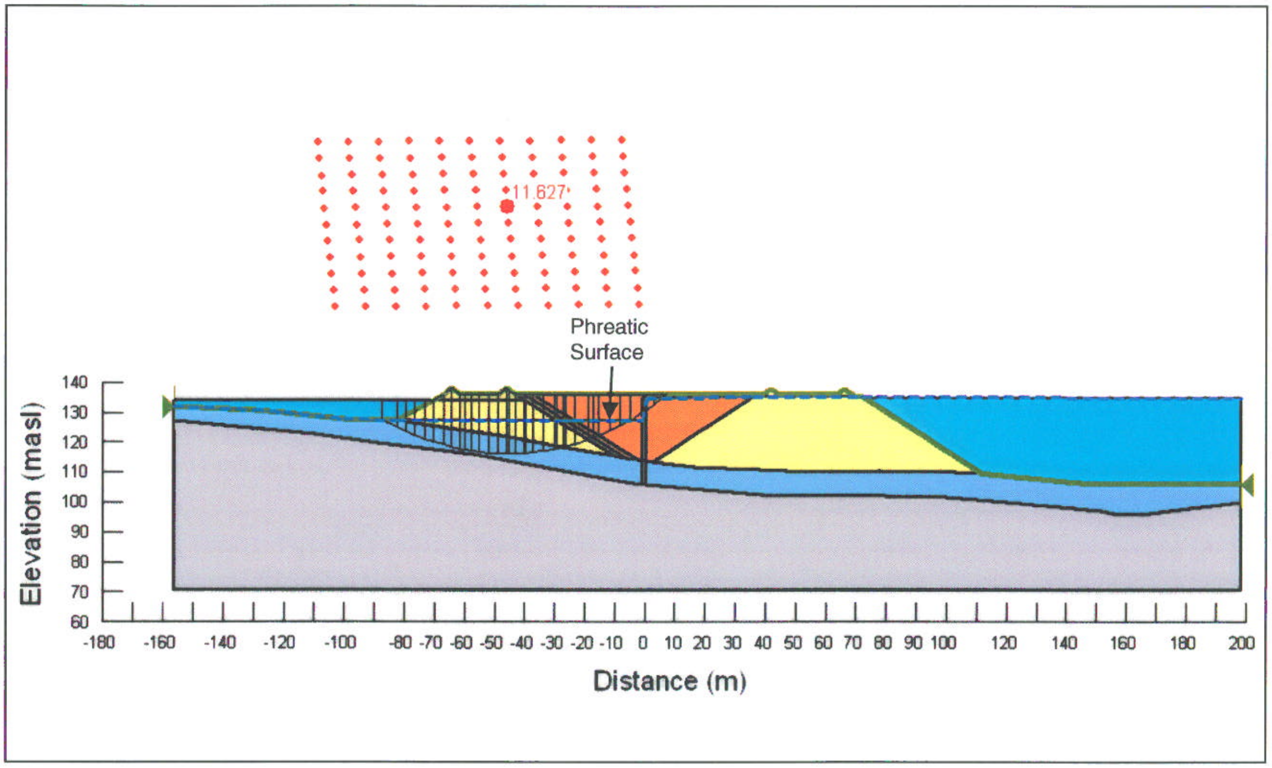


Pseudostatic a=0.035 g

Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-25
SLOPE/W Analysis
Deep Section, Post Drawdown
Downstream Failure



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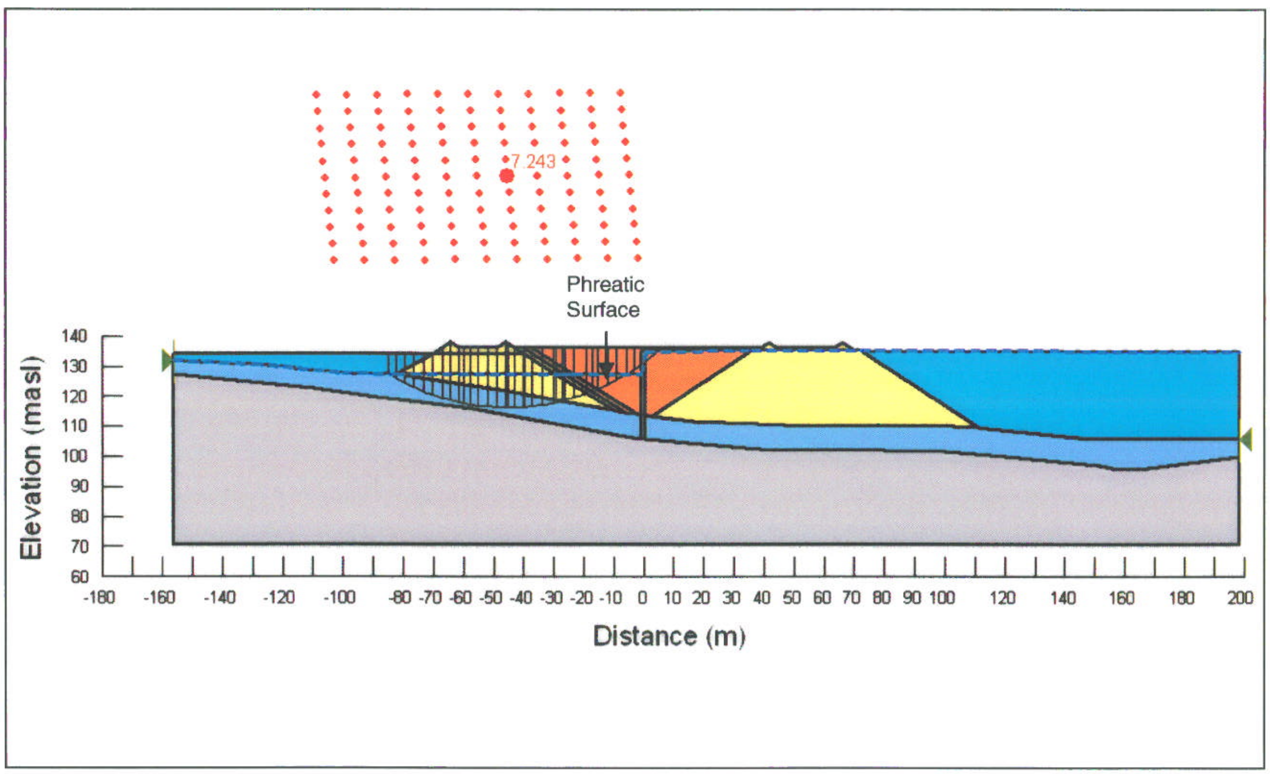
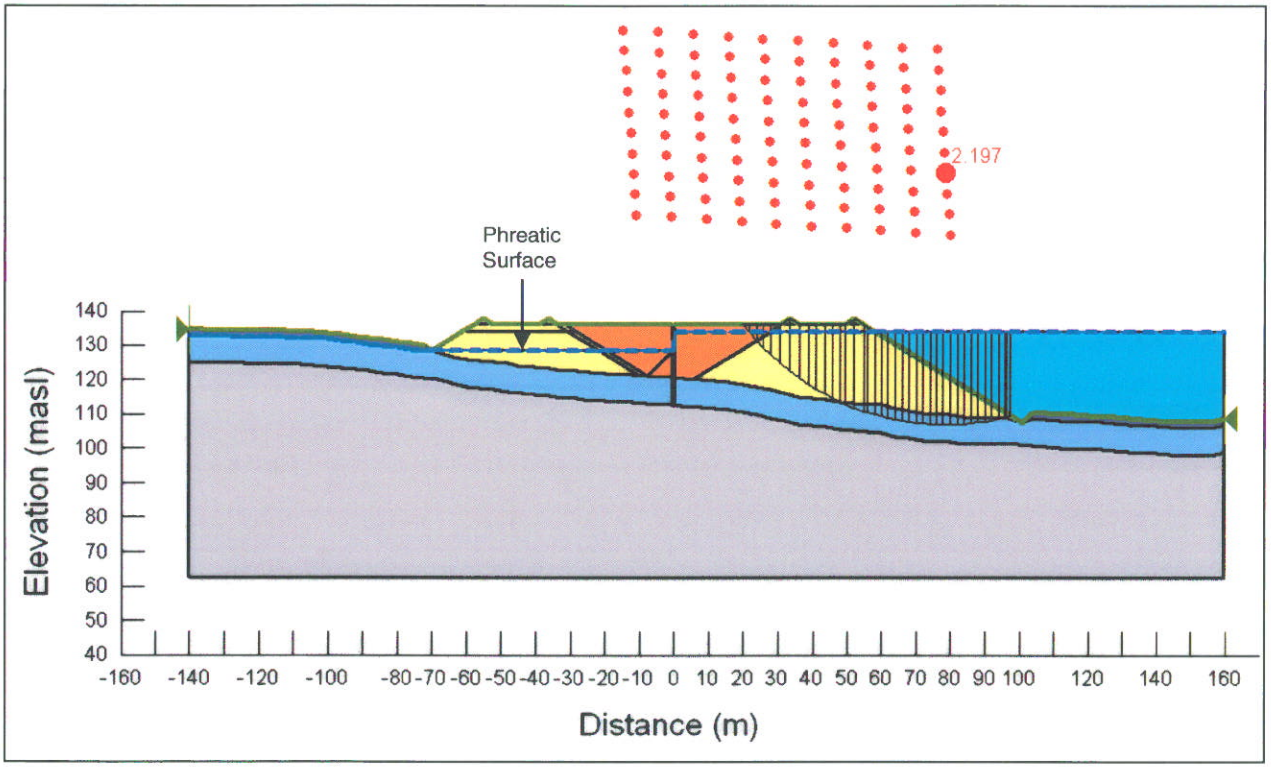


Pseudostatic a=0.035 g

Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-26
SLOPE/W Analysis
Deep Section, Post Drawdown
Downstream Failure



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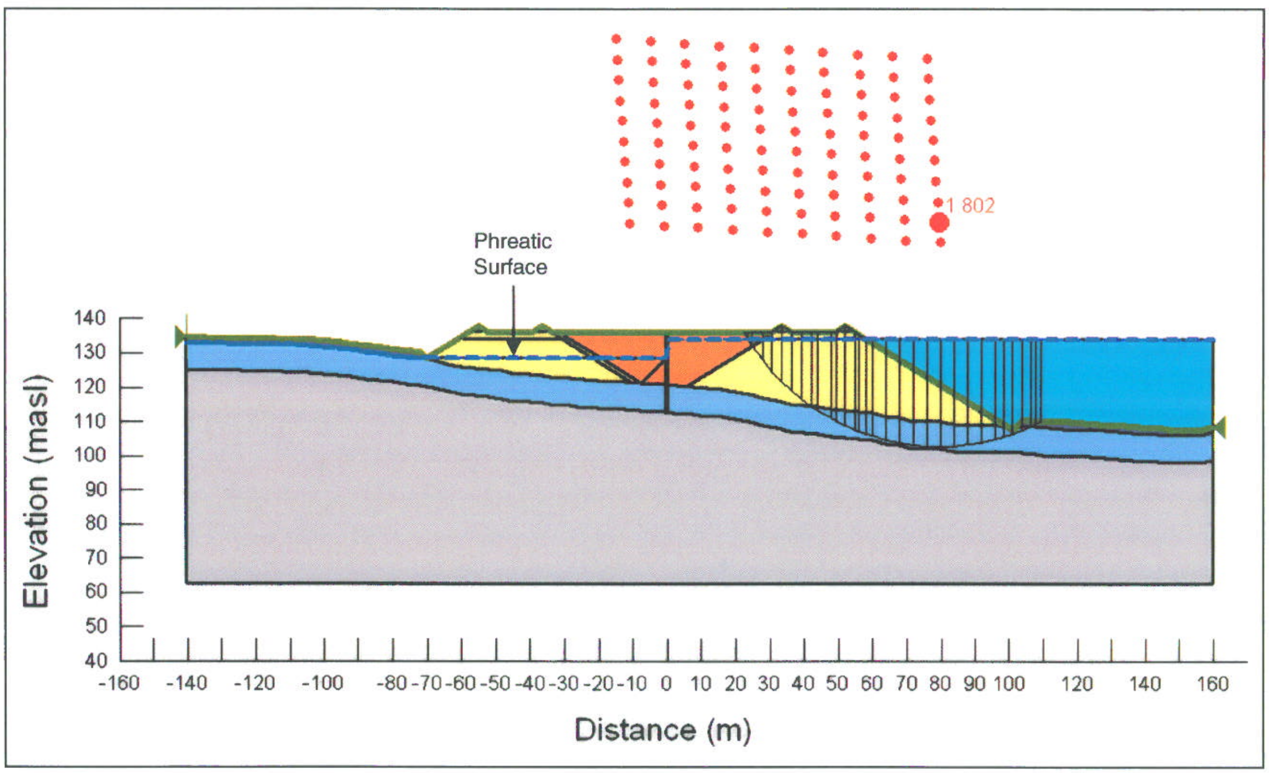

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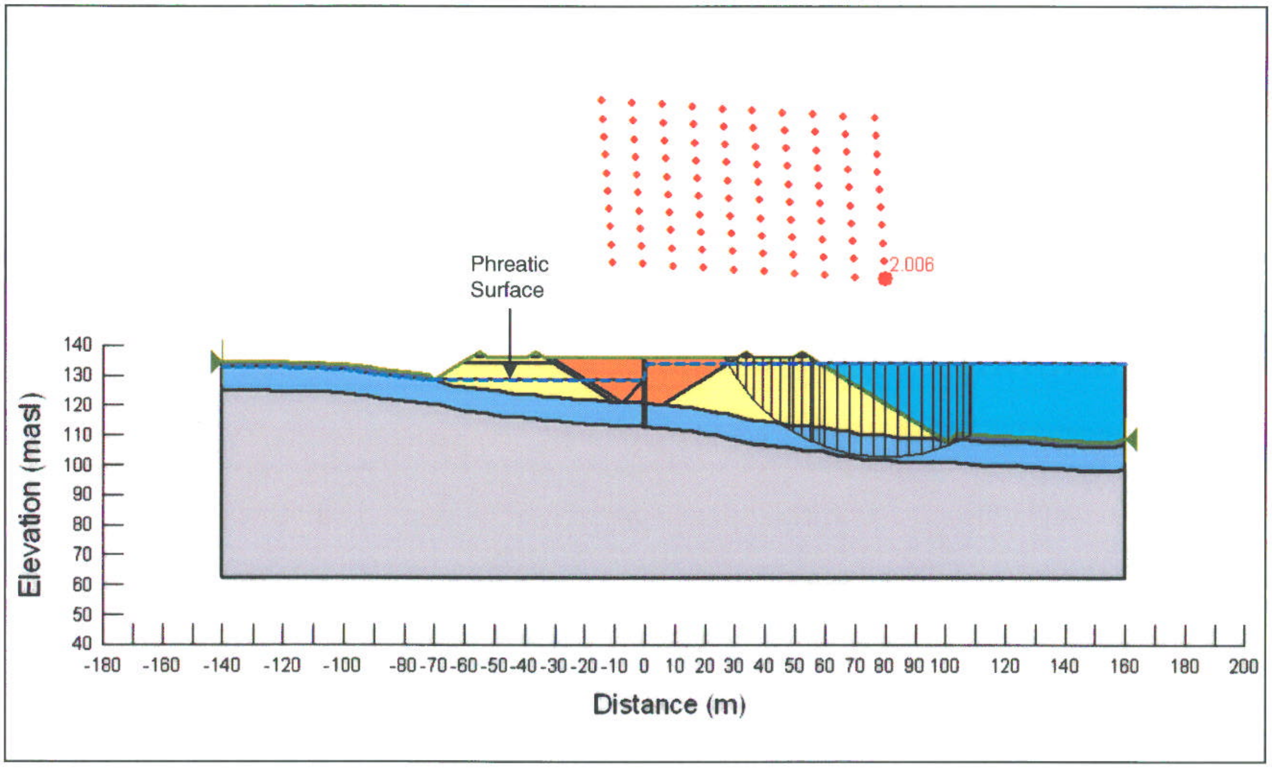
Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-27
SLOPE/W Analysis
Steep Section, Post Drawdown
Upstream Failure



