Appendix C: Additional Memorandum

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Giant Mines Refrigeration Energy Extraction Computation (C_{pl} revised)

Prepared By: Phil Bernardin
Date: September 27, 2010

INTRODUCTION

This document is being prepared to clearly identify the assumptions and method of calculation with respect to the rate of energy being removed from each of the Thermosyphon evaporator coils (part of the electo-mechanical refrigeration system).

SCOPE

It is important to note that the energy being withdrawn from each thermosyphon may not all be coming from the CO_2 which draws energy from the ground; external effects such as the environment may also be contributing energy transfer to the refrigerant. The equations within this document simply compute the amount of energy being absorbed by the refrigerant from the measurement point before the TX valve to the measurement point at the exit of the evaporator coil inside the thermosyphon. Further assumptions are also stated at the end of this document.

MEASURED VARIABLES

The following variables will be acquired from the field using transducers:

Variable	Transducer	Location	Units
Subcooled Liquid Refrigerant Temperature	RTD	Sufficient distance before the TX Valve to not be affected by the cold temperature after the TX valve	Degrees Fahrenheit
Superheated Vapour Refrigerant Temperature	RTD	Evaporator Outlet Coil	Degrees Fahrenheit
Liquid Pressure	0.5-5VDC Pressure Transducer	Sub-cooler Outlet Header, inside Plant	psig (psia+14.7psi)
Suction Pressure	0.5-5VDC Pressure Transducer	Suction Header, inside Plant	psig (psia+14.7psi)
Mass Flow	ABB Mass Flowmeter	Individual liquid line	lb/hr of refrigerant

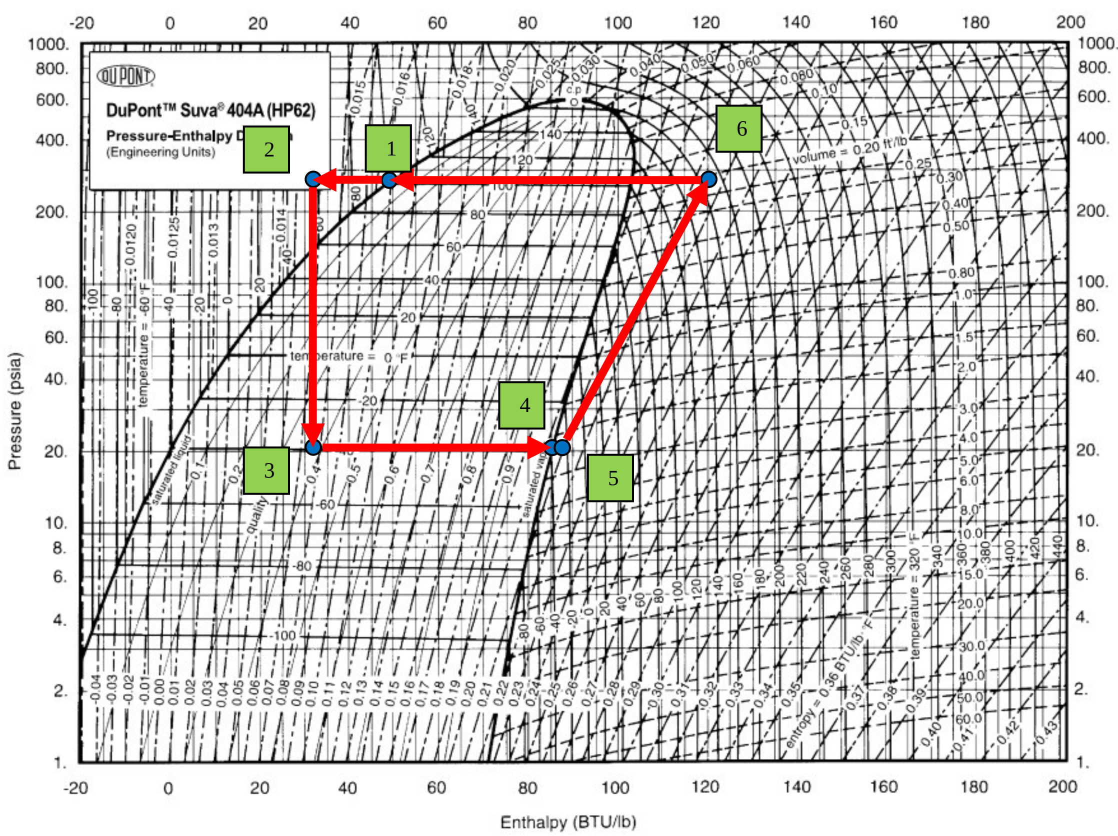
CALCULATION

This section goes over the calculation method used to compute the energy extracted by the refrigeration evaporator coils from the thermosyphon's CO_2. An example follows the method.

The fluid being used is [DuPont Suva® 404A Refrigerant].

The following [Pressure-Enthalpy] chart shows the 6 points of interest in the cycle.

