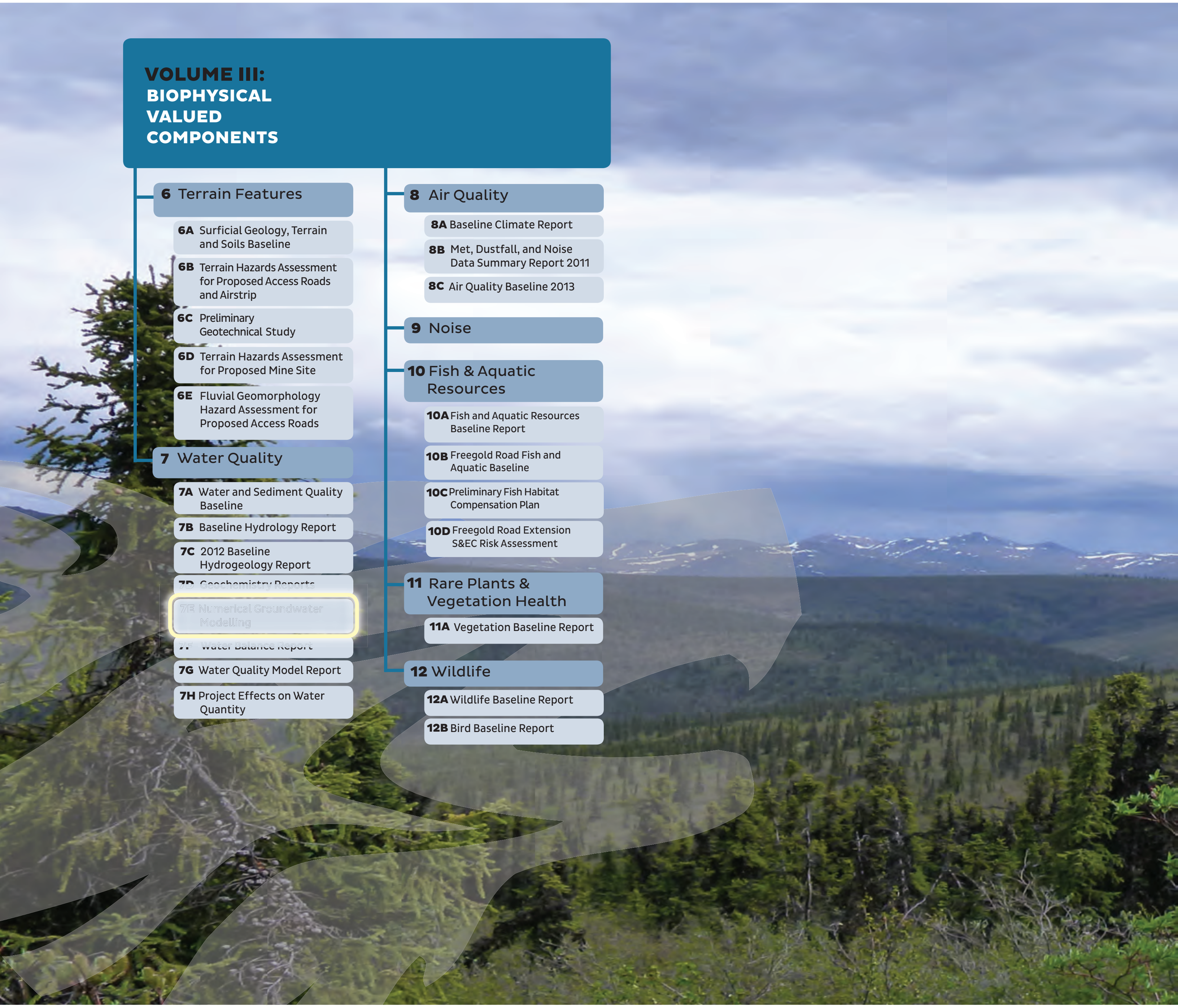
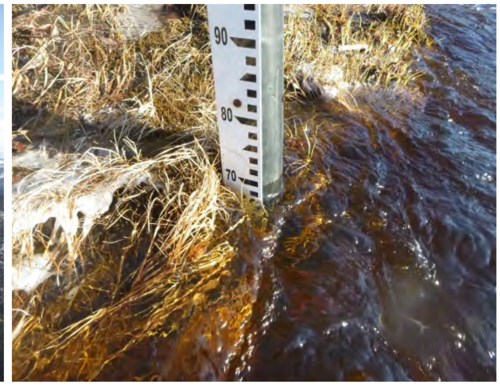
APPENDIX 7E: NUMERICAL GROUNDWATER MODELLING



VOLUME III: BIOPHYSICAL VALUED COMPONENTS

- **6** Terrain Features
  - **6A** Surficial Geology, Terrain and Soils Baseline
  - **6B** Terrain Hazards Assessment for Proposed Access Roads and Airstrip
  - **6C** Preliminary Geotechnical Study
  - **6D** Terrain Hazards Assessment for Proposed Mine Site
  - **6E** Fluvial Geomorphology Hazard Assessment for Proposed Access Roads
- **7** Water Quality
  - **7A** Water and Sediment Quality Baseline
  - **7B** Baseline Hydrology Report
  - **7C** 2012 Baseline Hydrogeology Report
  - **7D** Geochemistry Reports
  - **7E** Numerical Groundwater Modelling
  - **7F** Water Balance Report
  - **7G** Water Quality Model Report
  - **7H** Project Effects on Water Quantity
- **8** Air Quality
  - **8A** Baseline Climate Report
  - **8B** Met, Dustfall, and Noise Data Summary Report 2011
  - **8C** Air Quality Baseline 2013
- **9** Noise
- **10** Fish & Aquatic Resources
  - **10A** Fish and Aquatic Resources Baseline Report
  - **10B** Freegold Road Fish and Aquatic Baseline
  - **10C** Preliminary Fish Habitat Compensation Plan
  - **10D** Freegold Road Extension S&EC Risk Assessment
- **11** Rare Plants & Vegetation Health
  - **11A** Vegetation Baseline Report
- **12** Wildlife
  - **12A** Wildlife Baseline Report
  - **12B** Bird Baseline Report

CASINO MINING CORPORATION
CASINO PROJECT



NUMERICAL GROUNDWATER MODELLING

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CASINO MINING CORPORATION
CASINO PROJECT

NUMERICAL GROUNDWATER MODELLING
VA101-325/14-6

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0	Issued in Final	October 25, 2013	KJB
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EXECUTIVE SUMMARY

Knight Piésold Ltd. (KPL) was contracted by Casino Mining Corporation (CMC) to develop a series of numerical groundwater models for the Casino Project (the Project). The objective of the numerical modelling was to provide a representation of baseline groundwater conditions and to evaluate potential effects of the Project on hydrogeological conditions. To achieve this objective, a three-dimensional steady-state, regional-scale numerical groundwater model was developed using MODFLOW-SURFACT to simulate baseline hydrogeological conditions at the Project site. The baseline model was then modified to include proposed mine facilities in order to assess hydrogeological conditions during five phases of mine operations. Results of the numerical modelling will be used to support a comprehensive project proposal to the Yukon Environmental and Socio-Economic Assessment Board (YESAB).

Baseline Model and Calibration

The baseline model was calibrated to average annual groundwater elevations from 17 on-site groundwater monitoring wells and to estimates of average annual baseflow at six hydrometric stations within the study area. Baseflow estimates were obtained from the results of a baseline watershed model developed for the Project (KPL 2013c). The baseline model was successfully calibrated by iteratively adjusting hydraulic conductivity and groundwater recharge values until a suitable match between observed and simulated conditions was achieved. Recharge applied to the calibrated baseline model varied according to the distribution of permafrost; recharge in regions of permafrost was specified as 0 mm/yr and in regions of non-permafrost was specified as 124 mm/yr. The normalized root mean squared error (NRSME) for hydraulic head and baseflow targets in the calibrated baseline model was 1% and 3%, respectively.

The simulated baseline water table generally mimics the surface topography with groundwater elevations ranging from 1,450 meters above sea level (masl) in the high elevation region west of the mine site to 645 masl and 500 masl at the downstream extents of Casino Creek and Canadian/Britannia Creeks, respectively. Within the active model domain, groundwater recharge occurs along topographic highs where permafrost is absent and flows to groundwater discharge zones located within the valleys of Casino, Canadian, Britannia and Brynelson Creeks.

Mine Effects Models and Predicted Effects of Mine Operations

Five steady-state mine effects models were developed to simulate proposed mine infrastructure during key phases of Project development. The mine effects models were developed from the calibrated baseline model by telescopically refining the baseline model domain to a region surrounding the mine site. Separate mine effects models were developed for each of the Year 4, 10, 19, and 22 project phases and during Post-Closure when the Pit Lake is discharging.

The main objectives of simulating mine effects conditions were to:

1. Predict potential effects of proposed mine facilities on pre-project hydrogeologic conditions
2. Estimate seepage rates from and groundwater inflow to various components of the Tailings Management Facility (TMF)
3. Estimate the rate of groundwater inflow to the Open Pit during operational dewatering and the rate of seepage from the Pit Lake during Post-Closure when the Pit Lake is at its maximum elevation, and

4. Characterize potential groundwater flow pathways and estimate groundwater travel times from the major mine components.

Proposed major mine facilities consisting of the Heap Leach Facility, Open Pit, TMF and Ore and Low-Grade Ore Stockpiles were included in the mine effects models. Footprints of each facility were varied between models according to the Project phase. The TMF was explicitly constructed within the MODFLOW-SURFACT grid to include the following sub-components: Waste Rock, potentially acid generating (PAG) Tailings, Non-PAG Tailings and TMF Embankments. The footprint beneath all mine facilities was modelled as non-permafrost.

Open Pit and Pit Lake Simulation Results

Model results indicate that groundwater elevations surrounding the Open Pit are expected to decrease by up to 200 m during Open Pit dewatering. Simulated groundwater inflow rates to the Open Pit increase from the start of operations through Year 19 as the pit increases in size and depth. Modelled groundwater inflow rates reach a maximum of approximately 33 l/s during Year 19 when the extent of the Open Pit is largest. The capture zone of the Open Pit is predicted to extend into Casino and Canadian Creek watersheds. Results of MODPATH particle tracking indicate that the Open Pit capture zone is not expected to extend to the TMF facility footprint.

Upon closure, the Open Pit will be flooded to maintain a Pit Lake. Groundwater elevations directly surrounding the Pit Lake are expected to recover to the elevation of the Pit Lake water surface (approximately 1,100 masl). Based on the results of the Post-Closure model, groundwater inflow to and seepage from the Pit Lake are expected to be approximately 12 l/s. Model results indicate that the majority of seepage from the Pit Lake is expected to feed into the upper Casino Creek groundwater system. MODPATH particle tracking indicates that seepage from the Pit Lake is expected to discharge within the upper Casino Creek valley upslope of the TMF facility.

TMF Seepage Assessment

The mine effects models were used to estimate groundwater inflow rates into and seepage rates from and between various sub-components of the TMF. Results of a sensitivity analysis indicate that seepage through the TMF foundation is sensitive to the hydraulic conductivity of that unit. To address the sensitivity of predicted seepage rates to the presence of a local zone of higher hydraulic conductivity beneath the TMF, the seepage assessment was conducted using: 1) the Base Case model (Model 1) and 2) a revised model that included a local zone of increased hydraulic conductivity beneath the TMF facility (Model 2). Total seepage rates predicted by Model 2 are up to 25% higher than those predicted by Model 1. Both models predict that seepage rates from the TMF increase from the start of operations through Year 22. Maximum seepage rates can be summarized as follows:

- Results of Model 1 predict that total seepage from the TMF during Year 22 will be 31 l/s, of which approximately 16 l/s occurs as seepage flux through the TMF foundation materials and 15 l/s occurs as seepage flux through the embankment.
- Results of Model 2 predict that total seepage from the TMF during Year 22 will be 38 l/s, of which approximately 23 l/s occurs as seepage flux through the TMF foundation materials and 15 l/s occurs as seepage flux through the embankment.

Seepage rates estimated using the Post-Closure model are slightly lower than those estimated in Year 22 attributed to the lower hydraulic conductivity values associated with tailings consolidation.

Groundwater discharge to the TMF from the surrounding groundwater system is expected during all phases of the Casino Project. As the TMF footprint area grows from Year 4 through Year 19, groundwater inflow rates are predicted to increase to a maximum of approximately 35 l/s in Year 19 (results for both models). Post-Year 19, groundwater inflow rates are predicted to decrease slightly corresponding to an increase in supernatant pond elevation.

Based on the available data, Model 2 is considered to be an equally likely representation of Project hydrogeological conditions. As a conservative measure, the higher predicted TMF seepage and groundwater inflow rates from Model 2 were used to support geochemical source term development, water quantity modelling and water quality modelling as part of the YESAB proposal.

The vertical direction of flow between TMF sub-components and the foundation was assessed using the Post-Closure mine effects model. Model results indicate that upward vertical hydraulic gradients are predicted throughout the majority of the Waste Rock unit. This upward vertical hydraulic gradient is the result of groundwater flow from the adjacent hillslopes discharging into the valley. Downward vertical hydraulic gradients are predicted within the PAG and Non-PAG tailings. Water from the TMF supernatant pond is predicted to infiltrate the tailings units and flow downward into the foundation material and/or the TMF Embankment.

Simulation results indicate that seepage beneath the TMF West Embankment and through the topographic knob between embankments (“West Embankment foundation seepage”) is estimated to be approximately 6% (1.4 l/s) of the total Post-Closure foundation seepage from the TMF. West Embankment foundation seepage is derived from the Non-PAG tailings unit and simulation results indicate that it discharges primarily to the tributary southwest and downslope of the West Embankment, with lesser amounts discharging to Brynelson Creek and Casino Creek. Seepage through the West Embankment is approximately 5% (0.8 l/s) of the total Post-Closure embankment seepage.

The foundation seepage recovery efficiency of the water management pond downstream of the main TMF Embankment was estimated using a mass balance approach. Based on the results of the analysis, approximately 90-95% of the TMF foundation seepage is predicted to be recovered by the water management pond assuming that the pond is maintained with as low of a water level as possible. The remaining 5-10% of foundation seepage is expected to bypass the pond and discharge further downstream to Casino Creek.

<u>Ore Stockpile Travel Time Results</u>

To characterize potential seepage pathways from the proposed ore stockpiles, MODPATH particle tracking and endpoint analysis were conducted to delineate pathways and estimate seepage travel times from five stockpile locations. MODPATH analysis was completed using the Year 4, 10 and 19 models, which are the mine effects models with stockpiles present. Approximate groundwater travel time along the seepage pathways only considered advective travel and disregarded the effects of dispersion and diffusion. Results of the endpoint analysis and estimated travel times for peak concentrations to reach a discharge location (shown in parentheses assuming that the average travel time is representative of travel time of peak concentration) indicate that:

- Seepage through the Gold Ore Stockpile is predicted to discharge to the Open Pit (3 years) and TMF Supernatant Pond (1 year)
- Seepage through the Marginal Ore Stockpile is predicted to discharge to the Open Pit (<1 year)

- Seepage through the Low Grade Supergene Sulfide Ore Stockpile is predicted to discharge to the Open Pit (2 years) and TMF Supernatant Pond (28 years)
- Seepage through the Low Grade Supergene Oxide Ore Stockpile is predicted to discharge to the TMF Supernatant Pond (1 year), TMF Embankment drains (5 years) and the TMF Water Management Pond (27 years), and
- Seepage through the Supergene Oxide & Low Grade Hypogene Ore Stockpile is predicted to discharge to the Open Pit (2 years), TMF Supernatant Pond (1 year), TMF Embankment drains (8 years) and the TMF Water Management Pond (15 years).

Model results further indicate that travel times for stockpile seepage to reach the TMF Supernatant Pond, assuming advective transport, will range from less than 1 year to approximately 70 years. Advective seepage from the stockpiles is predicted to reach the TMF Water Management Pond between 12 years and 40 years. Based on the Year 19 mine build-out, approximately 10% of the seepage from the Low Grade Supergene Oxide Ore Stockpile is predicted to reach the TMF Water Management Pond. Similarly, approximately 1% of seepage from the Supergene Oxide & Low Grade Hypogene Ore Stockpile is predicted to reach the TMF Water Management Pond.

Summary

The results of baseline and mine-effects numerical groundwater models were used to inform water balance modelling, water quality modelling and geochemical source term development conducted as part of the YESAB proposal. The numerical models presented in this report provide a foundation that should be updated as new data are collected.

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ABBREVIATIONS

CMC	Casino Mining Corporation
the Project	Casino Project
HSU	hydrostratigraphic unit
KPL	Knight Piésold Ltd.
MAE	mean absolute error
masl	meters above sea level
Non-PAG	non-potentially acid generating
NRSME	normalized root mean square error
PAG	potentially acid generating
RMSE	root mean square error
TMF	Tailings Management Facility
TMR	telescopic mesh refinement
YESAB	Yukon Environmental and Socio-economic Assessment Board

1 – INTRODUCTION

Casino Mining Corporation (CMC) is preparing a proposal to the Yukon Environmental and Socio-economic Assessment Board (YESAB) for the Casino Project (the Project), a proposed copper-gold-molybdenum porphyry deposit in the Dawson Range Mountains of the Yukon Territory. The Project is located approximately 300 km northwest of Whitehorse, as illustrated on Figure 1.1.

Knight Piésold Ltd. (KPL) was contracted by CMC to develop a series of numerical groundwater models for the Project to provide a baseline representation of the groundwater system and to evaluate potential effects of proposed mine facilities on baseline hydrogeological conditions. The objectives of the numerical groundwater modelling were to:

1. Develop a conceptual understanding of the pre-project groundwater system based on the available hydrogeological and hydrologic data
2. Develop and calibrate a baseline numerical groundwater model to simulate pre-development hydrogeological conditions including groundwater flow directions, distribution of hydraulic head, and discharge of groundwater to creeks within the study area
3. Predict potential effects of proposed mine facilities on pre-project hydrogeologic conditions
4. Estimate seepage rates from and groundwater inflow to various components of the Tailings Management Facility (TMF)
5. Estimate the rate of groundwater inflow to the Open Pit during operational dewatering and the rate of seepage from the Pit Lake during Post-Closure when the Pit Lake is at its maximum elevation, and
6. Characterize potential groundwater flow pathways and estimate groundwater travel times from the major mine components.

To achieve these objectives, a three-dimensional steady-state, regional-scale numerical groundwater model was developed using MODFLOW-SURFACT to simulate baseline hydrogeological conditions at the Project site. The baseline model was then modified to include proposed mine facilities in order to assess hydrogeological conditions during five phases of mine operations. Results of the numerical modelling will be used to inform hydrological modelling, geochemical source term development and water quality modelling completed as part of the YESAB proposal and to support sections of the YESAB proposal itself.

LEGEND:

- PROJECT LOCATION
- CITY / TOWN
- EXISTING ROAD
- PROPOSED ACCESS ROAD
- PROVINCIAL BORDER

NOTES:

1. BASE MAP: ESRI ARCGIS ONLINE NATIONAL GEOGRAPHIC MAPPING.

2. COORDINATE GRID IS IN METRES.
COORDINATE SYSTEM: WGS 1984 WORLD MERCATOR.

3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:12,000,000 FOR 8.5x11 (LETTER) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	23OCT'13	ISSUED WITH REPORT	CC	CC	CAS	KJB

CASINO MINING CORPORATION

CASINO PROJECT

PROJECT LOCATION MAP

Knight Piésold CONSULTING

P/A NO. VA101-325/14

REF NO. 6

FIGURE 1.1

REV 0

2 – HYDROGEOLOGICAL CONCEPTUAL MODEL

2.1 PHYSIOGRAPHY, CLIMATE AND DRAINAGE

The Casino Project is located on the north slopes of the Dawson Mountain Range, approximately 300 km northwest of Whitehorse, Yukon Territory, Canada, as shown on Figure 1.1. Elevation across the site ranges from approximately 1,400 meters above sea level (masl) at the proposed Open Pit in the northwest portion of the study area, to approximately 700 masl in the southern portion of the Project area in the Casino Creek valley near the proposed tailings embankment.

Climate in the Casino Project area is characterized by long, cold, dry winters and by short, mild, wet summers. Snow is typically on the ground from September through June. Average annual precipitation is approximately 460 mm (KPL 2013e) and is typically highest during the summer months of July and August and lowest during the late winter months of February through April. Based on data from the Casino Project climate station, the mean annual temperature is approximately -3°C (KPL 2013e). July is the warmest month and January is the coldest month.

The site is situated in both the Canadian Creek and Casino Creek watersheds. Streamflows are typically highest in May associated with the melt of winter snowpack, with a second peak in late summer driven by summer rainfall events. Minimum streamflow is sustained by groundwater discharge and typically occurs in March or April (KPL 2013b). Streamflow data within the project area are available from nine active hydrometric stations located on Britannia Creek, Canadian Creek, Casino Creek and Dip Creek (KPL 2013d).

The Casino Project is situated within a region of discontinuous permafrost. Permafrost is inferred to be present at shallow depths on north-facing slopes and below organic soils in portions of the Casino Creek valley, and generally absent, or deeper, on south-facing slopes (AECOM 2011; KPL 2012a). Depth to permafrost based on data from thermistor strings is inferred to be 104 mbgs on a north-facing slope in the deposit area and 47 mbgs on a northeast-facing slope within the Casino Creek valley (KPL 2013b). Thermistors located on south-facing hill and valley slopes recorded temperatures above zero degrees Celsius.

2.2 HYDROSTRATIGRAPHIC UNITS

The geology of the Casino Project area consists primarily of intrusive igneous and metamorphic rock types, overlain by overburden with widespread occurrence of bedrock outcrops at higher elevation. Overburden thickness generally decreases as elevation increases and becomes discontinuous on hillslopes and topographic highs. The following stratigraphic units will provide pathways for groundwater flow (KPL 2013c):

- Overburden
- Weathered bedrock
- Unweathered bedrock, and
- Geologic structures.

A summary of the physical properties of each hydrostratigraphic unit is presented in Table 2.1. Each of the hydrostratigraphic units may be frozen or unfrozen based on the presence or absence of permafrost. The following discussion of hydrostratigraphic units is a summary of KPL (2013b).

Table 2.1 Properties of Hydrostratigraphic Units

Hydrostratigraphic Unit	Number of Tests	Hydraulic Conductivity (m/s)[1]		Estimated Effective Porosity (%)
		Range	Representative Value	
Overburden - Colluvium [2]	6	2E-08 to 5E-06	2E-07	15
Overburden - Alluvium [3]	3	7E-06 to 2E-05	1E-05	15
Weathered Bedrock	57	1E-10 to 2E-05	1E-07	0.1
Unweathered Bedrock	230	3E-10 to 3E-05	4E-08 [4]	0.01

NOTES:

1. VALUES DO NOT INCLUDE HIGH TAKE OR LOW TAKE TEST RESULTS.
2. DOES NOT INCLUDE VALUES FROM BRITANNIA CREEK SAND AND GRAVEL.
3. CONSISTS OF VALUES FROM BRITANNIA CREEK SAND AND GRAVEL.
4. VALUE REPRESENTATIVE OF DEEP BEDROCK, EXCLUDING TESTS CONDUCTED IN THE PATTON PORPHYRY, MICROBRECCIA, AND INTRUSION BRECCIA UNITS IN THE DEPOSIT AREA.

Overburden:

Alluvial materials are present in the creeks and flat valley bottoms of the Project area. The alluvial deposits generally consist of sands and gravelly sands that contain cobbles and small boulders. These deposits are inferred to range in thickness from 0 to 25 m within the valleys of Casino, Canadian and Britannia Creeks. Based on limited hydraulic conductivity tests, the hydraulic conductivity of the alluvial materials ranges from 7E-6 m/s to 2E-5 m/s (Table 2.1).

Colluvial deposits are identified as discontinuous blanket and veneer deposits on hillslopes and as colluvial aprons at the transition between hillslopes and valley bottoms. Colluvial materials are comprised of a mixture of silt, sand and weathered bedrock clasts. Colluvium at the site is generally thin (<2 m) along upper and mid-slopes and increases in thickness downslope and at transitions from hillslopes to valleys. Based on the results of six hydraulic conductivity tests, the hydraulic conductivity of the colluvial material ranges from 2E-8 m/s to 5E-6 m/s (Table 2.1).

Weathered bedrock:

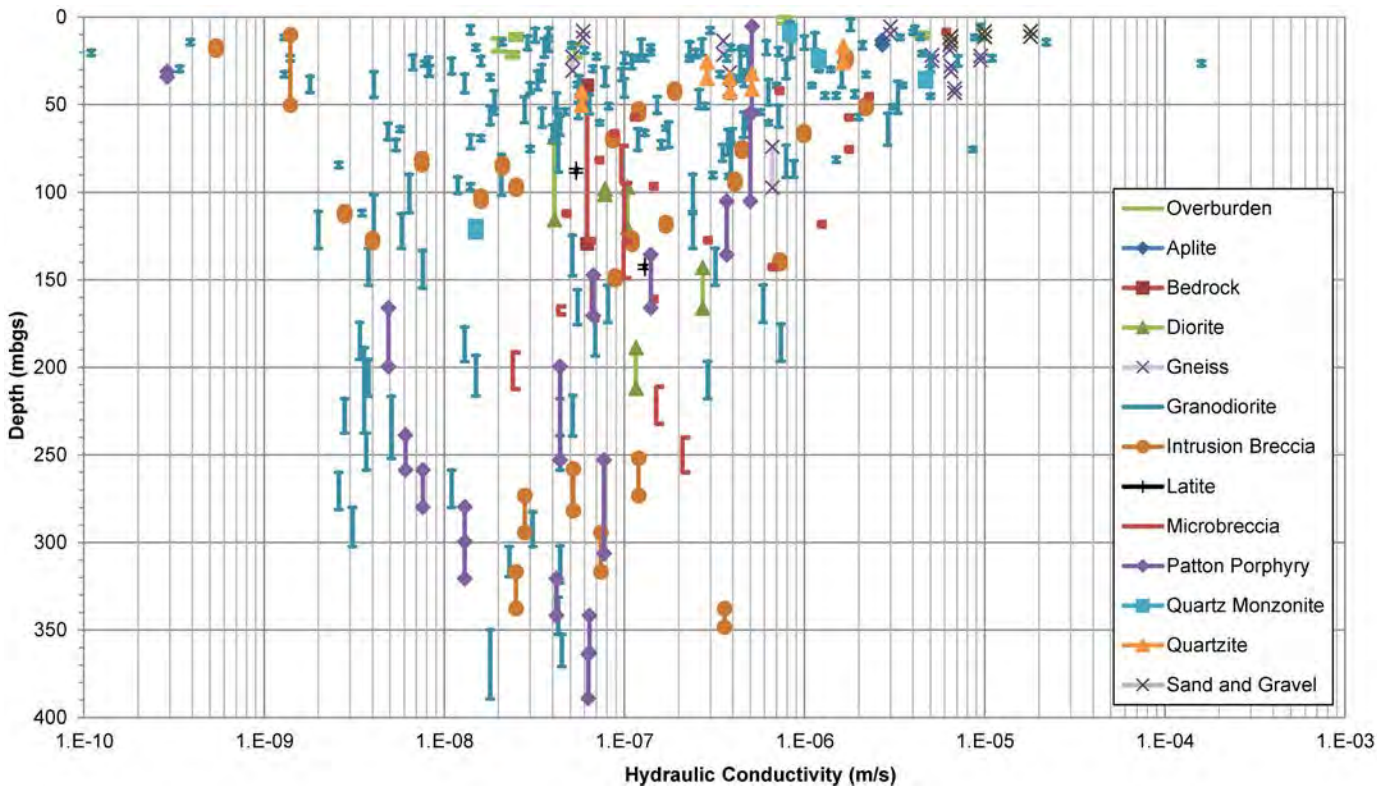
A zone of weathered bedrock lies above the competent bedrock throughout much of the study area and forms the uppermost hydrostratigraphic unit where overburden is absent. Weathering processes and a lack of glaciation have created conditions favouring the development of a thick weathered bedrock zone consisting predominantly of completely to slightly weathered intrusive and metamorphic rock types. In general, the weathered bedrock is thicker in upland areas than lowland areas; thickness of the weathered bedrock unit ranges from 200 m in the vicinity of the Open Pit, to tens of meters within the hillslope area and Casino Creek valley. Results of 57 hydraulic conductivity tests indicate that the hydraulic conductivity of the weathered bedrock ranges from 1E-10 m/s to 2E-5 m/s (Table 2.1).