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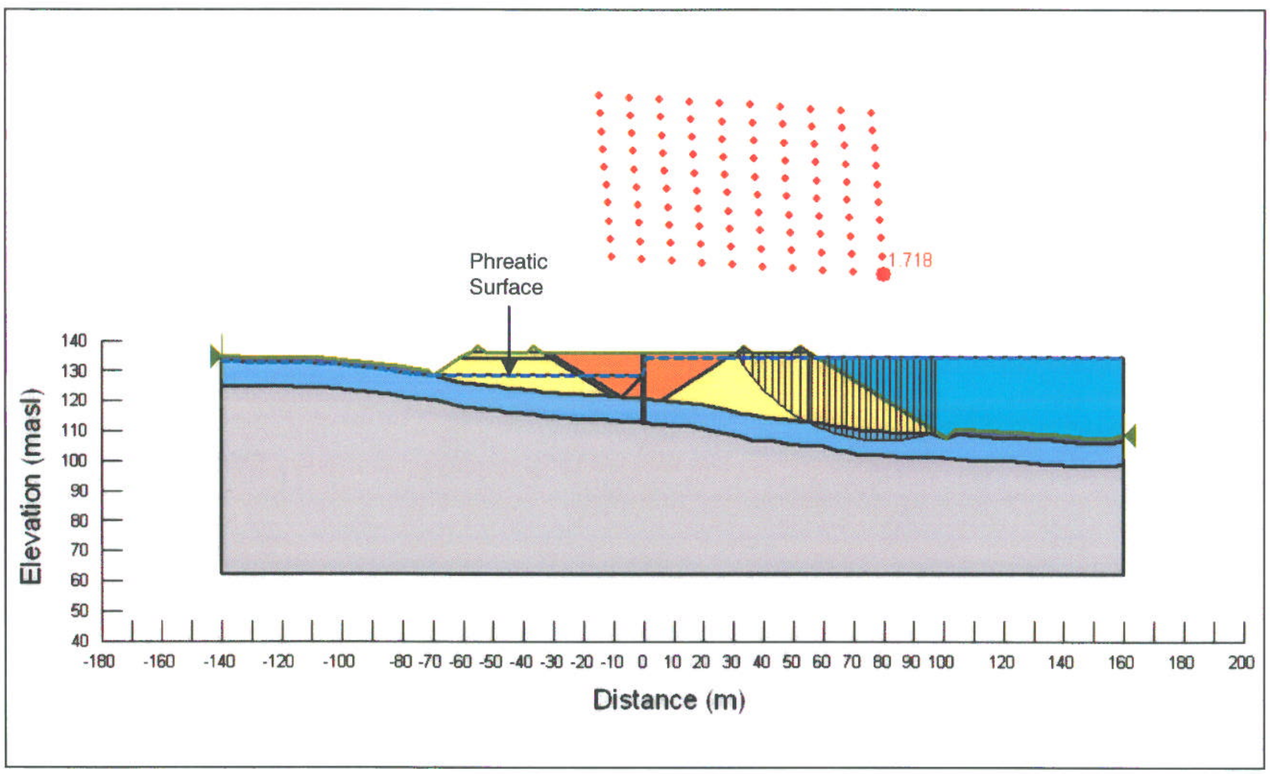
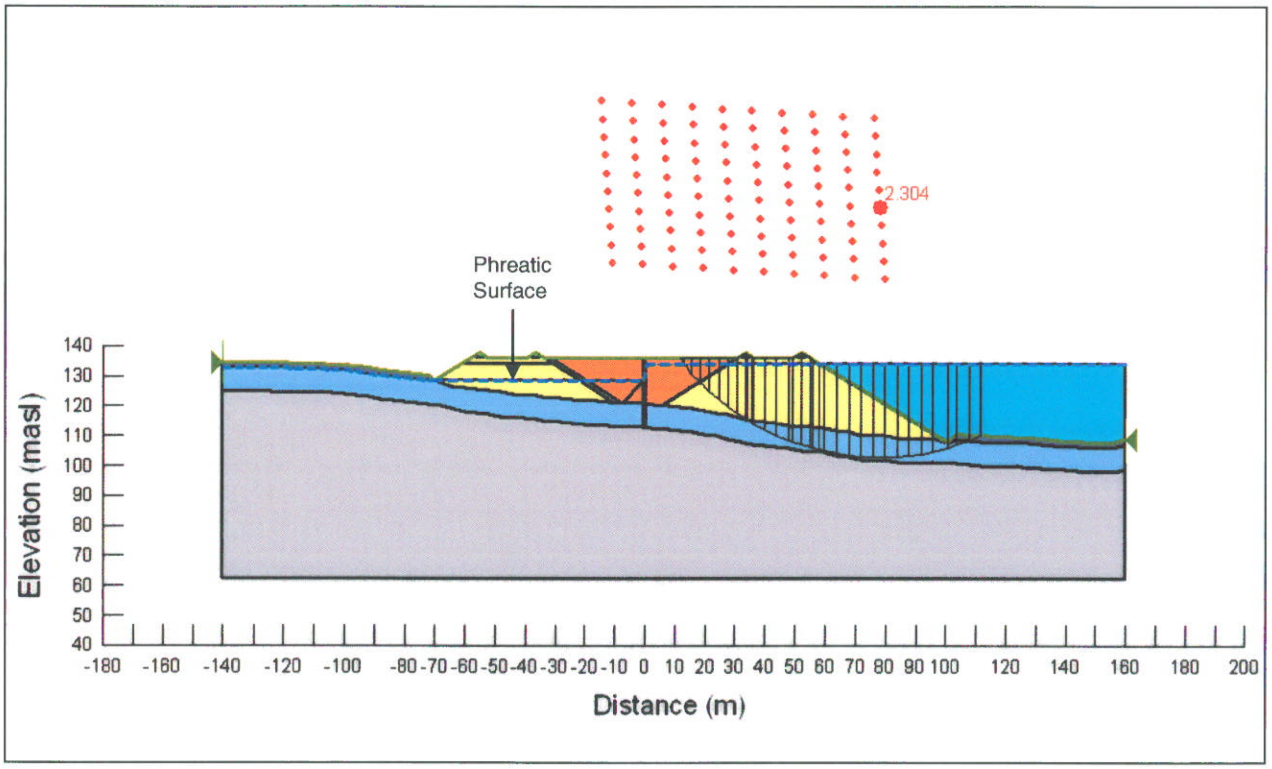


Pseudostatic a=0.035 g

Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-28
SLOPE/W Analysis
Steep Section, Post Drawdown
Upstream Failure



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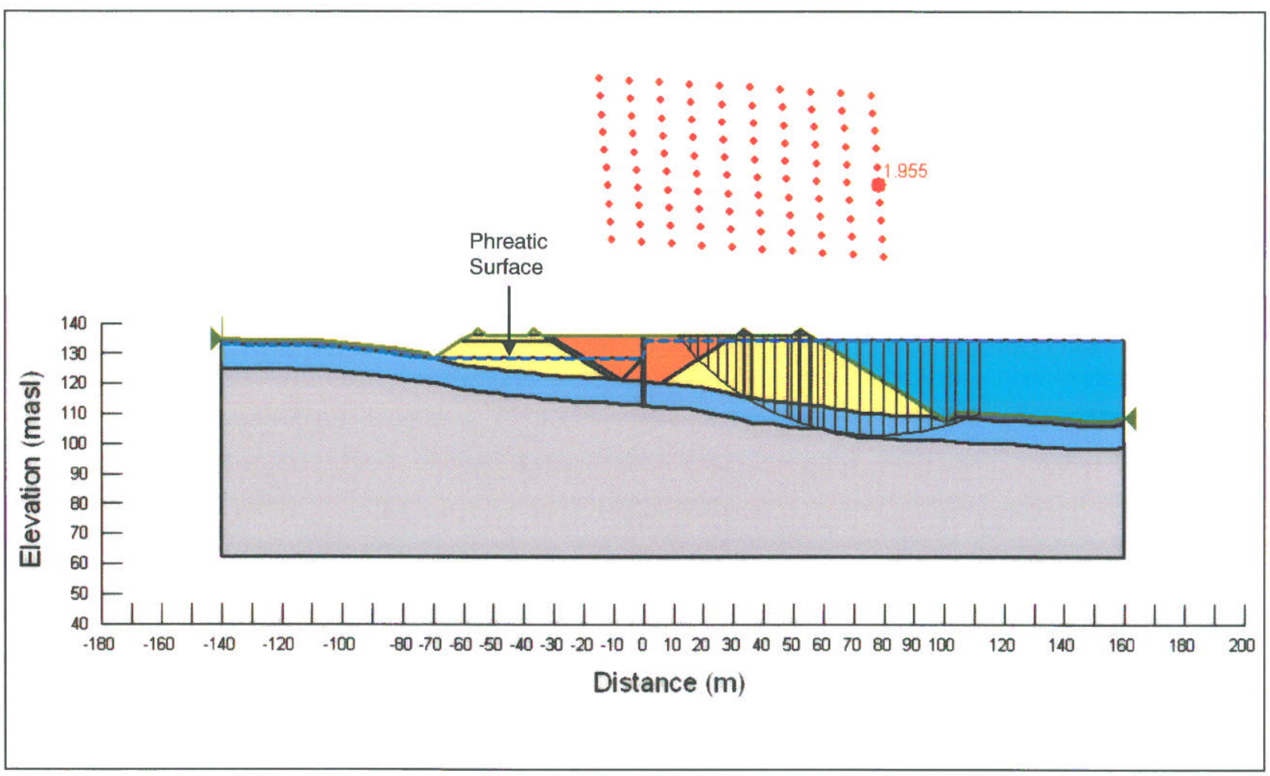
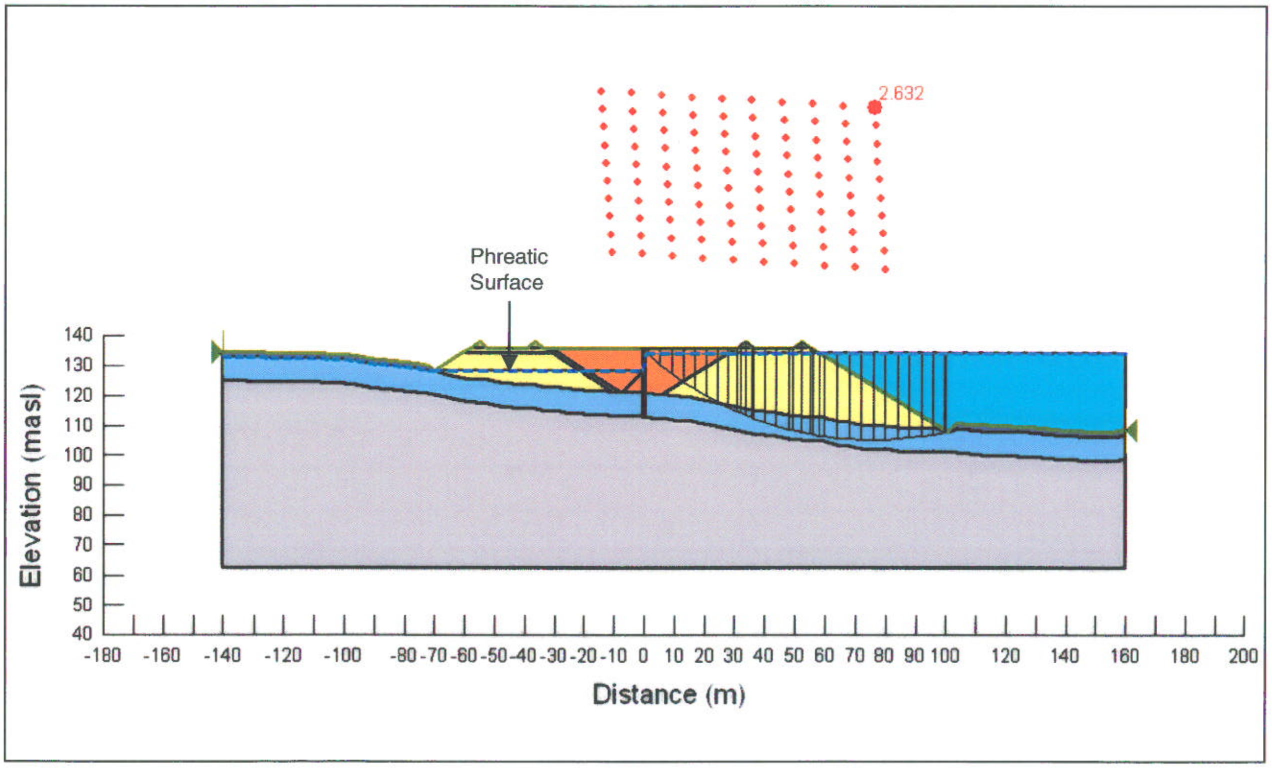


Pseudostatic a=0.035 g

Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-29
SLOPE/W Analysis
Steep Section, Post Drawdown
Upstream Failure



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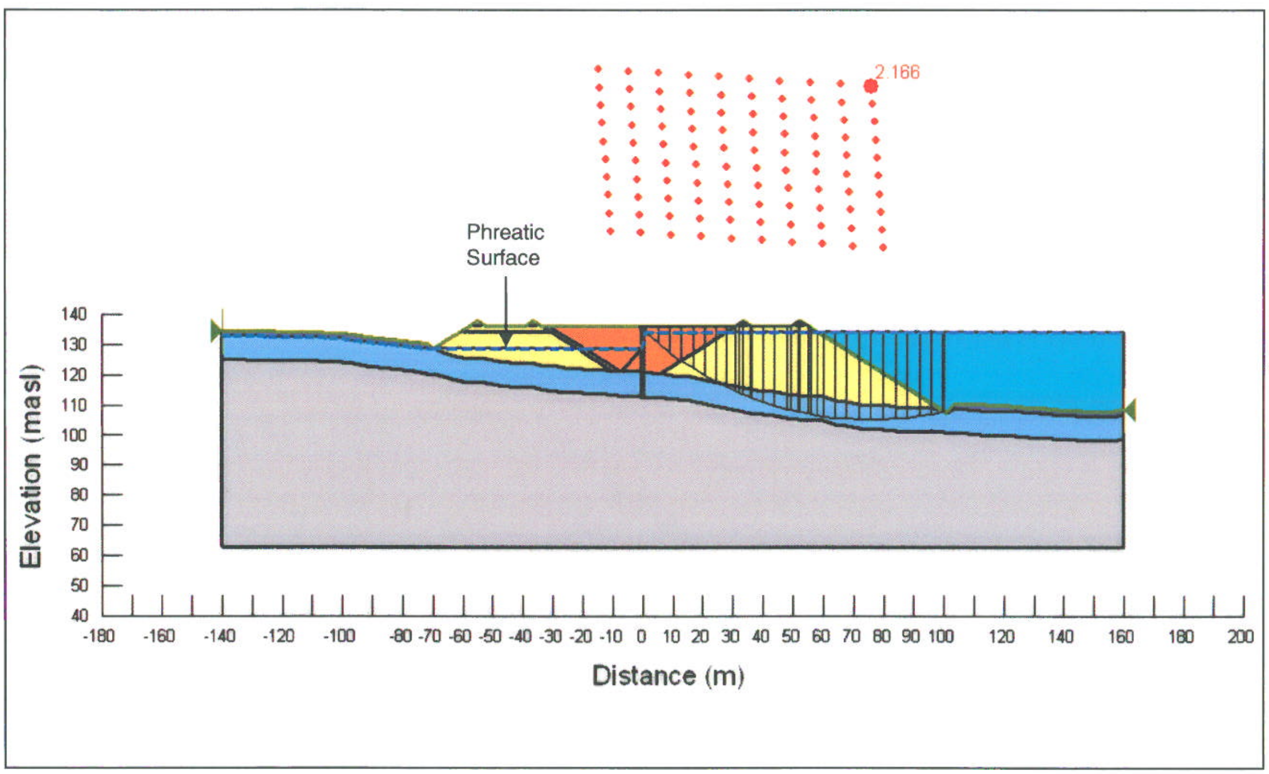
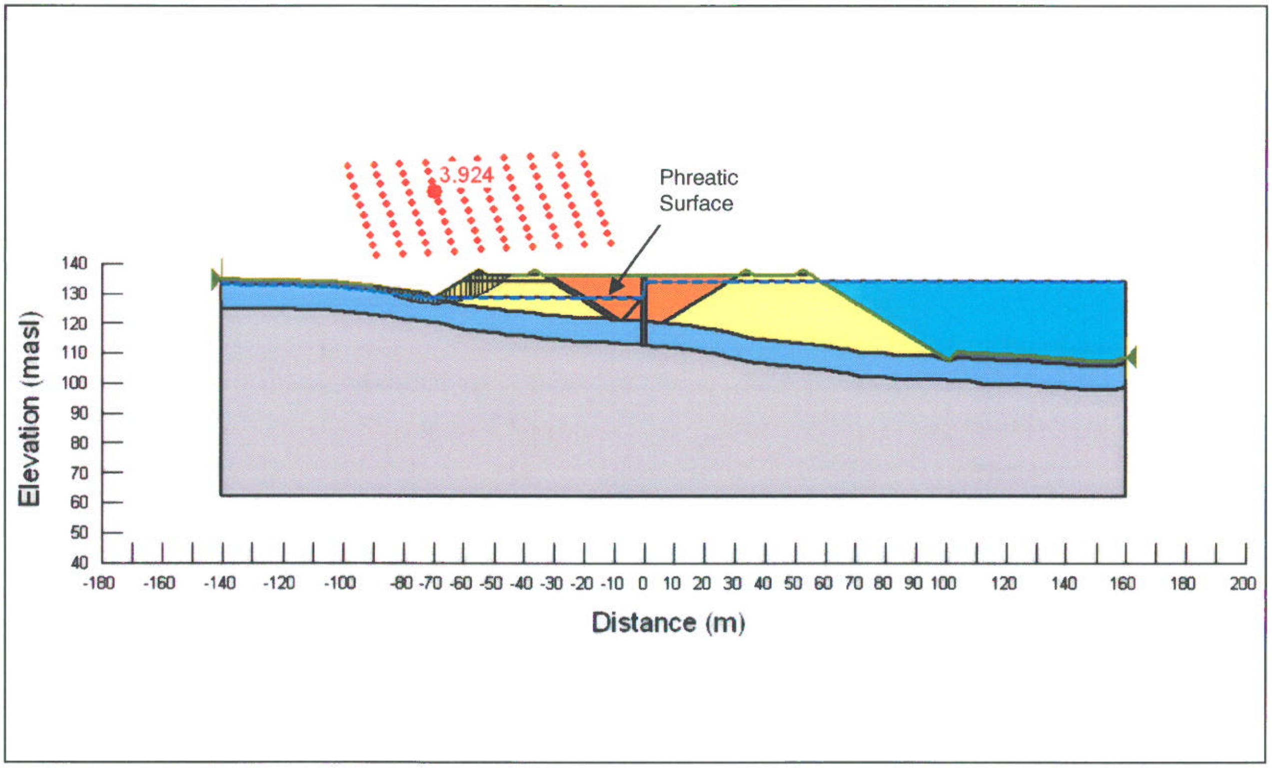