1) Condensor (Saturated Liquid point)
2) Sub-Cooled Liquid (directly before TX valve)
3) TX Valve Outlet/Evaporator Inlet
4) Evaporator (Saturated Vapour point)
5) Evaporator Outlet (Superheated Vapour)
6) Compressor Outlet



The amount of energy absorbed by the evaporator, including the energy absorbed within/by the TX valve is given by:

$$\dot{Q} = \dot{M}(h_5 - h_2)$$

Where:

$\dot{Q}$ = Energy Transfer Rate [BTU/hr]
$\dot{M}$ = Mass Flow Rate [lb/hr]
h = Enthalpy [BTU/lb]

Calculating h_5:

First, we need the pressure at P_5:

$$P_5 = P_{SH} + \Delta P$$

Where:

P_5 = Pressure [psia]
P_{SH} = Measured Transducer Suction Header Pressure [psia]
ΔP = Pressure Drop due to super-heated vapour refrigerant flow in 1-1/8" lines (assumption 3, approximately = 1.2 psi for 1.2 tons of cooling, see "Pressure Drops in Lines" attachment)

Once we have P_5, then we can compute the enthalpy at point 4 (h_4) using a chart lookup in the controller, because we know T_5 (measured value), and $P_4 = P_5$ (assumption 5 and 6).

We can then compute the super-heat energy added to fluid using the heat capacity and determine the enthalpy of point 5 using the following equation:

$$h_5 = h_4 + C_{PG}(T_5 - T_4)$$

Where:

C_{PG} = Vapour Heat Capacity [BTU/lb·F]
T = Temperature [F]

The next step is to determine the enthalpy at point 2, h_2.

First, we need the pressure at P_2:

$$P_2 = P_{SC} - \Delta P$$

P_2 = Pressure [psia]
P_{SC} = Measured Transducer Post-Sub-Cooler Header Pressure [psia]
ΔP = Pressure Drop due to sub-cooled liquid refrigerant flow in 1/2" lines (assumption 2 states that this is = 0, "Pressure Drops in Lines" attachment)

Once we have P_2 which is equal to P_1, then we can compute the enthalpy at point 1 (h_1) using a chart lookup in the controller.

We can then compute enthalpy of point 2 using the specific heat of the liquid refrigerant to account for the energy extracted during the sub-cooling process, and this yields the following equation:

$$h_2 = h_1 + C_{PL}(T_2 - T_1)$$

Where:

C_{PL} = Liquid Heat Capacity [BTU/lb·F]
T = Temperature [F]

In this equation, T_1 can be determined based on the saturated refrigerant properties via a lookup table because P_1 fixes this state, and T_2 can be determined using the measured RTD value.

****NEW**:** The liquid Heat Capacity can be approximated over the range of heat transfer from State 1 to State 2 using the following equation from Page 19 of the attached Transport Properties document.

$$T_{avg} = \frac{(T_2 - T_1)}{2} + T_1$$

$$C_{PL} = 0.306 + 4.083 \cdot 10^{-4} T_{avg} - 1.194 \cdot 10^{-6} {T_{avg}}^2 + 8.056 \cdot 10^{-8} {T_{avg}}^3$$

EXAMPLE CALCULATION

Here are some sample variable measurements which would normally be acquired from the PLC at runtime:

P_{SC} = 280 psia
P_{SH} = 18.8 psia
T_2 = 50F
T_5 = -28F
$\dot{M}$ = 250 lb/hr

First, we find P_5:

$$P_5 = P_{SH} + \Delta P$$

$$P_5 = (18.8\, psia) + (1.2\, psia) = 20\, psia$$

Setting $P_4 = P_5$, and using a lookup table in the PLC, we will find that the enthalpy of the saturated vapour with 1.0 quality is (see Thermodynamic Properties Attachment, page 11):

$$h_4 = 85.5 \text{ Btu/lb}$$

And that the corresponding saturation temperature is:

$$T_4 = -38.4F$$

With the measurement of T_5 above, we can compute h_5:

$$h_5 = h_4 + C_{PG}(T_5 - T_4)$$

Here, the vapour heat capacity can be approximated based on the attachment table as 0.185 BTU/lb·F. (see [labelled] page 13 of the Transport Properties attachment)

Accordingly:

$$h_5 = (85.5\, BTU/lb) + (0.185\, BTU/lb \cdot F)(-28F — 38.4F)$$

$$h_5 = (85.5\, BTU/lb) + (0.185\, BTU/lb \cdot F)(10.4F)$$
$$h_5 = 87.42\, BTU/lb$$

The next step is to determine h_2.

