Tamerlane Ventures Inc.

FEASIBILITY ASSESSMENT (PHASE 1)
OF PINE POINT MINE GROUND FREEZING PROJECT

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1.0 INTRODUCTION

1.1 GENERAL

EBA Engineering Consultants Ltd. (EBA) was retained by Century Mining Corporation (Century Mining) to conduct a feasibility evaluation of artificial ground freezing for managing seepage during mining at Tamerlane Ventures Inc. (Tamerlane)'s proposed Pine Point Mine, located on the south shore of Great Slave Lake near Hay River, NT.

1.2 PROJECT DETAILS

It is understood that the lead-zinc mine was operated by Cominco until it was shut down and decommissioned in 1987 as mining became uneconomic amid high dewatering costs. According to information provided by Mr. David Swisher of Century Mining, the ore body at the mine site extends from approximately 122 m to 168 m depth from the ground surface. The furthest extents of the ore body on the plan are in an ellipsoid shape of 90 m by 170 m. The current plan is to sink a 6.7 m diameter shaft 180 m deep to access the ore body. The envisioned mining method would be by sublevel retreat stoping utilizing cemented backfill every other stope.

According to information provided by Mr. Swisher, the general soil profile in the mine area consists of 26 to 45 m of gravels and glacial till overlying mudstone, limestone, dolomite, and dolomitic sandstone. The ground in and around the ore zone within the top 170 m depth is very porous and permeable. The dolomitic sandstone below the ore body is less porous and permeable. One method being considered to manage seepage during mining is to develop a frozen wall around the perimeter of the ore deposit. The design intent of the proposed ground freezing system is to seal off water seepage by creating a frozen wall of ice-saturated soil or rock of sufficient thickness that it is a nearly-impermeable barrier to seepage. This method is technically feasible as long as the base of the frozen wall extends into tight, low permeability rock such that groundwater inflow through the floor of the frozen curtain is manageable.

1.3 SCOPE OF WORK

On February 28, 2006, EBA submitted a proposal to Century Mining for a three-phase design of a ground freezing system to be used at the proposed Pine Point mine. The objective of the Phase 1 study is to assess the feasibility of the ground freezing option. As described in EBA's proposal, the scope of work consists of the following:

- Carry out thermal analyses to evaluate the feasibility of using a single row of vertical freeze pipes at a centre-to-centre spacing of 1.5 m;
- Conduct parametric sensitivity studies to assess the effects of various design parameters on developing of the frozen wall; and
- Summarize the basis and results of these thermal analyses in a report.

Authorization to proceed with the Phase 1 work was provided by Mr. Swisher under Tamerlane P.O. No. 2, dated March 21, 2006.

2.0 THERMAL ANALYSES

2.1 METHODOLOGY

Thermal analyses were carried out using EBA's proprietary two-dimensional finite element computer model, GEOTHERM. The theoretical basis for the model was described in Hwang (1976). The model simulates transient heat conduction with change of phase for a variety of boundary conditions, including heat flux, convective heat flux, temperature, and ground-air boundaries. The model facilitates the inclusion of temperature phase change relationships for saline soils, such that any freezing depression and unfrozen water content variations can be explicitly modeled. The model has been verified by comparing its results with closed form analytical solutions and many different field observations. The model has formed the basis for thermal evaluations and designs of ground freezing systems, foundations, pipelines, utilidor systems, landfills, and earthfill embankment structures in arctic and sub-arctic regions.

The frozen mass around vertical freeze pipes generally proceeds first radially around each pipe to form a cylinder until it coalesces with adjacent cylinders to form a continuous frozen wall that then grows in a lateral direction perpendicular to the axis of the row or circle of freeze pipes. Consequently, the lateral freezing process at a given depth can be simulated in a two-dimensional model by analyzing a horizontal slice through the freezing pipes and surrounding soil/rock. The simulated geometry can be further simplified if one or more symmetrical axes exist. In the current study, a single row of vertical freeze pipes at a center-to-center spacing of 1.5 m has been evaluated. Because of symmetry, the simulated geometry at a given depth has been simplified as a horizontal slice, as shown in Figure 1. Heat transfer between the freeze pipe wall and the surrounding soil or rock has been simulated as either a convective heat flux boundary or a temperature boundary, depending on the case studied. Zero-flux boundaries have been assigned to the remaining boundaries.

Thermal analyses have been carried out assuming that existing groundwater seepage rates in the ground are sufficiently small such that convective heat transfer due to groundwater seepage is negligible.

2.2 SOIL PROFILE AND PROPERTIES

Draft geological logs for ten boreholes (TV01 to TV10) drilled within the R-190 mineral zone area in the mine site were provided to EBA. No cores were obtained from the overburden. Based on these logs, the soil profile in the area consists of 26 to 45 m of overburden soils overlying mudstone, limestone, and dolomite down to 172.8 m depth (bottom of the deepest hole). Table 1 lists the soil and rock types and associated depth ranges.

TABLE 1: SOIL PROFILE AND DEPTH RANGES AT MINE SITE	
Soil/Rock Type	Depth Range (m)
Overburden	0 – (26 to 45)
Mudstone/Shale	(26 to 45) – (45 to 56)
Limestone	(45 to 56) – (94 to 108)
Dolomite	(94 to 108) – (≤ 172.8)

According to information provided by Mr. Swisher, overburden soils are gravel and glacial till, and the dolomite is underlain by dolomitic sandstone.

Laboratory physical and mechanical test results for three rock core samples recovered from a depth range of 60 to 113 m were provided to EBA. The samples had a total porosity of 12 to 20 % and a specific gravity of 2.85 to 2.90. No laboratory test results for the overburden and mudstone were available during this study. Photos of cores recovered from Borehole TV10 indicate that the mudstone broke into thin, planar discs with a Rock Quality Designation (RQD) of 0.

Table 2 lists the soil/rock physical and thermal properties used in the thermal analyses. Two sets of physical and thermal properties for the dolomite were assumed for the sensitivity analyses presented in Section 4.4 of this report.

