Supporting Document C6

Groundwater Modelling Update: Giant Mine Remediation Project (SRK, 2005)

Indian and Northern Affairs Canada

Groundwater Modelling Update Giant Mine Remediation Project

Prepared for:

Department of Indian Affairs and Northern Development
5th Floor, PreCambrian Building
P.O. Box 1500
Yellowknife, N.T.
X1A 2R3

Prepared by:

SRK Consulting
Engineers and Scientists

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Groundwater Modelling Update

Giant Mine Remediation Project

Department of Indian and Northern Development

Suite 500, PreCambrian Building
4920 – 52nd Street
Yellowknife NT
X1A 3T1

SRK Consulting (Canada) Inc.
Suite 800, 1066 West Hastings Street
Vancouver, B.C. V6E 3X2

Tel: 604.681.4196 Fax: 604.687.5532
E-mail: vancouver@srk.com Web site: www.srk.com

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Author
Dan Mackie, M.Sc.
Hydrogeologist

Reviewed by
Michael Royle, M.App.Sci., P.Geo.(NT)
Senior Hydrogeologist

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1 Introduction

This addendum to the Giant Mine report, *"Groundwater Modelling: Model Design and Simulation Results (SRK, 2005)"* presents an updated groundwater numerical model of the current conditions and reflood models presented in 2004. The revised model incorporates preliminary data collected from the supplementary multi-level observation wells installed in 2004 and the updated water balance produced for the Giant Mine Remediation Plan. The model has also been used to provide illustration of the influence of tunnels on groundwater flow near arsenic stopes after full reflood.

1.1 Objectives

The specific objectives of the updated numerical model were:

- Recalibration of the model using new data from the expanded monitoring system, and
- Provide illustration of preferred tunnel flow around frozen chambers.

2 Additional and Updated Calibration Data

Additional calibration data is available from the supplementary monitoring wells installed in 2004 (data collected in September 2004, January & May 2005) and the updated mine water balance completed in 2005.

2.1 Updated Water Level Data

The water level database for the Giant Mine has been significantly increased since submission of the original 2004 groundwater modeling report. In August and September 2004, nine new multi-level observation wells were installed at the Giant Mine to fill in sections of the mine perimeter that were recognized as gaps in the site database. Details of the new multi-level monitoring systems are included in *"Groundwater Monitoring System Installation Report (SRK, 2005)"*. Fourteen multi-level observation systems now exist at the Giant Mine for pressure/water level information, comprising 129 pressure monitoring points. Figure 1 shows locations for the newly installed observation systems, the five previously existing multi-level systems and open exploration drillholes used for water level measurements.

The conceptual model used as the basis for the original model suggested the presence of a small perched groundwater system east and northeast of the mine between the mine and Great Slave Lake. The perched or shallow system in these areas is thought to be constrained by higher conductivity bedrock at shallow depths resulting from exfoliation after glacial unloading. This higher conductivity bedrock overlies significantly lower conductivity rock. In areas over the mine workings ("mine envelope") and to the east of the mine, the shallow system infiltrates vertically to the underground tunnels. In 2004, multi-level systems were installed in these areas, in part to provide better control on water levels to the east and northeast of the mine.

Pressure and hydraulic conductivity data from the newly installed systems suggest that the shallow water table to the east and northeast of the mine does exist. Pressure data from shallow zones in exploration drillholes indicate equivalent water levels close to ground surface. Deeper zones have significantly lower pressures, suggesting drainage towards the mine workings. Pressure data from drillholes completed as part of the installation program show downwards gradients, but typically have equivalent water levels within five to fifteen meters of ground surface. Only isolated deeper zones show water levels more than fifteen meters below ground surface. Figure 2 is an updated water table map for the mine using shallow water levels from systems installed in exploration boreholes. Depressurized deeper zones suggest that deeper zones of the bedrock may be more significantly dewatered due to the mine workings.

Hydraulic conductivity data from newly installed systems indicates that the bedrock conductivity is typically low (generally less than $1x10^{-7}$ m/s). Data from drillhole S-DIAND-023, completed to 125 meters vertical depth, indicate a decreasing hydraulic conductivity trend with depth. Higher hydraulic conductivity values at shallow depths correlate with the occurrence of numerous iron-stained fractures. The staining suggests water flow through the open fractures. Data from a limited number of other drillholes across the site show a similar trend.

Pressure data from the new multi-level monitoring systems were assessed to determine appropriate zones for use as calibration points. A total of 25 calibration points were chosen for the updated model. Six of these are open-hole water levels. The remaining 19 are from multi-level systems. For some multi-level systems, two observation points have been chosen from different depths, such as on either side of a fault, where piezometric levels are seen to change significantly in the well profile. Multiple, depth-variable, calibration points were identified for many of the multi-level systems, both the older and newer installations, to provide improved control on groundwater levels and gradients over the original model. Table 1 lists water levels (converted from pressure data where appropriate) used in the previous numerical model and those for the updated model. Locations of each open-hole water level and multi-level systems are shown on Figure 1.

Table 1: Old and New Calibration Points

Drillhole	Original Calibration Head	Descriptor	Updated Calibration Head	Descriptor
MP Installations				
S-DIAND-001	1819	North of TS Flt	1825	North of TS Flt
	1813	South of TS Flt	1812	South of TS Flt
S-DIAND-002	--	Not included	1841	Average
S-DIAND-021	--	N/A	1852	East of WB Flt
	--	--	1854	West of WB Flt
S-DIAND-022	--	N/A	1835	North of Ak Flt
	--	--	1839	South of Ak Flt
S-DIAND-023	--	N/A	1842	Shallow
	--	--	1837	Deep
S-DIAND-024	--	N/A	1840	Average
S-1857	1757	East of WB Flt	1746	East of WB Flt
	1848	West of WB Flt	1848	West of WB Flt
S-1858b	--	Not included	1749	Intermediate
S-1859	1837	OH	1801	Intermediate
S-1860	1800	Zone 1	1840	Intermediate
S-1954	--	N/A	1826	Intermediate
S-1955	--	Not included	1828	Shallow
S-1956	--	N/A	1850	Shallow
	--	--	1843	Deep
S-2224	1835	OH	1815	Intermediate
Open Hole Water Levels for both models				
S-1848	--	Not included	1802	OH
S-2223	1832	OH	1832	OH
GRP-2137	1844	OH-average	1844	OH-average
GRP-2138	1844	OH-average	1844	OH-average
NB94-10	1849	OH	1849	OH
NB94-11	1849	OH	1849	OH

As described in the 2004 Groundwater Modelling report, scale differences exist between measurements taken from open holes vs. the multi-level systems. Readers are referred to the *"Giant Mine Groundwater Modelling Report (SRK, 2004)"* for more detail.

A calibration range of +/- 100m, as used in the original model was again used for the updated model.

2.2 Updated Water Balance

An updated mine water balance was created for the Giant Mine Remediation Plan (Supporting Document "M" of the Giant Mine Remediation Draft Plan). This water balance revised a number of inputs used for the Giant Mine groundwater model, including flow into the mine from the Northwest Pond. Table 2 lists values used for the original numerical model and updated values.

Table 2: Water Balance Input and Calibration Values

	Flow Rates in m^3/day	
	Original Model	Updated Model
Northwest Pond	400	790
Combined Settling and Polishing Pond area	0	52
Total Inflow	1940	2400

Recharge values were not changed for the updated water balance. Recharge values for the updated model were not modified from the original model. Recharge is separated into two zones:

1. Regional recharge (7.3 mm/yr = 2.5% of total precipitation)
2. Recharge within the drill envelope (52 mm/yr = 18% total precipitation)

3 Numerical Models

3.1 Verification of Original Model

The steady-state current conditions model from the 2004 study was updated to include the new calibration points. Figure 3 shows results of this simulation. Figure 4 compares calculated vs. observed head for the original model using both the 2004 and 2005 observation points.

Comparison of calculated vs. observed head for the two models indicates that the original model does not adequately simulate the new calibration data, particularly in the area east of the mine. Observation points located east of the mine are identified on Figure 4.

Table 3 compares water balance outputs for the models with the 2004 and updated targets.

Table 3: Water Balance Outputs for Original and Revised Models

	Original Model			Revised Model	
	Fixed Boundary Condition	Modelling Target	Original Model Output	Fixed Boundary Condition	Modelling Target
Northwest Pond	400		400	790	
Settling and Polishing Ponds		n/a	n/a		52
Total Mine Outflow		1940	1263		2400

Note: all flows measured in m^3/day

Comparison of water balance outputs in Table 3 indicates that the original model water balance, while reasonable compared to the original inflow target, is significantly less when compared to the updated water balance. Tunnel inflow is low and the original model did not have infiltration from the Northwest Pond at the updated level. In addition, explicit infiltration from polishing and settling ponds was not included in the original model, which the updated water balance shows to be a component of total tunnel inflow.

The original model was not considered to reasonably simulate the updated calibration data and therefore required modifications to the model parameters.

3.2 Updated Current Conditions Model

The “current condition” model simulates the fully dewatered mine as it is today. The revised model conditions included increased inflow from the Northwest Pond and the Settling and Polishing Ponds. The model was modified to improve the calibration to the updated inflow data. To achieve a reasonable calibration to observed values, the distribution and value of hydraulic conductivity zones were adjusted.

3.2.1 Results

The updated current conditions model required changes in the distribution and value of hydraulic conductivity zones in order to calibrate to the new monitoring well piezometric data. Boundary conditions and recharge values remained the same. The updated hydraulic conductivity values are listed in Table 4. Conductivity values from the original model are included for comparison.

Table 4: Updated Bedrock Hydraulic Conductivity Values

Layer	Depth (m)	Original Model K (m/s) (K_h=K_v)	K_h (m/s)	K_v (m/s)
1	0 - 35	$1x10^{-7}$	$5x10^{-6}$	$5x10^{-7}$
2	35 - 68	$1x10^{-7}$	$1x10^{-6}$	$1x10^{-7}$
3	68 - 103	$1x10^{-7}$	$1x10^{-8}$	$1x10^{-8}$
4-9	103 - 418	**$5x10^{-9}$	$1x10^{-9}$	$1x10^{-9}$
10-14	418 - 1037	$5x10^{-10}$	$1x10^{-10}$	$1x10^{-10}$

**In the initial model, this conductivity value was assigned to a maximum depth of 305m. Below that, conductivity was equivalent to that of the deeper layers.

Only layers 1and 2 were assigned anisotropic conductivity distributions. Anisotropic conditions were used to represent the shallow effects of glacial unloading, which causes subhorizontal fractures in the near surface bedrock as the glacial loading is removed. In these layers:

$$K_h > K_v \quad \text{(where } K_v \text{ assumed to be one order of magnitude less than } K_h\text{)}$$

Overall, hydraulic conductivity values are within the range of values determined from shallow hydraulic testing results and expected values observed in similar geological conditions. At many locations (eg: S-DIAND-023) fractures within the upper 30 metres were identified showing indications of flow (i.e: iron-staining) and had higher conductivity values than tests at greater depths within the same drillhole.

The increased flux at the Northwest Pond was accommodated by increasing the hydraulic conductivity of the uppermost model layer in the area immediately underlying the pond. Flow from the Northwest Pond into the mine has been identified as a significant source of mine inflow, possibly along exploration drillholes or other mining-induced features. Increase of the hydraulic conductivity below the pond is justified based on this assumption.

Flux at the Polishing and Settling Ponds was fixed to the calculated rate and did not require increase of hydraulic conductivity below the ponds.

Figure 5 shows results of the revised model. Figures 6 and 7 show 3-D views and cross-sections respectively. Table 5 summarises the water balance from the updated model.

Table 5: Water Balance from Updated Model

Mine Inflow Sources	Updated Model Target/Set Value (m^3/day)	Updated Model Output (m^3/day)
NWP Infiltration	790	790
Settling and Polishing Ponds Infiltration	52	52
Total Mine Inflow (including pond infiltration)	2400	1318

The updated model tunnel flow, approximately 55% of measured dewatering rates, is still lower than observed in the original model (approximately 65% of the original target value). In both model versions, the underestimation of flow is interpreted to be partially due to the low hydraulic conductivities required to achieve calibration to the piezometric levels and the simplified mine geometry used for model construction, which does not include any of the stopes, raises, and ramps. However, it is likely that the main difference is the lack of direct inflow to the mine from Baker Creek through the open pits, drillholes, etc. It was decided not to include these inflows as specified fluxes to balance the inflow as they would not intrinsically improve the model.

3.2.2 Sensitivity Runs

Select sensitivity runs from the original current conditions model were completed on the updated Current Conditions model. Sensitivity runs focused on the impact of recharge variations. Summary figures for the sensitivity runs are included in Appendix A. Table 6 summarises results.

Table 6: Summary of Sensitivity Runs

		Model Water Balance (m^3/day)				Specific Inflow (m^3/day)		Head Calibration	
ID	Change	IN	OUT	Recharge	Error %	Tunnel Inflow	Flow from GSL	RMS	ME
G3 Base Case Model	Recharge in drill envelope = 52 mm/yr Recharge outside drill envelope = 7.5 mm/yr	1626	3331	1705	0	1318	392	22	17
G3S1	Homogeneous Areal Recharge = 30mm/yr	934	4786	3852	0.3	1446	811	22	16
G3S2	Recharge outside drill envelope, Northwest Pond, Polishing and Setting Ponds = 10.5mm/yr	1515	3525	2010	0.2	1342	477	22	17
G3S3	Recharge outside drill envelope, Northwest Pond, Polishing and Setting Ponds = 30mm/yr	931	4838	3906	0.3	1492	1007	21	16
G3S4	High recharge zone east of mine = 30 mm/yr; Recharge in remaining area outside of mine = 7.5mm/yr	1590	3418	1827	0.1	1348	476	22	17

Note: RMS = root mean square
ME = mean error

Sensitivity runs indicate that changes in recharge result in only very small head increases and relatively small changes to total tunnel inflow. The maximum increase in tunnel flow, observed in G3S3, represents an increase of only about 13% over the base case model. Increases in recharge result in higher discharge to Great Slave Lake. The updated model is only slightly sensitive to reasonable variations in recharge, as was the original model.

3.3 Updated Reflood Model

3.3.1 Results

The reflooded conditions model was re-run using hydraulic conductivity parameters from the updated current conditions model. Recharge values for the Northwest Pond and Settling/Polishing Ponds were set to the regional recharge value (7.5mm/yr). Tunnel parameters were not modified from the original model, with the tunnel hydraulic conductivity maintained at 1 m/s.

Figure 8 shows results of the reflood model. Table 8 summarises water balance data.

Table 7: Reflood Water Balance

Model Water Balance	
Model Boundary Inflow	1685 m^3/d
Recharge (from precipitation)	862 m^3/d
Total Model Boundary Outflow	2547 m^3/d
Water Balance Error	0.5%
Detailed Water Balance	
Flow to Great Slave Lake (around flooded mine)	648 m^3/d
Spill Point Outflow	518 m^3/d
Observation Points	
Spill Point Elevation	1825 m
Max Tunnel Observation Point Head (north end of mine)	1825.56 m
Min Tunnel Observation Point Head (near Spill Point)	1825 m

Results from the reflood model indicate that, with updated bedrock hydraulic conductivity values, the tunnel system imparts significant control on groundwater flow in the mine area. Head values at observation points along the mine workings are very close to the spill point elevation, even at the north end of the mine 2,500 m away, and indicate a relatively low gradient within the tunnels themselves, which is expected with open pipe flow.

3.3.2 Extreme Case Scenarios

Three extreme case scenarios were simulated using the revised model:

1. G3EC1: High Conductivity Townsite Fault;
2. G3EC2: High Conductivity Layers 1 and 2; and
3. G3EC3: High Conductivity Layers 1 through 3.

For G3EC1, the Townsite Fault was incorporated as a high conductivity discrete element extending from Great Slave Lake to the mine workings for the entire model thickness. Properties of the fault are:

- Thickness: 1 meter
- Hydraulic Conductivity: $1x10^{-5}$ m/s along the entire length
- Transfer rate: equivalent to bedrock at each layer

Observations of the fault made in drifts intersecting the structure, during active mining, indicate that it is a discrete structure, on the order of 1 to 10 cm. No significant inflow has been observed.

For G3EC2 and G3EC3, layer conductivities were increased from values used in the calibrated current conditions model:

Horizontal hydraulic conductivity = $1x10^{-5}$ m/s

Vertical hydraulic conductivity = $1x10^{-6}$ m/s

Figures 9 to 11 show results of these simulations. Table 9 summarises water balance results.