Unweathered bedrock:

Unweathered bedrock underlies the weathered bedrock unit over the majority of the study area and consists of fresh to slightly weathered, blocky, hard, competent coarse grained intrusive rock and metamorphic rock types. Bedrock consists predominantly of granodiorite, diorite, quartzite, gneiss, latite, microbreccia, and Patton Porphyry. Within the unweathered bedrock, groundwater is inferred to flow primarily within structural discontinuities and joints at the local scale. Results of 230 hydraulic conductivity tests indicate that hydraulic conductivity of the unweathered bedrock ranges from 3E-10 m/s to 3E-5 m/s and exhibits a decreasing trend with depth below ground surface (Figure 2.1).

Geologic Structures:

Numerous faults have been identified within the project area (KPL 2013b). Faults can serve as both conduits and barriers to groundwater flow. Based on the limited available hydrologic data collected within fault zones, the permeability of faults is considered similar to the bedrock hydraulic conductivity.



NOTES:

1. THIS FIGURE INCLUDES PACKER TESTING, RESPONSE TESTING, AND PUMP TESTING RESULTS REPORTED IN KPL (2013B).
2. 'BEDROCK' IS ASSIGNED WHERE TESTED ROCK TYPE IS UNSPECIFIED.
3. HYDRAULIC CONDUCTIVITY VALUES FROM LUGEON TESTS WERE USED IN THIS FIGURE WHEN A LUGEON TEST AND RESPONSE TEST WERE BOTH CONDUCTED ON THE SAME BEDROCK INTERVAL.
4. PLOT DOES NOT INCLUDE HIGH TAKE OR LOW TAKE TESTS.
5. LENGTH ALONG HOLE PLOTTED AS DEPTH FOR ANGLED DRILLHOLES.

Figure 2.1 Hydraulic Conductivity with Depth

2.3 GROUNDWATER FLOW

Groundwater at the Project site flows from recharge zones located in topographic highs, such as the vicinity of the proposed Open Pit, towards discharge zones located in Casino, Canadian and Britannia Creek valleys. An inferred groundwater divide is located within the footprint of the proposed Open Pit which divides the Canadian Creek and Casino Creek watersheds. Within the uplands of the proposed Open Pit, the groundwater table is encountered at depths up to and exceeding 100 m below ground surface (mbgs; KPL 2013b). Measured hydraulic heads along hillslopes are 5 to 20 mbgs and are artesian within Casino Creek valley (KPL 2013b). Measured hydraulic heads within Proctor Gulch, located west of the proposed Open Pit, are up to 10 m above ground surface (magl).

At the local scale, geologic structures (faults and fractures) are expected to influence groundwater flow pathways and hydraulic gradients. Within the unweathered hydrostratigraphic unit groundwater is inferred to flow primarily within structural discontinuities and joints. However, considering the highly fractured, faulted, and weathered nature of the bedrock, groundwater flow is assumed to be homogeneous and isotropic at the regional scale for the purpose of regional and project-site scale assessment of groundwater flow.

Groundwater recharge in the study area was estimated at approximately 13% of the mean annual precipitation (460 mm/yr) based on a watershed model constructed for the project that was calibrated to long-term synthetic streamflow records at eight hydrology stations (KPL 2013c). The distribution and ice content of permafrost is expected to locally control recharge to the water table. Frozen soils with high ice content will have lower infiltration rates which effectively limit recharge to groundwater and increase surface water runoff. Focused recharge to groundwater is expected where permafrost is absent.

Groundwater discharge from the deep (regional) groundwater flow system contributes to streamflow in Casino, Canadian and Britannia Creeks year-round and sustains baseflow (low flows) in Casino Creek and the lower reaches of Canadian Creek during the winter and early spring months (KPL 2013d). Groundwater discharge in the natural system is expected to be focused within "windows" of the subsurface that are permafrost-free. At the regional-scale, however, the net volume of groundwater discharge to the creek valleys is expected to be independent of permafrost distribution, particularly considering the relatively steep valley slopes that drive groundwater flow at the Project site. It is considered sufficient for the purpose of this regional hydrogeology assessment to consider the subsurface as a homogeneous unit that is permafrost-free. Any hydrogeologic studies that are focused at a smaller-scale should consider the spatial distribution of permafrost.

3 – BASELINE NUMERICAL MODEL

3.1 OVERVIEW

A steady-state, regional-scale numerical groundwater model was developed to simulate baseline hydrogeological conditions and to provide the basis required to assess potential effects of the Project on the local groundwater system. The model was developed using the MODFLOW-SURFACT computer code run in the Groundwater Vistas (version 6.20; ESI, 2011) graphical user interface. MODFLOW-SURFACT is a three-dimensional finite-difference flow model developed by the U.S. Geological Survey and HGL Software Systems that has become an industry standard for groundwater modelling applications (Hydrogeologic Inc., 1996).

Model boundary conditions and input parameters (i.e., groundwater recharge and hydraulic conductivity) govern the flow of groundwater within the model and control the addition or removal of water from the model domain. The baseline model was calibrated to average annual groundwater elevation data collected from on-site groundwater monitoring wells and to baseflow estimates for hydrology stations located on the major surface water drainages within the study area.

The results of the baseline model are believed to be representative of the pre-development hydrogeological conditions including groundwater flow directions, distribution of hydraulic head and groundwater/surface water interaction on a project-site scale. Baseline model development, calibration and results are discussed in the sections that follow.

3.2 BASELINE MODEL GEOMETRY AND GRID

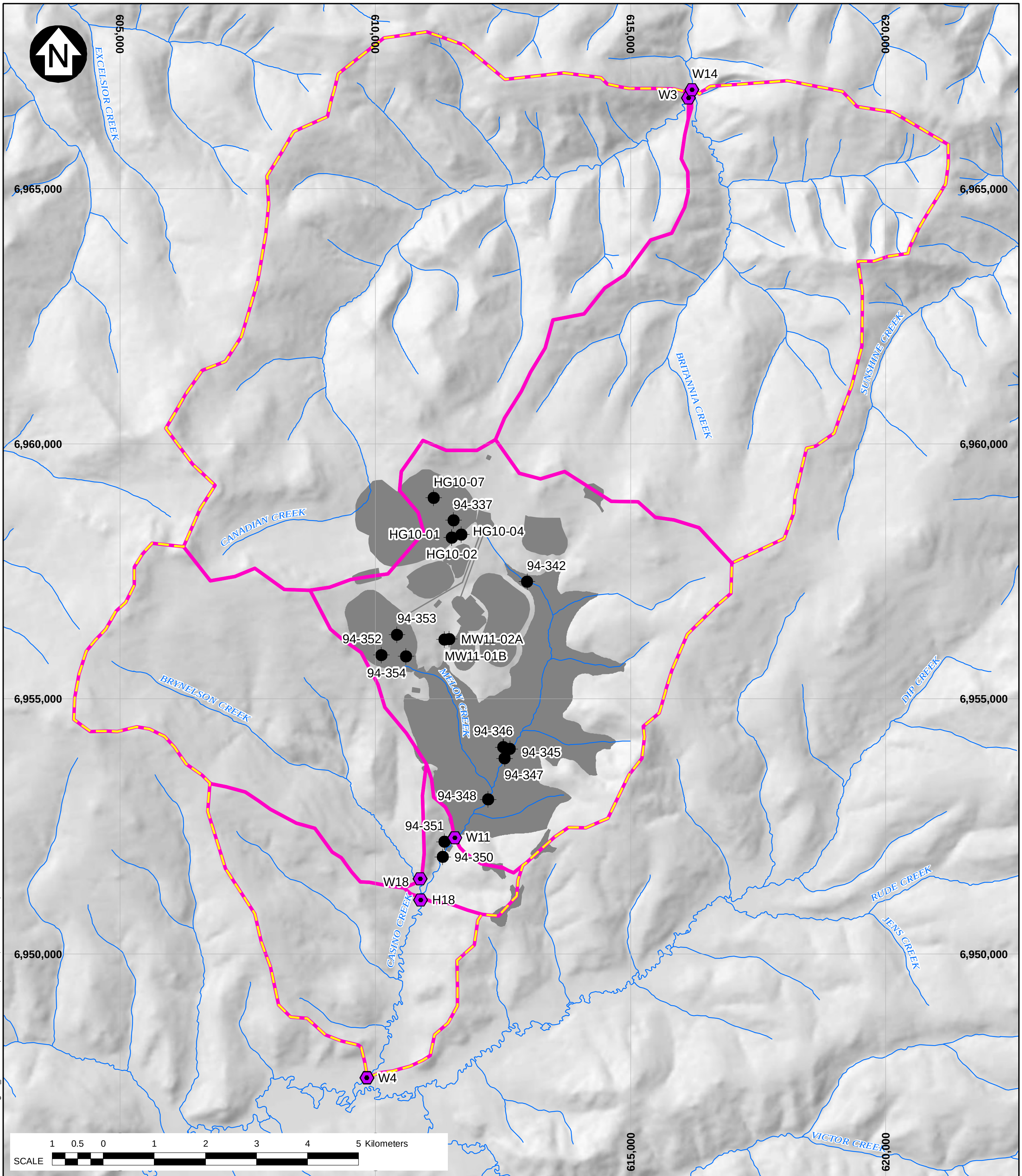
The baseline model domain encompasses an area of 191 km^2 with the Casino Project site located at its center, as shown on Figure 3.1. The model domain extends south to include the Casino Creek and Brynelson Creek watersheds in their entirety and north to include the Canadian and Britannia Creek watersheds extending to their point of confluence. The perimeter of the active model domain is defined by the watershed boundaries of Casino, Canadian, and Britannia Creeks. Groundwater flow divides are inferred to be coincident with watershed boundaries.

The model has a rectangular grid of 151 rows by 122 columns covering an area of approximately 20 km by 17 km. The model is divided into 4 layers in the vertical dimension for a total of 73,688 cells, approximately 45,000 of which are active. Cell size is 100 m by 100 m within the mine site and expands to 200 m by 200 m at the edges of the model. The grid is refined in the vicinity of the mine site in order to provide a higher resolution over that portion of the model domain. A maximum grid expansion factor of 1.5 was used to increase dimensions of adjacent cells. The finite-difference grid is shown on Figure 3.2.

Ground surface elevation was defined in Layer 1 of the model using a GIS-based contour shapefile of surface topography. Elevation within the active model domain ranges from approximately 500 masl at the downstream extents of Casino, Canadian, and Britannia Creeks to 1,600 masl in the mountainous terrain near the proposed mine site.

The finite-difference grid was discretized into four layers of increasing thickness with depth:

- Layer 1 is generally 30 m thick (top elevation defined by GIS contour shapefile)
- Layer 2 is 100 m thick
- Layer 3 is 250 m thick, and
- Layer 4 is of variable thickness, with a base elevation equal to mean sea level.



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LEGEND:

- GIS.KP.FULCRUMGROUNDWQ EVENTS
- BASEFLOW CALIBRATION TARGET
- RIVER/CREEK
- BASELINE NUMERICAL MODEL EXTENTS
- WATERSHED DIVIDE
- CASINO PROPOSED FACILITIES

NOTES:

1. BASE MAP: ESRI ARCGIS ONLINE YUKON SHADED RELIEF.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:100,000 FOR 8.5x11 (LETTER) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

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CASINO MINING CORPORATION

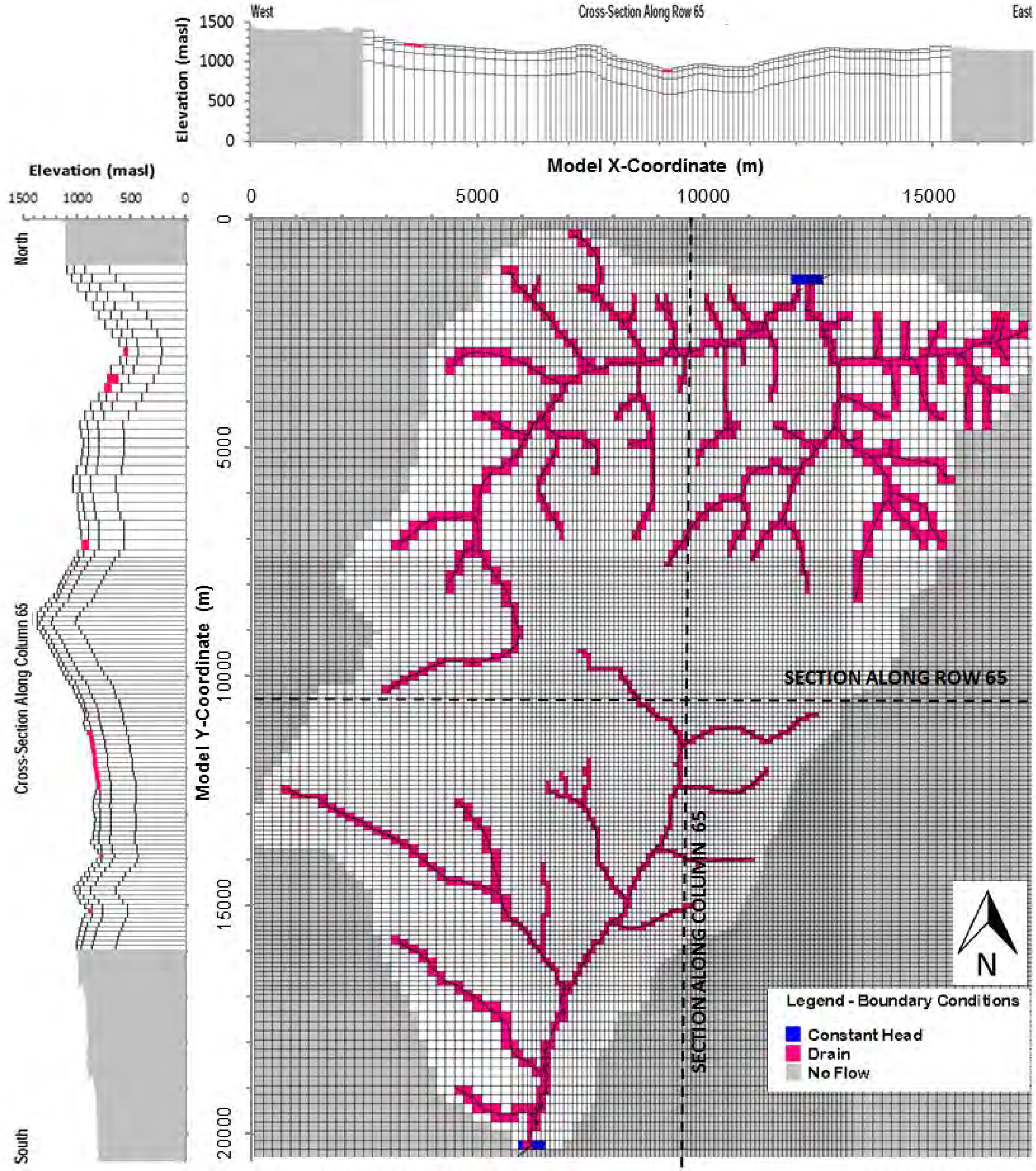
CASINO PROJECT

BASELINE NUMERICAL MODEL EXTENTS AND CALIBRATION TARGET LOCATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-325/14	6

FIGURE 3.1 REV 0



NOTES:

1. THE PLAN VIEW FIGURE SHOWS THE BOUNDARY CONDITIONS FOR LAYER 1 OF THE BASELINE MODEL.

Figure 3.2 Numerical Grid, Model Layers and Boundary Conditions

Due to steep surface topography, some modification of Layer 1 was required to ensure that adjoining model cells shared a minimum 5-meter overlap along the vertical dimension. A uniform thickness was assigned to Layers 2 and 3 based on characterization of the hydrostratigraphic units represented by each layer. The bottom of the model domain (Layer 4) was set to a uniform elevation of 0 masl.

All four layers were modelled as unconfined layers (MODFLOW Layer Type 3).

3.3 HYDROSTRATIGRAPHIC UNITS AND MODEL LAYERS

The model layers represent three hydrostratigraphic units based on the conceptual model presented in Section 2. The hydrostratigraphic units represented in the numerical model include:

- Alluvial deposits – alluvial deposits are represented in Layer 1 by grid cells adjacent to Casino, Canadian, Britannia and Brynelson Creeks.
- Colluvial deposits – colluvial deposits are represented in Layer 1. Since colluvial materials are characterized as thin (< 5m) and discontinuous on hillslopes, this unit is inferred to have the same material properties as weathered bedrock.
- Weathered bedrock – weathered bedrock is represented by all grid cells of Layer 1 with the exception of those that represent the alluvial materials along Casino, Canadian, Britiannia and Brynelson Creeks.
- Unweathered bedrock – unweathered bedrock is represented by model Layers 2 through 4. The unweathered bedrock unit was subdivided into three layers to allow hydraulic conductivity values to decrease with depth. Even though several types of bedrock are present at the site, bedrock within the model is assumed to be a homogeneous unit which was sufficient for the purpose of this hydrogeology assessment.

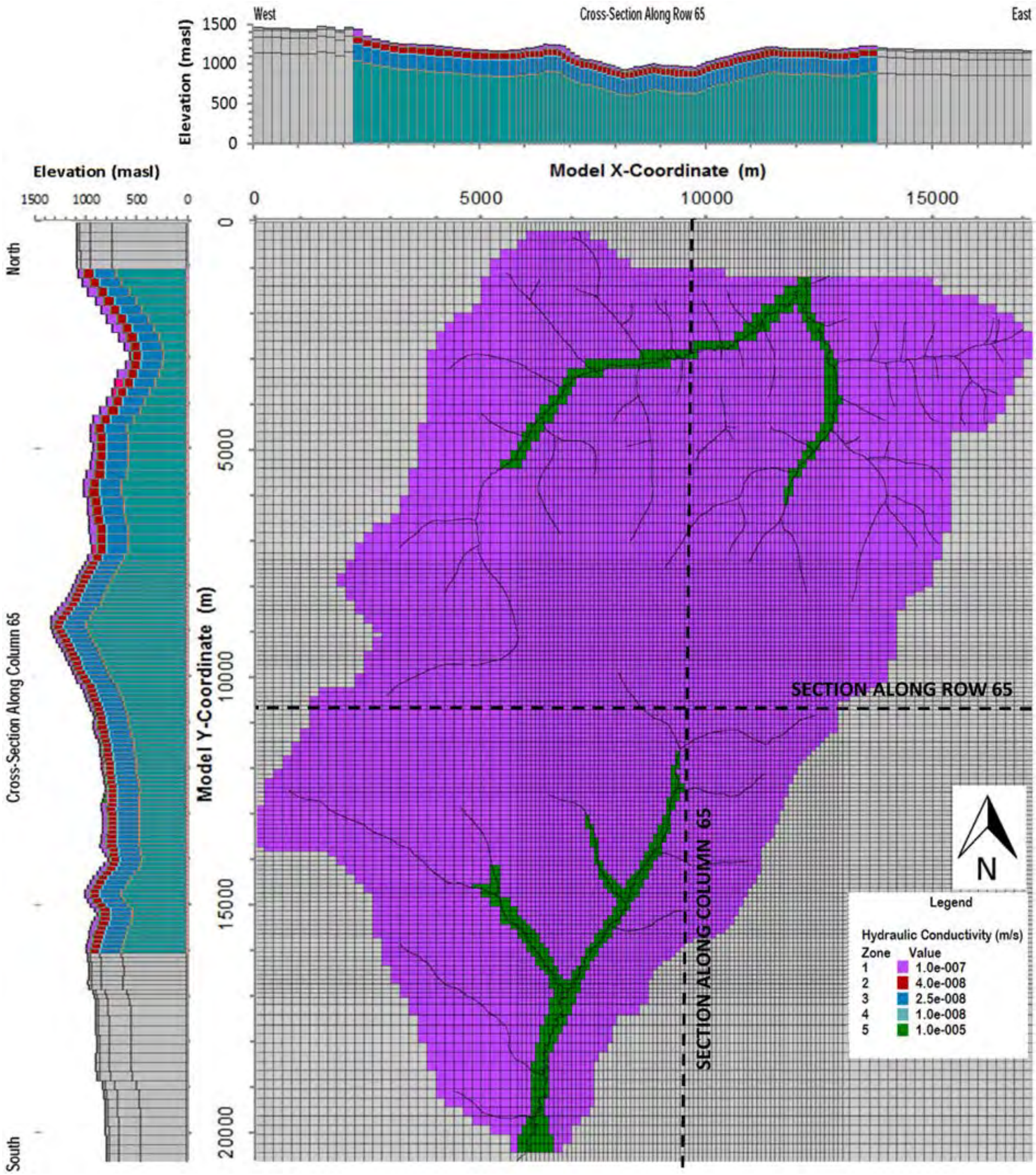
3.4 HYDRAULIC CONDUCTIVITY

Initial values of hydraulic conductivity were assigned to the hydrostratigraphic units/model layers based on available hydraulic test data (Table 2.1). Initial hydraulic conductivity values assigned to the model were varied within the range of observed and expected values during calibration of the baseline model as discussed in Section 3.6. The calibrated hydraulic conductivity values assigned to each model layer were assumed to be isotropic ($K_x = K_y = K_z$) and are summarized in Table 3.1.

Table 3.1 Baseline Model Hydraulic Conductivity Values

Hydrostratigraphic Unit	MODFLOW Layer	Hydraulic Conductivity (K_h, K_v) (m/s)
Alluvial Deposits	Layer 1	1.0E-05
Weathered Bedrock and Colluvium	Layer 1	1.0E-07
Unweathered Bedrock	Layer 2	4.0E-08
Unweathered Bedrock	Layer 3	2.5E-08
Unweathered Bedrock	Layer 4	1.0E-08

The cells in Layer 1 were subdivided into two hydraulic conductivity zones in order to differentiate between the two hydrostratigraphic units modelled in this layer. One zone represents the alluvial deposits along Casino, Canadian and Britannia Creeks and the second zone represents the weathered bedrock unit (including a thin colluvium cover) across the remainder of the study area. Plan and section views of the spatial distribution of the two property zones are presented on Figure 3.3.



NOTES:

1. THE PLAN VIEW FIGURE DISPLAYS THE HYDRAULIC CONDUCTIVITY ZONES ASSIGNED TO MODEL LAYER 1. THE SECTION VIEWS DISPLAY THE HYDRAULIC CONDUCTIVITY ZONES IN MODEL LAYERS 1 THROUGH 4.

Figure 3.3 Hydraulic Conductivity Zones

During the calibration process, hydraulic conductivity values assigned to the alluvial deposits along Casino Creek, Britannia Creek and Canadian Creek were varied independently. The best model fit to observed conditions was obtained by assigning all alluvial deposits a hydraulic conductivity value of 1E-5 m/s.

Model Layers 2 through 4 were assigned hydraulic conductivity values representative of unweathered bedrock. As shown on Figure 2.1, hydraulic conductivity values exhibit a decreasing trend with depth below ground surface. To reflect this trend in the model, the unweathered bedrock unit was divided into three separate model layers and hydraulic conductivity values were assigned to decrease in each subsequent layer.

3.5 BASELINE MODEL BOUNDARY CONDITIONS

Boundary conditions are used to specify groundwater sources and sinks in the model domain. The boundary conditions used to define the active model domain are shown on Figure 3.2 and include:

1. No-flow boundaries
2. Constant head boundaries to represent stream stage where a stream crosses the model boundary
3. Drain cells to represent creeks, and
4. Meteoric recharge.

3.5.1 No Flow Boundary Conditions

Most of the perimeter of the active model domain is defined by no-flow boundary conditions that correspond to the inferred groundwater divides at the Casino, Canadian and Britannia Creek watershed boundaries. Of the total 73,688 grid cells, approximately 29,000 are no-flow boundary cells. No-flow cells are specified as inactive and are excluded from the groundwater flow calculations within the MODFLOW model. The locations of the no-flow cells are shown on Figure 3.2 for Layer 1 and are the same in all layers of the model.

3.5.2 Constant Head Boundary Conditions

Constant head boundary conditions were specified at model perimeter locations where Casino, Canadian and Britannia Creeks exit the model domain. The stage assigned to a constant head cell was set equal to the streambed elevation at the point where the respective creek exits the model domain. Creek stages were set to 645 masl for Casino Creek and 500 masl for Canadian and Britannia based on the top elevation of model Layer 1. The constant head boundaries shown for Layer 1 on Figure 3.2 extend down through all layers of the model.

3.5.3 Drain Boundary Conditions

Casino, Canadian and Britannia Creeks and their tributaries were modelled using drain cells. Drain cells act as a groundwater sink and allow groundwater to be removed from the model surface where the simulated piezometric head is higher than a predefined drain stage. No water discharges the model via the drains if the simulated piezometric head is below the drain stage elevation. Drain stages were set equal to ground surface elevations along the stream channels in Layer 1. The rate of groundwater flux across the drain is dependent on a streambed conductance coefficient. Conductance coefficients were varied during model calibration in order to obtain a best fit to average annual baseflow estimates at the on-site hydrology stations. Conductance values ranged from 10 m^2/day to 50 m^2/day.

3.5.4 Recharge

A primary control of groundwater recharge in the study area is the spatial distribution of the discontinuous permafrost. Two groundwater recharge zones were defined in the model to represent inferred regions of permafrost and non-permafrost as presented in the 2012 Baseline Hydrogeology Report (KPL 2013b). Zones of permafrost were defined in the model by importing a GIS shapefile outlining the mapped distribution of permafrost. Regions of the model surface characterised as permafrost were assumed to have zero groundwater recharge.

The initial input value for recharge in regions of non-permafrost was based on watershed modelling performed by KPL (2013c) which suggested that approximately 13% of the 460 mm annual precipitation provides recharge to groundwater. This initial value was varied within an expected range during calibration of the baseline model. The calibrated groundwater recharge rate applied to non-permafrost zones in the baseline model was 124 mm/yr (Table 3.2), which is equal to an average of 55 mm/yr over the entire modelled area. The spatial distribution of the two groundwater recharge zones applied to the model is illustrated on Figure 3.4.