TABLE 2: PHYSICAL AND THERMAL PROPERTIES USED IN THERMAL MODEL							
Soil / Rock	Bulk Density (Mg/m^3)	Moisture Content (%)	Thermal Conductivity (W/m-K)		Specific Heat (kJ/kg-K)		Latent Heat (MJ/m^3)
			Frozen	Unfrozen	Frozen	Unfrozen	
Glacial Till	1.9	30	2.4	1.4	1.07	1.53	142
Mudstone	2.1	20	2.0	1.6	1.02	1.31	97
Limestone	2.5	8	2.3	1.9	0.83	0.99	61
Dolomite No. 1	2.5	8	3.0	2.6	0.83	0.99	61
Dolomite No. 2	2.3	15	2.9	2.4	0.91	1.18	100

Given that EBA has very limited information on site-specific soil properties, reasonable but slightly conservative estimates of the soil and rock physical parameters (gravimetric moisture content and bulk density) have been used in this feasibility study. Thermal properties of the soils and rocks at this site have not been measured. The thermal properties have been estimated based on published data for similar soils/rocks and engineering judgment.

The soils/rocks have been assumed to be fresh-water-saturated.

2.3 GROUND THERMAL CONDITIONS

The mine site is located in an area of sporadic discontinuous permafrost. The long-term average annual air temperature at Hay River is –2.9 °C (Canadian Climate Normals 1971-2000, Environment Canada website). No measured ground temperatures at the site were available for the current study.

Noel and Hockley (2004) reported a measured ground temperature profile over the top 100 m depth at the Giant Mine site in Yellowknife, located approximately 180 km north of the Pine Point mine site. The average geothermal gradient was about 0.03°C/m.

The initial ground temperatures at the mine site were assumed to be 0°C at the ground surface, increasing linearly with depth at a rate of 0.03°C/m. Warmer initial ground temperatures have been considered in some cases to assess the sensitivity of the initial ground temperature to the development of the frozen wall.

2.4 FREEZING PIPE SYSTEM

The following assumptions have been applied in the thermal analyses:

- Thirty percent calcium chloride solution as the circulating fluid in the freeze pipes;
- Brine temperature of –30°C; and
- Brine fluid flowing down through an inner pipe inside a larger diameter pipe and flowing up through the annulus between the two pipes.

The sensitivity of freeze pipe dimensions and brine pumping rates were also considered:

- Freeze pipe dimensions:
  - a 51 mm (2") diameter inner pipe inside a 102 mm (4") diameter, schedule 40 steel pipe, and
  - a 38 mm (1.5") diameter inner pipe inside a 76 mm (3") diameter, schedule 40 steel pipe.
- Fluid flow rates:
  - a flow rate that maintains the fluid in the annulus within a laminar flow range (<5.0 L/s for 51/102 mm pipes and <3.9 L/s for 38/76 mm pipes), and
  - a very high flow rate that produces a thermal boundary condition, inside of the outer pipe wall, that is equivalent to a fixed temperature boundary condition.

3.0 CASES SIMULATED

A total of 14 cases have been simulated in this study, as summarized in Table 3.

TABLE 3: CASES SIMULATED					
Case	Soil/Rock	Simulated Depth (m)	Initial Soil/Rock Temperature (°C)	Pipe Wall Boundary Condition*	Pipe Diameters (Inner/Outer) (mm)
1	Glacial Till	45	1.4	H1	51/102
2	Mudstone	56	1.7	H1	51/102
3	Limestone	108	3.2	H1	51/102
4	Dolomite No. 1	170	5.1	H1	51/102
5	Glacial Till	45	1.4	T	51/102
6	Mudstone	56	1.7	T	51/102
7	Limestone	108	3.2	T	51/102
8	Dolomite No. 1	170	5.1	T	51/102
9	Dolomite No. 2	170	5.1	H1	51/102
10	Dolomite No. 2	170	5.1	T	51/102
11	Glacial Till	45	5.0	H1	51/102
12	Dolomite No. 1	170	10.0	H1	51/102
13	Glacial Till	45	1.4	H2	38/76
14	Glacial Till	45	1.4	T	38/76

*Note:

H1: convective heat flux boundary with a convective heat transfer coefficient of 45.5 W/(m².°C) for laminar flow in the annulus between 51/102 mm pipes;
H2: convective heat flux boundary with a convective heat transfer coefficient of 64.3 W/(m².°C) for laminar flow in the annulus between 38/76 mm pipes
T: temperature boundary of –30 °C

4.0 RESULTS AND DISCUSSION

4.1 BASE CASES (CASES 1 TO 4)

Four base cases have been evaluated to estimate the progress of frozen wall development with freezing time for four soil/rock types and assumed initial temperatures. It was assumed that the chilled fluid of –30°C flows down the inner pipe and up through the annulus of the 51/102 mm pipes at a rate of 4.0 L/s (< 5.0 L/s) such that flow is laminar. The temperature of the fluid in the annulus rises slightly as it flows up the annulus because of the heat gained from the surrounding soil/rock. The fluid temperatures for Cases 1 to 4 were calculated based on estimated heat fluxes (see Section 4.2 for details) after one week of freezing and range between –28°C and –30°C. Fluid temperatures are expected to be warmer during the first week after freezing is initiated and slightly colder thereafter.

As expected, the ground temperature increases with increasing radial distance away from the freeze pipe (see Figure 2) and the frozen wall grows with freezing time (see Figure 3). Figure 4 presents the predicted minimum thickness of the frozen wall at maximum temperatures of 0, –2, and –5°C with freezing time for Case 1. For example, after three months of ground freezing, the minimum thicknesses of the frozen wall at or colder than temperatures of 0, –2, and –5°C are 3.8, 2.8, and 2.2 m, respectively. Figure 5 shows the estimated minimum thicknesses of the frozen wall at or colder than –2°C with freezing time for Cases 1 to 4. Figure 5 indicates that the frozen wall thickness is greater for a soil at a deeper depth for these cases even though the initial ground temperature increases with depth. This is because the rocks at depth generally have either higher thermal conductivity and/or lower porosity (i.e., less latent heat). The estimated minimum thicknesses of the frozen wall at or colder than –2°C after three months of freezing are 2.8, 3.3, 4.2, and 4.7 m for Cases 1 to 4, respectively.