Table 8: Extreme Case Scenario Water Balance Results

Model	Change	A2 Pit Spill Point Outflow (m3/day)	Flow to GSL (m3/day)	Deflection of head contours
G3reflood	Base case reflood	518	648	Base case
G3EC1	High K Townsite Fault	508	658	Minor
G3EC2	High K Layers 1 & 2	1474	1610	Minor
G3EC3	High K Layers 1, 2 & 3	2564	2197	Minor

Results from G3EC1 (high conductivity Townsite Fault) indicate minor influence on spill point outflow, suggesting that the fault, using the assigned parameters, could deflect flow from the spill point to Great Slave Lake on the order of 10 m^3/d, or approximately 2% of the base case spill point outflow.

It is important to note that the Townsite Fault is described as having a narrow, discrete form, and that no significant inflow has ever been observed. Under current conditions, the head differential between Great Slave Lake and the mine workings would be significantly higher than at reflood. This suggests that the results of this scenario overestimate the likely flow along this structure.

Results from G3EC1 and G3EC2 indicate that high hydraulic conductivity at shallow depths would impact the flow system under reflooded conditions. Groundwater passing through shallow levels of the mine area would be less influenced by the presence of the mine workings, resulting in increased flow to Great Slave Lake. Under current conditions, the shallow hydraulic conductivities used in these scenarios lead to poor model calibration.

3.3.3 Arsenic Stope Flow Paths

Model simulations were completed to assess the groundwater flow paths in the areas of the stopes under unfrozen and frozen conditions.

Two simulations utilising variable arsenic stope hydraulic conductivities were completed:

1. Unfrozen conditions – Arsenic stope hydraulic conductivity slightly less than bedrock (arsenic trioxide dust hydraulics conductivity measured to be 7 x 10^{-7} m/s, ref: SRK, 2004)
2. Frozen conditions - Arsenic-stope hydraulic conductivity four orders of magnitude less than bedrock

Particle tracking methods were used to assess groundwater flow pathways in the vicinity of the stope areas. Arsenic stope area AR1 was incorporated in the mesh and a simplified tunnel system assigned a hydraulic conductivity ten orders of magnitude greater than bedrock. Flow across the model domain was based on the regional gradient. AR1 was used as no tunnels are located upgradient of the arsenic stopes to intercept ground water flow. Therefore, this would be the area most likely to have flow through the stopes if not collected by the open tunnels.

Figure 12 illustrates results of these two models.

In the unfrozen scenario, results indicate that groundwater flowing from the upgradient side of the arsenic stopes would bypass individual arsenic stopes and flow towards the tunnel system. All particles that pass within relatively close proximity of the arsenic stopes are captured by the tunnels.

In the frozen scenario, results indicate that particles will bypass the entire frozen block, which will have hydraulic conductivity many orders of magnitude less than the surrounding bedrock.

4 Model Comparisons

4.1 Current Conditions

The significant differences between the original and revised models are:

- Increased flux from the Northwest Pond
- Inclusion of the Polishing and Settling Ponds as constant flux sources
- Modification of hydraulic conductivity distribution.

Flux from the ponds was input as fixed values and coincide with values determined as part of the mine water balance update.

The most significant difference in model setup between the revised and updated current conditions models is the distribution of hydraulic conductivity. The largest change to hydraulic conductivity parameters occurs within the three uppermost layers. Layers one and two are anisotropic. This anisotropy represents exfoliation of shallow bedrock due to glacial unloading.

Results of the revised model show that the drawdown cone around the mine is less apparent than in the original model and the tunnel system appears to have less influence on shallow groundwater in the area east of the mine. Cross-sections show that flow is towards the tunnels at all mine levels, similar to the original model. However, the seepage face on the uppermost 100L is much shallower than the original model. This is likely a result of the low hydraulic conductivity values required to calibrate to observed heads and the simplified tunnel system, which does not include stopes, raises, etc.

The revised model also shows that the influence of mine dewatering at shallow levels is less pronounced than in the original model (refer to Figures 3 and 5 for comparison). In the revised model, a groundwater divide is apparent in shallow layers northeast of the mine, between the mine and Great Slave Lake. Calculated vs. observed heads at observation points in this area, shown in Figure 4, suggest that this representation of the shallow groundwater system is reasonable. Water levels to the east of the mine are more shallow in the revised model and calibrate more closely, but do not show the shallow, possibly perched, system.

While better in the revised model than the original model, simulated heads at observation points located to the east of the mine remain below measured data using a reasonable parameter distribution. There are no data to suggest that either hydraulic conductivity in this area is lower than other areas of the mine, or that recharge is higher. Other factors may be influencing this area, such as fracture distribution or local enhanced recharge due to the presence of the South, Central and North tailings ponds. Geochemical monitoring at the recently installed nearby monitoring wells is currently being carried out to investigate this.

Water levels at some observation points west of the mine are over estimated, particularly in the area between the mine and the Westbay Fault. This suggests either unrecognized variations in hydraulic conductivity or recharge, or that mine workings in this area cause greater drawdown than simulated. However, water levels in the area of the newly installed multi-level system S-DIAND-021, also located to the west of the mine, are more reasonably simulated, suggesting this variation is probably local.

The ability of the revised model to provide improved calibration to significantly more observation points than the original model suggests that this model is a better representation of the actual groundwater system. Calibration to multiple points in multi-level systems indicates that the gradients in the area of those systems are generally well represented. The influence of long open drillholes below the multi-level systems completed in exploration drillholes cannot be accurately represented in the model and account for some of the less well-calibrated points. The presence of a perched shallow system east of the mine would explain these discrepancies.

4.2 Reflood

Results of the revised reflood model do not vary significantly from those of the original reflood model. Groundwater flow is dominated by the high conductivity tunnel system and spill point at the rim of the A2 Pit.

Results of the extreme case scenarios indicate that higher conductivities for shallow layers can have an impact on model results. While these scenarios lead to higher discharges to Great Slave Lake, the conductivity values are too high to allow calibration to observed heads under current conditions. Hydraulic testing indicated that these high conductivity values are not generally observed at the site.

Simulations of groundwater flow in the vicinity of arsenic chambers under unfrozen and frozen conditions indicate that water will bypass the chambers and be controlled by the high conductivity tunnels. Particles initiated on the upgradient side of the chambers flow towards the tunnels, around both the unfrozen and frozen chambers.

5 Conclusions

The revised current conditions and reflood models adequately simulate conditions and illustrate concepts. Results suggest that:

- The tunnel system controls groundwater flow in the mine area under reflood conditions;
- Even if the Townsite Fault had higher hydraulic conductivities, it would not impart significant control on tunnel flow;
- A shallow perched system to the east of the mine is plausible; and
- Shallow hydraulic conductivities may be affected by open fractures caused by glacial unloading.

This report, **"Giant Mine Remediation Project Groundwater Modelling Update"**, has been prepared by SRK Consulting (Canada) Inc.

Dan Mackie, M.Sc.
Hydrogeologist

Reviewed by:

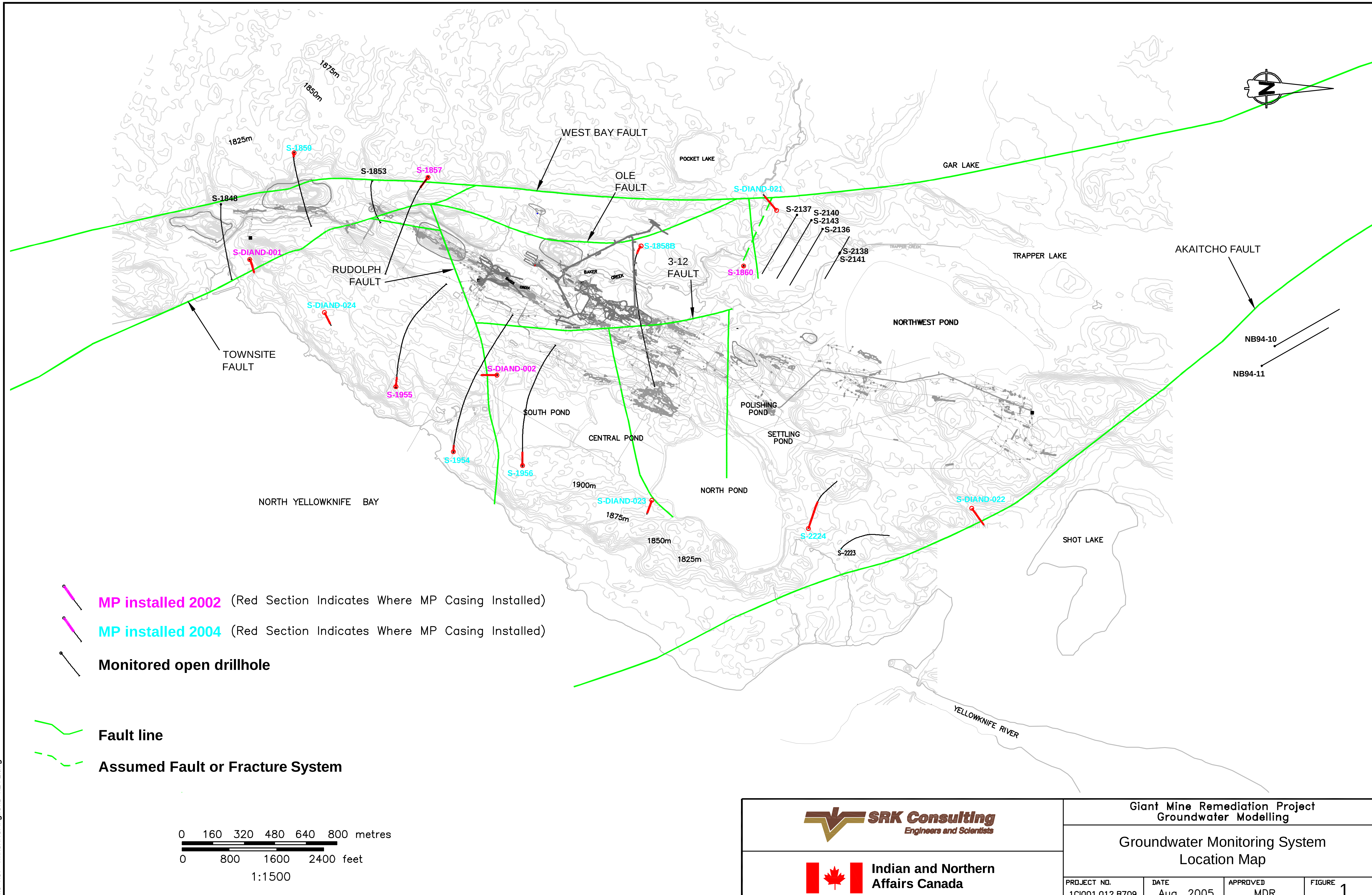
Michael Royle, M.App.Sci., P.Geo (NT)
Senior Hydrogeologist

6 References

"Arsenic Trioxide Chamber Drilling and Testing Program", (SRK, 2004).

"Groundwater Modelling: Model Design and Simulation Results", (SRK, 2005).

Figures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RUDOLPH FAULT
3-12 FAULT
TOWNSITE FAULT
AKAITCHO FAULT
POCKET LAKE
GAR LAKE
TRAPPER LAKE
NORTHWEST POND
POLISHING POND
SETTLING POND
SOUTH POND
CENTRAL POND
NORTH POND
SHOT LAKE
NORTH YELLOWKNIFE BAY
YELLOWKNIFE RIVER
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NB94-10
NB94-11
MP installed 2002 (Red Section Indicates Where MP Casing Installed)
MP installed 2004 (Red Section Indicates Where MP Casing Installed)
Monitored open drillhole
Fault line
Assumed Fault or Fracture System
0 160 320 480 640 800 metres
0 800 1600 2400 feet
1:1500
SRK Consulting
Engineers and Scientists
Indian and Northern Affairs Canada
Giant Mine Remediation Project
Groundwater Modelling
Groundwater Monitoring System Location Map
PROJECT NO. 1CI001.012.B709
DATE Aug. 2005
APPROVED MDR
FIGURE 1
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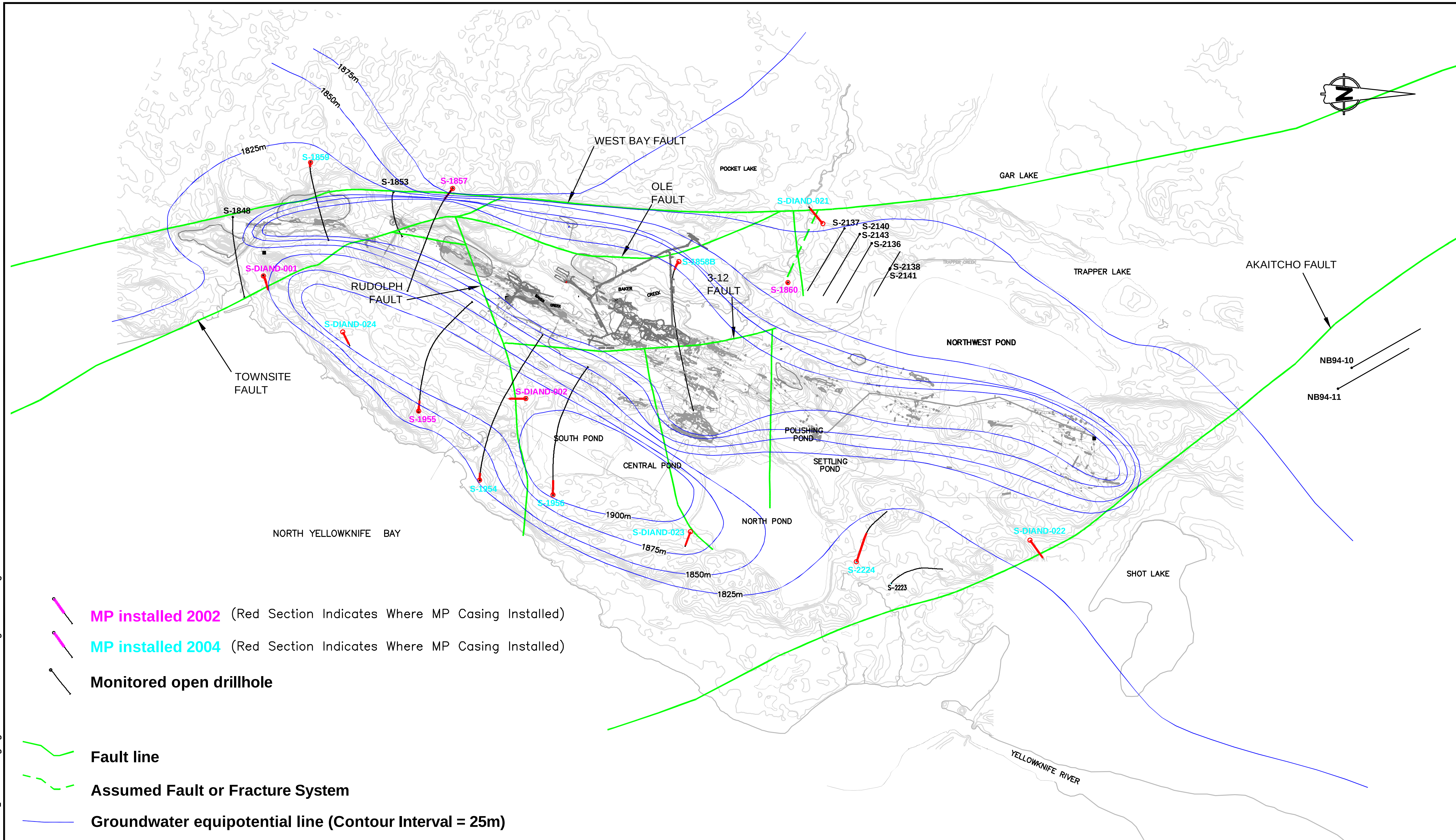

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Giant Mine Remediation Project
Groundwater Modelling