Table 3.2 Baseline Model Groundwater Recharge Rates

Recharge Zone Designation	Total Area (km^2)	Groundwater Recharge (mm/year)	Groundwater Recharge (% of MAP)
Permafrost Regions	106	0	-
Non-Permafrost Regions	84	124	22
Model Average	191	55	11

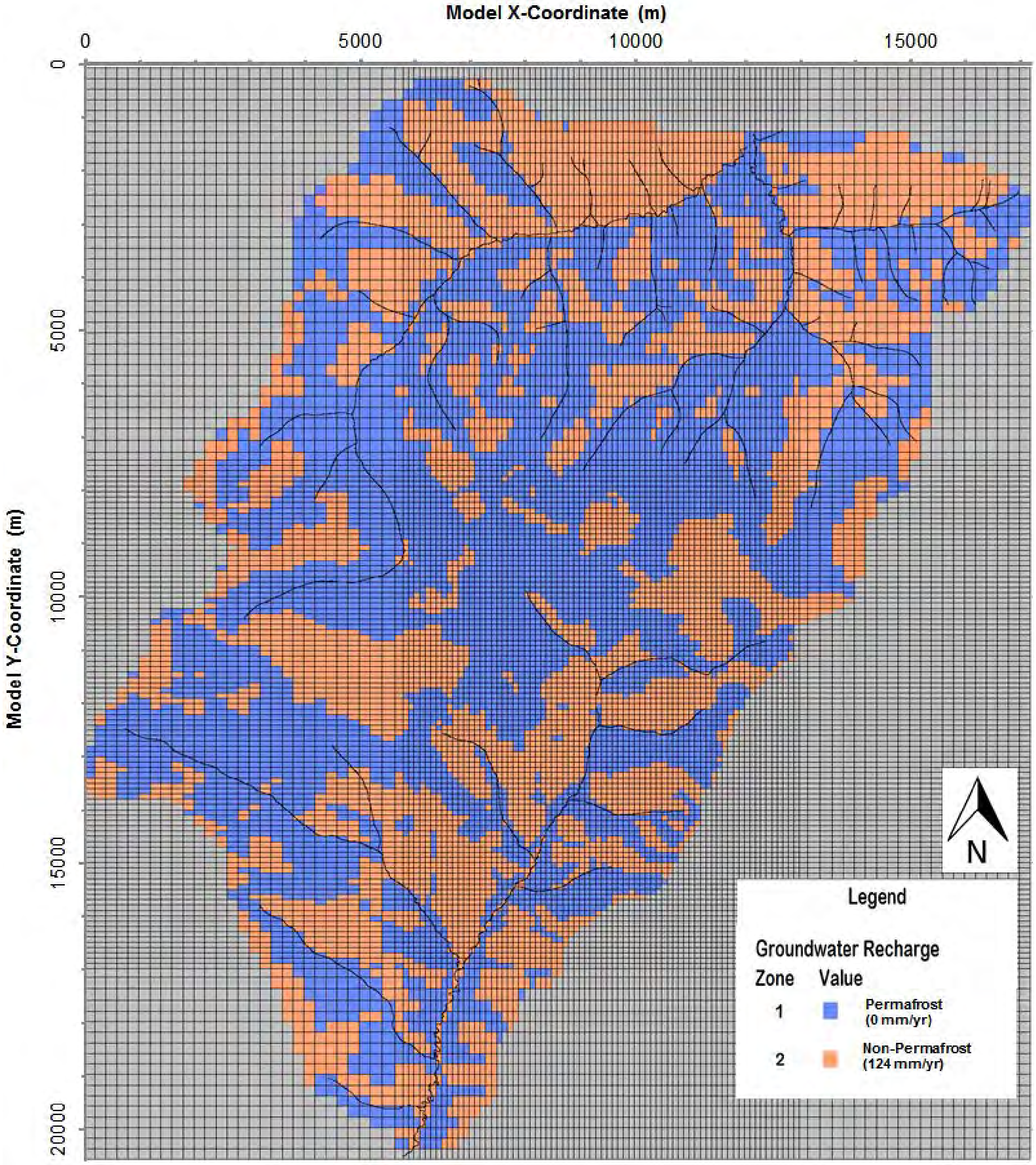
NOTES:
1. MAP = MEAN ANNUAL PRECIPITATION.

3.6 BASELINE MODEL CALIBRATION

The baseline model was calibrated using an iterative trial-and-error method in order to refine the match between model predictions and observed pre-development conditions at the site. Hydraulic conductivity and groundwater recharge rates were the primary calibration parameters varied during the calibration process. These parameters were systematically varied to achieve the best match to average hydraulic head measurements in monitoring wells and estimates of average annual baseflow conditions at the hydrology stations within the study area. The locations of the groundwater elevation and baseflow calibration targets are shown on Figure 3.1.

The PCG-5 solver was used to solve the groundwater flow equations in MODFLOW-SURFACT, with the following solver parameters:

- Number of outer iterations: 500
- Number of inner iterations:1000
- Maximum orthogonalizations: 10, and
- Head change criterion: 0.001 meters.



NOTES:

1. THE DISTRIBUTION OF PERMAFROST AND NON-PERMAFROST ZONES IS BASED ON KPL (2012A) AND PRESENTED IN KPL (2013B).

Figure 3.4 Groundwater Recharge Zones

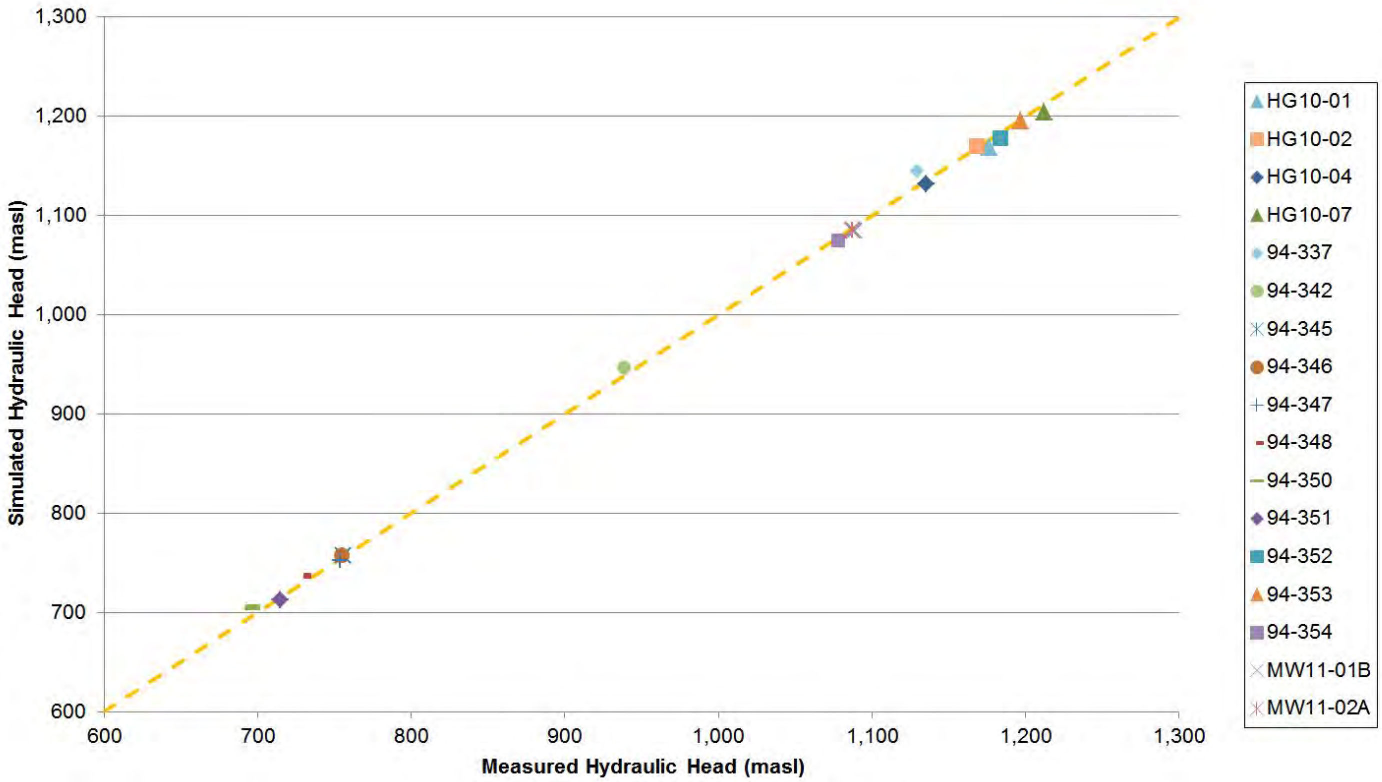
3.6.1 Hydraulic Head Targets

The baseline model was calibrated to average annual hydraulic heads recorded by manual measurement at 17 monitoring well locations across the project area. The locations of the hydraulic head targets are shown on Figure 3.1. The measured water levels used in the model are the average groundwater levels recorded over the period of data collection and consist of between 5 and 17 measurements at each site. A summary of the measured and simulated hydraulic heads at the model calibration targets is provided in Table 3.3 and on Figure 3.5.

Table 3.3 Observed and Simulated Hydraulic Heads

Well I.D.	Measured Groundwater Elevation (masl)	Simulated Groundwater Elevation (masl)	Residual Head (m)
HG10-01	1,177	1,168	8.4
HG10-02	1,169	1,168	1.6
HG10-04	1,135	1,131	4.1
HG10-07	1,212	1,204	8.4
94-337	1,129	1,144	-14.4
94-342	939	946	-6.7
94-345	756	757	-1.0
94-346	756	756	0.0
94-347	753	753	0.4
94-348	731	736	-5.3
94-350	698	705	-7.0
94-351	715	713	1.6
94-352	1,185	1,176	8.7
94-353	1,197	1,195	2.7
94-354	1,078	1,075	2.9
MW11-01B	1,089	1,083	5.4
MW11-02A	1,088	1,085	3.3
		MAE (m)	**4.8**
		RMSE (m)	**6.0**
		NRMSE	**1%**

NOTES:
1. THE VALUES LISTED AS MEASURED GROUNDWATER ELEVATIONS ARE AVERAGE ELEVATIONS OVER THE AVAILABLE PERIOD OF MEASURED DATA.
2. MAE = MEAN ABSOLUTE ERROR.
3. RMSE = ROOT MEAN SQUARE ERROR.
4. NRMSE = NORMALIZED ROOT MEAN SQUARE ERROR.



NOTES:
1. MEASURED HYDRAULIC HEADS ARE VALUES AVERAGED OVER THE PERIOD OF AVAILABLE DATA.

Figure 3.5 Observed vs. Simulated Hydraulic Heads

The primary calibration criterion was to achieve a normalized root mean squared error (NRMSE) of 5% (0.05) or less for hydraulic head targets. After calibration, a NRMSE of 1% (0.01) was achieved, satisfying the calibration criterion. All of the simulated hydraulic heads, with the exception of 94-337, are within 10 m of the observed value. The mean absolute error (MAE) for all hydraulic head targets is 4.8 meters.

3.6.2 Baseflow Targets

Average annual baseflows at six hydrometric stations on Casino, Canadian, Brynelson and Britannia Creeks in the study area were used as baseflow calibration targets. Baseflow targets were estimated using the results of a baseline watershed model developed by KPL for the Project (KPL 2013c). The baseline watershed model was calibrated to on-site and long-term synthetic streamflows using inputs of average monthly temperature and precipitation. Average annual baseflow at each hydrologic station was calculated from a monthly streamflow series spanning 37 years (1975 to 2012). Baseflow targets are summarized in Table 3.4 and are considered to be representative of average annual baseflow conditions.

Table 3.4 Baseflow Calibration Targets and Results

Hydrometric Station	Average Annual Baseflow from Watershed Model (l/s)	Average Annual Modflow Simulated Baseflow (l/s)	Residual Baseflow (l/s)	Relative Percent Difference (%)
Upper Casino Creek (W11)	66	65	-1	-1.0
Middle Casino Creek (H18)	105	111	6	5.6
Lower Casino Creek (W4)	144	143	-1	-1.0
Brynelsen Creek (W18)	39	42	3	6.8
Britannia Creek (W14)	71	74	3	4.1
Canadian Creek (W3)	104	102	-2	-2.3
			MAE (%)	**3.1**
			RMSE (l/s)	**3.1**
			NRMSE	**3%**

NOTES:

1. AVERAGE ANNUAL BASEFLOW VALUES ARE THE RESULT OF WATERSHED MODELLING CONDUCTED FOR THE PROJECT BY KPL (2013C).

Average annual baseflow estimates were compared with the simulated groundwater discharge to drain cells representing creeks. Drain cells were grouped into reaches corresponding to channel segments draining to one of the six hydrology stations.

The primary calibration criterion for baseflow calibration targets was to achieve a NRMSE of 5% (0.05) or less. After model calibration, a NRMSE of 3% (0.03) was achieved, satisfying the calibration criterion. Table 3.4 provides a summary of the calibration results for baseflow at the hydrometric stations and Figure 3.6 presents a plot of observed versus simulated baseflows. All model simulated baseflows are less than 7% of the target baseflow value and the MAE for all baseflow targets is approximately 3%.

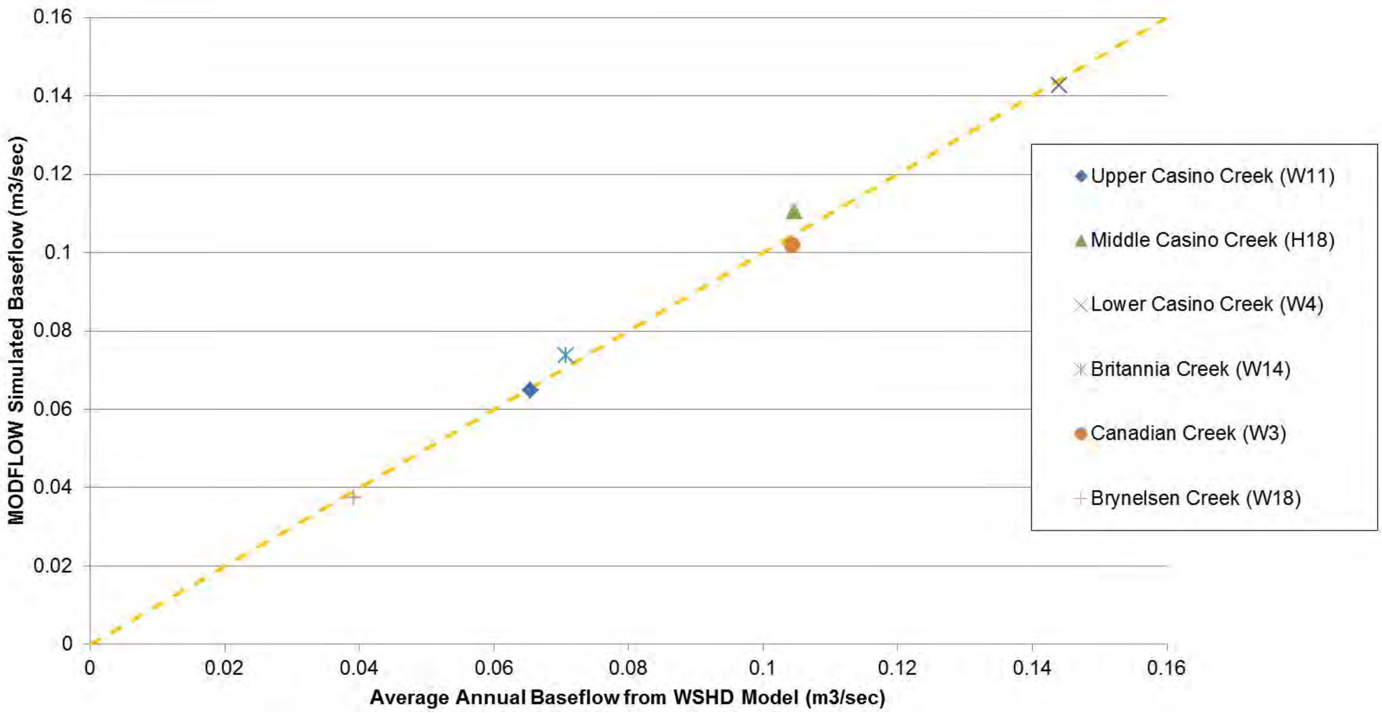


Figure 3.6 Average Annual Baseflow Estimates vs. Simulated Baseflow

3.7 BASELINE MODEL RESULTS

A water table contour map for the calibrated baseline model is presented in Figure 3.7. The simulated water table generally mimics the surface topography with groundwater elevations ranging from 1,450 masl in the high elevation region to the west of the mine site to 645 masl and 500 masl at the downstream extents of Casino Creek and Canadian/Britannia Creeks, respectively.

A plan view of groundwater flow directions is presented on Figure 3.8. Red arrows on Figure 3.8 indicate where groundwater flow has a predominantly downward vertical component of flow (recharge) and blue arrows indicate where there is a predominantly upward vertical component of flow (discharge). The figure illustrates that groundwater recharge occurs within topographic highs and groundwater flows downslope to discharge zones in creek valleys. Cross-sections depicting simulated groundwater flow directions along with surface water drainages are presented on Figure 3.9.

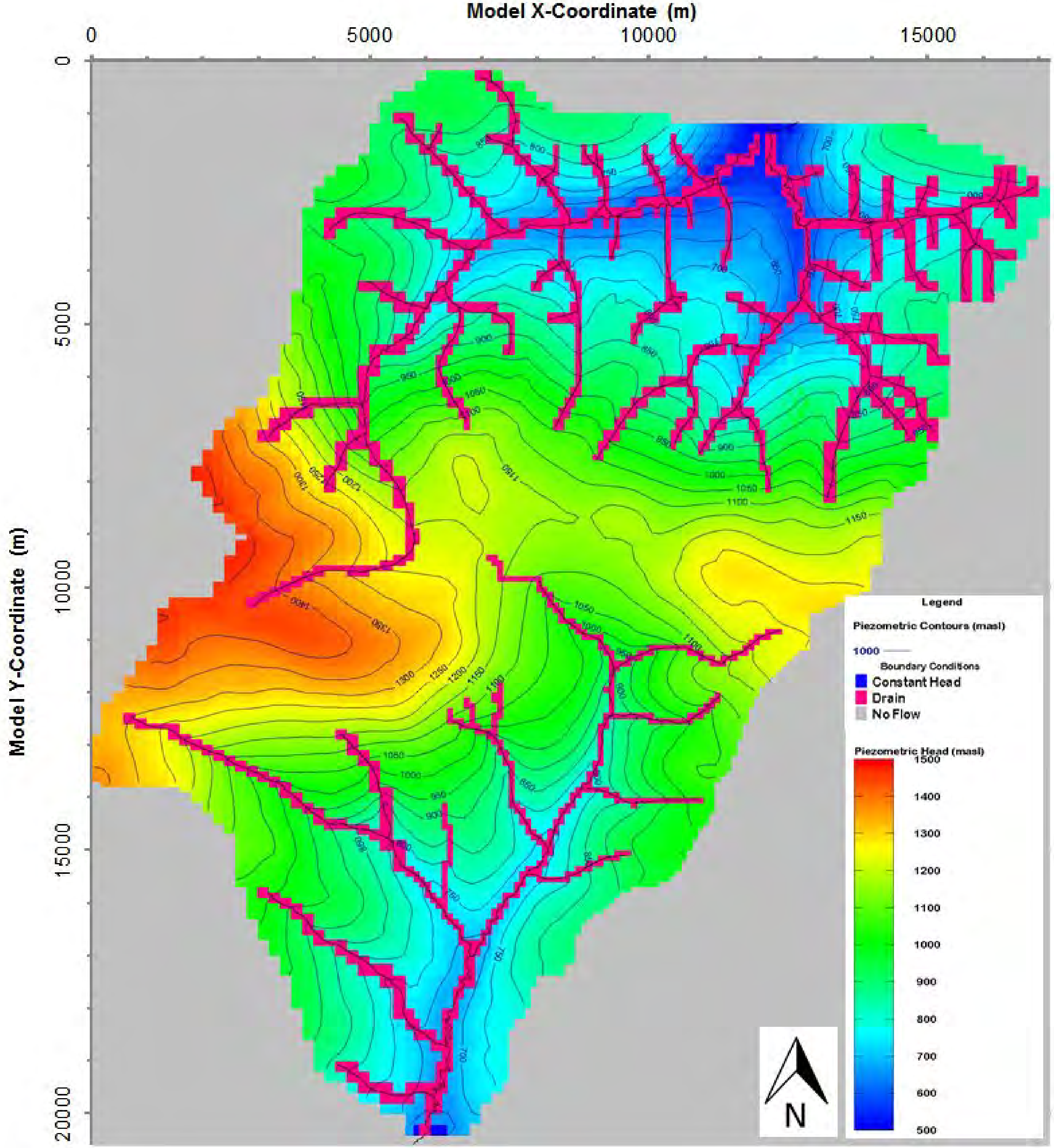
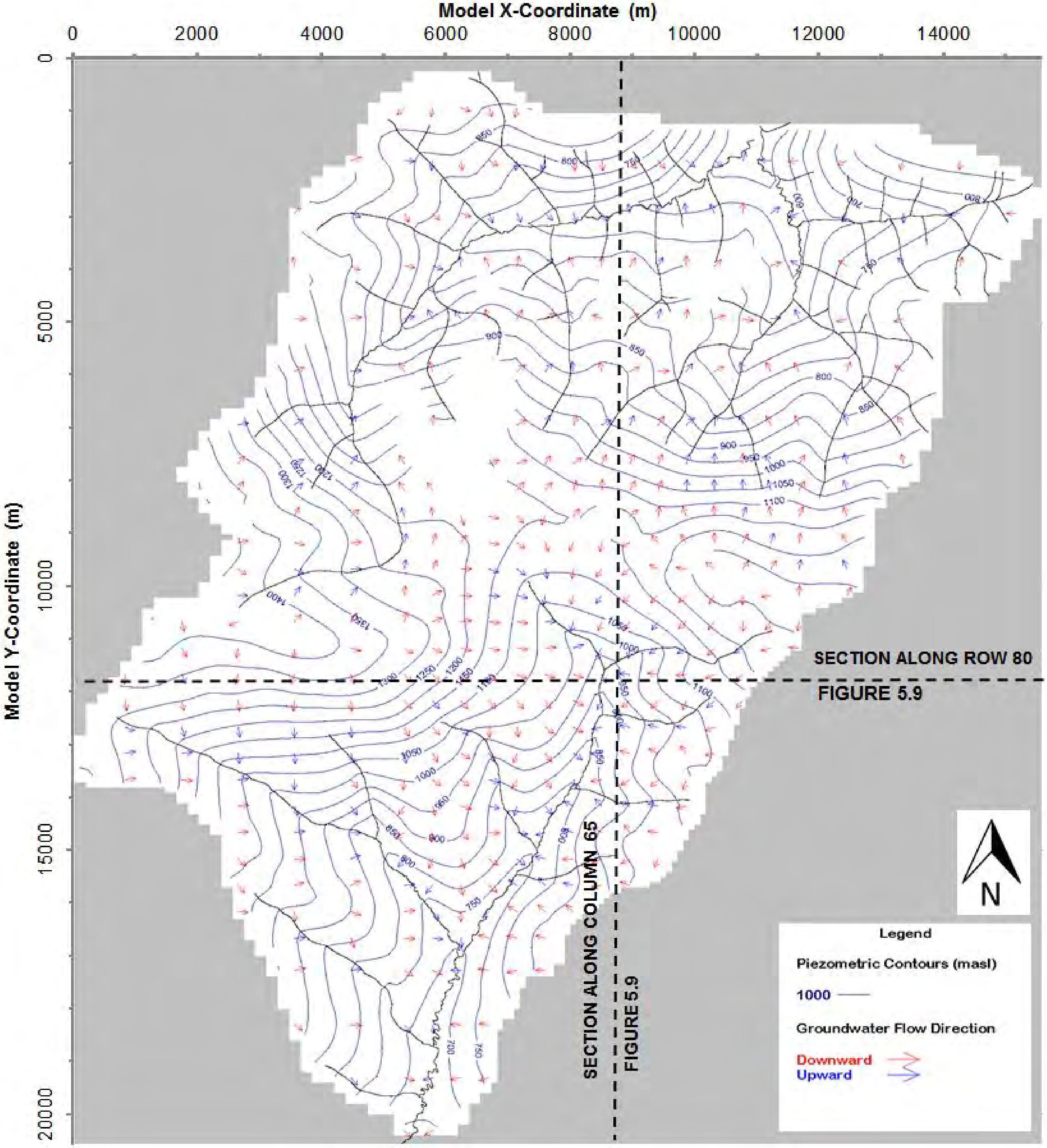


Figure 3.7 Simulated Water Table Contour Map



NOTES:

1. THE GROUNDWATER CONTOURS AND FLOW DIRECTIONS SHOWN ABOVE ARE FROM MODEL LAYER 2.
2. FLOW ARROWS AND PIEZOMETRIC CONTOURS ARE NOT SHOWN WHERE DRY CELLS ARE PRESENT IN LAYER 2.