4.2 HEAT FLUX THROUGH A FREEZE PIPE WALL

The ground releases heat to the chilled fluid through a freeze pipe wall during the freezing process. The heat flux varies with time and depth (i.e., lithology and initial temperature). The total heat flux through the freeze pipes can be used to determine an appropriate refrigeration plant capacity. Figure 6 presents the predicted heat flux with freezing time for Cases 1 to 4. Figure 6 indicates that the heat flux ranges from 1100 W/m^2 after 3 hours of freezing to 150 W/m^2 after 3 months of freezing. The heat flux after 2.5 days of freezing is generally less than 50% of its value after 3 hours of freezing.

The change in fluid temperature with depth at a given time can be calculated from the estimated heat fluxes. For example, a temperature rise of 1.8°C is estimated for fluid flowing from a depth of 170 m to the ground surface based on the estimated heat fluxes presented in Figure 6 at 7.5 days of freezing.

4.3 EFFECT OF BOUNDARY CONDITIONS AND FLUID FLOW RATE (CASES 5 TO 8)

Laminar flow inside the annulus of the freeze pipes was assumed for Base Cases 1 to 4. A convective heat flux boundary with a constant convective heat transfer coefficient of 45.5 $W/(m^2.°C)$ was applied to the inner surface of the outer freezing pipe for these cases.

When the flow rate exceeds the laminar flow limit (e.g., 5.0 L/s for 51/102 mm pipes), the flow will gradually transform into a turbulent phase that has a significantly higher convective heat transfer coefficient than laminar flow. When the convective heat transfer coefficient is sufficiently large, the thermal boundary condition is equivalent to a fixed temperature boundary condition.

A constant temperature of –30°C was applied to Cases 5 to 8 to evaluate the effects of freeze pipe boundary conditions or fluid flow rates on the development of the frozen wall. Cases 5 to 8 are fixed-temperature boundary condition versions of Cases 1 to 4, respectively. Table 4 compares the results for Cases 5 to 8 with those for Cases 1 to 4.

TABLE 4: COMPARISON OF ESTIMATED MINIMUM FROZEN WALL THICKNESSES FOR TWO BOUNDARY CONDITIONS					
Case	Soil/Rock	Pipe Wall Boundary Conditions*	Minimum Thickness of Wall at or Colder Than –2 °C (m)		
			Freezing Time (months)		
			1	3	5
1	Glacial Till	H1	0.8	2.8	4.1
5	Glacial Till	T	1.5	3.6	5.0
2	Mudstone	H1	1.3	3.3	4.7
6	Mudstone	T	1.8	4.0	5.4
3	Limestone	H1	1.8	4.2	6.0
7	Limestone	T	2.4	5.0	6.8
4	Dolomite No. 1	H1	2.0	4.7	6.6
8	Dolomite No. 1	T	2.8	5.6	7.6

*Note: refer to Table 3 for a description of the pipe wall boundary conditions.

Table 4 indicates that the estimated differences in frozen wall thicknesses due to different boundary conditions (or fluid flow rates) range from 0.5 to 1.0 m.

4.4 EFFECT OF SOIL/ROCK INITIAL MOISTURE CONTENT (POROSITY) (CASES 9 AND 10)

The moisture content of a soil or rock influences its latent heat and thermal conductivity. Generally, a saturated soil or rock mass with a higher moisture content (porosity) has higher latent heat and lower unfrozen thermal conductivity, which tend to retard the rate of frozen wall development.

There are very limited measured moisture contents for the soils and rocks available for this study. To evaluate the sensitivity of moisture content on the rate of frozen wall development, Cases 9 and 10 have been simulated with an assumed moisture content of 15% for Dolomite No. 2, compared to a moisture content of 8% for Dolomite No. 1 (Cases 4 and 8). The results are presented in Table 5.

TABLE 5: COMPARISON OF ESTIMATED FROZEN WALL THICKNESSES FOR DOLOMITE WITH TWO ASSUMED MOISTURE CONTENTS						
Case	Rock	Moisture Content (%)	Pipe Wall Boundary Conditions*	Minimum Thickness of Wall at or Colder Than –2 °C (m)		
				Freezing Time (months)		
				1	3	5
4	Dolomite No. 1	8	H1	2.0	4.7	6.6
9	Dolomite No. 2	15	H1	1.3	3.6	5.1
8	Dolomite No. 1	8	T	2.8	5.6	7.6
10	Dolomite No. 2	15	T	2.1	4.5	6.0

*Note: Refer to Table 3 for description of pipe wall boundary conditions.

Table 5 indicates that the estimated differences in frozen wall thicknesses in the dolomite for two assumed moisture contents range from 0.7 to 1.6 m. The differences are almost identical for the two boundary conditions.

4.5 EFFECT OF SOIL/ROCK INITIAL TEMPERATURE (CASES 11 AND 12)

It is expected that a warm soil or rock will take longer to develop a frozen wall than a cooler material. There are no measured deep ground temperature data in the mine site area available for the current study. Therefore, Cases 11 and 12 were carried out to evaluate the effect of initial ground temperature. Table 6 compares the estimated minimum frozen wall thicknesses for the glacial till and dolomite layers with different initial ground temperatures. The convective heat flux boundary (H1) was assumed for all cases.

TABLE 6: COMPARISON OF ESTIMATED FROZEN WALL THICKNESSES FOR GLACIAL TILL AND DOLOMITE WITH DIFFERENT ASSUMED INITIAL GROUND TEMPERATURES					
Case	Soil/Rock	Initial Ground Temperature (°C)	Minimum Thickness of Wall at or Colder Than –2 °C (m)		
			Freezing Time (month)		
			1	3	5
1	Glacial Till	1.4	0.8	2.8	4.1
11	Glacial Till	5.0	0.6	2.6	3.8
4	Dolomite No. 1	5.1	2.0	4.7	6.6
12	Dolomite No. 1	10.0	1.6	4.1	5.8

Table 6 indicates that the estimated differences in frozen wall thicknesses due to initial ground temperatures range from 0.2 to 0.3 m for the glacial till and from 0.4 to 0.8 m for the dolomite.