Revised Conceptual Groundwater Table Map

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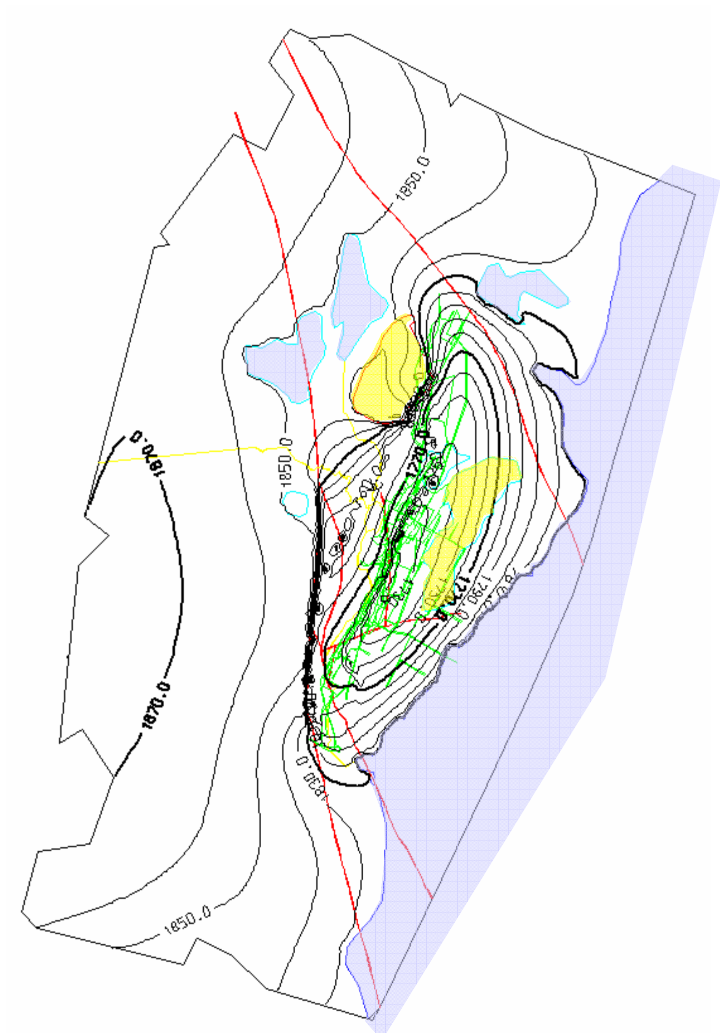

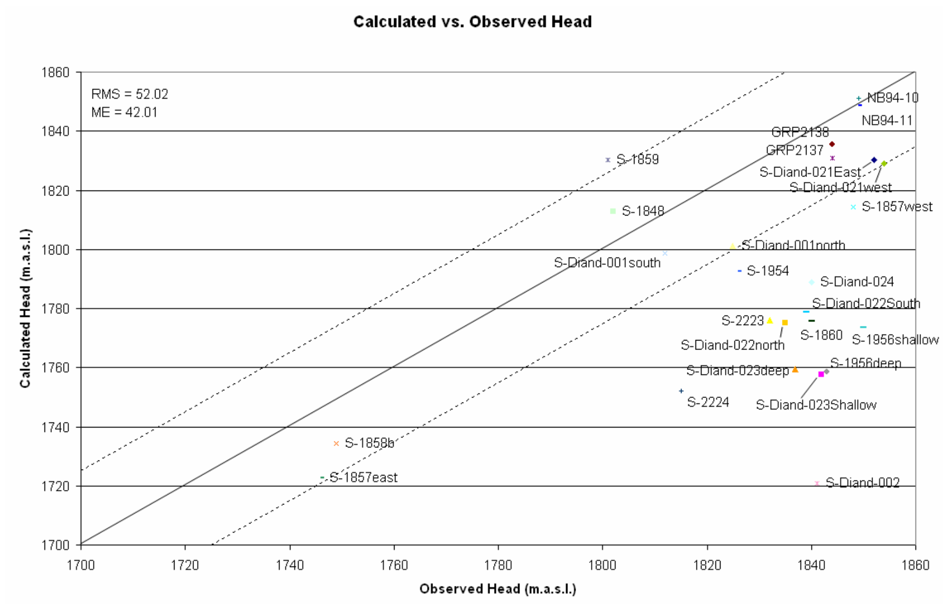

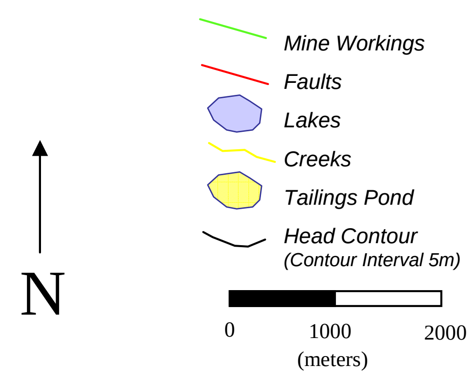

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Giant Mine Remediation Project
Groundwater Modelling

2004 Model w/ Updated Observation Points

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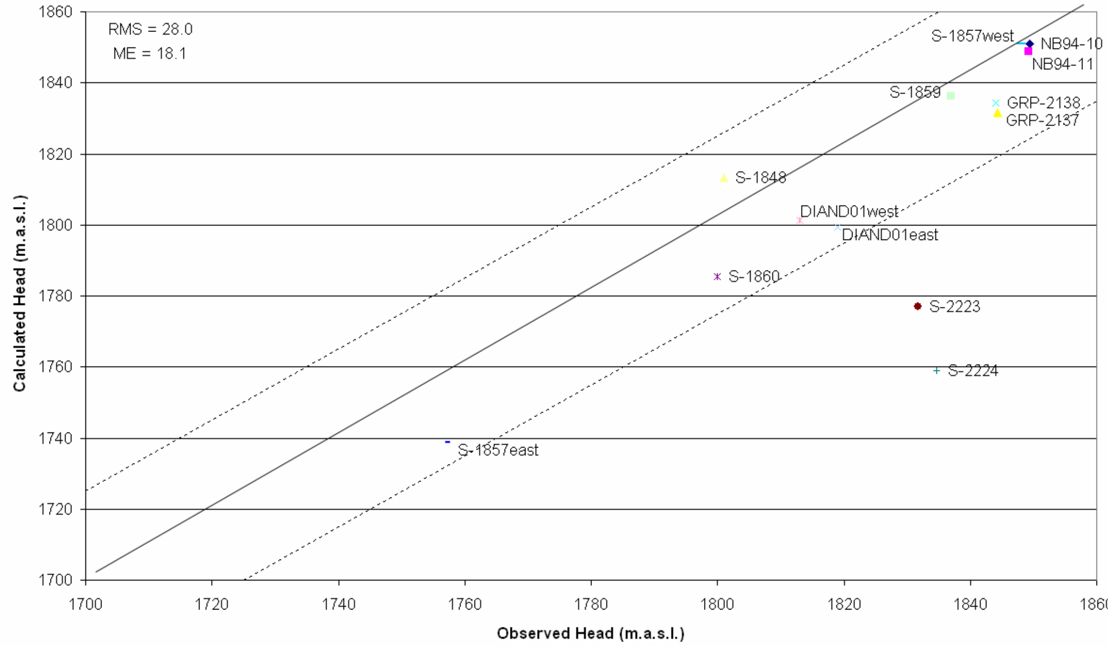
1CI001.12.B77	July 2005	DM	3

G2
Calculated vs. Observed Head



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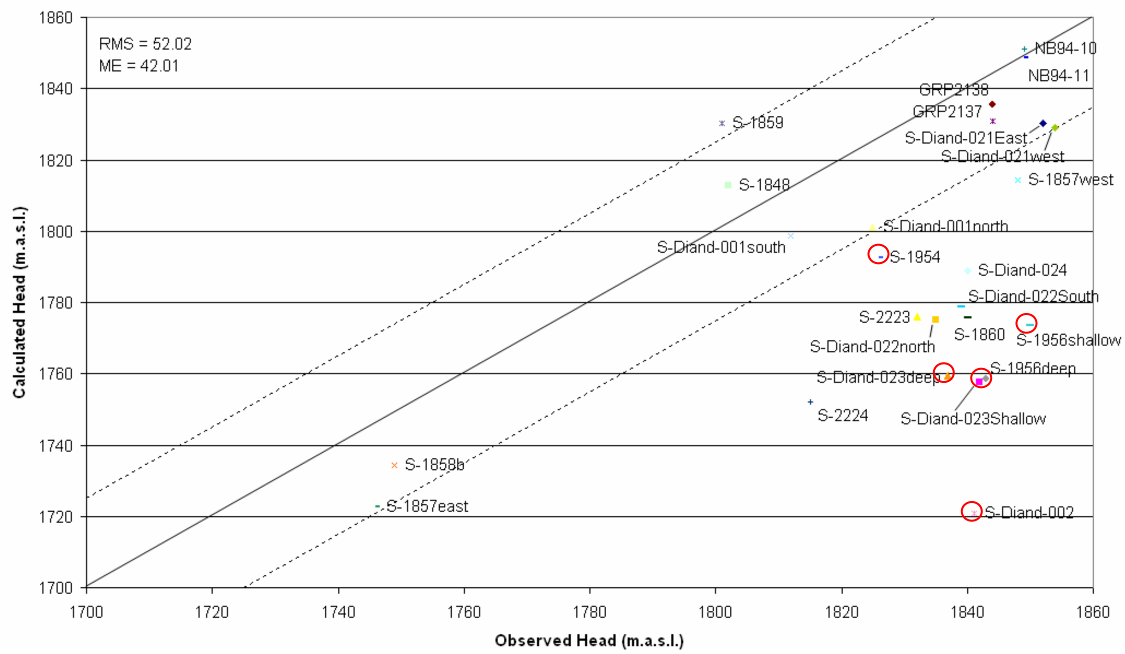
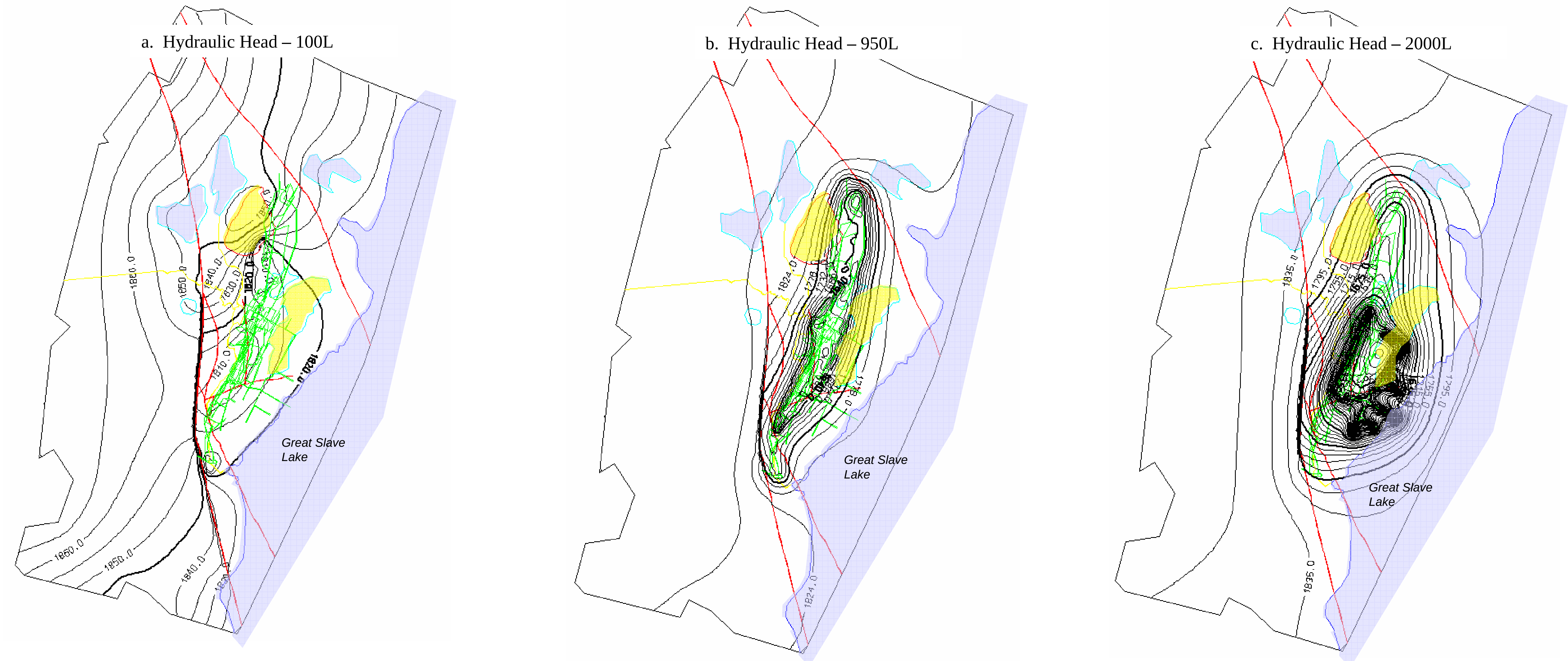
Calculated vs. Observed Head

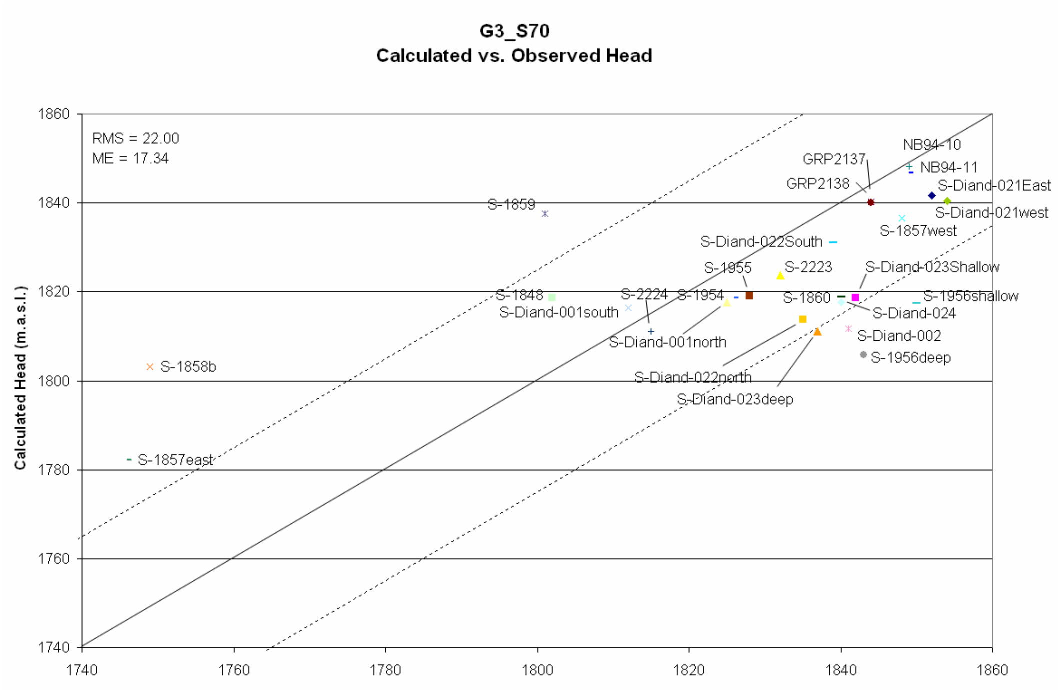


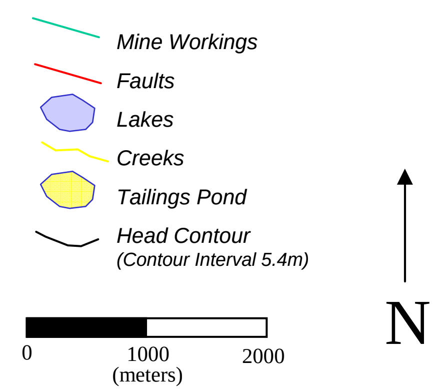
Points in circle are located east of c-shaft

SRK Consulting *Engineers and Scientists*	Giant Mine Remediation Project Groundwater Modelling
Indian and Northern Affairs Canada	**Calculated vs. Observed Head for 2004 and Revised Observation Pts**