Figure 3.8 Groundwater Flow Directions (Plan View)

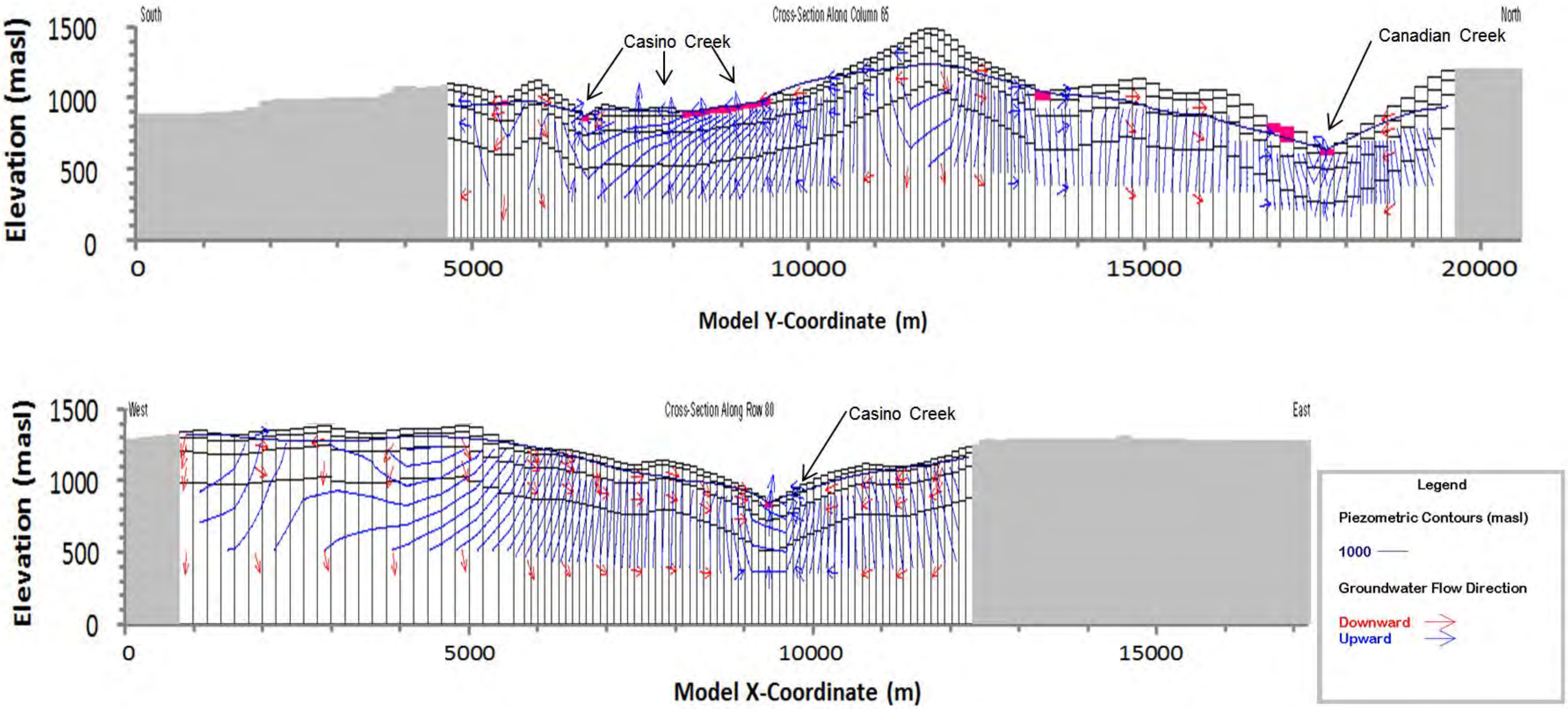


Figure 3.9 Groundwater Flow Directions (Section View)

4 – MINE EFFECTS NUMERICAL MODELS

4.1 OVERVIEW

A series of mine-scale groundwater models were developed to assess potential effects of the Casino Project on pre-development hydrogeological conditions. Five steady-state models were completed to simulate proposed mine infrastructure during key phases of project development. Models were developed for the Year 4, 10, 19 and 22 project phases and during Post-Closure when the Pit Lake is discharging. The mine effects models were developed from the calibrated baseline groundwater model using MODFLOW-SURFACT. The main objectives of the models were to:

- Characterize potential effects of mine facilities on baseline hydrogeology
- Estimate groundwater inflow rates to the Open Pit
- Estimate seepage rates from the Pit Lake during Post-Closure when the Pit Lake is at its maximum elevation
- Estimate seepage rates from the TMF
- Estimate groundwater inflow rates to the TMF, and
- Characterize potential seepage pathways from key mine facilities.

The results of the mine effects modelling along with the methodology and assumptions used to develop the models are presented in the sections that follow. A detailed description of a seepage analysis completed for the Tailings Management Facility is provided in Section 5 and a description of seepage pathways for ore stockpiles is presented in Section 6. Results from the mine effects models will be used to inform the water quality modelling and geochemical source term development in support of the YESAB proposal.

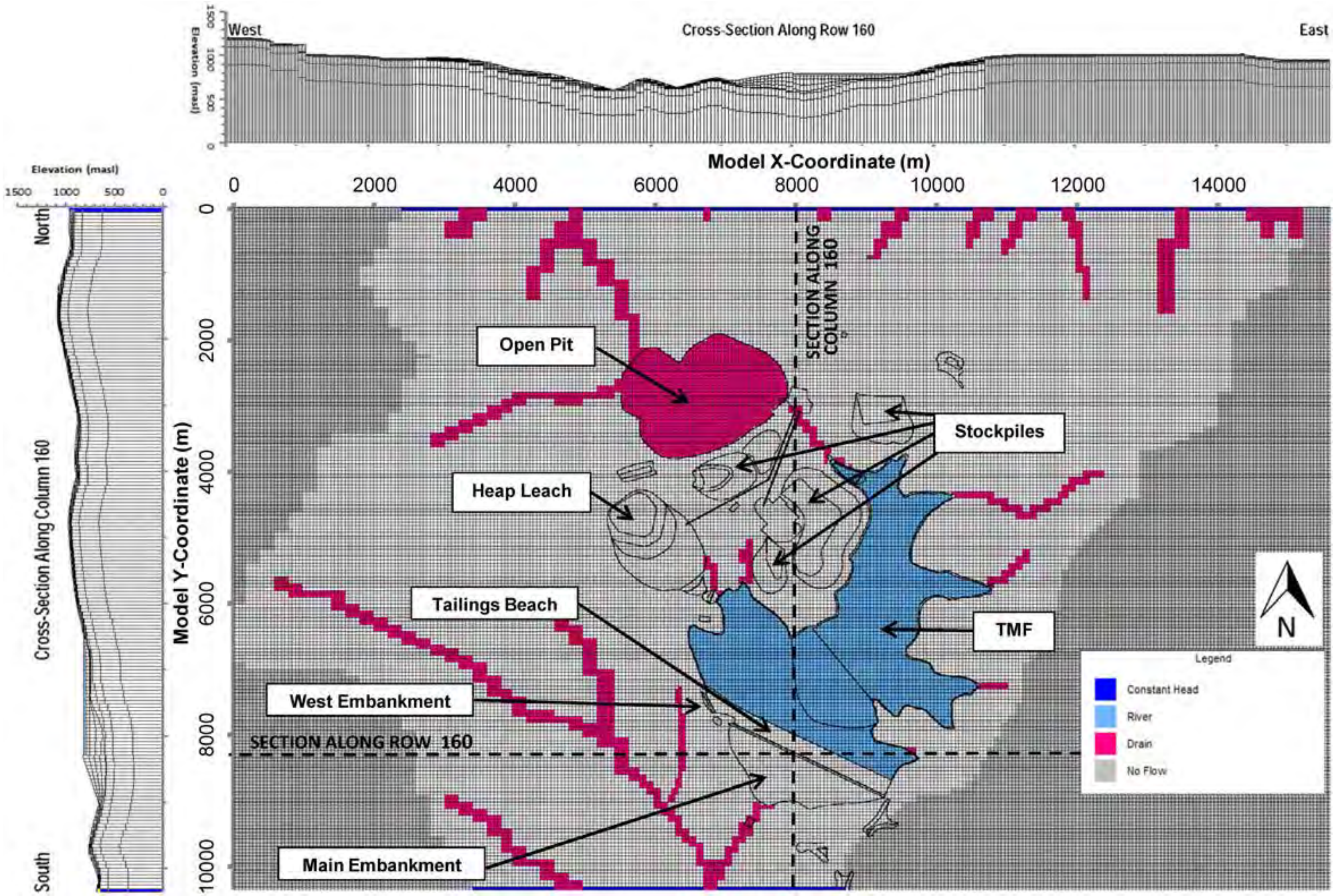
4.2 MINE EFFECTS MODEL GEOMETRY, LAYERING AND GRID

The effects models were developed from the calibrated regional baseline model by telescopically refining, or “cutting out”, a section of the baseline model domain, centered on the mine site. Grid cells in the mine effects models were refined to 50 m by 50 m across the refined model domain. This model construction yields higher resolution calculations while reducing model size and simulation run times. The refined mine effects model domain and the locations of proposed mine facilities are shown in Figure 4.1.

Each mine effects model has a rectangular grid of 200 rows by 310 columns by 8 layers for a total of 496,000 cells, of which approximately 332,000 are active. The active model domain encompasses an area of 108 km^2 and is approximately 15 km in the east-west dimension and 10 km in the north-south dimension. The numerical grid and model layering of the mine effects models are shown on Figure 4.1.

In addition to the four layers used in the baseline model, four additional layers were added to the top of the models to allow for tailings, waste rock and TMF Embankment materials to be constructed in three dimensions above the baseline ground surface. The layering of the models is as follows:

- Facilities Layers 1-4 vary between 1 and 75 m thick, as defined by mine facility elevations
- Baseline Layer 1 is generally 30 m thick (top elevation defined by GIS contour shapefile)
- Baseline Layer 2 is 100 m thick
- Baseline Layer 3 is 250 m thick, and
- Baseline Layer 4 is of variable thickness, with base elevation equal to mean sea level.



NOTES:

1. THE PLAN VIEW IMAGE ABOVE PRESENTS LAYER 1 OF THE YEAR 22 MINE EFFECTS MODEL.
2. CONSTANT HEAD BOUNDARIES WERE DEFINED BY THE CALIBRATED REGIONAL-SCALE BASELINE MODEL DURING THE TELESCOPIC MESH REFINEMENT PROCESS.

Figure 4.1 Mine Effects Models Numerical Grid, Model Layers and Boundary Conditions

4.3 HYDRAULIC CONDUCTIVITY

The hydraulic conductivity values assigned to Baseline Layers 1 through 4 remained unchanged from the baseline model. Five additional hydraulic conductivity zones were added to the mine effects models to define the hydraulic conductivity of tailings, waste rock and TMF embankment materials in Facility Layers 1 through 4. Hydraulic conductivity assignments for the TMF sub-components are presented on Figure 4.2 and further discussed in Section 4.5.1.

4.4 MINE EFFECTS MODEL BOUNDARY CONDITIONS

The boundary conditions used to define the domain of the mine effects models were transferred from the baseline model to the telescopically refined model. The boundary conditions used to define the active model domain are shown on Figure 4.1.

4.4.1 No Flow Boundary Conditions

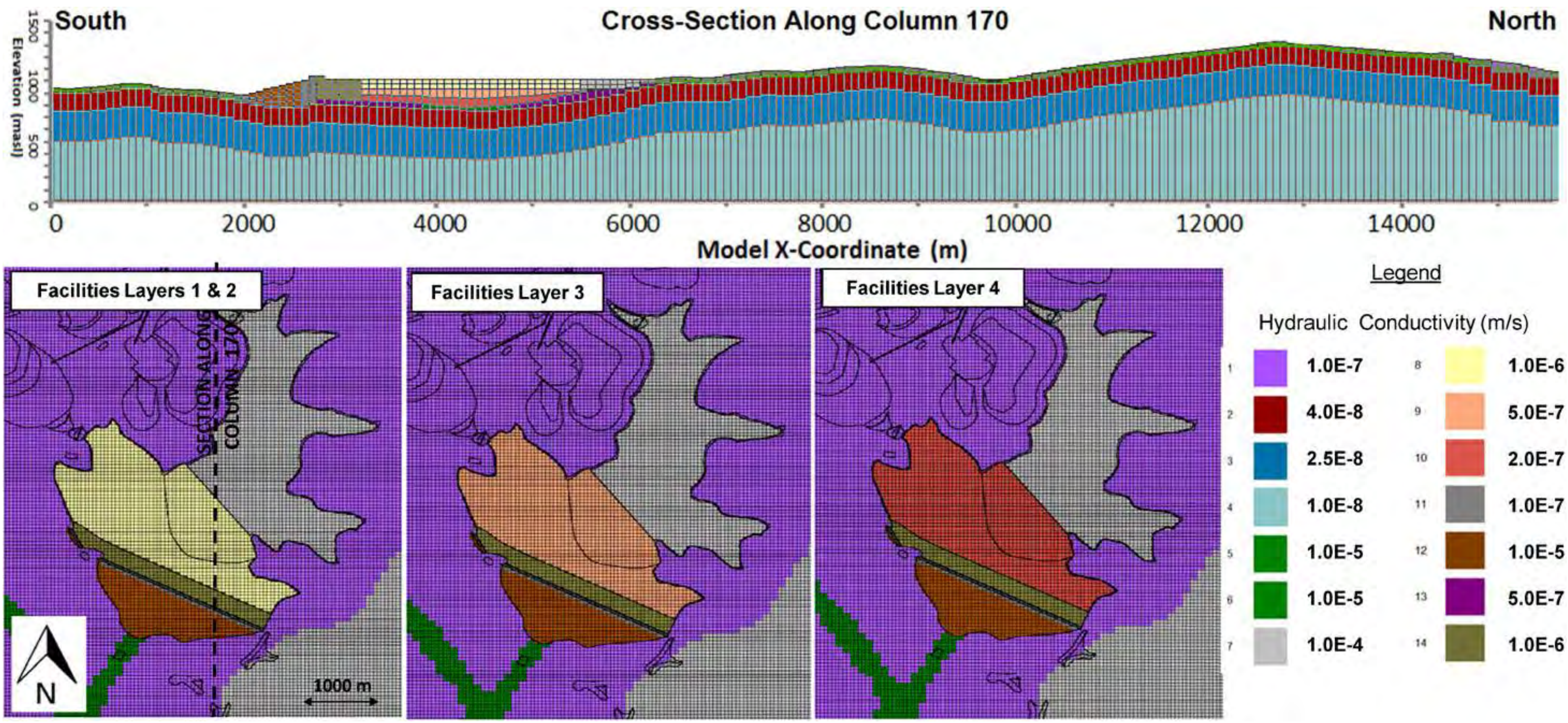
No-flow boundary cells define the east and west boundaries of the mine effects models along assumed groundwater divides. The no-flow boundary cells were transferred directly from the regional baseline model during telescopic mesh refinement. No-flow cells are specified as inactive and are excluded from MODFLOW calculations.

4.4.2 Constant Head Boundary Conditions

Constant head boundaries were used to define the northern and southern boundaries of the mine effects models along the interfaces of the TMR “cut-out” and the regional baseline model. Constant head values were assigned to cells based on the piezometric head distribution of the baseline model. All layers of the mine effects model have cells assigned a constant head boundary condition at the same location as shown in Figure 4.1.

4.4.3 Drain Boundary Conditions

Drain boundary conditions transferred from the baseline model were used to simulate groundwater discharge to creeks within the active model domain. The drain conductance and elevations remained unchanged from the baseline model. Drain cells representing creeks located within the footprint of the Open Pit, ore stockpiles, heap leach facility and TMF were removed from the model.



NOTES:

1. THE IMAGES SHOWN ABOVE ARE TAKEN FROM THE YEAR 22 MINE EFFECTS MODEL.
2. HORIZONTAL HYDRAULIC CONDUCTIVITIES ARE SHOWN IN THE FIGURE. HYDRAULIC CONDUCTIVITIES IN ZONES 1 THROUGH 6 ARE ISOTROPIC. ANISOTROPY RATIOS FOR ZONES 7 THROUGH 11 ARE PRESENTED IN TABLE 4.1.
3. HYDRAULIC CONDUCTIVITY ZONE 13 WAS NOT ASSIGNED IN MODEL 1.

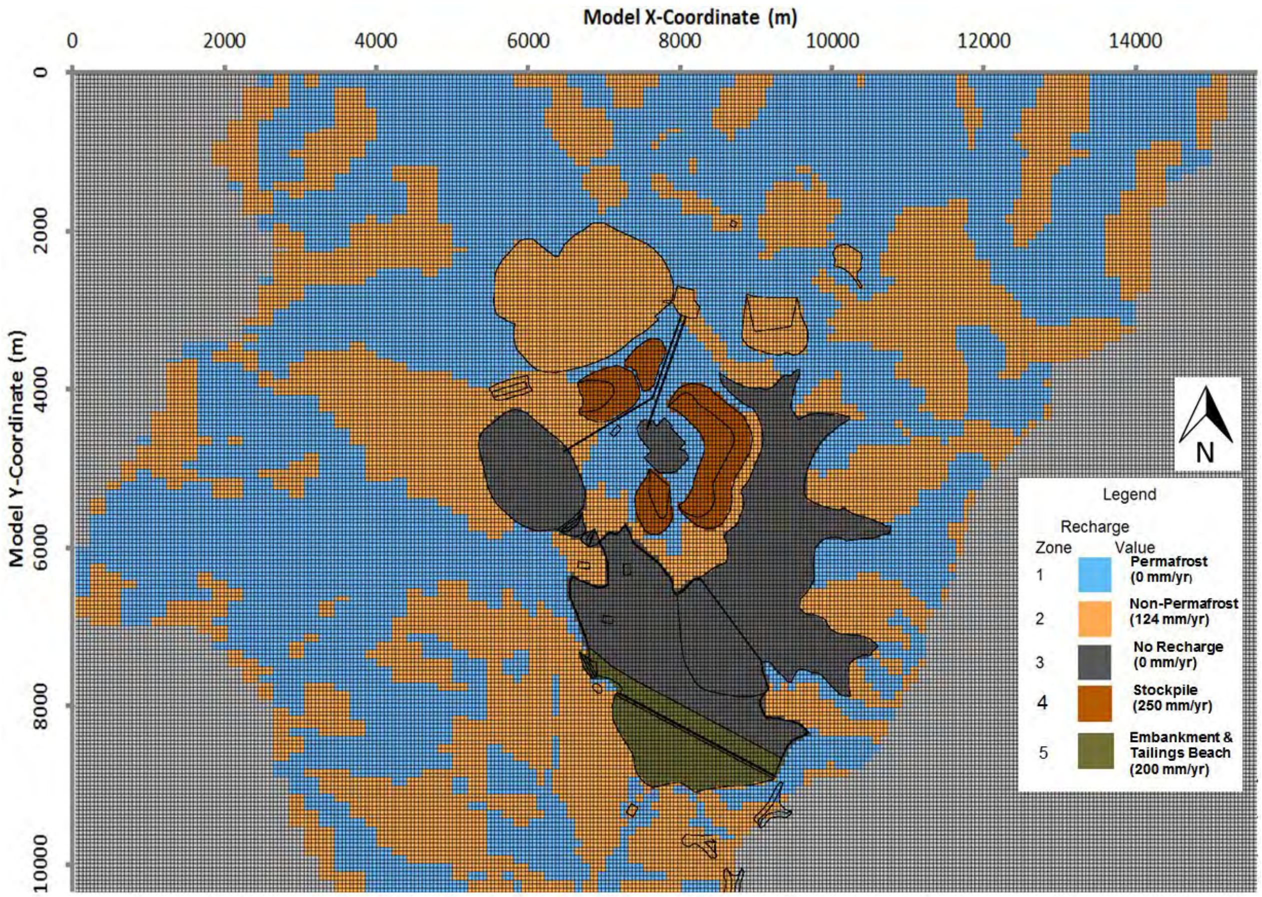
Figure 4.2 Mine Effects Model Hydraulic Conductivity Zones (Model 1)

4.4.4 Groundwater Recharge

The spatial distribution and rate of groundwater recharge for areas undisturbed by proposed mine facilities remained unchanged from the baseline model. Changes to the specified groundwater recharge boundary condition in the mine effects model were made for the following mine components:

- Heap Leach Facility
- Open Pit
- Ore & Low-Grade Ore Stockpiles, and
- TMF (Main and West Embankments, tailings beach, tailings, waste rock and supernatant pond).

Areas beneath the proposed ore stockpiles, Open Pit and TMF embankment that were classified as regions of permafrost in the baseline model were reclassified as ‘non-permafrost’ to account for anticipated degradation of permafrost beneath major mine facilities. The area below the heap leach was assumed to have zero groundwater recharge due to installation of a low-permeability liner at the bottom of the facility. A recharge rate of 200 mm/yr was applied to the tailings beach in the Year 4, 10, 19 and 22 mine effects models. The beach recharge rate was reduced to 90 mm/yr in the Post-Closure model to simulate reduced infiltration after tailings deposition (spiggoting of tailings over the tailings beach) is no longer active. Recharge to ore stockpiles was specified at 250 mm/yr. Estimates of recharge to mine facilities were obtained from the mine operations watershed model (KPL 2013c). The groundwater recharge zones specified in the mine effects models are shown on Figure 4.3. No recharge is indicated for the TMF footprint on Figure 4.3 as recharge to tailings and waste rock materials is controlled by the RIV boundary cells of the supernatant pond.



NOTES:

1. THE IMAGES SHOWN ABOVE ARE FROM THE YEAR 19 MINE EFFECTS MODEL.
2. THE GOLD ORE STOCKPILE IS NO LONGER PRESENT IN YEAR 19.
3. A RECHARGE RATE OF ZERO WAS ASSIGNED TO THE TMF SINCE RECHARGE TO TAILINGS AND WASTE ROCK MATERIALS IS CONTROLLED BY THE RIV BOUNDARY CELLS OF THE SUPERNATANT POND.

Figure 4.3 Mine Effects Model Groundwater Recharge Zones

4.5 SIMULATION OF MINE COMPONENTS

Mine facilities were incorporated into the mine effects models to simulate potential effects of the project on pre-development hydrogeological conditions. Each mine effects model simulates mine components during a key 'snapshot' phase of mine development. The phases simulated in the models correspond to the staged project layout figures presented in Appendix A. A discussion detailing how each facility is represented in the models is provided in the following subsections.

4.5.1 Tailings Management Facility

Three distinct types of tailings and waste rock materials will be deposited within segregated regions of the TMF. The following TMF sub-components were defined in the models:

- Main and West TMF Embankments
- Potentially Acid Generating (PAG) Tailings
- Non-PAG Tailings, and
- Waste Rock Storage Area.

In order to assess seepage fluxes between the TMF sub-components, the TMF was explicitly defined in the mine effects models in three-dimensions. Tailings, waste rock and embankment materials were built up in Facilities Layers 1 through 4, as shown on Figure 4.2. Each material type was assigned a representative hydraulic conductivity value. Tailings hydraulic conductivity was further subdivided into three categories: (1) unconsolidated tailings, (2) consolidating tailings and (3) consolidated tailings. These hydraulic conductivity values were assigned to the tailings materials in the four Facilities Layers such that hydraulic conductivity values decrease with depth. Immediately upstream of the TMF Embankments, the tailings deposit was assigned a horizontal hydraulic conductivity value of 1E-6 m/s along a width of 250 m to represent the potential for sandier tailings (a "beach") adjacent to the Embankments. Hydraulic conductivity values representative of consolidating (Facilities Layers 1 and 2) and consolidated (Facilities Layers 3 and 4) tailings were assigned to the Post-Closure model to simulate a post-consolidation tailings mass. The tailings beach material was assigned the same hydraulic conductivity in the Post-Closure model. The hydraulic conductivity values assigned to the TMF subcomponents are summarized in Table 4.1.

Table 4.1 TMF Hydraulic Conductivity Values

TMF Sub-Component	Horizontal Saturated Hydraulic Conductivity, Kh (m/s)	Vertical Saturated Hydraulic Conductivity, Kv (m/s)	Anisotropy (Kv/Kh)
Waste Rock	1.E-04	1.E-04	1
Coarse Tailings - Tailings Beach	1.E-06	1.E-07	0.1
Unconsolidated Tailings	1.E-06	1.E-07	0.1
Consolidating Tailings	5.E-07	5.E-08	0.1
Consolidated Tailings	2.E-07	2.E-08	0.1
TMF Embankment - Core Zone	1.E-07	1.E-07	1
TMF Embankment - Cyclone Sand	1.E-05	1.E-05	1

The TMF Embankments were constructed by importing GIS-based shapefiles to Groundwater Vistas to define the embankment elevations. The embankments were simulated as two zones: a low permeability core with a hydraulic conductivity of 1E-7 m/s and a portion consisting of cyclone sand with a hydraulic conductivity of 1E-5 m/s. The embankment drainage systems are represented by drain cells underneath the TMF Embankments in Facilities Layer 4.

The TMF supernatant pond was simulated by assigning river boundary cells within the TMF footprint in Facilities Layer 1. The stage of the river cells was defined by the supernatant pond elevations for each phase as shown for Years 4, 10, 19 and 22 on Figure A.6. A conductance term was calculated by multiplying the cell width and length by the vertical hydraulic conductivity of the underlying tailings or waste rock materials. Additional discussion of the methodology used to simulate the TMF is provided as part of the seepage assessment presented in Section 5.

4.5.2 Open Pit

Drain boundary cells were specified in the mine effects models to simulate operational dewatering of the Open Pit during active mining. Operational pit shells for Years 4, 10, 19 and 22 were used to assign drain cells in Baseline Layers 1 through 4 within the extent of the Open Pit. Drain elevations were set equal to the elevation of the pit shell at a given cell location. Drain conductance was assigned a value high enough to allow water to drain freely into the Open Pit while still minimizing mass balance error (250 m^2/day).

4.5.3 Pit Lake (Post-Closure Model)

Upon closure, the Open Pit will be allowed to fill to create a Pit Lake. The pit will fill to a maximum water surface elevation of 1,100 masl, above which excess water will discharge via an engineered spillway. The Pit Lake was modelled by specifying river boundary cells using the River Package (Harbaugh et al, 2000) within the extents of the ultimate open pit shell. A stage of 1,100 masl was assigned to the river cells. A conductance term was estimated for the river cells based on cell geometry and hydraulic conductivity assigned to the surrounding materials. Above the ultimate elevation of the Pit Lake, drain cells were assigned to the model to allow groundwater discharge along the pit highwall.

4.5.4 Ore Stockpiles

Ore stockpiles were simulated by modifying groundwater recharge rates applied to stockpile footprints at the locations shown on Figure 4.3. A recharge rate of 250 mm/year was assigned to the ore stockpiles based on the results of watershed modelling conducted by KPL (2013c).

4.5.5 Heap Leach Facility

The Heap Leach Facility was simulated by specifying a groundwater recharge rate of zero to the model surface in the facility footprint. A small amount of leakage may be expected through the liner, however, the magnitude of recharge associated with the liner leakage is considered negligible and does not influence simulated groundwater flow paths.

4.6 MINE EFFECTS MODEL RESULTS

The major mine components of the proposed Casino Project are expected to have localized effects on groundwater elevations within the project area. Simulated water table contour maps representing Baseline, Year 4, 10, 19, and 22 conditions and during Post-Closure when the pit is discharging are provided in Appendix B. Comparison of water table contours representing baseline conditions and phases of the mine life indicate that groundwater elevations surrounding the TMF supernatant pond are predicted to increase as supernatant water elevations in the TMF increase. Groundwater elevations surrounding the Open Pit are predicted to decrease by up to 450 m during operational pit dewatering.

4.6.1 Open Pit Results: Operations

The mine effects models were used to estimate groundwater inflow rates to the Open Pit during operational dewatering and to assess the extent of groundwater drawdown surrounding the Open

Pit. Local groundwater drawdown associated with operational dewatering of the Open Pit during Years 4, 10, 19, and 22 is shown on water table contour plots located in Appendix B.

Simulated groundwater inflows to the Open Pit are shown on Figure 4.4. Model results show that groundwater inflows are expected to increase from the start of operations through Year 19 as the Open Pit increases in size. Simulated groundwater inflows reach a maximum of approximately 33 l/s during Year 19 when the extent of the Open Pit is greatest.