Pseudostatic a=0.035 g

Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-30
SLOPE/W Analysis
Steep Section, Post Drawdown
Upstream Failure



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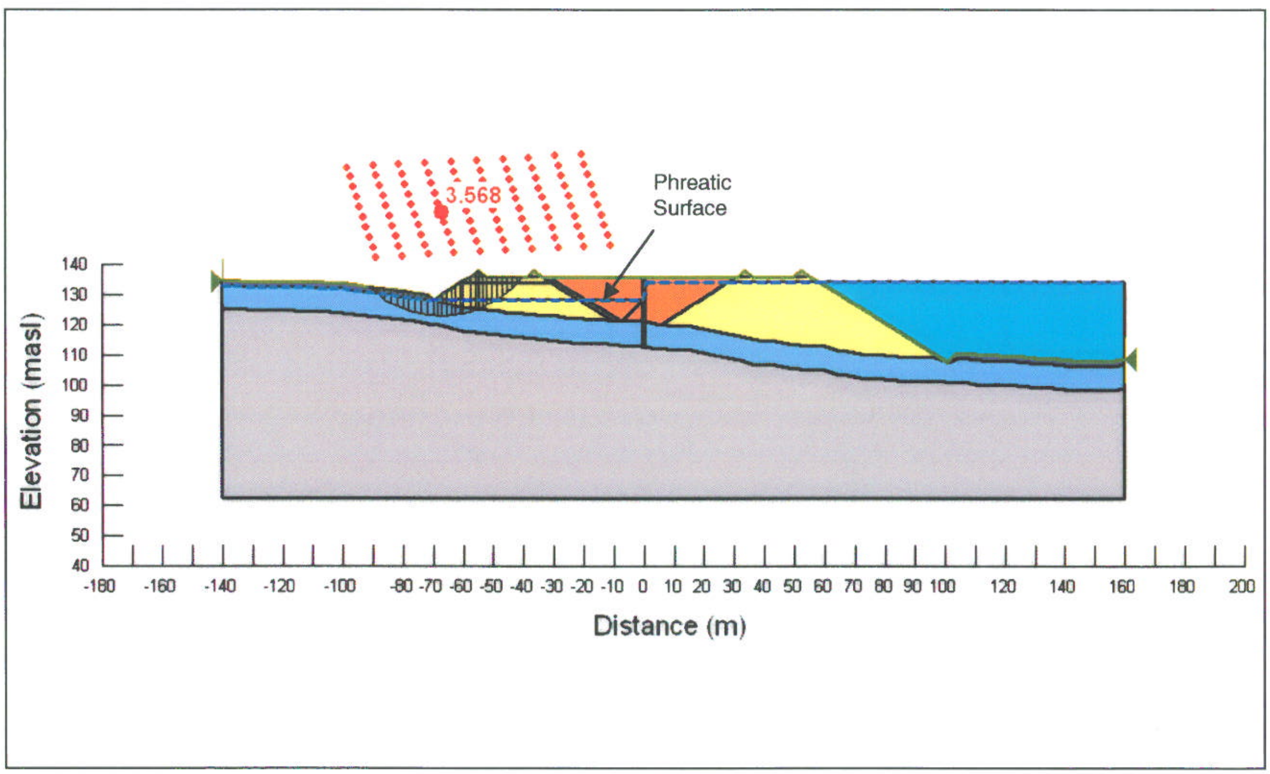

Pseudostatic a=0.035 g

Figure III-31
SLOPE/W Analysis
Steep Section, Post Drawdown
Downstream Failure

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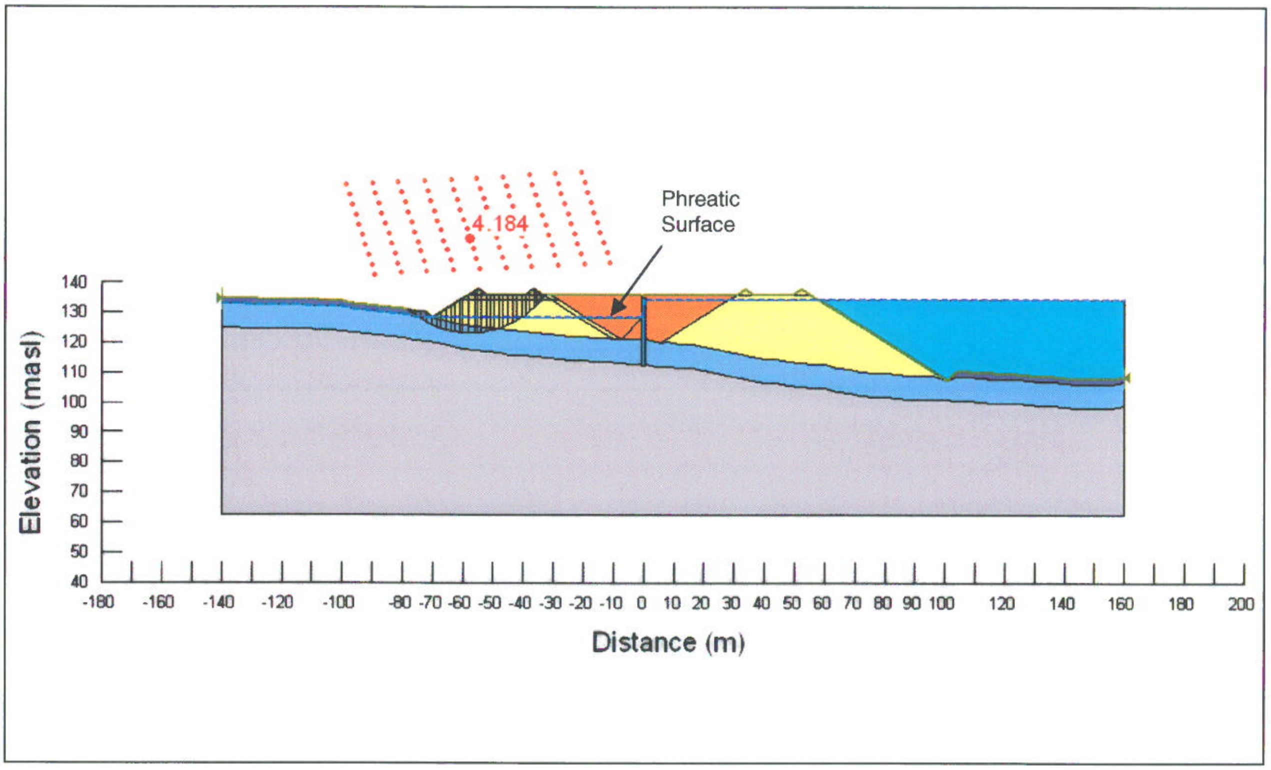
Meadowbank Gold Project
06-1413-081



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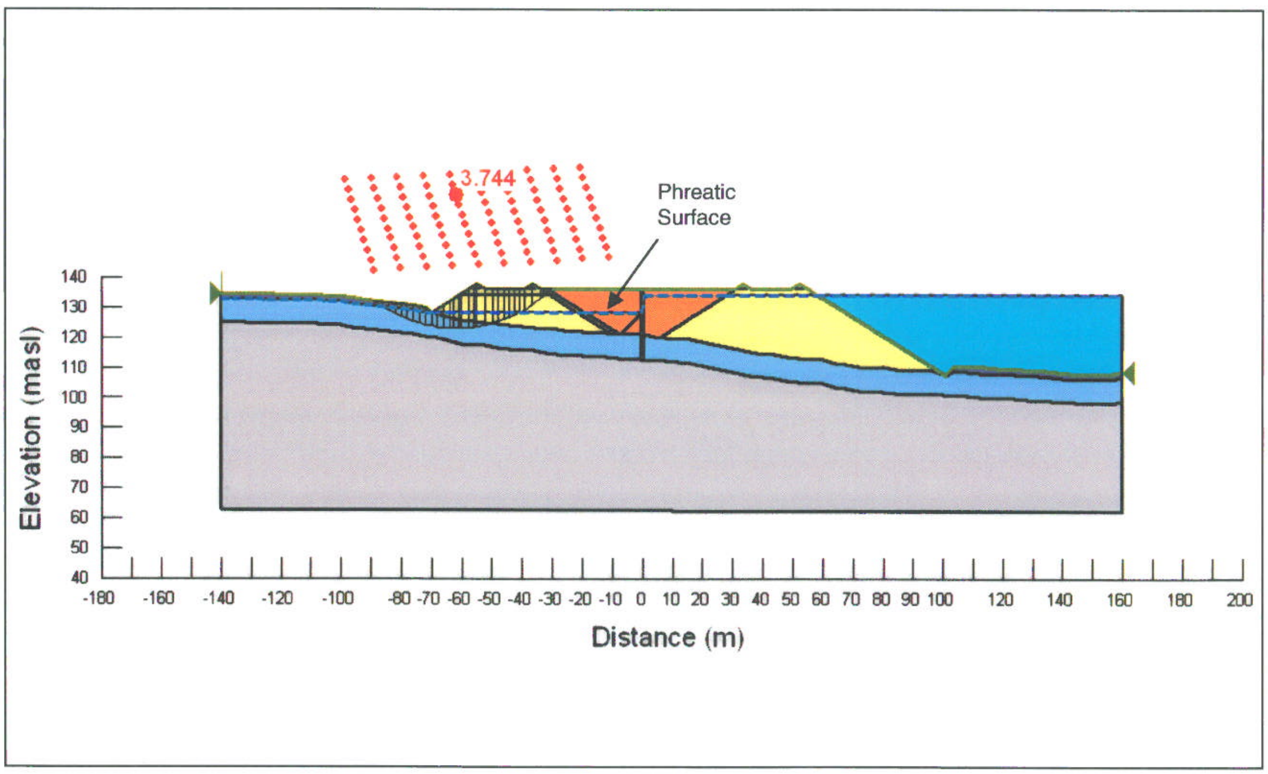

Pseudostatic a=0.035 g

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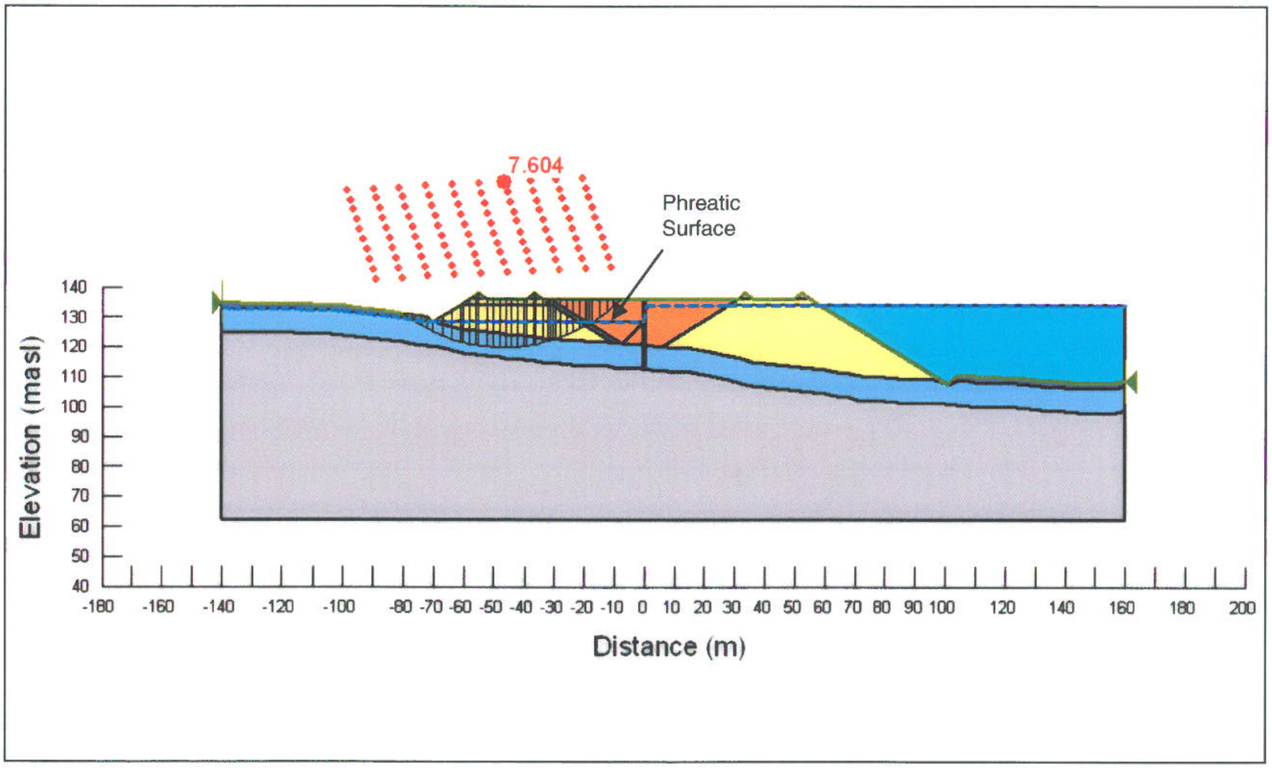
Meadowbank Gold Project
06-1413-081

Figure III-32
SLOPE/W Analysis
Steep Section, Post Drawdown
Downstream Failure



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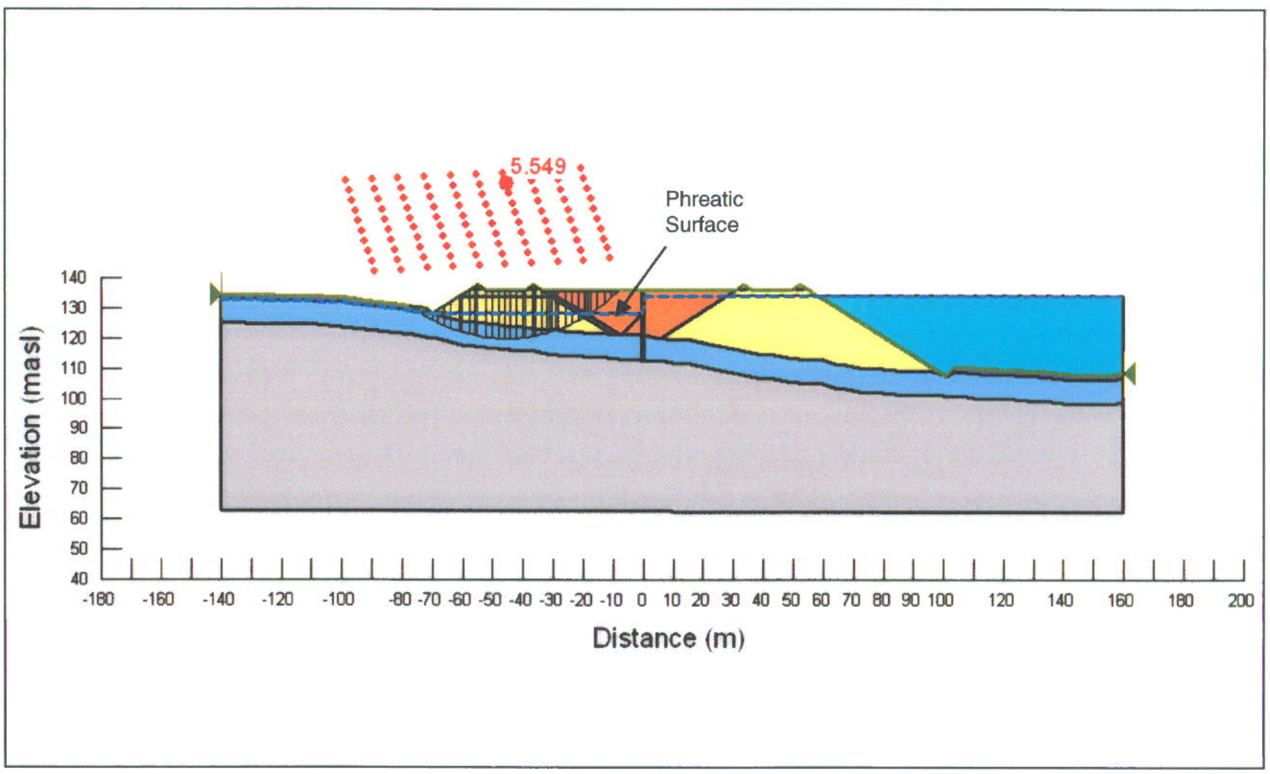

