Appendix F12

KSM Open Pit Depressurization

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Dear Mr. Smolik,

Re: KSM Project 2012 Pre-Feasibility Study Update: Open Pit Depressurization

Seabridge Gold Inc. (Seabridge) is completing a Pre-Feasibility Study Update (PFSU) for the Kerr-Sulphurets-Mitchell (KSM) project in northwestern BC. As a part of this update, new open pit shells were developed by Moose Mountain Technical Services (MMTS) for the Mitchell, Sulphurets, and Kerr zones; an open pit is no longer being considered for the Iron Cap zone. These pit shells were used to evaluate and update the depressurization recommendations provided to Seabridge as part of the 2011 PFS (BGC, 2011a). This letter report summarizes the available data, methods used, and the results of our analysis.

1.0 PROJECT BACKGROUND

The KSM Project is a large copper gold deposit located approximately 65 km north of Stewart, B.C. in a historically active mining region. BGC Engineering Inc. (BGC) has contributed to a Scoping Study and a Pre-Feasibility Study in 2009 and 2010/2011 respectively. A PFSU is currently underway and expected to be complete June 2012. As part of the PFSU, BGC carried out open pit slope design updates (BGC, 2012a). This report summarizes the open pit depressurization analyses to complement open pit slope geotechnical design studies for the PFSU.

The PFSU mine plan includes four main zones that are to be mined using a combination of block cave and open pit mining methods. For the Mitchell zone a combination of open pit and block caving methods are planned, while in the Sulphurets and Kerr Zones only open pit methods are planned. The block cave for the Mitchell zone will follow the completion of the open pit, extending the depth of the resource extraction 180 m below the final pit floor to an elevation of 235 masl. In the Iron Cap zone only block caving methods will be employed. The elevation of the resource extraction for the Iron Cap zone is to be 1,210 masl, approximately 440 m to 200 m below ground; the existing topography in the Iron Cap zone ranges from 1,650 to 1,410 masl.

The proposed Mitchell ultimate (final phase) open pit geometry has changed significantly from the last stage of study, as a result of the addition of the block cave below the ultimate pit. The total mined height of the north wall has been reduced from 1,650 m to 1,200 m. The heights of the other final walls have also been reduced. The currently proposed Mitchell ultimate pit will be mined to a final depth of 400 meters above sea level (masl), as opposed to 230 masl in the last study; the existing valley bottom ranges from 800 to 1,000 masl. The footprint and geometry of both the proposed Sulphurets and Kerr pits have minor changes from the open pits of the 2011 PFSU. In the previous PFS study, the Iron Cap zone was to be mined as an open pit to a final depth of 1,100 masl.

In addition to changes to the open pits, pit development sequencing and timing has also changed from the 2011 PFSU.

2.0 PAST AND CURRENT WORK

BGC compiled hydrogeologic data collected by BGC, Klohn Crippen Berger Limited (KCBL) and Rescan Environmental Services Limited (Rescan) in the vicinity of the proposed open pits during the 2008, 2009, and 2010 field seasons and formulated a conceptual hydrogeologic model for the project area in the vicinity of the open pits. A numerical hydrogeologic model was developed using MODFLOW Surfact (HydroGeoLogic, 1998) to carry out PFS-level depressurization studies, documented in BGC 2011a, to support open pit slope design recommendations (BGC 2011b, BGC 2011c, BGC 2011d, BGC 2011e).

A 2011 site investigation was carried out by KCBL in the mine area, which focused on data collection at the Mitchell Glacier, West McTagg Glacier, and Water Storage Dam (KCBL, 2012), and included seismic surveys to help characterize foundations of several mine facilities. With the exception of a few measurements taken by KCBL in 2011, groundwater elevation data was not collected during 2011. The available 2011 KCBL data was reviewed and changes to the existing BGC conceptual and numerical model developed for pit depressurization in 2011 were not warranted. Therefore, the existing model was used to carry out simulations using the March 2012 open pit mining plans.

The primary goal of the current study was to evaluate depressurization of the 2012 PFSU open pits. Estimates of the required number of vertical dewatering wells, adits and horizontal drains required to achieve sufficient depressurization of the rock mass, as well as associated groundwater extraction rates are provided. Recommendations for pumping well design and staging are provided to assist Seabridge with estimating pre-feasibility level project costs.

An additional goal of the groundwater modeling study was to estimate groundwater inflows to the block caves. Golder Associates (Golder) is responsible for the block cave mine planning and sequencing. Surface water management and dewatering of the underground workings will be required during block cave mining, and will be addressed for this PFSU by Golder and KCBL. As mentioned above, block cave mining will begin when open pit mining is complete at Mitchell. Active depressurization of the Mitchell pit slopes will cease when block cave mining commences, because the slopes will no longer be safely accessible (Golder, 2012a; personal communication March 2012 with Ross Hammett from Golder Associates), and slope depressurization will no longer be required. Therefore, depressurization recommendations for Mitchell Pit are only considered up to the end of open pit mining. Groundwater inflows to the Iron Cap block cave and Mitchell Pit and block cave are provided for the period after open pit mining is complete in these zones.

3.0 CONCEPTUAL HYDROGEOLOGIC MODEL

3.1. Current Conditions

Surface topography can be expected to have a pervasive influence on the underlying mountain groundwater flow system (Forster and Smith, 1988). The elevation of the site ranges from approximately 520 meters in Sulphurets Creek valley to over 2,300 meters at the highest peaks. Valley glaciers fill the upper portions of the larger valleys (see Drawing 2) from just below the tree line, which lies at about 1,240 masl, and upwards.

Measured groundwater elevations suggest that the water table is a subdued replica of topography, with depths to groundwater typically being greater in the uplands relative to the valley bottoms. Groundwater enters the flow system from infiltration of precipitation and snowmelt, with lesser components supplied by surface water infiltration in creeks and gullies.

The hydrostratigraphy of the site is composed of a thin layer (typically less than 10 m thick) of glacial till or colluvium underlain by bedrock (see Drawing 3 of BGC 2011a). The geometric mean of hydraulic conductivity data available for these overburden units is $2x10^{-7}$ m/s. Thicker overburden deposits are confined to local sections of the valley bottom and are not present in the vicinity of the proposed open pits.

Site wide, a general trend of decreasing bedrock hydraulic conductivity with depth has been observed, although the hydraulic conductivity varies by typically three to four orders of magnitude at any given depth. The existing data set suggests that variations in hydraulic conductivity observed at a given depth interval within the Mitchell pit area appear to be more strongly influenced by location relative to the Mitchell Thrust Fault (MTF). Likewise, within the Sulphurets Pit area, bedrock hydraulic conductivity may be influenced by location relative to the Sulphurets Thrust Fault (STF) as the geometric mean of test results for bedrock above the STF is approximately an order of magnitude higher than test results below the STF (BGC, 2011a).

The hydrogeologic system is dominated by fractured bedrock formations with overburden in the valley bottoms playing a minor role. Groundwater seeps are common on the valley slopes (Rescan, 2010a and 2010b). Permafrost may be present at higher elevations (greater than 1600 masl on north facing slopes and greater than 1750 or 1850 masl on all slopes) within the study area (BGC, 2011f) and could limit groundwater recharge and flow within these areas. However, the limited data available to date suggests permafrost is not present in the pit areas. Therefore, permafrost has not been distinguished or included in the conceptual model (and groundwater model).

The project area is drained by Sulphurets Creek into the Unuk River. Approximately 38% of the Sulphurets Creek watershed is glacier covered, and the surface water hydrologic system is described as primarily a glacier-augmented system (Rescan, 2010c). Although sub-glacial groundwater flow has been documented in several geographic locations (Sigurdsson, 1990), little work has been done on glacier-scale groundwater flow, and models to date in the literature have not included coupled subglacial-subsurface drainage (Flowers and Clark, 2002). Rates of basal melting are unlikely to exceed the range of 1 mm/yr to 100 mm/yr over extended time periods, whereas surface melting rates in ablation areas are typically up to four orders of magnitude greater (1,000 mm/yr to 10,000 mm/yr; Boulton et al., 1995). Therefore it was assumed that a relatively low rate of recharge would infiltrate under the glacier covered areas (see Section 4.2).

3.2. Open Pit Dewatering and Depressurization

Slope stability analyses of the Mitchell, Kerr, and Sulphurets pits indicate that specific depressurization targets must be achieved at the bench and interramp scales (BGC, 2012a). Depressurization goals are listed in Appendix A for geotechnical design sectors for each pit. In general, full depressurization must be attained for an area extending approximately 50 m behind the excavated slope face. In addition, depressurization of the overall pit slope to minimize the potential for rock mass failure is required for the north wall of the Mitchell pit (BGC, 2012a). These depressurization requirements for the north wall of Mitchell pit translate to the need for the water table to be set back 150 m to 200 m from the pit face.

The proposed Mitchell open pit spans the Mitchell valley (Drawing 2), and planned pit excavations reach a maximum depth of approximately 500 m below current ground surface. Therefore, it is expected that perimeter wells, while they typically have a long life and are desirable in that respect, will have limited impacts to dewatering later in the mine life. As a result (and consistent with the 2011 analysis), in-pit wells and horizontal drains are proposed to achieve the bench and interramp scale Mitchell pit depressurization. In-pit horizontal drains will be especially important at depths below the MTF within the pit (elevations lower than approximately 1,100 masl on the south side of Mitchell valley, and elevations lower than approximately 900 masl on the north side of Mitchell valley), to intercept groundwater flows to the pit where the bedrock hydraulic conductivity is low and where vertical wells will be less effective.

To achieve the depressurization goals of the upper north slope of Mitchell Pit, the results from previous simulations (BGC, 2011a) suggest that an adit and drainage gallery will be required. The topography allows for a dewatering adit to be constructed from the valley bottom, extending from the east to the west side of the north wall of the ultimate Mitchell Pit.

The Sulphurets and Kerr pits are located high on mountain ridges and slopes; the planned pit excavations reach maximum depths below current ground surface of approximately 400 m and 300 m, respectively. Based on previous simulation results (BGC, 2011a), it is expected that a combination of vertical in-pit wells and horizontal drains will be capable of achieving the depressurization targets for these pits.

3.3. Block Cave Groundwater Inflows

Caving (block caving, sub-level caving) below an operating or end-of-life open pit is proposed or underway for several of the largest mines in the world including: Chuquicamata, Bingham Canyon, Grasberg, and Palabora. BGC reviewed the published literature to develop a description of the ground deformations associated with a combined open pit and cave mine plan (BGC, 2012b). The conceptual model of the ground deformation associated with an open pit and block cave is found in Figure 1, and can be broadly divided based on the extent and magnitude of the ground disturbance observed into two zones (Butcher and Jenkins, 2006):

1. “Micro-deformation” zone
2. “Macro-deformation” zone

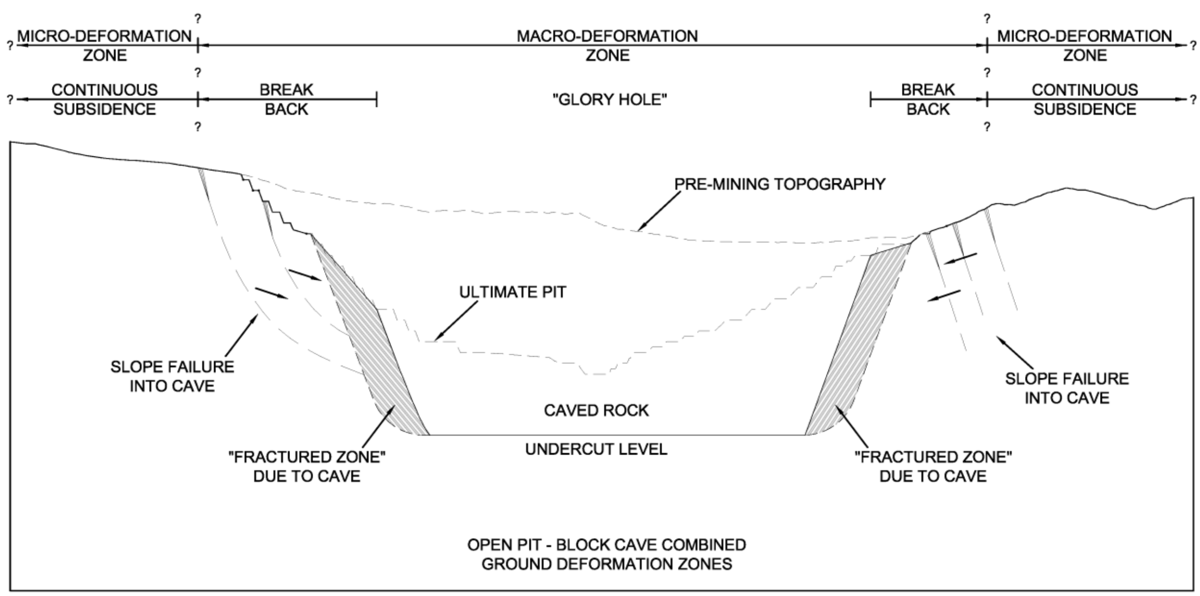

Figure 1. Conceptual model of the combined ground disturbance from a block cave developed below an open pit.

The micro-deformation zone is considered to be an area where little or no cracking of the ground is observed. Displacements due to the adjacent excavation are expressed as ground-tilting or "continuous" subsidence, where the ground is not disrupted by discrete cracks or down-dropped blocks. Ground displacements are expected to be a few meters or less, decreasing as the distance from the cave increases. This zone may extend hundreds of meters from the limit of the cave. The extent of the micro-deformation zone is not addressed in the current study (BGC, 2012b).

The macro-deformation zone, or "crater", includes the glory-hole above the undercut level and the area of break-back around the glory-hole limit. The area of break-back may be further divided into a "fractured" zone associated with the limits of the main cave area and an area of induced open pit slope relaxation or instability above the cave limits. The well documented failure of the Palabora open pit (Moss et al., 2006) is an example of features that may be found in the area of slope instability. The extent of the Mitchell glory hole has been estimated by Golder (Golder, 2012b). BGC estimated the ultimate limits of the macro-deformation zone in a separate assessment (BGC, 2012b). The conceptual Open Pit-Block Cave interaction model developed by BGC (BGC, 2012b) was adopted for the current study, and a literature review was carried out to try to define how the hydrogeologic material properties might change as a result of the ground deformations.

While a significant body of research and associated literature is becoming available regarding predictions of ground deformations associated with block caving below or adjacent to open pits, published works regarding the hydrogeology of the groundwater flow system are lacking. Several studies (Moss et al. 2006, Karzulovic et al. 1994, ICS, 2004) do, however, discuss the properties of the caved rock (see Figure 1), and suggest that storm runoff reports to the underground in such scenarios rapidly, indicating that the caved material becomes very permeable and may have a hydraulic conductivity of 10^{-2} to 10^{-1} m/s. Therefore it is assumed here that the open pit will act as a catch basin and runoff will immediately report to the cave and require management. These surface flows are not included in this groundwater study and BGC understands that these flows will be considered by KCBL and Golder in their design work.

Studies evaluating changes to the hydrogeologic material properties in the break-back zone were not found. Conceptually, the hydrogeologic properties of the fractured zone are likely similar to the caved material and the zone would drain rapidly. Because of the high deformations anticipated in the break-back zone, increased permeability (several orders of magnitude) and storage (due to fracture growth, etc.) are inferred to result. Material properties may be altered in the micro-deformation zone as well, but the extent of alteration was assumed to be negligible for this work.

4.0 PREDICTIVE DEPRESSURIZATION SIMULATIONS

4.1. Overview

Groundwater Vistas (version 5.41; ESI, 2007), a graphical user interface, was used to develop the MODFLOW Surfact groundwater flow model for the site (BGC, 2011a). MODFLOW is an industry standard three-dimensional (3-D), finite difference groundwater flow model developed by the U.S. Geological Survey (Harbaugh et al, 2000). The model utilized the add-on packages available in Surfact (Version 3.0; HydroGeoLogic, 1998) in order to simulate variably saturated flow and seepage faces. The 3-D groundwater flow model domain encompasses the area shown in Drawing 2. As discussed above, no changes to the conceptual hydrogeologic model for the project vicinity are warranted at this time and therefore revision of the 3-D numerical groundwater flow model previously developed for the KSM pit depressurization analyses (BGC, 2011a) was not required. The only changes to the model were to the boundary conditions of the predictive simulations for the open pits, wells, adit and gallery, and block cave, in order to reflect the new plans and sequencing. In addition, in order to evaluate potential groundwater inflows to the block caves, material properties of bedrock within the estimated Mitchell Pit break-back limits were altered. A detailed description of the numerical model can be found in BGC, 2011a; a brief description is provided below, together with descriptions of the modifications to boundary conditions and material properties for the predictive simulations.

4.2. Model Description

The model grid consists of 169 columns and 268 rows, covering an area of approximately 21.5 km by 18 km. Ten model layers discretize the domain in the vertical dimension for a total of approximately 452,900 grid blocks; 398,500 of which are active. Uniform 50 m by 50 m grid blocks were defined in the vicinity of the proposed open pits. The horizontal dimensions of grid blocks were expanded away from the pit area. In the vertical direction, the upper 425 m was divided into 5 layers increasing in thickness from 20 m in Layer 1 to 200 m in Layer 5. The underlying layers range from 50 m thick in the valley bottoms to 600 m thick below the ridge tops. The base of the model was set at a uniform elevation of 350 masl.

The hydraulic conductivity within the Mitchell pit and Sulphurets pit areas were distributed based on proximity to the Mitchell Thrust Fault and Sulphurets Thrust Fault, respectively, as well as depth. Outside of the proposed Mitchell and Sulphurets pit areas, hydraulic conductivity was assigned by bedrock group and to decrease with depth. Overburden was assigned to model layers 1 and 2 where it is interpreted to be thicker than 20 m. The values of hydraulic conductivity assigned to each hydrogeologic unit were initially based on the results of hydraulic testing, but were subsequently refined during model calibration, and are presented in Table 1.

Areal recharge was assigned to the water table to represent groundwater recharge from precipitation and runoff. To represent the anticipated orographic influence recharge was divided into four zones; valley, mid-slope, uplands, and glacier covered areas. Recharge rates applied to unglaciated areas increased from 128 mm/yr in the valleys to 218 mm/yr in the uplands. A relatively low rate of recharge of 40 mm/yr was applied to glacier covered areas.

Three types of boundary conditions were assigned to the pre-disturbance model domain: specified head boundaries, head-dependent boundaries and no-flow boundaries. Creeks within the model domain, including the Mitchell, McTagg, Ted Morris and Sulphurets Creek, were simulated using the River Package. Lakes lying within the model domain (i.e., Sulphurets and Bruce Jack Lake) were modeled using a specified-head boundary. The ridgelines located to the north, east, west and south of the active model domain were set as no-flow boundaries. These ridges represent inferred groundwater divides. Grid blocks lying outside of this region were deactivated within the model.

4.3. Simulations

Transient predictive simulations were performed using production pit shells provided by MMTS (2012) for twelve phases of the mine life: pre-production (years -2, and -1), years 1, 2, 3, 4, 5, 10, 20, 30, 40 and end of open pit mining (year 50). The progression of the open pits is shown on Drawings 3 and 4. Mining of the open pits occurs as follows:

- Mitchell is pre-stripped and mined from Year -2 to Year 23;
- Kerr is mined from Year 27 to Year 50; and
- Sulphurets is pre-stripped and mined from Years -2 to 6, and then from Year 21 to 27.

Footprints and elevations of the block cave mining plans at Mitchell Pit and Iron Cap were provided by Golder (2012b), and were also simulated as part of this work. Phases were not available for the block caves, which occur from Year 26 to 55 for Mitchell and from Year 32 to 51 for Iron Cap. In addition to the footprints, glory hole and fractured bedrock limits were provided by Golder (Golder, 2012b) and break-back limits were estimated by BGC (BGC, 2012b) (see Appendix E).

The goals of the simulations with respect to open pit depressurization were to:

- draw the water table down immediately behind the pit slopes to meet depressurization requirements, and
- estimate the total groundwater extraction rate required to depressurize the Mitchell, Kerr, and Sulphurets pit walls using vertical wells and/or other techniques.

The goal of the simulations with respect to block caving was to try to bracket the potential range of groundwater inflows to the block caves.

The results of the numerical simulations were used to estimate the number of dewatering wells and horizontal drains required to meet depressurization requirements during open pit mining. Because the depressurization requirements for the north wall of Mitchell pit require that the water table be set back 150 m to 200 m from the pit face (see Section 3.2 and Appendix A) an adit and drainage gallery was evaluated for the upper slope, as was done previously (BGC, 2011a).

4.3.1. Boundary Conditions

Open pit mining operational shells were simulated using head-dependent boundaries constrained to outflow (i.e. drains) for the years specified above. Water levels within drain cells were specified at the depth of mining. Drains representing the pit (see Drawing 5) were turned on (i.e. became active) within the model according to the sequencing provided by MMTS (see Drawings 3 and 4). The conductance of the drains was set to a high value to allow water to freely drain into the simulated open pits.

For simulations using wells, drain cells were used to simulate vertical dewatering wells within the model. This allows the model to predict potential dewatering rates based on generated hydraulic gradients and hydrogeologic parameters rather than specifying well intake (i.e. pumping) rates *a priori.* All wells were assumed to be screened across their entire extent. The drain was set at the bottom of the well screen, with the water level set to the desired level (i.e. at the pump intake). Gridblocks used to represent the well were assigned elevated values of hydraulic conductivity, and the conductance of these cells was also set to a high value to allow water to freely flow into the simulated wells and out the drain boundary. Dewatering wells of variable depth (on average 200 m deep) were introduced to the model to control groundwater inflows to the pit with the introduction of the expanding pit shells.

The adit and drainage gallery were simulated using drain cells as well. As done previously (BGC, 2011a), the conductance of both the adit and gallery drain cells was calculated using the Thiem solution and the Peaceman (1983) formula. Gallery drains were assumed to be 5-inch diameter, 300 m long, and drilled in fans of three on 50 m spacing along the dewatering adit. The adit was assumed to be 4 m in diameter.

Horizontal drains from the pit face were not explicitly simulated with the model. Rather, residual flows reporting to the open pits (i.e. those flows not intercepted by the adit or wells) were assumed to be those captured by horizontal drains, and required drains were estimated independent of the model, based on the available bench face length per pit phase.

To evaluate the block cave inflows, “caved rock” and the “fractured zone” (see Figure 1 and Appendix E) were simulated using head-dependent boundaries constrained to outflow (i.e. drains). Water levels within drain cells were specified at the depth of the undercut levels (i.e., 235 masl for Mitchell and 1,210 masl for Iron Cap). Drains representing the caved and fractured zone rock were turned on (i.e. became active) within the model the year of block cave commencement (Year 26 for Mitchell and 32 for Iron Cap). The conductance of the drains was set to a high value to allow water to freely drain into the zone. As noted previously, phases for block caving were not available.

4.3.2. Material Properties

As described in Section 3.3, material properties of the bedrock within the zone of macro-deformation are expected to be significantly altered by the disturbance caused by open pit - block cave interactions. There is great uncertainty in the magnitude of material property alteration, and guidance from literature on the subject is not available. Therefore, for the purpose of this work the hydraulic conductivity of the bedrock within the estimated break-back limits of Mitchell Pit (see Appendix E) was increased by two orders of magnitude, while storage was increased by factor of five, and specific yield was increased by a factor of two to five. The material properties were adjusted two years after the start of block cave mining in the Mitchell zone. Material properties were not altered in the Iron Cap zone, because open pit mining will not occur there.

4.4. Open Pit Depressurization Simulation Results

4.4.1. Unmitigated Flows

Using best estimate parameters with the existing groundwater model, a simulation that incorporated no mitigative dewatering techniques (i.e. no wells, drains or adits) was performed to provide a minimum bound on the groundwater flow rates that would result from dewatering. Flow results for this simulation are presented in Drawing 6 for the Mitchell, Kerr, and Sulphurets pits. Predicted pit wall pore pressures are not reduced sufficiently to make this a viable development scenario for any of the pits, as indicated in the depth to water plots on Drawings 7 through 9. The predicted average pit inflows for the duration of active mining in each pit for this simulation are: 5,900 m^3/d to Mitchell; 1,100 m^3/d to Kerr; and 500 m^3/d to Sulphurets.

4.4.2. Mitigated Flows

A systematic trial-and-error approach was used to determine the vertical in-pit well scheme for the proposed open pits as each develops throughout the mine life using the pit phases provided. In-pit vertical wells were initially evaluated using a uniform spacing of 250 m within each pit. To minimize the required number of vertical in-pit wells, individual well flow rates were evaluated, and wells were removed from the plan if an average flow rate of 10 US gpm could not be maintained in the wells of the Mitchell and Sulphurets zones. Likewise, wells were removed from the plan if an average flow rate of 5 US gpm could not be maintained in the Kerr Pit wells. This approach, in combination with the overall smaller open pit in the Mitchell Zone, results in a lower number of required in-pit wells than estimated in BGC, 2011a for each zone. Resulting well layouts for the pit phases are provided in Appendix B.

Simulations were attempted without the use of an adit; however, sufficient depressurization could not be achieved for the Mitchell Pit upper north-slope. Therefore, simulations were carried out with the drainage adit approximately 450 m behind the slope. Plots of predicted inflows to vertical dewatering wells, the adit and drainage gallery, and residual inflows to horizontal drains are provided in Drawing 10 for the resulting base case dewatering system for the open pits. Depth to water plots at the end of mining for each pit are provided in Drawing 11 (Mitchell), 12 (for Sulphurets), and 13 (for Kerr), and illustrate that depressurization is achieved for much of the pit areas, but that horizontal drains will nonetheless be required to sufficiently reduce pore pressures behind the slope face(s). The well, adit, and drain development summary are provided in Table 2, while annual flows are provided in Table 3 for all pits using the base case dewatering scheme.