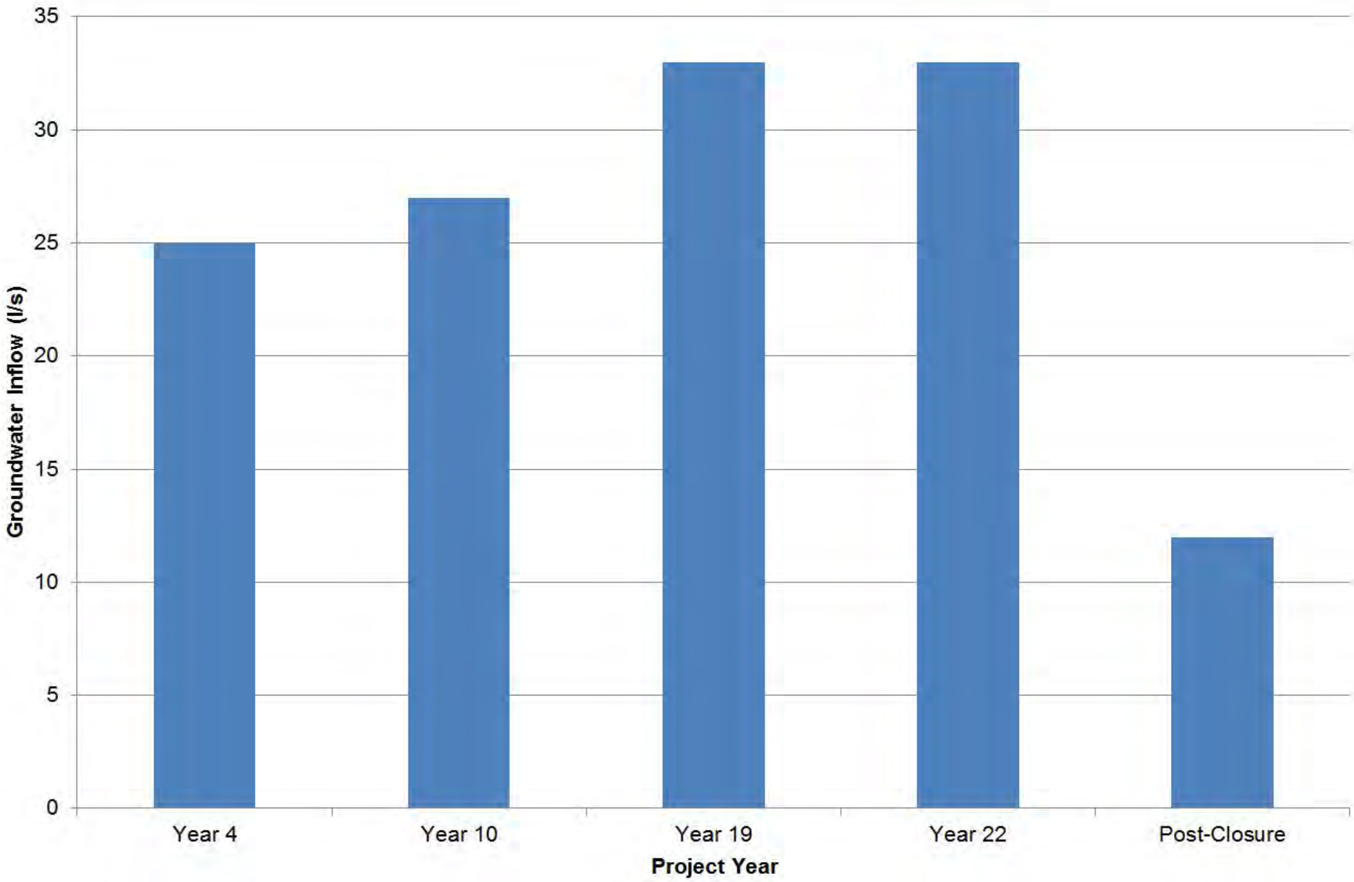
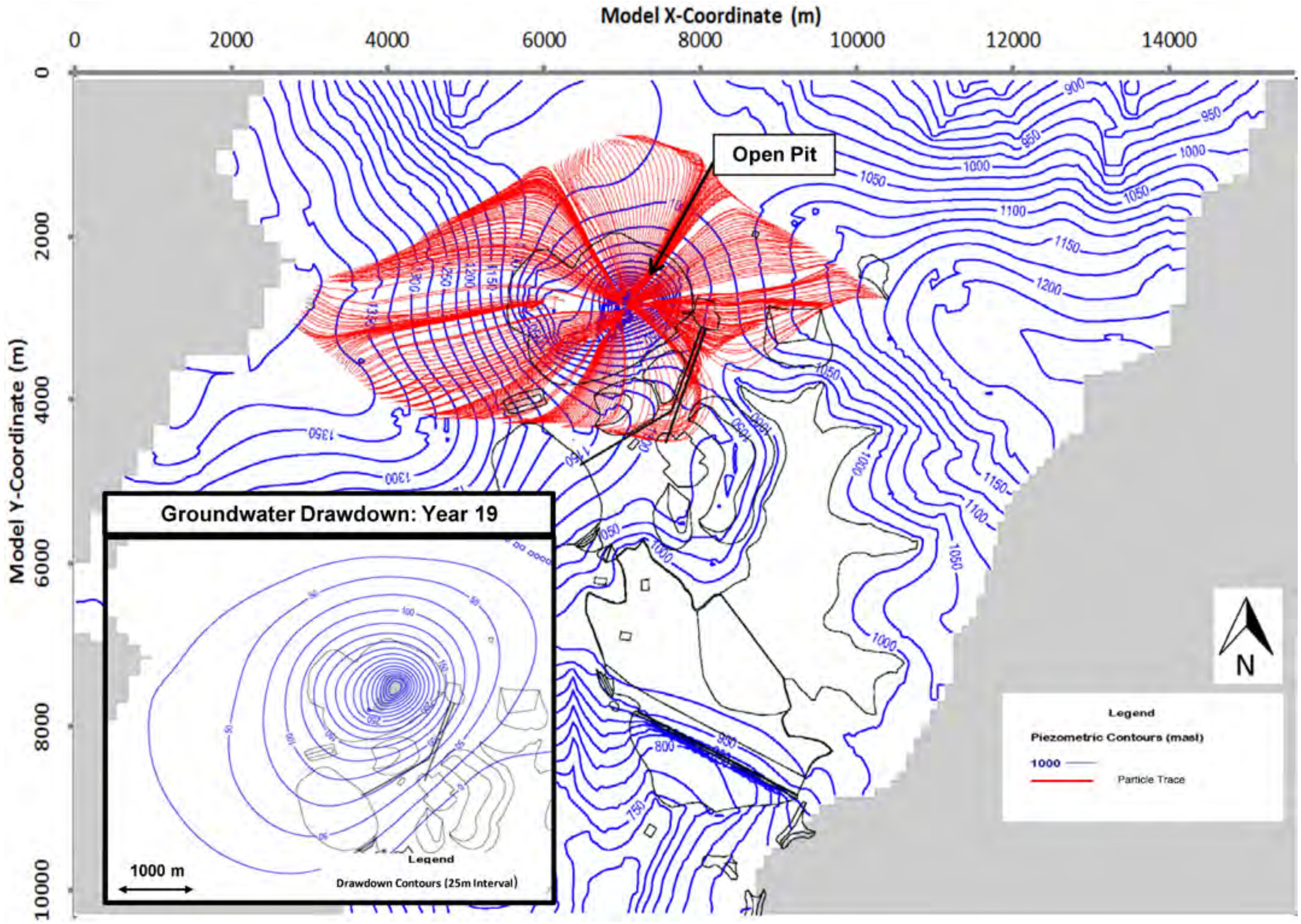


Figure 4.4 Simulated Groundwater Inflow to Open Pit

MODPATH particle tracking (Pollok 1994) was used to delineate the capture zone of the proposed Open Pit at the predicted maximum extent of de-watering (Year 19) as shown on Figure 4.5. Particles were added to the model within Baseline Layers 2 through 4 along a capture zone boundary initially estimated based on water table contours. The particles were tracked forward for the 19 year mine life. The capture zone was expanded or contracted iteratively until all MODPATH particle release locations reported to the Open Pit. Results of MODPATH particle tracking indicate that the Open Pit capture zone is not expected to extend to the TMF facility footprint.



NOTES:

1. THE PIT CAPTURE ZONE IS SHOWN FOR YEAR 19, WHEN THE PIT IS AT ITS MAXIMUM EXTENT.
2. THE SUBSET IMAGE SHOWS CONTOURS OF GROUNDWATER DRAWDOWN IN YEAR 19 RELATIVE TO BASELINE GROUNDWATER ELEVATIONS.

Figure 4.5 MODPATH Delineation of Open Pit Capture Zone

4.6.2 Open Pit Results: Post-Closure Model

Upon closure, the Open Pit will be flooded to maintain a Pit Lake and groundwater elevations immediately surrounding the Open Pit are expected to recover to the water surface elevation of the Pit Lake (1,100 masl; Figure B.6). The Post-Closure model predicts that groundwater inflows to and seepage from the Pit Lake will be approximately 12 l/s. Based on simulated water table contours, the majority of seepage from the Pit Lake is expected to feed into the groundwater system of upper Casino Creek.

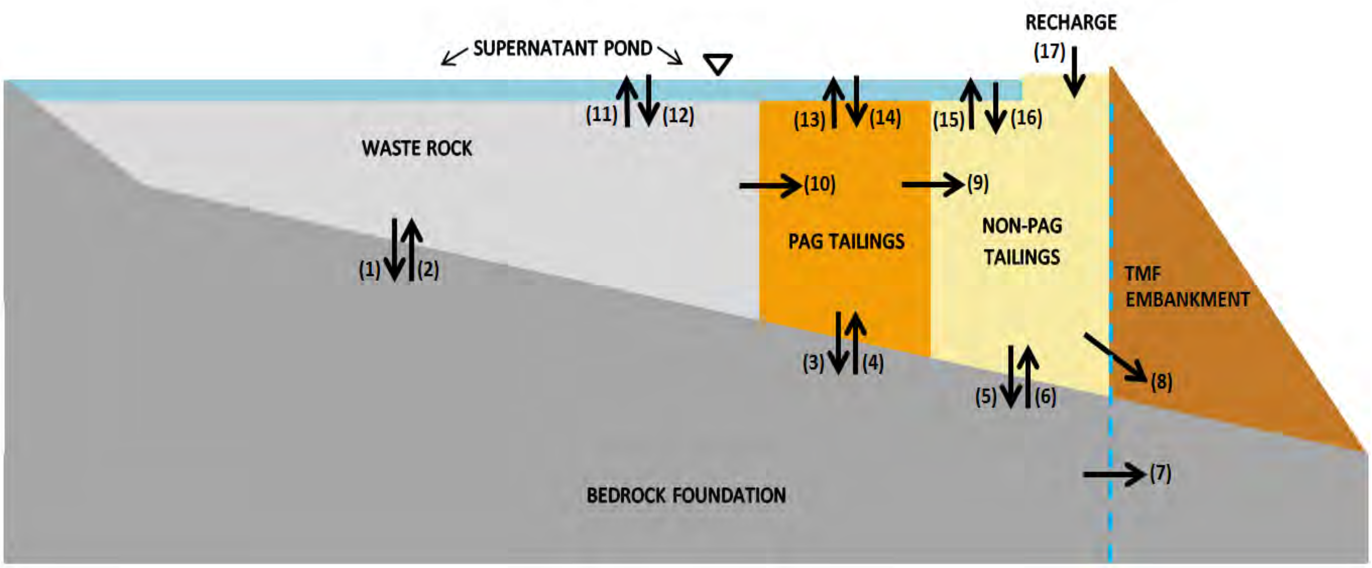
MODPATH particle tracking was used to assess the down gradient discharge location of seepage from the Pit Lake. Results of the particle tracking suggest that the Pit Lake will discharge to surface within the upper valley of Casino Creek, upslope of the TMF.

5 – TMF SEEPAGE ASSESSMENT

5.1 OVERVIEW

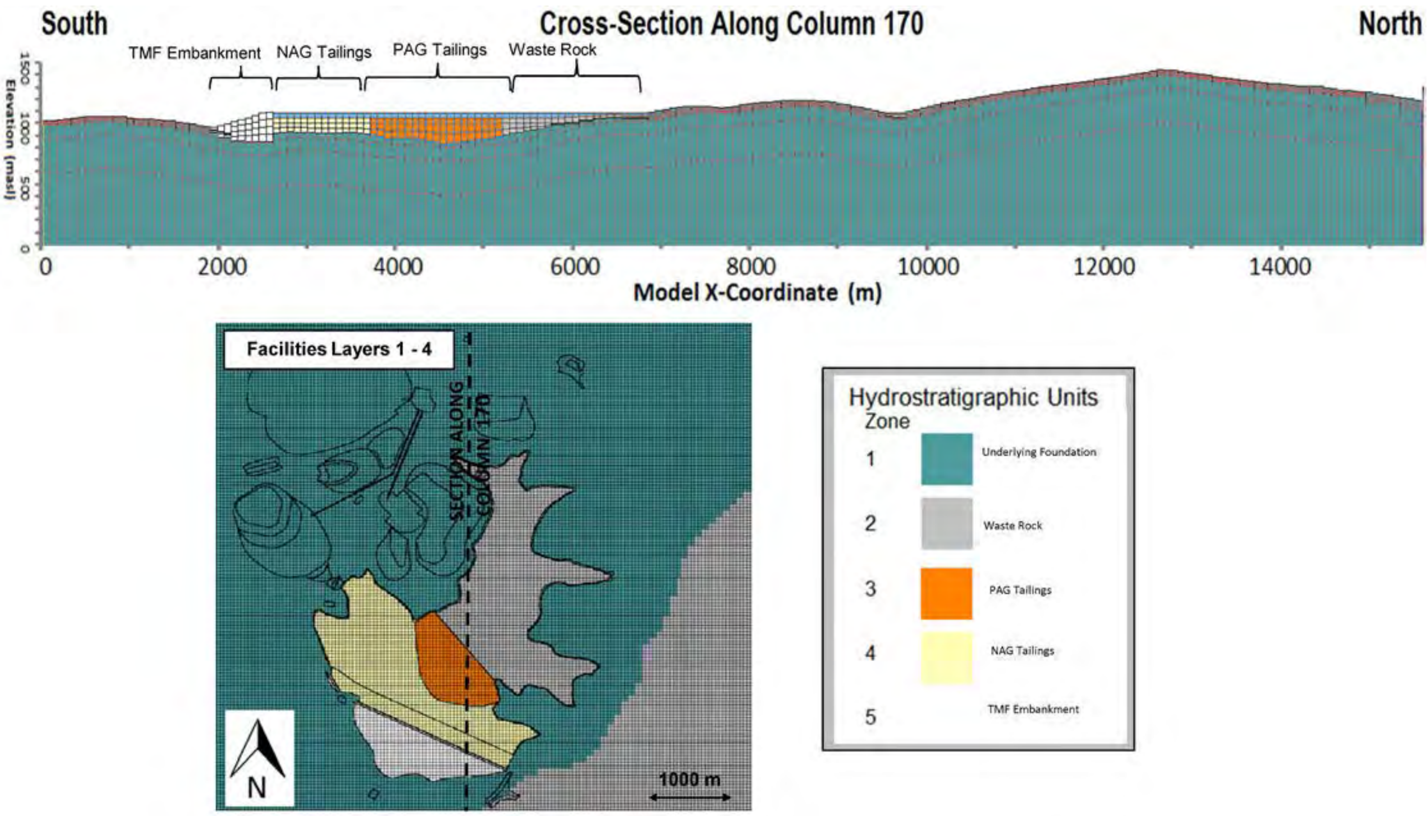
To support water quality modelling and geochemical source term development, a seepage assessment was completed for the Casino TMF using the mine effects models. The analysis quantified foundation and embankment seepage rates, groundwater inflow rates and flux rates between the TMF tailings and waste rock. In addition, the models were used to simulate the flow regime within the TMF. The seepage recovery efficiency of the water management pond downstream of the TMF embankment was assessed using the predicted TMF seepage rates. The seepage assessment methodology and results are presented in the following sections.

A conceptual model of the TMF sub-components included in the mine effects models is presented on Figure 5.1, and discretization of the TMF is shown on Figure 5.2. The TMF construction in each operations model (Years 4, 10, 19 and 22) and in the Post-Closure model follow the staged development of the mine as presented on figures in Appendix A.



NOTES:
1. FLUX PATHWAY (7) IS CALCULATED AS THE SUM OF TERMS (1), (3), and (5).

Figure 5.1 TMF Conceptual Model and Flux Pathways



NOTES:

1. THE IMAGES SHOWN ABOVE WERE TAKEN FROM THE YEAR 22 MINE EFFECTS MODEL.
2. THE CROSS SECTION ABOVE SHOWS THE 3-DIMENSIONAL CONSTRUCTION OF TAILINGS AND WASTE ROCK MATERIALS WITHIN THE TMF.

Figure 5.2 TMF Sub-Components/Hydrostratigraphic Units

5.2 TMF SEEPAGE ASSESSMENT METHODOLOGY

The Hydrostratigraphic Unit (HSU) package in Groundwater Vistas was used to generate a water budget for the TMF. The HSU package allows the user to group model cells into “hydrostratigraphic units,” or zones, in order to track inflow and outflow from these defined regions of the model. Cells located within each TMF sub-component in the mine effects model were grouped together into an HSU to allow inflow and outflow from each sub-component to be tracked. An additional HSU zone was assigned to the foundation materials underlying the TMF to assess foundation seepage from the base of the facility. The five HSUs defined for the TMF seepage assessment and the model layers to which they were assigned include (Figure 5.2):

1. PAG Tailings (Facilities Layers 1 – 4)
2. Non-PAG Tailings (Facilities Layers 1 – 4)
3. Waste Rock Storage Area (Facilities Layers 1 – 4)
4. TMF Embankments (Facilities Layers 1 – 4), and
5. Underlying foundation materials (Baseline Layers 1 – 4).

Seventeen flux pathways were tracked between the aforementioned HSU zones as shown in Figure 5.1:

1. Seepage from Waste Rock Storage Area to the Foundation
2. Groundwater Inflow to Waste Rock Storage Area from Foundation
3. Seepage from PAG Tailings to the Foundation
4. Groundwater Inflow to PAG Tailings from Foundation
5. Seepage from Non-PAG Tailings to the Foundation
6. Groundwater Inflow to Non-PAG Tailings from Foundation
7. Seepage through Foundation under Embankment
8. Seepage through Embankment
9. Flux from PAG Tailings to Non-PAG Tailings
10. Flux from Waste Rock Storage Area to PAG Tailings
11. Flux from Waste Rock Storage Area to TMF Pond
12. Flux from TMF Pond to Waste Rock Storage Area
13. Flux from PAG Tailings to TMF Pond
14. Flux from TMF Pond to PAG Tailings
15. Flux from Non-PAG Tailings to TMF Pond
16. Flux from TMF Pond to Non-PAG Tailings, and
17. Recharge to Tailings Beach.

5.3 RESULTS OF TMF SEEPAGE ASSESSMENT

5.3.1 Results of TMF Seepage and Groundwater Inflow Assessment

Results of a sensitivity analysis (see Section 5.4) indicate that seepage through the TMF foundation displays a strong sensitivity to the hydraulic conductivity of that unit. To address the sensitivity of predicted seepage rates to the presence of a local zone of higher hydraulic conductivity beneath the TMF, the seepage assessment was conducted using:

1. The Base Case model (Model 1), and
2. A revised model that includes a local zone of increased hydraulic conductivity beneath the TMF facility (Model 2).

5.3.1.1 Base Case (Model 1)

Results of the TMF seepage analysis using the Base Case models (Model 1) are presented in Table 5.1 for the five mine effects models. Seepage rates from the TMF are predicted to increase from the start of operations through Year 22. Total seepage from the TMF during Year 22 is predicted to be 31 l/s, of which approximately 16 l/s occurs as seepage flux through the TMF foundation materials (pathway 7) and 15 l/s occurs as seepage flux through the embankment (pathway 8). Estimated seepage rates using the Post-Closure model are slightly lower than those estimated in Year 22 attributed to the lower hydraulic conductivity values associated with tailings consolidation.

As part of the seepage assessment, the mine effects models were used to track groundwater inflow to each of the sub-components/materials in the TMF. The results of the groundwater inflow analysis are also included in Table 5.1 for Model 1. Model results show that groundwater discharge to the TMF from the surrounding groundwater system is expected during all phases of the Casino Project. As the TMF footprint area grows from Year 4 through Year 19, groundwater inflow rates are predicted to increase to a maximum of approximately 35 l/s in Year 19. Post-Year 19, groundwater inflow rates are predicted to decrease slightly corresponding to an increase in supernatant pond elevation.

Table 5.1 Results of TMF Seepage and Groundwater Inflow Analysis (Model 1)

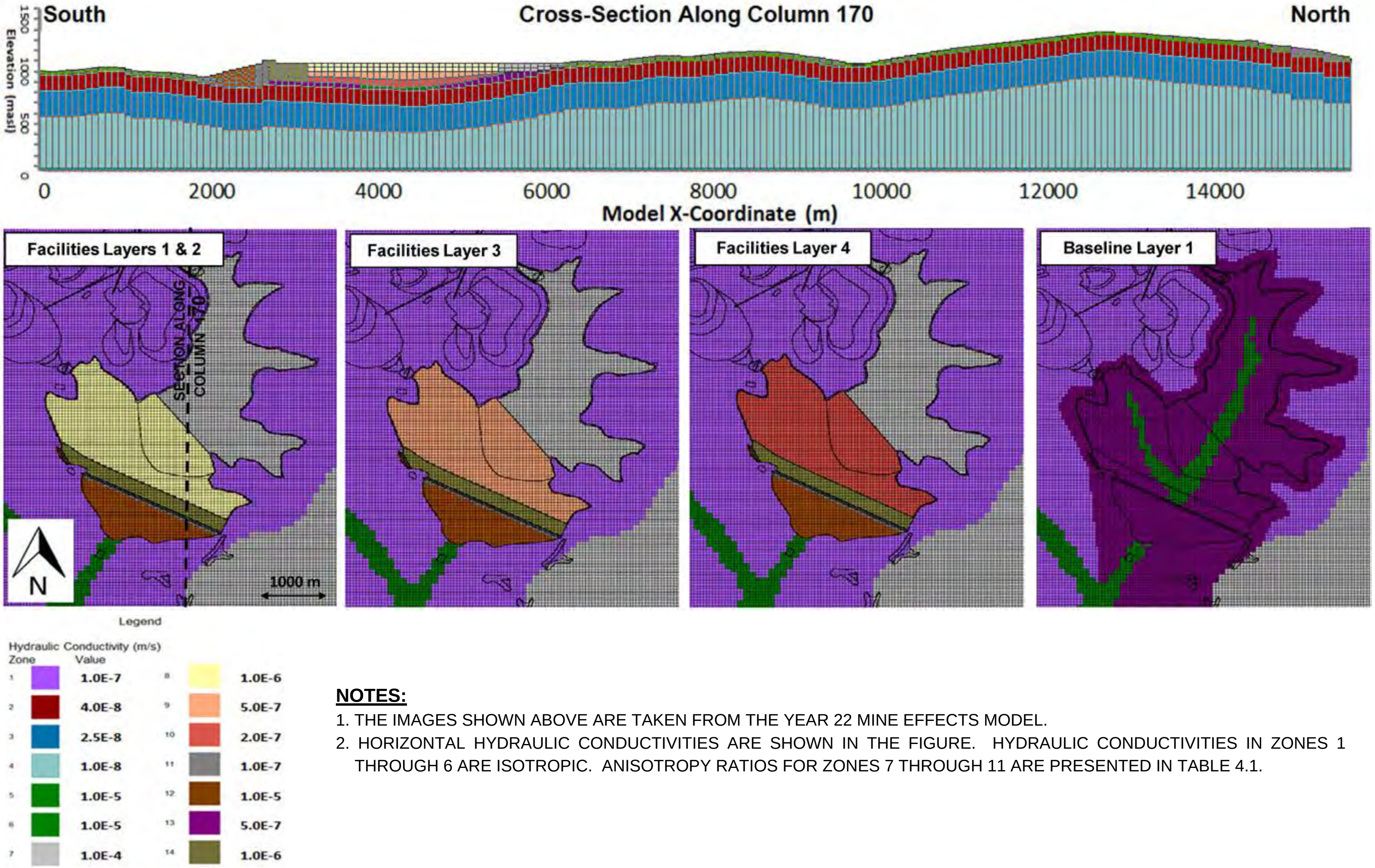
Flux Pathway	Simulated Flux Rates (l/s)				
	Year 4	Year 10	Year 19	Year 22	Post-Closure
(1) Seepage from Waste Rock to the Foundation	0.8	1.3	2.5	2.7	3.1
(2) Groundwater Inflow to Waste Rock from Foundation	20.3	23.3	25.9	22.5	21.0
(3) Seepage from PAG Tailings to the Foundation	0.5	1.1	1.7	1.8	1.9
(4) Groundwater Inflow to PAG Tailings from Foundation	1.1	0.7	0.4	0.3	0.3
(5) Seepage from Non-PAG Tailings to the Foundation	1.7	5.7	10.0	11.3	9.8
(6) Groundwater Inflow to Non-PAG Tailings from Foundation	7.7	8.3	8.8	7.9	5.0
(7) Seepage through Foundation under Embankment	3.0	8.1	14.3	15.8	14.8
(8) Seepage through Embankment	5.9	8.1	15.6	15.4	14.7
(9) Flux from PAG Tailings to Non-PAG Tailings	0.9	0.7	2.8	2.8	4.6
(10) Flux from Waste Rock to PAG Tailings	0.1	0.3	0.5	0.6	0.8
(11) Flux from Waste Rock to TMF Pond	20.1	22.8	25.6	22.0	20.5
(12) Flux from TMF Pond to Waste Rock	0.7	1.1	2.8	2.8	3.3
(13) Flux from PAG Tailings to TMF Pond	0.6	0.8	0.3	0.2	0.2
(14) Flux from TMF Pond to PAG Tailings	0.8	1.5	3.9	3.9	5.7
(15) Flux from Non-PAG Tailings to TMF Pond	5.0	6.0	5.6	4.4	5.2
(16) Flux from TMF Pond to Non-PAG Tailings	1.6	7.5	15.2	16.0	18.1
(17) Recharge to Tailings Beach	2.5	3.3	4.3	4.3	2.1
Total Foundation and Embankment Seepage from TMF	**9**	**16**	**30**	**31**	**29**
Groundwater Inflows	**29**	**32**	**35**	**31**	**26**

NOTES:

1. FLUXES PRESENTED FOR PATHWAYS (1) AND (14) ARE SIGNIFICANTLY LESS THAN 1 LITER PER SECOND AND ARE COMPARABLE IN MAGNITUDE TO THE ERROR ASSOCIATED WITH THE ANALYSIS METHODOLOGY.

5.3.1.2 Revised Model with a Local Zone of Increased Hydraulic Conductivity beneath the TMF Facility (Model 2)

The mine effects Model 2 includes a zone of increased hydraulic conductivity beneath the TMF as shown on Figure 5.3. The local zone of increased hydraulic conductivity was specified within Baseline Layer 1 and was assigned a value of 5E-7 m/s (increased from 1E-7 m/s). The hydraulic conductivity assignment for the remainder of Baseline Layer 1 was unchanged from the baseline model.



NOTES:

1. THE IMAGES SHOWN ABOVE ARE TAKEN FROM THE YEAR 22 MINE EFFECTS MODEL.
2. HORIZONTAL HYDRAULIC CONDUCTIVITIES ARE SHOWN IN THE FIGURE. HYDRAULIC CONDUCTIVITIES IN ZONES 1 THROUGH 6 ARE ISOTROPIC. ANISOTROPY RATIOS FOR ZONES 7 THROUGH 11 ARE PRESENTED IN TABLE 4.1.