4.6 EFFECTS OF FREEZE PIPE DIMENSIONS (CASES 13 AND 14)

Cases 13 and 14 were carried out to evaluate the effect of freeze pipe dimensions on the frozen wall thickness. An alternate freeze pipe configuration of 38 mm (1.5") diameter inner pipe inside 76 mm (3") diameter, schedule 40 steel pipe was evaluated. A convective heat flux boundary with a constant convective heat transfer coefficient of 64.3 W/(m^2-°C) for laminar flow in the annulus between 38/76 mm pipes was applied to the inside surface of the outer freezing pipe for Case 13. A temperature boundary of –30°C was applied for Case 14. The estimated frozen wall thicknesses at selected freeze time intervals are summarized in Table 7.

TABLE 7: COMPARISON OF ESTIMATED FROZEN WALL THICKNESSES IN GLACIAL TILL FOR TWO FREEZING PIPE DIMENSIONS

Case	Freeze Pipe Diameters (Inner/Outer) (mm)	Pipe Wall Boundary Conditions*	Minimum Thickness of Wall at or Colder Than –2 °C (m)		
			Freezing Time (month)		
			1	3	5
1	51/102	H1	0.8	2.8	4.1
13	38/76	H2	0.7	2.7	4.0
5	51/102	T	1.5	3.6	5.0
14	38/76	T	1.4	3.4	4.8

*Note: refer to Table 3 for description of pipe wall boundary conditions.

Table 7 indicates that the estimated differences in frozen wall thicknesses for the two freezing pipe dimensions range only from 0.1 to 0.2 m.

4.7 UNCERTAINTIES AND RISKS

Ground freezing is feasible for managing groundwater seepage as long as the frozen wall is sufficiently thick, cold, and ice-saturated to effectively act as an impermeable cut-off wall. The results presented in Section 4 have been based on limited available information and a number of assumptions. The development of the frozen wall and its performance after dewatering can be negatively affected if site conditions are different from those assumed in the analyses, as summarized below:

- There is very limited hydrogeological information available. The analyses assumed that the existing groundwater seepage rates at the site are sufficiently small that convective heat transfer due to groundwater seepage is negligible. Groundwater flow across a ground freezing system during initial freezing may delay or even prevent the development of a continuous frozen wall.

- Similarly, groundwater seepage through the low-permeability dolomitic sandstone at the base of the frozen wall may, if sufficiently high, cause thermal erosion of the base of the frozen wall and thus make it difficult to seal off against groundwater seepage.
- The soils/rocks were assumed to be fresh-water-saturated. The effective practical freezing point is depressed for saline soils or soils that contain hydrocarbons or are contaminated with petroleum products. Air-filled voids or cavities may delay development of the frozen wall and may act as a conduit for groundwater flow during dewatering.

Because of these uncertainties, there is a risk that the frozen wall may not fully develop and/or may not act as an impermeable barrier to seepage, although the risk may be mitigated by selecting conservative parameters for design or by applying appropriate factors of safety. Sensitivity thermal analyses conducted for this Phase 1 study have identified certain parameters that are more sensitive to the development of the frozen wall than others. Additional detailed geotechnical and hydrogeological investigations can improve the understanding of the site conditions and reduce these risks.

It should be noted that leaks in the frozen wall after dewatering may be difficult to seal off through ground freezing alone if seepage rates are sufficiently high. Other measures, such as grouting, may be required should this situation arise.

Other uncertainties or considerations that have not been addressed in the current study will be evaluated in the next phase.

5.0 CONCLUSIONS

Thermal analyses have been carried out to evaluate the feasibility using a single row of vertical freeze pipes at a center-to-center spacing of 1.5 m. Parametric sensitivity studies have also been conducted to assess the effects of various parameters on the development of the frozen wall. The major findings from the analyses are summarized below:

- A continuous frozen wall with sufficient thickness can be developed from artificial ground freezing.
- The estimated minimum thickness of the frozen wall at or colder than –2°C ranges from 2.4 to 5.6 m after three months of freezing and 3.8 to 7.6 m after five months of freezing for the various cases studied.
- Both the moisture content (or porosity) of a soil/rock and the boundary condition (or the fluid flow rate) inside a freezing pipe affect the estimated frozen wall thickness. High moisture contents and low brine flow rates retard the rate at which the frozen wall develops.
- The rate of the frozen wall growth is less sensitive to the initial ground temperature.
- The rate of frozen wall development is relatively insensitive to the freeze pipe diameters evaluated.

6.0 RECOMMENDATIONS

The following further studies in the next phase – conceptual design of ground freezing system – are recommended:

- Determine the minimum required frozen wall depth and thickness prior to dewatering; when required, conduct seepage analyses to quantify the seepage volumes and evaluate seepage effects on thermal conditions of the frozen wall;
- Determine the minimum "buffer" thickness of rock between the excavated stope and the frozen wall based on thermal and stress-deformation analyses;
- Select an appropriate freezing system with sufficient freeze plant and brine pump capacities;
- Refine the Phase 1 thermal analyses based on the proposed freezing system;
- Develop a preliminary construction schedule and cost estimate to implement the ground freezing system; and
- Summarize the findings in a report.

7.0 LIMITATIONS

This work has been carried out without having conducted a geotechnical site investigation at the project site designed to evaluate the feasibility of artificial ground freezing for managing seepage. The recommendations presented in this report are based on subsurface information provided by Century Mining. EBA has not verified that these conditions are considered representative of the general conditions at this site. Engineering judgment has been applied in developing the design calculations described in this report.

8.0 CLOSURE

EBA Engineering Consultants Ltd. is pleased to have been retained by Century Mining Corporation to conduct this feasibility thermal evaluation of ground freezing for managing seepage inflows during the planned mine operation at the proposed Pine Point mine site. It is understood that the information presented in this report will be used to provide a basis for further studies. EBA would be pleased to provide further assistance with the design of the ground freezing system.

This report has been prepared for the exclusive use of the owner, Tamerlane Ventures Inc., and its agent, Century Mining Corporation, for the specific use at the proposed Pine Point mine site.

Should you have any questions, please contact the undersigned.