4.4.2.1. Mitchell Pit

The average annual groundwater extraction rate for Mitchell pit is predicted to be approximately 11,980 m^3/d throughout mining of the pit; 6,580 m^3/d will be captured by vertical wells, 4,460 m^3/d will be captured by the adit and drainage gallery, while the remaining 940 m^3/d will report to the pit as seepage intercepted by horizontal drains. Based on groundwater modeling results, approximately 76 x 200 m deep in-pit wells will be required during open pit mining of Mitchell pit, and the total drilling length for the vertical wells is estimated to be approximately 15,200 m. A maximum of 38 in-pit wells would operate in a given year. In addition, it is estimated that approximately 628 km of horizontal drains (100 to 300 m in length on 50 m spacing; see Section 5.2) over 23 years of mining will be required to aid in depressurization of the pit slopes. The adit was assumed to be 4 m in diameter and 3.5 km long, with 5-inch diameter by 300 m long drains installed in fans of three on 50 m spacing along the adit, for a total drain drilling length of approximately 63,000 m.

4.4.2.2. Kerr Pit

The average groundwater extraction rate for the Kerr pit is predicted to be approximately 1,200 m^3/d; 740 m^3/d will be captured by vertical in-pit wells, while the remaining 460 m^3/d will be captured by horizontal drains. Approximately 36 x 200 m deep vertical wells with a total drilling length of 7,200 m will be required throughout the life of the pit. A maximum of 18 in-pit wells would operate in a given year. In addition, it is estimated that approximately 108 km of horizontal drains (100 to 140 m in length on 50 m spacing; see Section 5.2) over 23 years of mining will be required to aid in depressurization of the pit slopes.

4.4.2.3. Sulphurets Pit

The average flow to the Sulphurets pit is predicted to be 1,010 m^3/d; 890 m^3/d will be captured by vertical in-pit wells, while the remaining 120 m^3/d will be captured by horizontal drains. Approximately 30 x 200 m deep vertical wells with a total drilling length of 6,000 m will be required throughout the life of the pit. A maximum of 15 in-pit wells would operate in a given year. In addition, it is estimated that approximately 166 km of horizontal drains (100 to 160 m in length on 50 m spacing; see Section 5.2) over 13 years of mining will be required to aid in depressurization of the pit slopes.

4.5. Block Cave Groundwater Flow Results

The average annual groundwater inflow rate for the Mitchell pit and cave is predicted to be approximately 10,300 m^3/d throughout mining of the cave (see Table 3); an average groundwater inflow of 2,400 m^3/d will report to the adit throughout this time. A maximum groundwater inflow to the cave and pit of 68,700 m^3/d was estimated during Year 28, the year the bedrock material properties were increased within the estimated break-back limits. The large peak simulated inflow is a result of instantaneous adjustment of the material properties. It is likely that bedrock properties would change over time, and therefore the total simulated flows would report to the cave progressively throughout mining rather than suddenly.

The average annual groundwater inflow rate for the Iron Cap cave is predicted to be approximately 2,200 m^3/d throughout mining of the cave (see Table 3). A maximum groundwater inflow of 9,600 m^3/d was estimated during Year 37. The large peak simulated inflow is a result of instantaneous introduction of the final block cave and fracture zone limits (i.e., phases were not available). A plot of predicted groundwater inflows to the Mitchell pit and cave, and the Iron Cap cave is presented in Drawing 14.

4.6. Sensitivity Analyses

Sensitivity simulations were performed to evaluate changes to predicted pit inflows and dewatering rates for each pit for a reasonable range of input parameters. For each set of sensitivity simulations, hydraulic parameters were modified to investigate the impact on the base case mitigated depressurization simulation results. The following five simulation runs were performed to compare to the base case dewatering results:

1. Hydraulic conductivity of all hydrogeologic units was increased by a factor of five.
2. Hydraulic conductivity of all hydrogeologic units was decreased by a factor of five.
3. Specific storage (S_s) of all units was increased by a factor of 5, while specific yield (Sy) was increased by a factor of two.
4. Recharge for each recharge zone was increased by a factor of two.
5. Hydraulic conductivity and S_s of all hydrogeologic units was increased by a factor of five, while Sy was increased by a factor of two, and recharge in each zone increased by a factor of two (i.e., a combination of sensitivity runs 1, 3 and 4).

Plots of average predicted inflows to the open pits (i.e., horizontal drains), dewatering wells, adit and block caves for each sensitivity scenario relative to the base case results are provided in Appendix C, and average annual flows for each case are summarized in Table 4 (during open pit mining) and Table 5 (during block cave mining duration). Results of the sensitivity simulations demonstrate that:

- Significant changes in predicted pit inflows and well extraction rates are found for scenarios where hydraulic conductivity is increased (Runs 1 and 5) or decreased (Run 2) relative to the base case for Mitchell Pit. If the bulk hydraulic conductivity of the hydrogeologic units is found to be a factor of five greater than assumed in the base case (Runs 1 and 5), the total predicted amount of groundwater to be handled by the Mitchell pit dewatering system would increase by a factor of between 1.4 to 2.1. Similarly, groundwater inflows to the Mitchell block cave and pit increase by a factor of 1.4 to 2.0. Residual flows to Kerr and Sulphurets are lower or nearly cease for these scenarios, due to resulting lowered hydraulic heads at higher elevations, and more effective vertical wells. If the bulk hydraulic conductivity is decreased by a factor of five relative to the base case (Run 2) the spacing of the vertical wells is less effective at depressurization and increased seepage reports to each pit. Total flows to the proposed pits increase relative to the base case for Kerr and Sulphurets for this scenario due to higher hydraulic heads within the ridges. Obtaining larger scale estimates of the bulk rock mass hydraulic conductivity within the proposed pit areas (i.e. pumping tests) would remove some of the uncertainty associated with this parameter. It will be important to continue to characterize the permeability of all hydrogeologic units as the mine develops and dewatering wells are installed in order to make any necessary adaptations to the dewatering program (i.e., number, size and depth of wells, adits, drains and spacing).
- The ability to achieve depressurization targets is sensitive to hydraulic conductivity. Depths to water below ground for Mitchell pit at the end of open pit mining are provided on plots C5 and C6 for sensitivity runs 1 (high K) and 2 (low K), respectively. The plots demonstrate that depressurization goals are more easily met with higher hydraulic conductivity, but more difficult if the bedrock hydraulic conductivity is lower.
- Storage is also a sensitive parameter for the hydrogeologic system. Overall groundwater inflows for Mitchell pit during open pit mining increase by a factor of about 1.3 relative to the base case when only specific storage and specific yield are increased (Run 3), and increase by a factor of 1.7 during block cave mining. Groundwater flows to Kerr and Sulphurets pit increase by factors of about 2.0 and 1.6 respectively. Obtaining estimates of bedrock storage properties within the proposed pit areas through pumping tests would again remove some of the uncertainty associated with this parameter.
- Recharge is an important parameter for the hydrogeologic system. Increasing recharge (Run 4) resulted in higher flows for each pit during open pit mining relative to the base case (factor of 1.1 for Mitchell Pit up to factor of 1.3 for Sulphurets Pit).

5.0 2012 PFS UPDATE DEPRESSURIZATION SYSTEM DESIGN

In order to depressurize the proposed Mitchell pit slopes, a combination of vertical in-pit wells, horizontal in-pit drains, and a dewatering adit are recommended. In-pit wells and horizontal drains will be used to mitigate groundwater inflows as the pit develops and as benches become established. It is expected that horizontal drains will be important in the deeper portions of the pit where vertical wells may be less effective due to the lower hydraulic conductivity of the bedrock at depth (see Drawing 11). The adit is required to achieve the depressurization requirements of the Mitchell Pit upper North Slope.

In-pit vertical wells and horizontal drains will also be required to lower the water table during mining activities for Kerr and Sulphurets pit. The estimated numbers of vertical dewatering wells that will be needed to achieve depressurization objectives are provided in Tables 2 and 3. The number of wells is approximate; the actual number of wells installed and their locations will need to be modified to account for such factors as:

- poor drilling conditions (i.e. lost holes);
- low (or high) yielding wells;
- topographic or structural controls (e.g. avalanche chutes and/or run-out control plans, dewatering well bench locations and access, etc.); and
- significant changes in pit development strategy.

A schematic diagram showing a typical vertical pit dewatering well and horizontal drain specification is provided in Appendix D to support cost estimating for the depressurization system. The locations of wells used in the model to achieve depressurization objectives are shown in Appendix B for the pit phases considered as guidance to mine planners for project cost estimation.

5.1. In-Pit Wells

Anticipated yields for Mitchell wells range from 1.0 L/s to 12 L/s (16 US gpm to 191 US gpm), and up to 38 in-pit wells may be operating at once (Tables 2 and 3). The depths for in-pit wells will be variable and dependent upon factors such as collar elevation relative to the bottom of the pits, duration each well is active, and bedrock hydraulic conductivity. However, it is estimated that the average well depth will be approximately 200 m and that on average each well will be mined out once, requiring a total drilling length of approximately 15,200 m of in-pit wells.

Anticipated yields for Kerr and Sulphurets wells range from 0.3 L/s to 4.0 L/s (4 US gpm to 64 US gpm). Up to 18 and 15 in-pit wells may be operating at once at Kerr and Sulphurets, respectively (Table 2 and 3). An average well depth of 200 m was assumed, and on average each well will be mined out once, resulting in a combined total drilling length of approximately 13,200 m of in-pit wells for these pits.

The number of wells proposed does not include any redundancy to facilitate maintenance of the wells. Some level of redundancy in the number of wells will be required to account for well and pump maintenance. The level of redundancy will depend on the ability of pump maintenance personnel to replace the pumps in a timely manner and should be determined by mine planners at future stages of project design based on the tolerable level of risk to the operation.

5.2. Horizontal Drains

In-pit horizontal drains will be required for each pit to meet stability requirements. Horizontal drain layouts will largely need to be field fit. Typically, drains will be installed to intersect fractures along benches where seeps are observed to occur, or in response to increasing or undesirable pressure readings in the pit slope instrumentation network. To meet stability requirements for the majority of the slopes, the water table should be depressurized to approximately 50 m behind the pit wall (see Appendix A); therefore, drain lengths of 100 m are recommended at approximately 50 m spacing. Horizontal drains from the pit face were not explicitly simulated with the model. Rather, residual flows reporting to the open pits (i.e. those flows not intercepted by the adit or wells) were assumed to be those captured by horizontal drains, and required drains were estimated independent of the model, based on the available bench face length per pit shell phase.

Table 6 provides a horizontal drain drilling schedule for each pit phase available. The estimates assume drains are drilled as benches become available. For the pit phases reviewed; approximately 902 km of horizontal drain drilling is expected to be required, 70% of which will be located in the Mitchell Pit. Table 6 also provides the estimated number of drains present for each pit at the phase end; it is anticipated that only 10 to 30% of the drainholes will collect seepage (i.e., the majority of the drain holes drilled will be dry) and need to be managed during any given phase.

5.3. Mitchell Pit Upper North Slope Adit

A 3.5 km long adit and drainage gallery, described in Table 7, will be required to achieve depressurization targets identified by the BGC pit geotechnical design team for the Mitchell pit upper North Slope (BGC, 2012a). Based on the simulation results, the adit should be approximately 450 m behind the ultimate pit slope, at a low elevation within the valley. Simulated portals daylight at 900 masl and 850 masl on the east and west sides of the Mitchell Pit. Drainholes will need to be drilled off of the adit to extend the influence of the drainage gallery. Simulations without the drainholes did not achieve the depressurization goals (BGC, 2011a). Based on the simulation results, the drainholes should be 300 m long drilled in fans of at least three at locations spaced 50 m along the adit. The adit and gallery were assumed to drain by gravity.

6.0 SUMMARY

A 3-D numerical model, developed as part of the 2011 PFSU study (BGC, 2011a), was used to evaluate the degree of effort required to depressurize the 2012 PFSU open pit slopes to satisfy geotechnical constraints identified as part of the Kerr, Sulphurets, and Mitchell open pit slope studies (BGC, 2012a), as well as to estimate groundwater inflows to the block caves in the Mitchell and Iron Cap zones.

Estimates of the required number of vertical dewatering wells, adits and horizontal drains required to achieve sufficient depressurization of the rock mass, as well as associated groundwater extraction rates are provided. The methods used were consistent with the 2011 approach; however in order to minimize the required number of vertical in-pit wells, individual well flow rates were evaluated, and wells were removed from the plan if sufficient flow rates (5 to 10 US gpm) could not be maintained. This approach, in combination with the overall smaller open pit in the Mitchell Zone, results in a lower number of required in-pit wells than specified in BGC, 2011a for each zone.

The efficiency of the proposed pit dewatering system is sensitive to the hydraulic properties of the bedrock. It will be important to continue to characterize the hydraulic properties of the bedrock as site investigations and design advances at the next stage of the project. Currently available estimates of rock mass hydraulic conductivity in the vicinity of the open pits are limited to point scale measurements (e.g. slug tests and constant rate packer injection tests during drilling). Obtaining larger scale estimates of rock mass hydraulic conductivity and storage properties (i.e. pumping tests) to confirm the feasibility of the proposed depressurization system will be necessary at the next stage of project design.

Groundwater inflows reported for the block caves are sensitive to the assumptions of the limits of the break-back zone, as well as the assumed changes to material properties, and timing of these material property changes, due to the open pit-block cave interactions. It may be more appropriate to implement material property changes gradually (vs. suddenly as done here) based on predicted deformation rates, should these become available at the next level of study. While a significant body of research and literature is becoming available regarding predictions of ground deformations associated with block caving below or adjacent to open pits, published works regarding the hydrogeology of the systems are lacking. Predictions of groundwater inflows to the block caves should be reevaluated as more information becomes available.

7.0 CLOSURE

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We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

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TABLES

Table 1. Calibrated Hydraulic Parameters Assigned to Hydrogeologic Units

Hydrogeologic Unit	Model Layer(s)	Model Depth Extent (mbgs)	Hydraulic Conductivity (m/s)		Specific Storage (1/m)	Specific Yield (-)
			Horizontal	Kh:Kv		
Outside Mitchell, Sulphurets, and Iron Cap Pit Area						
Till Deposits	1 and 2	0 to 50	7E-07	1	0.000005	0.1
Shallow Stuhini Bedrock	1 to 3	0 to 125	1E-07	1	5E-06	0.10
Stuhini Bedrock	4	125 to 225	9E-09	1	1E-06	0.01
Stuhini Bedrock	5 to 10	225 to -350	1E-09	1	1E-06	0.01
Shallow Hazelton Bedrock	1 to 3	0 to 125	1E-07	1	5E-06	0.10
Hazelton Bedrock	4	125 to 225	2E-08	1	1E-06	0.01
Hazelton Bedrock	5 to 10	225 to -350	1E-09	1	1E-06	0.01
Within Mitchell, Sulphurets, and Iron Cap Pit Area						
Shallow Bedrock below STF and Above MTF	1 and 2	0 to 50	1E-06	1	5E-06	0.10
Bedrock above MTF and below STF - North and South Slopes	3 to 6	50 to varies	2E-08	1	1E-06	0.01
Bedrock Below MTF - Valley Bottom	1 to 3	0 to 125	1E-06	1	5E-06	0.10
Bedrock Below MTF	4 to 6	125 to varies	1E-08	1	1E-06	0.01
Bedrock Below MTF	7 to 10	varies to -350	1E-09	1	1E-06	0.01
Shallow Bedrock Above STF	1 and 2	0 to 50	7E-07	1	5E-06	0.10
Bedrock Above STF	3	50 to 125	1E-07	1	1E-06	0.01
Bedrock Above STF	4 to 6	125 to varies	1E-08	1	1E-06	0.01
Suphurets Zone, STF foot wall	3 to 6	50 to varies	1E-09	1	1E-06	0.01
Shallow Bedrock In Iron Cap Pit Area	1 to 3	0 to 125	1E-07	1	5E-06	0.10
Bedrock In Iron Cap Pit Area	4 to 6	125 to varies	2E-08	1	1E-06	0.01

Notes:
1. "MTF" indicates Mitchell Thrust Fault.
2. "STF" indicates Sulphurets Thrust Fault.

Table 2. Annual Summary of Dewatering and Depressurization Measures by Open Pit

Mine Year	Mitchell Pit					Kerr Pit			Sulphurets Pit			Annual Summary		
	Operating Vertical Wells [1]	Installed Wells	Horizontal Drains (m)	Adit (m)	Gallery (m)	Operating Vertical Wells [1]	Installed Wells	Horizontal Drains (m)	Operating Vertical Wells [1]	Installed Wells	Horizontal Drains (m)	Operating Vertical Wells [1]	Installed Wells	Horizontal Drains (m)
-3	5	5							4	4		9	9	-
-2	5		15,000						4		6000	9	0	21,000
-1	20	15	15,000						4		6000	24	15	21,000
1	20		22,400						8	4	9,000	28	4	31,400
2	20		25,200						8		5,400	28	0	30,600
3	26	6	23,800						12	4	5,200	38	10	29,000
4	26		31,200						12		2,600	38	0	33,800
5	26		22,200						12		5,400	38	0	27,600
6	26		30,400	2,361					12		4,800	38	0	35,200
7	26		30,400	1,139					12			38	0	30,400
8	26		30,400		36,500				12			38	0	30,400
9	38	22	30,400		26,500				12			50	22	30,400
10	38		30,400						12			50	0	30,400
11	38		29,310						12			50	0	29,310
12	38	10	29,310						12			50	10	29,310
13	38		29,310						12			50	0	29,310
14	38		29,310						12			50	0	29,310
15	38	10	29,310						12			50	10	29,310
16	38		29,310						12			50	0	29,310
17	38		29,310						12			50	0	29,310
18	38		29,310						12			50	0	29,310
19	38	8	29,310						12			50	8	29,310
20	38		29,310						15	8		53	8	29,310
21	38		14,100						15		18,270	53	0	32,370
22	38		14,100						15		18,270	53	0	32,370
23	38								15	5	18,270	53	5	18,270
24	38								15		18,270	53	0	18,270
25	38					7	7		15	5	18,270	60	12	18,270
26						7			15		18,270	22	0	18,270
27						7		3,150	15		12,180	22	0	15,330
28						7		3,150				7	0	3,150
29						7		3,150				7	0	3,150
30						7		3,150				7	0	3,150
31						7		4,660				7	0	4,660
32						7		4,660				7	0	4,660
33						7		4,660				7	0	4,660
34						13	10	4,660				13	10	4,660
35						13		4,660				13	0	4,660
36						13		4,660				13	0	4,660
37						13		4,660				13	0	4,660
38						13		4,660				13	0	4,660
39						13	5	4,660				13	5	4,660
40						13		4,660				13	0	4,660
41						13		4,840				13	0	4,840
42						13		4,840				13	0	4,840
43						13		4,840				13	0	4,840
44						18	10	4,840				18	10	4,840
45						18		4,840				18	0	4,840
46						18		4,840				18	0	4,840
47						18	4	4,840				18	4	4,840
48						18		4,840				18	0	4,840
49						18		4,840				18	0	4,840
50						18		4,840				18	0	4,840
Maximum	38					18			15			60		
Total		76	628,100	3,500	63,000		36	107,600		30	166,200		142	901,900

Notes:

1. Number of vertical wells shown during mine year are total operating by year for specific open pit.
2. Horizontal drains shown as meters drilled during mine year.
3. On average, each vertical well is mined out once and replaced during mine life.
4. Dark grey highlight indicates years of active mining for open pit.
5. Vertical wells are all 200 m deep. See Appendix D for additional approximate well dimensions and materials.

Table 3. Annual Open Pit and Block Cave Flow Summary

	Mitchell Pit and Cave [1]							Kerr Pit					Sulphurets Pit					Iron Cap Cave
Mine Year	Operating Vertical Wells [2]	Total Vertical Well Flow (m^3/d)	Average Flow Per Well (m^3/d)	Average Flow Per Well (USgpm)	Total Adit Flow (m^3/d)	Total Horizontal Drain Flow (m^3/d)	Groundwater Inflows to Cave (m^3/d)	Operating Vertical Wells [2]	Total Vertical Well Flow (m^3/d)	Average Flow Per Well (m^3/d)	Average Flow Per Well (USgpm)	Total Horizontal Drain Flow (m^3/d)	Operating Vertical Wells [2]	Total Vertical Well Flow (m^3/d)	Average Flow Per Well (m^3/d)	Average Flow Per Well (USgpm)	Total Horizontal Drain Flow (m^3/d)	Groundwater Inflows (m^3/d)
-3	5	3,200	640	117									4	1,500	375	69		
-2	5	5,200	1,040	191		50							4	1,400	350	64	25	
-1	20	7,600	380	70		100							4	1,300	325	60	50	
1	20	7,900	395	72		200							8	1,100	138	25	100	
2	20	8,300	415	76		700							8	900	113	21	125	
3	26	8,700	335	61		800							12	950	79	15	125	
4	26	9,100	350	64		1,000							12	1,000	83	15	125	
5	26	9,500	365	67		1,200							12	1,000	83	15	125	
6	26	9,900	381	70		1,300							12	1,050	88	16	125	
7	26	10,300	396	73	5,250	1,500							12	1,100	92	17	125	
8	26	9,500	365	67	5,250	1,300							12	1,000	83	15	100	
9	38	8,700	229	42	5,250	1,100							12	950	79	15	50	
10	38	7,900	208	38	5,250	900							12	900	75	14	25	
11	38	7,100	187	34	5,250	700							12	800	67	12	25	
12	38	6,400	168	31	5,250	450							12	800	67	12	0	
13	38	6,100	161	29	5,050	600							12	750	63	11	0	
14	38	5,900	155	28	4,800	700							12	750	63	11	0	
15	38	5,600	147	27	4,600	850							12	750	63	11	0	
16	38	5,400	142	26	4,400	950							12	750	63	11	0	
17	38	5,200	137	25	4,200	1,100							12	700	58	11	0	
18	38	4,800	126	23	4,000	1,200							12	700	58	11	0	
19	38	4,400	116	21	3,800	1,300							12	700	58	11	0	
20	38	4,100	108	20	3,600	1,450							15	650	43	8	0	
21	38	3,700	97	18	3,400	1,550							15	650	43	8	0	
22	38	3,300	87	16	3,200	1,700							15	700	47	9	0	
23	38	3,300	87	16	3,200	1,650							15	700	47	9	200	
24	38	3,300	87	16	3,100	1,600							15	750	50	9	300	
25	38	3,300	87	16	3,100	1,600		7	500				15	750	50	9	500	
26					3,100		7,800	7	700				15	800	53	10	600	
27					3,100		15,200	7	900	129	24	100	15	800	53	10	800	
28					3,100		68,700	7	800	114	21	100						
29					2,700		26,300	7	700	100	18	100						
30					2,700		17,200	7	650	93	17	50						
31					2,700		10,000	7	600	86	16	25						
32					2,700		8,600	7	500	71	13	25						8,500
33					2,700		6,400	7	400	57	10	25						1,900
34					2,600		7,700	13	350	27	5	0						1,400
35					2,600		8,000	13	300	23	4	0						1,700
36					2,600		6,300	13	550	42	8	200						1,800
37					2,600		6,100	13	800	62	11	300						9,600
38					2,600		5,300	13	1,000	77	14	500						1,900
39					2,300		5,600	13	1,300	100	18	600						1,500
40					2,300		6,300	13	1,600	123	23	800						1,500
41					2,300		4,900	13	1,000	77	14	400						1,700
42					2,300		5,300	13	600	46	8	50						1,300
43					2,300		4,400	13	650	50	9	400						1,300
44					1,800		5,700	18	700	39	7	700						1,100
45					1,800		6,300	18	800	44	8	1,000						1,400
46					1,800		5,200	18	900	50	9	1,400						1,500
47					1,800		5,100	18	1,000	56	10	1,750						1,200
48					1,800		4,500	18	800	44	8	1,300						1,200
49					1,800		4,900	18	600	33	6	850						1,000
50					1,800		5,700	18	400	22	4	400						1,100
51					1,800		5,100											1,100
52-55					1,800		5,100											
Average (Open Pit Mining Years)		6,580	280	51	4,460	940			740	65	12	460		890	97	18	120	
Average (Block Cave Mining Years)					2,400		10,300											2,200

Notes:

1. Mitchell Pit flows presented in years 26 to 55 are total flows reporting to the block cave and open pit.
2. Number of vertical wells shown during mine year are total operating by year for specific open pit.
3. See Appendix D for vertical well schematic.
4. Grey highlight indicates years of active mining for open pit.
5. Blue highlight indicates years of active underground block cave mining.

Table 4. Sensitivity Run Summary for Open Pit Mining Duration

Run [1]	Average Annual Flow Rate	Mitchell Pit [2] (m^3/d)	Kerr Pit [3] (m^3/d)	Sulphurets Pit [4] (m^3/d)
Basecase	Residual Pit Inflow (horizontal drains)	940	460	120
Sensitivity 1		720	43	30
Sensitivity 2		3,408	2,297	794
Sensitivity 3		2,016	1,256	366
Sensitivity 4		1,327	553	169
Sensitivity 5		1,027	203	98
Basecase	Vertical Wells	6,580	740	890
Sensitivity 1		10,912	494	1,087
Sensitivity 2		3,161	673	762
Sensitivity 3		8,190	1,161	1,277
Sensitivity 4		7,341	840	1,120
Sensitivity 5		16,286	778	2,101
Basecase	Adit and Drainage Gallery	4,460	--	--
Sensitivity 1		5,118	--	--
Sensitivity 2		1,847	--	--
Sensitivity 3		5,553	--	--
Sensitivity 4		4,425	--	--
Sensitivity 5		7,977	--	--
Basecase	Total (Residual + Wells + Adit)	11,980	1,200	1,010
Sensitivity 1		16,750	537	1,117
Sensitivity 2		8,416	2,970	1,556
Sensitivity 3		15,759	2,417	1,643
Sensitivity 4		13,093	1,393	1,289
Sensitivity 5		25,290	981	2,199

Notes:

1. Sensitivity Simulation variations from basecase are described as follows:
   > Sensitivity 1: Raised all hydraulic conductivity units by a factor of 5
   > Sensitivity 2: Lowered all hydraulic conductivity units by a factor of 5
   > Sensitivity 3: Raised storage by a factor of 5 and specific yield (Sy) by factor of 2
   > Sensitivity 4: Raised recharge by factor of 2 for each area
   > Sensitivity 5: Combination of Sensitivity Run 1, 3, and 4 (raised K, S, Sy and recharge)
2. Mitchell flows represent average flows simulated during open pit mining from Mine Year -2 to 23.
3. Kerr flows represent average flow simulated during mining from Year 27 to 50.
4. Sulphurets flows represent average flows simulated during mining from Year -3 to 27.