Since we know that $P_1 = P_2 = P_{SC}$ = 280 psia (since we are ignoring pressure drop due to the liquid flow through the ½" line, assumption 2), we can perform a table lookup and find that T_1 is 108.65F and h_1 is 52.8 BTU/lb. (see Thermodynamic Properties Attachment, page 8)

We can now compute h_2 based on:

$$h_2 = h_1 + C_P(T_2 - T_1)$$

From the Saturated Liquid Heat Capacity table attached, we have an average value of 0.38 Btu/lb or so. (see [labelled] page 4 of the Transport Properties attachment)

$$h_2 = h_1 + C_{PL}(T_2 - T_1)$$

If we compute C_{PL} based on the equation of state, and $T_{avg}=T_2-T_1=79.325F$, we get $C_{PL}=0.371BTU/lb\cdot F$.

$$h_2 = (52.8\,BTU/lb) + (0.371\,BTU/lb\cdot F)(50F - 108.65F)$$

$$h_2 = 31.04\,BTU/lb$$

And from our main energy equation:

$$\dot{Q} = \dot{M}(h_5 - h_2)$$

We find that

$$\dot{Q} = (250\,lb/hr)(87.42\,BTU/lb - 31.04\,BTU/lb) = \mathbf{14,095\,BTU/hr}$$

ASSUMPTIONS

The following assumptions have been made for the purposes of the calculation above:

1)
   a. The specific heat values for the gas super-heating enthalpy calculations have been approximated here.
   b. For the Liquid Heat Capacity, the actual value may be determined using an integration, considering that the sub-cooling accounts for a considerable amount of enthalpy difference from the saturated liquid. This equation is given on Page 19 of the attached Transport Properties document.
2) Pressure loss in the liquid line has a negligible effect.
3) Pressure loss in the vapour line is assumed to be a constant 1.2 psi or so, and may be altered while running.
4) The energy calculation above represents the amount of energy absorbed by the refrigerant, and does not exclusively represent the amount of energy being drawn out of the ground from the thermosyphon.
5) Pressure changes due to gravity are ignored.
6) Pressure drops/changes in the evaporator coil are ignored.

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Draft Memo

To:	Mark Cronk, [PWGSC]	**Date:**	November 5, 2010
cc:	Daryl Hockley, Warren Medernach [SRK]	**From:**	Dan Hewitt, Peter Mikes, Greg Newman
Subject:	Giant FOS – Start-Up Protocol	**Project #:**	1CS019.017

One of the primary objectives of the freeze optimization study (FOS) at the Giant Mine Remediation Project is to compare the performance of several variants of freezing systems. The primary options are active freezing, passive freezing and hybrid freezing systems. In addition, each primary option has variants with regards to piping and connection details. To obtain maximum value from the freeze optimization study, careful consideration was given to the start-up protocol to ensure that all data required for proper evaluation is acquired.

This memo presents SRK's recommendations for activation of the freeze groups in a sequence that will best allow the study objectives to be met. It also provides recommendations for start-up of the mechanical components of the freezing systems. Recommendations for data collection and management have been provided in a separate memo.

Section 3 provides information as a basis for detailed start-up planning. Many of the decisions made during this planning exercise will follow through into the post start-up operating phase of the FOS.

1 Freeze Pipe Grouping Start-up Sequence

A summary of the freeze pipe groups and start-up dates are provided in Table 1. The objective in determining the date selection was to start up each group as soon as possible without compromising the ability to make direct comparisons between the freeze technology variants or any components of the Remediation Plan (e.g., drift plugs).

Table 1: Freeze Group Activation Summary

Group	Technology	Start-Up Date	Details
A	Active, 4.5" pipes, two serial pairs connected in parallel	November 2010	
B	Hybrid, 3" pipes grouted into raw hole	November 2010	
C	Active, 3" pipes, parallel connection	November 2010	
D	Active, 4.5" pipes, serial connection	TBD	Start date to be determined following finalization of the drift plug design.
E	Active on start-up, details to be determined	Summer 2011	Active freezing to start in late Spring or early Summer 2011.
F	Hybrid, 4" pipes grouted into raw hole	November 2010	Start in passive mode only. Convert to hybrid in Spring 2011.
G	Hybrid, 2.5" pipes grouted into a 4.5" pipe grouted into raw hole	November 2010	Start in passive mode only. Convert to hybrid in Spring 2011.

H	Active, 4.5” pipes, parallel connection	Summer 2011	Active freezing to start in late Spring or early Summer 2011.
J	Active, 4.5” pipes, serial connection	TBD	Start date to be determined following finalization of the drift plug design.
K	Active, 4.5” pipes, serial connection	TBD	Start date to be determined following finalization of the drift plug design.
L	Active, 4.5” pipes, serial connection	TBD	Start date to be determined following finalization of the drift plug design.
M	Active, 3” freeze pipe grouted inside 4.5” pipe grouted into raw hole, parallel connection	November 2010	
UG	Active, 3.5” pipes, parallel connection	November 2010	

The following sections provide details as to the logic behind the selection of the start-up dates. An excerpt from as built drawing C05 showing the freeze pipe groupings is attached for reference.