Figure 5.3 Mine Effects Model Hydraulic Conductivity Zones (Model 2)

Simulated seepage rates and groundwater inflows from Model 2 are presented in Table 5.2. Total seepage from the TMF during Year 22 is predicted to be 38 l/s, of which approximately 23 l/s occurs as seepage flux through the TMF foundation materials (pathway 7) and 15 l/s occurs as seepage flux through the embankment (pathway 8). Simulated foundation and embankment seepage rates are presented on Figure 5.4 for the operations (Year 4, 10, 19 and 22) and Post-Closure models. Similar to Model 1, groundwater inflow rates are predicted to increase to a maximum of approximately 35 l/s in Year 19 and decrease slightly after Year 19. Groundwater inflow rates (l/s) and unit groundwater inflow rates (l/s/km^2 of TMF area) simulated by each of the Model 2 mine effects models are shown on Figure 5.5.

Based on the available data, Model 2 is considered to be an equally likely representation of Project hydrogeological conditions. Since Model 2 predicts seepage rates that are higher during all phases of the mine life, predictions of TMF seepage and groundwater inflow rates from Model 2 were used to support geochemical source term development, water quantity modelling and water quality modelling as part of the YESAB proposal.

Table 5.2 Results of TMF Seepage and Groundwater Inflow Analysis (Model 2)

Flux Pathway	Simulated Flux Rates (l/s)				
	Year 4	**Year 10**	**Year 19**	**Year 22**	**Post-Closure**
(1) Seepage from Waste Rock to the Foundation	1.2	1.5	3.2	3.4	3.9
(2) Groundwater Inflow to Waste Rock from Foundation	22.4	26.2	26.9	23.4	23.1
(3) Seepage from PAG Tailings to the Foundation	0.7	1.8	3.0	3.0	3.3
(4) Groundwater Inflow to PAG Tailings from Foundation	0.6	0.5	0.3	0.3	0.3
(5) Seepage from Non-PAG Tailings to the Foundation	3.0	9.9	15.6	16.5	14.8
(6) Groundwater Inflow to Non-PAG Tailings from Foundation	7.1	7.9	7.9	6.8	4.6
(7) Seepage through Foundation under Embankment	4.8	13.2	21.7	22.9	22.0
(8) Seepage through Embankment	4.7	7.3	13.3	15.4	14.0
(9) Flux from PAG Tailings to Non-PAG Tailings	1.0	0.8	3.1	3.0	5.1
(10) Flux from Waste Rock to PAG Tailings	0.2	0.3	0.7	0.9	1.1
(11) Flux from Waste Rock to TMF Pond	22.3	26.7	26.8	22.9	22.5
(12) Flux from TMF Pond to Waste Rock	1.2	2.4	3.6	3.7	4.4
(13) Flux from PAG Tailings to TMF Pond	0.4	0.5	0.2	0.2	0.2
(14) Flux from TMF Pond to PAG Tailings	1.2	2.3	5.3	5.1	7.3
(15) Flux from Non-PAG Tailings to TMF Pond	5.1	6.2	5.5	4.3	2.8
(16) Flux from TMF Pond to Non-PAG Tailings	2.1	11.4	19.0	22.0	19.9
(17) Recharge to Tailings Beach	2.5	3.3	4.3	4.3	2.1
Total Foundation and Embankment Seepage from TMF	**9**	**20**	**35**	**38**	**36**
Groundwater Inflows	**30**	**34**	**35**	**30**	**28**

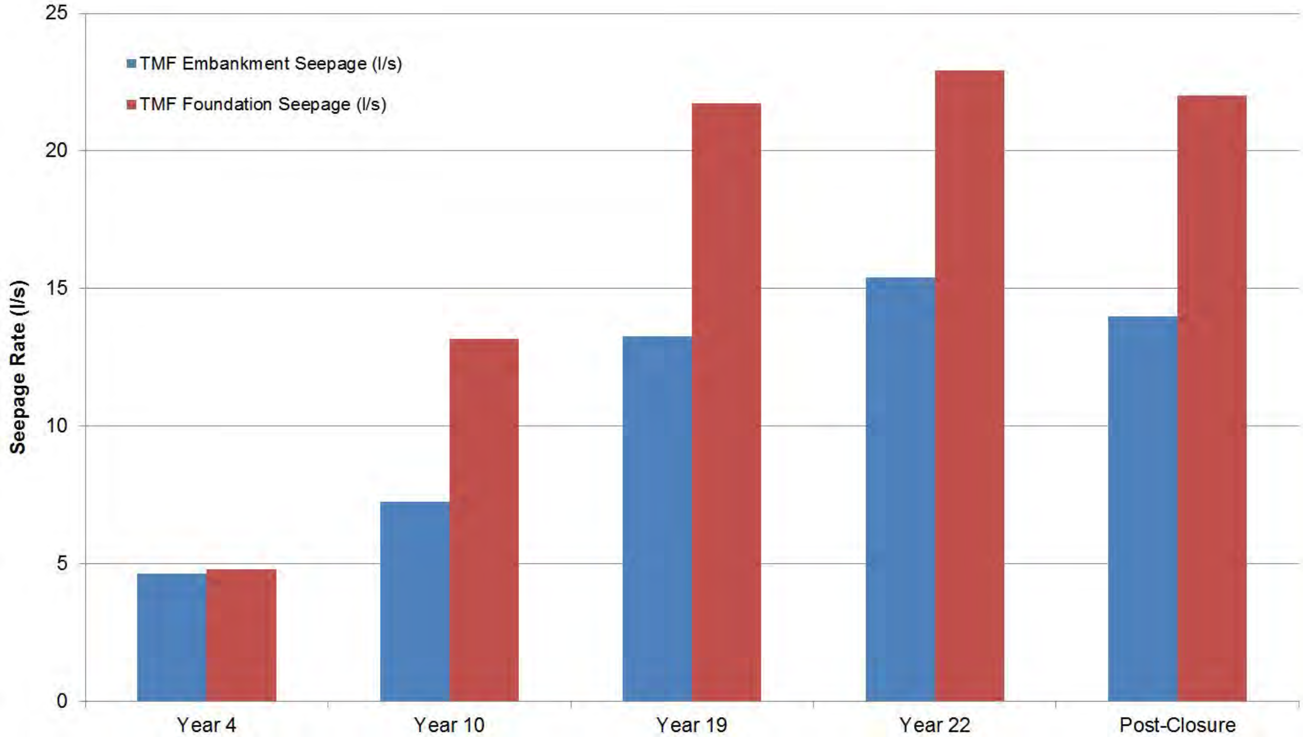
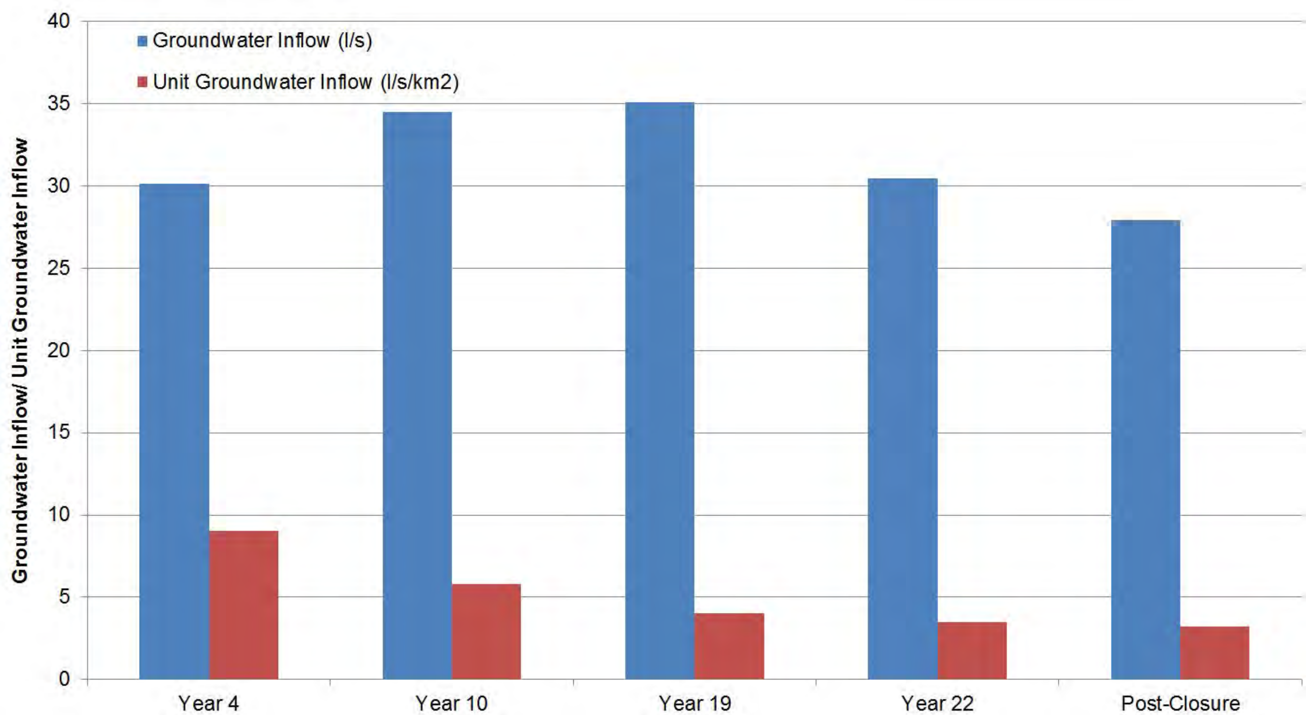


Figure 5.4 Simulated TMF Embankment and Foundation Seepage Rates



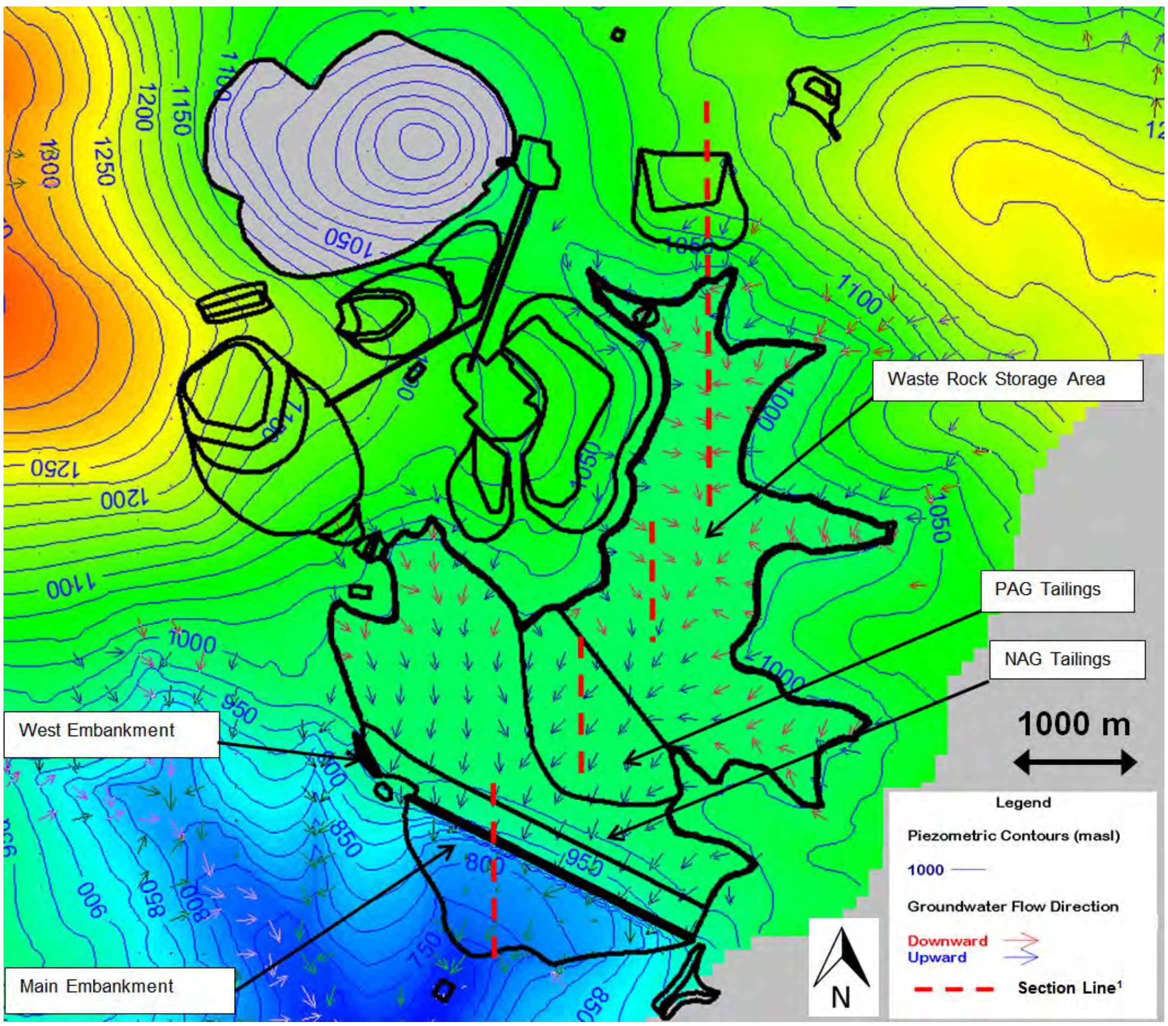
NOTES:

1. GROUNDWATER INFLOW IS CALCULATED AS THE SUM OF TERMS (2), (4), (6) and (8).

Figure 5.5 Simulated Groundwater Inflow to TMF

5.3.2 Predicted TMF Flow Regime

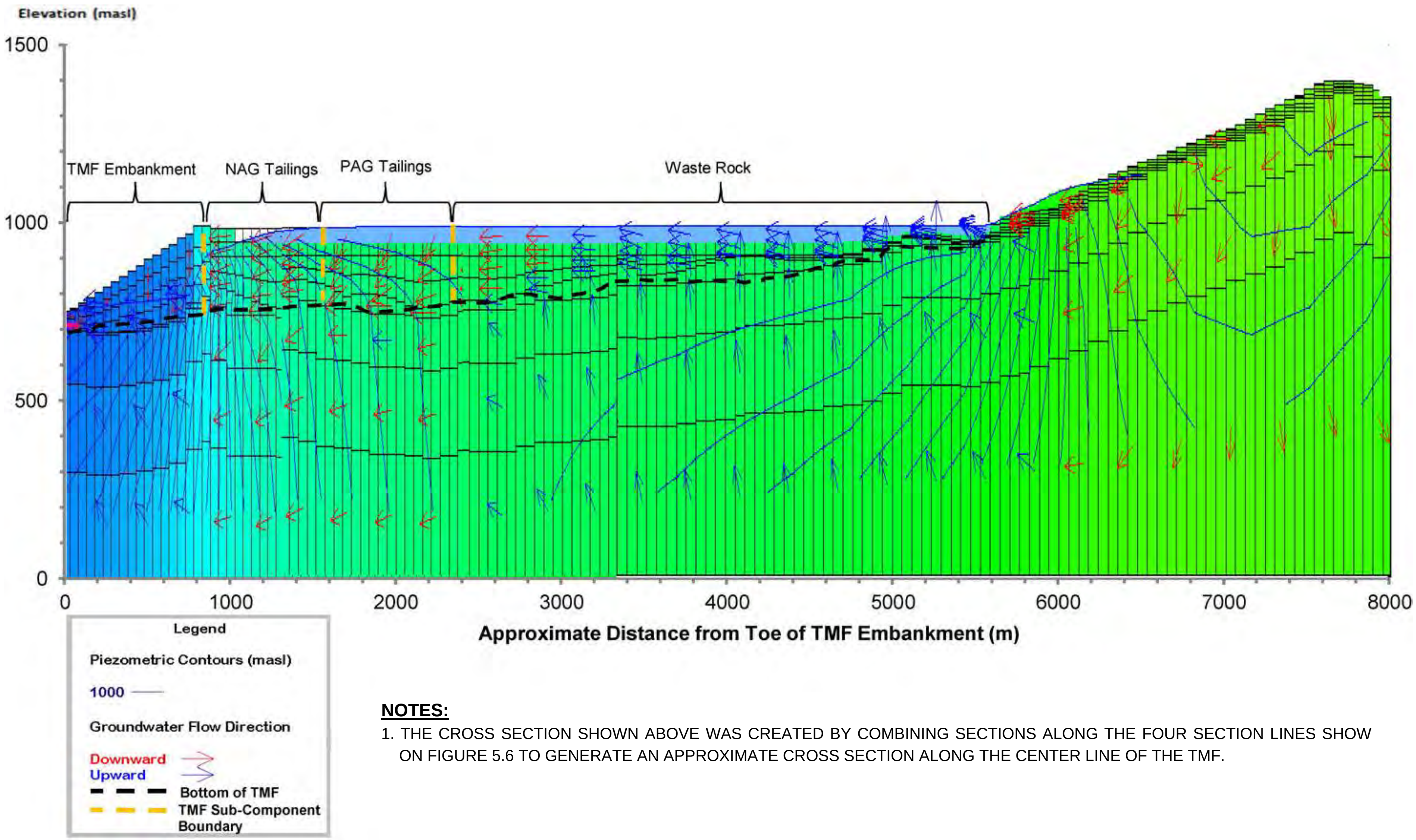
An analysis of the predicted flow regime within the TMF waste rock and tailings materials was completed using results from Post-Closure Model 2. The predicted groundwater flow regime within the TMF is illustrated in plan-view in Figure 5.6 and in cross-sectional view along the approximate centerline of the TMF in Figure 5.7. The cross-section depicting groundwater flow along the approximate facility centerline was created by combining four cross-sections aligned with the model grid at the locations shown on Figure 5.6. Model results indicate that upward vertical hydraulic gradients are predicted throughout the majority of the Waste Rock Storage Area. This upward vertical hydraulic gradient is the result of groundwater flow discharging from the adjacent hillslopes into the valley. Predicted vertical hydraulic gradients within the PAG and Non-PAG tailings are primarily downward. Water from the TMF supernatant pond is predicted to infiltrate the tailings units and flow downward into the foundation material and/or the TMF Embankment.



NOTES:

1. THE CROSS SECTION SHOWN ON FIGURE 5.7 WAS CREATED BY COMBINING FOUR SECTIONS ALONG THE LINES SHOWN ABOVE TO GENERATE AN APPROXIMATE CROSS SECTION ALONG THE CENTER LINE OF THE TMF.

Figure 5.6 Simulated TMF Groundwater Flow (Plan View)



NOTES:

1. THE CROSS SECTION SHOWN ABOVE WAS CREATED BY COMBINING SECTIONS ALONG THE FOUR SECTION LINES SHOW ON FIGURE 5.6 TO GENERATE AN APPROXIMATE CROSS SECTION ALONG THE CENTER LINE OF THE TMF.

Figure 5.7 Simulated TMF Groundwater Flow (Section View)

The flow regime illustrated on Figures 5.6 and 5.7 agrees with the results presented in Table 5.2. In general, upward vertical hydraulic gradients prevail in the waste rock unit where groundwater inflow rates are predicted to be greatest. Similarly, downward vertical hydraulic gradients are present beneath the Non-PAG tailings where TMF seepage rates are greatest.

5.3.3 TMF Seepage through the West Embankment

The Groundwater Vistas HSU package was used along with MODPATH to assess the rate of foundation seepage beneath the TMF West Embankment and through the topographic knob between embankments ("West Embankment foundation seepage"). The West Embankment foundation seepage assessment was conducted using only the Post-Closure model (using Model 2) since the mine plan indicates that the elevation of the supernatant pond is expected to approach the West Embankment only slightly before Year 19 (Appendix A).

To conduct the seepage assessment, MODPATH forward particle tracking was used to delineate the footprint of the TMF from which West Embankment foundation seepage is predicted to originate. A new HSU was then assigned to this delineated area in Baseline Layer 1 to quantify the foundation seepage rate to the base of the facility under the West Embankment.

Simulation results indicate that West Embankment foundation seepage is estimated to be approximately 6% (1.4 l/s) of the total Post-Closure foundation seepage from the TMF. Simulation results indicate that West Embankment foundation seepage originates from the Non-PAG tailings unit and that it discharges primarily to the tributary southwest and downslope of the West Embankment, with lesser portions contributing to Brynelson Creek and Casino Creek.

Seepage through the West Embankment is approximately 5% (0.8 l/s) of the total Post-Closure embankment seepage.

5.3.4 Water Management Pond Seepage Recovery Efficiency

The seepage recovery efficiency of the water management pond downstream of the TMF Main Embankment was estimated using a mass balance calculation taking into consideration predicted seepage through and beneath the Main TMF Embankment seepage and the capacity for groundwater flow through the alluvial deposit beneath the water management pond. As presented in Table 5.2, results of the TMF seepage assessment indicate that seepage through the TMF Main Embankment and foundation at the end of operations (Year 22) is predicted to be 36 l/s (38 l/s total TMF seepage minus the 2 l/s seepage through the TMF West Embankment). The capacity for groundwater flow beneath the water management pond within the Casino Creek valley alluvium was determined using a Darcy flow calculation to be 3 l/s. The Darcy calculation used a hydraulic conductivity for the alluvial deposit of 1E-5 m/s, an average height of alluvial sediments of 20 m, a width of the alluvial sediments of 250 m, and a hydraulic gradient of 0.05 m/m.

Based on a comparison of the Main Embankment seepage with the capacity of groundwater flow in the alluvium beneath the water management pond, approximately 90-95% of the TMF seepage is predicted to be recovered by the water management pond. Calculation of this recovery efficiency assumes that the pond is maintained with as low of a water level as possible. The remaining 5-10% of TMF seepage is predicted to bypass the pond and discharge further downstream to Casino Creek. A MODPATH particle tracking analysis was not used for the analysis due to the sensitivity of simulated results to the MODPATH-input sink strength that controls termination criterion for particle flow paths.

5.4 SENSITIVITY ANALYSIS

5.4.1 Hydraulic Conductivity of TMF Sub-Components

A sensitivity analysis was conducted to assess the sensitivity of simulated seepage rates to hydraulic conductivity values assigned to TMF sub-components. The analysis was conducted using the Post-Closure Model 2 and by systematically varying the hydraulic conductivity value assigned to the tailings, waste rock, TMF Embankments, and underlying foundation materials. For each sensitivity simulation, a single hydraulic parameter was modified from the base case value by an order of magnitude to evaluate the corresponding effect on TMF seepage rates. Model sensitivity to the following parameters was assessed by increasing and decreasing the Model 2 base case value by an order of magnitude:

- Hydraulic conductivity of PAG and Non-PAG tailings
- Hydraulic conductivity of the TMF Embankment core
- Hydraulic conductivity of the underlying foundation materials (Baseline Layer 1), and
- Hydraulic conductivity of Waste Rock Storage Area.

Plots showing the predicted TMF Embankment and foundation seepage rates for each sensitivity analysis are provided in Appendix C. As a reminder, base case Model 2 estimates of Post-Closure foundation seepage and embankment seepage are 22 l/s and 14 l/s, respectively, and total seepage is 36 l/s (Table 5.2). Results of the sensitivity analysis demonstrate that:

- Increasing the hydraulic conductivity of the PAG and Non-PAG tailings units by an order of magnitude increases the embankment and foundation seepage rates by approximately 50% to 32 l/s and 22 l/s, respectively (Figure C.1). The increased seepage rate is primarily contributed from the Non-PAG tailings unit and is accompanied by a slight decrease in foundation seepage rates from the PAG tailings and Waste Rock units. The opposing change in magnitude of the simulated seepage rates from the PAG and Non-PAG tailings units is attributed to a downstream shift in the simulated extent of upwelling within the TMF (a downward vertical hydraulic gradient between the PAG tailings and foundation units is present over a larger portion of the PAG tailings). Decreasing the hydraulic conductivity of the tailings units results in a greater portion of foundation seepage originating from the Waste Rock unit and less from the tailings units. The hydraulic conductivity of the consolidating and consolidated tailings units were varied as part of this analysis and the hydraulic conductivity value assigned to the beach unit remained unchanged.
- Both foundation and embankment seepage rates are sensitive to change of TMF Embankment core hydraulic conductivity (Figure C.2). Increasing the hydraulic conductivity of the embankment core by an order of magnitude (from 1E-7 m/s) increases embankment seepage by approximately 50% (to 22 l/s), while a decrease in hydraulic conductivity results in about a 70% decrease in embankment seepage (to 4 l/s). Simulated foundation seepage rates also double for an order of magnitude increase in embankment core hydraulic conductivity and exhibit a slight decrease (<2 l/s) for an order of magnitude decrease in hydraulic conductivity value.
- Foundation seepage predictions display a strong sensitivity to the hydraulic conductivity of the foundation materials beneath the TMF. Increasing the hydraulic conductivity of the foundation

materials by an order of magnitude (to 5E-6 m/s) increases foundation seepage by almost 300% (to 84 l/s); decreasing the value results in an estimated foundation seepage rate of 14 l/s. The upper value of hydraulic conductivity used in this sensitivity assessment is greater than the range of expected values for foundation materials. The hydraulic conductivity assigned to the foundation materials in Model 2 is five times greater than the value assigned in Model 1, and results in a 35% increase in foundation seepage. The simulated embankment seepage decreases slightly with an order of magnitude increase or decrease in foundation hydraulic conductivity.

- Predicted foundation and embankment seepage rates are not sensitive to the value of hydraulic conductivity of the waste rock unit within the expected range of hydraulic conductivity values. Increasing/decreasing the hydraulic conductivity of the waste rock by an order of magnitude results in no noticeable change to foundation or embankment seepage rates.

The hydraulic conductivity of TMF sub-components has implications for seepage rates as well as the flow regime between TMF sub-components and the foundation. Seepage results display a strong sensitivity to the value of foundation hydraulic conductivity. The sensitivity to foundation material hydraulic conductivity has been addressed in this study by adopting predicted seepage rates from Model 2, a model that includes a local zone of increased hydraulic conductivity beneath the TMF.

5.4.2 Post-Closure Tailings Cover over the Waste Rock Storage Area

A sensitivity analysis was conducted to assess the sensitivity of simulated Post-Closure seepage rates to explicitly including a proposed tailings cover over the Waste Rock Storage Area in the model. The proposed 3 m tailings cover was represented in the Post-Closure mine effects model by decreasing the conductance of the river cells representing the supernatant pond over the waste rock. Conductance values were calculated by multiplying RIV cell dimensions by the vertical hydraulic conductivity of the tailings (1E-7 m/s) and specifying a riverbed thickness of 3 m. Simulation results indicate that including the tailings cover in the model provides only a slight reduction (<10%) in groundwater inflow to waste rock unit from the surrounding foundation materials and in flux from the waste rock units to the TMF supernatant pond. The remainder of the seepage fluxes between TMF sub-components did not noticeably change.