Table 5. Sensitivity Run Summary for Block Cave Mining Duration

Run [1]	Average Annual Flow Rate	Mitchell Pit + Cave [2] (m^3/d)	Iron Cap Block Cave [3] (m^3/d)
Basecase	Groundwater Inflows	10,300	2,200
Sensitivity 1		14,059	1,142
Sensitivity 2		9,179	2,505
Sensitivity 3		17,050	3,166
Sensitivity 4		10,421	2,585
Sensitivity 5		20,458	2,020
Basecase	Adit and Drainage Gallery	2,396	--
Sensitivity 1		2,626	--
Sensitivity 2		1,467	--
Sensitivity 3		2,804	--
Sensitivity 4		2,491	--
Sensitivity 5		3,353	--
Basecase	Total	12,696	2,200
Sensitivity 1		16,685	1,142
Sensitivity 2		10,646	2,505
Sensitivity 3		19,854	3,166
Sensitivity 4		12,912	2,585
Sensitivity 5		23,811	2,020

Notes:

1. Sensitivity Simulation variations from basecase are described as follows:
   > Sensitivity 1: Raised all hydraulic conductivity units by a factor of 5
   > Sensitivity 2: Lowered all hydraulic conductivity units by a factor of 5
   > Sensitivity 3: Raised storage by a factor of 5 and specific yield (Sy) by factor of 2
   > Sensitivity 4: Raised recharge by factor of 2 for each area
   > Sensitivity 5: Combination of Sensitivity Run 1, 3, and 4 (raised K, S, Sy and recharge)
2. Mitchell Pit + Cave flows represent simulated average groundwater inflows to the workings from Year 26 to 55.
3. Iron Cap flows represent simulated average groundwater inflows to the workings from Year 32 to 51.

Table 6. Open Pit Horizontal Drain Estimates during Open Pit Mining

Mine Year / Open Pit Phase	Pit	Bench Length Excavated (m)	Average Drain Length (m)	Drain Spacing (m)	Number of Drains Drilled [2]	Total Drilling Length (m)	Estimated Number of Drains Present at Phase End [3]
	Mitchell	26,200	100	50	524	52,400	
	Mitchell - North I	0	100	50	0	0	524
1	Sulphurets	10,500	100	50	210	21,000	210
	Kerr	0	100	50	0	0	0
	TOTAL	**36,700**			**734**	**73,400**	**734**
	Mitchell	12,600	100	50	252	25,200	
	Mitchell - North I	0	100	50	0	0	540
2	Sulphurets	2,700	100	50	54	5,400	212
	Kerr	0	100	50	0	0	0
	TOTAL	**15,300**			**306**	**30,600**	**752**
	Mitchell	10,900	100	50	218	21,800	
	Mitchell - North I	1,000	100	50	20	2,000	562
3	Sulphurets	2,600	100	50	52	5,200	211
	Kerr	0	100	50	0	0	0
	TOTAL	**14,500**			**290**	**29,000**	**773**
	Mitchell	14,900	100	50	298	29,800	
	Mitchell - North I	700	100	50	14	1,400	593
4	Sulphurets	1,300	100	50	26	2,600	237
	Kerr	0	100	50	0	0	0
	TOTAL	**16,900**			**338**	**33,800**	**830**
	Mitchell	11,100	100	50	222	22,200	
	Mitchell - North I	0	100	50	0	0	667
5	Sulphurets	2,700	100	50	54	5,400	255
	Kerr	0	100	50	0	0	0
	TOTAL	**13,800**			**276**	**27,600**	**922**
	Mitchell	66,300	100	50	1,326	132,600	
	Mitchell - North I	9,700	100	50	194	19,400	1,533
06 - 10	Sulphurets	2,400	100	50	48	4,800	303
	Kerr	0	100	50	0	0	0
	TOTAL	**78,400**			**1,568**	**156,800**	**1,836**
	Mitchell	66,900	150	50	1,338	200,700	
	Mitchell - North I	15,400	300	50	308	92,400	1,677
11 - 20	Sulphurets	0	100	50	0	0	303
	Kerr	0	100	50	0	0	0
	TOTAL	**82,300**			**1,646**	**293,100**	**1,980**
	Mitchell	3,600	150	50	72	10,800	
	Mitchell - North I	2,900	300	50	58	17,400	1,807
21 - 30	Sulphurets	60,900	100	50	1,218	121,800	1,233
	Kerr	6,300	100	50	126	12,600	126
	TOTAL	**73,700**			**1,474**	**162,600**	**3,166**
	Mitchell	0	150	50	0	0	
	Mitchell - North I	0	300	50	0	0	1,807
31 - 40	Sulphurets	0	100	50	0	0	1,233
	Kerr	23,300	100	50	466	46,600	592
	TOTAL	**23,300**			**466**	**46,600**	**3,632**
	Mitchell	0	150	50	0	0	
	Mitchell - North I	0	300	50	0	0	1,807
41 - 50	Sulphurets	0	100	50	0	0	1,233
	Kerr	24,200	100	50	484	48,400	1,076
	TOTAL	**24,200**			**484**	**48,400**	**4,116**
Life of Mine Total		**379,100**			**7,582**	**901,900**	
Mitchell Total		**242,200**			**4,844**	**628,100**	
Kerr Total		**53,800**			**1,076**	**107,600**	
Sulphurets Total		**83,100**			**1,662**	**166,200**	

Notes

1. See Appendix D2 schematic for approximate horizontal drain dimensions and materials.

2. Number of drains drilled for each pit phase is based on bench length excavated and assumed drain spacing. Drains will be mined out as necessary for the pit to expand to the next phase.

3. The number of drains present reflects the number of drains drilled during the current phase, and drains remaining from previous pit phases. It is only expected that 10 to 30% of the drains present during any given phase will flow.

Table 7. Mitchell Pit North Slope Adit Requirements

Adit:	
Adit East Portal Elevation: [1]	900
Adit West Portal Elevation: [1]	850
Adit distance behind Ultimate Pit (m):	450
Adit Length (m): [1]	3,500
Adit cross-section (m^2):	16
Adit Volume (m^3):	56,000
Drainage Gallery:	
Drain spacing (m):	50
Drain length (m):	300
Assumed number of Fans [2,3] :	3
Total Drain Meterage (m):	63,000

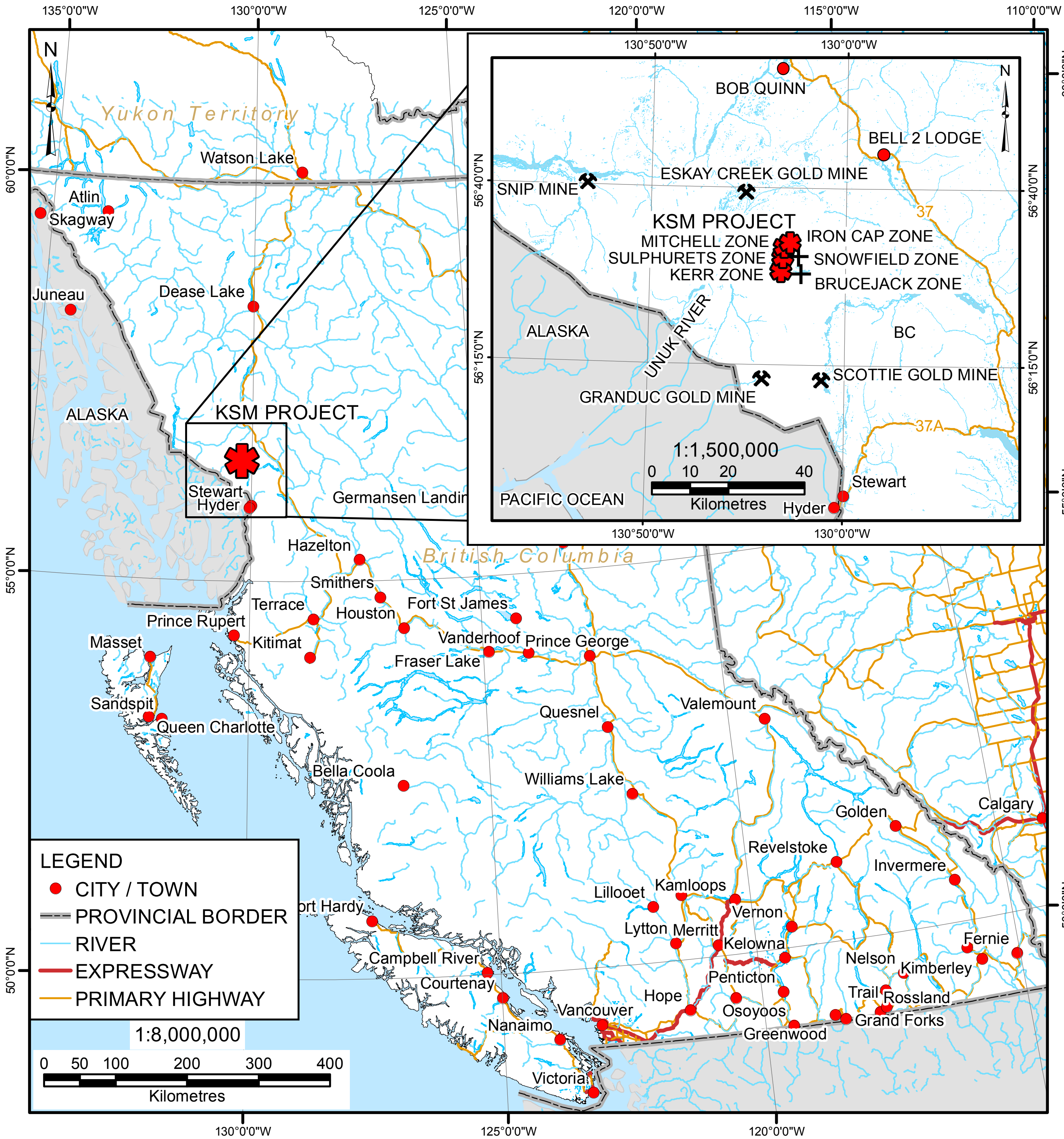
Notes:

1. Portal elevations and adit length are approximate. Portals could be raised or lowered +/- 50 m in elevation.

2. Drains to fan from subhorizontal to vertical (upward from adit). No drains to go deeper than adit to avoid pumping.

3. Assume 4-inch diameter drain hole with 2 inch SCH 80 perforated PVC.

DRAWINGS



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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT:
KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE:
PROJECT LOCATION

CLIENT:
SEABRIDGE GOLD INC.

PROJECT No.:	DWG No.:	REV.:
0638-013	01	

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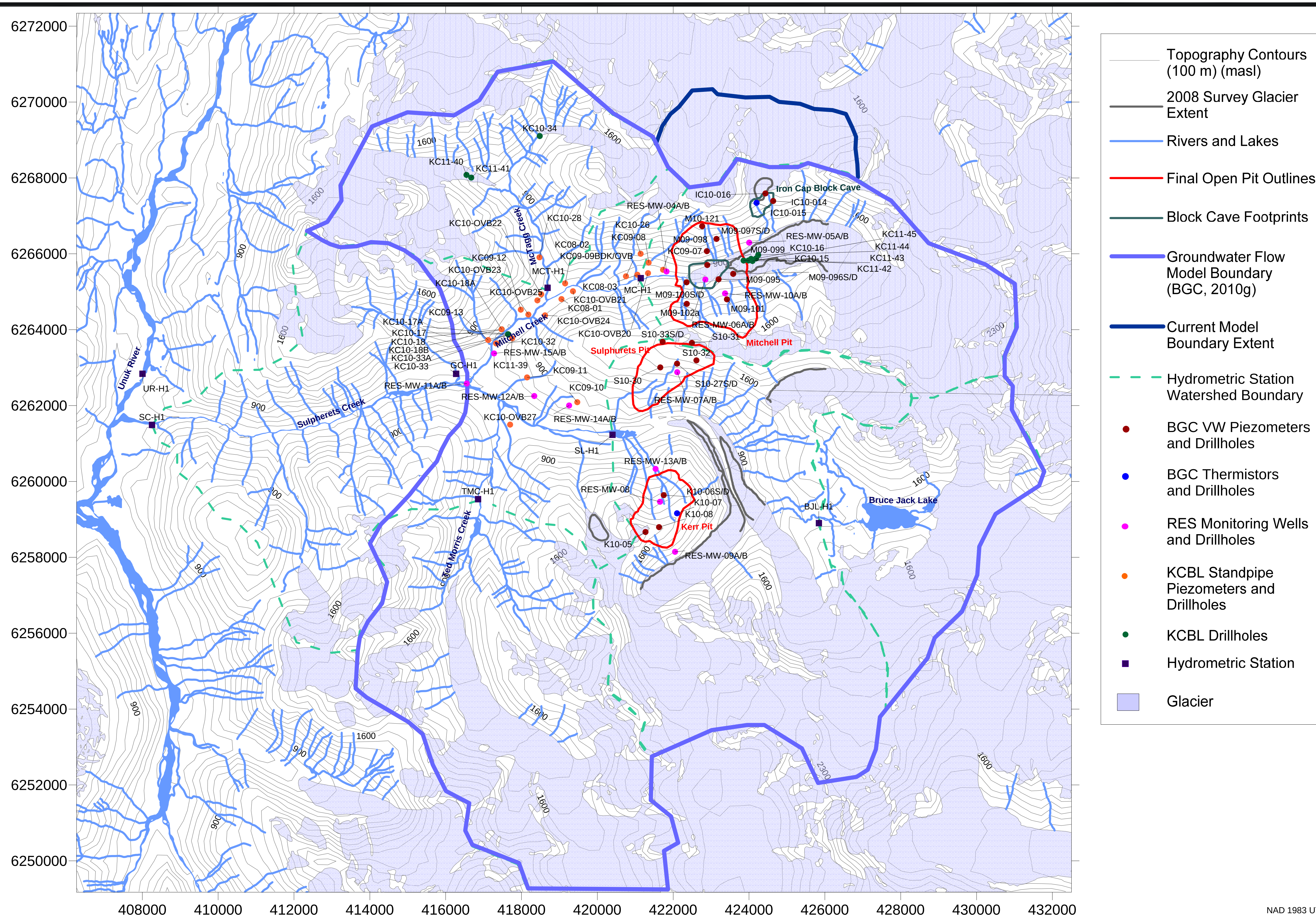

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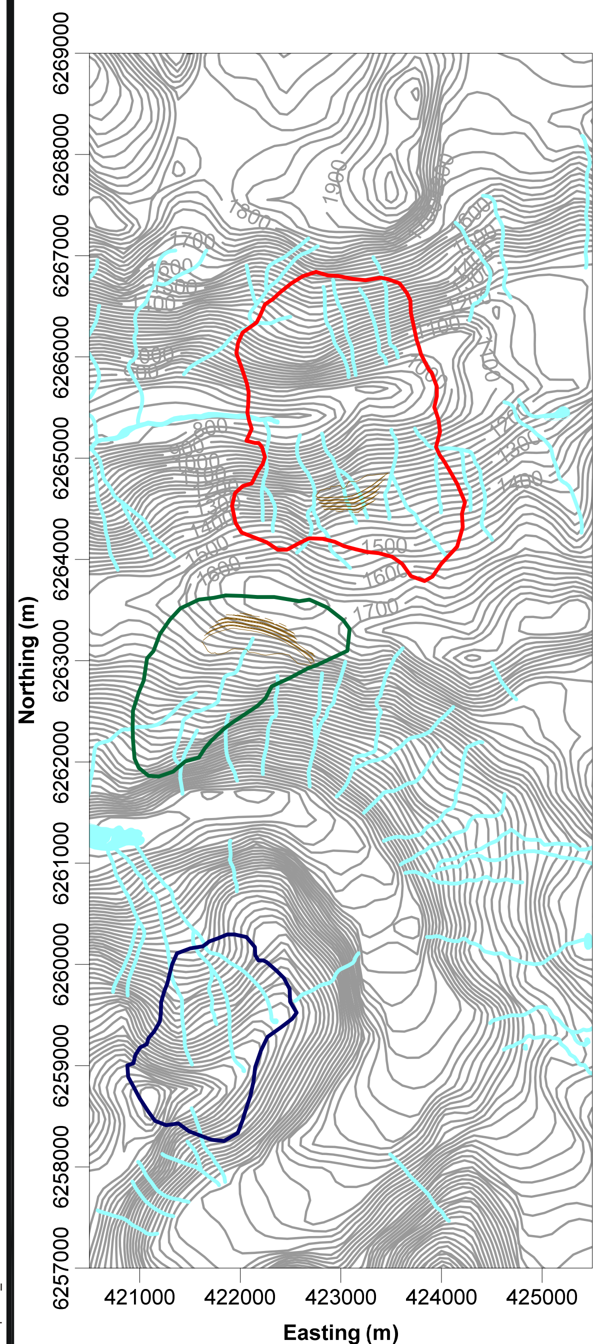
CLIENT: SEABRIDGE GOLD INC.

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: SITE PLAN

PROJECT No.:	DWG No.:	REV.:
0638-013	2	



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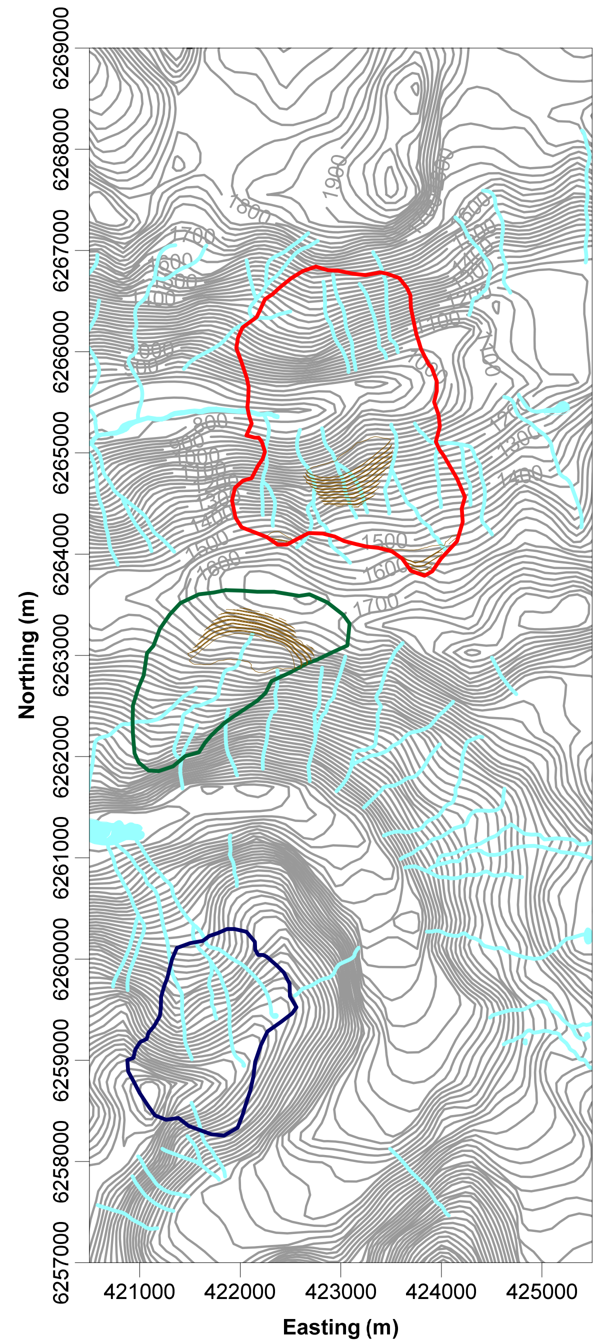
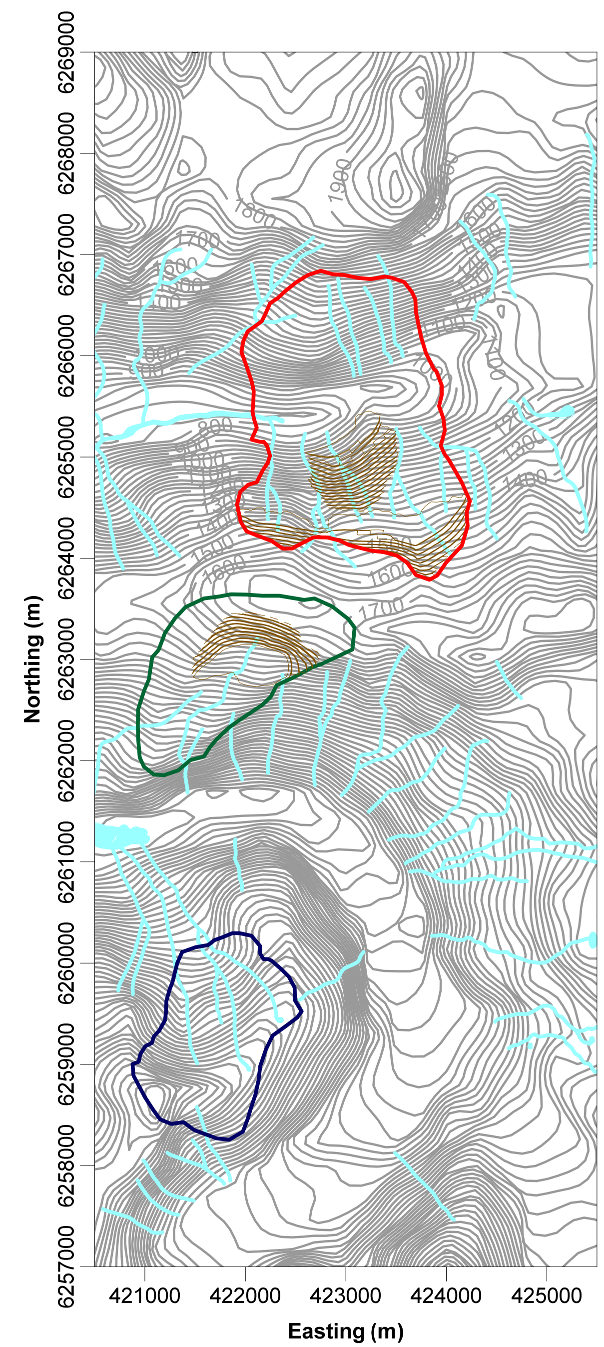


YR -1 EOP



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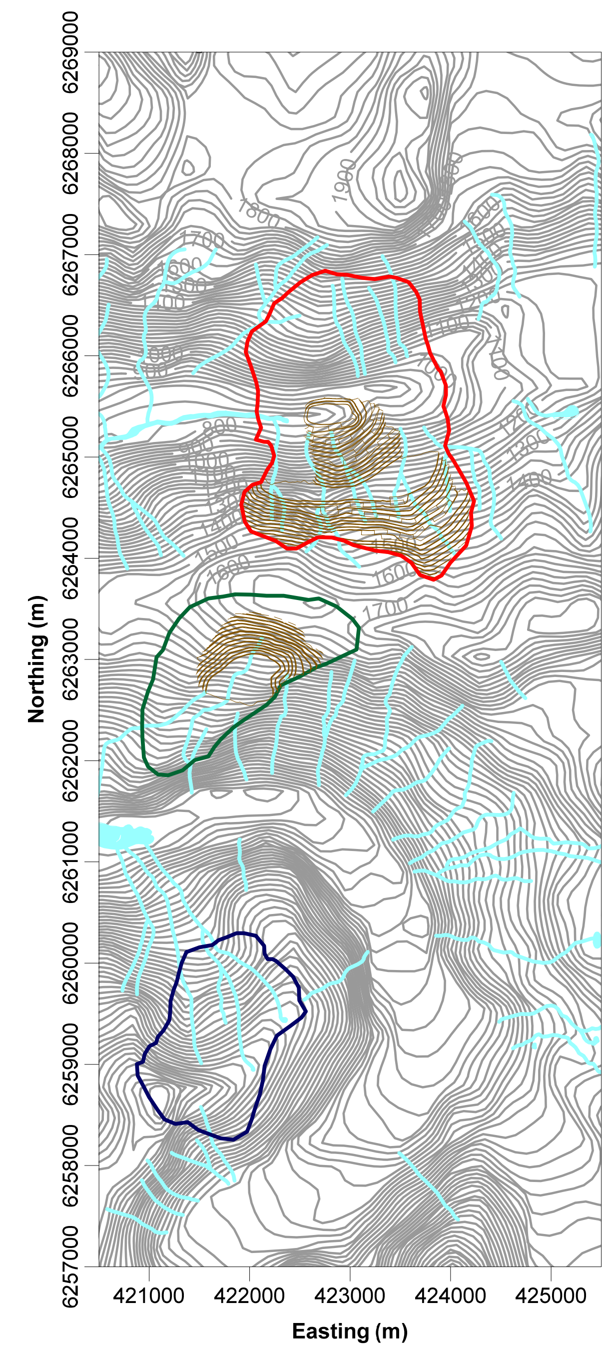

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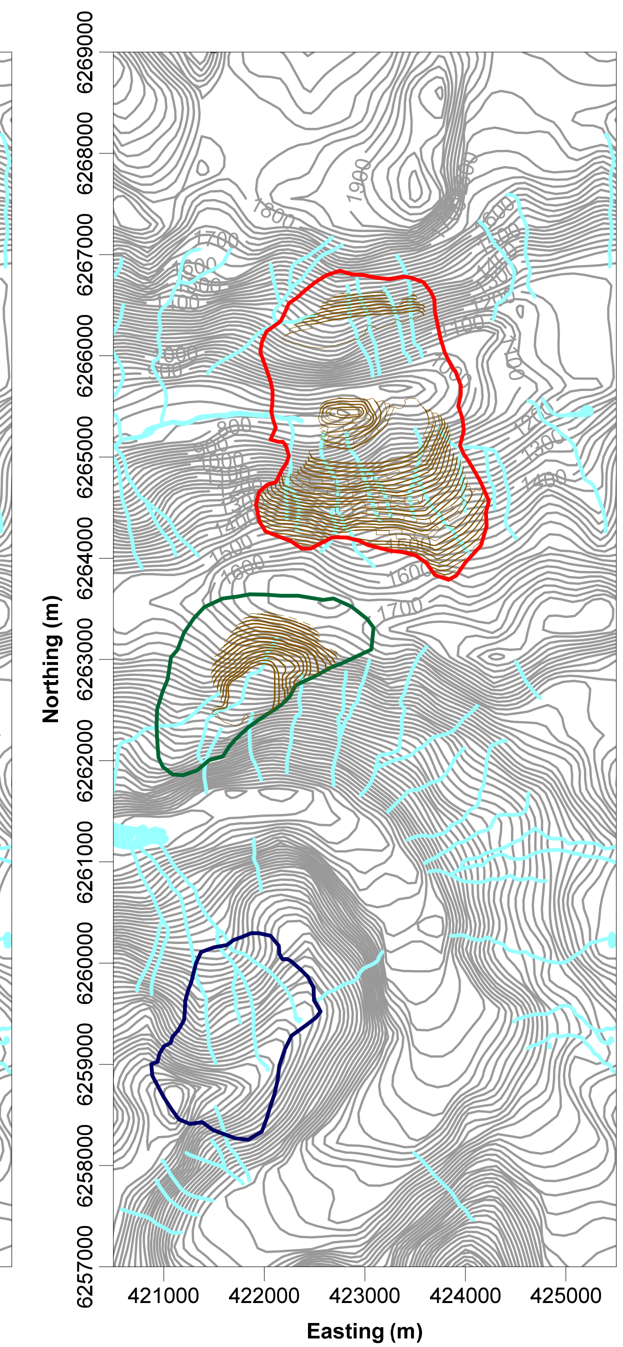

YEAR 5 EOP

MITCHELL PIT OUTLINE (FINAL)	INACTIVE CELLS		EOP OPEN PIT CONTOURS
SULPHURETS PIT OUTLINE (FINAL)	HYDROLOGY		TOPOGRAPHIC CONTOURS (masl)
KERR PIT OUTLINE (FINAL)			

Note: KSM End of Period (EOP) pits shown were provided by MMTS March 20 2012.