GROUPS A, B, C, and M

- Groups A, B, C and M are to be activated at the same time upon start-up.
- Groups A and B are to provide a direct comparison of active freezing between the active and hybrid thermosyphon technologies.
- Group M is to be turned on at the same time as Group A to provide a comparison of active freezing with 4.5” vs. 3” sized piping.
- To have a fair comparison between Groups A and B, Group C is to be turned on at the same time as Group M. This is so that boundary effects north of Group A are similar to boundary effects south of Group B.

GROUPS E, F, G and H

- Groups F and G are to operate as passive thermosyphons for the winter 2010-11, and switched to hybrid mode in the spring.
- The two groups are to be charged with enough carbon dioxide to allow for passive operation at temperatures below -10C.
- Groups F and G will be converted to hybrid operation in the spring of 2011, once air temperatures warm to the extent that further passive operation becomes ineffective.
- To avoid interference with the passively operating systems, the start-up of the neighbouring Groups E and H are to be delayed to summer 2011until two to three months after switching Groups F and G to hybrid operation.
- This approach allows for:
    - Comparison of 4” thermosyphons (Group F) with 2.5” thermosyphons (Group G) under passive operation and high heat loads;
    - Comparison of passive operation in winter of 2010-11 (from Groups F and G) against hybrid operation from Group B; and
    - Passive operation of Groups F and G in winter of 2010-11 to hybrid operation in summer and winter of 2011-12. Both passive and active modes will allow a further understanding of how the climate influences what is happening in the ground.

GROUPS D, J, K and L

- Groups D, J, K and L will not be activated until a drift plug plan is finalized.
- If the selected drift plug design is such that it will not be impacted by frozen conditions, the groups may be activated. Otherwise, these groups are to be activated following the plug installations.

UNDERGROUND FREEZE PIPES

- The underground freeze pipes will be activated the same time as surface Groups A, B, C and M.
- This will allow freezing of the saturated dust in the bottom of the chamber to commence as soon as possible.
- The underground pipes will also provide an additional cooling load to the freeze plant, allowing it to operate within its optimum range.
- There is a small chance that cooling from the underground active freeze pipes may impact the performance of the thermosyphons in Groups F and G. Cooling at the base of the thermosyphons could cause an excess amount of liquid carbon dioxide to accumulate at the bottom of the pipe while Groups F and G are operating in passive mode. During the winter 2010-2011, the thermosyphon performance is to be monitored for adverse or unusual behaviour.

2 Mechanical System Start-Up

After consulting with Startec, the following procedure is recommended for starting up the mechanical component of the program:

- Startec / AECOM to commission the brine pumps and brine circuit by pumping through all brine freeze pipes to the established flow rate of 15 USGPM per freeze hole (or series of holes). When satisfactory, shut the pumping system down.
- At a later time, commission the freeze plant compressors using the warm Dynalene in the storage tank as a test load. Do not circulate through any of the ground freeze pipes. When satisfactory, shut the compressors down.
- When the thermosyphon systems are ready to start up:
    - Re-start the Dynalene pumping circuit using the full system of pipes;
    - Allow to circulate and, while doing so, use the air bleed off nipples to purge air from the system;
    - When complete, turn OFF the necessary valves on the return side (first) then supply side of the freeze pipe heads that are in groups NOT scheduled to be part of the start up freezing; and
    - Keep Dynalene circulating in all freeze pipe heads that are part of the groupings discussed above for November start-up.
- Once the flows are balanced, close the bypass valve on the main supply headers such that Dynalene is circulating through the freeze plant heat exchangers and through the desired ground pipe groups.
- Restart the compressors to begin cooling the circulating Dynalene (and by default the Dynalene in the storage tank).

It is not necessary to bring the freeze pipes on in small groups as the compressors will be programmed by Startec to limit their load and to not enter an overloaded state which would draw too much amperage. The freeze plant will run at near capacity during the initial cooling stage and then will unload to a value somewhat less than design load as not all the freeze system will be active at this time.

The freeze plant has two 60 TR compressors. They are able to run at a coefficient of performance (COP) of 1.55 when 100% loaded, and this drops off to 0.695 at a load of 25%. A COP of greater than 1.0 is desired as this means the electrical energy input is less than the heat energy output. At lower loads, the electrical energy input is greater than the ground heat extraction and therefore less efficient. Based on this, the plant should not be run for very long with a small load. Starting the specified surface groups at the same time as the underground freeze pipes will ensure that the plant does not run inefficiently.

Arctic Foundations has provided a detailed, three part draft commissioning plan for the thermosyphon system. Commissioning will be performed by them. During commissioning, the thermosyphons will be charged with CO_2 and all thermosyphons are anticipated to operate in hybrid mode for at least three days. This phase of the commissioning will need to be coordinated with start-up of the Dynalene system.

Commissioning and start-up coordination planning to merge the activation of both freeze systems is a larger issue better addressed outside of this memo.