Respectfully submitted,
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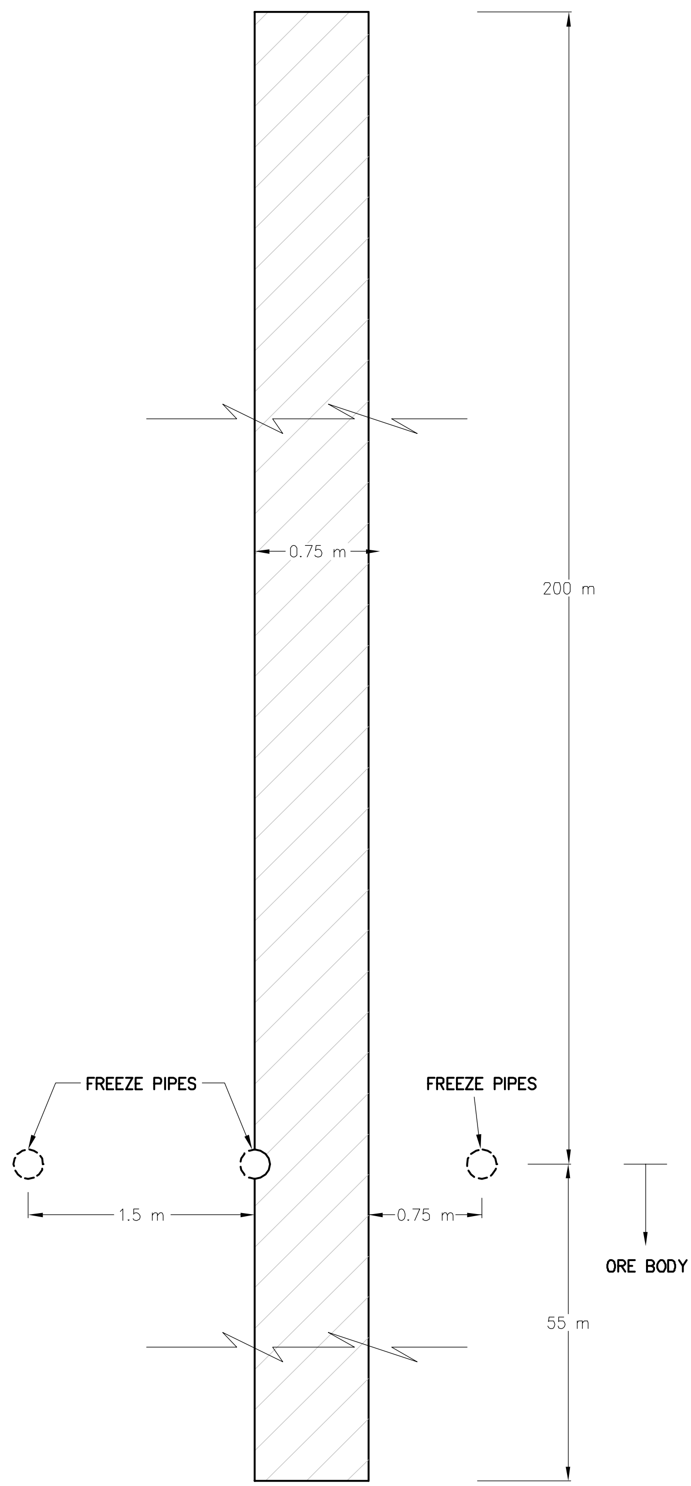
FIGURES



NOTE: DRAWING NOT TO SCALE

Figure 1
Simulated Geometry
for a Single Row of Freezing Pipes at 1.5 m Spacing

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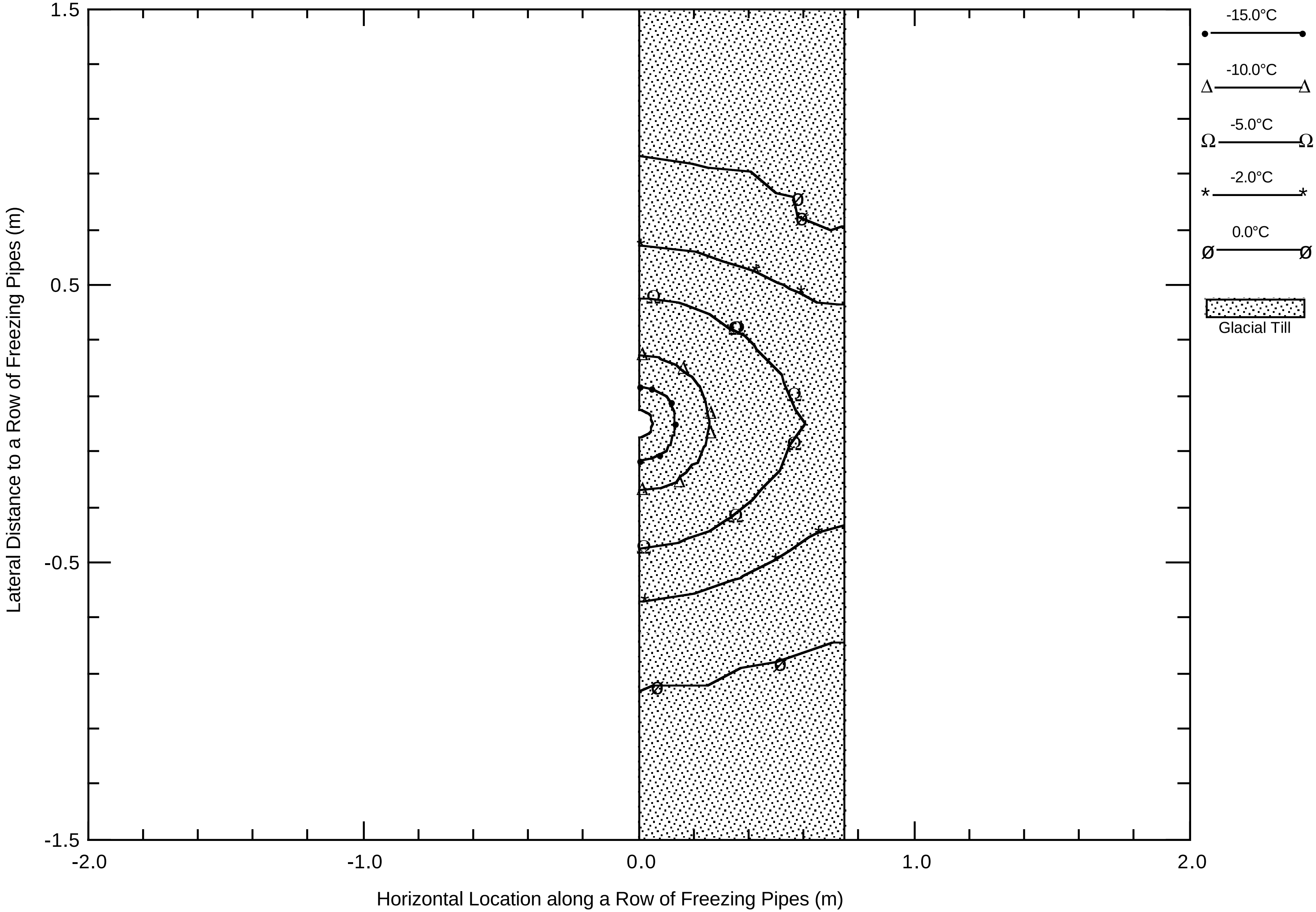