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

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DATE:	JUNE 2012
DRAWN:	RT
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CLIENT: SEABRIDGE GOLD INC.

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: OPEN PIT DEVELOPMENT PLAN FOR YEARS -2, -1, 1, 3, and 5

PROJECT No.:	DWG No.:	REV.:
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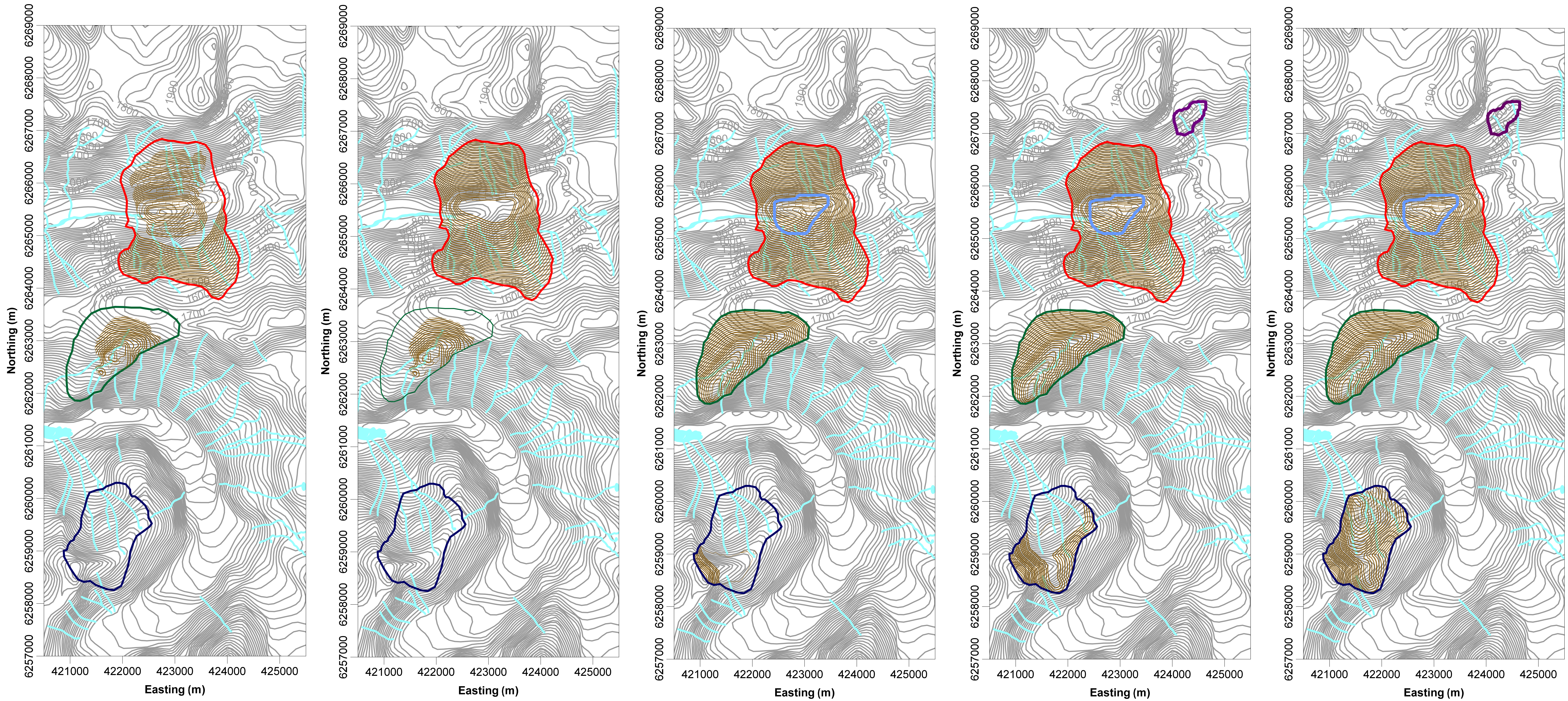

YR 10 EOP

YR 20 EOP

YEAR 30 EOP

YEAR 40 EOP

YEAR 50 (End of Open Pit Mining)

MITCHELL PIT OUTLINE (FINAL)	IRON CAP CAVE FOOTPRINT	EOP OPEN PIT CONTOURS
SULPHURETS PIT OUTLINE (FINAL)	MITCHELL CAVE FOOTPRINT	TOPOGRAPHIC CONTOURS (masl)
KERR PIT OUTLINE (FINAL)		HYDROLOGY

Note:

1. KSM End of Period (EOP) pits shown were provided by MMTS March 20, 2012.
2. Mitchell and Iron Cap block cave footprints were provided by Golder May 25, 2012.

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	AS SHOWN
DATE:	JUNE 2012
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CLIENT: SEABRIDGE GOLD INC.

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: OPEN PIT DEVELOPMENT PLAN FOR YEARS 10, 20, 30, 40, and 50 WITH BLOCK CAVE FOOTPRINTS

PROJECT No.:	DWG No.:	REV.:
0638-013	4	0

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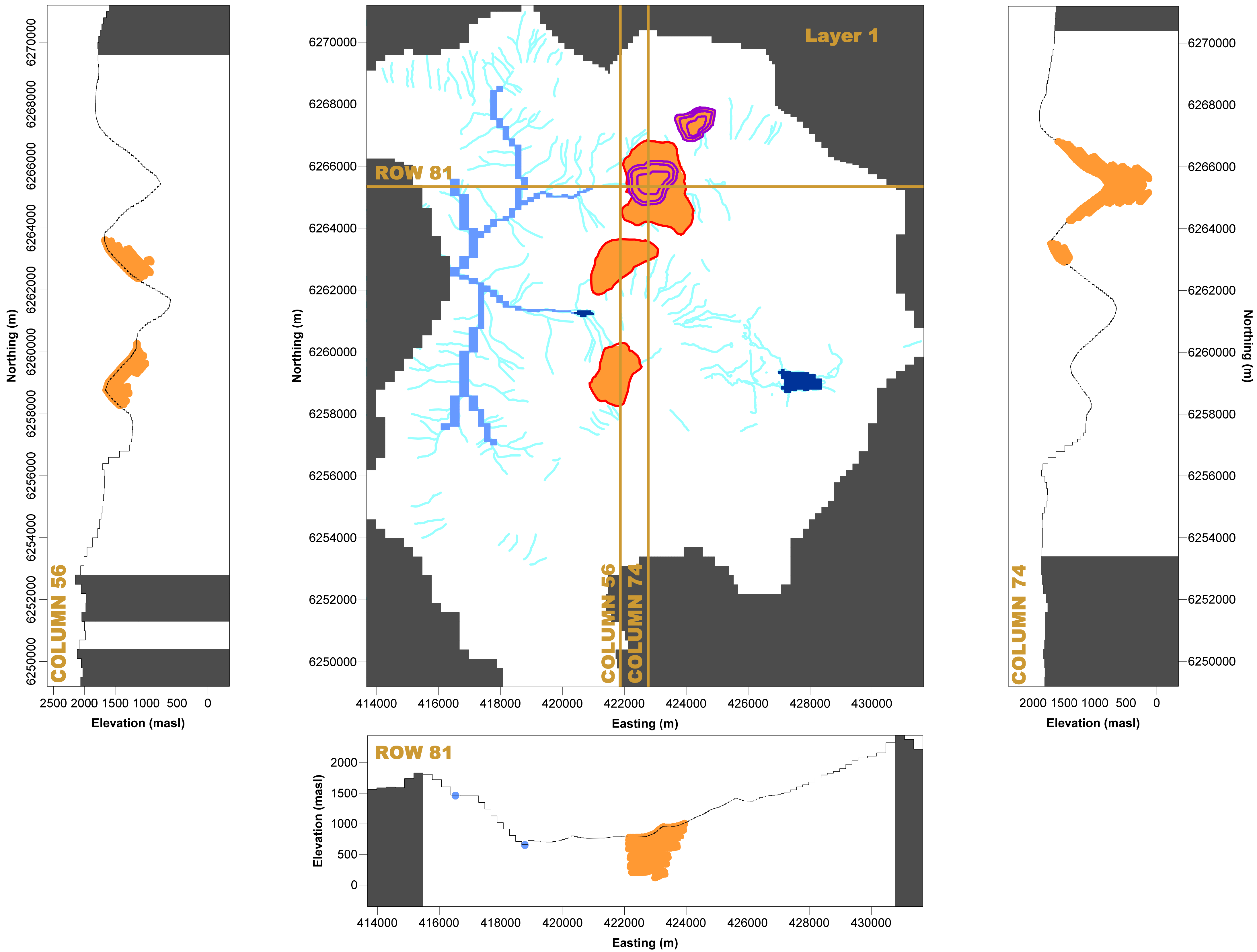

NOTES:

1. CROSS-SECTION VERTICAL EXAGGERATION 2X.
2. ONLY OPEN PIT DRAIN BOUNDARIES ARE SHOWN FOR THE UNMITIGATED CASE, ALONG WITH BLOCK CAVE AND FRACTURE ZONE LIMIT DRAIN BOUNDARIES.

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE: AS SHOWN
DATE: JUNE 2012
DRAWN: RT
DESIGNED: RT
CHECKED: RT
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PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: PREDICTIVE SIMULATIONS: BOUNDARY CONDITIONS

PROJECT No.: 0638-013
DWG No.: 5
REV.: 0

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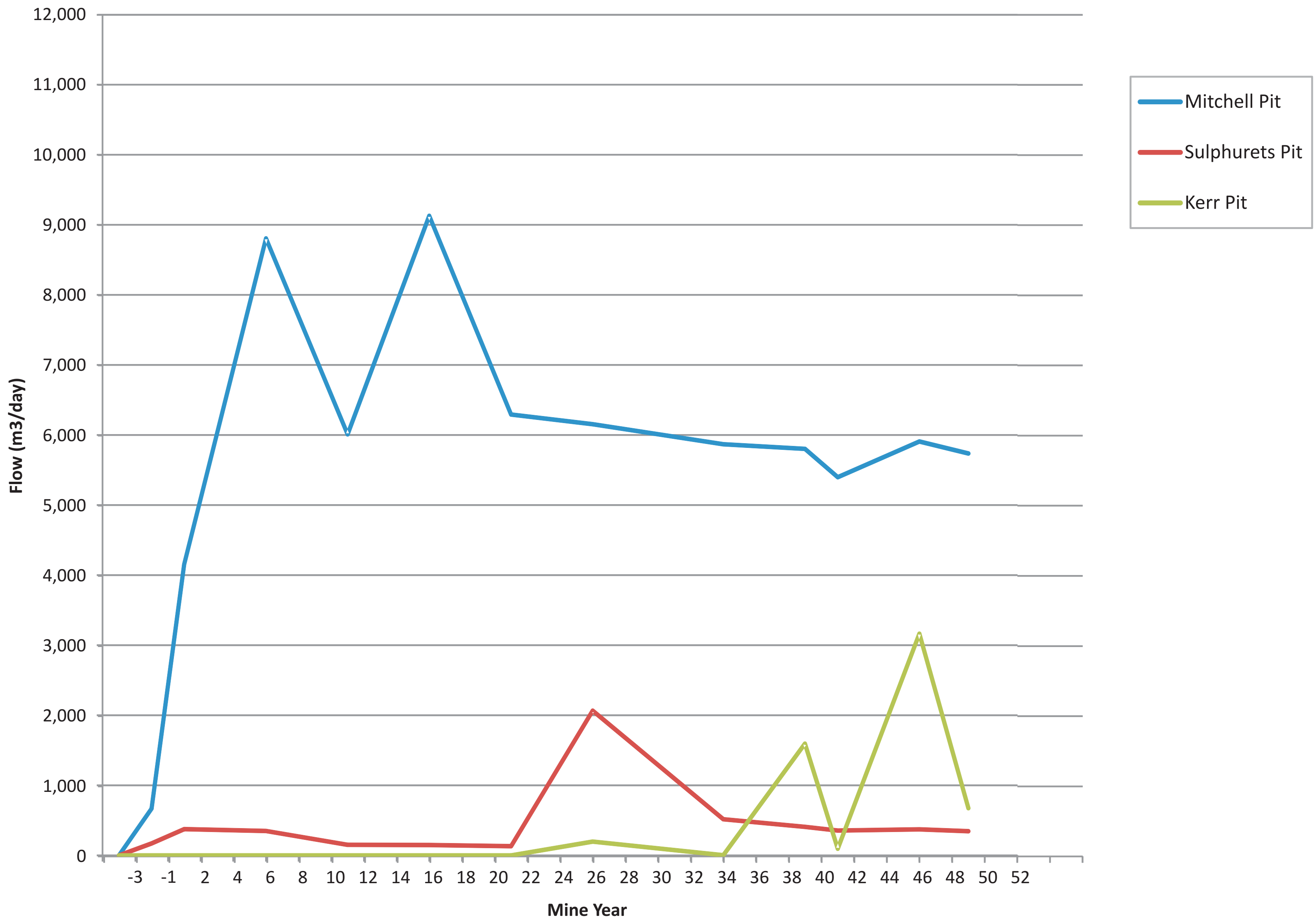

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DATE:	JUNE 2012	CHECKED:	RT
DRAWN:	RT	APPROVED:	TC

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CLIENT:
SEABRIDGE GOLD INC.

PROJECT:
KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE:
OPEN PIT FLOW RESULTS
NO MITIGATION

PROJECT No.:	DWG No.:	REV.:
0638-013	6	0

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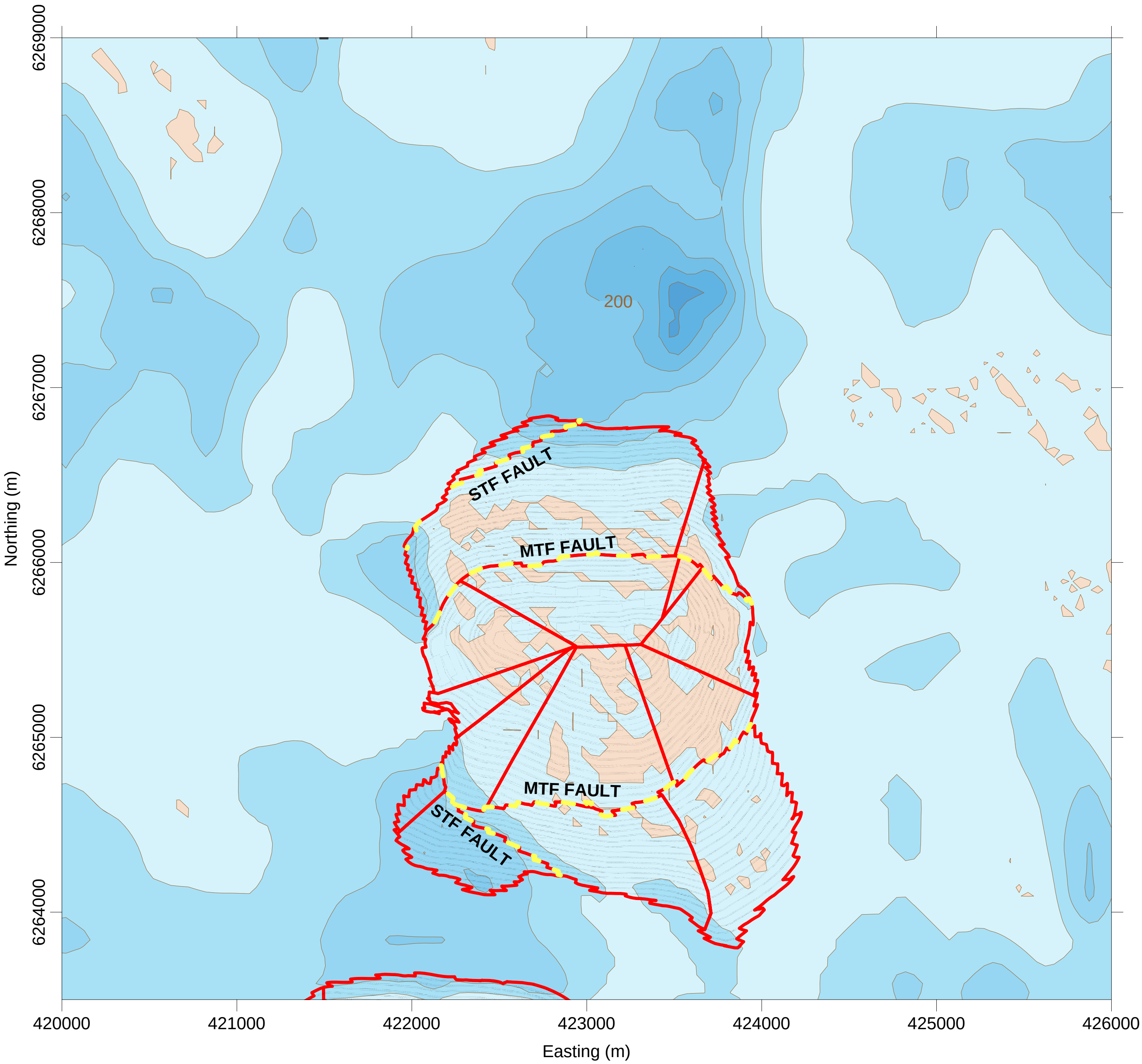

Notes:

1. *Depth to water within each pit outline is shown relative to the simulated base of pit shell (i.e. pink areas represent seepage breakout).*
2. *Pit slope design sectors are from BGC, 2012.*

Depth to Water (mbgs): -50, 0, 50, 100, 150, 200, 250, 300, 350, 400, 450

LOM PIT 10 m CONTOURS
FINAL PIT OUTLINE AND SECTORS
MAJOR FAULT TRACES

SCALE:	AS SHOWN	DESIGNED:	RT
DATE:	JUNE 2012	CHECKED:	RT
DRAWN:	RT	APPROVED:	TC

BGC ENGINEERING INC.
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PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: MITCHELL PIT DEPTH TO WATER AT END OF OPEN PIT MINING - NO MITIGATION

CLIENT: SEABRIDGE GOLD INC.

PROJECT No:	DWG No:	REV.
0638-013	7	0

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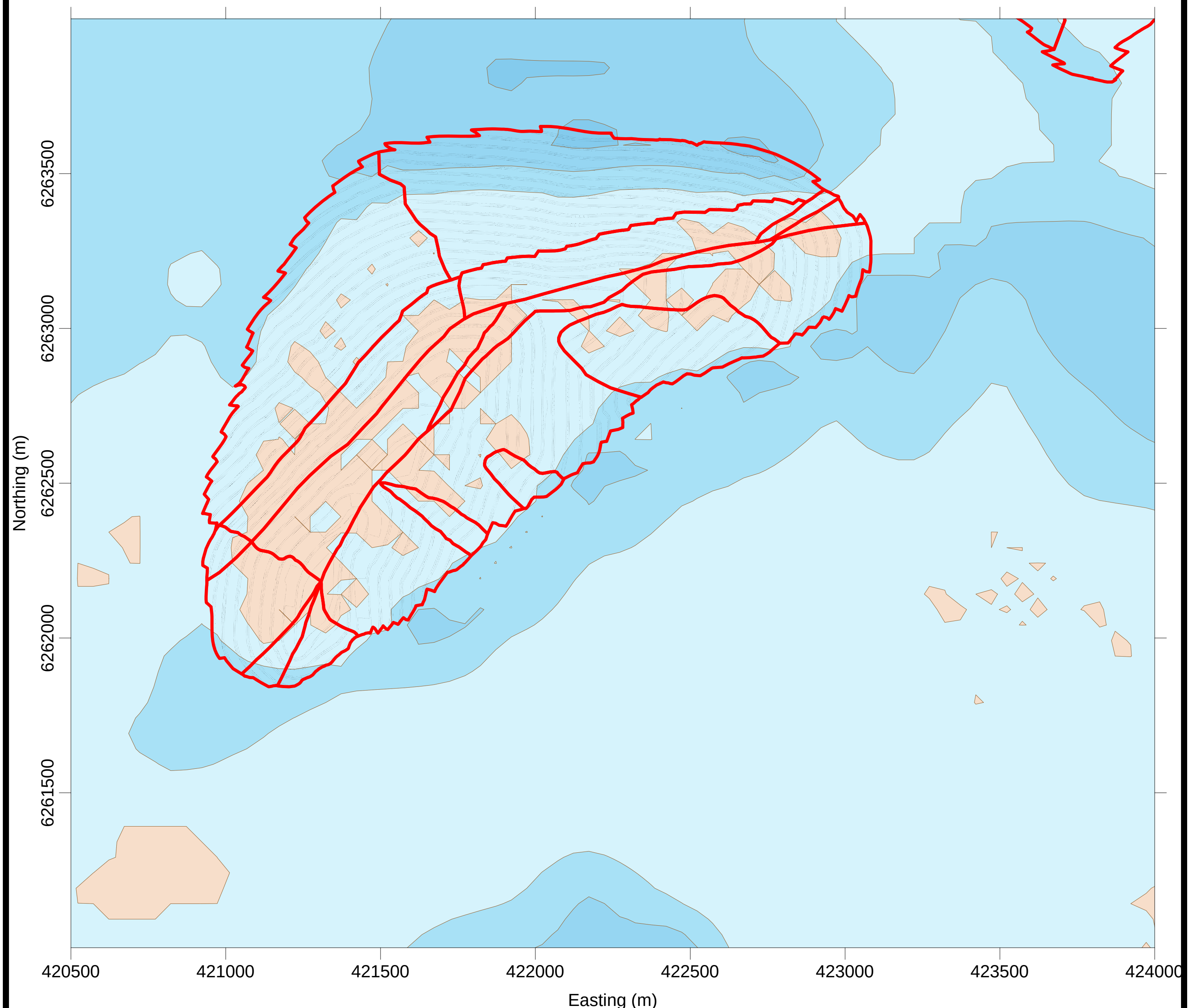

Notes:

1. *Depth to water within each pit outline is shown relative to the simulated base of pit shell (i.e. pink areas represent seepage breakout).*
2. *Pit slope design sectors are from BGC, 2012.*

LOM PIT 10 m CONTOURS

FINAL PIT OUTLINE AND SECTORS

SCALE:	AS SHOWN	DESIGNED:	RT
DATE:	JUNE 2012	CHECKED:	RT
DRAWN:	RT	APPROVED:	TC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: SULPHURETS PIT DEPTH TO WATER AT END OF OPEN PIT MINING (YEAR 27) - NO MITIGATION