3 Start-up Planning Issues

The broad start-up requirements are itemized as a basis for detailed planning and determining roles. They include pre-start-up activities, staffing, inspections and reporting. They will be expanded and built upon as the time comes closer to activate the freeze systems and more people have had input into their particular requirements. Revisions will be made where they become apparent during start-up planning through to the end of construction and during commissioning.

Once the freeze plants are active and operating conditions become apparent, further revisions can be expected. A preliminary listing of planning areas is presented in the following sections as a starting point to decide on areas requiring regular attention, roles, responsibilities, and report formats.

Components of the freeze system can be sorted for reporting purposes and start-up planning into:

- General site;
- Dynalene freeze plant;
- Surface Dynalene distribution system and freeze pipes;
- Underground distribution system and freeze pipes;
- Thermosyphon freeze plant;
- Distribution system for heat exchangers on thermosyphons;
- Thermosyphon pipes;
- Instrumentation holes, surface and underground;
- Instrumentation shack;
- Weather station; and
- Power supply.

3.1 Checks and Inspections before Freeze Activation

Routine inspection checklist documentation to be prepared on the following items so that field inspections can be made and status confirmed:

- Active freeze pipe connections;
- Inlet and outlet freeze pipe valves to be open or closed and condition;
- Dynalene freeze plant and flow rates through each parallel connected freeze pipe, each set of series connected freeze pipes, east and west surface distribution pipes, underground distribution pipes;
- Thermosyphon freeze plant and refrigerant flow rates;
- All temperatures and flow rates of freeze systems to be activated (once those not to be activated have been isolated);
- All other temperatures;
- Other data of concern, e.g. power draws, weather; and,
- Weather station.

Status of valves, flow readings, etc., c/w identification tags are to be identified prior to activation of freeze plants.

3.2 Commissioning

Commissioning is to be the responsibility of the respective freeze system designers and suppliers.

3.2.1 Dynalene Freeze System

The Startec plant is to be commissioned by the supplier as indicated in Section 2. AECOM and/or Nuna will be expected to coordinate this work with commissioning of the Dynalene distribution piping for the active freeze pipes.

3.2.2 Thermosyphon Freeze System

Arctic Foundations will be expected to coordinate the commissioning of all components of the thermosyphon freeze system. Details of the all instrumentation will be required for performance evaluation purposes and are to be included in the FOS instrumentation data logging system being set up by AECOM.

3.2.3 Instrumentation

Instrumentation is to be commissioned and operational prior to activating the freeze system. The planning details are beyond the scope of this memo and are being prepared by AECOM. The initial data readings will provide a baseline for ground conditions and system operation before activating the freeze system. This information will be necessary for performance evaluation. In general terms, the start-up planning and commissioning would ensure that:

- All instrumentation data is being received at the instrumentation shack;
- Data conversions are being performed properly;
- Conversion of data from electrical signal to calibrated units is being done correctly;
- Data transmission links on and off site are operating in good order; and
- Data historian is storing data in proper format.

4 Staffing Requirement

The facility will require an operator, or operators, to carry out routine inspections and implement instructions from the engineering team, such as, “Activate Group X at flowrate Y and temperature Z.” Over several months, the operator(s) will develop a feel for the system that goes beyond anything the engineering team could provide, for example how it responds to adjustments, where locations exist for potential damage (birds, animals, ice, wind, etc.), what the normal operating plants sound like (e.g., vibration noise), what normal oscillation in pressure gauges may be, what a stuck gauge looks like, etc. That level of understanding will be extremely helpful in trouble shooting and planning future tests. It would also contribute to design of the full scale freeze program.

The operator(s) should be familiar with instrumentation, pumping circuits, and freeze plants. Legal requirements that may also need to be addressed, e.g. certification requirement to operate a refrigeration plant.

Other particulars to be considered include:

- Level of staffing required – determine whether a part time position can cover daily work;
- Coverage for surface versus underground facilities – a different person could be assigned to the simpler underground inspections where there are no pumps, thermosyphons or local instrumentation readouts;
- Lines of communication for the position should be defined in the contract or employment agreement;
- Interfaces and boundary limits with maintenance staff working for the various suppliers need to be clarified.

Regarding timing, early involvement of the operator(s) with start-up planning and commissioning will provide the opportunity to become familiar with the engineering team, the freeze system components and how they work. They could also contribute to the requirements for inspections, reporting, maintenance and related issues.

5 Inspection Requirements

The objective of all inspections is to assess the current state of the system, look for abnormal conditions, check for damage, carry out preventive maintenance, etc., to ultimately provide assurance that the system is and will continue to operate as designed. All areas are to remain accessible for adjustment and maintenance if necessary.

Snow should be kept cleared such that there is a walkable path around the site from pipe to pipe, to the freeze plants and to the instrumentation shack. Vehicle access may be required in winter and areas requiring snow removal need to be marked before snow accumulates. Vehicle and equipment access should be restricted for performance of specific work that is required.