PROJECT:	DATE:	APPROVED:	FIGURE:
1CI001.12.B77	July 2005	MDR	4







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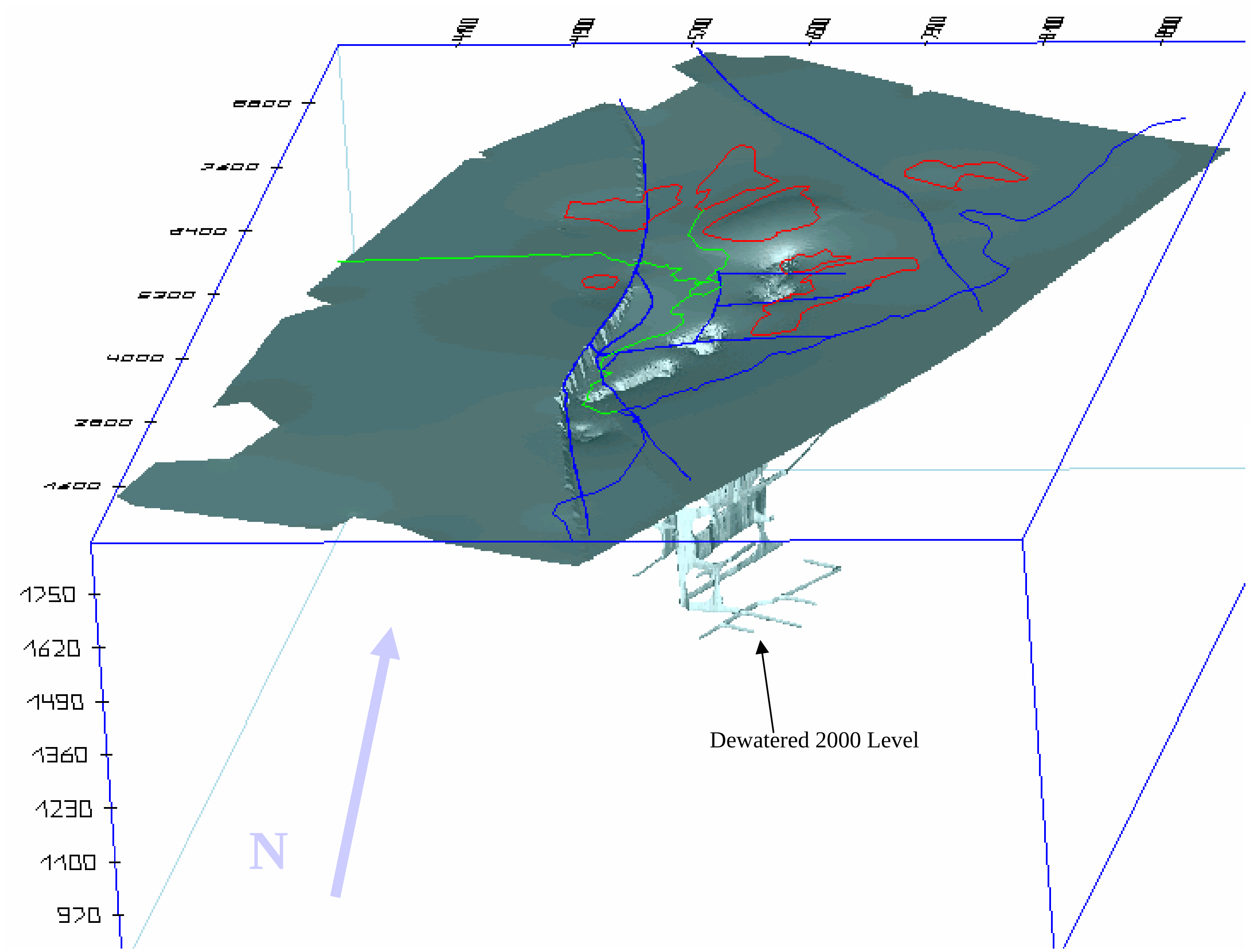
Giant Mine Remediation Project
Groundwater Modelling

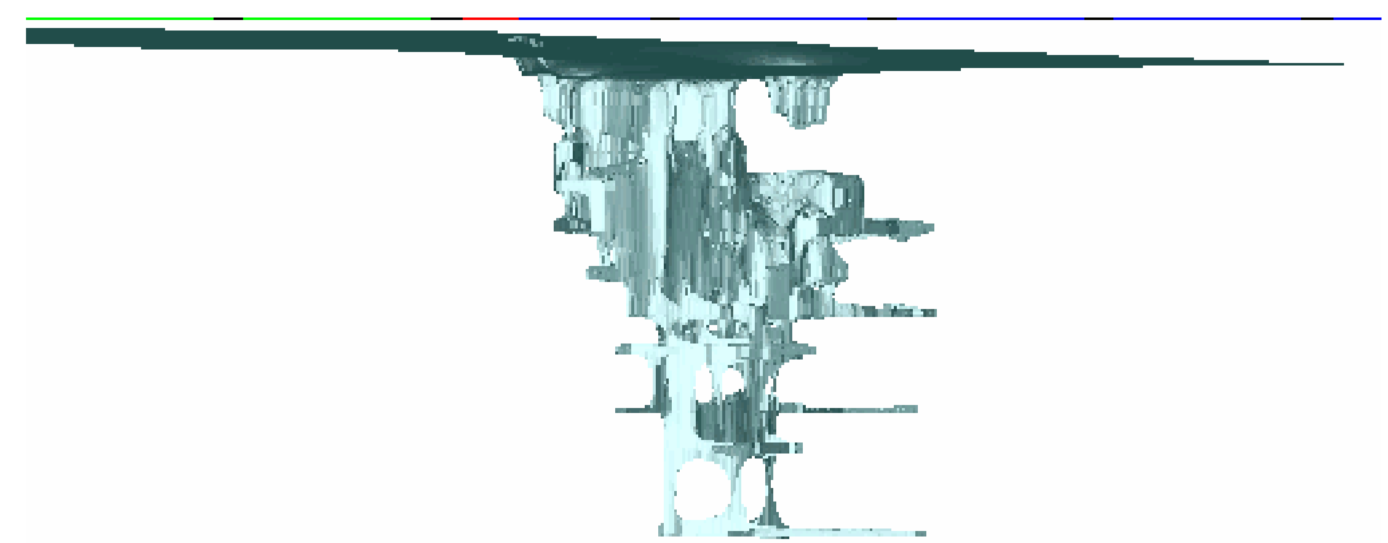
Updated Model – Dewatered Conditions

PROJECT:	DATE:	APPROVED:	FIGURE:
1CI001.12.B77	July 2005	MDR	5



5.5a Oblique view looking north of deep groundwater surface

5.5b Sideways view of workings looking west, showing depressurized zone



5.5c End view of workings looking north, showing depressurized zone

Dark colours - high head

Light colours – low head

Isosurfaces of 100 psi

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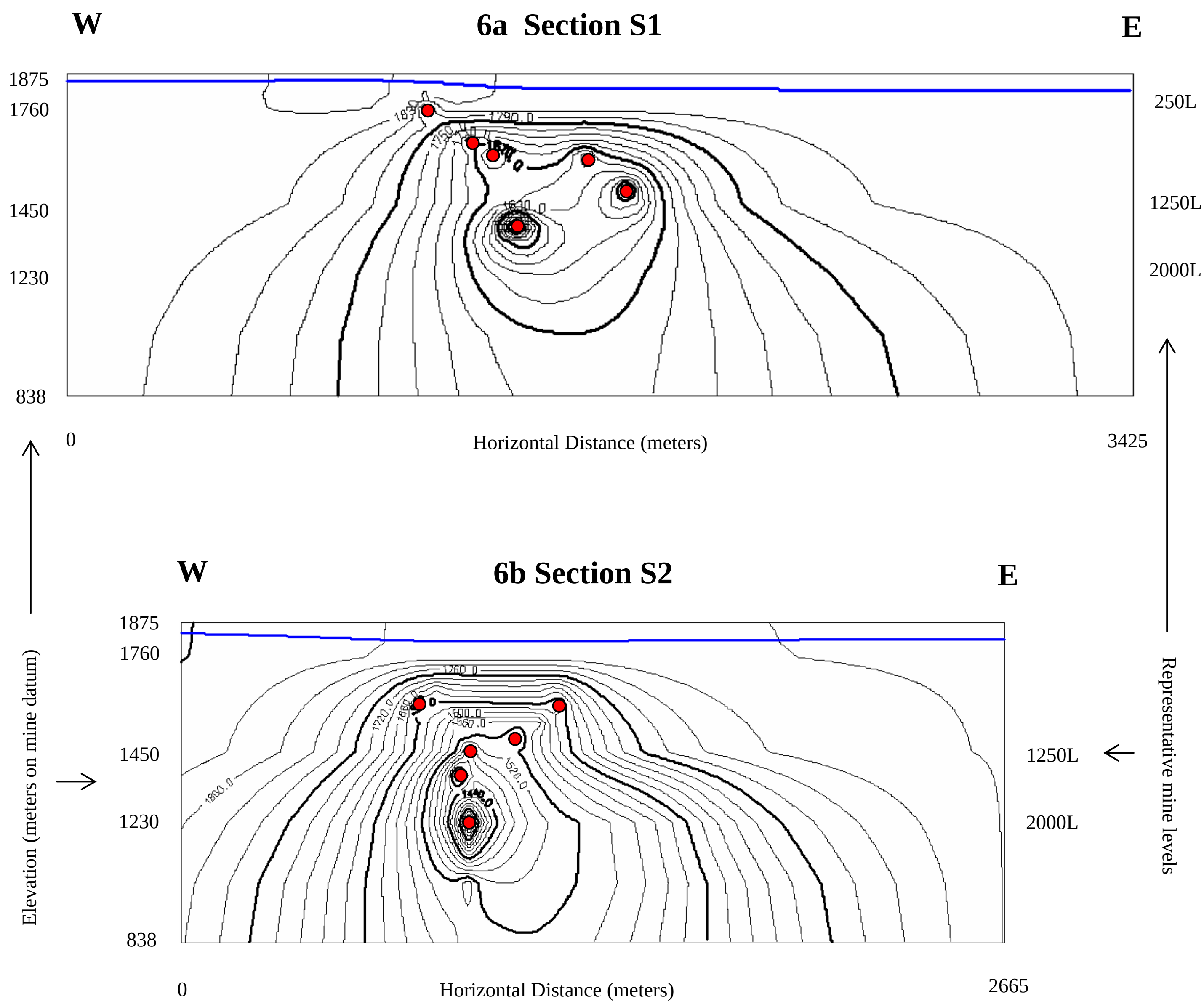
Giant Mine Remediation Project
Groundwater Modelling

3D Projection of Dewatered Scenario (updated model)

PROJECT:	DATE:	APPROVED:	FIGURE:
1CI001.12.B77	July 2005	MDR	6



No vertical exaggeration

0 kPa pressure contour

Head contour (20 meter interval)

Approximate tunnel cross section (only tunnels below the 0 kPa line are shown)

Note: blue line represents exact model output of water table. In vicinity of mine workings, actual seepage face is likely more complex, and tunnels will NOT be in a completely saturated system

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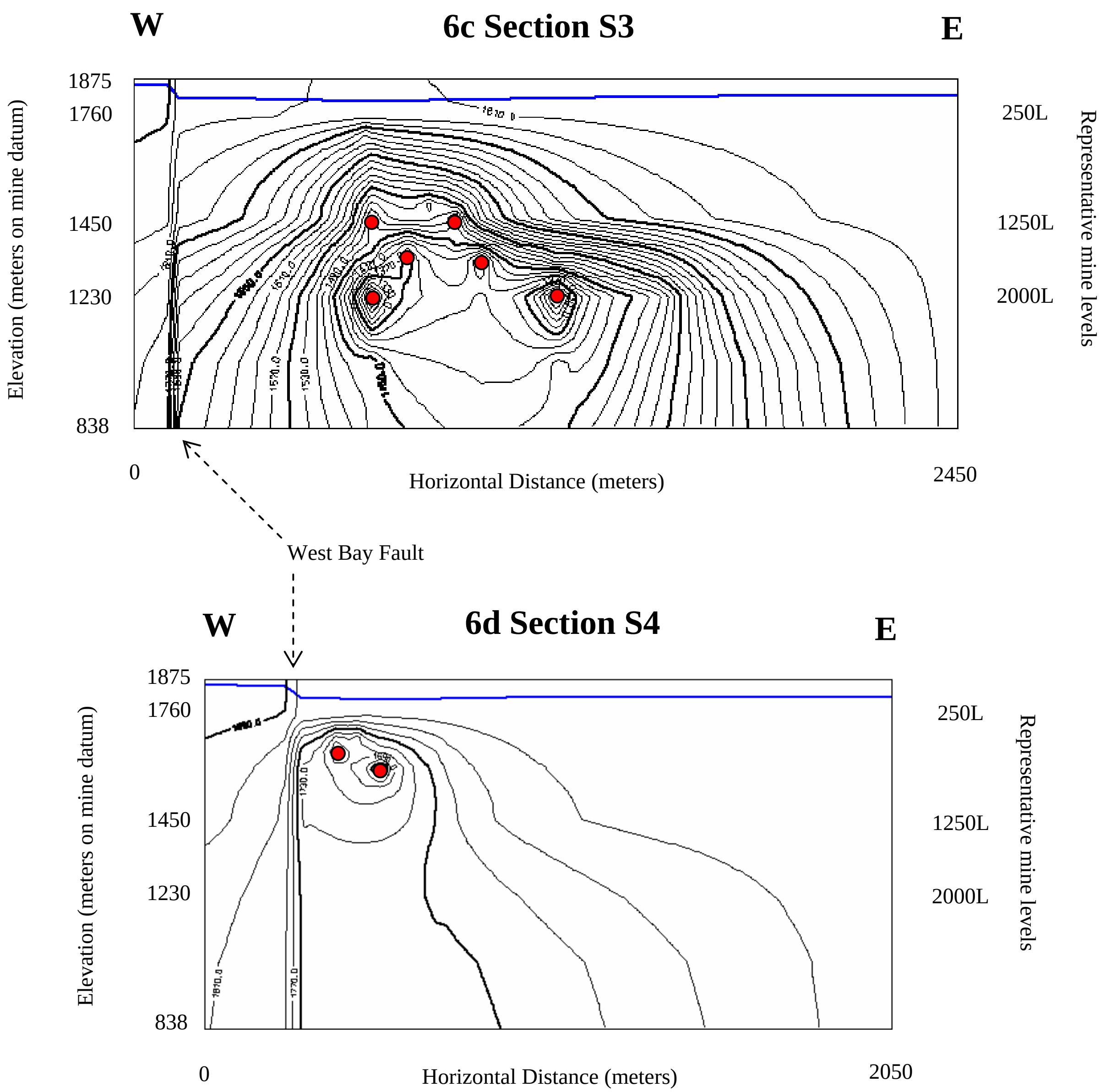
Groundwater Modelling

Cross Sections for Dewatered Conditions (model G3)

PROJECT:	DATE:	APPROVED:	FIGURE:
1CI001.12.B77	June 2005	MDR	7a-b



No vertical exaggeration

0 kPa pressure contour

Head contour (20 meter interval)

Approximate tunnel cross section

(only tunnels below the 0 kPa line are shown)

Note: blue line represents exact model output of water table. In vicinity of mine workings, actual seepage face is likely more complex, and tunnels will NOT be in a completely saturated system