Figure 2

Example Plot Showing Temperature Distribution around a Freezing Pipe After One Month of Freezing for Case 1

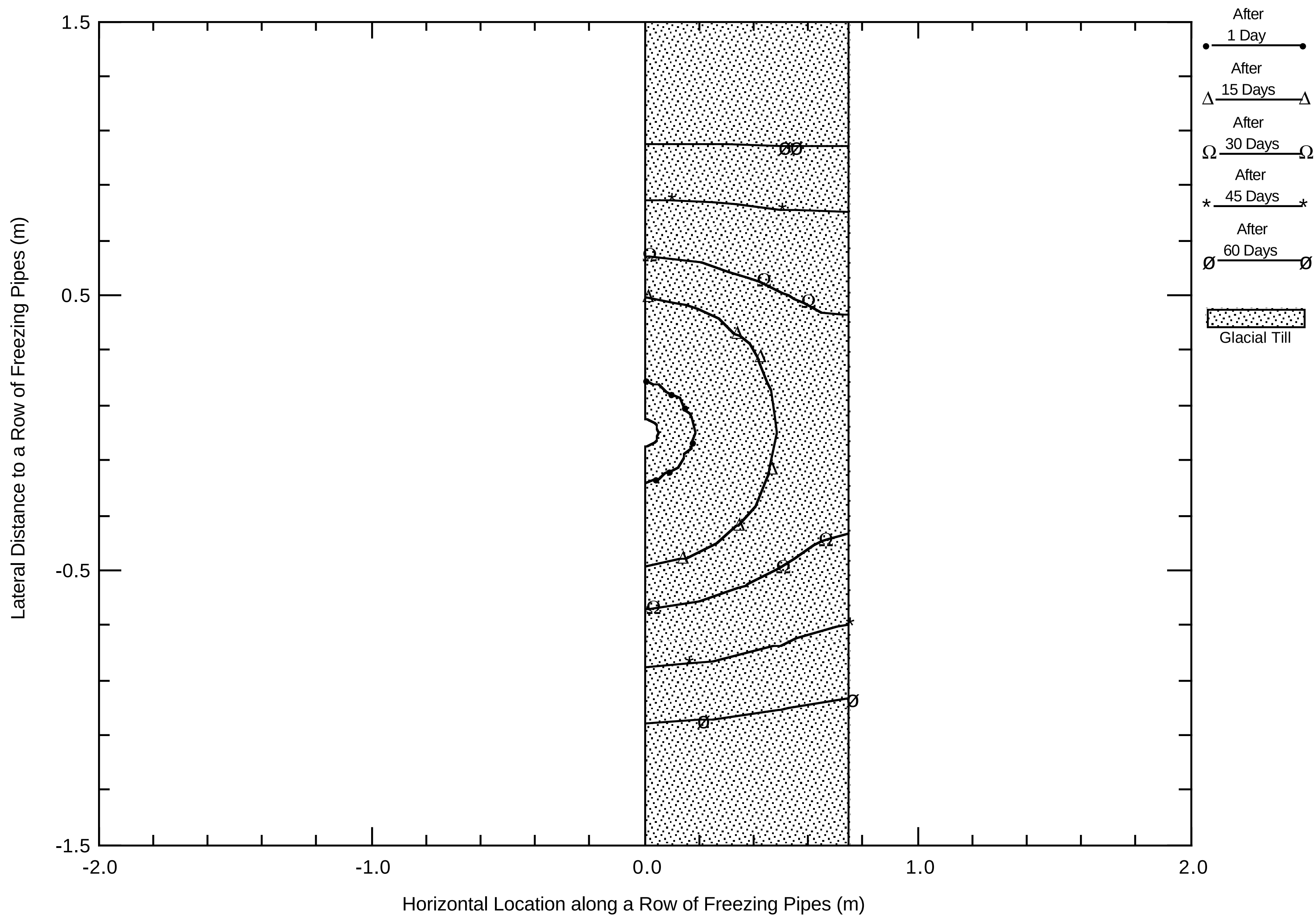

Figure 3

Example Plot Showing -2 Celsius Degree Isotherms around a Freezing Pipe After Various Times of Freezing for Case 1