The operator should check that there is a similar appearance to all operating freeze pipe heads and thermosyphon condensers. For example, if there is no ice build-up on a freeze head but all others around are covered in ice, this may be a sign that there is a blockage or a reduced flow in the system that is not detected by the instrumentation.

As a follow through to operation, recommendations should be provided by designers and freeze system suppliers for routine checks, preventive maintenance and emergency procedures.

Regular visual inspection for leaks, damage and other unusual conditions and maintenance on a scheduled and unscheduled basis for the following areas:

- General condition – access, debris, ice/snow build-up, damage, electrical substation, other visual;
- Distribution system, surface and underground – pipe runs, insulation, supports, valves, flow meters, etc.;
- Active freeze pipe connections – inlet and outlet tubing, valves, flow meters, connections;
- Condition of operating valves - once each week all operating valves are "bumped" and then set back to the original pre-bump state. This should ensure there is no rust build up on moving parts. It may be necessary to use WD-40, or similar product, to provide a light lubricant to moving parts. Valves should not be "bumped" on any random day and the date of any adjustment should be noted so that if there is an observed change in monitoring data it can be cross referenced to any physical field adjustments (intended or otherwise);
- Weather station operation - particular attention to wind speed detector, general condition and possible damage from birds, ice, etc.;
- Freeze system performance – visual reading and manual recording of key instrumentation parameters;
- Monitor and record other information to be determined;
- Take action when abnormal conditions are noticed;
- Housekeeping and site upkeep;
- Schedule of daily activities for the above;
- Freeze plant maintenance according to manufacturers' specifications - the freeze plant vendors (Startec and AF) to supply a schedule and list of recommended routine checks and preventive maintenance; and
- Other maintenance to be scheduled.

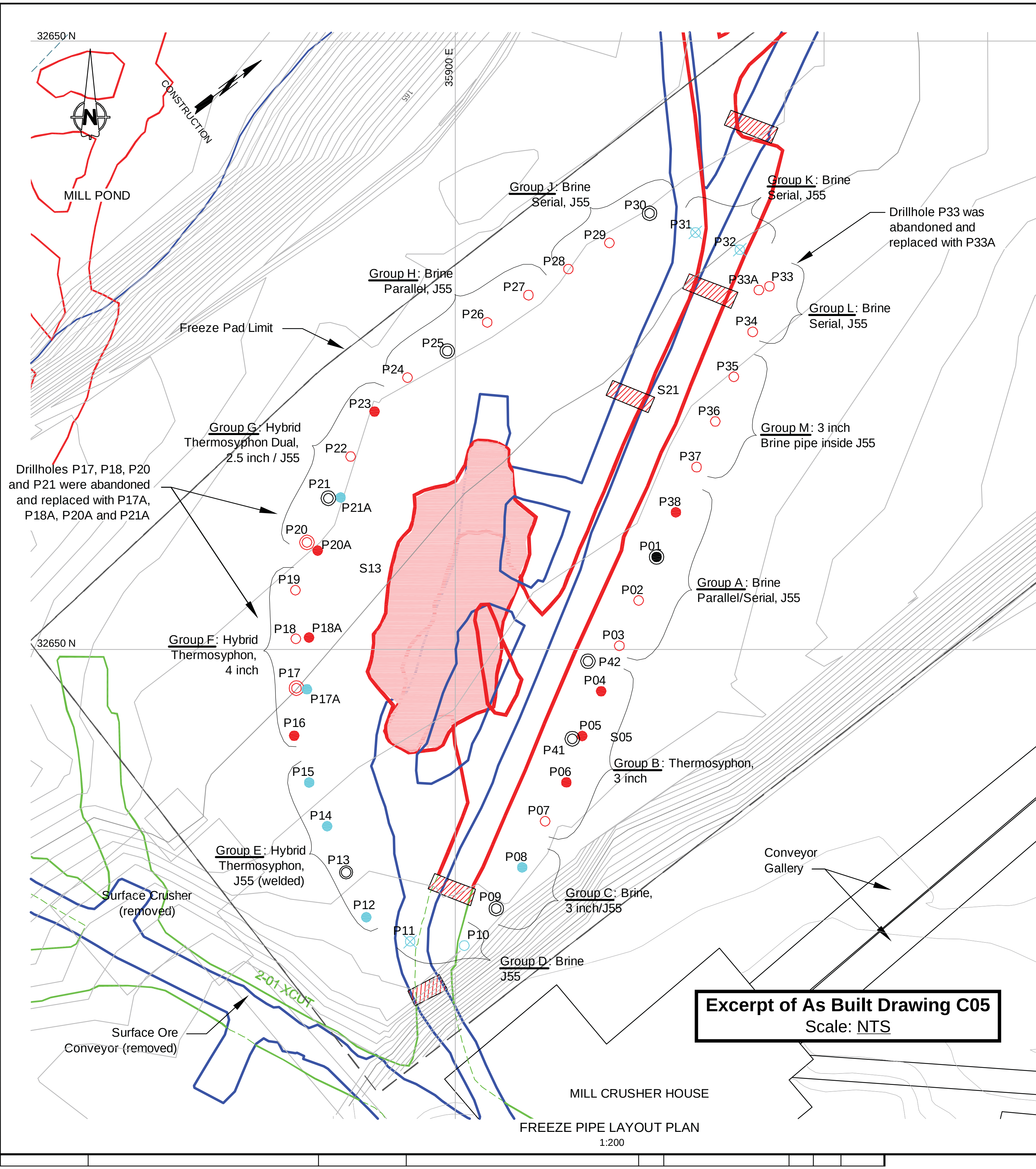
Emergency procedures will be needed in order to respond to abnormal conditions for performance, e.g. freeze pipe flow out of range, as well as infrastructure, e.g. Dynalene leak at a tubing connection. The care and maintenance contractor, Arctic Foundations, Startec and designated others would be expected to be available for emergency response.