CLIENT	PROJECT No:	DWG No:	REV.
SEABRIDGE GOLD INC.	0638-013	8	0

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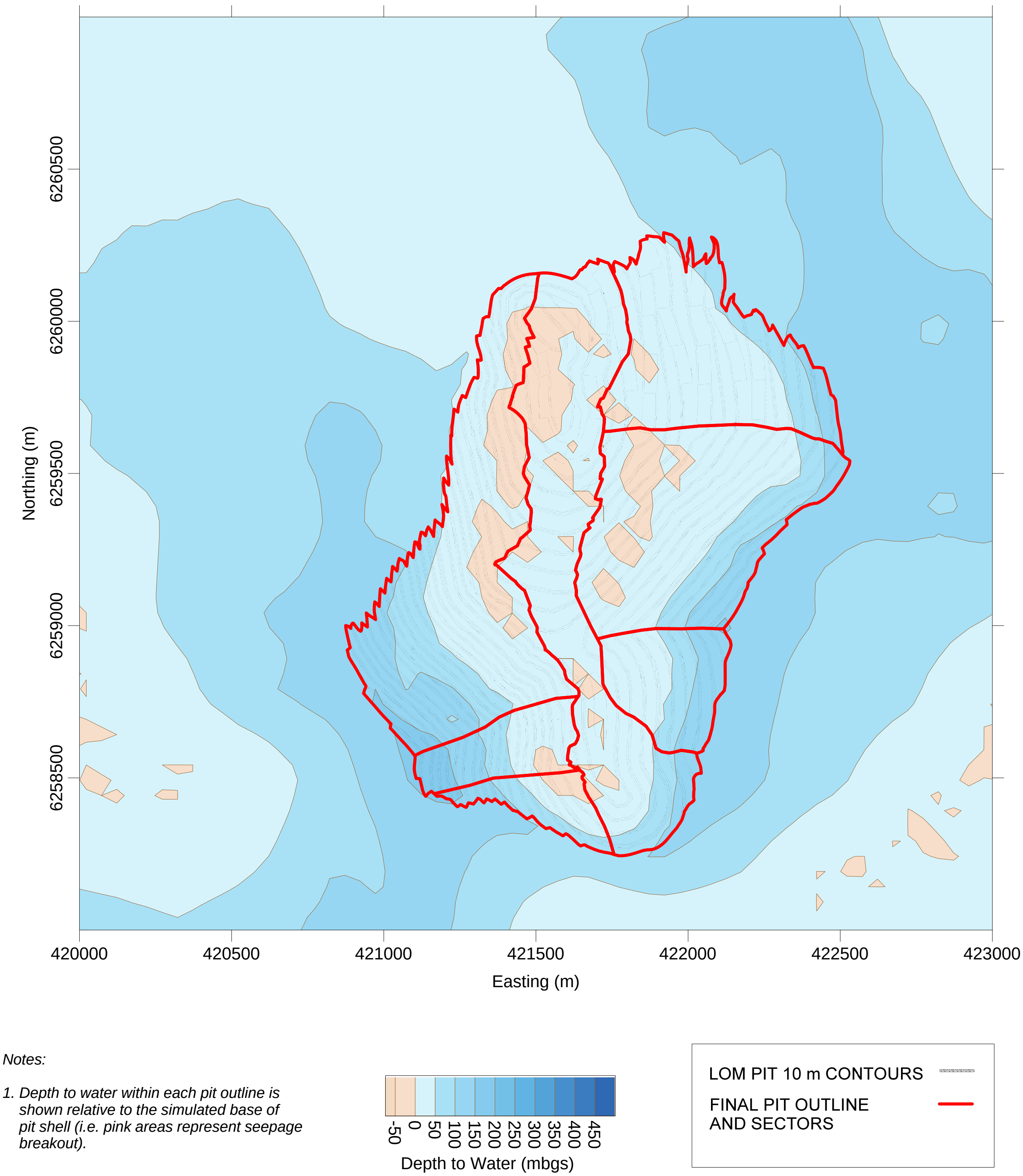

Notes:

1. *Depth to water within each pit outline is shown relative to the simulated base of pit shell (i.e. pink areas represent seepage breakout).*

SCALE:	AS SHOWN	DESIGNED:	RT
DATE:	JUNE 2012	CHECKED:	RT
DRAWN:	RT	APPROVED:	TC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: KERR PIT DEPTH TO WATER AT END OF OPEN PIT MINING (YEAR 50) - NO MITIGATION

CLIENT	PROJECT No:	DWG No:	REV.
SEABRIDGE GOLD INC.	0638-013	9	0

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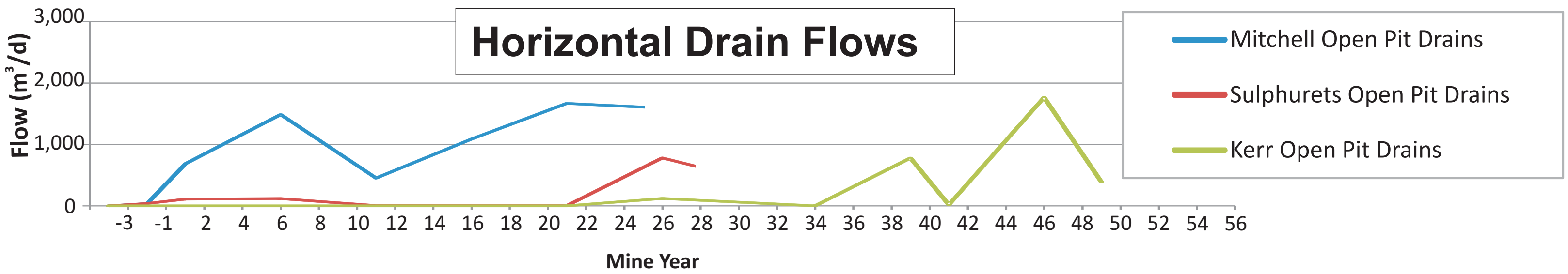
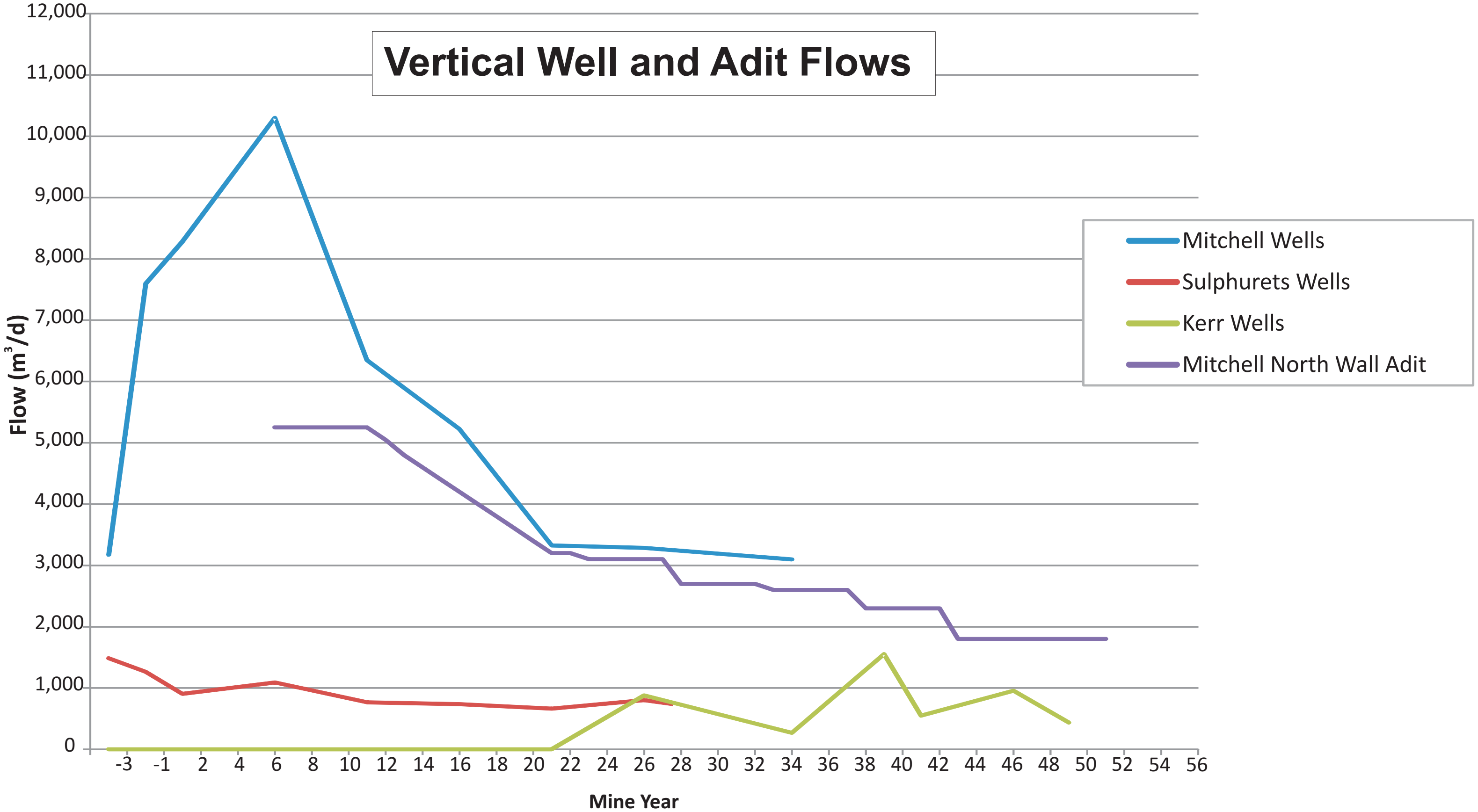
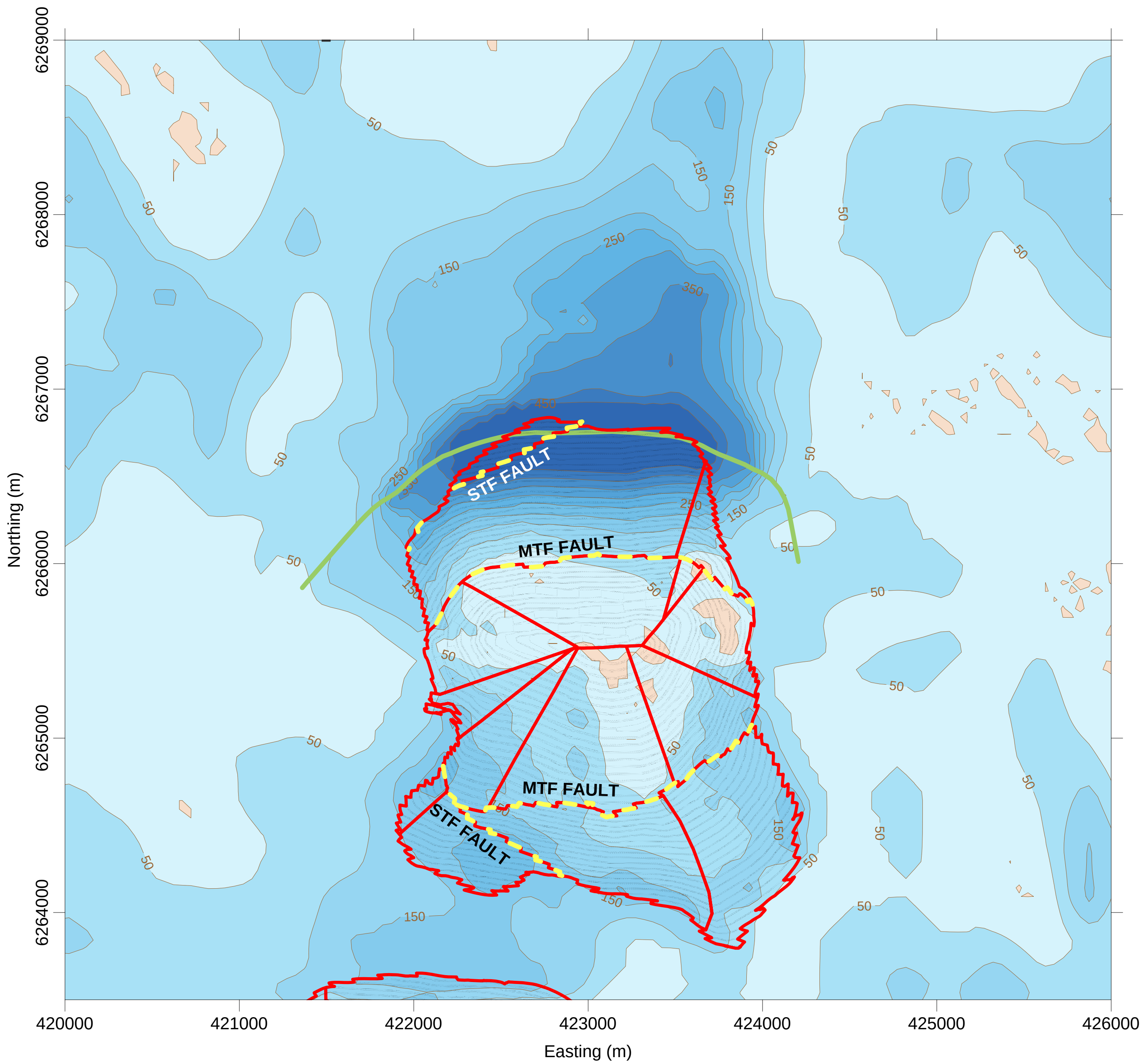


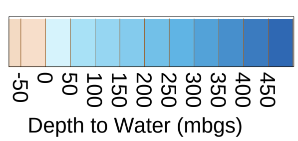


SCALE: NTS	DESIGNED: RT	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE OPEN PIT DEPRESSURIZATION ANALYSES
DATE: JUNE 2012	CHECKED: RT		TITLE: OPEN PIT DEPRESSURIZATION FLOW RESULTS WITH PLANNED MITIGATION
DRAWN: RT	APPROVED: TC	CLIENT: SEABRIDGE GOLD INC.	PROJECT No.: 0638-013 · DWG No.: 10 · REV.: 0



Notes:

1. *Depth to water is shown relative to the simulated base of pit shell (i.e. pink areas represent seepage breakout).*
2. *Pit slope design sectors are from BGC, 2012.*



Legend	
LOM PIT 10 m CONTOURS	
FINAL PIT OUTLINE AND SECTORS	
MAJOR FAULT TRACES	
NORTH WALL ADIT TRACE	

SCALE:	AS SHOWN	DESIGNED:	RT
DATE:	JUNE 2012	CHECKED:	RT
DRAWN:	RT	APPROVED:	TC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: MITCHELL PIT DEPTH TO WATER AT END OF OPEN PIT MINING (Year 23) WITH BASE CASE MITIGATION

CLIENT	PROJECT No:	DWG No:	REV.
SEABRIDGE GOLD INC.	0638-013	11	0

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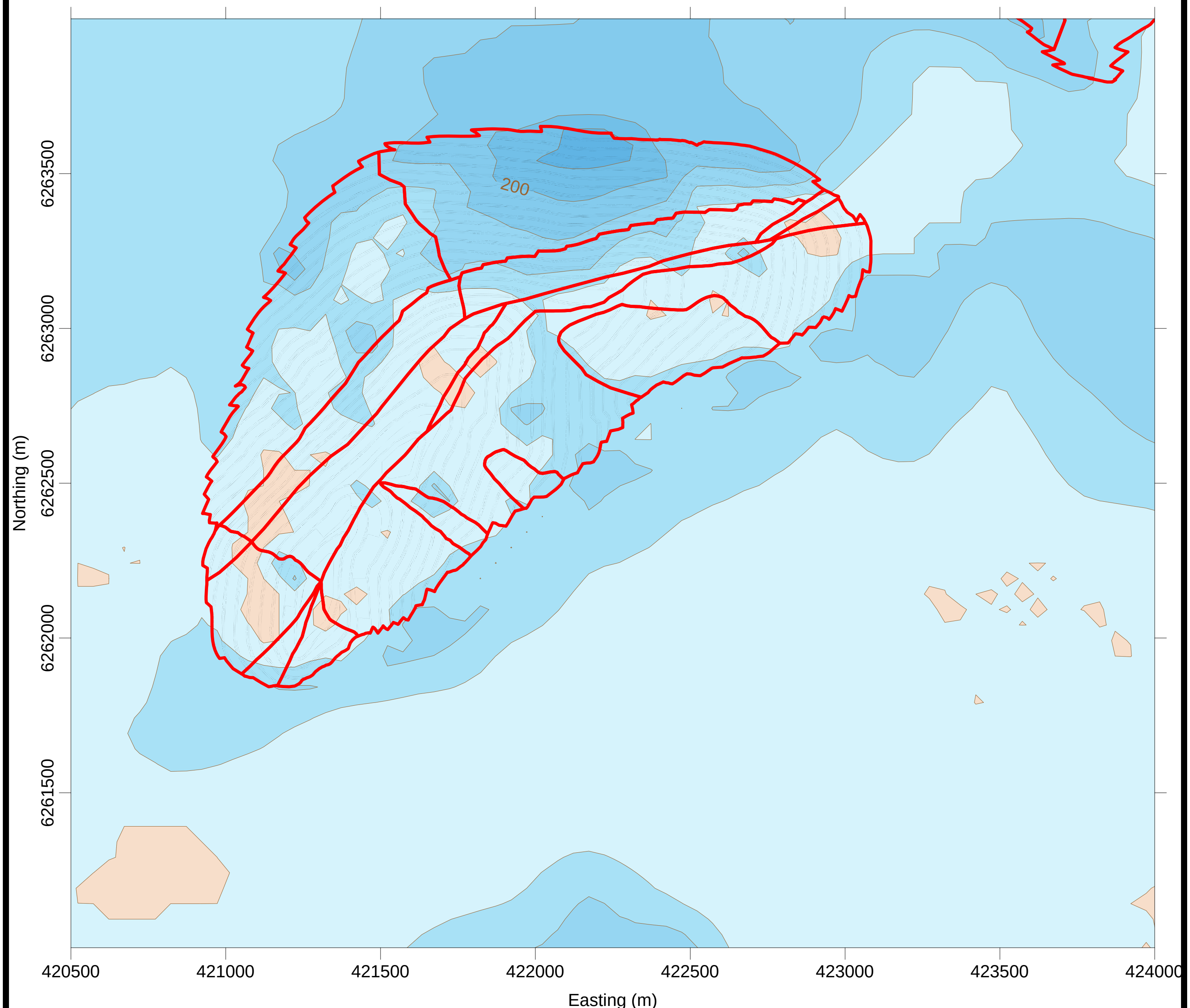

Notes:

1. *Depth to water within each pit outline is shown relative to the simulated base of pit shell (i.e. pink areas represent seepage breakout).*
2. *Pit slope design sectors are from BGC, 2012.*

LOM PIT 10 m CONTOURS

FINAL PIT OUTLINE AND SECTORS

SCALE:	AS SHOWN	DESIGNED:	RT
DATE:	JUNE 2012	CHECKED:	RT
DRAWN:	RT	APPROVED:	TC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: SULPHURETS PIT DEPTH TO WATER AT END OF OPEN PIT MINING (YEAR 27) WITH BASE CASE MITIGATION

CLIENT: SEABRIDGE GOLD INC.

PROJECT No:	DWG No:	REV.
0638-013	12	0

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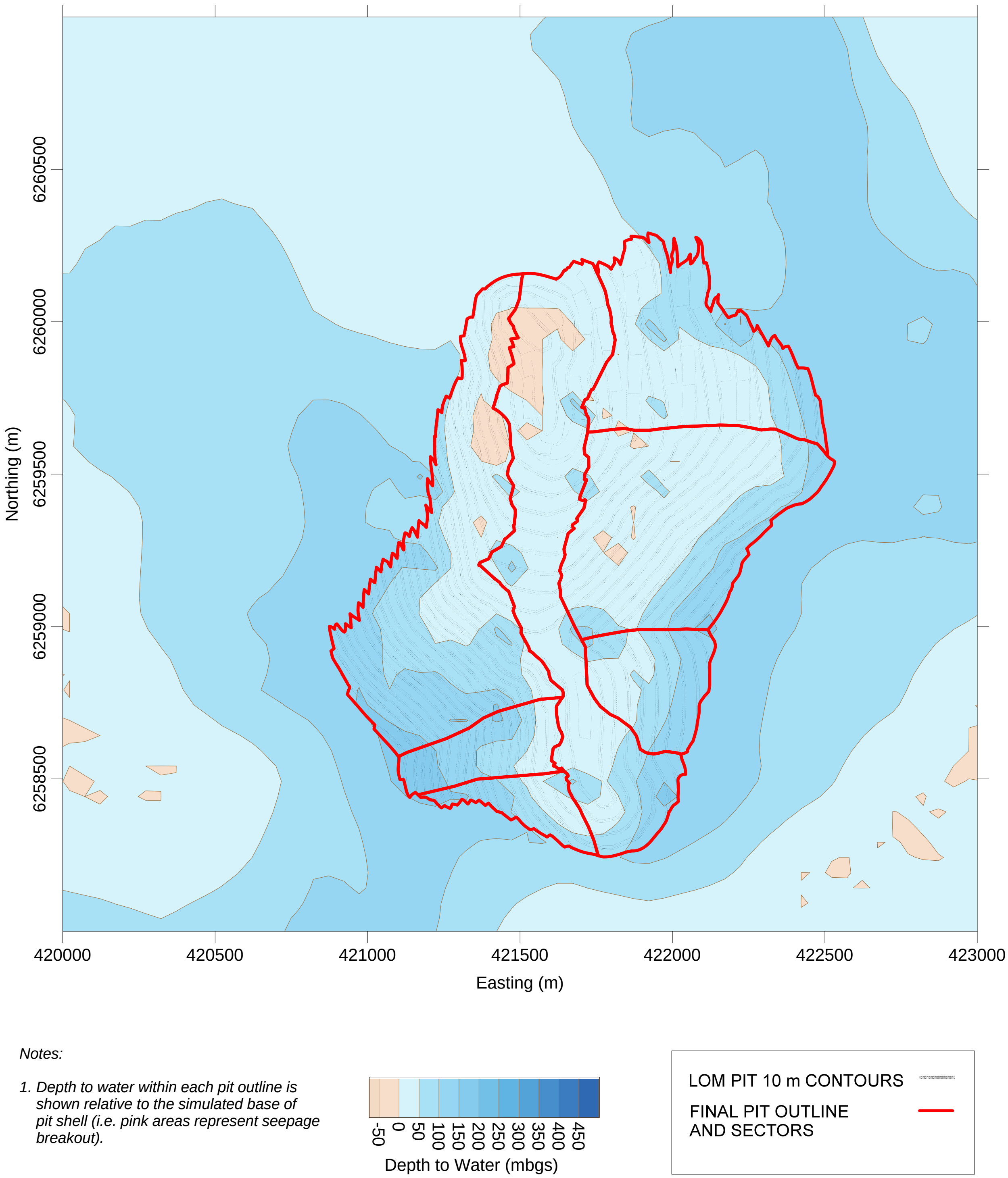


Notes:

1. Depth to water within each pit outline is shown relative to the simulated base of pit shell (i.e. pink areas represent seepage breakout).

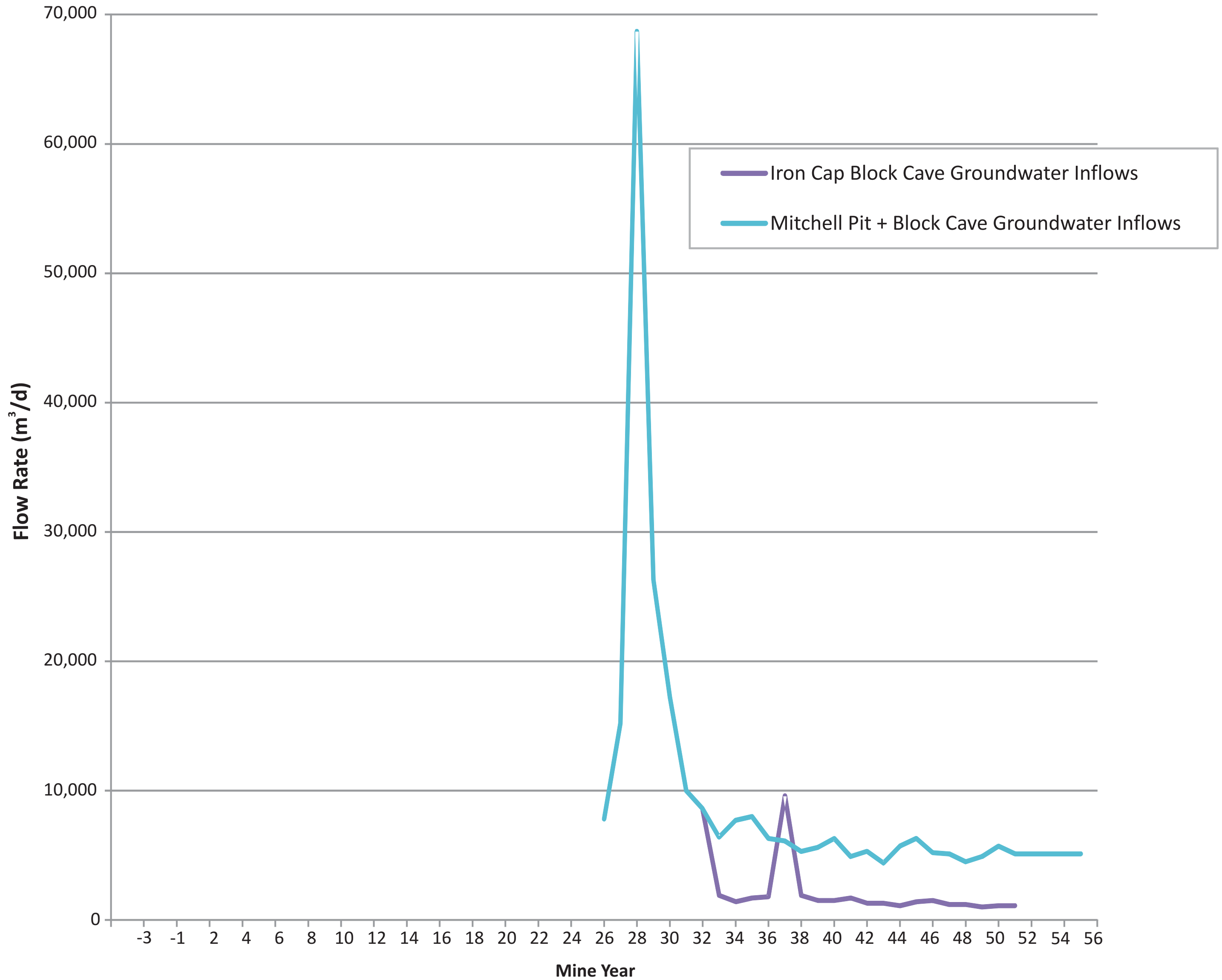
SCALE:	AS SHOWN	DESIGNED:	RT
DATE:	JUNE 2012	CHECKED:	RT
DRAWN:	RT	APPROVED:	TC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: KERR PIT DEPTH TO WATER AT END OF OPEN PIT MINING (YEAR 50) WITH BASE CASE MITIGATION

CLIENT	PROJECT No:	DWG No:	REV.
SEABRIDGE GOLD INC.	0638-013	13	0



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DATE:	JUNE 2012	CHECKED:	RT
DRAWN:	RT	APPROVED:	TC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT:
SEABRIDGE GOLD INC.