6 – ORE STOCKPILE MODPATH PARTICLE TRACKING

To characterize potential seepage pathways from the proposed ore stockpiles, MODPATH particle tracking was implemented to delineate pathways and estimate seepage travel times from five stockpile locations. MODPATH analysis was completed using the mine effects models with stockpiles present, which were the Year 4, 10 and 19 models, and was conducted using mine effects Model 2. The following stockpiles were included in the analysis:

- Gold Ore Stockpile
- Marginal Grade Ore Stockpile
- Low Grade Supergene Sulfide Ore Stockpile
- Low Grade Supergene Oxide Ore Stockpile, and
- Supergene Oxide & Low Grade Hypogene Ore Stockpiles.

MODPATH combined with end point analysis was used to determine the discharge location of potential seepage from each stockpile. Endpoint analysis allows the user to identify steady-state flow lines that terminate (discharge) at a cell along the model boundary. The MODPATH simulation can be used to calculate approximate groundwater travel times along the seepage pathways by taking into consideration an assumed effective porosity. Effective porosities of 0.1% (0.001) for weathered bedrock, 0.01% (0.0001) for unweathered bedrock and 15% (0.15) for alluvial material were specified for the MODPATH velocity calculations. Travel times are representative of advective transport and do not include effects from dispersion or diffusion.

MODPATH results are sensitive to specification of the “sink strength” input parameter, which defines the termination criterion for particle traces flowing through boundary cells. All MODPATH scenarios presented herein adopt a “stop at 50 percent strength” weak sink option to discontinue particle traces in boundary cells, meaning that the particle trace stops if the boundary condition removes 50 percent or more of the water in the cell. Conceptually this means that the model terminates a particle trace in a cell if >50% of the water in the cell is removed.

The results of the MODPATH stockpile analysis are summarized in Table 6.1 and include seepage discharge locations and approximate travel times. The simulated MODPATH seepage pathways for each of the stockpiles are provided in Appendix D. Results of the endpoint analysis and estimated travel times for peak concentrations to reach a discharge location (shown in parentheses assuming that the average travel time is representative of travel time of peak concentration) indicate that:

- Seepage through the Gold Ore Stockpile is predicted to discharge to the Open Pit (3 years) and TMF Supernatant Pond (1 year),
- Seepage through the Marginal Ore Stockpile is predicted to discharge to the Open Pit (<1 year),
- Seepage through the Low Grade Supergene Sulfide Ore Stockpile is predicted to discharge to the Open Pit (2 years) and TMF Supernatant Pond (28 years),
- Seepage through the Low Grade Supergene Oxide Ore Stockpile is predicted to discharge to the TMF Supernatant Pond (1 year), TMF Embankment drains (5 years) and the TMF Water Management Pond (27 years), and
- Seepage through the Supergene Oxide & Low Grade Hypogene Ore Stockpile is predicted to discharge to the Open Pit (2 years), TMF Supernatant Pond (1 year), TMF Embankment drains (8 years) and the TMF Water Management Pond (15 years).

Model results further indicate that travel times for stockpile seepage to reach the TMF Supernatant Pond, assuming advective transport, will range from less than 1 year to approximately 70 years. Advective seepage from the stockpiles is predicted to reach the TMF Water Management Pond between 12 years and 40 years. Based on the Year 19 mine build-out, approximately 10% of the seepage from the Low Grade Supergene Oxide Ore Stockpile is predicted to reach the TMF Water Management Pond. Similarly, approximately 1% of seepage from the Supergene Oxide & Low Grade Hypogene Ore Stockpile is predicted to reach the TMF Water Management Pond.

Table 6.1 Results of MODPATH Stockpile Particle Tracking and Advective Travel Times

Stockpile I.D. MODPATH Discharge Location	Percent of Total Seepage Discharge (%)			Travel Time to Discharge Location (Years)[1]			
	Year 4	Year 10	Year 19	Average	Median	Minimum	Maximum
Gold Ore Stockpile	-	-	-	-	-	-	-
Open Pit	15%	20%	20%	3.1	2.8	1.3	7.3
TMF Supernatant Pond	85%	80%	80%	0.8	0.5	0.1	4.7
Marginal Grade Ore Stockpile	-	-	-	-	-	-	-
Open Pit	100%	100%	100%	0.6	0.4	0.2	2.6
Low Grade Supergene Sulfide Ore Stockpile	-	-	-	-	-	-	-
Open Pit	95%	95%	100%	1.9	1.1	0.3	8.7
TMF Supernatant Pond[2]	5%	5%	0%	28	24	4.6	71
Low Grade Supergene Oxide Ore Stockpile	-	-	-	-	-	-	-
TMF Supernatant Pond	70%	70%	65%	0.9	0.4	0.1	27
TMF Embankment Drains	30%	30%	25%	5.4	3.2	1.9	18
TMF Water Management Pond	0%	0%	10%	27	27	16	40
Supergene Oxide & Low Grade Hypogene Ore Stockpile	-	-	-	-	-	-	-
Open Pit	5%	4%	3%	2.2	1.9	1.2	4.9
TMF Supernatant Pond	95%	95%	95%	0.8	0.3	<0.1	11
TMF Embankment Drains	0%	1%	1%	8.3	8.5	6.3	10
TMF Water Management Pond	0%	0%	1%	15	13	12	20

NOTES:

1. APPROXIMATE SEEPAGE TRAVEL TIMES FROM THE STOCKPILES TO THE DISCHARGE LOCATIONS WERE CALCULATED USING AN ASSUMED EFFECTIVE POROSITY OF 0.1% (0.001) FOR WEATHERED BEDROCK, 0.01% (0.0001) FOR UNWEATHERED BEDROCK AND 15% (0.15) FOR ALLUVIAL MATERIALS.
2. TRAVEL TIMES ARE PROVIDED FOR THE YEAR 10 MINE EFFECTS MODEL. ALL OTHER TRAVEL TIMES ARE PROVIDED FOR YEAR 19.
3. TRAVEL TIMES ARE BASED ON ADVECTIVE TRAVEL ONLY AND DISREGARD THE EFFECTS OF DISPERSION AND DIFFUSION.

7 – CONCLUSION

A steady-state baseline numerical groundwater model was developed for the Casino Project to provide a representation of baseline groundwater conditions and to serve as a basis from which to evaluate potential effects of the Project on hydrogeological conditions. The steady-state baseline model was calibrated to average annual hydrogeologic conditions. The calibrated baseline model was then modified to create five steady-state mine effects models representing five key phases of Project development. Major proposed mine facilities were represented in the mine effects models, including the Heap Leach Facility, Open Pit, TMF and Ore Stockpiles. The TMF was explicitly constructed in three-dimensions within the model grid, including the definition of three distinct types of tailings and waste rock materials, thereby allowing a detailed TMF seepage assessment to be conducted.

Results of mine effects modelling indicate that simulated groundwater inflow rates to and water table drawdown surrounding the proposed Open Pit during operational dewatering are expected to increase from the start of operations through Year 19 as the pit increases in size and depth. Model results predict that groundwater inflow is expected to reach a maximum of approximately 35 l/s during Year 19 when the Open Pit is largest. During closure, groundwater elevations directly surrounding the Pit Lake are expected to recover to the elevation of the Pit Lake water surface. Groundwater inflow to and seepage from the Pit Lake during Post-Closure when the Pit Lake is at its maximum elevation are expected to be approximately 12 l/s. Model results indicate that groundwater seepage from the Pit Lake is expected to contribute to Casino Creek watershed.

The mine effects models were used to estimate groundwater inflow rates into and seepage rates from and between various sub-components of the TMF. Model results predict that TMF seepage rates are expected to increase from the start of operations through Year 22. Total seepage from the TMF during Year 22 is predicted to be 38 l/s, of which approximately 23 l/s occurs as seepage flux through the TMF foundation materials and 15 l/s occurs as seepage flux through the embankment. Seepage rates estimated using the Post-Closure model are slightly lower than those estimated in Year 22 attributed to the lower hydraulic conductivity values associated with tailings consolidation. Simulated groundwater discharge to the TMF from the surrounding groundwater system is expected to increase to a maximum of approximately 35 l/s in Year 19. Post-Year 19, groundwater inflow rates are predicted to decrease slightly corresponding to an increase in supernatant pond elevation.

A seepage analysis was conducted to assess pathways of potential seepage originating from the five proposed ore stockpiles. Results are presented showing the estimated groundwater seepage pathways from each stockpile, the discharge location of seepage pathways and seepage travel times.

The results of baseline and mine-effects numerical groundwater models were used to inform water balance modelling, water quality modelling and geochemical source term development conducted as part of the YESAB proposal. The numerical models presented in this report provide a foundation that should be updated as new data are collected. Additional head and streamflow data will help refine baseline model calibration and will improve model defensibility as a tool for making predictions of mine effects on hydrogeological conditions.

8 – REFERENCES

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000. MODFLOW-2000, the U.S. Geological Survey modular ground-water model -- User guide to modularization concepts and the Ground-Water Flow Process: U.S. Geological Survey Open-File Report 00-92, 121 pp.

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KPL, 2013c. Casino Copper-Gold Project. Baseline and Mine Operations Watershed Model, Casino Project (Ref. No. VA13-01614).

KPL, 2013d. Casino Copper-Gold Project. 2013 Baseline Hydrology Report (Ref. No. VA101-325/14-5).

KPL, 2013e. Casino Copper-Gold Project. Baseline Climate Report (Ref. No. VA101-325/14-7).

Pollock, D.W., 1994. User's Guide for MODPATH/MODPATH-PLOT, Version 3: A particle tracking post-processing package for MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model: U.S. Geological Survey Open-File Report 94-464, 6 ch.

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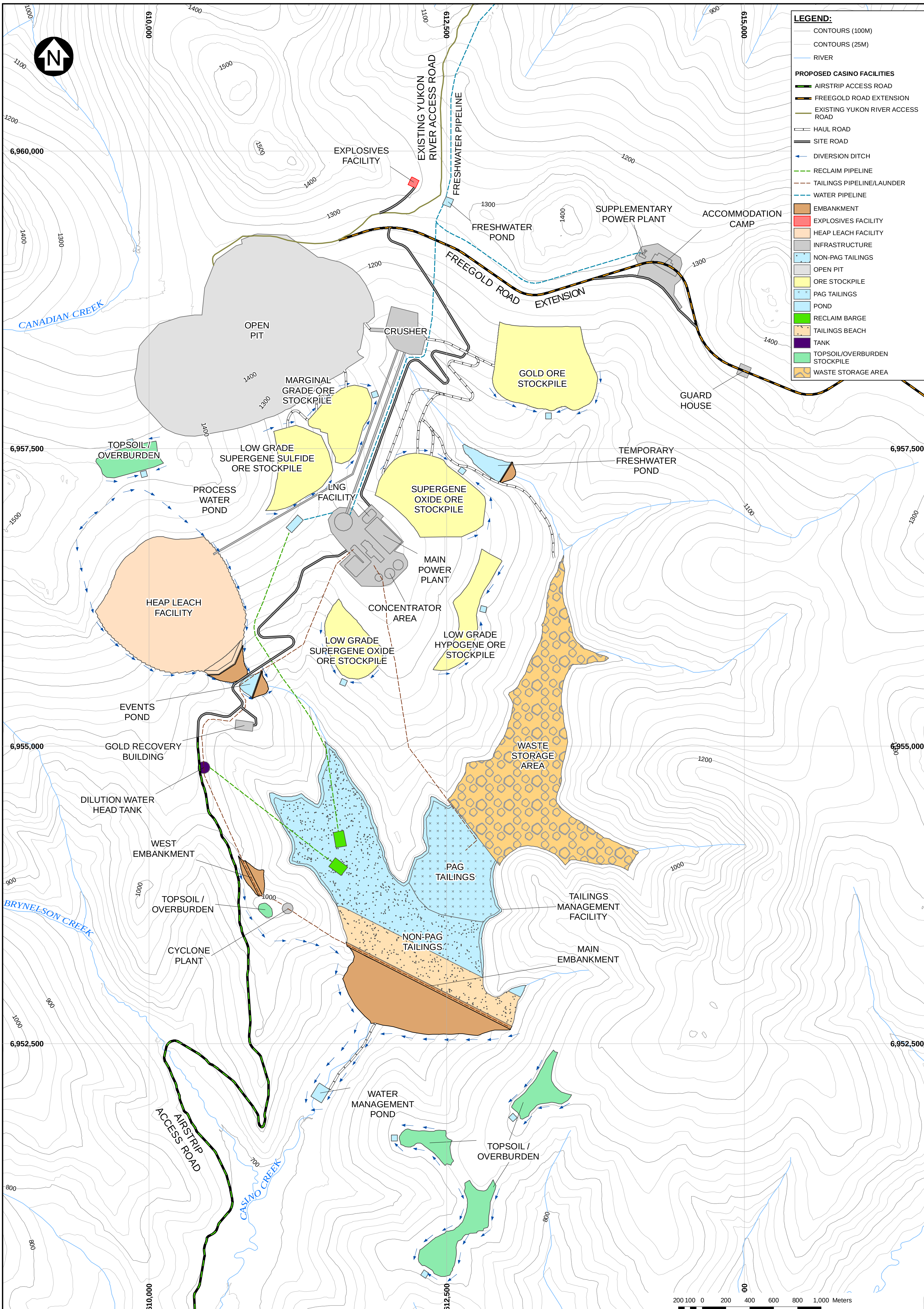
APPENDIX A

STAGED GENERAL ARRANGEMENT FIGURES AND TAILINGS MANAGEMENT FACILITY DESIGNS

(Pages A-1 to A-5)



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NOTES:

1. BASE MAP: RIVERS FROM CANVEC, CONTOURS FROM EAGLE MAPPING.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:30,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTOUR INTERVAL IS 25 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	18DEC'13	ISSUED WITH REPORT	CC	CC	CAS	KJB

CASINO MINING CORPORATION

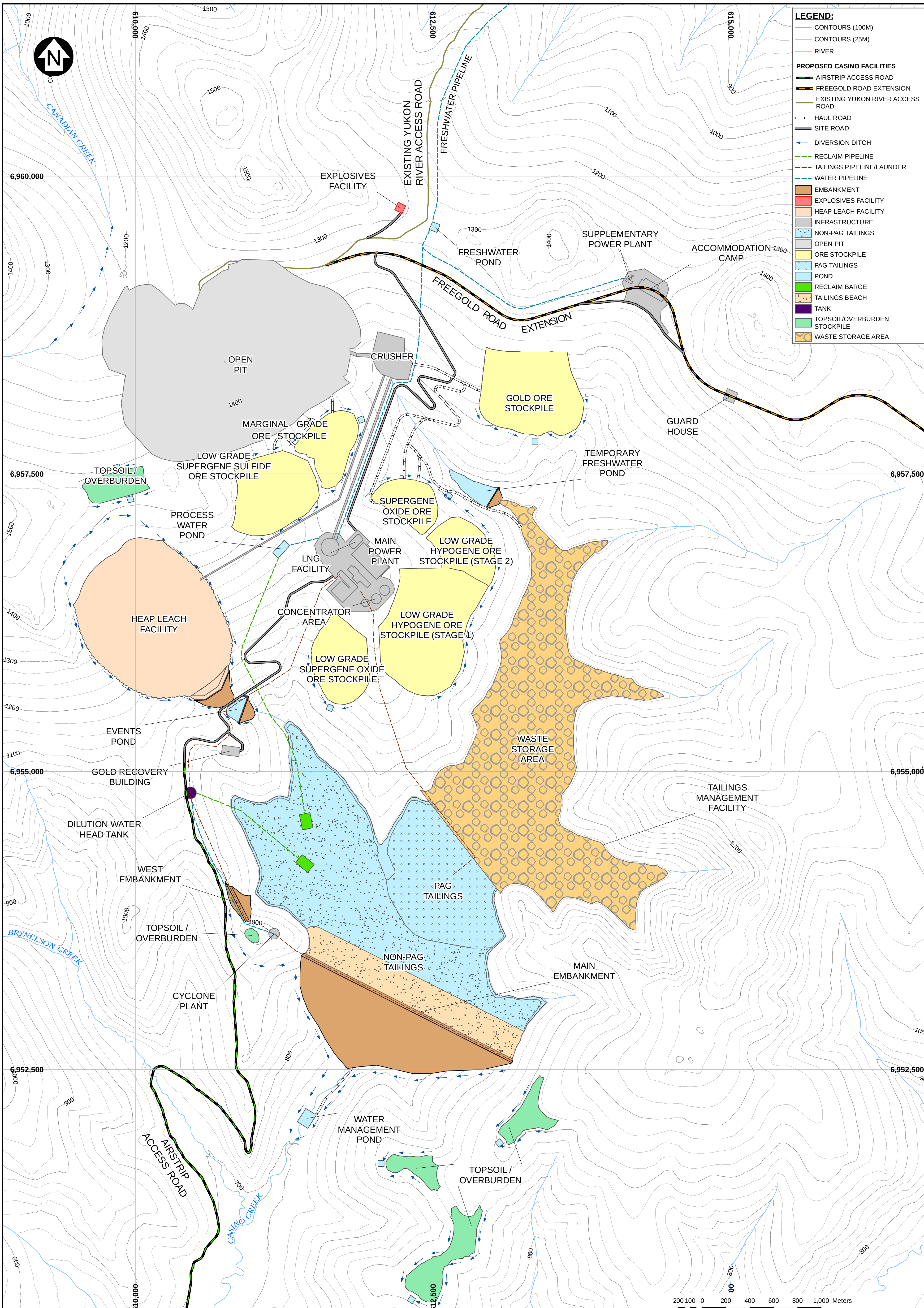
CASINO PROJECT

GENERAL ARRANGEMENT (YEAR 4)

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-325/14	6

FIGURE A.1 REV 1



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NOTES:

1. BASE MAP: RIVERS FROM CANVEC, CONTOURS FROM EAGLE MAPPING.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:30,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTOUR INTERVAL IS 25 METRES.

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GENERAL ARRANGEMENT (YEAR 10)

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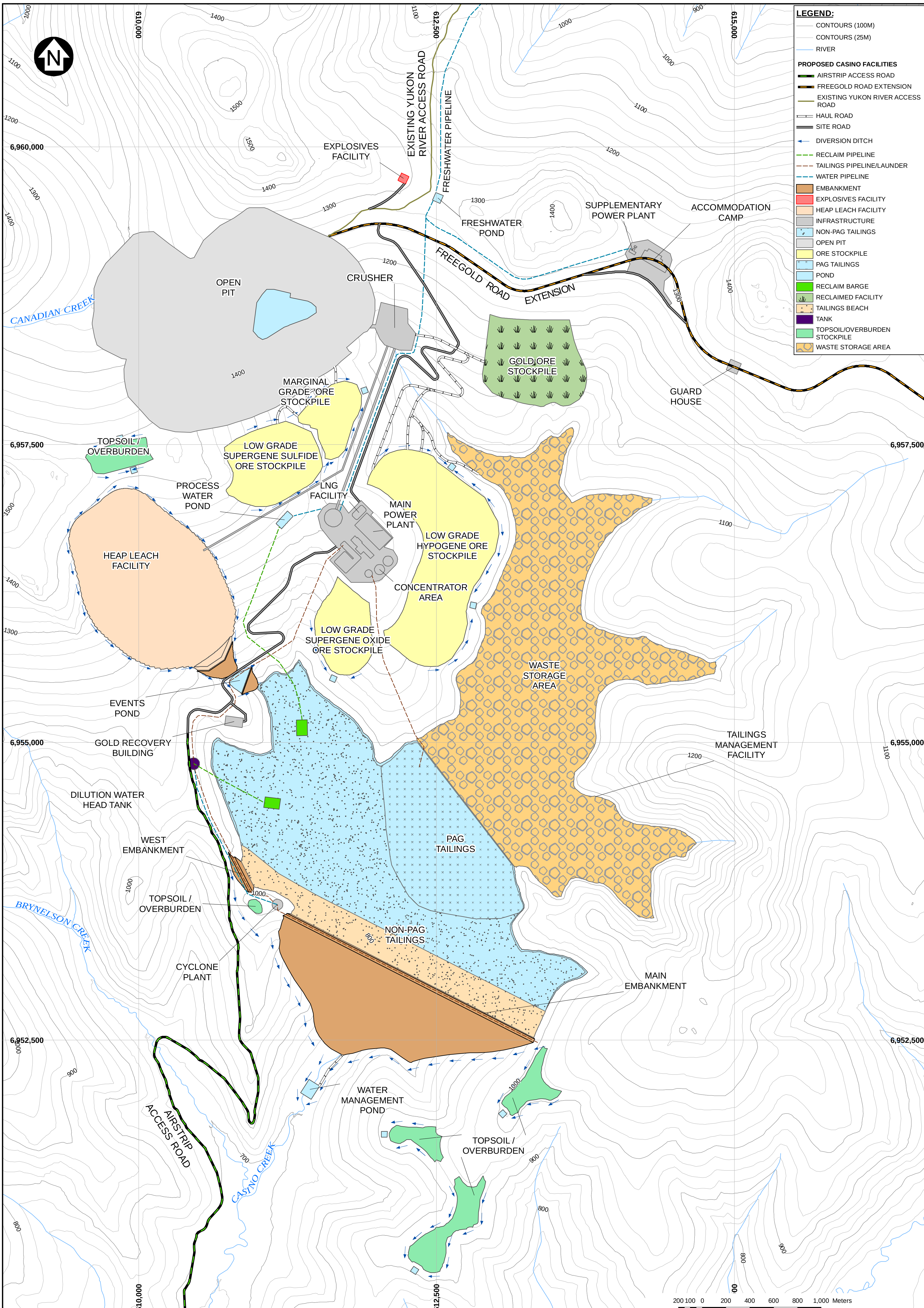
P/A NO.	REF NO.
VA101-325/14	6

FIGURE A.2 REV 1



NOTES:

1. BASE MAP: RIVERS FROM CANVEC, CONTOURS FROM EAGLE MAPPING.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:30,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTOUR INTERVAL IS 25 METRES.

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GENERAL ARRANGEMENT (YEAR 19)

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-325/14	6

FIGURE A.3 REV 1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
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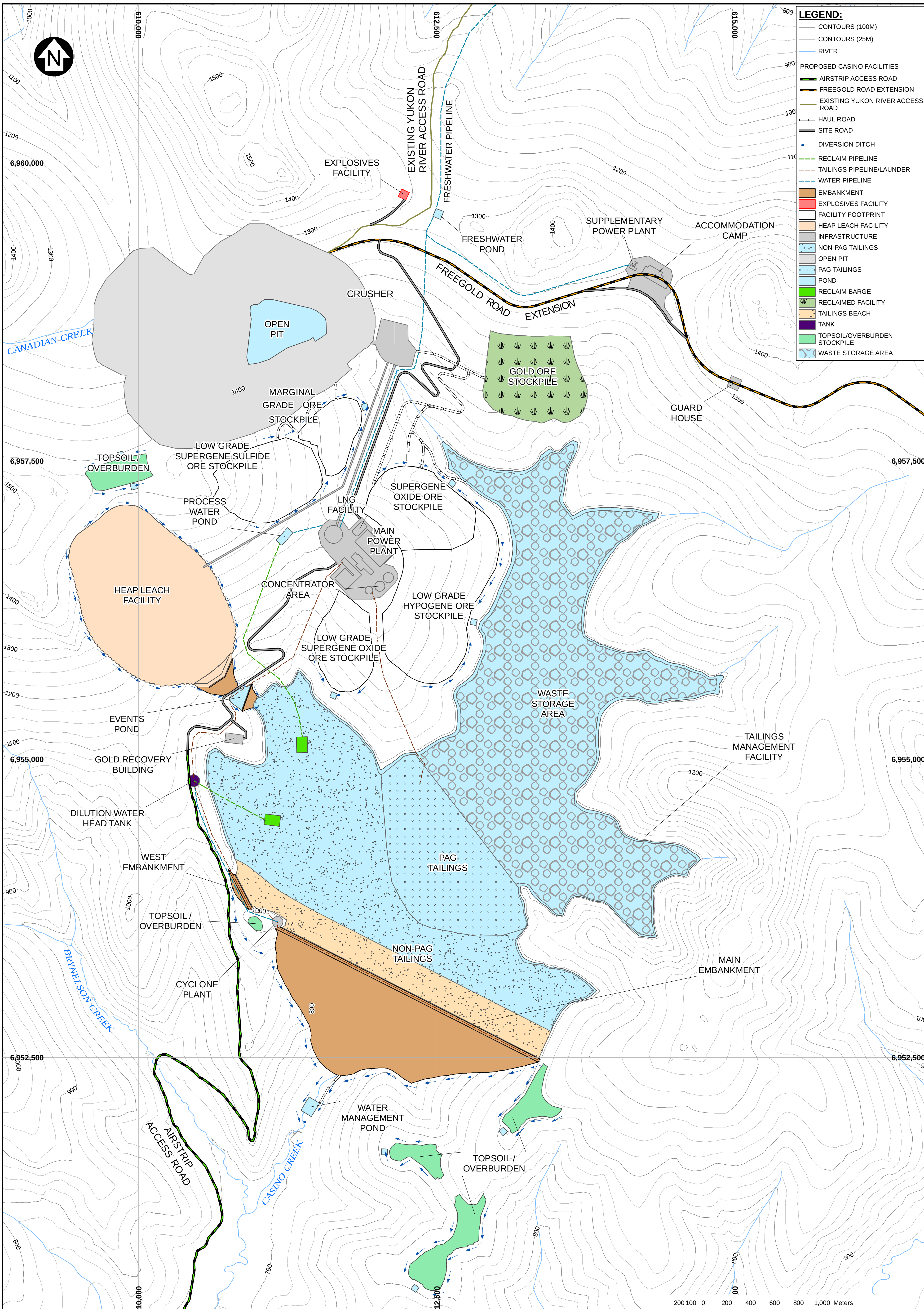

NOTES:

1. BASE MAP: RIVERS FROM CANVEC, CONTOURS FROM EAGLE MAPPING.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:30,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTOUR INTERVAL IS 25 METRES.