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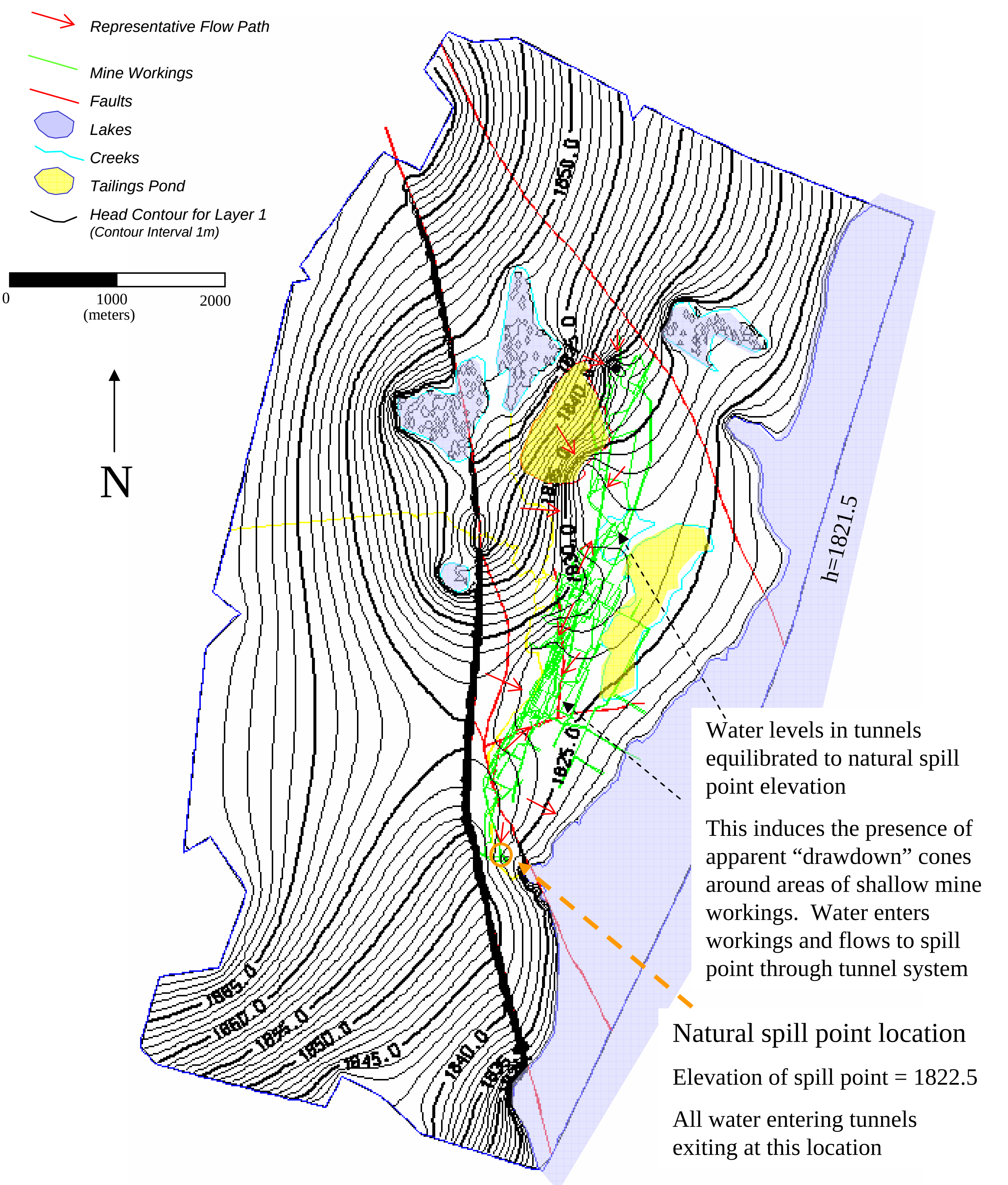
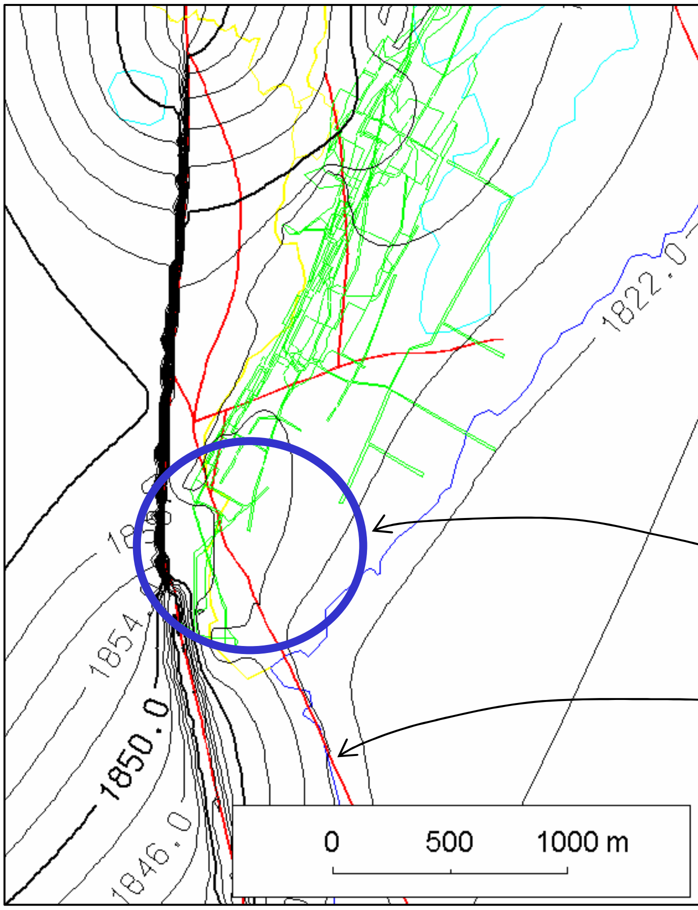
Groundwater Modelling

Cross Sections for Dewatered Conditions (model G3)

PROJECT:	DATE:	APPROVED:	FIGURE:
1CI001.12.B77	June 2005	MDR	7c-d



SRK Consulting Engineers and Scientists	Giant Mine Remediation Project Groundwater Modelling			
	Revised Reflood Model Results			
Indian and Northern Affairs Canada	PROJECT: 1CI001.12.B77	DATE: July 2005	APPROVED: MDR	FIGURE: 8



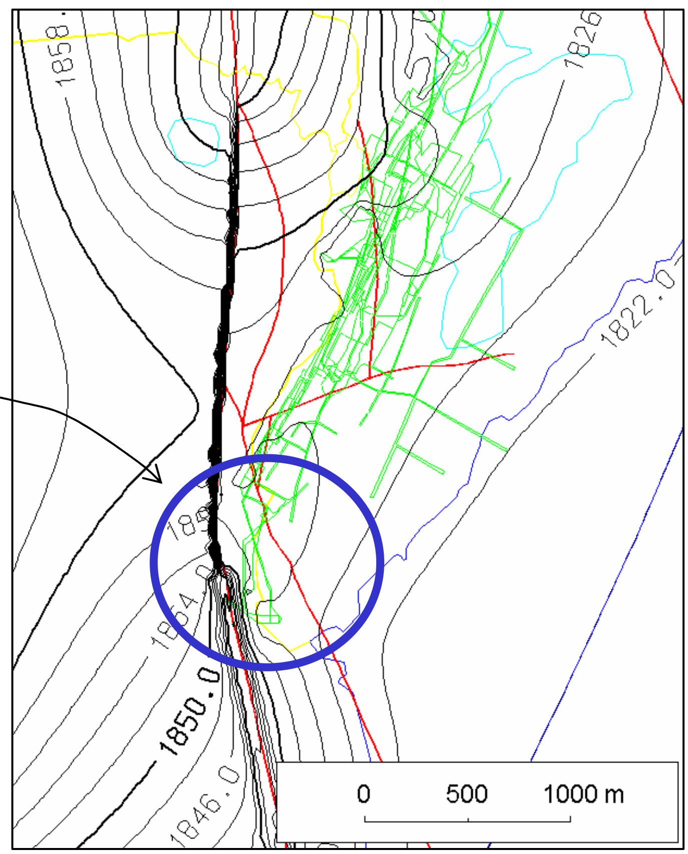
a. Head contours on 250 level for reflood base model

NOTE – contour indicates flow away from fault

Townsite Fault

b. Head contours on 250 level for high conductivity Townsite Fault

NOTE – contour indicates flow towards fault



Model	Spill Point Outflow (m3/d)
Base	518
High K fault	508

N

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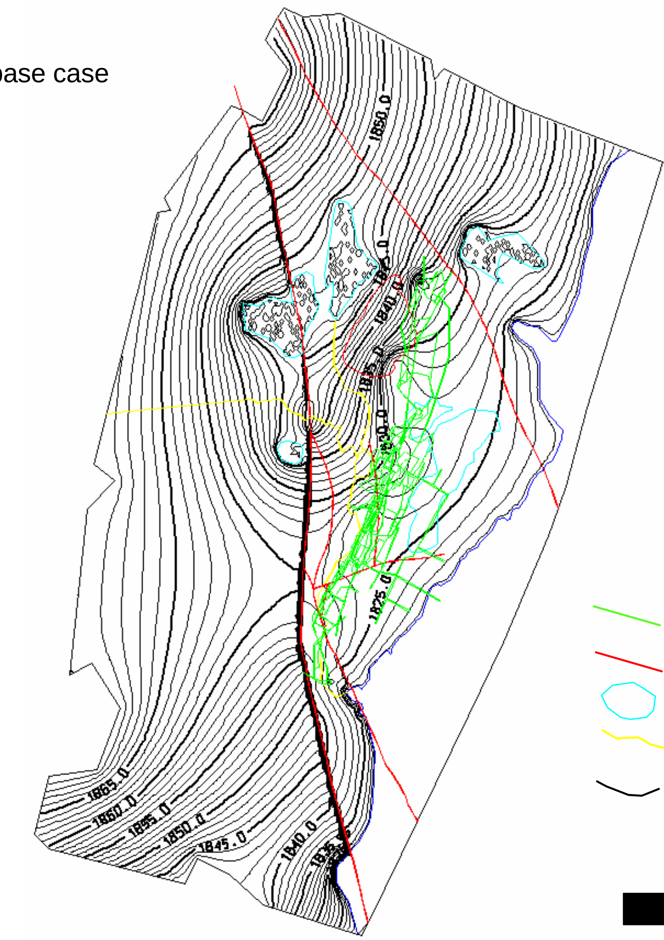
Giant Mine Remediation Project
Groundwater Modelling

High Conductivity Townsite Fault

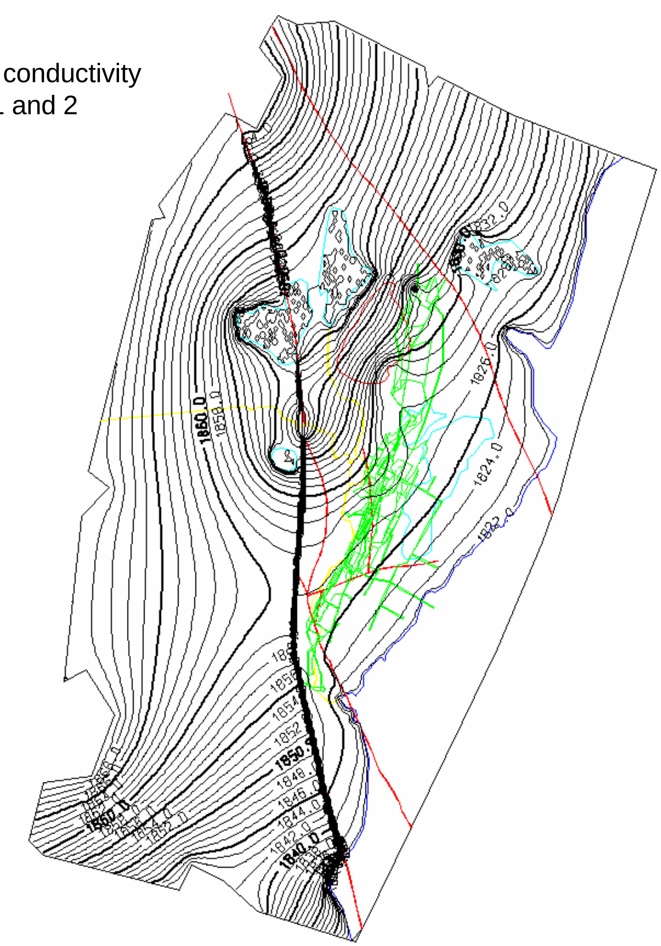
Model Results

PROJECT:	DATE:	APPROVED:	FIGURE:
1CI001.12.B77	July 2005	MDR	9

a. Reflood base case



b. High conductivity layers 1 and 2



N

Mine Workings

Faults

Lakes / Tailings Pond

Creeks

Head Contour
(Contour Interval 1 m)

0 (meters) 2000

Model	Flow to Great Slave Lake (m3/d)
Base	648
High K Layers	1610

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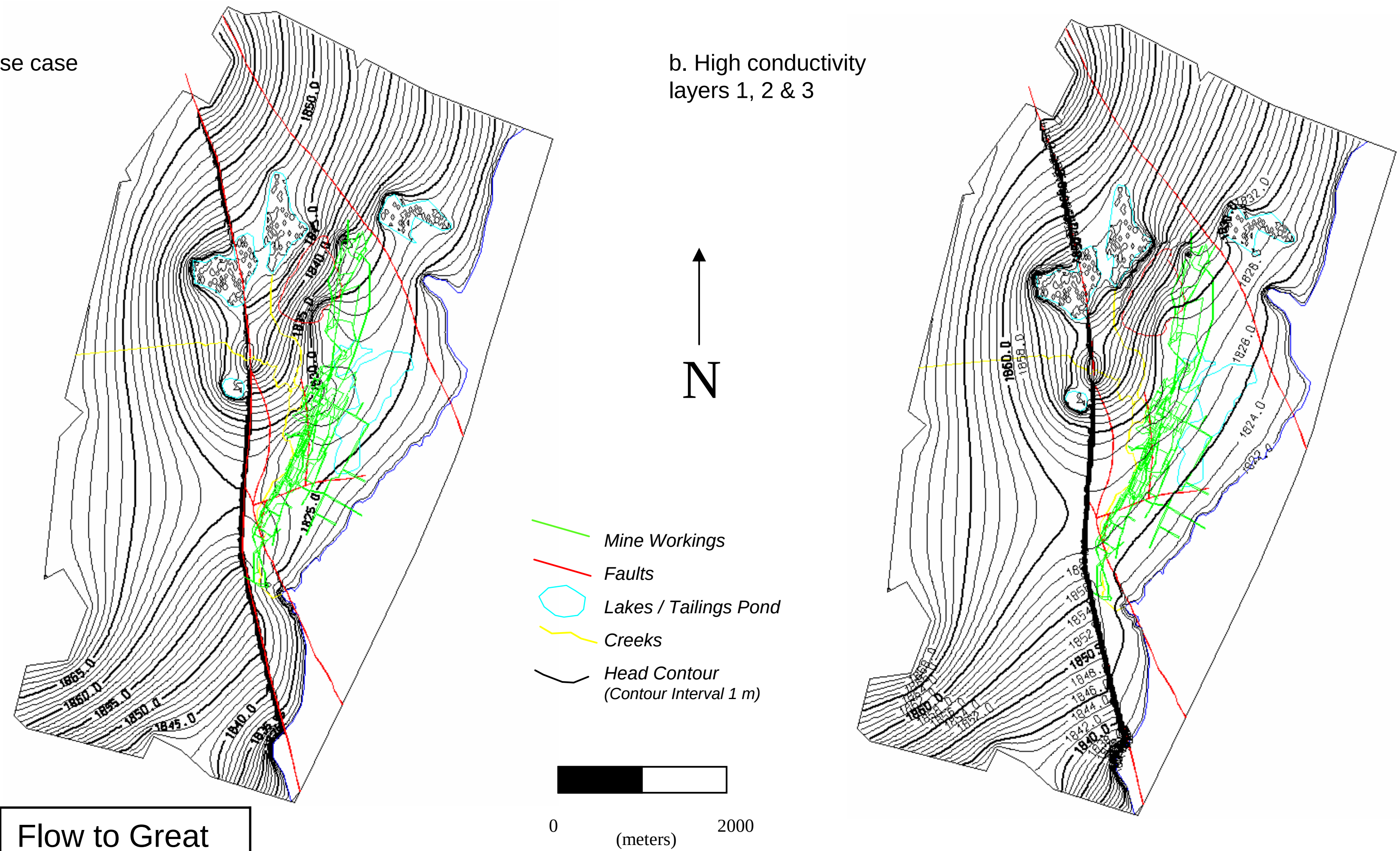
Giant Mine Remediation Project
Groundwater Modelling

High Conductivity Layers 1 & 2

Model Results

PROJECT:	DATE:	APPROVED:	FIGURE:
1CI001.12.B77	July 2005	DM	**10**



Model	Flow to Great Slave Lake (m3/d)
Base	648
High K Layers	2197

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Giant Mine Remediation Project
Groundwater Modelling

High Conductivity Layers 1- 3

Model Results

PROJECT:	DATE:	APPROVED:	FIGURE:
1CI001.12.B77	July 2005	DM	**11**

Regional Gradient

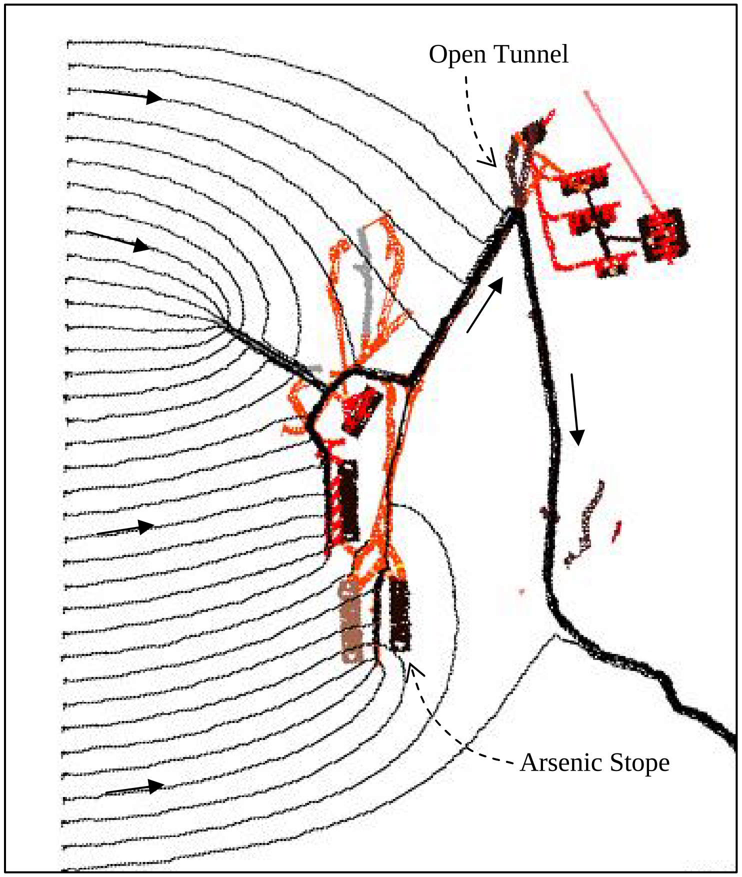

Fig 12a. Base Case Model

(K_{stope} = 7 x 10^{-7} m/s)