PROJECT:
KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE:
OPEN PIT AND BLOCK CAVE FLOW RESULTS
DURING BLOCK CAVE MINING YEARS

PROJECT No.:	DWG No.:	REV.:
0638-013	14	0

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APPENDIX A

Table A1: Mitchell Pit Depressurization Requirements

Geotechnical Domain	Design Sector(s)	Description	Expected Max Slope Height (m)	Dewatering Assumption			Min Oa Horizontal Setback to WT[1] (m)	Pre-Mining Conditions	Unmitigated LOM Watertable	Average Horizontal Drain Length (m)[2]	Vertical Wells[3]	Other / Comments
				Bench	Inter-ramp / Interberm	Overall Slope						
I	I-173	North dipping	1100	Structures Depressurized	Structures Depressurized, Partially depressurized Rock mass	Partially Saturated (50% of potential failure mass saturated)	**50**	In valley bottom watertable is generally at surface, and above is a subdued replica of topography approximately 50 m bgs at the crest of the proposed pit	The unmitigated watertable essentially parallels the pit slope in this domain with little to no set-back.	150	Y	
	I-220	NE Dipping	1100				**50**	Watertable is at surface in the valley bottom, 100 m bgs at the crest of the proposed pit and a subdued replica of topography in between.	The unmitigated watertable essentially parallels the pit slope in this domain with little to no set-back.	150	Y	
	I-240	NE Dipping	500				**50**	Watertable is at surface in the valley bottom, 50 m bgs at the crest of the proposed pit and a subdued replica of topography in between.	The unmitigated watertable essentially parallels the pit slope in this domain with little to no set-back.	150	Y	
	I-275	East dipping, adjacent to OPC	500				**50**	Watertable is approximately at ground surface for this entire sector, approx paralleling the creek / glacier	The unmitigated watertable essentially parallels the pit slope in this domain with little to no set-back.	150	Y	
	I-338	South dipping, high wall	1200				**150**	Watertable is approx 75 m below ground surface at the crest of the proposed pit, at surface at the current valley bottom, and undulates between surface and 100 m bgs over the existing slope	The unmitigated watertable essentially parallels the pit slope in this domain with little to no set-back.	300	Y	A Dewatering Adit and Drainage Gallery are proposed to assist with depressurization of this slope and to function as a back up system for the Mitchell Diversion Tunnel
	I-028	South dipping, high wall	1200				**150**	Watertable is approx 50 bgs at the crest of the proposed pit, at surface at the current valley bottom, and undulates between those points to a max bgs depth of 100 m	The unmitigated watertable essentially parallels the pit slope in this domain with little to no set-back.	300	N	A Dewatering Adit and Drainage Gallery are proposed to assist with depressurization of this slope and to function as a back up system for the Mitchell Diversion Tunnel
	I-078	West Dipping, adjacent to Mitchell Diversion inlet	550				**50**	Watertable is approximately at ground surface for this entire sector, approx paralleling the creek / glacier	The unmitigated watertable essentially parallels the pit slope in this domain with little to no set-back.	150	Y	
	I-125	NW dipping	700				**50**	In valley bottom watertable is basically at surface, and above is a subdued replica of topography approximately 50 m bgs at the crest of the proposed pit	The unmitigated watertable essentially parallels the pit slope in this domain with little to no set-back.	150	Y	
II	II-325	South Dipping Upper Section of highwall	700			Partially depressurized (25% of potential failure mass saturated)	**200**	Watertable is approx 75 m below ground surface at the crest of the proposed pit, at surface at the current valley bottom, and undulates between surface and 100 m bgs over the existing slope	The unmitigated watertable parallels the pit slope with very little set back for approximately half of the domain, then the set back gradually increases to approximately 250 m behind the pit face	100	N	A Dewatering Adit and Drainage Gallery are proposed to assist with depressurization of this slope and to function as a back up system for the Mitchell Diversion Tunnel
	II-035	SW Dipping	500				**50**	Watertable is approx 50 bgs at the crest of the proposed pit, at surface at the current valley bottom, and undulates between those points to a max bgs depth of 100 m	The unmitigated watertable at the base of this domain is approximately at the pit face then slopes back to approximately 150 m behind the pit face	100	Y	
III	III-138	NW dipping	450			Partially Saturated (50% of potential failure mass saturated)	**50**	Subdued replica of topography the groundwater table is approx 50 m bgs	The unmitigated watertable essentially parallels the pit slope in this domain with little to no set-back.	100	Y	
	III-189	North dipping	450				**50**	Subdued replica of topography the groundwater table is approx 50 m bgs	The unmigitaged watertable at the base of this domain is approximately at the pit face, follows the pit face for approximately 150 m of elevation and gradually slopes back to approx 150 m behind the pit at the height of slope.	100	Y	
IV	IV-200	NE Dipping	360			Partially depressurized (25% of potential failure mass saturated)	**50**	Watertable is at surface in the valley bottom, 100 m bgs at the crest of the proposed pit and a subdued replica of topography in between.	The unmitigated watertable in this domain is parallel to the pit wall approximately 150 m behind the face.	100	N	
	IV-240	NE Dipping	300				**50**	Watertable is at surface in the valley bottom, 100 m bgs at the crest of the proposed pit and a subdued replica of topography in between.	The unmitigated watertable in this domain is parallel to the pit wall approximately 150 m behind the face.	100	N	
	IV-003	Upper Section of highwall	250				**350**	Watertable is approx 75 m below ground surface at the crest of the proposed pit, at surface at the current valley bottom, and undulates between surface and 100 m bgs over the existing slope	The unmitigated watertable in this domain parallels the pit face approximately 150 m into the slope.	100	N	

Notes:
1. Setback to water estimated from mid-slope of slide analyses assuming 50% of failure mass is saturated.
2. Horizontal drain lengths have been estimated considering a 50% effective length. 100 m drains will likely be required during operations on those slopes where the LOM watertable meets bench and interberm depressurization
3. Vertical wells have been modeled based on a nominal spacing, placement has not been optimized wrt pit phasing at this stage of study.

Table A2: Sulphurets Pit Dewatering Requirements

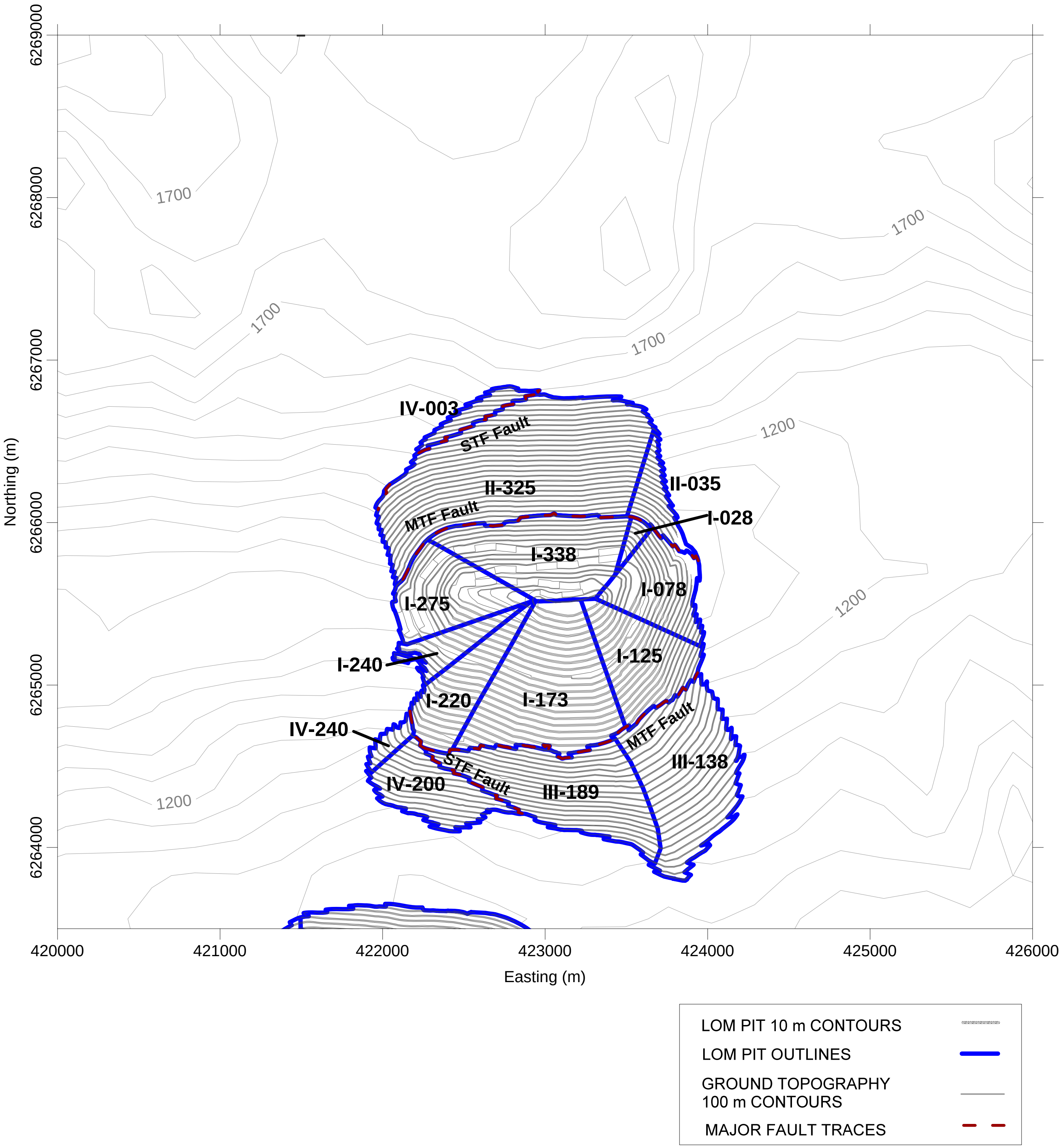
Geotechnical Domain	Design Sector(s)	Max Slope Height (m)	Depressurization Assumption					Pre-Mining Conditions	Unmitigated EOL Watertable (No Drains or Wells)	Min Horizontal Drain Length (m)[4]	Vertical Wells	Other / Comments
			Bench	Inter-ramp / Interberm	IBa Setback to WT[1] (m)	Overall Slope	Oa Setback to WT[2] (m)					
SHW-V	SHW-323	420			40		**50**	Watertable is approx 100 m below ground surface at the ridge crest of the proposed pit, and follows topography to ~50 m below at the downhill crest of the pit	At the base of this design sector the watertable is approximately at the pit wall, and slopes back into the wall to a maximum elevation of 1450 masl	100	Y	
	SHW-028	120			**80**		50	Watertable is approx 50 m below ground surface, subdued replica of topography	This sector is mostly dry based on the 3d model, the watertable reaches a maximum elevation of 1450 m just above the base of it.	160	N	
SFW-C	SFW-C-265	270			50		**50**	Watertable is approx 50 m below ground surface, subdued replica of topography	In this sector the watertable is near to the pit face	100	N	
	SFW-C-333	500			50		**50**	Watertable is approx 70 m below ground surface at the crest of the proposed pit, and follows topography	In this sector the watertable is approximately at the pit face	100	Y	
	SFW-C-015	500			50		**50**	Watertable is approx 100 m below ground surface at the ridge crest of the proposed pit, and follows topography to ~50 m below at the downhill crest of the pit	In this sector the pit walls are mostly dry	100	Y	
	SFW-C-045	400			50		**50**	Watertable is approx 50 m below ground surface, subdued replica of topography	In this sector the watertable is near to the pit face	100	N	
	SFW-C-070	250			50		**50**	Watertable is approx 50 m below ground surface, subdued replica of topography	In this sector the watertable is near to the pit face	100	N	
SFW-V	SFW-190	150			50		**50**	Watertable is approx 50 m below ground surface, subdued replica of topography	In this sector the pit walls are mostly dry	100	Y	
	SFW-222	150			50		**50**	Watertable is approx 50 m below ground surface, subdued replica of topography	In this sector the pit walls are mostly dry	100	N	
	SFW-269	150			50		**50**	Watertable is approx 70 m below ground surface at the crest of the proposed pit, and follows topography	In this sector the watertable is approximately at the pit face	100	Y	
	SFW-333	150			50		**50**	Watertable is approx 100 m below ground surface at the ridge crest of the proposed pit, and follows topography to ~50 m below at the downhill crest of the pit	In this sector the watertable is approximately at the pit face	100	Y	
	SFW-033	400			50		**50**	Watertable is approx 50 m below ground surface, subdued replica of topography	In this sector the watertable is approximately at the pit face	100	Y	
	SFW-090	600			50		**50**	Watertable is approx 50 m below ground surface, subdued replica of topography	In this sector the watertable is approximately at the pit face at the base of the pit and slopes back gradually to approximately 100 m behind the pit wall	100	Y	
	SFW-146	150			50		**50**	Watertable is approx 50 m below ground surface, subdued replica of topography	In this sector the watertable is approximately at the pit face	100	N	

Notes:
1. Set back to water for interberm slopes estimated based depressurizing on potentially critical structures, rounded up to the nearest 10 m.
2. Setback to water estimated from mid-slope of slide analyses assuming 50% of failure mass is saturated.
3. Setback that will control the overall slope dewatering scheme has been identified in bold text.
4. Horizontal drain lengths have been estimated assuming a 50% effective length.
5. Vertical wells have been modeled based on a nominal spacing, placement has not been optimized for pit phasing at this stage of study.

Table A3: Kerr Pit Dewatering Requirements

<table>
<tr><th rowspan="2">Geotechnical Domain</th><th rowspan="2">Design Sector(s)</th><th rowspan="2">Max Slope Height (m)</th><th colspan="5">Depressurization Assumptions</th><th rowspan="2">Pre-Mining Conditions</th><th rowspan="2">Unmitigated EOL Watertable</th><th rowspan="2">Min Horizontal Drain Length (m)[4]</th><th rowspan="2">Vertical Wells</th><th rowspan="2">Other / Comments</th></tr>
<tr><th>Bench</th><th>Inter-ramp / Interberm</th><th>IBa Setback to WT[1] (m)</th><th>Overall Slope</th><th>Oa Setback to WT[2] (m)</th></tr>
<tr><td rowspan="4">KVOL</td><td>KVOL-236</td><td>600</td><td rowspan="6">Structures Depressurized</td><td rowspan="4">Structures Depressurized, Partially Saturated Rock mass</td><td>50</td><td rowspan="4">Partially Saturated (50% of failed mass saturated)</td><td>50</td><td>Watertable 100 m below surface at top of slope, at the base of this design sector the watertable is at surface</td><td>The watertable in this sector is approximately at the pit wall.</td><td>100</td><td>Y</td><td></td></tr>
<tr><td>KVOL-065</td><td>450</td><td>50</td><td>50</td><td>Watertable 100 m below the surface for this sector</td><td>The watertable in this sector dips back into the slope to a maximum set back of 150 m</td><td>100</td><td>Y</td><td></td></tr>
<tr><td>KVOL-126</td><td>600</td><td>60</td><td>50</td><td>Watertable 100 m below surface at top of slope, at the base of this design sector the watertable is at surface</td><td>The watertable in this sector is approximately at the pit face below the top 150 m, which are nearly dry based on the 3d model</td><td>120</td><td>Y</td><td></td></tr>
<tr><td>KVOL-160</td><td>600</td><td>70</td><td>50</td><td>Watertable 100 m below surface at top of slope, at the base of this design sector the watertable is at surface</td><td>The watertable in this sector is approximately at the pit face below the top 150 m, which are nearly dry based on the 3d model</td><td>140</td><td>Y</td><td></td></tr>
<tr><td rowspan="2">KALT</td><td>KALT-180</td><td>420</td><td rowspan="2">Structures Depressurized, Partially Depressurized Rock mass</td><td>30</td><td rowspan="2">Partially Depressurized (25% of failed mass saturated)</td><td>50</td><td>Watertable 100 m below surface at top of slope, at the base of this design sector the watertable is at surface</td><td>The watertable in this sector is approximately at the pit wall.</td><td>100</td><td>Y</td><td></td></tr>
<tr><td>KALT-000</td><td>120</td><td>30</td><td>50</td><td>Watertable 100 m below the surface for this sector</td><td>The watertable in this sector is approximately at the pit wall.</td><td>100</td><td>Y</td><td></td></tr>
</table>

Notes:
1. Set back to water for interberm slopes estimated based depressurizing on potentially critical structures, rounded up to the nearest 10 m.
2. Setback to water estimated from mid-slope of slide analyses assuming 50% of failure mass is saturated.
3. Setback that will control the overall slope dewatering scheme has been identified in bold text.
4. Horizontal drain lengths have been estimated assuming a 50% effective length.
5. Vertical wells have been modeled based on a nominal spacing, placement has not been optimized for pit phasing at this stage of study.



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AN APPLIED EARTH SCIENCES COMPANY

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: MITCHELL PIT DESIGN SECTORS

CLIENT: SEABRIDGE GOLD INC.

PROJECT No: 0638-013
DWG No: A1
REV. A

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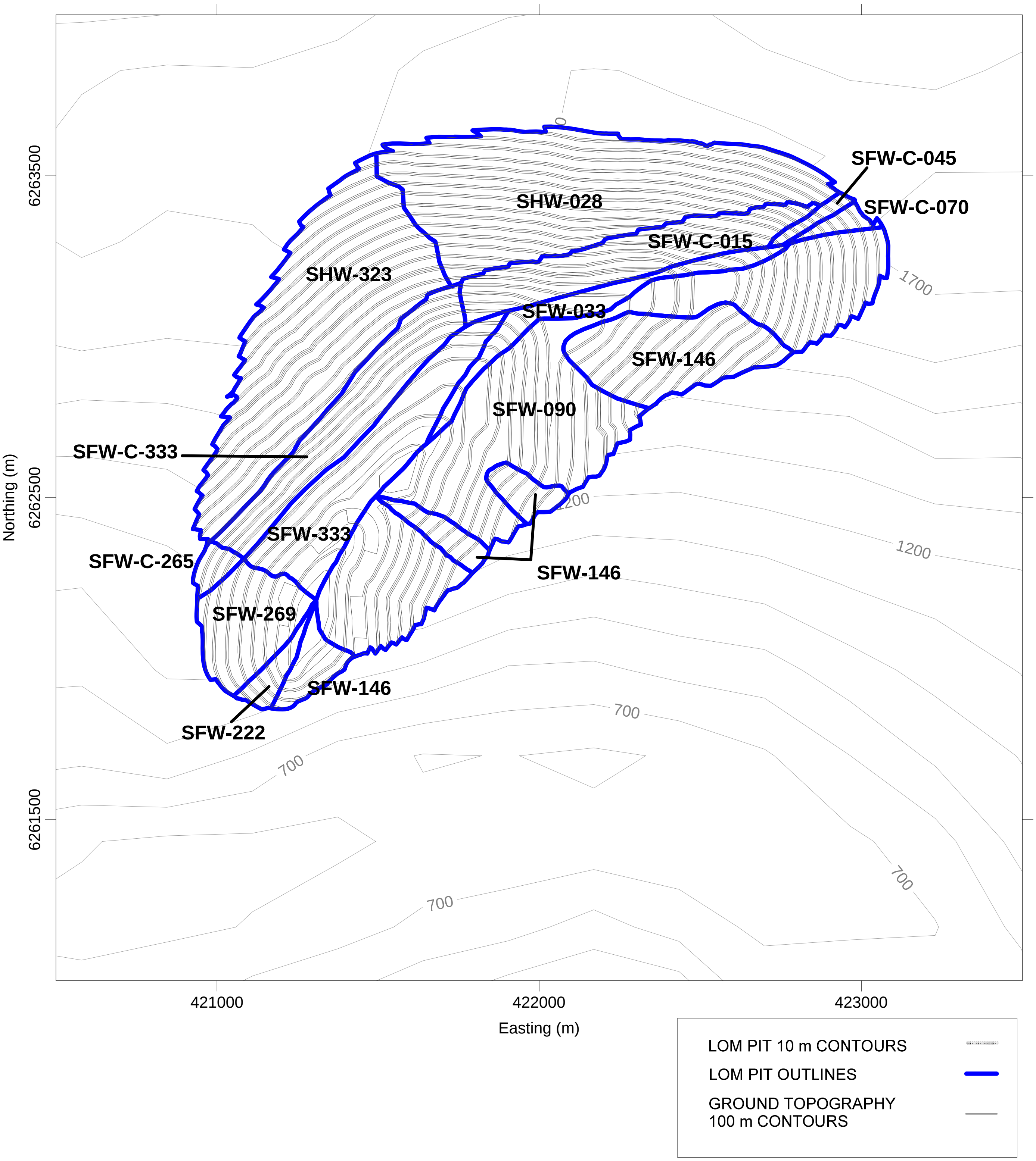

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PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: SULPHURETS DESIGN SECTORS

CLIENT	PROJECT No:	DWG No:	REV.
SEABRIDGE GOLD INC.	0638-013	A2	A

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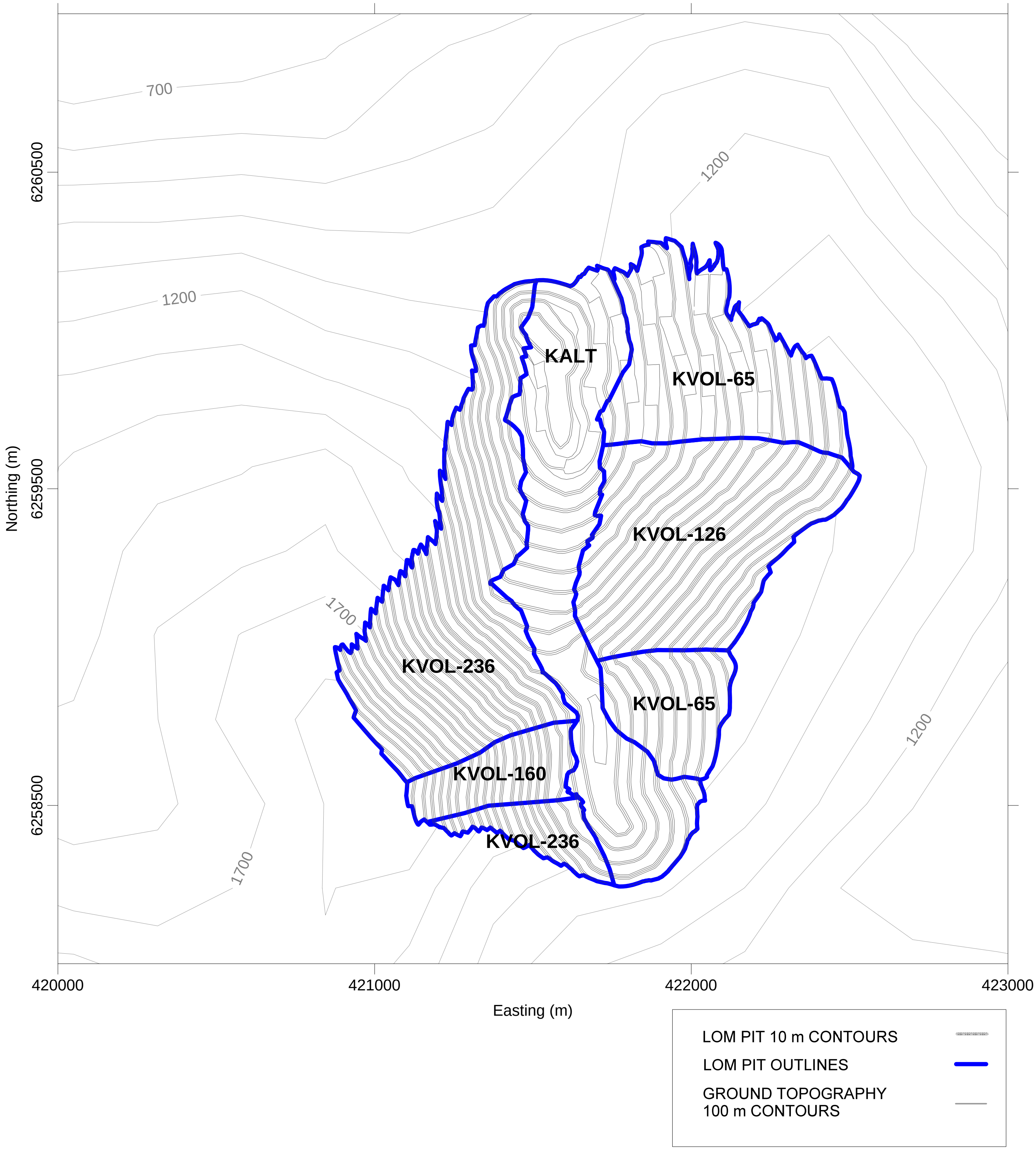

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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: KERR DESIGN SECTORS