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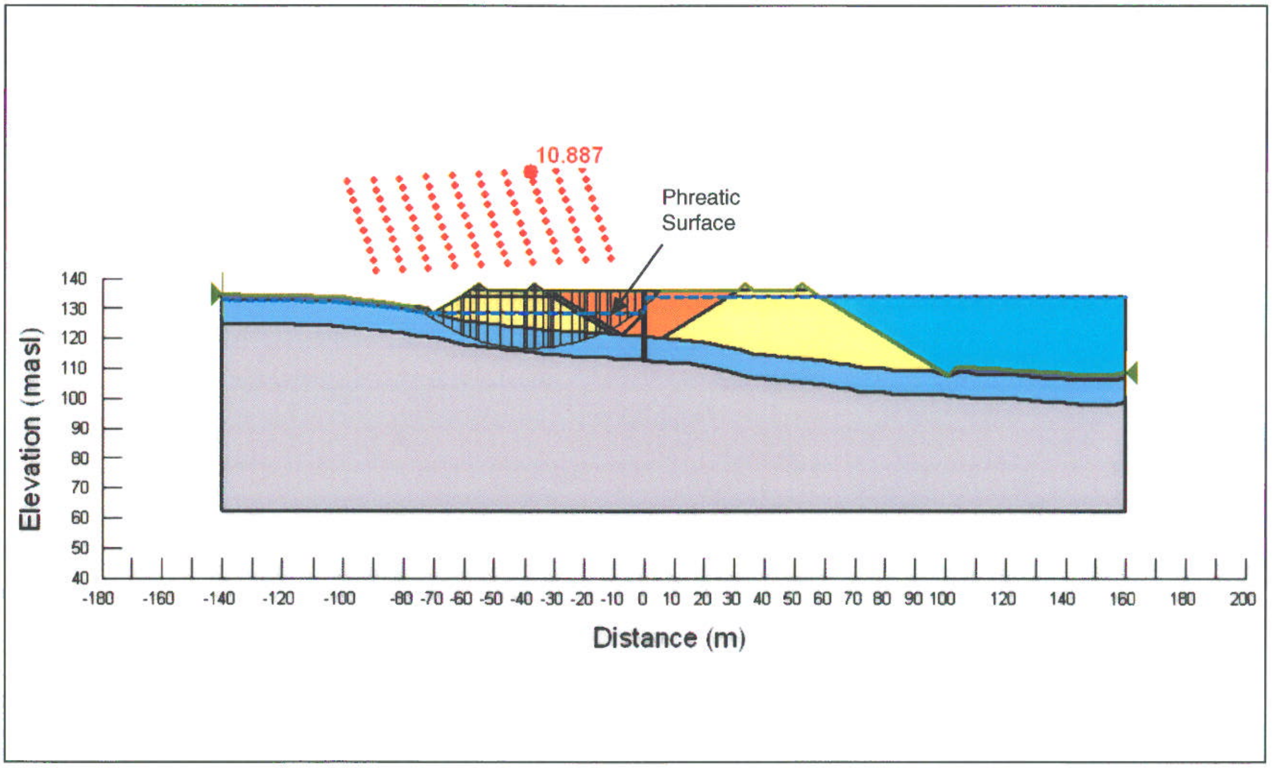
Figure III-33
SLOPE/W Analysis
Steep Section, Post Drawdown
Downstream Failure



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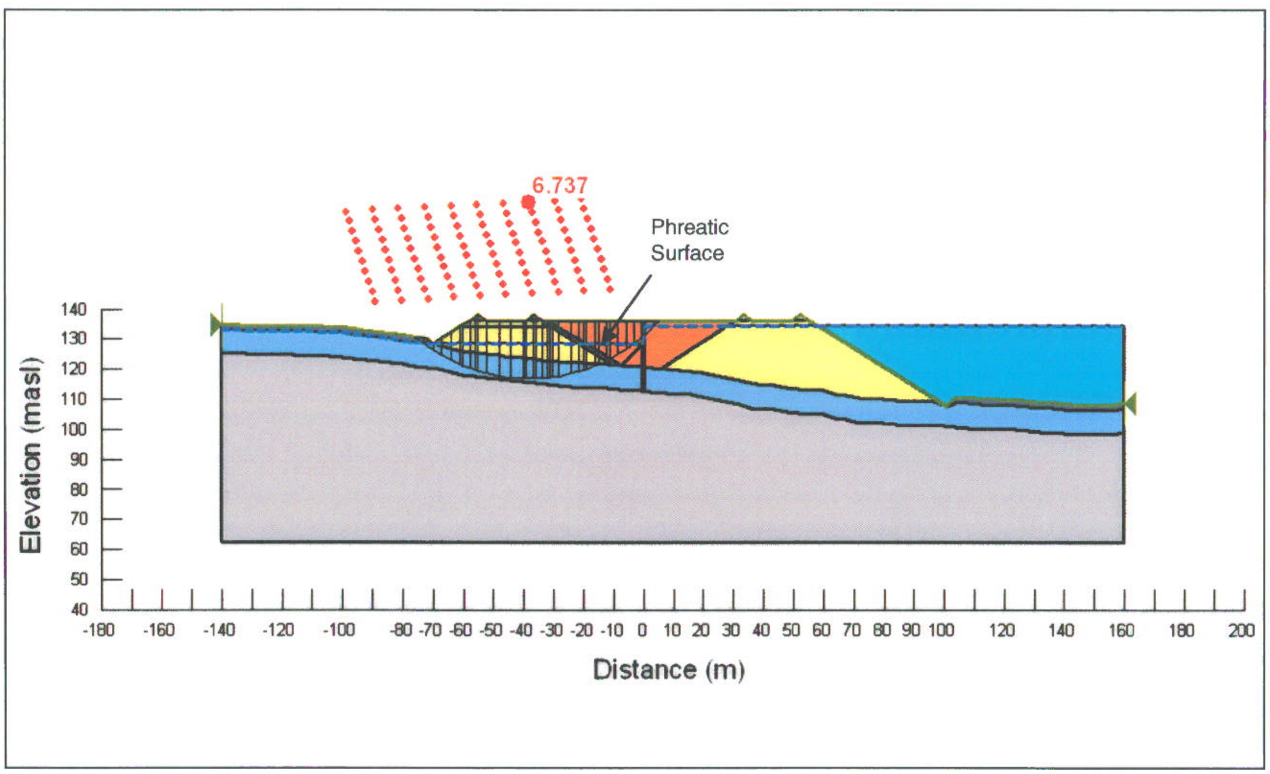

Pseudostatic a=0.035 g

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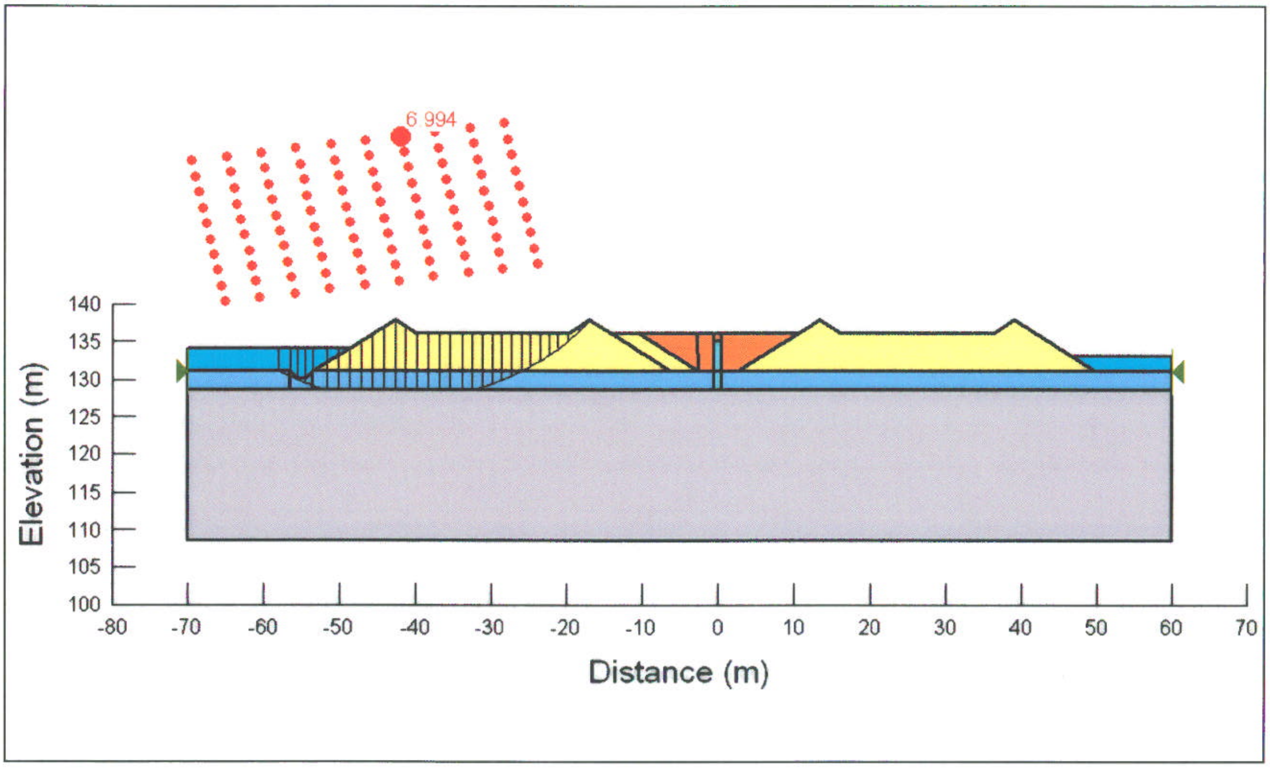
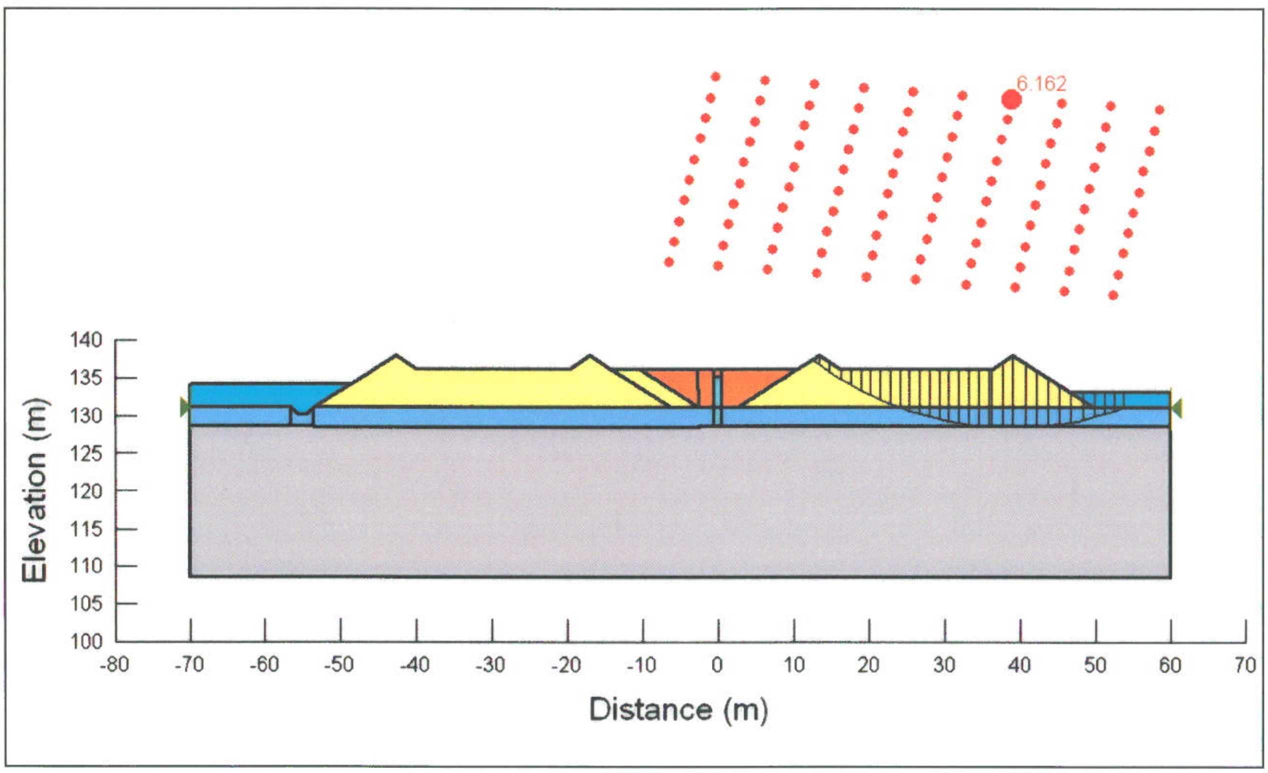
Figure III-34
SLOPE/W Analysis
Steep Section, Post Drawdown
Downstream Failure



Upstream



Downstream

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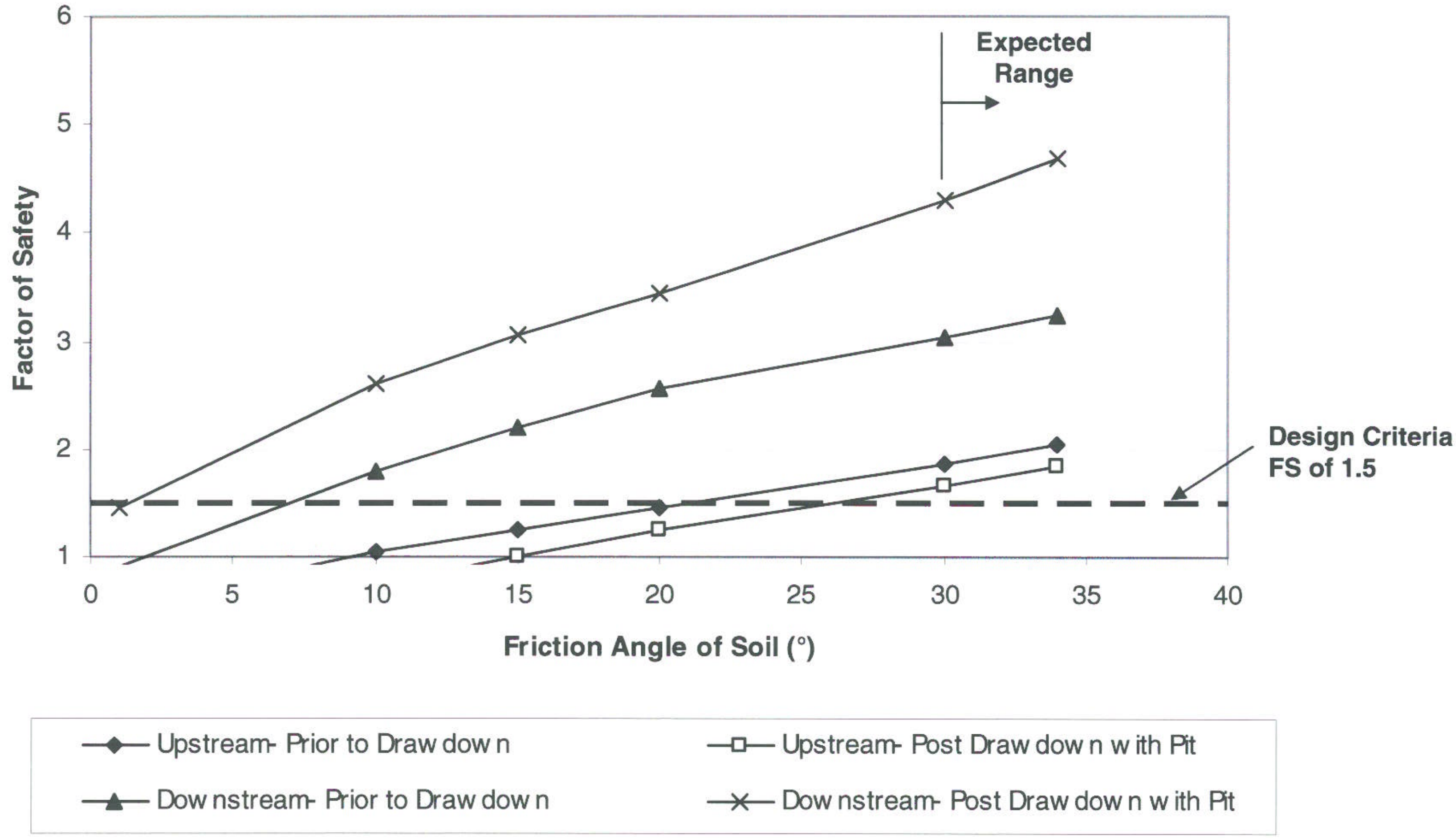
Figure III-35
SLOPE/W Analysis
East Dike
Pseudostatic, a=0.035 g



Golder Associates	Factor of Safety versus Friction Angle of Soil Meadowbank Mining Corporation Meadowbank Gold Project
Drawn: KD / App'd:	Date: Mar. 09, 2007 / Figure: III-36