($K_{bedrock}$ = 1 x 10^{-6} m/s)

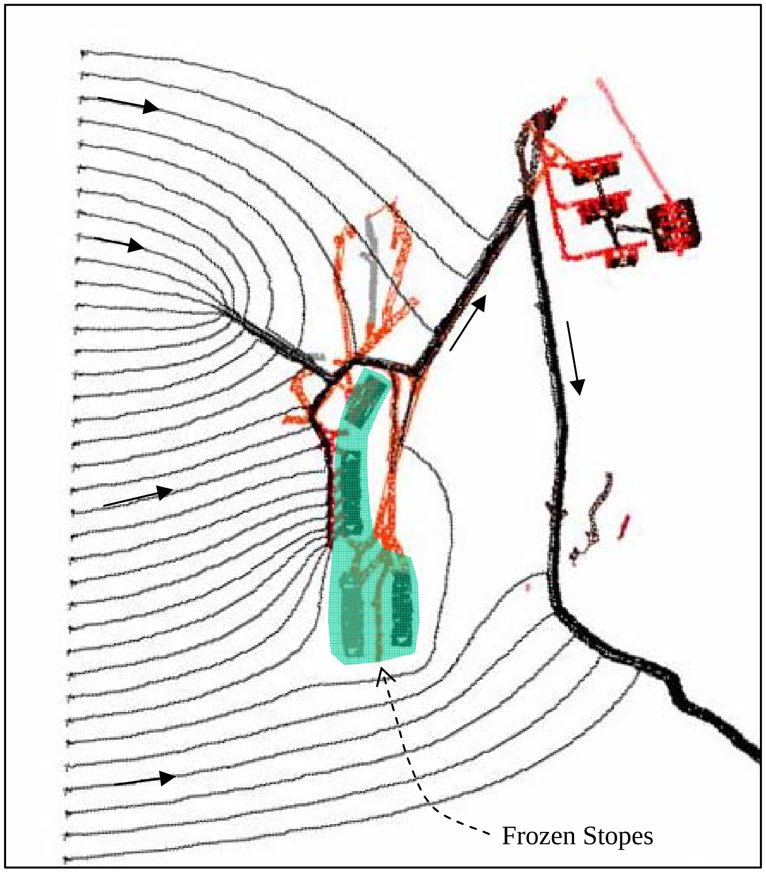

Fig 12b. Frozen Block Model

($K_{frozen\ block}$ = 0.0001 $K_{bedrock}$)

NOTE: Tunnels around stopes simplified

K_{tunnel} = 1×10^{10} x $K_{bedrock}$

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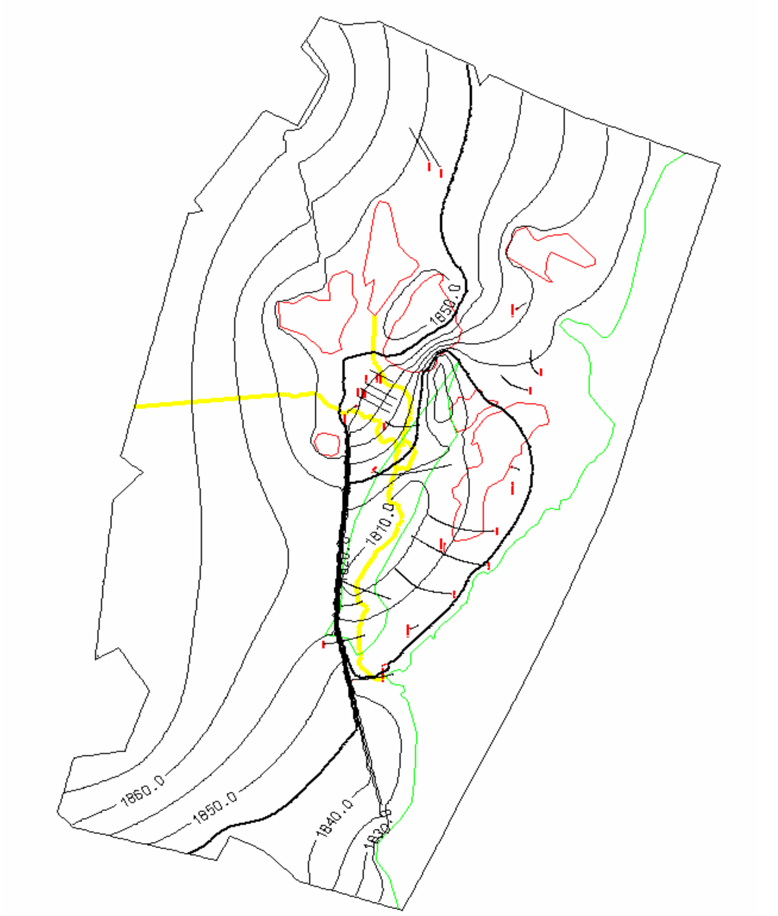
Giant Mine Remediation Project
Groundwater Modelling

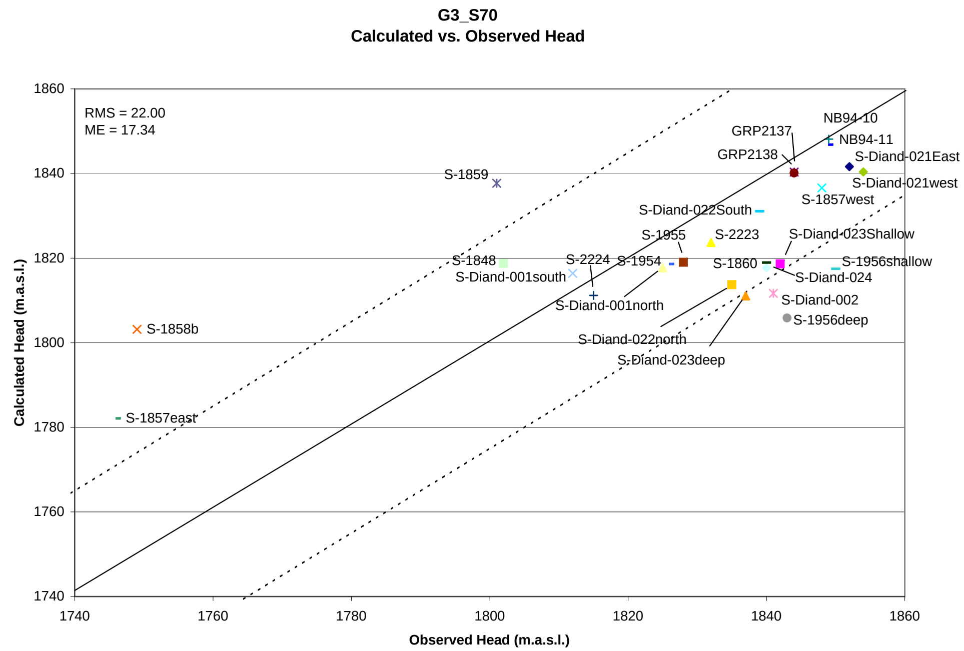
Frozen Chamber Pathline Comparison

(Full Reflood Scenario)

PROJECT:	DATE:	APPROVED:	FIGURE:
1CI001.12.B77	July 2005	MDR	12

Appendix A
Model Output Files





Conductivity							
Zone	Bedrock Layers	Kh	Kv	Faults WB	Wb min	TS	
1	1	5.00E-06	5.00E-07	5.01E-08	1.005E-11	1.02E-08	Akaitcho
	2	1.00E-06	1.00E-07	5.01E-08	1.005E-11	1.02E-08	and
	3	1.00E-08	1.00E-08	5.01E-08	1.005E-11	1.02E-08	Rudolph
2	4-9	1.00E-09	1.00E-09	5.01E-10	5.005E-12	1.02E-10	= bedrock K
3	9-14	1.00E-10	1.00E-10	5.01E-11	5.005E-13	1.02E-11	
Mine Envelope		Layers 1	5.00E-06	Layer 2	1.00E-06		
NWP		Layers 1-2	1.00E-06				

Water Balance (all values m3/d unless noted)

	m3/d	mm/yr	% avg annual
Total Rech/Precip	863.2		
Outside Drill Envelope		7.3	2.5%
Inside Drill Envelope		52	18.1%
NWP Flux	790	416	
Settl/Polish Pond	52	39	
Great Slave Lake	-392		
Ext bound GW flow	869		
Tunnel inflow	-1318		

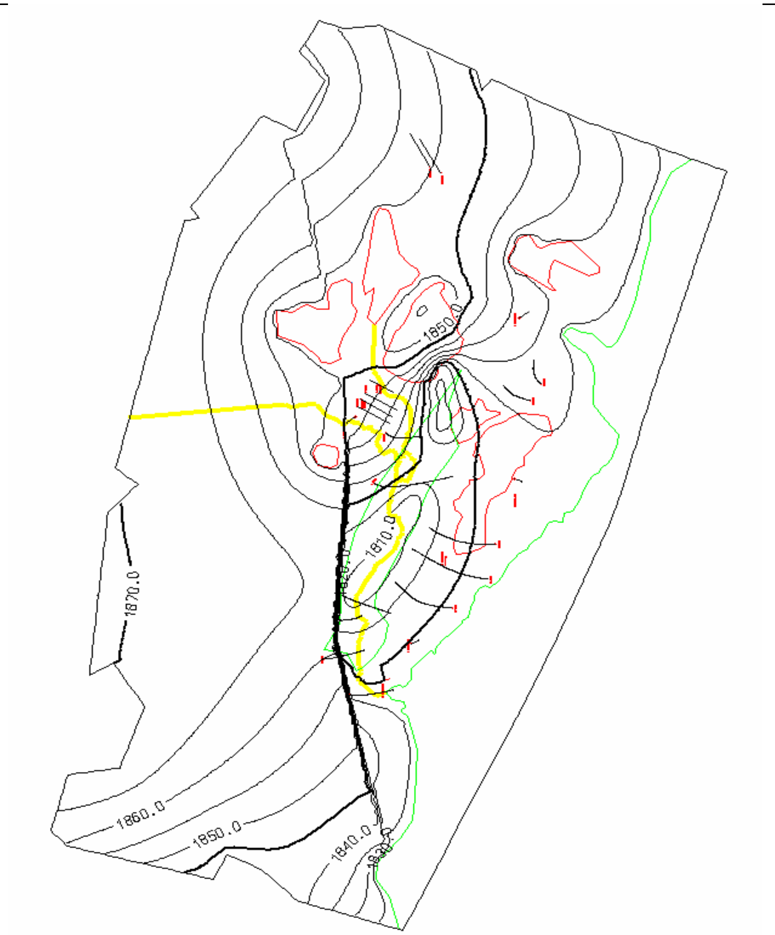
Total In	**1625.5**
Total Out	**-3330.7**
Total Rech	**1705.2**
Imbalance	**0**
% of Total out	**0.00%**

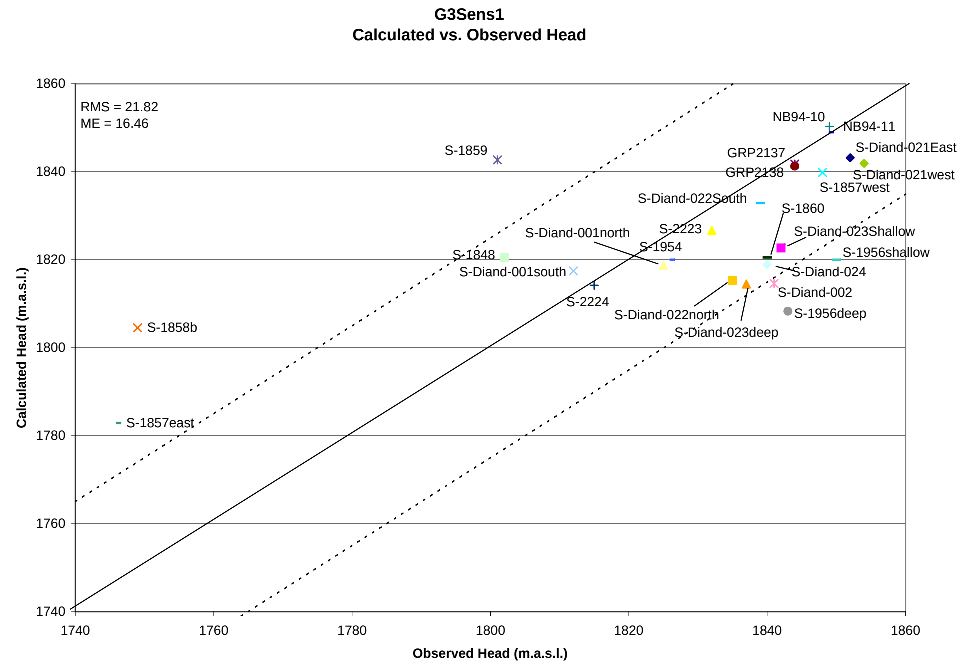
Current Conditions model

Anisotropic bedrock K in shallow layers (exfoliation)

No Mounding above ground surface in area of mine
Drawdown cone shallow (100L dry in central areas only)

G3S70





			Conductivity				
Zone	**Bedrock Layers**	**Kh**	**Kv**	**Faults WB**	**Wb min**	**TS**	
1	1	5.00E-06	5.00E-07	5.01E-08	1.005E-11	1.02E-08	Akaitcho
	2	1.00E-06	1.00E-07	5.01E-08	1.005E-11	1.02E-08	and
	3	1.00E-08	1.00E-08	5.01E-08	1.005E-11	1.02E-08	Rudolph
2	4-9	1.00E-09	1.00E-09	5.01E-10	5.005E-12	1.02E-10	= bedrock K
3	9-14	1.00E-10	1.00E-10	5.01E-11	5.005E-13	1.02E-11	
Drill Envelope		Layers 1	5.00E-06	Layer 2	1.00E-06		
NWP		Layers 1-2	1.00E-06				

Water Balance (all values m3/d unless noted)

	m3/d	mm/yr	% avg annual
Total Rech/Precip	3010		
Outside Drill Envelope		**30**	10.4%
Inside Drill Envelope		**30**	10.4%
NWP Flux	790	416	
Settl/Polish Pond	52	39	
Great Slave Lake	-811		
Ext bound GW flow	-969		
Tunnel inflow	-1446		

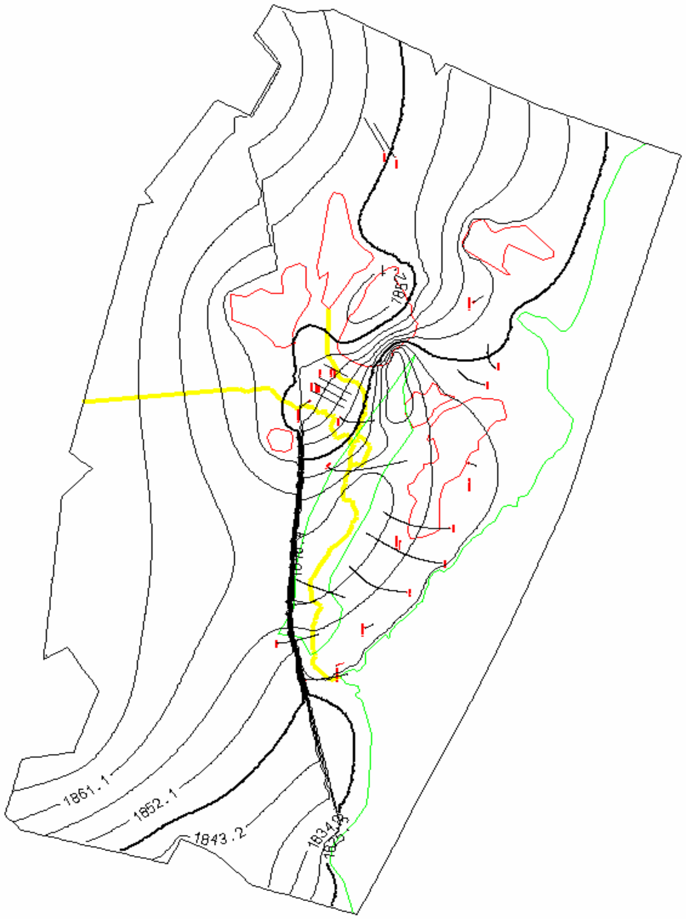
Total In	**933.7**
Total Out	**-4785.9**
Total Rech	**3851.9**
Imbalance	**-0.3**
% of Total out	**0.01%**