CLIENT	PROJECT No:	DWG No:	REV.
SEABRIDGE GOLD INC.	0638-013	A3	A

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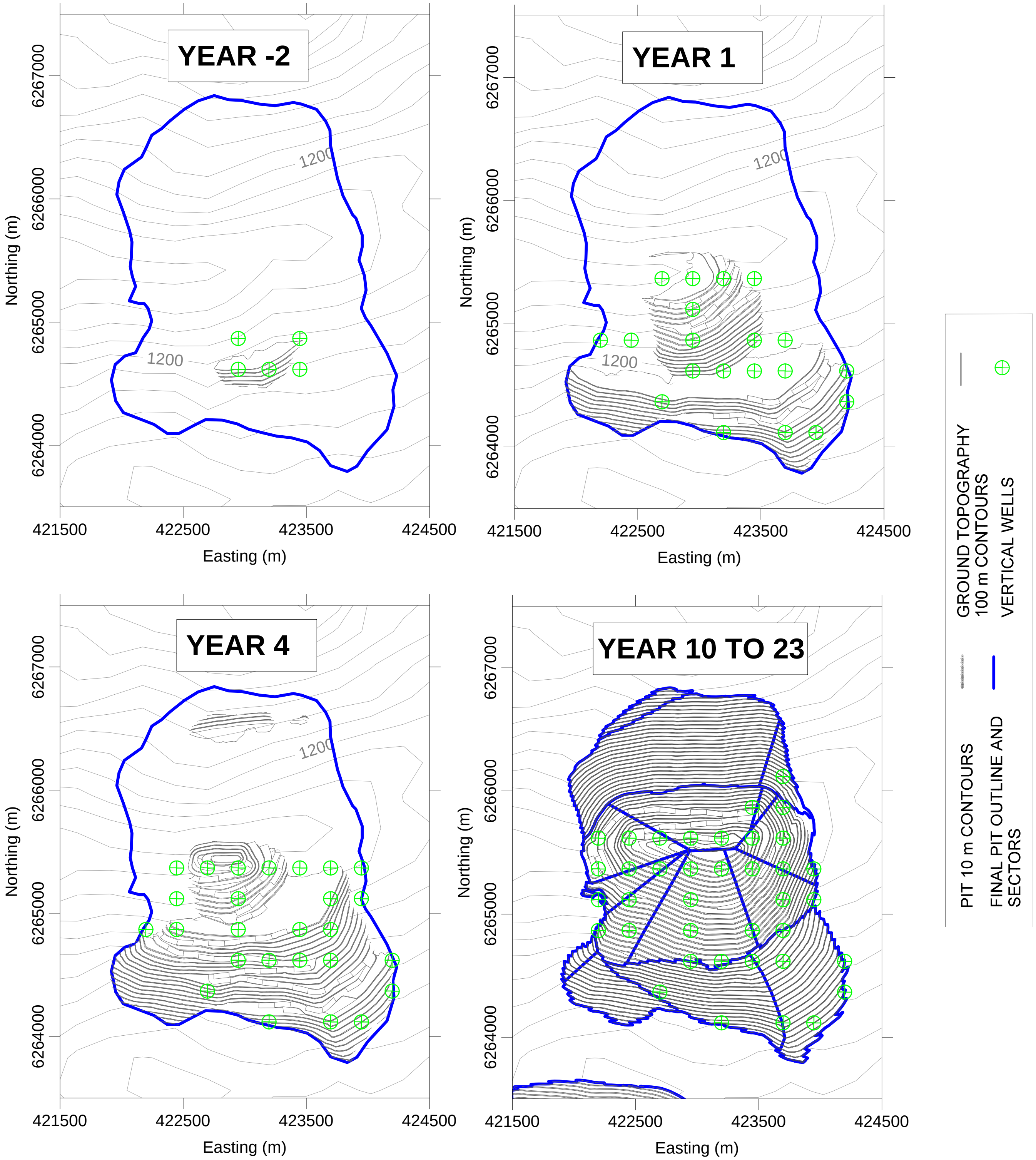
APPENDIX B



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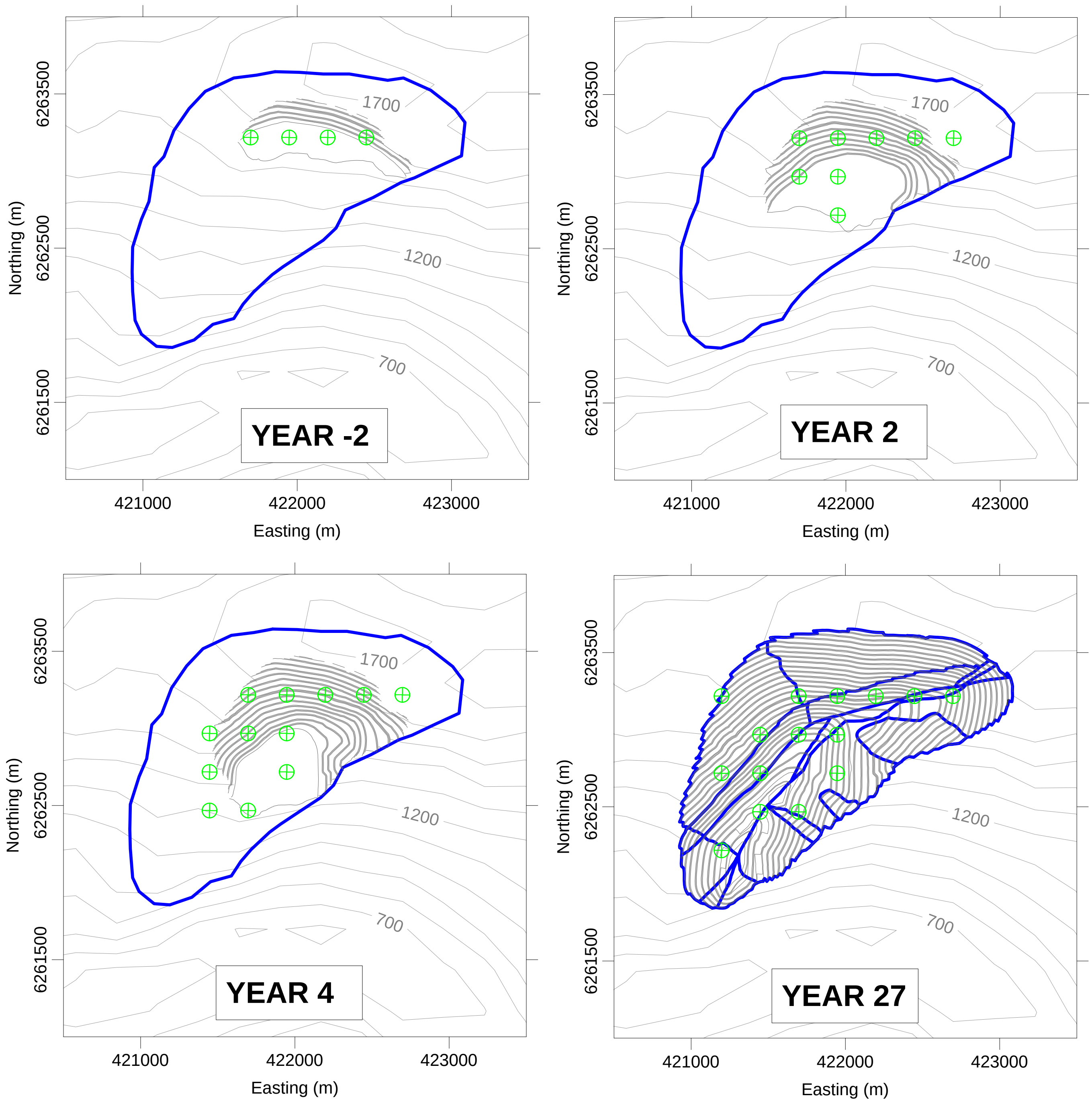
PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: MITCHELL PIT WELL LAYOUTS

CLIENT: SEABRIDGE GOLD INC.

PROJECT No:	DWG No:	REV.
0638-013	B1	A



PIT 10 m CONTOURS	GROUND TOPOGRAPHY 100 m CONTOURS
FINAL PIT OUTLINE AND SECTORS	VERTICAL WELLS

SCALE:	AS SHOWN	DESIGNED:	RT
DATE:	JUNE 2012	CHECKED:	RT
DRAWN:	RT	APPROVED:	TC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: SULPHURETS PIT WELL LAYOUTS

CLIENT	PROJECT No:	DWG No:	REV.
SEABRIDGE GOLD INC.	0638-013	B2	A

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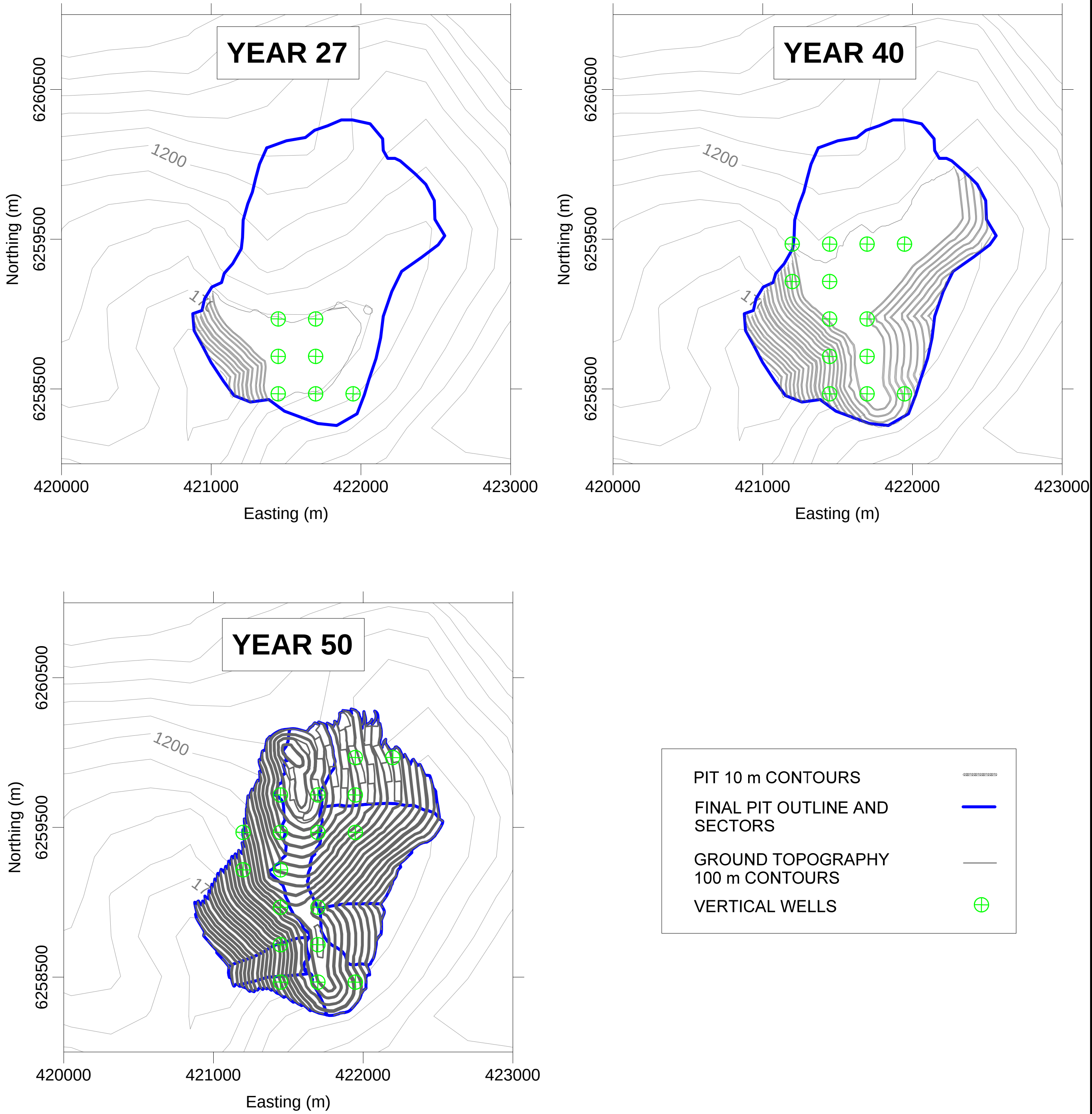

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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: KERR PIT WELL LAYOUTS

CLIENT: SEABRIDGE GOLD INC.	PROJECT No: 0638-013	DWG No: B3	REV. A

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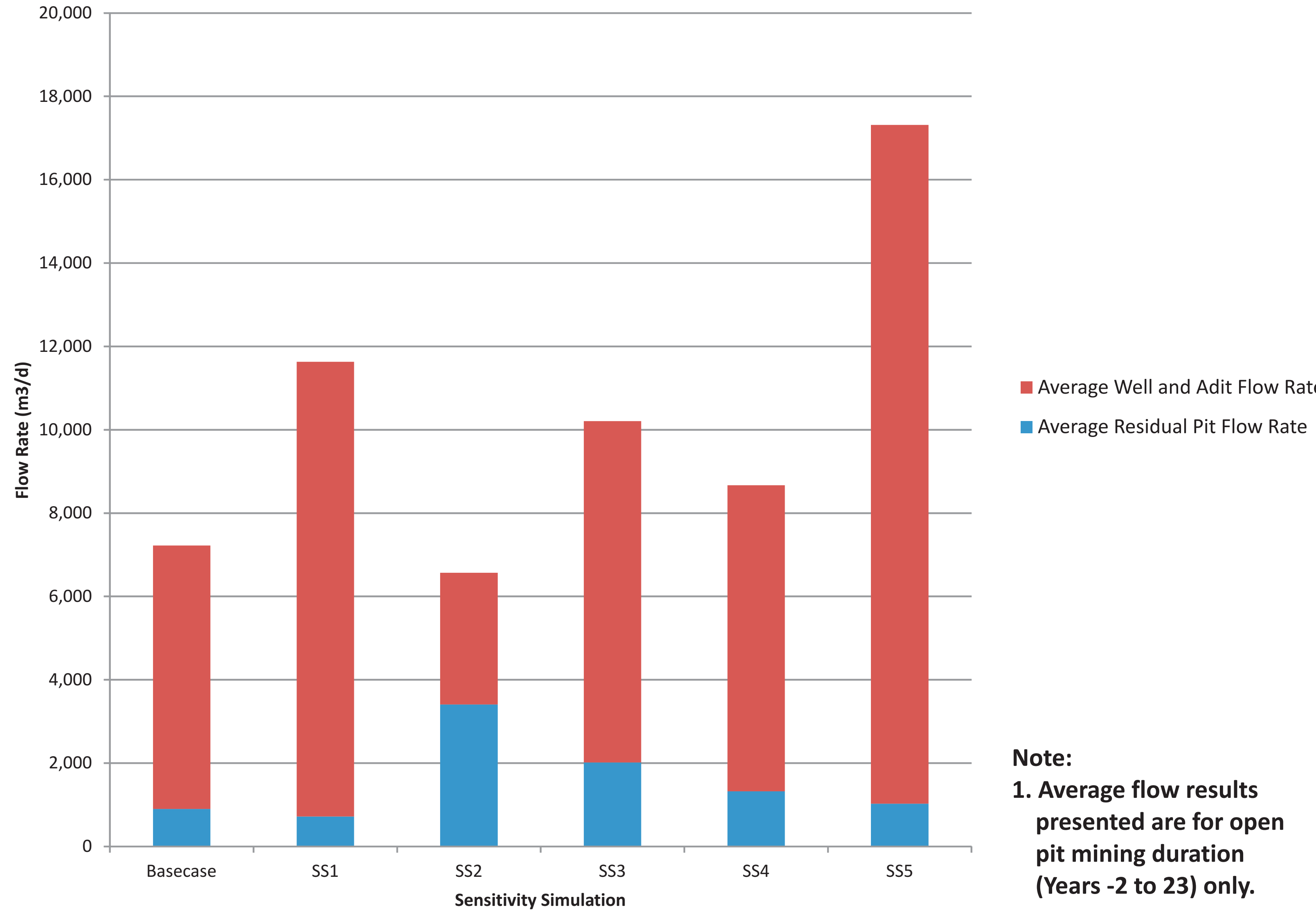
APPENDIX C



Note:

1. Average flow results presented are for open pit mining duration (Years -2 to 23) only.

SCALE: NTS	DESIGNED: RT	PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE OPEN PIT DEPRESSURIZATION ANALYSES	
DATE: JUNE 2012	CHECKED: RT	TITLE: SENSITIVITY ANALYSES VS BASE CASE MITCHELL PIT AVERAGE RESULTS	
DRAWN: RT	APPROVED: TC		

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: SEABRIDGE GOLD INC.

PROJECT No.:	DWG No.:	REV.:
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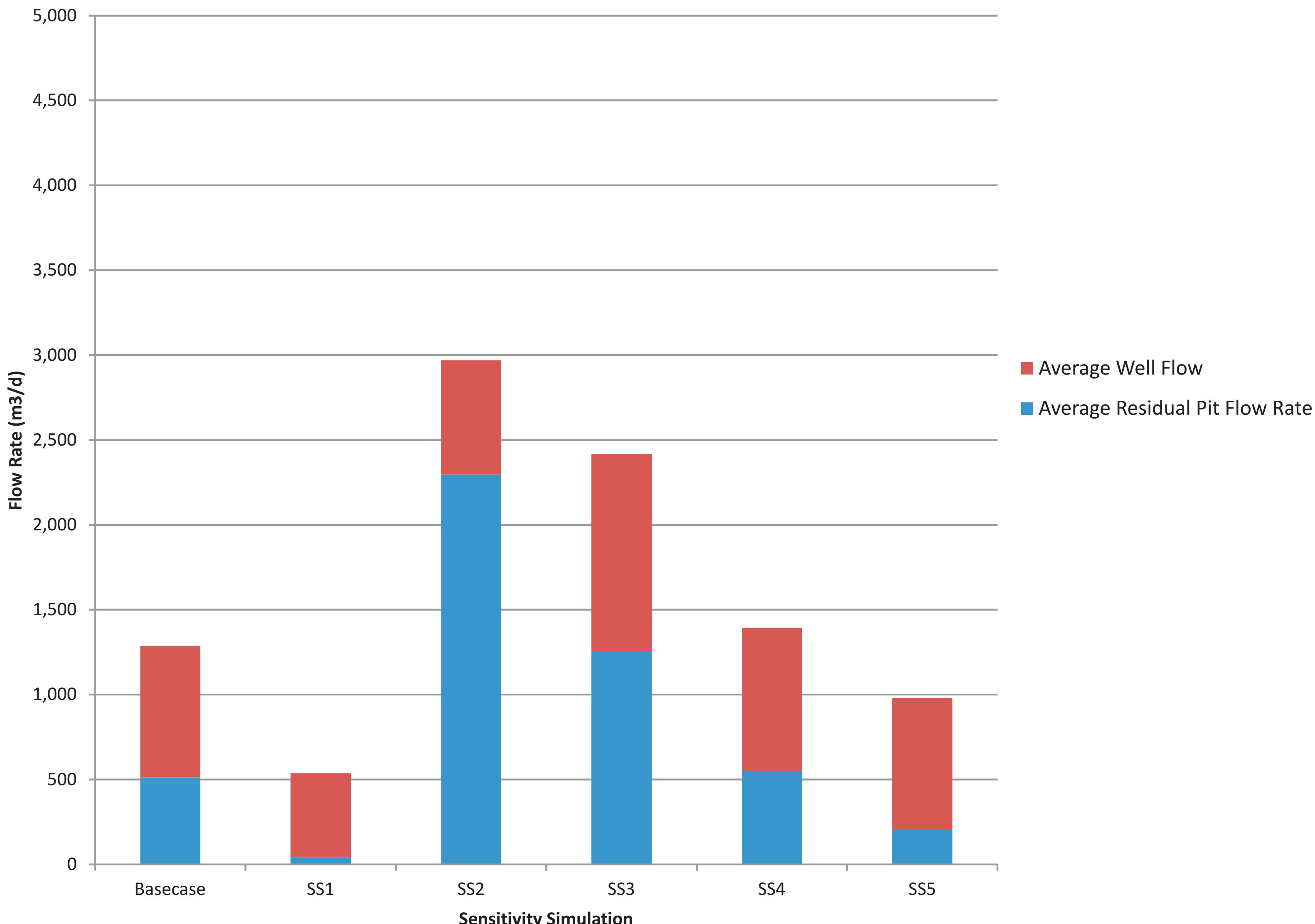

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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT:
SEABRIDGE GOLD INC.

PROJECT:
KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE:
SENSITIVITY ANALYSES VS BASE CASE
KERR PIT AVERAGE RESULTS

PROJECT No.:	DWG No.:	REV.:
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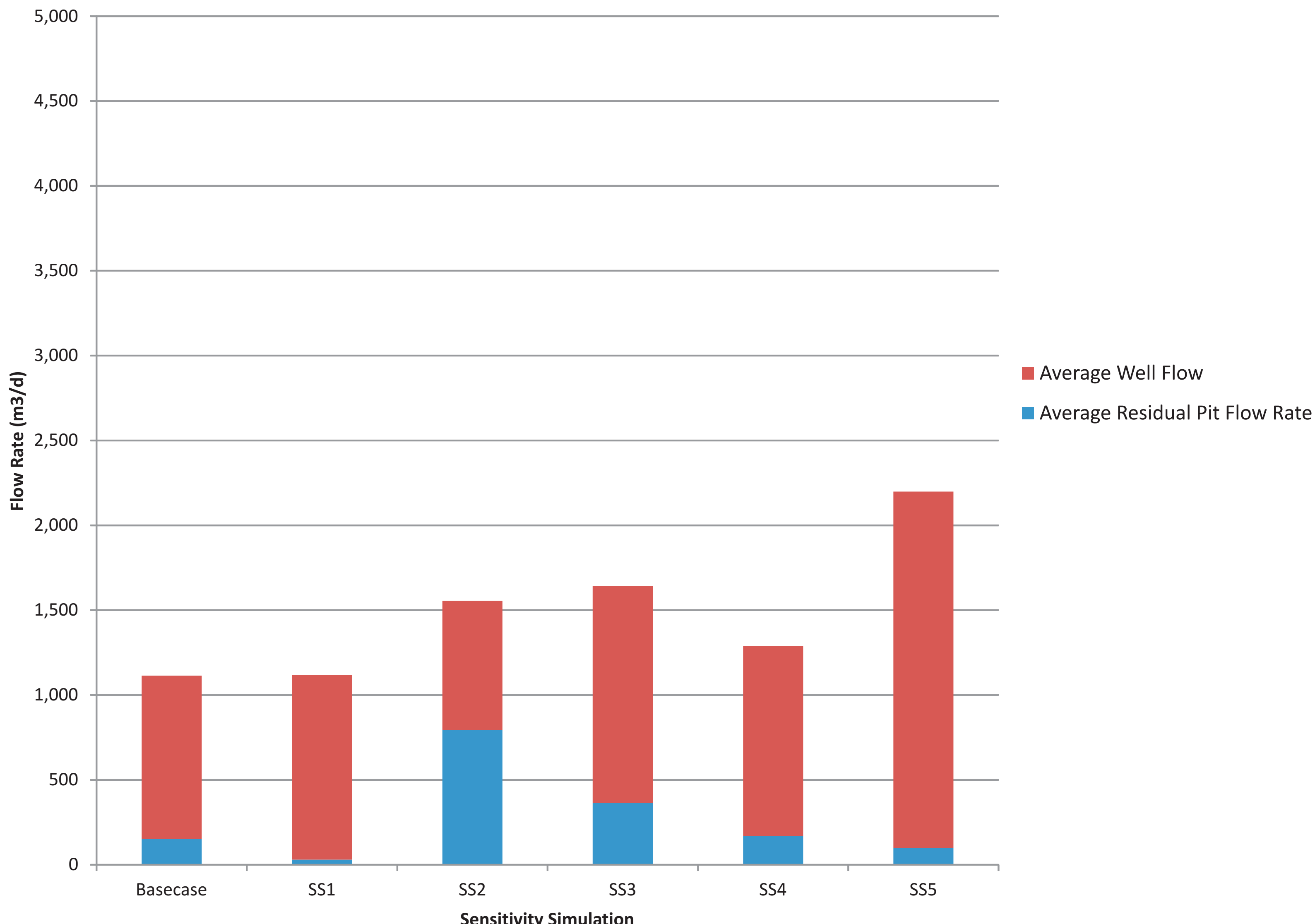

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CLIENT:
SEABRIDGE GOLD INC.