6 Reporting

Reports are to be submitted on a daily, weekly and monthly basis:

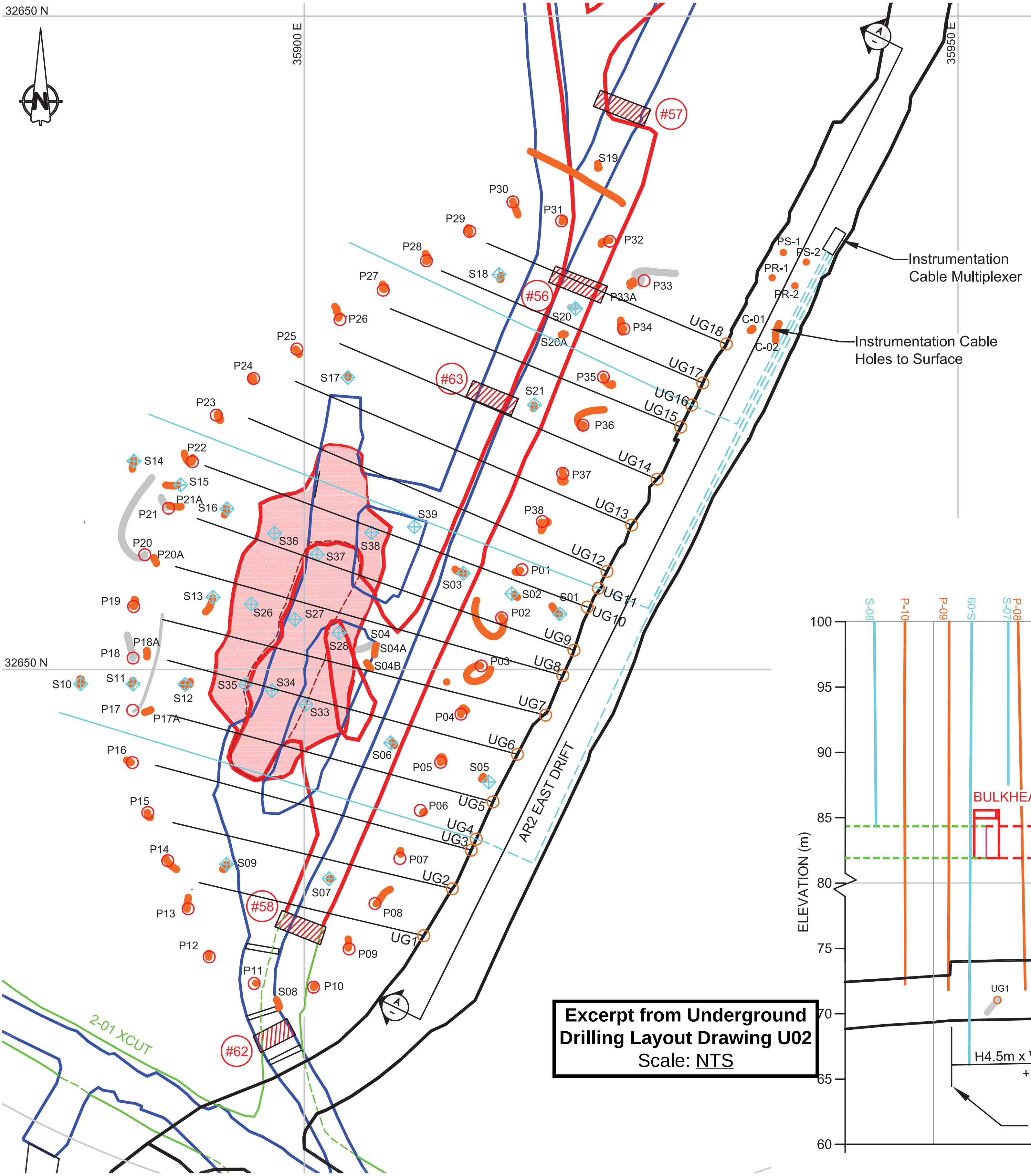
- Daily record of all daily checks and inspections;
- Daily update of key performance parameters and trends;
- Weekly and monthly summaries of performance, abnormal conditions, action taken and maintenance performed; and
- Paper and computer report – paper report formats to be determined; HMI's to be developed for computer generated reports

Example report formats will be proposed. But, as discussed in the data management memo, we expect the formats and details of many reports to be modified over the first month or two of operation.