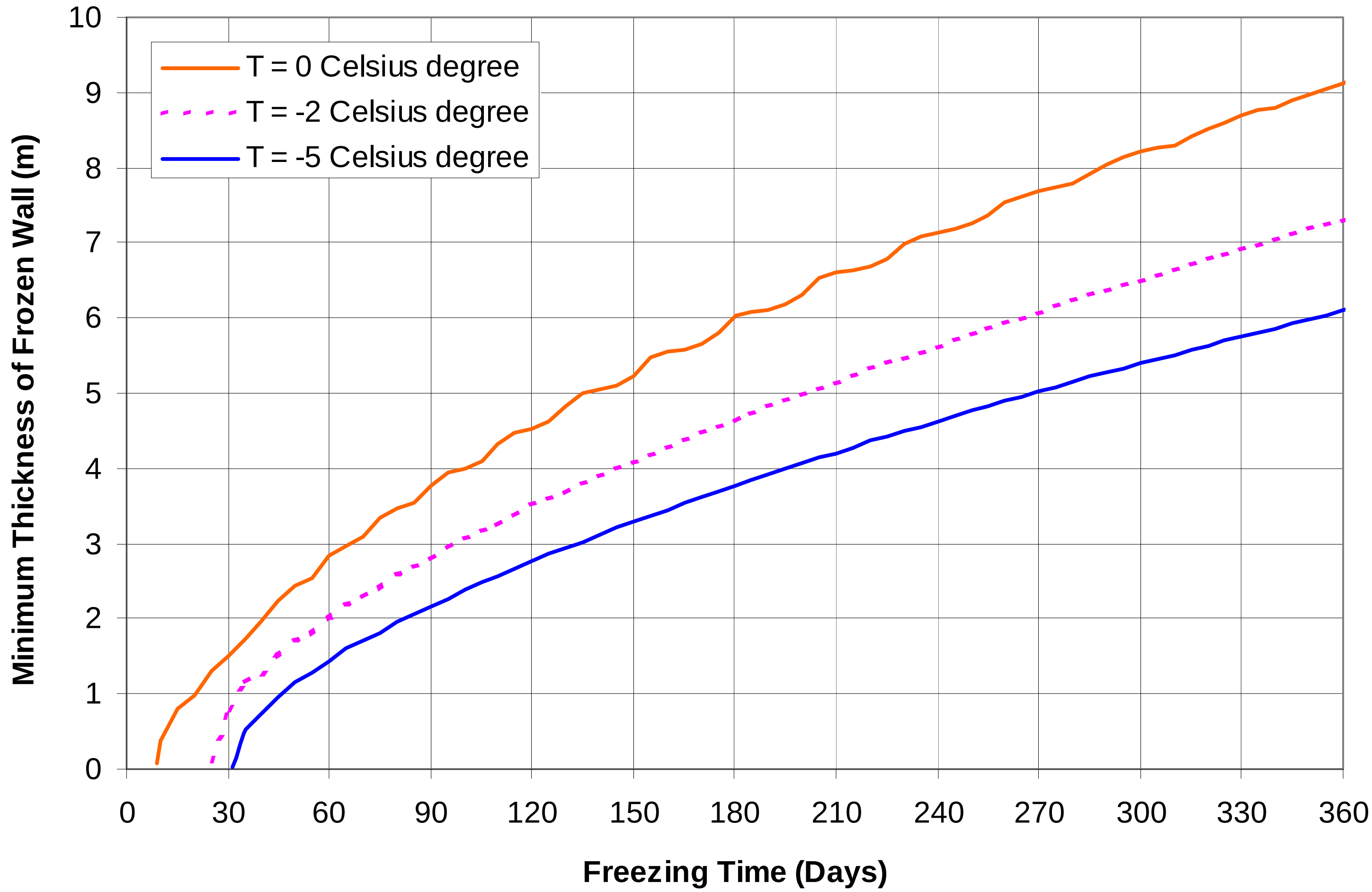

Figure 4
Freezing Time vs. Estimated Minimum Thickness of Frozen Wall
at or Colder Than 0, -2, and –5 Celsius Degrees for Case 1