PROJECT:
KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE:
SENSITIVITY ANALYSES VS BASE CASE
SULPHURETS PIT AVERAGE RESULTS

PROJECT No.:	DWG No.:	REV.:
0638-013	C3	0

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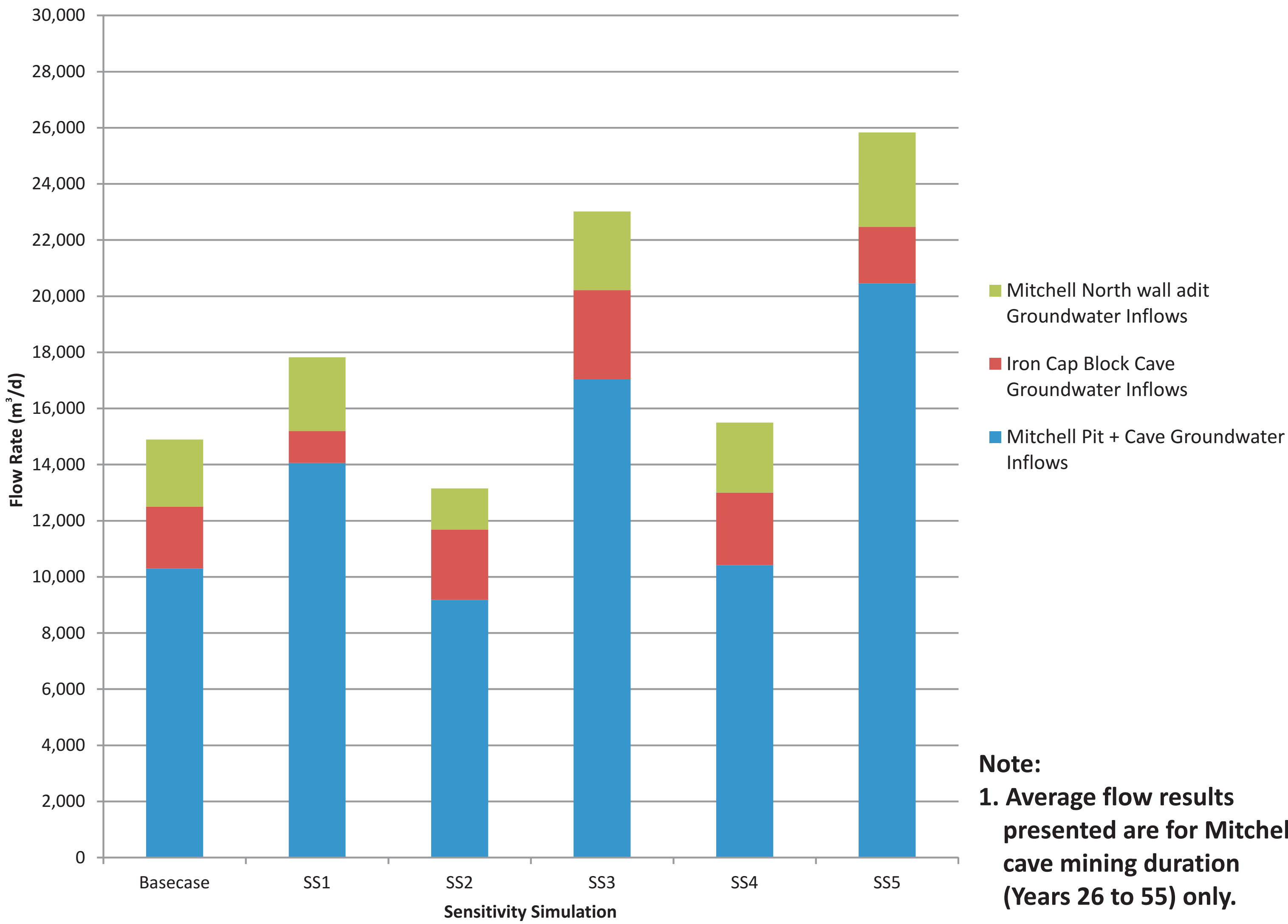

Note:

1. Average flow results presented are for Mitchell cave mining duration (Years 26 to 55) only.

SCALE: NTS	DESIGNED: RT	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE OPEN PIT DEPRESSURIZATION ANALYSES
DATE: JUNE 2012	CHECKED: RT		TITLE: SENSITIVITY ANALYSES VS BASE CASE PIT AND CAVE AVERAGE FLOW RESULTS
DRAWN: RT	APPROVED: TC	CLIENT: SEABRIDGE GOLD INC.	PROJECT No.: 0638-013 / DWG No.: C4 / REV.: 0

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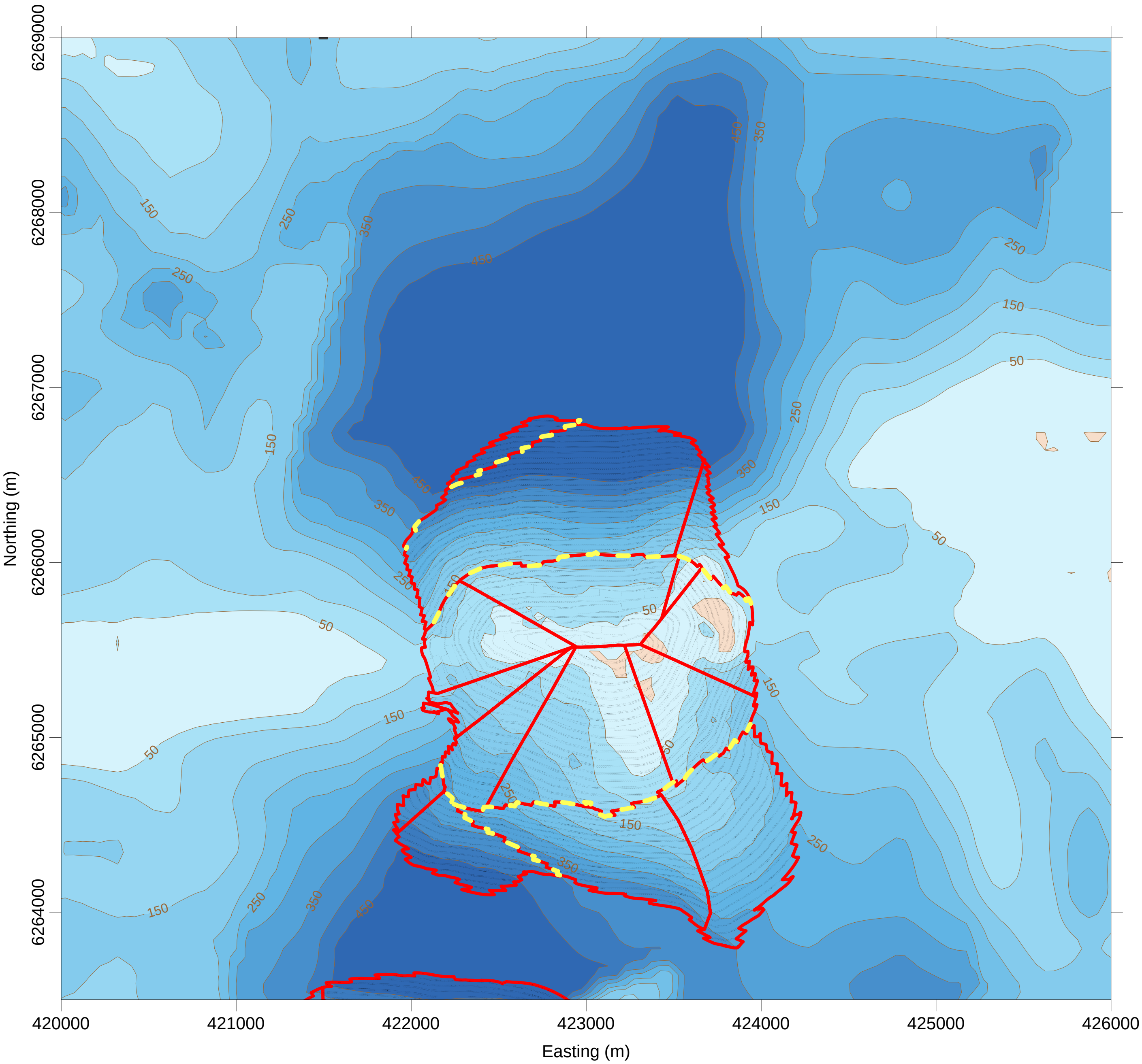


Notes:

1. *Depth to water is shown relative to the simulated base of pit shell (i.e. pink areas represent seepage breakout).*
2. *Pit slope design sectors are from BGC, 2012.*

Depth to Water (mbgs): -50, 0, 50, 100, 150, 200, 250, 300, 350, 400, 450

LOM PIT 10 m CONTOURS

FINAL PIT OUTLINE AND SECTORS

MAJOR FAULT TRACES

SCALE:	AS SHOWN	DESIGNED:	RT
DATE:	JUNE 2012	CHECKED:	RT
DRAWN:	RT	APPROVED:	TC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

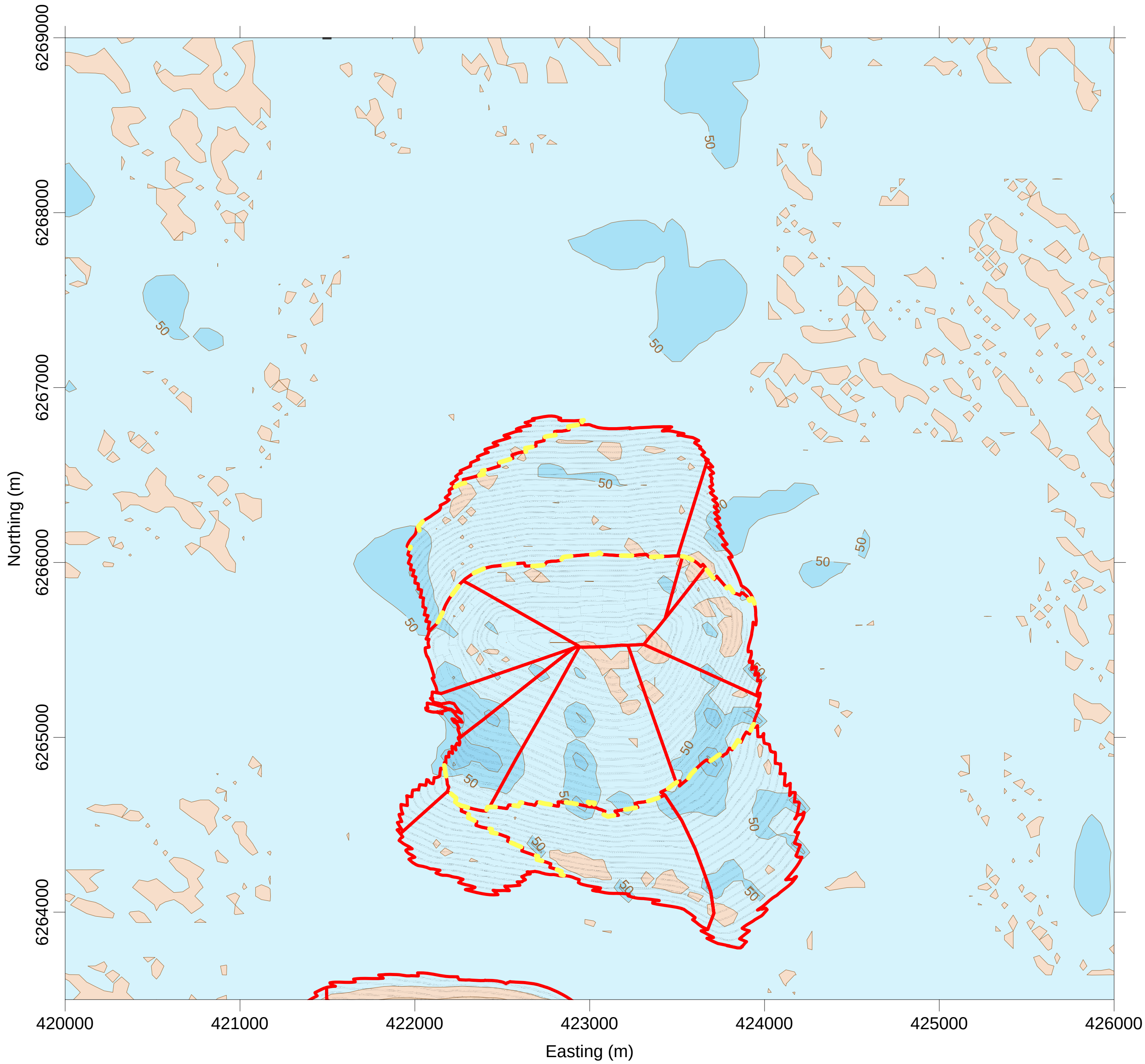
PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: MITCHELL PIT DEPTH TO WATER AT END OF OPEN PIT MINING (Year 23) WITH BASE CASE MITIGATION FOR SENSITIVITY RUN 1 (HIGH K)

CLIENT: SEABRIDGE GOLD INC.

PROJECT No:	DWG No:	REV.
0638-013	C5	0

K:/Projects/0638-013 KSM PFS Update and EA Support/20 PFS Hydrogeo/Reporting/APPENDICES/APPENDIX C/C5_Mitchell_DTW.srf



Notes:

1. *Depth to water is shown relative to the simulated base of pit shell (i.e. pink areas represent seepage breakout).*
2. *Pit slope design sectors are from BGC, 2012.*

-50 0 50 100 150 200 250 300 350 400 450

Depth to Water (mbgs)

LOM PIT 10 m CONTOURS

FINAL PIT OUTLINE AND SECTORS

MAJOR FAULT TRACES

SCALE:	AS SHOWN	DESIGNED:	RT
DATE:	JUNE 2012	CHECKED:	RT
DRAWN:	RT	APPROVED:	TC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

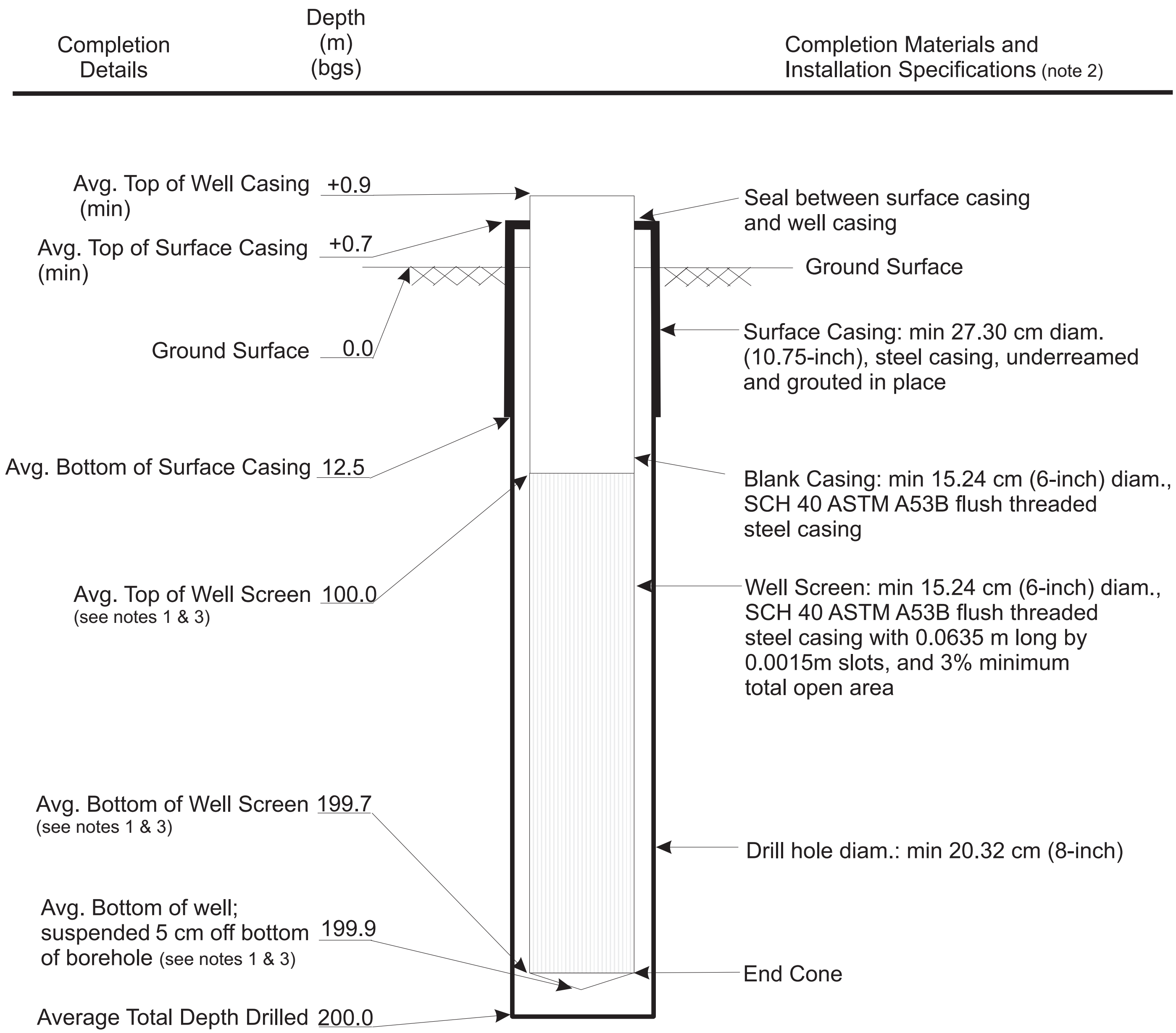
TITLE: MITCHELL PIT DEPTH TO WATER AT
END OF OPEN PIT MINING (Year 23) WITH BASE CASE
MITIGATION FOR SENSITIVITY RUN 2 (LOW K)

CLIENT: SEABRIDGE GOLD INC.

PROJECT No:	DWG No:	REV.
0638-013	C6	0

APPENDIX D

Vertical Dewatering Well Design Schematic



Notes:
1. Dimensions and depths indicated are for vertical dewatering wells.
2. Material types and specifications noted are based experience at similar sites. Alternate materials may be specified for well construction provided similar material performance can be demonstrated.
3. Anticipated pumping rates per well: 0.3 to 6.3 L/s (5 - 100 US gpm).
4. Drawing is not to scale.

SCALE:	NTS	DESIGNED:	RT
DATE:	JUNE 2012	CHECKED:	RT
DRAWN:	RT	APPROVED:	TC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: DEWATERING WELL DESIGN SCHEMATIC

CLIENT: SEABRIDGE GOLD INC.

PROJECT No.:	DWG No.:	REV.:
0638-013	D1	0

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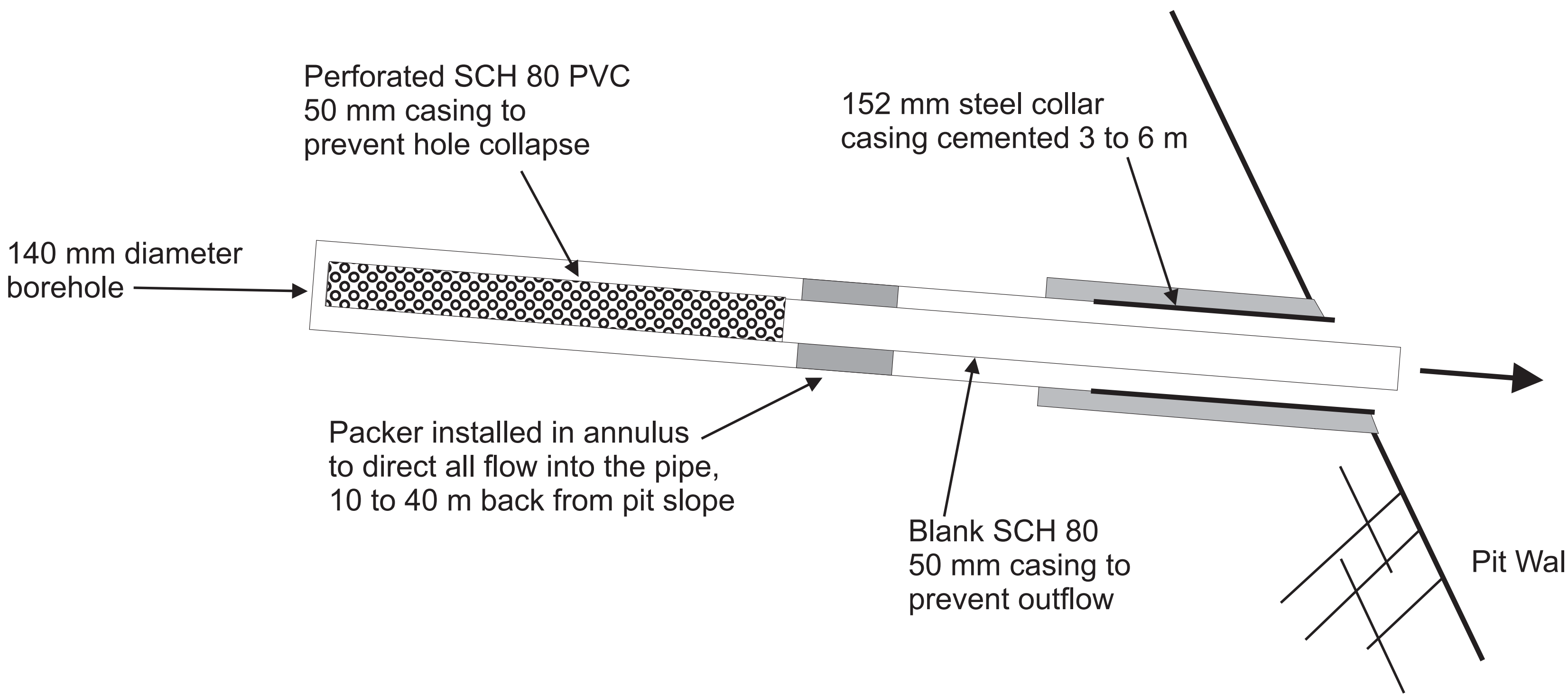


SCALE: NTS	DESIGNED: RT		
DATE: JUNE 2012	CHECKED: RT		
DRAWN: RT	APPROVED: TC		

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: SEABRIDGE GOLD INC.

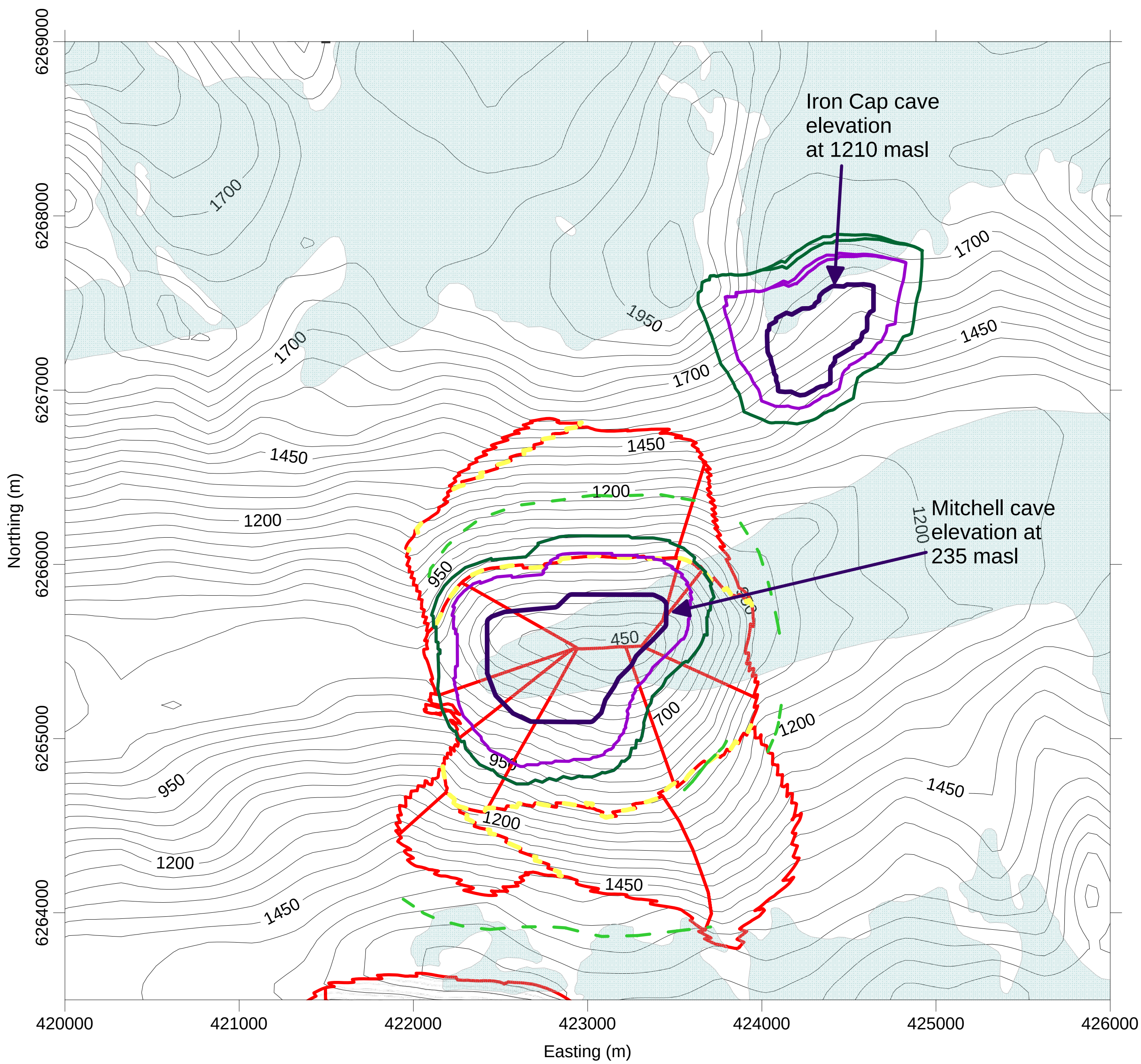
PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE
OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: HORIZONTAL DRAIN SCHEMATIC

PROJECT No.:	DWG No.:	REV.:
0638-013	D2	0

K:\Projects\0638-013 KSM PFS Update and EA Support\20 PFS Hydrogeo\Reporting\APPENDICES\APPENDIX D\AppendixD_HorizontalDrainSchematics_REV1.cdr

APPENDIX E



Notes:

1. *Open Pit shell provided by MMTS on February 6, 2012.*
2. *Block cave footprints and subsidence limits from Golder.*
3. *Break back limit estimated by BGC. The break-back limit is the limit of the macro-deformation zone.*

50 m TOPO CONTOURS	BLOCK CAVE FOOTPRINT
MAJOR FAULT TRACES	GLORY HOLE LIMIT
FINAL PIT OUTLINE AND SECTORS	FRACTURE ZONE LIMIT
	ESTIMATED BREAK-BACK LIMIT

SCALE:	AS SHOWN	DESIGNED:	RT
DATE:	JUNE 2012	CHECKED:	RT
DRAWN:	RT	APPROVED:	TC

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: KSM PROJECT PRE-FEASIBILITY STUDY UPDATE OPEN PIT DEPRESSURIZATION ANALYSES

TITLE: MITCHELL PIT AND IRON CAP ZONE BLOCK CAVE

CLIENT: SEABRIDGE GOLD INC.

PROJECT No:	DWG No:	REV.
0638-013	E1	0

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