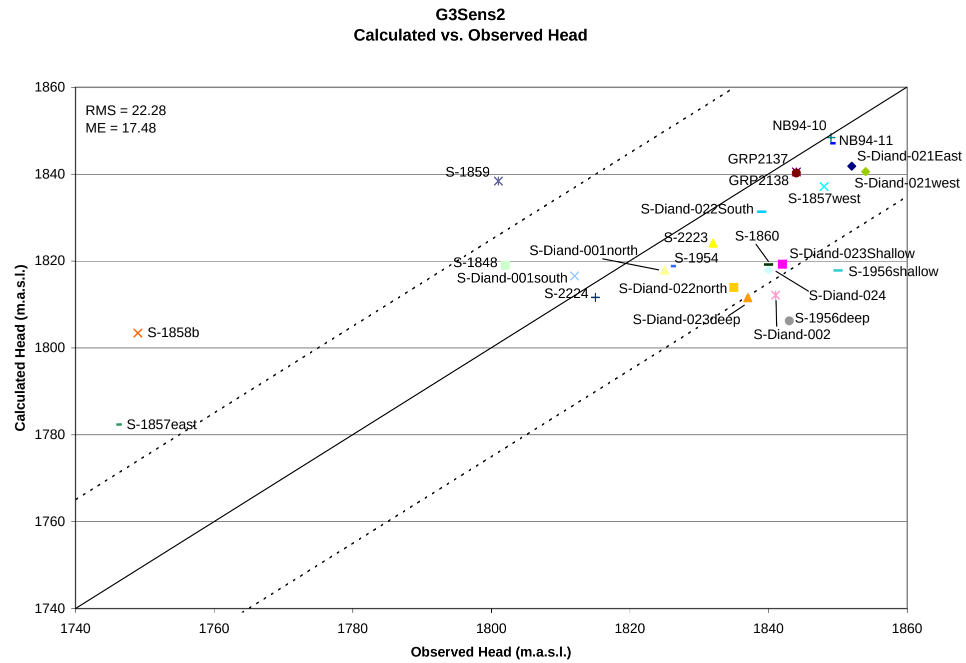
Sensitivity Run - G3S70 base model
High Regional Recharge

Anisotropic bedrock K in shallow layers (exfoliation)

No Mounding above ground surface in area of mine
Drawdown cone shallow (100L dry in central areas only)

G3Sens1





Conductivity							
Zone	Bedrock Layers	Kh	Kv	Faults WB	Wb min	TS	
1	1	5.00E-06	5.00E-07	5.01E-08	1.005E-11	1.02E-08	Akaitcho
	2	1.00E-06	1.00E-07	5.01E-08	1.005E-11	1.02E-08	and
	3	1.00E-08	1.00E-08	5.01E-08	1.005E-11	1.02E-08	Rudolph
2	4-9	1.00E-09	1.00E-09	5.01E-10	5.005E-12	1.02E-10	= bedrock K
3	9-14	1.00E-10	1.00E-10	5.01E-11	5.005E-13	1.02E-11	
Drill Envelope		Layers 1	5.00E-06	Layer 2	1.00E-06		
NWP		Layers 1-2	1.00E-06				

Sensitivity Run - G3S70 base model

High Regional Recharge

Anisotropic bedrock K in shallow layers (exfoliation)

No Mounding above ground surface in area of mine

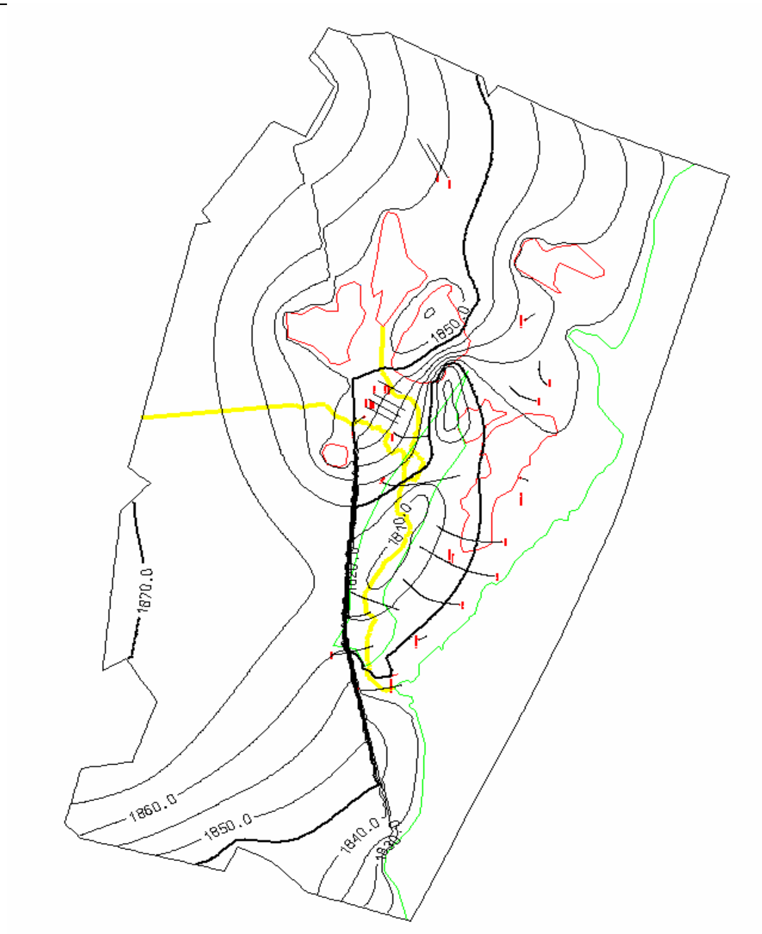
Drawdown cone shallow (100L dry in central areas only)

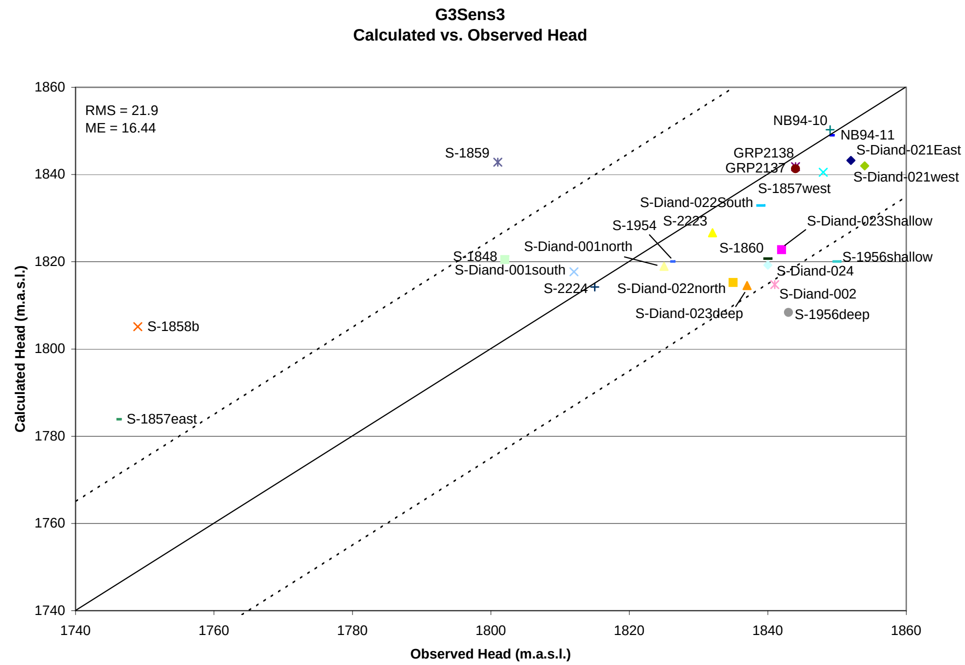
G3Sens2

Water Balance (all values m3/d unless noted)

	m3/d	mm/yr	% avg annual
Total Rech/Precip	1168		
Outside Drill Envelope		**10.5**	3.6%
Inside Drill Envelope		52	18.1%
NWP Flux	790	416	
Settl/Polish Pond	52	39	
Great Slave Lake	-477		
Ext bound GW flow	738		
Tunnel inflow	-1342		

Total In	**1514.9**
Total Out	**-3525.1**
Total Rech	**2010**
Imbalance	**-0.2**
% of Total out	**0.01%**





Sensitivity Run - G3S70 base model
High Regional Recharge

Anisotropic bedrock K in shallow layers (exfoliation)

No Mounding above ground surface in area of mine
Drawdown cone shallow (100L dry in central areas only)

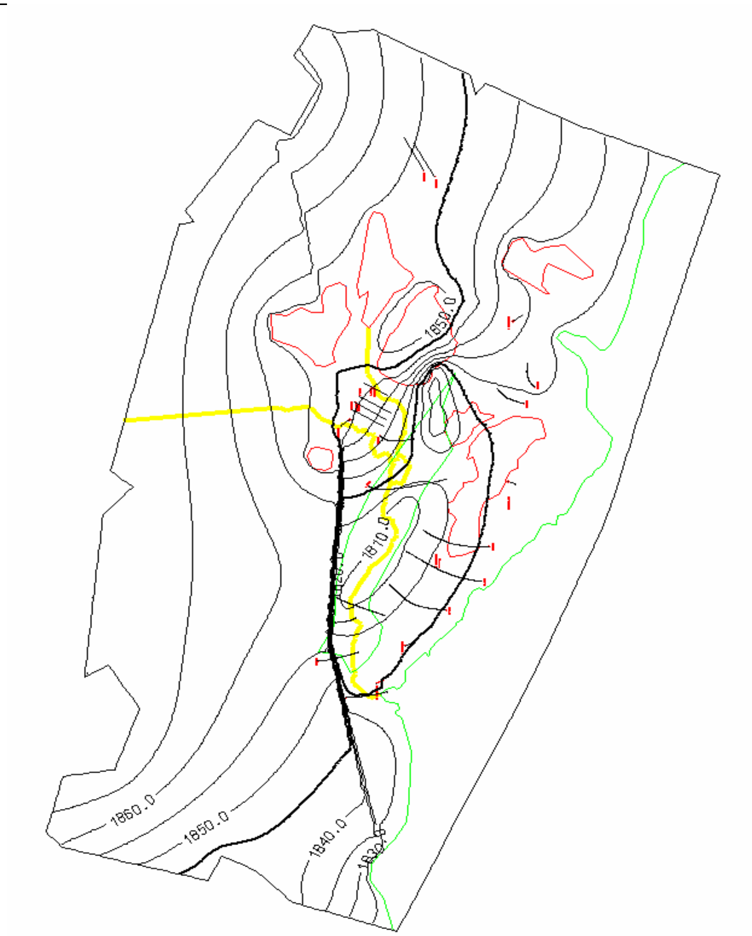
G3Sens3

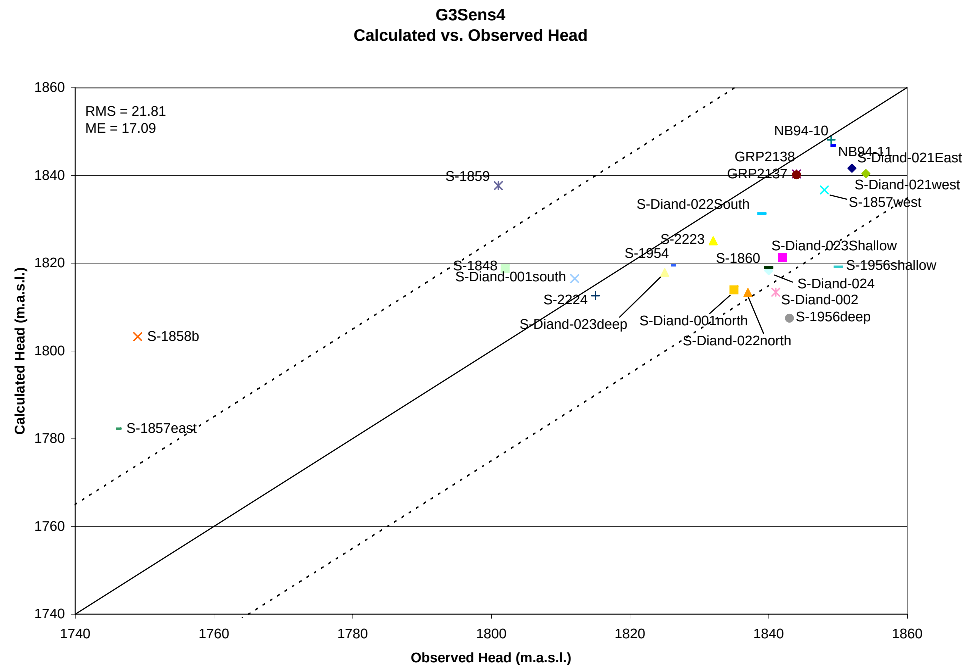
Conductivity							
Zone	**Bedrock Layers**	**Kh**	**Kv**	**Faults WB**	**Wb min**	**TS**	
1	1	5.00E-06	5.00E-07	5.01E-08	1.005E-11	1.02E-08	Akaitcho
	2	1.00E-06	1.00E-07	5.01E-08	1.005E-11	1.02E-08	and
	3	1.00E-08	1.00E-08	5.01E-08	1.005E-11	1.02E-08	Rudolph
2	4-9	1.00E-09	1.00E-09	5.01E-10	5.005E-12	1.02E-10	= bedrock K
3	9-14	1.00E-10	1.00E-10	5.01E-11	5.005E-13	1.02E-11	
Drill Envelope		Layers 1	5.00E-06	Layer 2	1.00E-06		
NWP		Layers 1-2	1.00E-06				

Water Balance (all values m3/d unless noted)

	m3/d	mm/yr	% avg annual
Total Rech/Precip	3065		
Outside Drill Envelope		**30**	10.4%
Inside Drill Envelope		52	18.1%
NWP Flux	790	416	
Settl/Polish Pond	52	39	
Great Slave Lake	-1007		
Ext bound GW flow	-76		
Tunnel inflow	-1492		

Total In	**931.2**
Total Out	**-4838.4**
Total Rech	**3906.9**
Imbalance	**-0.3**
% of Total out	**0.01%**





G3Sens4

Sensitivity Run - G3S70 base model

High Recharge Zone to east of mine workings (30mm/yr)

Anisotropic bedrock K in shallow layers (exfoliation)

No Mounding above ground surface in area of mine
Drawdown cone shallow (100L dry in central areas only)

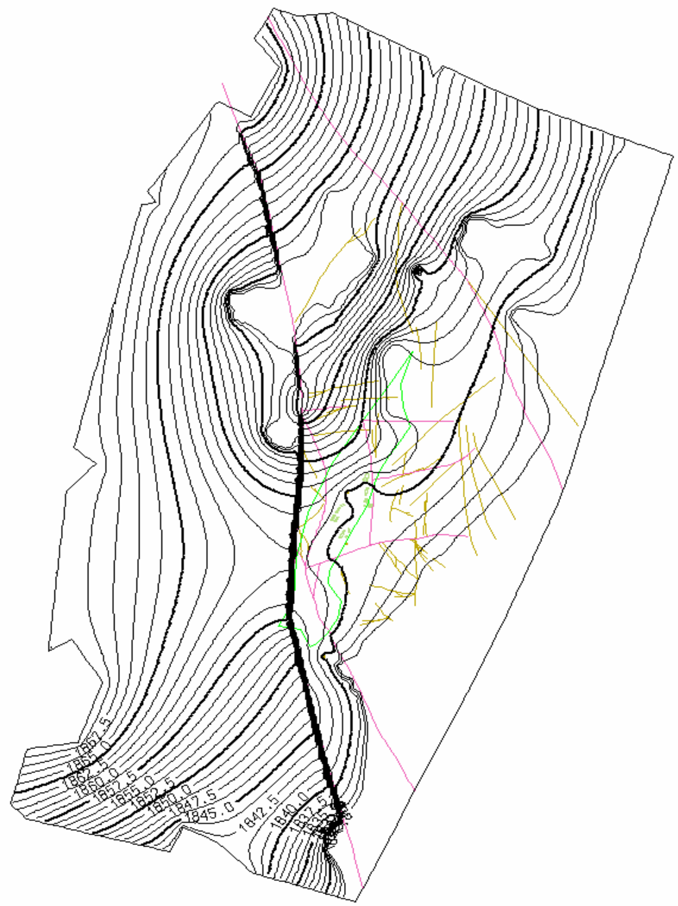
Conductivity

Zone	Bedrock Layers	Kh	Kv	Faults WB	Wb min	TS	
1	1	5.00E-06	5.00E-07	5.01E-08	1.005E-11	1.02E-08	Akaitcho
	2	1.00E-06	1.00E-07	5.01E-08	1.005E-11	1.02E-08	and
	3	1.00E-08	1.00E-08	5.01E-08	1.005E-11	1.02E-08	Rudolph
2	4-9	1.00E-09	1.00E-09	5.01E-10	5.005E-12	1.02E-10	= bedrock K
3	9-14	1.00E-10	1.00E-10	5.01E-11	5.005E-13	1.02E-11	
Drill Envelope		Layers 1	5.00E-06	Layer 2	1.00E-06		
NWP		Layers 1-2	1.00E-06				