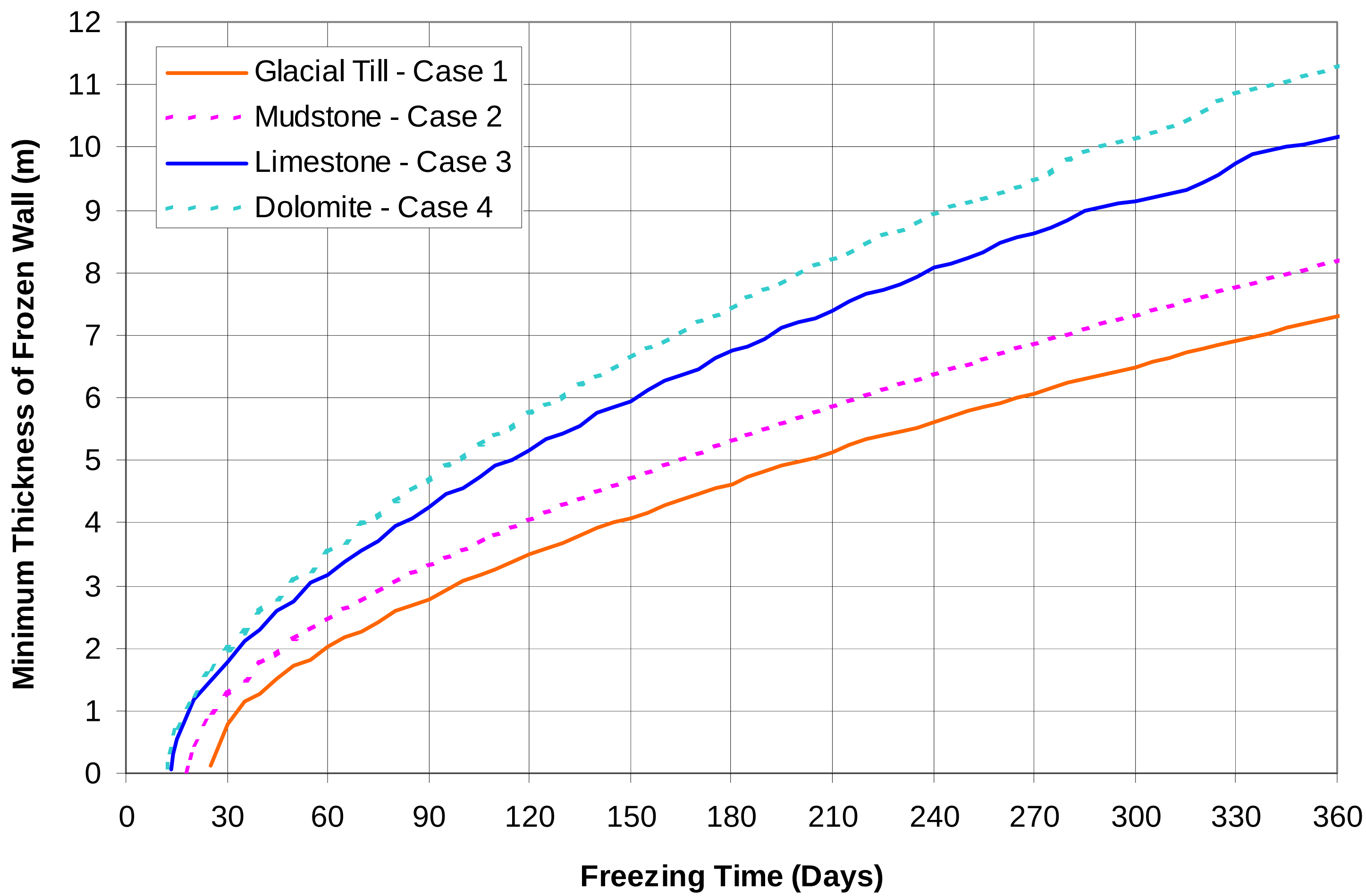

Figure 5
Freezing Time vs. Estimated Minimum Thickness of Frozen Wall
at or Colder Than -2 Celsius Degrees for Cases 1 to 4

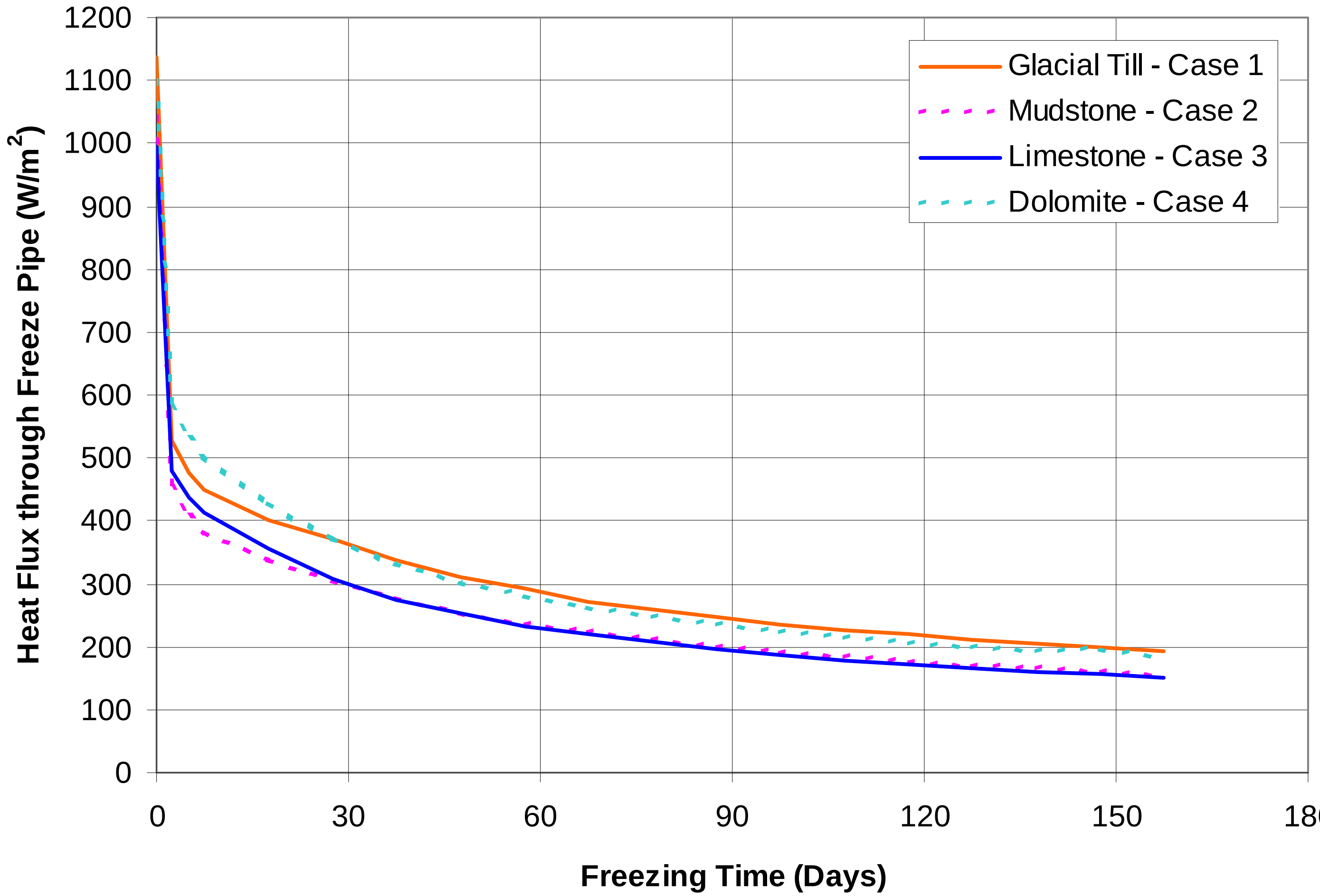

Figure 6
Freezing Time vs. Estimated Heat Fluxes through Freezing Pipe Surface for Cases 1 to 4

APPENDIX

APPENDIX A EBA GENERAL CONDITIONS

GEOTECHNICAL REPORT – GENERAL CONDITIONS

This report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

2.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

3.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

4.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

5.0 SURFACE WATER AND GROUNDWATER CONDITIONS

Surface and groundwater conditions mentioned in this report are those observed at the times recorded in the report. These conditions vary with geological detail between observation sites; annual, seasonal and special meteorologic conditions; and with development activity. Interpretation of water conditions from observations and records is judgmental and constitutes an evaluation of circumstances as influenced by geology, meteorology and development activity. Deviations from these observations may occur during the course of development activities.

6.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

7.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

8.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

9.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

10.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

11.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

12.0 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the client's expense upon written request, otherwise samples will be discarded.

13.0 STANDARD OF CARE

Services performed by EBA for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

14.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

15.0 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by EBA shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by EBA shall be deemed to be the overall original for the Project.

The Client agrees that both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. The Client warrants that EBA's instruments of professional service will be used only and exactly as submitted by EBA.

The Client recognizes and agrees that electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.