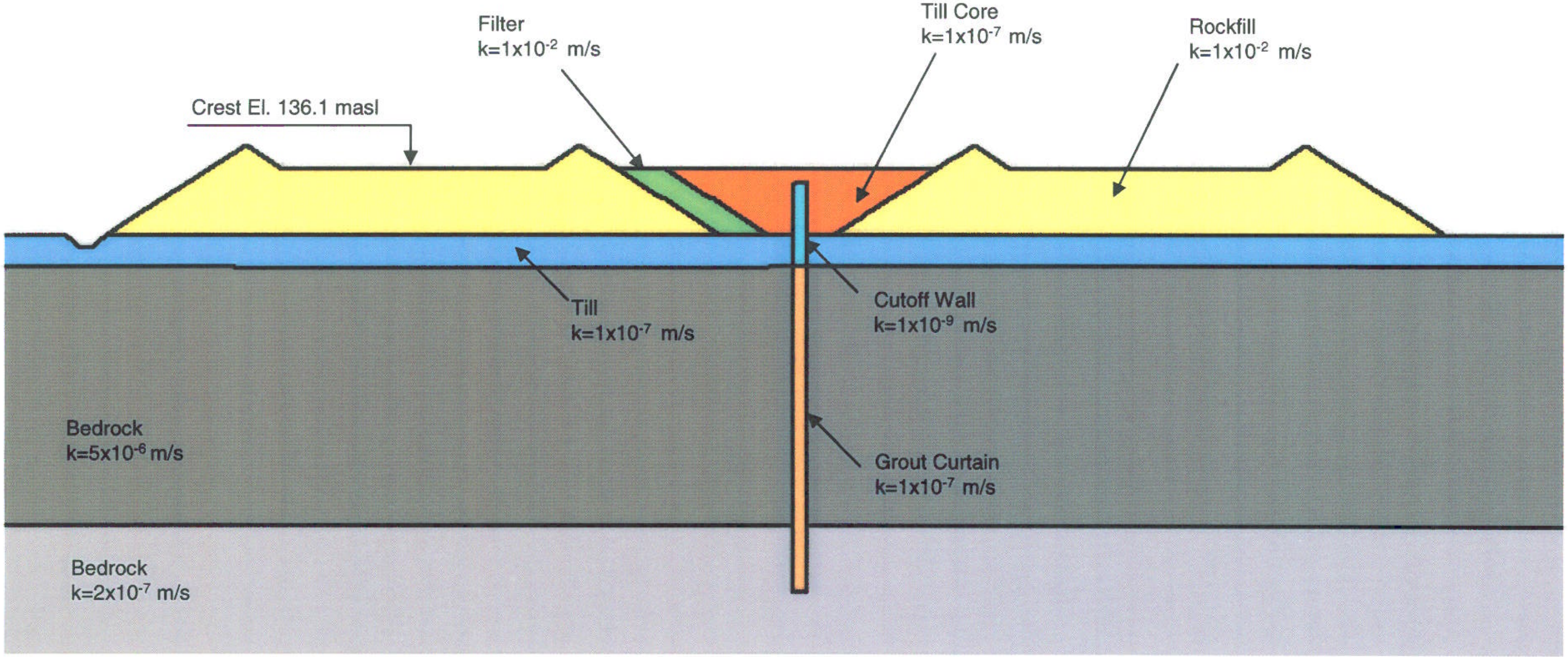


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Figure III-37
Shallow Section
Seepage Analysis

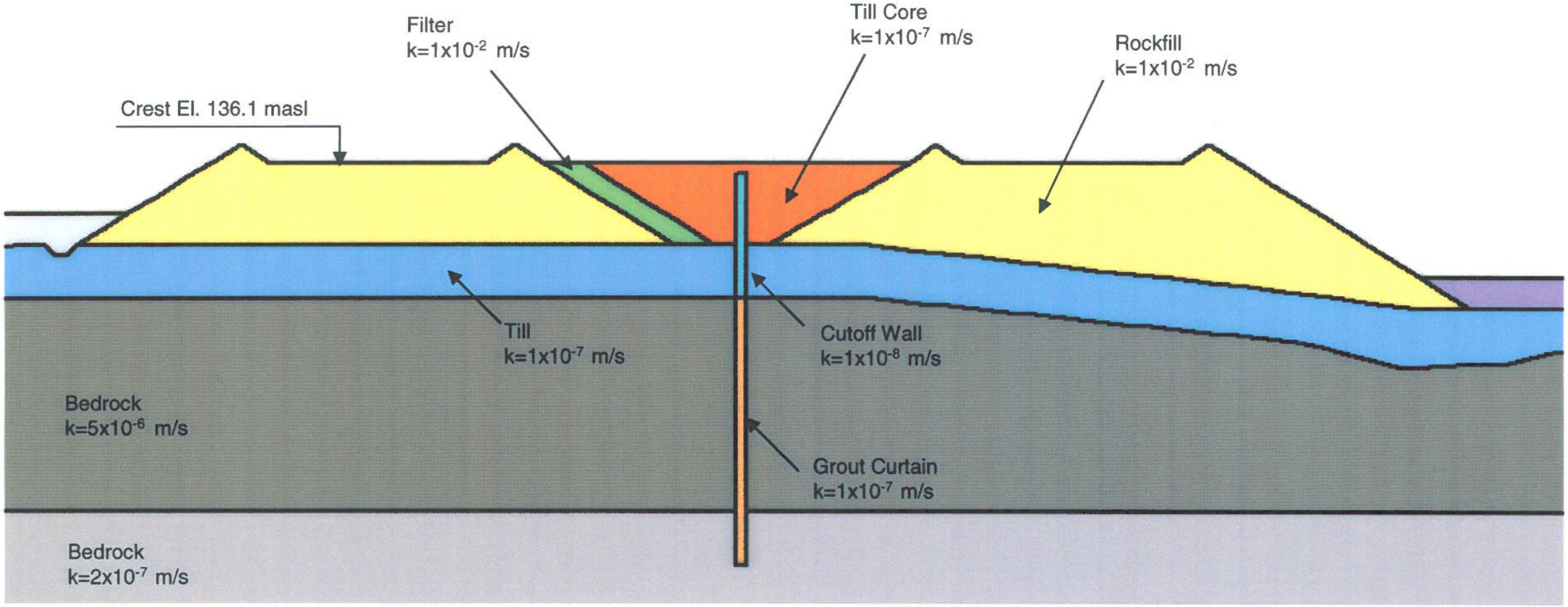

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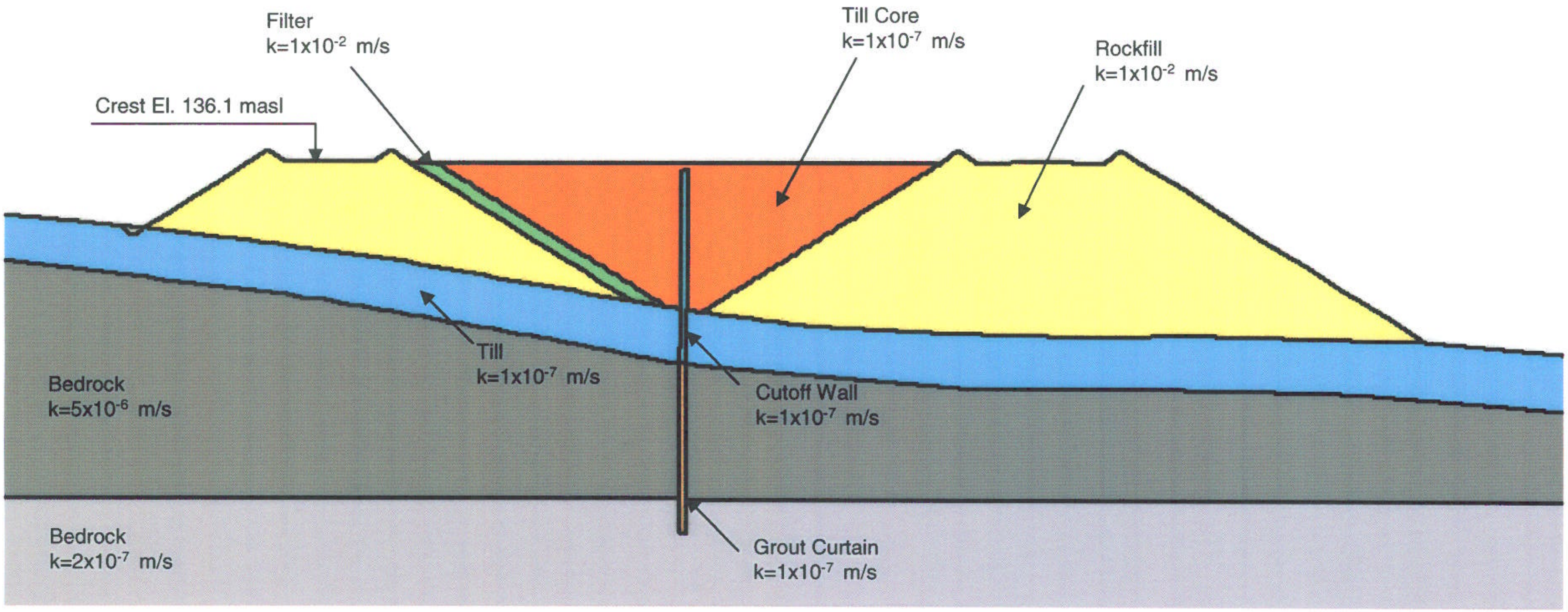
Figure III-38
Medium Section
Seepage Analysis



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Meadowbank Gold Project
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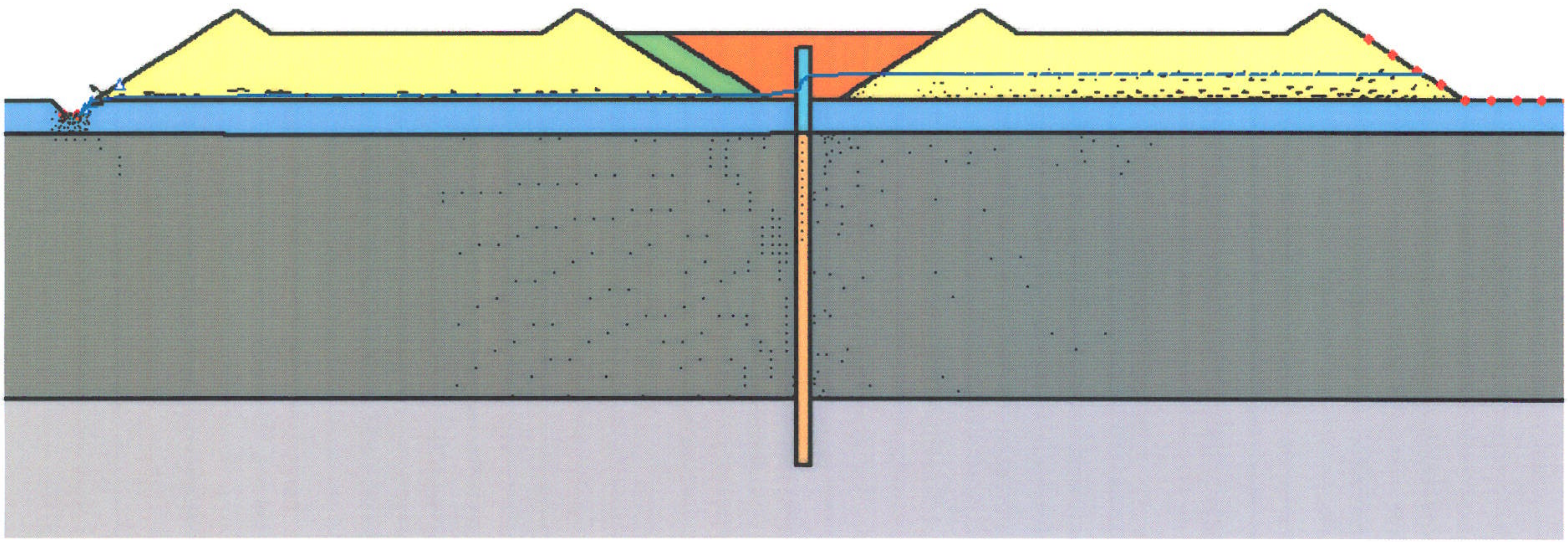
Figure III-39
Deep Section
Seepage Analysis



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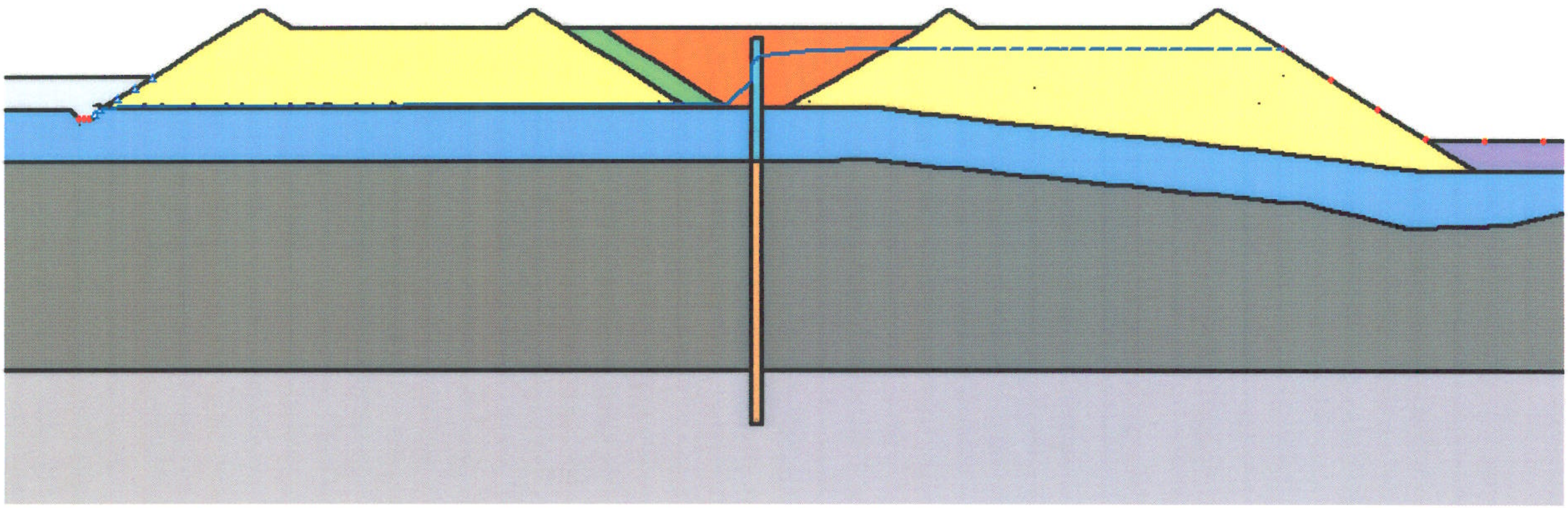
Meadowbank Gold Project
06-1413-081

Figure III-40
SEEP/W Analysis
Shallow Section – East Dike
Post Drawdown Case



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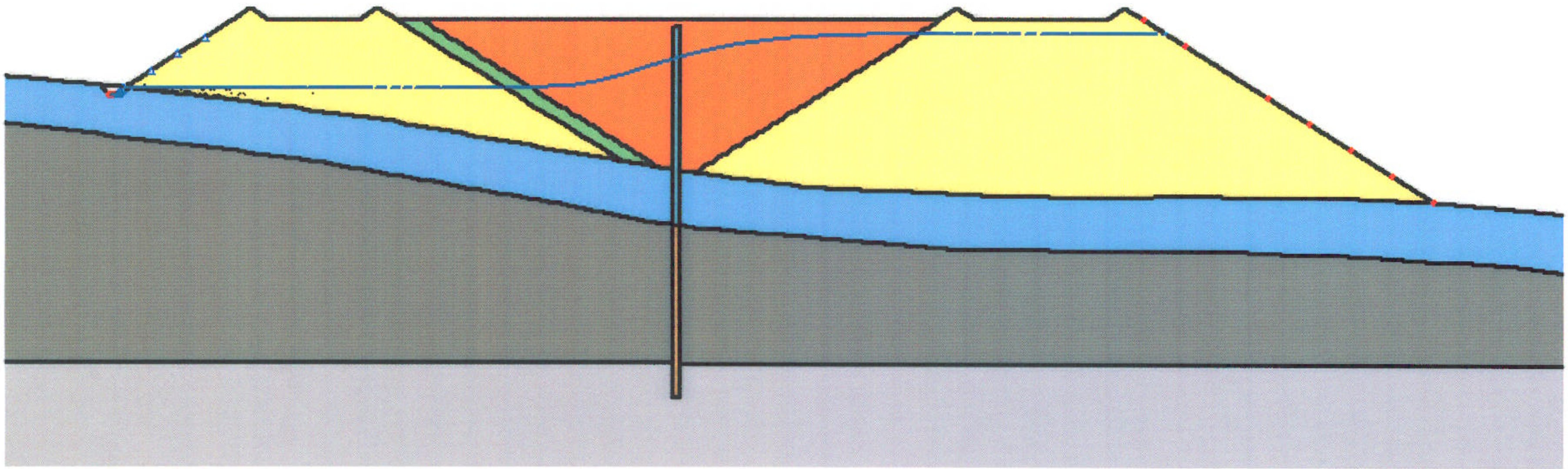
Meadowbank Gold Project
06-1413-081