Water Balance (all values m3/d unless noted)

	m3/d	mm/yr	% avg annual
Total Rech/Precip	985		
Outside Drill Envelope		7.5	2.6%
Inside Drill Envelope		52	18.1%
NWP Flux	790	416	
Settl/Polish Pond	52	39	
Great Slave Lake	-476		
Ext bound GW flow	865		
Tunnel inflow	-1348		

Total In	**1590.4**
Total Out	**-3417.5**
Total Rech	**1827**
Imbalance	**-0.1**
% of Total out	**0.00%**



G3S70 model base - *reflood version*

Tunnels input as high K discrete elements

Tunnel-controlled flow system

G3refloodbase

OBSERVATION POINT WATER LEVELS

Level	Geographic Location North	Central	South
100L	1825.56	1825.38	1825.00
250L	1825.56		1825.25
450L	1825.38		1825.10
590L	1825.49		1825.11
750L	1825.49		1825.13
950L	1825.42		1825.28
1100L	1825.47	1825.37	1825.33
1250L	1825.36		1825.33
1500L	1825.45	1825.35	1825.33
1650L	1825.35		1825.33
2000L	1825.35	1825.33	
2000L east-under GSL			1825.33

Spill Point Elevation = 1825m
A2 pit rim - natural spill point

Max head	1825.56
Min head	1825.00
stdev	0.14

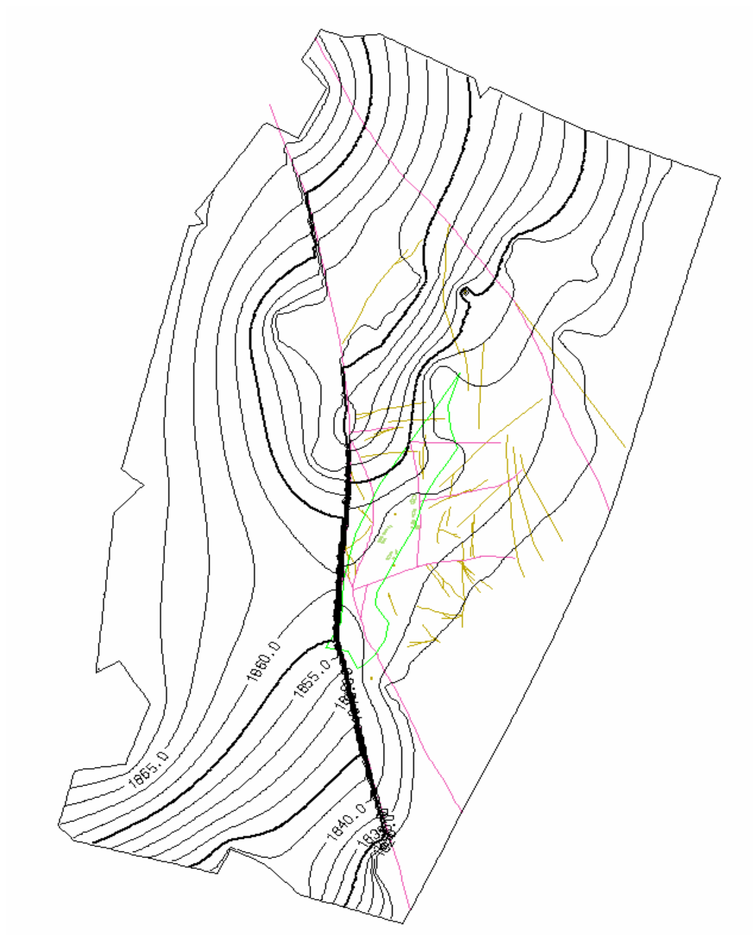
Tunnel conductivity = 1 x 10^{0} m/s

Conductivity							
Zone	**Bedrock Layers**	**Kh**	**Kv**	**Faults WB**	**Wb min**	**TS**	
1	1	5.00E-06	5.00E-07	5.01E-08	1.005E-11	1.02E-08	Akaitcho
	2	1.00E-06	1.00E-07	5.01E-08	1.005E-11	1.02E-08	and
	3	1.00E-08	1.00E-08	5.01E-08	1.005E-11	1.02E-08	Rudolph
2	4-9	1.00E-09	1.00E-09	5.01E-10	5.005E-12	1.02E-10	= bedrock K
3	9-14	1.00E-10	1.00E-10	5.01E-11	5.005E-13	1.02E-11	
Drill Envelope		Layers 1	5.00E-06	Layer 2	1.00E-06		
NWP		Layers 1-2	1.00E-06				

Water Balance (all values m3/d unless noted)

	m3/d	mm/yr	% avg annual
Total Rech/Precip	862.2		
Outside Drill Envelope		7.3	2.5%
Inside Drill Envelope		52	18.1%
NWP Flux	Part of recharge		
Settl/Polish Pond	Part of recharge		
Great Slave Lake	-647.8		
Ext bound GW flow	860.8		
Spill Point Outflow	-517.5		

Total In	**1685**
Total Out	**-2546.7**
Total Rech	**862.2**
Imbalance	**0.5**
% of Total out	**-0.02%**



OBSERVATION POINT WATER LEVELS

Level	Geographic Location North	Central	South
100L	1825.56	1825.38	1825.00
250L	1825.56		1825.25
450L	1825.38		1825.10
590L	1825.49		1825.11
750L	1825.49		1825.13
950L	1825.41		1825.27
1100L	1825.46	1825.37	1825.32
1250L	1825.36		1825.33
1500L	1825.45	1825.35	1825.33
1650L	1825.35		1825.33
2000L	1825.35	1825.33	
2000L east-under GSL			1825.33

Spill Point Elevation = 1825m
A2 pit rim - natural spill point

Max head	1825.56
Min head	1825.00
stdev	0.14

Tunnel conductivity = 1 x 10^{0} m/s

Zone	Bedrock Layers	Kh	Kv	Faults WB	Wb min	TS	
Conductivity							
1	1	5.00E-06	5.00E-07	5.01E-08	1.005E-11	**1.00E-05**	Akaitcho
	2	1.00E-06	1.00E-07	5.01E-08	1.005E-11	**1.00E-05**	and
	3	1.00E-08	1.00E-08	5.01E-08	1.005E-11	**1.00E-05**	Rudolph
2	4-9	1.00E-09	1.00E-09	5.01E-10	5.005E-12	**1.00E-05**	= bedrock K
3	9-14	1.00E-10	1.00E-10	5.01E-11	5.005E-13	**1.00E-05**	
Drill Envelope		Layers 1	5.00E-06	Layer 2	1.00E-06		
NWP		Layers 1-2	1.00E-06				

G3S70 model base - Reflood version

High K Townsite Fault

Fault K = 1x10^{-5} m/s

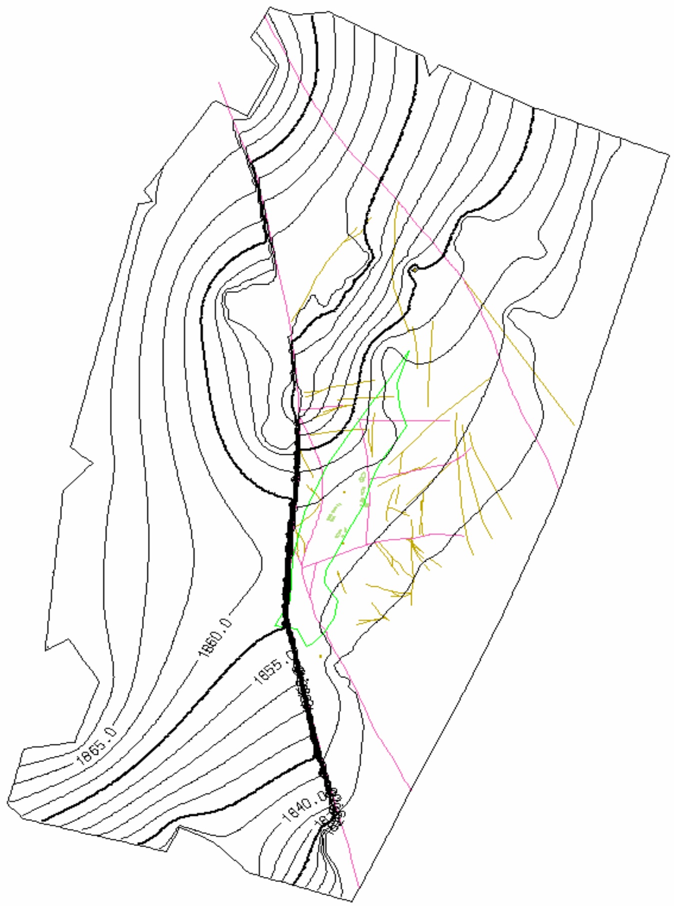
Tunnels input as high K discrete elements
Tunnel-controlled flow system

G3EC1

Water Balance (all values m3/d unless noted)

	m3/d	mm/yr	% avg annual
Total Rech/Precip	862.2		
Outside Drill Envelope		7.3	2.5%
Inside Drill Envelope		52	18.1%
NWP Flux	Part of recharge		
Settl/Polish Pond	Part of recharge		
Great Slave Lake	-658.2		
Ext bound GW flow	862.7		
Spill Point Outflow	-507.8		

Total In	**1686.1**
Total Out	**-2547.8**
Total Rech	**862.2**
Imbalance	**0.5**
% of Total out	**-0.02%**



OBSERVATION POINT WATER LEVELS

	Geographic Location		
Level	North	Central	South
100L	1826.94	1826.17	1825.00
250L	1826.90		1825.75
450L	1826.19		1825.29
590L	1826.71		1825.32
750L	1826.68		1825.38
950L	1826.35		1825.85
1100L	1826.59	1826.20	1826.02
1250L	1826.16		1826.03
1500L	1826.54	1826.11	1826.04
1650L	1826.11		1826.05
2000L	1826.11	1826.05	
		2000L east-under GSL	1826.05

Spill Point Elevation = 1825m
A2 pit rim - natural spill point

Max head	1826.94
Min head	1825.00
stdev	0.48

Tunnel conductivity = 1 x 10^0 m/s

Conductivity							
Zone	**Bedrock Layers**	**Kh**	**Kv**	**Faults WB**	**Wb min**	**TS**	
1	1	**1.00E-05**	**1.00E-06**	5.01E-08	1.005E-11	1.02E-08	Akaitcho
	2	**1.00E-05**	**1.00E-06**	5.01E-08	1.005E-11	1.02E-08	and
	3	1.00E-08	1.00E-08	5.01E-08	1.005E-11	1.02E-08	Rudolph
2	4-9	1.00E-09	1.00E-09	5.01E-10	5.005E-12	1.02E-10	= bedrock K
3	9-14	1.00E-10	1.00E-10	5.01E-11	5.005E-13	1.02E-11	
Drill Envelope		Layers 1	5.00E-06	Layer 2	1.00E-06		
NWP		Layers 1-2	1.00E-06				

G3S70 model base - reflood version

High K Layers 1 and 2

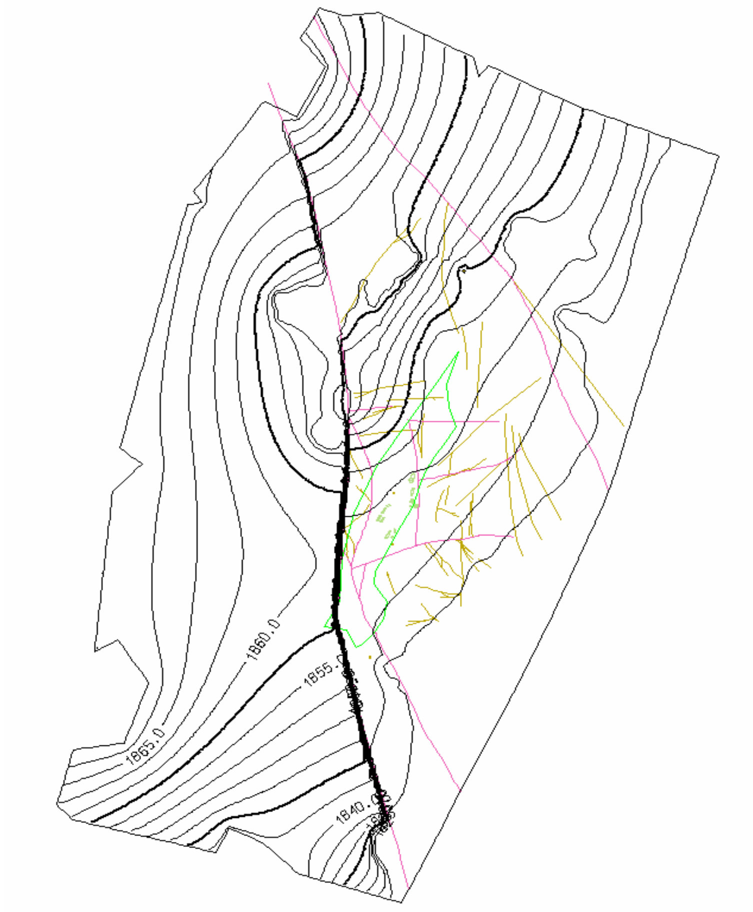
Tunnels input as high K discrete elements
Tunnel-controlled flow system

G3EC2

Water Balance (all values m3/d unless noted)

	m3/d	mm/yr	% avg annual
Total Rech/Precip	862.2		
Outside Drill Envelope		7.3	2.5%
Inside Drill Envelope		52	18.1%
NWP Flux	Part of recharge		
Settl/Polish Pond	Part of recharge		
Great Slave Lake	-1610.2		
Ext bound GW flow	3510.8		
Spill Point Outflow	-1474.4		

Total In	**6584.6**
Total Out	**-7449.5**
Total Rech	**862.2**
Imbalance	**-2.7**
% of Total out	**0.04%**



G3S70 model base - reflood version

High K Layers 1 thru 3

Tunnels input as high K discrete elements
Tunnel-controlled flow system

G3EC3

OBSERVATION POINT WATER LEVELS

Level	Geographic Location North	Central	South
100L	1828.55	1827.05	1825.00
250L	1828.55		1826.30
450L	1827.13		1825.50
590L	1828.12		1825.56
750L	1828.06		1825.67
950L	1827.43		1826.50
1100L	1827.89	1827.16	1826.81
1250L	1827.07		1826.84
1500L	1827.79	1826.98	1826.84
1650L	1826.99		1826.87
2000L	1826.98	1826.87	
2000L east-under GSL			1826.87

Spill Point Elevation = 1825m
A2 pit rim - natural spill point

Max head	1828.55
Min head	1825.00
stdev	0.89

Tunnel conductivity = 1 x 10^0 m/s

Conductivity

Zone	Bedrock Layers	Kh	Kv	Faults WB	Wb min	TS	
1	1	**1.00E-05**	**1.00E-06**	5.01E-08	1.005E-11	1.02E-08	Akaitcho
	2	**1.00E-05**	**1.00E-06**	5.01E-08	1.005E-11	1.02E-08	and
	3	**1.00E-05**	**1.00E-06**	5.01E-08	1.005E-11	1.02E-08	Rudolph
2	4-9	1.00E-09	1.00E-09	5.01E-10	5.005E-12	1.02E-10	= bedrock K
3	9-14	1.00E-10	1.00E-10	5.01E-11	5.005E-13	1.02E-11	
Drill Envelope		Layers 1	5.00E-06	Layer 2	1.00E-06		
NWP		Layers 1-2	1.00E-06				

Water Balance (all values m3/d unless noted)

	m3/d	mm/yr	% avg annual
Total Rech/Precip	862.2		
Outside Drill Envelope		7.3	2.5%
Inside Drill Envelope		52	18.1%
NWP Flux	Part of recharge		
Settl/Polish Pond	Part of recharge		
Great Slave Lake	-2196.9		
Ext bound GW flow	6116.7		
Spill Point Outflow	-2564		

Total In	**11504.8**
Total Out	**-12370.9**
Total Rech	**862.2**
Imbalance	**-3.9**
% of Total out	**0.03%**