Excerpt of As Built Drawing C05

Scale: NTS



UNDERGROUND DRILLING PLAN

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Draft Memo

To:	Mark Cronk [PWGSC]	**Date:**	October 26, 2010
cc:	Daryl Hockley, Dan Hewitt, Peter Mikes, Greg Newman [SRK]	**From:**	Warren Medernach
Subject:	Giant FOS –Data Management	**Project #:**	1CS019.017

When instrumentation data becomes available, SRK requests access to view the current status of the freeze system, including flow rates and temperatures throughout the system, operational data from both freeze plants, climate conditions, etc., at all times. SRK will also require the ability to access any and all logged instrumentation readings and times.

SRK will use the raw data to run queries, perform calculations and make charts for viewing and assessment. Access to all raw data is required so that, based on the actual data, comparisons can be made to investigate any deviations that were not expected at the start of the project. The data will also be used to calibrate the thermal model.

It is SRK's intent to store the raw data in a SQL Server database to provide a robust data storage environment and flexible data access options for the analysis and assessment processes. With the amount of data potentially being generated on this project, a SQL Server option will be used rather than a file based system like Microsoft Access or Excel. There are many advantages to a server based storage solution including:

- Removal of file based storage limitations;
- Tools to automate data loading and processing; and
- Built-in backup and archiving processes.

The flexibility of this solution is that applications such as Microsoft Access and Excel can be used as the front-end user interfaces to perform calculations and track performance for analysis and assessment. In this case, instead of the data residing in an Access MDB file or an Excel XLS file, the data is actually being referenced directly from the SQL Server.

In order to coordinate the work between the FOS data logging system and SRK's needs for evaluation, a conference call was held by AECOM and SRK to understand the data system and discuss how the requirements of both applications can be met. The meeting took place on October 20, 2010. In attendance were Duncan Cook and Ryan Jalowica from AECOM and from SRK there were Greg Newman, Warren Medernach, Peter Mikes and Dan Hewitt. Newcomers to the group were Ryan, an instrumentation programmer, and Warren, a database specialist. During the meeting, there was clarification of known items and identification of parts of the system in progress were undecided.

It was determined that the raw data would be in a format suitable for uploading into a SQL database and accessible to SRK to be able to download remotely. Further details relating to database management were discussed during the conference:

- The data logging system is being developed to store the raw data in the Historian Server. MODBUS banks will communicate with PLC's and raw data can be scaled in the PLC's before being transferred to the Historian. It was decided that no scaling would be done by the PLC's.

- An interface is being provided to run pre-defined reports against the data.
    - AECOM has indicated that the data logging system will have the capability to create customized reports. These will be available to clients and other authorized users. SRK's reports will be geared toward operation and evaluation of the freeze study.
    - AECOM and SRK agree that presentation views (for both the data logging system and SRK's evaluation) will develop as data accumulates and it becomes apparent how to better display the data.
- The system will be capturing log files which will be stored in a .dbm, and/or .csv format. Both of these file formats are a simple common delimited format and can be easily imported into a SQL database.
    - The exact structure was not discussed in detail other than it may be similar to the Akaitcho system where there will be seven columns of data: six columns for variables plus a time stamp field.
        - Once it is known what the data stream will actually look like, a more accurate calculation can be performed to estimate the amount of data that will be captured over a given period of time. This information will be used to size SRK's storage requirement for the SQL database.
- The daily raw data log files will be made available for download.
    - The details of this interface have yet to be defined. Options discussed included manually accessing the server via Remote Desktop and downloading the data files.
        - It would be preferred to automate this process in some fashion to pull the log file data directly from web server on a daily basis and push to an internal SRK server.
        - SRK's downloads can be reduced by selecting a specific time period to download and avoid overwriting data already on hand.
- There are approximately 750 to 1000 data points.
- The frequency of data capture will be every 30 minutes for parameters that will or could have a high rate of change.
- Upon alarm, all data will be logged to indicate conditions at the time of alarm.
- SRK will add additional reference information to the data points. An example of system nomenclature is the thermistors where each string will be referenced to a drill hole and each temperature bead will be numbered from 1 to 11, consistent with location in the hole. SRK will add spatial information to each bead so the temperature reading can be referenced in 3D for modelling.

We understand that AECOM is preparing a document that outlines the rules of recording for instrumentation, i.e. what is measured, how often, and when alarms are triggered. SRK would like the opportunity to review this document prior to start-up and potentially to meet with AECOM to finalize the data acquisition rules.