Figure III-41
SEEP/W Analysis
Medium Section – Bay Dike
Post Drawdown Case



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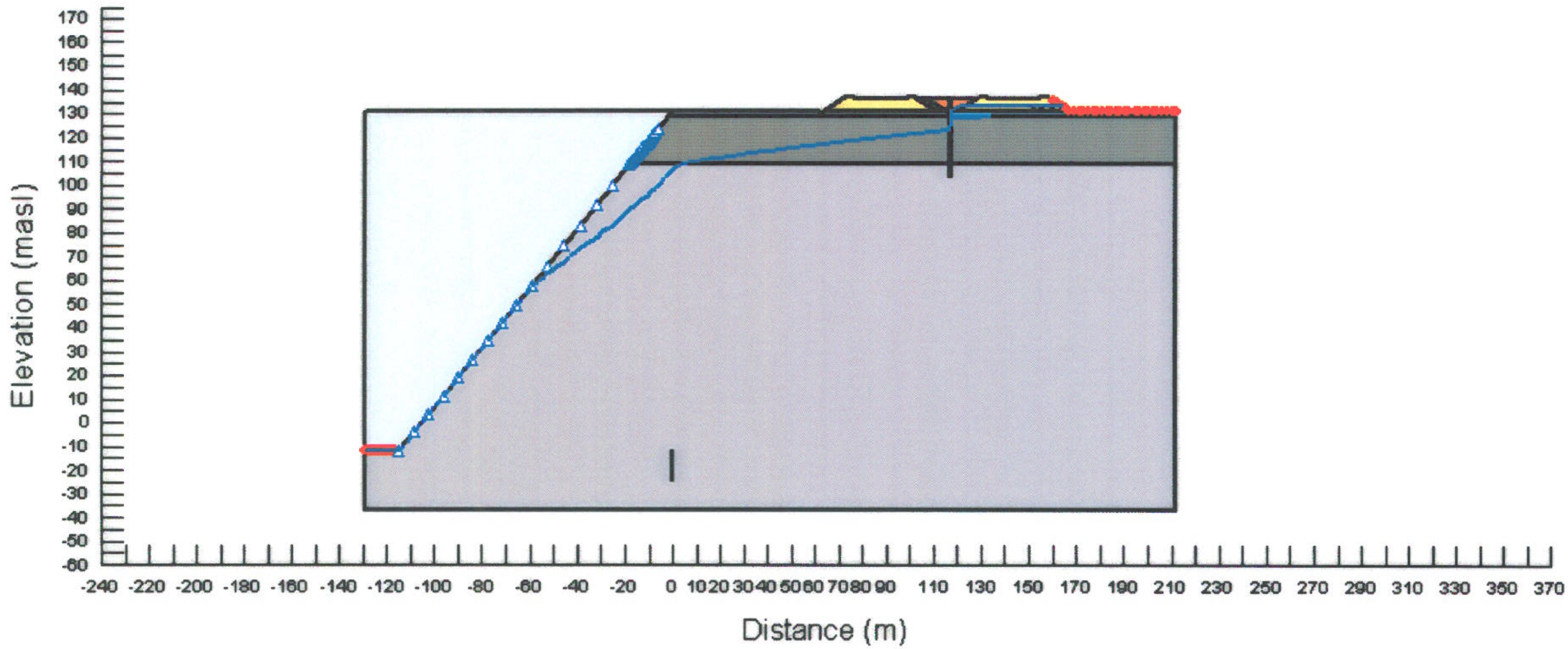
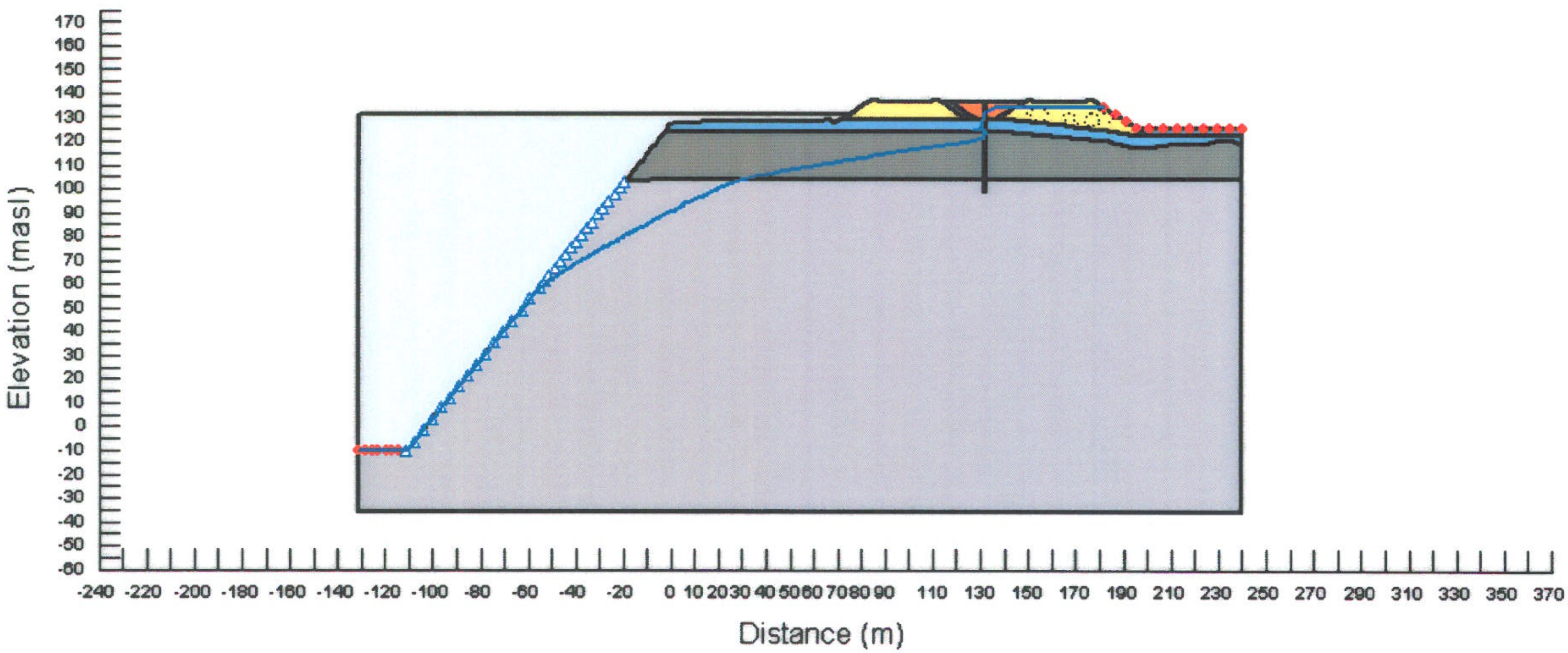
Meadowbank Gold Project
06-1413-081

Figure III-42
SEEP/W Analysis
Deep Section – Goose Dike
Post Drawdown Case



Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-43
SEEP/W Analysis
Shallow Section – East Dike
Full Pit Case



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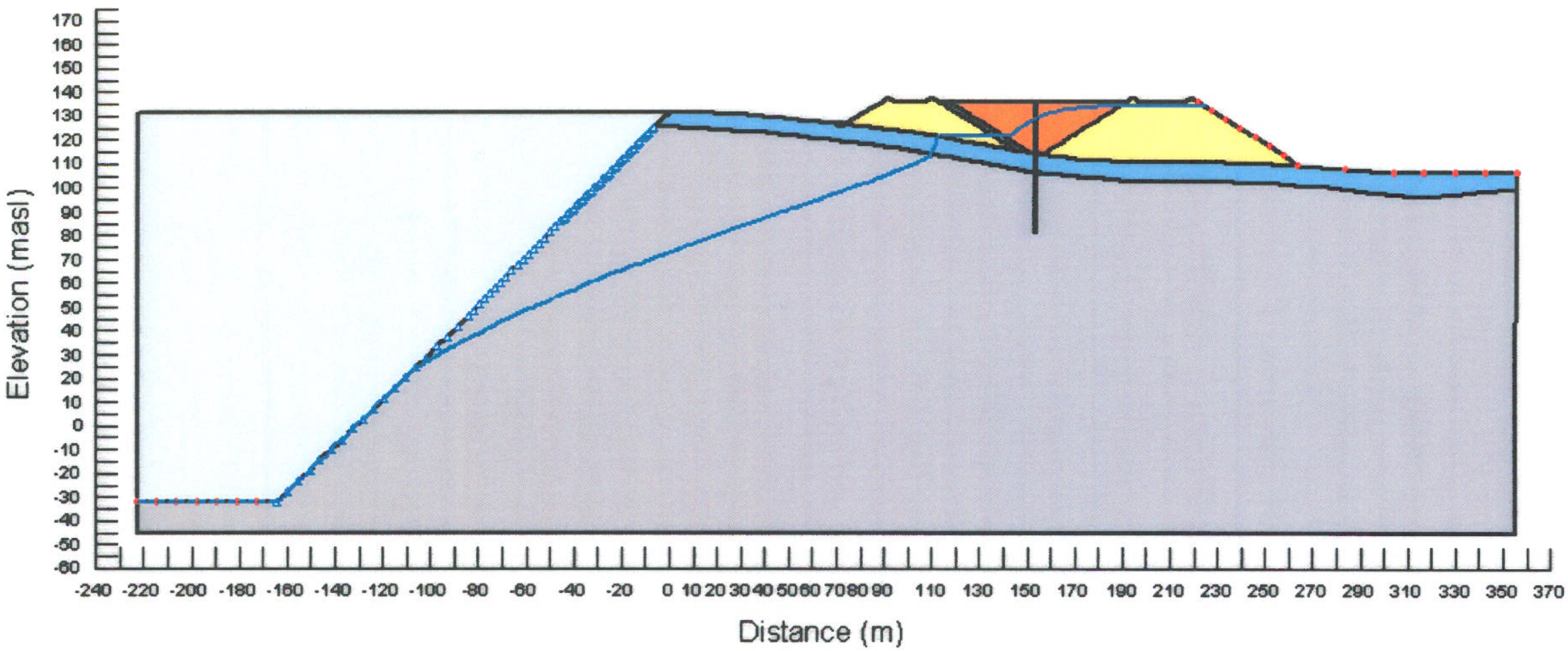
Meadowbank Gold Project
06-1413-081

Figure III-44
SEEP/W Analysis
Medium Section – Bay Zone Dike
Full Pit Case



Meadowbank Mining Corporation
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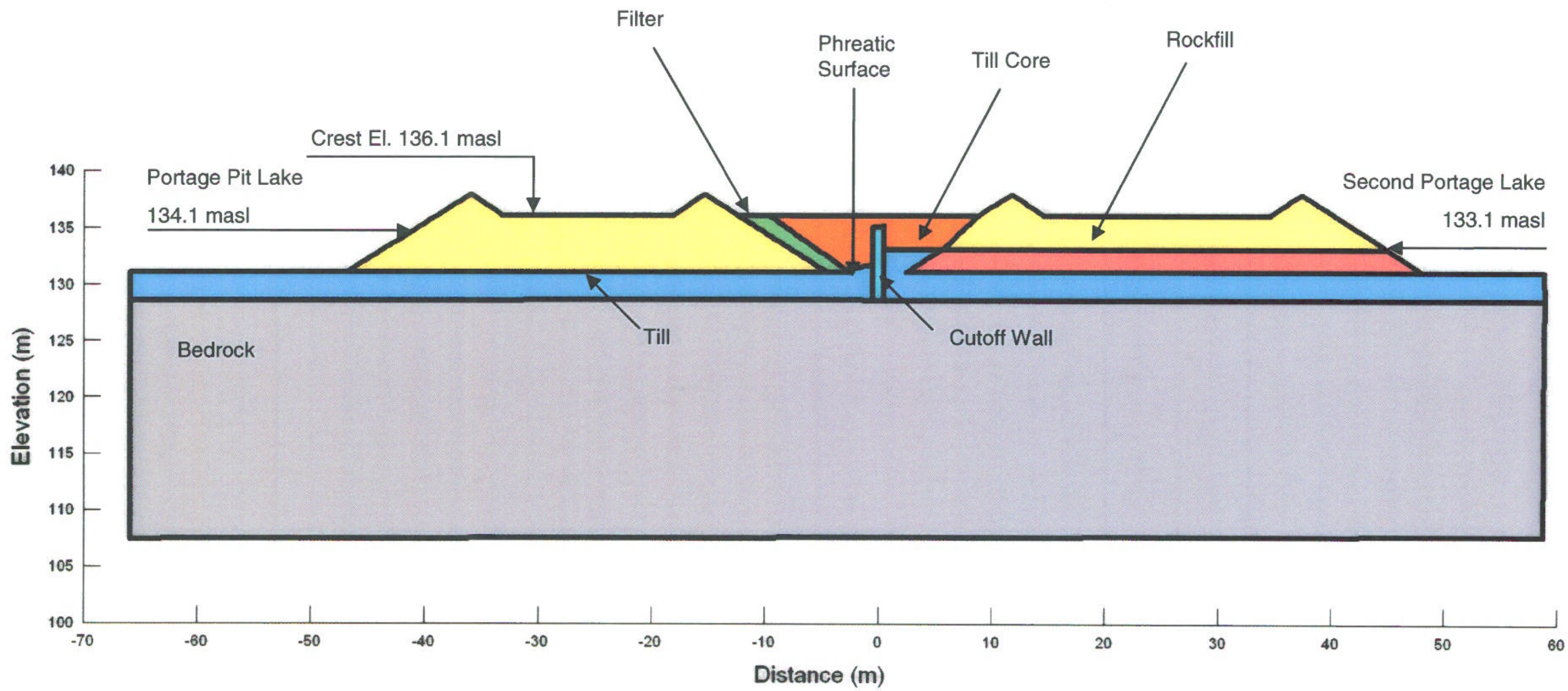
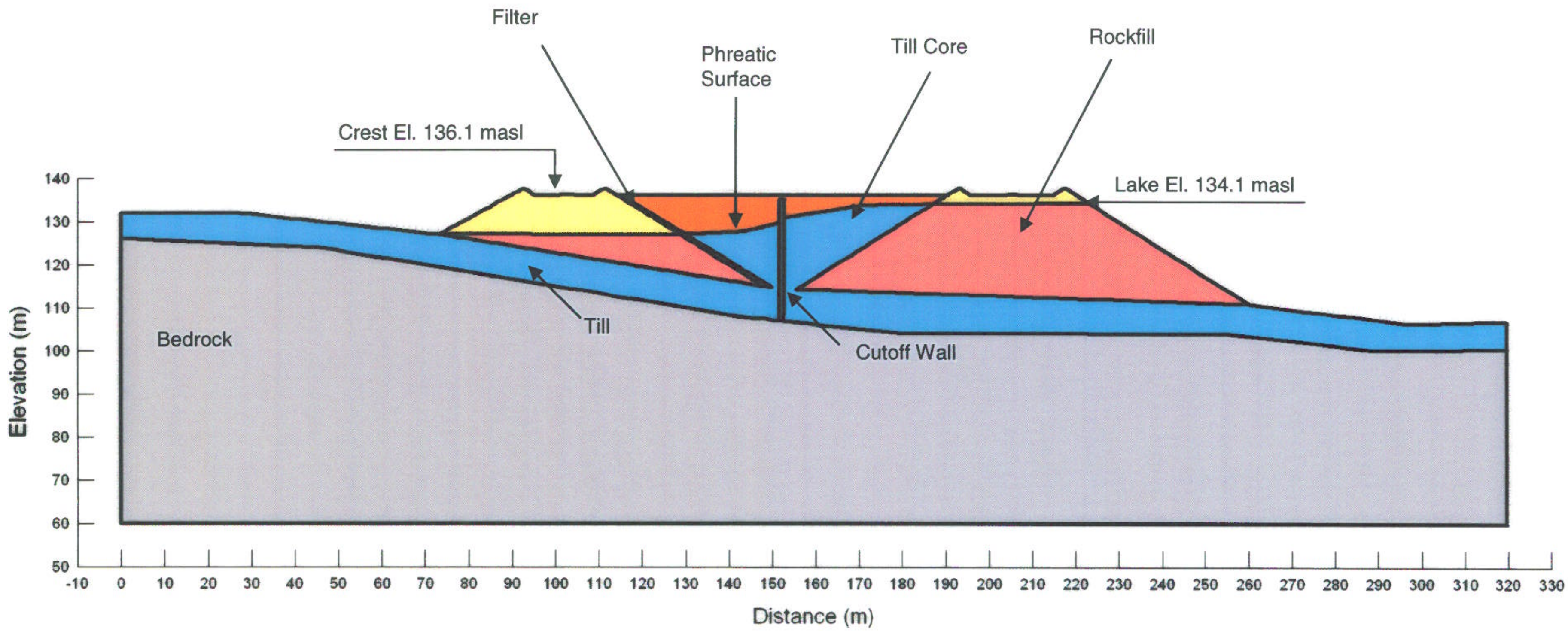
06-1413-081

Figure III-45
SEEP/W Analysis
Deep Section – Goose Dike
Full Pit Case



Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-46
TEMP/W Analysis
East Section



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06-1413-081

Figure III-47
TEMP/W Analysis
Goose Section

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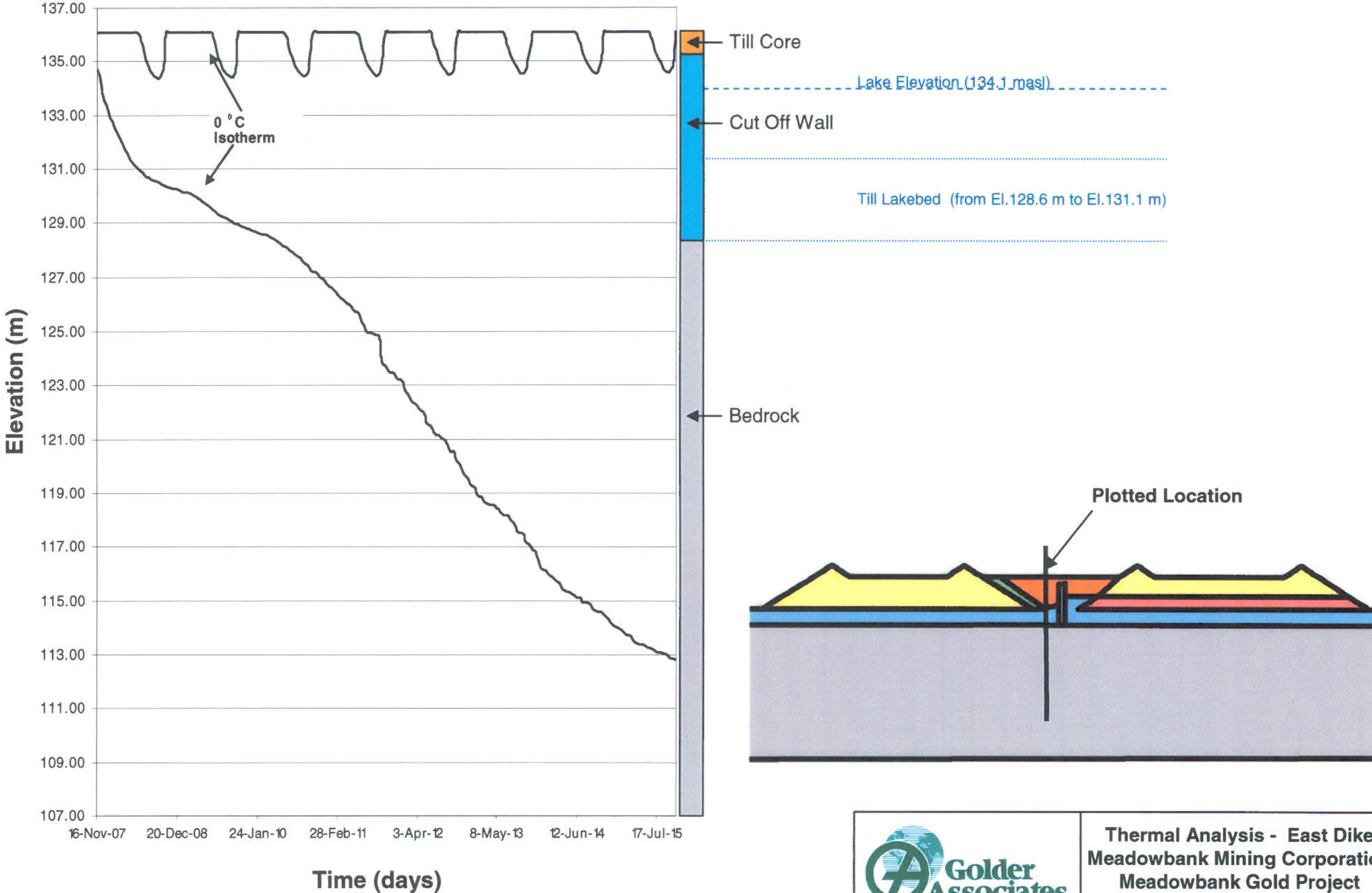
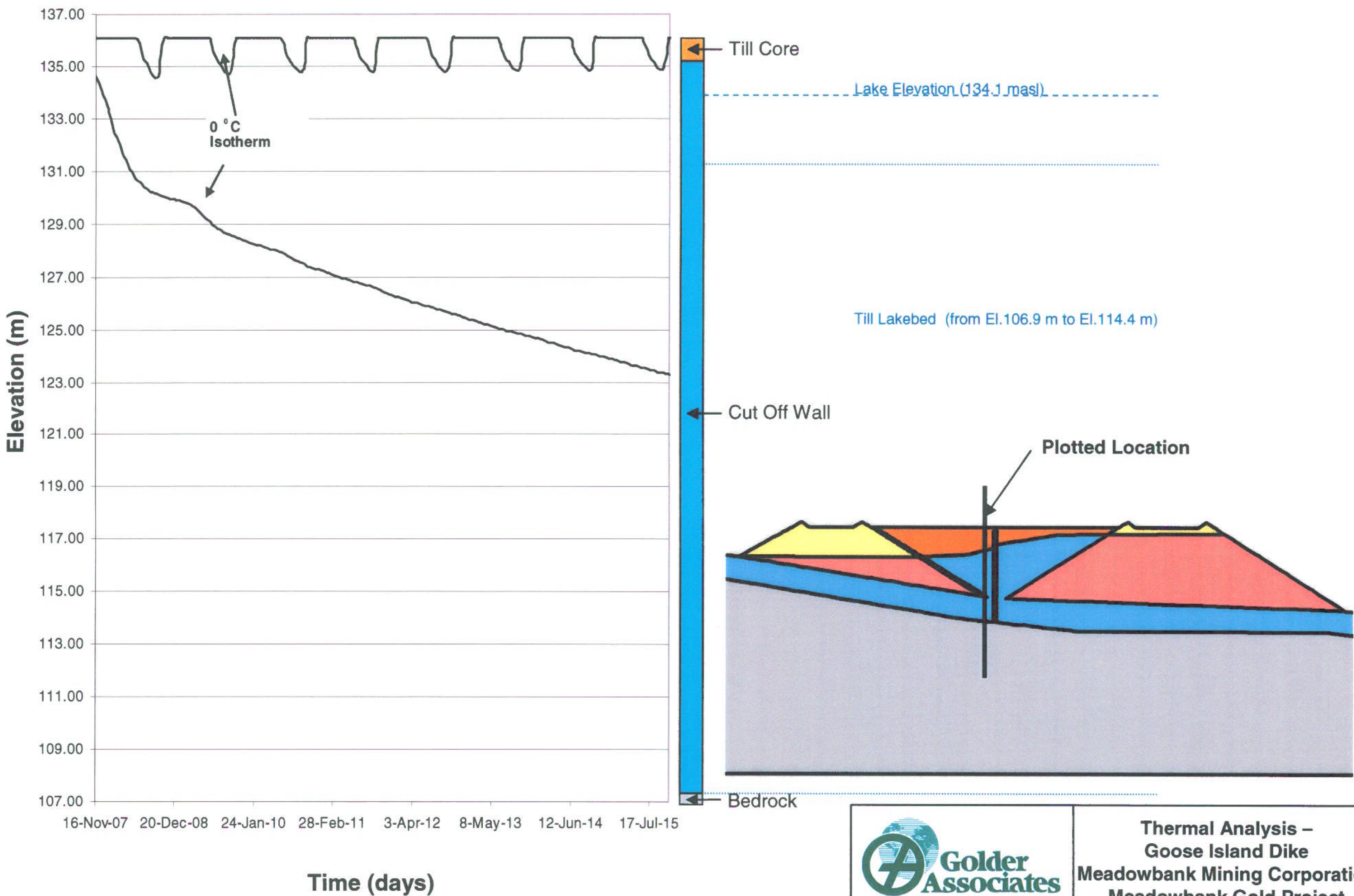


Golder Associates	Thermal Analysis - East Dike Meadowbank Mining Corporation Meadowbank Gold Project		
Drawn: KD	App'd:	Date: Mar. 09, 2007	Figure: III-48

Revision No.: 06-1413-081



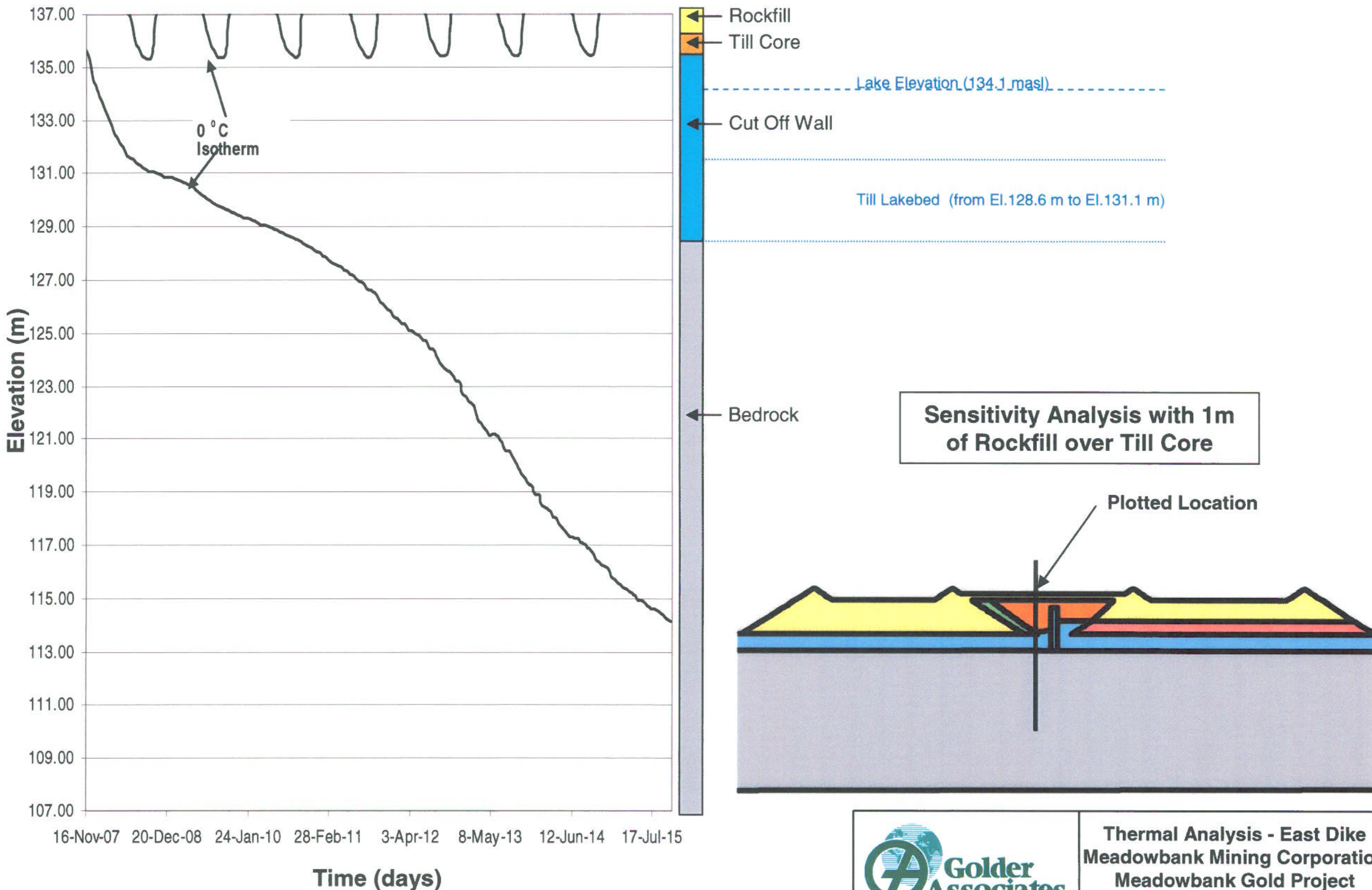
Golder Associates

Thermal Analysis – Goose Island Dike
Meadowbank Mining Corporation
Meadowbank Gold Project

Drawn: KD	App'd:	Date: Mar. 09, 2007	Figure: **III-49**

Revision No.: 06-1413-081

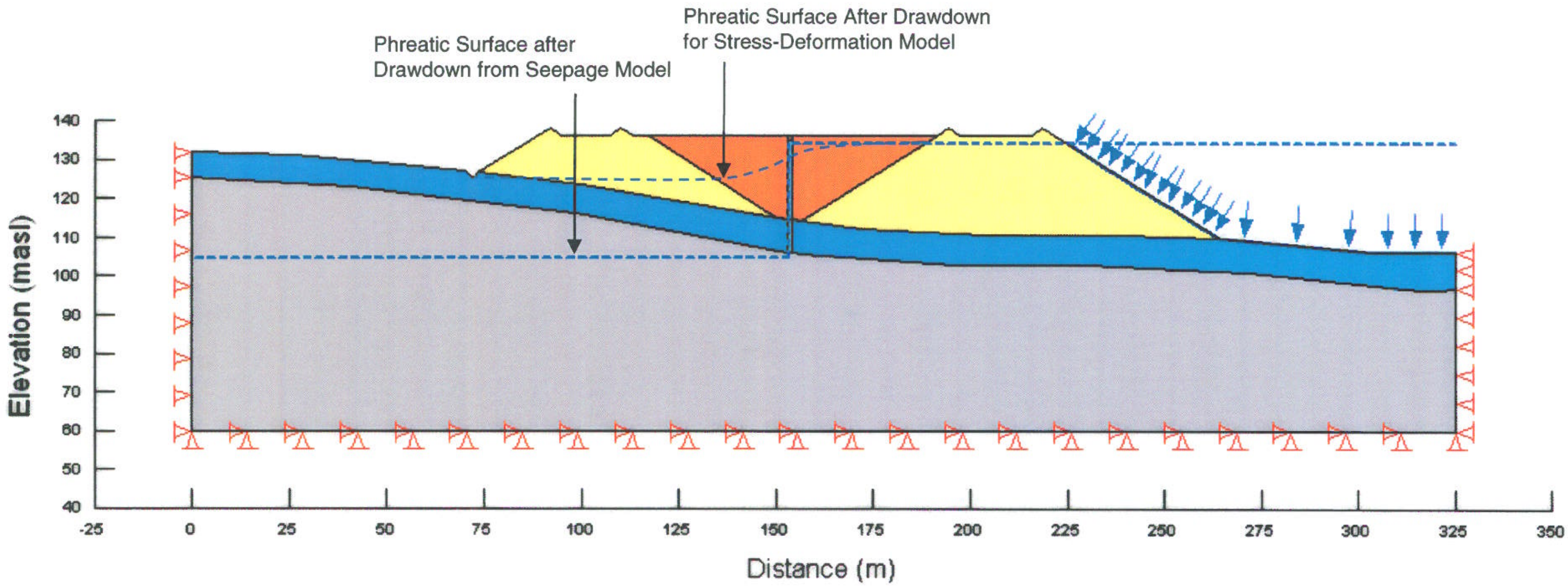
PROJECT NO. 06-1413-081 DRAWN: KD REVIEWED BY: DATE: 09-03-07 FILE LOCATION:



Sensitivity Analysis with 1m of Rockfill over Till Core

Golder Associates	Thermal Analysis - East Dike Meadowbank Mining Corporation Meadowbank Gold Project		
Drawn: KD	App'd:	Date: Mar. 09, 2007	Figure: III-50

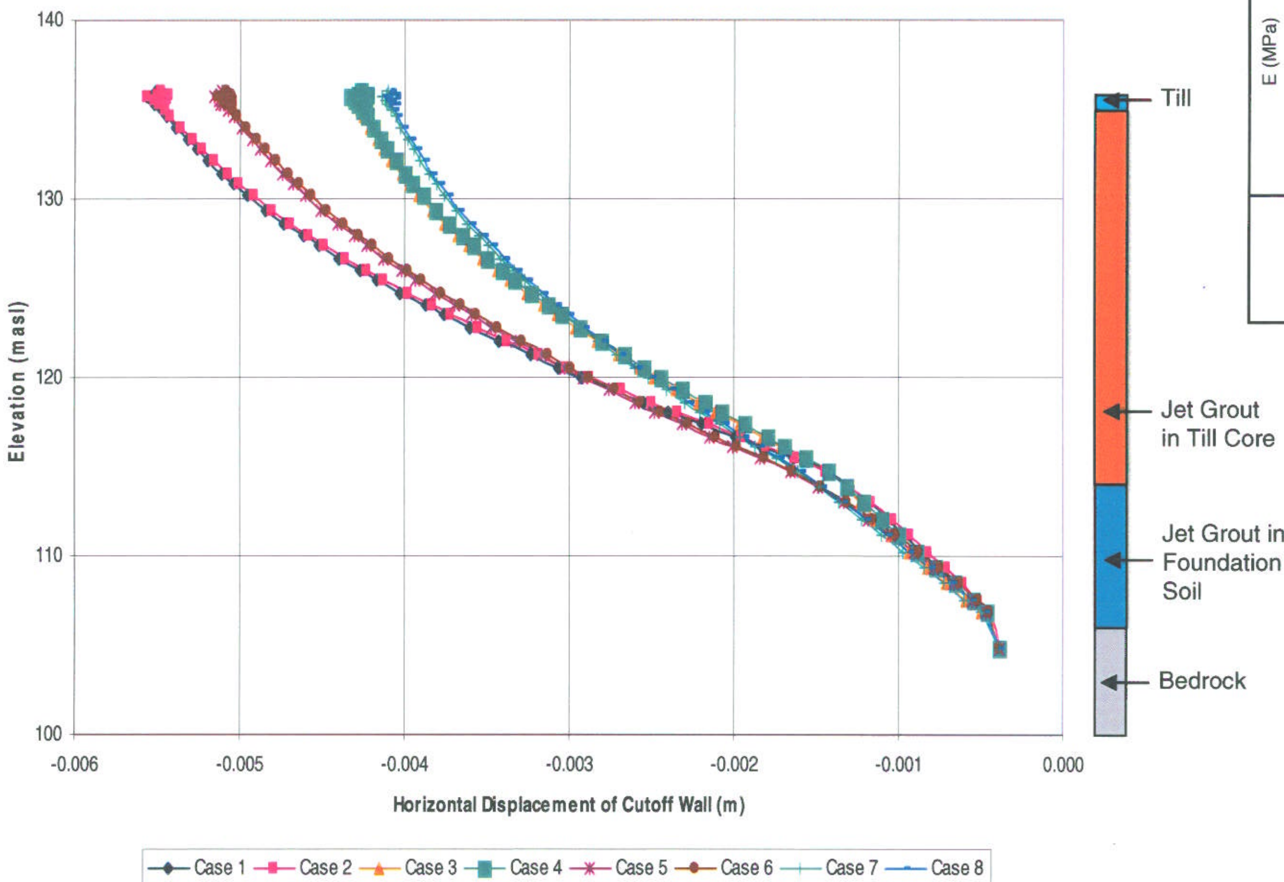
Revision No.: 06-1413-081



Meadowbank Mining Corporation
Meadowbank Gold Project
06-1413-081

Figure III-51
SIGMA/W Analysis
Section

Cutoff Wall Horizontal Deformation due to Drawdown
Sensistivity Analysis Results



		Till Core	Rockfill	In-Situ Till	Jet Grout
E (MPa)	Case 1	20	15	50	100
	Case 2	20	15	50	500
	Case 3	20	30	50	100
	Case 4	20	30	50	500
	Case 5	40	15	50	100
	Case 6	40	15	50	500
	Case 7	40	30	50	100
	Case 8	40	30	50	500
	Unit Weight (kN/m^3)	21.4	21.8	21.4	21.4
	Ko	0.4	0.4	0.5	0.5

Golder Associates

Maximum Deformation Of Cutoff Wall
Goose Island Dike, Deep Section
Meadowbank Mining Corporation
Meadowbank Gold Project

Drawn: KD | App'd: | Date: Mar. 09, 2007 | Figure: **III-52**

APPENDIX IV

DIKE CONSTRUCTION AND CUTOFF WALL REVIEW

DISCUSSION OF CONSTRUCTION TECHNIQUES AND CUTOFF WALL TECHNOLOGIES

A discussion of construction techniques proposed in the report is presented for placement of rock fill and till in the wet, for appropriate concepts for slurry trench cutoff wall. A description of jet grouting is included.

1.1 Placement of Rock Fill and Till in the Wet

Rockfill sideslopes are expected to vary from 1.32 Horizontal: 1 Vertical (the angle of repose of rockfill dumped on land) to about 1.8 Horizontal: 1 Vertical. The sideslope achieved will depend on the strength of the embankment foundation. At Diavik Diamond Mines, sideslopes achieved on the two dewatering dikes constructed to date have ranged between 1.6 Horizontal: 1 Vertical and 1.7 Horizontal: 1 Vertical in water depths up to about 30 m. At the Canso Causeway, constructed from 1952 through 1954, between Nova Scotia and Cape Breton Island, the sideslopes achieved on the rockfill embankment were about 1.5 Horizontal: 1 Vertical in water depths up to 65 m.

Placement of till in the wet also has a historical precedent. At the Hugh Keenlyside Arrow Dam (Bazett 1970) till was dumped in windrows and pushed into the water by bulldozer.

> "The till was seen to be placed by a mechanism of slides occurring under the weight of these windrows as these were advanced by the bulldozers. Small slides were observed on the first day of placing and became more pronounced and continued throughout the test. The slides in the early stages of the dumping tore some of the sand-gravel of the initial platform from place and the fill had apparently lost ground. The slides were not always the same: some appeared merely as distortion of the fill; some were clearly marked by tension cracks and small failure scarps. The slides were very small in size. Movement was not dramatic, but was slow and easily controlled. Subsidence of the fill was rarely more than 60 to 90 cm; horizontal extent of the surface of the fill was seldom more than 7.5 to 10.5 m parallel to the edge of the fill and for a width of 60 to 90 cm, normal to the edge of the fill. Some spilling of material over the face of the fill directly into water was normally observed although it was avoided to the extent possible. The desired slides could be induced by dropping the blade at the face of the fill or alternatively, undesirable spilling could be increased by the bulldozer operator virtually throwing material over the crest of the fill.

Slides were larger at the portion of the fill where the depth of water was greatest. The slides were most easily controlled when placing close to the water level. At a height of 4.5 m above water level, danger to the bulldozer became apparent. Placing at a height above water level of 60 cm was not convenient. The bulldozer operation was normally carried out at a height of about 1.5 m which could reduce to 60 cm after shaping and trimming. The height of the fill was maintained at about 1.5 m above water level."

Although methods for placement of the till are suggested here, the contractor will be required to carry out tests of placement techniques at the start of the construction program.

1.2 Cutoff Wall

The purpose of the cutoff wall is to provide an engineered, low hydraulic conductivity element within the dewatering dike section to control seepage within the foundation soil and within the till core.

The Meadowbank area is a glaciated terrain. Till blankets much of the lake bottoms, but areas of relatively permeable granular materials have been identified in the geotechnical investigations. Materials that can transmit large seepage flows or allow internal erosion of the foundation can have dimensions that are too small to detect with conventional investigation methods. The solution to dealing with these potentially higher permeability granular foundation materials is to construct a cutoff wall completely through the foundation soil to bedrock.

A cutoff wall would not be required for the till core if the quality of till in the core could be strictly controlled for gradation and consolidation. Since a seepage cutoff will be constructed through the till core to reach the foundation, the effort to process the till core materials can be reduced.

The type of cutoff selected is based on the hydraulic head that must be retained at the maximum depth of the cutoff, on the resistance of the cutoff to erosion by seepage at cracks or similar defects and on the ease or simplicity of construction.

Cutoff technologies considered for the dewatering dikes include:

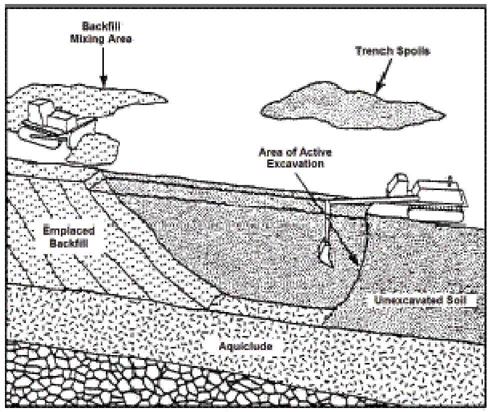
- Soil-bentonite slurry trench, a trench is excavated into the till; water in the trench is mixed with bentonite which cakes on the sides of the trench, holding it open. Soils removed from the trench are mixed with water-bentonite mixtures and replaced in the trench. This technology will be used for depths to bedrock of less than 8 m.

- Soil-cement-bentonite cutoff – the same method is used as for soil-bentonite slurry walls, but cement is added to the soil-bentonite mixture prior to placement in the trench. Addition of cement increases the erosion resistance but also increases the hydraulic conductivity. This technology will be used for depths to bedrock of between 8 m and 15 m.

- Jet Grouting – a series of holes are drilled along the alignment. In each hole grout is sprayed at very high pressure from a rotating nozzle into the surrounding soil. The solid and grout mixture are completely mixed by the rotating jet, resulting in a line of interlocking soil-cement-bentonite columns. If holes are pre-drilled, then the cutoff may be socketed into bedrock. This technology will be used for depths to bedrock greater than 15 m. Jet grouting will also be used areas where high concentrations of boulders slow or prevent excavation of a trench. In this case, jet grouting would be carried out in the gap between the bottom of the cutoff wall and the bedrock.

1.2.1 Slurry Trench Construction

A slurry trench cutoff wall is constructed by excavating a narrow vertical trench, typically 0.6 to 2 m wide, through the pervious materials to relatively impervious underlying strata. The trench is kept full during excavation with a slurry suspension of bentonite in water. The slurry acts to stabilize the walls of the trench preventing their collapse during excavation. The slurry also deposits a filter cake on the walls of the trench, which contributes to the low permeability of the completed cutoff. Numerous experiences in a wide variety of soils from rock to soft clay have shown that a very long and deep trench will remain open, provided that it is filled with slurry and provided the groundwater level is about a metre below the slurry level. D'Appolonia (1980) reports that trenches more than 30 m deep and 300 m long have stayed open for several weeks between excavation and backfilling. A schematic of a slurry trench operation is shown in the graphic.



Cross section of a soil-bentonite slurry trench, showing excavation and backfilling operations (after USACE (1997), from Spooner et al. (1985))

After excavation, the trench is backfilled by displacing the slurry with an engineered material having the required engineering properties. When impermeability, rather than structural strength, is the required property of the cutoff, the best and least expensive backfill material is usually a paste composed of soil with a gradation similar to till and bentonite slurry. At depths less than about 20 m, backhoes are generally the most efficient equipment for excavation. At greater depths, draglines and clamshells have been used. The method of trench excavation is basically unimportant from a technical point of view. It is only important that the cutoff everywhere extends to the impervious stratum. Verticality of the trench is also irrelevant except as it affects trench continuity. The digging action of backhoes assures that unexcavated material does not remain in the trench provided that rudimentary care is taken.

Testing by Xanthakos (1979) showed that hydraulic gradients of 30 to 40 were required to cause blow-out of soil-bentonite mixtures with 10-30% passing the No. 200 sieve. Xanthakos recommended that a Factor-of-Safety of 4 against blow-out be used for selecting the cutoff wall thickness, resulting in a maximum allowable hydraulic gradient across the wall of 8. Millet et al (1992) report that a typical relationship that has been used for soil-bentonite backfill slurry walls is that the wall should have a thickness of 1.5 m to 2.3 m for walls up to 30 m in depth and consider that detailed studies of arching and hydrofracturing are required for significant deviations from this guideline. The U.S. Corp of Engineers (1993) recommends using a Factor-of-Safety of 3 against blow-out, resulting in a maximum allowable hydraulic gradient across the wall of 10, based on testing on soil-bentonite mixes of widely graded gravels with little sand. For Meadowbank the more conservative maximum hydraulic gradient of 8 has been selected for design, and the maximum hydraulic head across the wall has been assumed to be the depth of water over bedrock because permeable soil layers may provide a direct hydraulic connection between the lake and the bedrock.

Beier and Strobl (1985) carried out internal erosion tests on various types of soil-cement-bentonite cutoff walls for dams, and based on their results recommended using a Factor-of-Safety of 2 against the critical gradient for internal erosion. For cutoffs comprising cement and bentonite slurry with a filler, the critical gradient was found to be 100, and the recommended maximum gradient for design was 50. Cutoff constructed using a plastic concrete tremied into a slurry supported trench were found to have a critical gradient of 300 with the recommended maximum gradient for design of 150. For Meadowbank, in the sections of the cutoff considered for soil-cement-bentonite cutoff or jet-grout cutoff, the maximum estimated gradients based on a 1 m wall thickness are less than 10, well below the recommended values proposed by Beier and Strobl (1985).

Along the East Dike alignment, the maximum estimated depth to bedrock below lake level is 7.1 m and a wall thickness of 1 m exceeds the Factor-of-Safety requirement against blow-out. Along the Bay Zone Dike alignment, the maximum estimated depth to bedrock below lake level is 15 m and a wall thickness of 2 m will be required to provide a Factor-of-Safety of 4 against blow-out. It is expected that increasing the cutoff wall thickness along the Bay Zone will be cost effective relative to adding cement to the backfill to increase erosion resistance because this will allow the same construction technique to be used along the full length of the dikes to be constructed prior to start-up and will reduce the requirement for cement. The decision to use a wider soil-bentonite wall or to use soil-cement-bentonite backfill will be made based on discussions with the slurry wall contractor considering the equipment that will be mobilized to site.

Along the Goose Island dike, the maximum estimated depth to bedrock below lake level is about 28 m. Jet grouting is proposed for the sections of this cutoff wall that have a depth to bedrock greater than 14 m to provide an overlap with the soil-cement-bentonite cutoff wall sections.

For till materials taken from Meadowbank, laboratory testing of 1.2% bentonite content soil slurries indicated hydraulic conductivity values of 2.5×10^{-9} m/s. Mixtures with 6% bentonite had hydraulic conductivity values of near 5×10^{-11} m/s. Laboratory testing also demonstrated that 4% cement, 4% bentonite soil mixtures will set up overnight to a stiff consistency, with hydraulic conductivity values of 5×10^{-9} m/s. Laboratory testing results are included in Appendix I.

The cutoff walls will be constructed and operated in a near neutral pH environment of uncontaminated water. Chemical stability of the cutoff walls will not be a concern.

The stability of the slurry supported trench depends on the density of the slurry, height of the slurry above the groundwater level and the strength of the soil through which the trench is excavated. The strength of the till core material, and hence the stability of the slurry supported trench, will depend on consolidation or densification of the core material. Along the East Dike, the first to be constructed, the depth of till core that will be excavated is a maximum of 8 m, and typically 5 m or less, with the top of the trench 3 m above the lake level. An in-trench slurry density of about 1.05 t/m^3 will be required for stability. Along the Bay Zone Dike, the depth of till core to be excavated is typically less than 8 m, with a short section reaching 12 m. The top of the trench will be 2 m above lake level. In trench slurry density of about 1.2 t/m^3 will be required for trench stability.

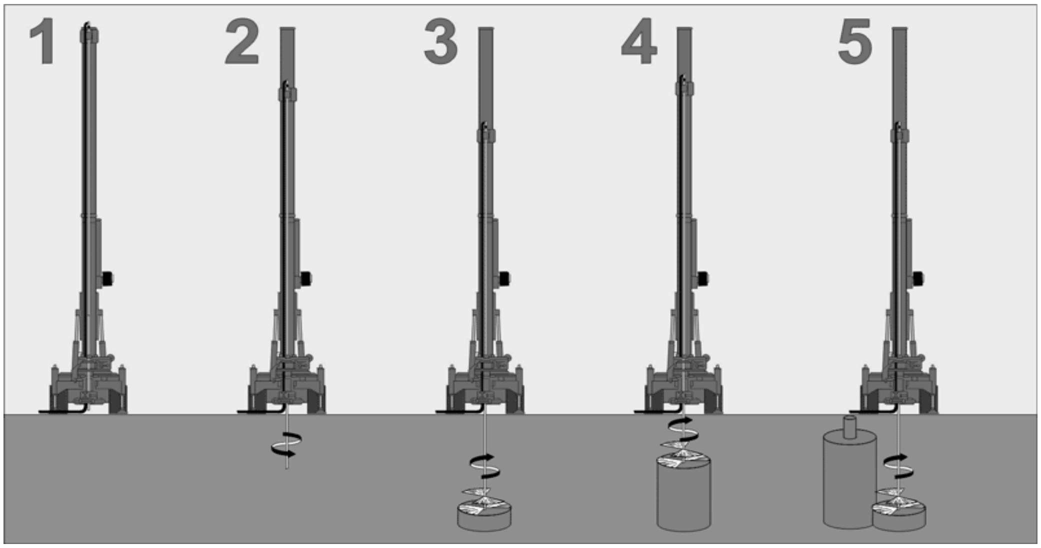
The strength of the till core will be measured prior to trench excavation using a cone penetrometer test (CPT). If the results show that the strength of the till after consolidation under the surcharge load will not provide a stable trench with the slurry density achievable on site, the till can be densified using heavy tamping or dynamic compaction techniques. The use of dynamic compaction is not common in silty materials below the water table, but the technique has been successfully applied to densify a saturated silt and sandy silt along a river bank to a depth of 11 m as reported by Dumas et al (1994).

The Goose Island Dike will be constructed at least 2 years after the East Dike and Bay Zone Dike. The deeper sections of the cutoff wall for the Goose Island Dike will be constructed using jet grouting technology. For the sections of the cutoff wall that will be constructed using a slurry supported trench, the depth of the till core is typically 8 m or less, with a section less than 200 m in length having a maximum depth of 12 m. The experience developed from constructing the cutoff walls along the East Dike and Bay Zone Dike will be applied to the Goose Island Dike.

1.2.2 Description of Jet Grouting

Jet grouting is a ground improvement technique that can be used in a wide range of ground conditions. It involves the in-situ mixing of soil with cement grout to form a column of soil and grout with predetermined strength and permeability.

Jet grouting was developed in the 1960's for ground water control applications in the Middle East and Africa. The process involves the insertion of a special drilling tool to the required depth using a rotary drilling technique, followed by carefully controlled grout injection while rotating and withdrawing the drill steel. The column is formed by the action of the high pressure grout eroding the in-situ ground perpendicular to the angle of insertion to a predetermined radius around the tool. The eroded material is mixed with the grout to form a soil-grout matrix.



From Havard-Baker

The strength and permeability of the columns can be controlled by the water / cement ratio and the addition of admixtures to the grout. The diameter of the column is controlled by the rotation and lift speed of the drill tool. Jet grouting is often used for the control of groundwater around dams or areas of contaminated ground by creating overlapping columns that form a continuous barrier of known thickness. Ground permeability can be reduced to the order of 10^{-9} m/s. Jet grouting has been carried out to depths of 50 m and has been used in both frozen and unfrozen till in the arctic (Schwank, 2003).

Jet grouting systems are typically divided into three categories, depending on the number of injection nozzles and the medium used to erode the soil.

In the single fluid system, grout is pumped down through the drilling rods and exits horizontal nozzles in the tool at high velocity. This causes erosion of the ground and the placement and mixing of grout in most homogeneous soil-cement element with the highest strength and the least amount of grout-spoil return, but can cause heave problems in certain ground conditions.

In the double fluid system, grout and air are supplied down the drill steel to different, concentric nozzles. Grout is used for eroding and mixing with the soil. The air shrouds the grout jet and increases erosion efficiency. The double system is more effective in cohesive soils than the single system. The air reduces the strength of the column as compared to the single system, and produces greater spoil returns.

In the triple fluid system, grout, air and water are pumped through three different lines to the tool. High velocity air and water form the erosion medium. Grout is injected at a lower velocity from separate nozzles below the erosion jet. This somewhat separates the erosion process from the grouting process and yields a higher quality inclusion. The triple system is the most effective system for cohesive soils, and because the grout replaces a substantial portion of the eroded soil, it is less likely to cause heaving of the ground.