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GENERAL ARRANGEMENT (YEAR 22)

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-325/14	6

FIGURE A.4 REV 1

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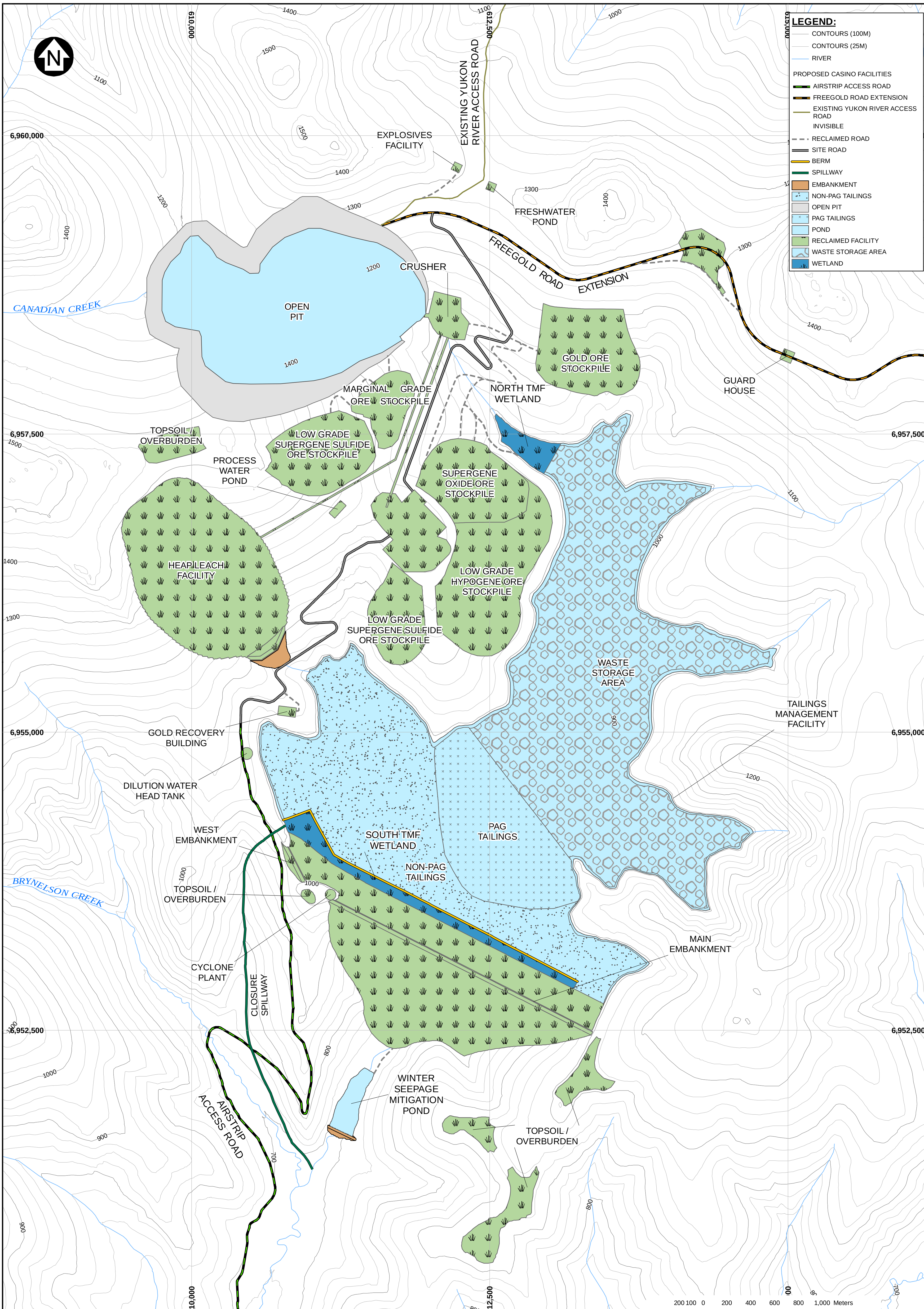

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NOTES:

1. BASE MAP: RIVERS FROM CANVEC, CONTOURS FROM EAGLE MAPPING.

2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.

3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:30,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

4. CONTOUR INTERVAL IS 25 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	18DEC'13	ISSUED WITH REPORT	CC	CC	CAS	KJB

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CASINO PROJECT

GENERAL ARRANGEMENT (POST-CLOSURE)

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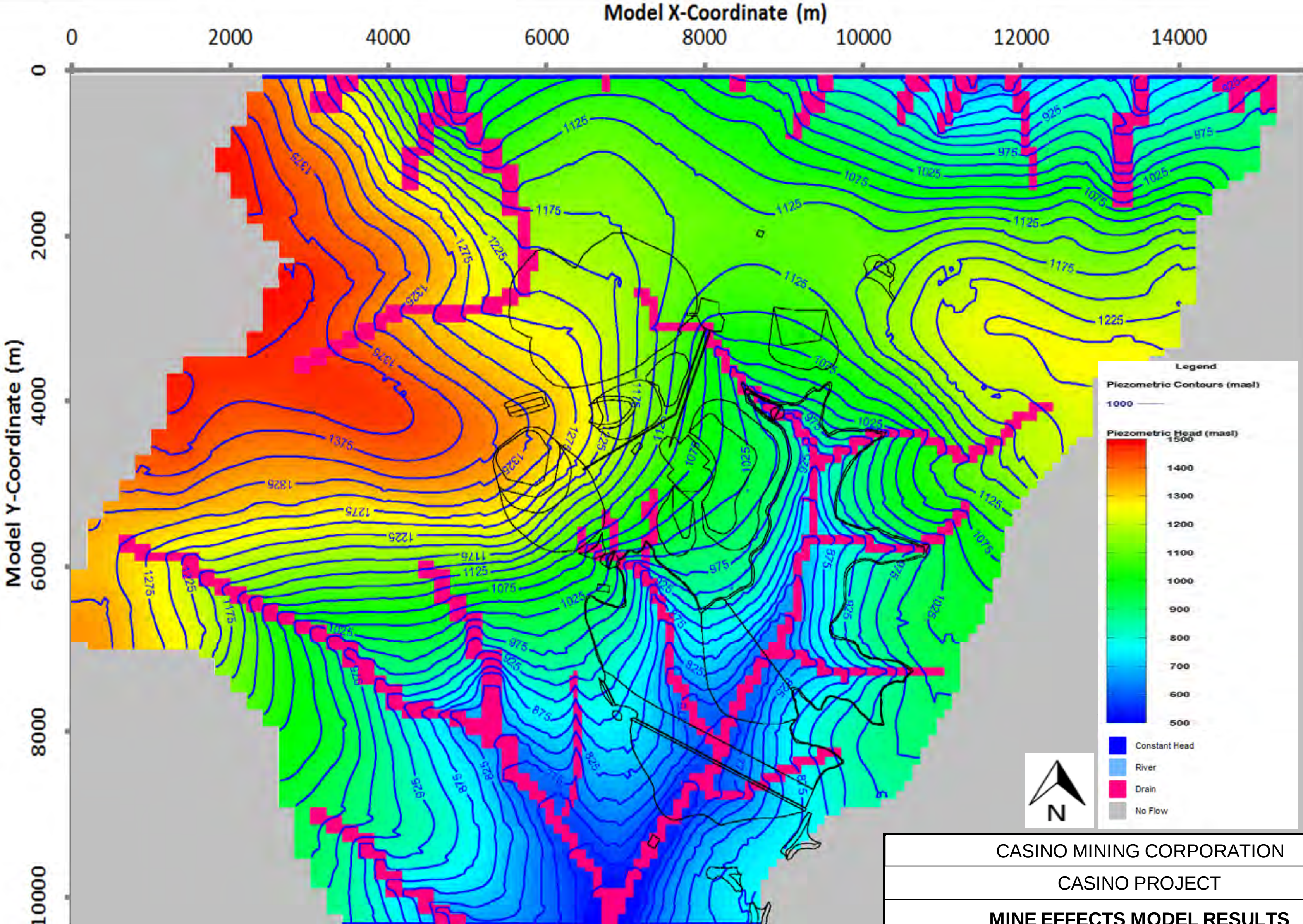
P/A NO. VA101-325/14 | REF NO. 6

FIGURE A-5 REV 1

APPENDIX B

MINE EFFECTS MODEL RESULTS: SIMULATED WATER TABLE CONTOURS

(Pages B-1 to B-6)



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CASINO PROJECT

MINE EFFECTS MODEL RESULTS
SIMULATED WATER TABLE CONTOURS:
PRE-DEVELOPMENT

Knight Piésold
CONSULTING

P/A NO.	REF. NO.
VA101-325/14	6

FIGURE B.1 REV 0

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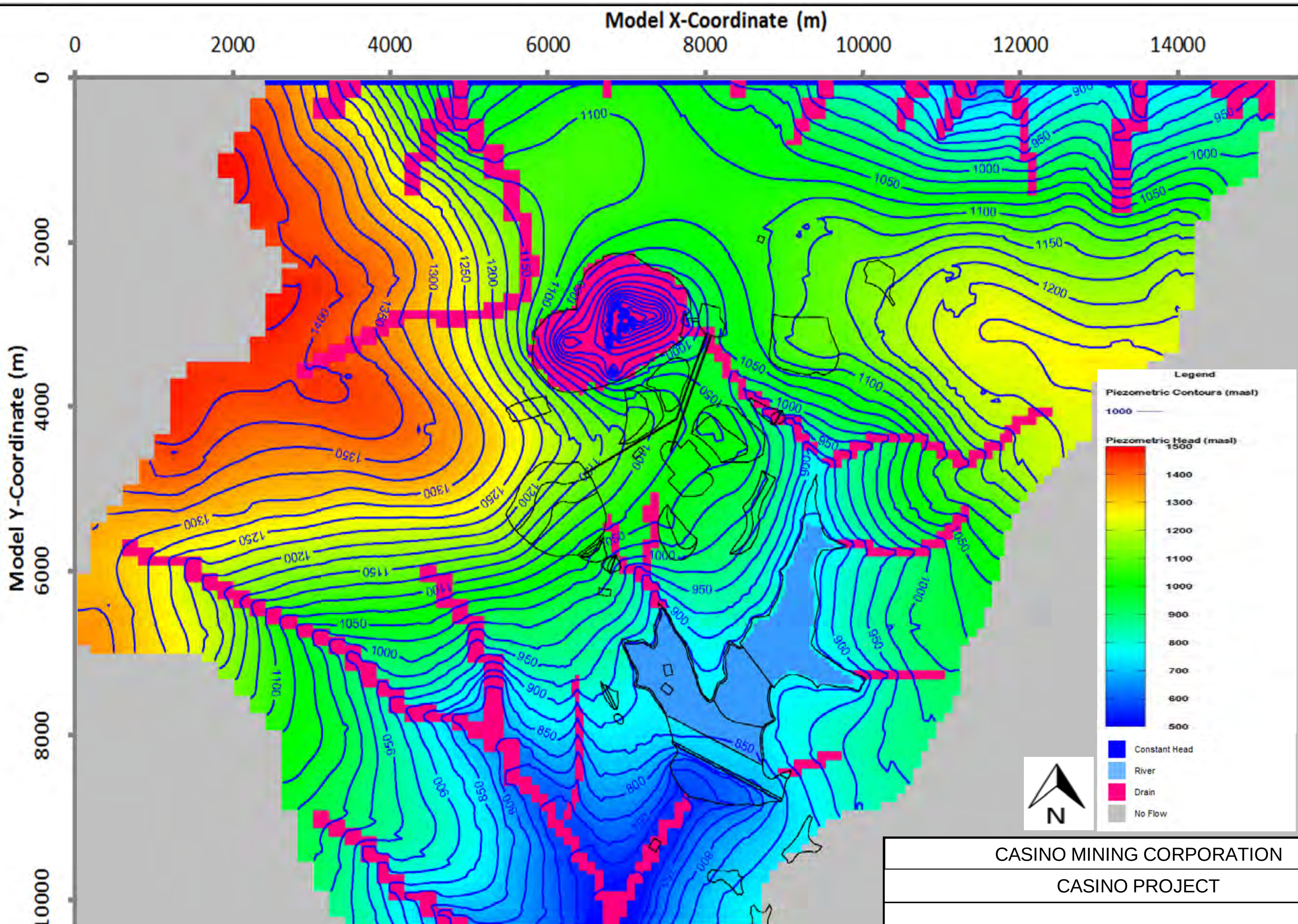

CASINO MINING CORPORATION
CASINO PROJECT
MINE EFFECTS MODEL RESULTS **SIMULATED WATER TABLE CONTOURS: YEAR 4**

Knight Piésold CONSULTING	P/A NO. VA101-325/14	REF. NO. 6
	FIGURE B.2	REV 0

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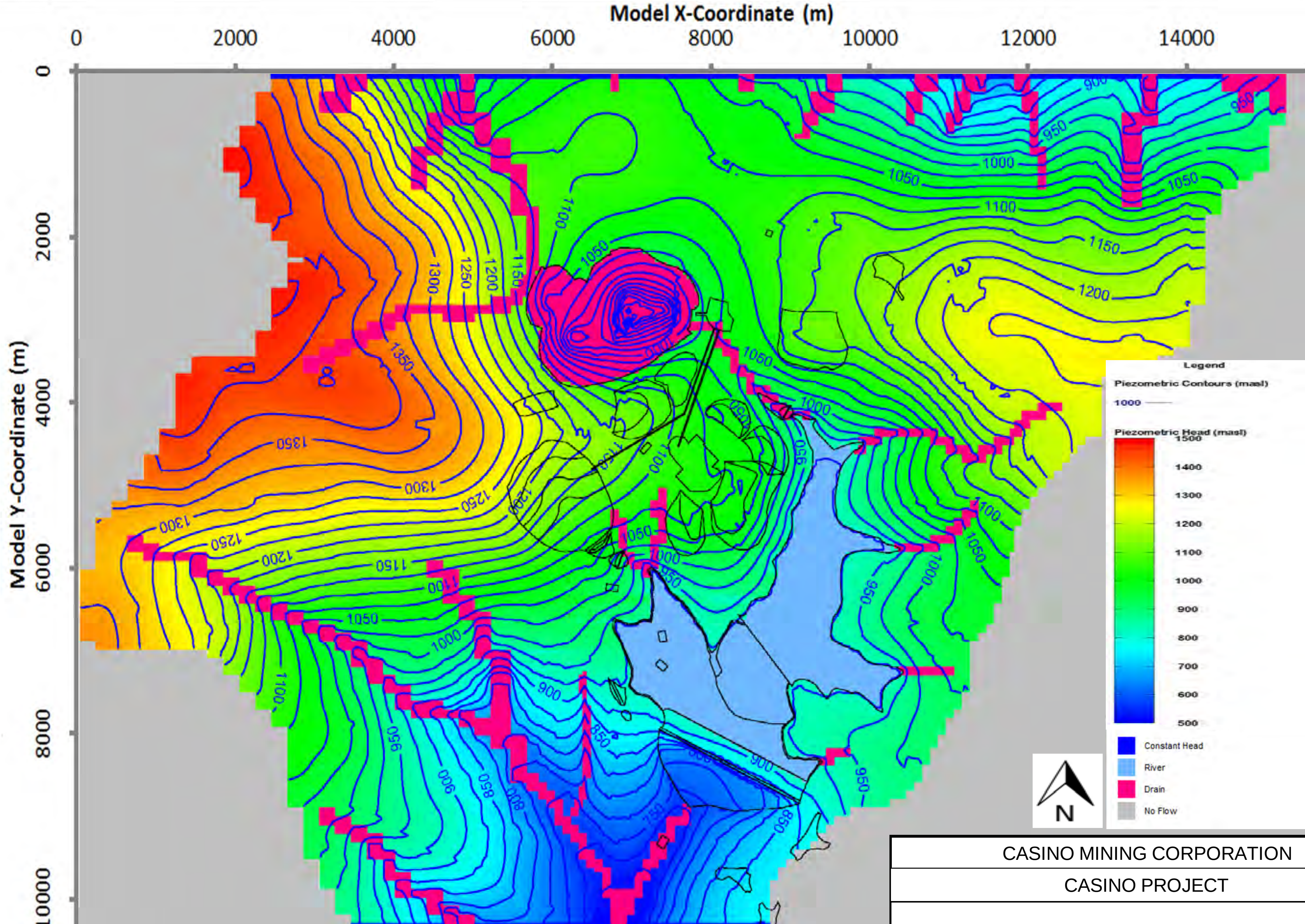

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CASINO PROJECT

MINE EFFECTS MODEL RESULTS
SIMULATED WATER TABLE CONTOURS: YEAR 10

Knight Piésold CONSULTING	P/A NO. VA101-325/14	REF. NO. 6
	FIGURE B.3	REV 0

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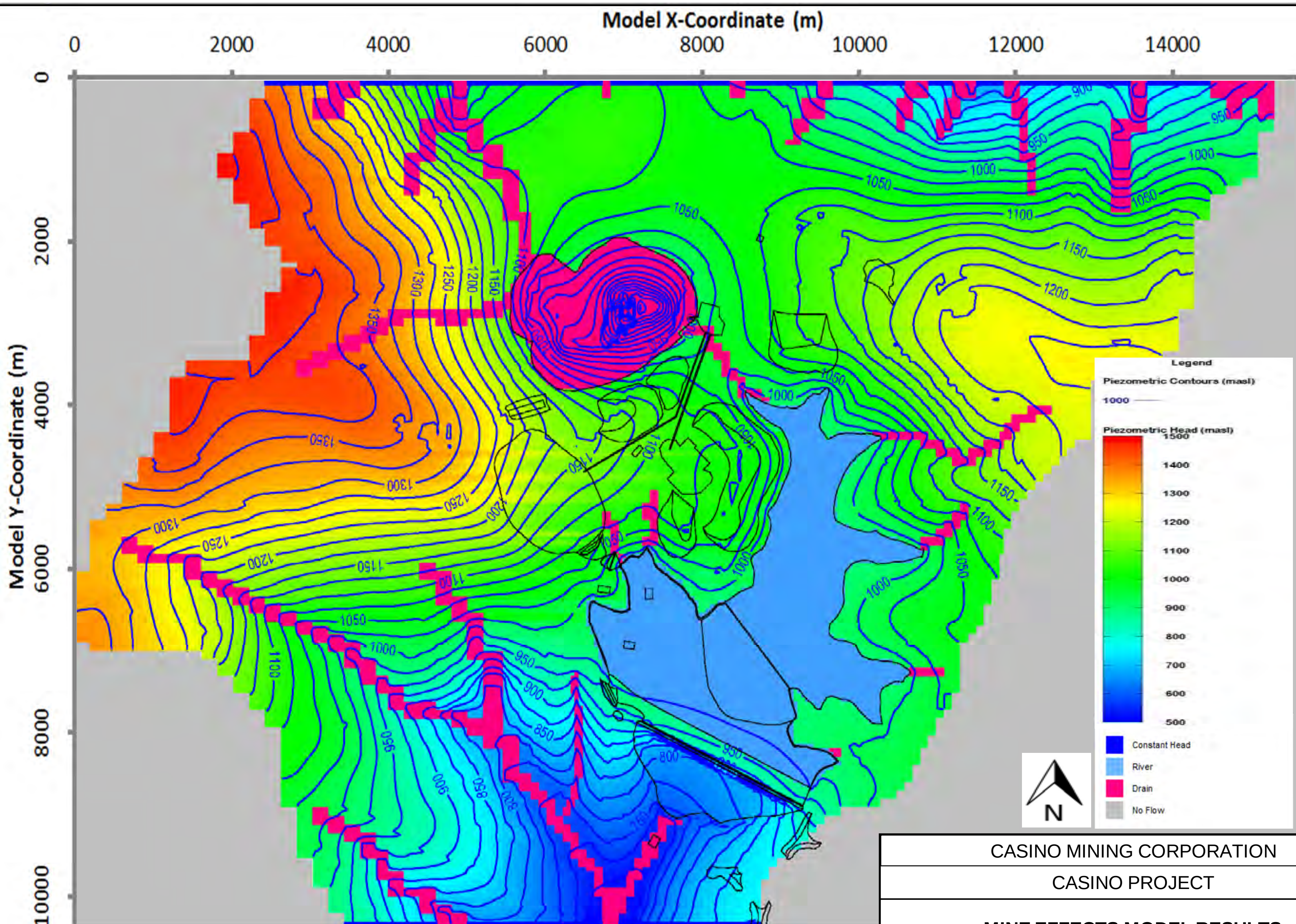

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MINE EFFECTS MODEL RESULTS
SIMULATED WATER TABLE CONTOURS: YEAR 19

Knight Piésold CONSULTING

P/A NO. VA101-325/14

REF. NO. 6

FIGURE B.4

REV 0

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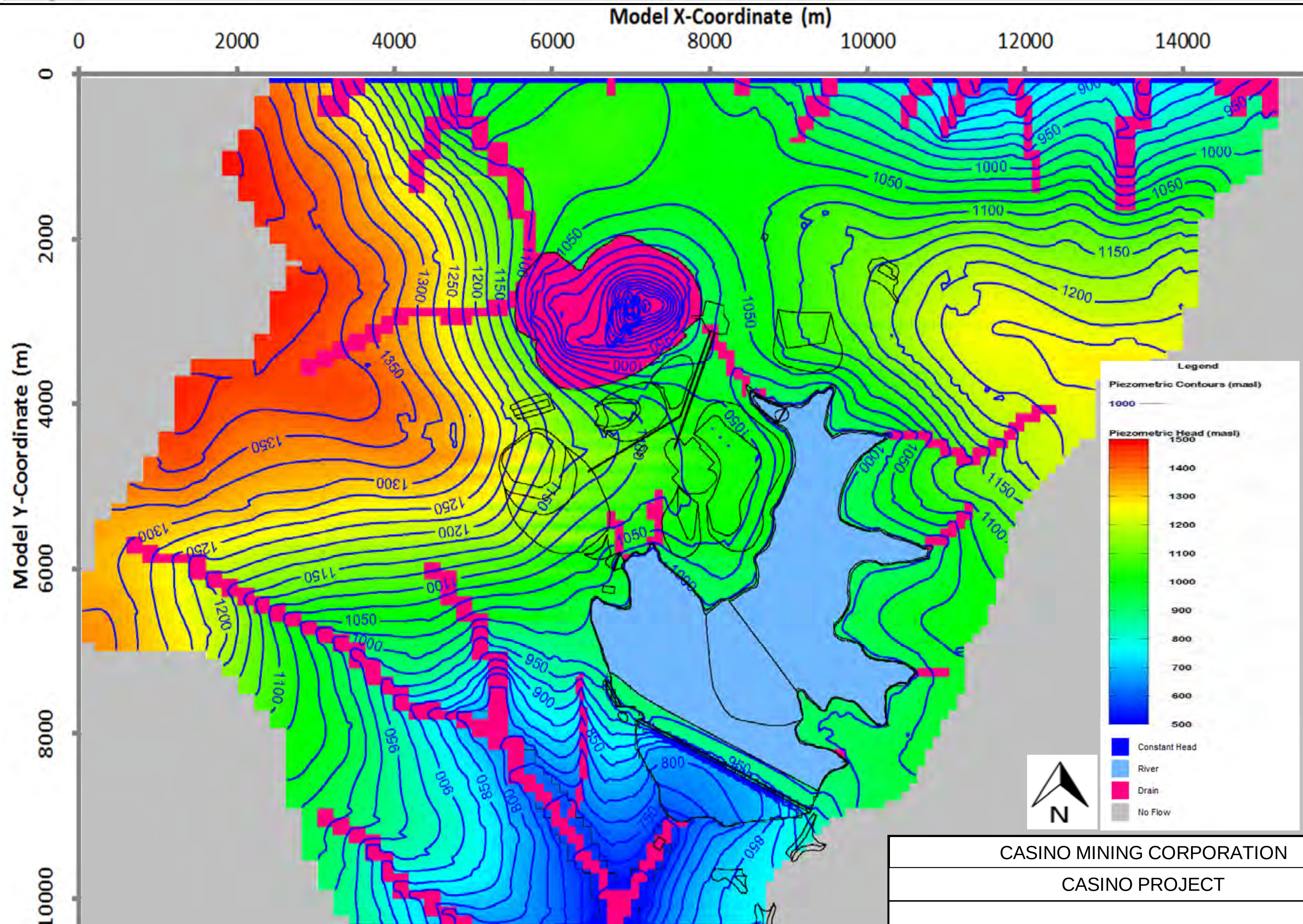

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MINE EFFECTS MODEL RESULTS
SIMULATED WATER TABLE CONTOURS: YEAR 22

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-325/14	6

FIGURE B.5 REV 0

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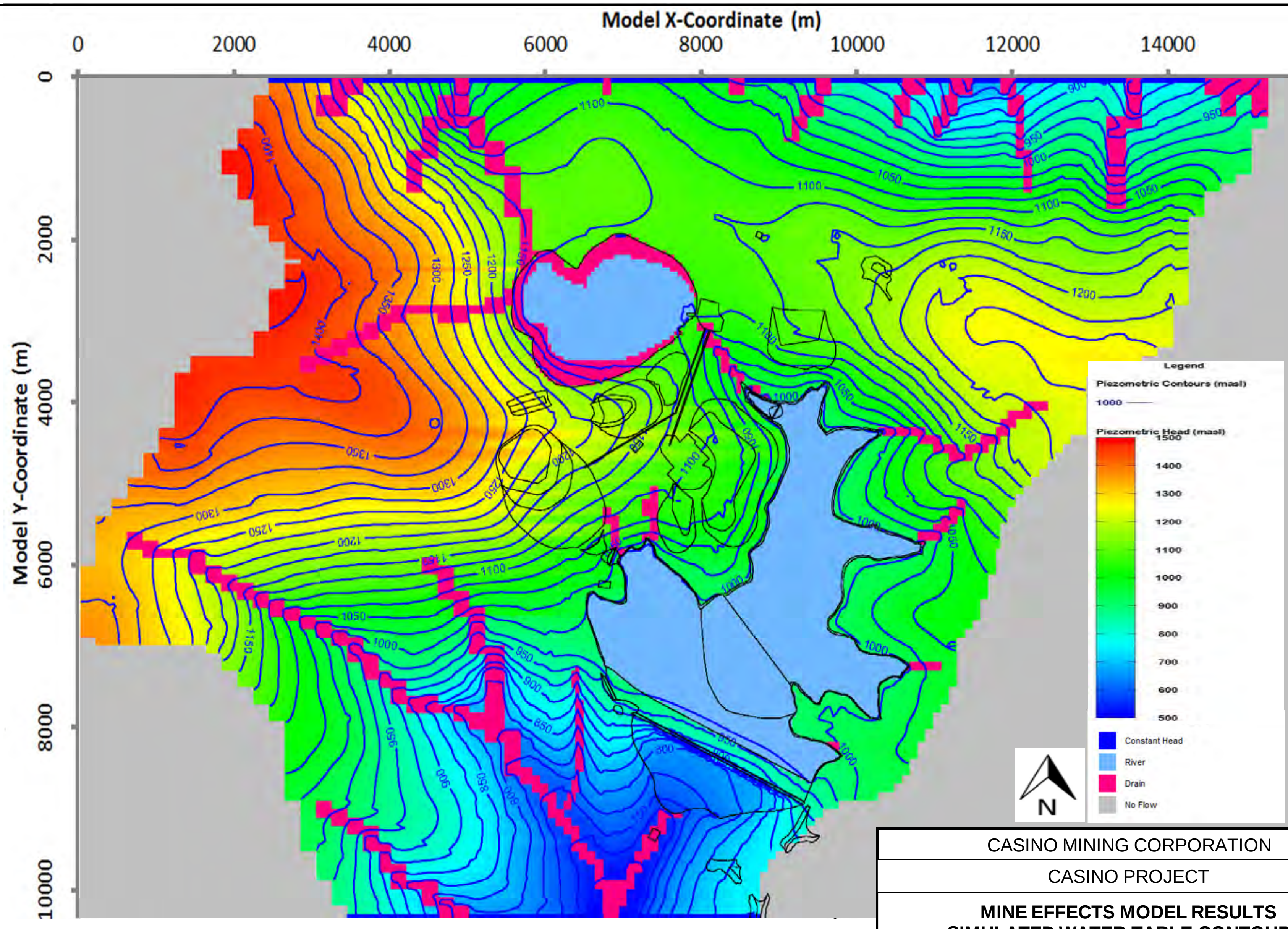


CASINO MINING CORPORATION

CASINO PROJECT

MINE EFFECTS MODEL RESULTS
SIMULATED WATER TABLE CONTOURS:
POST-CLOSURE

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-325/14	6

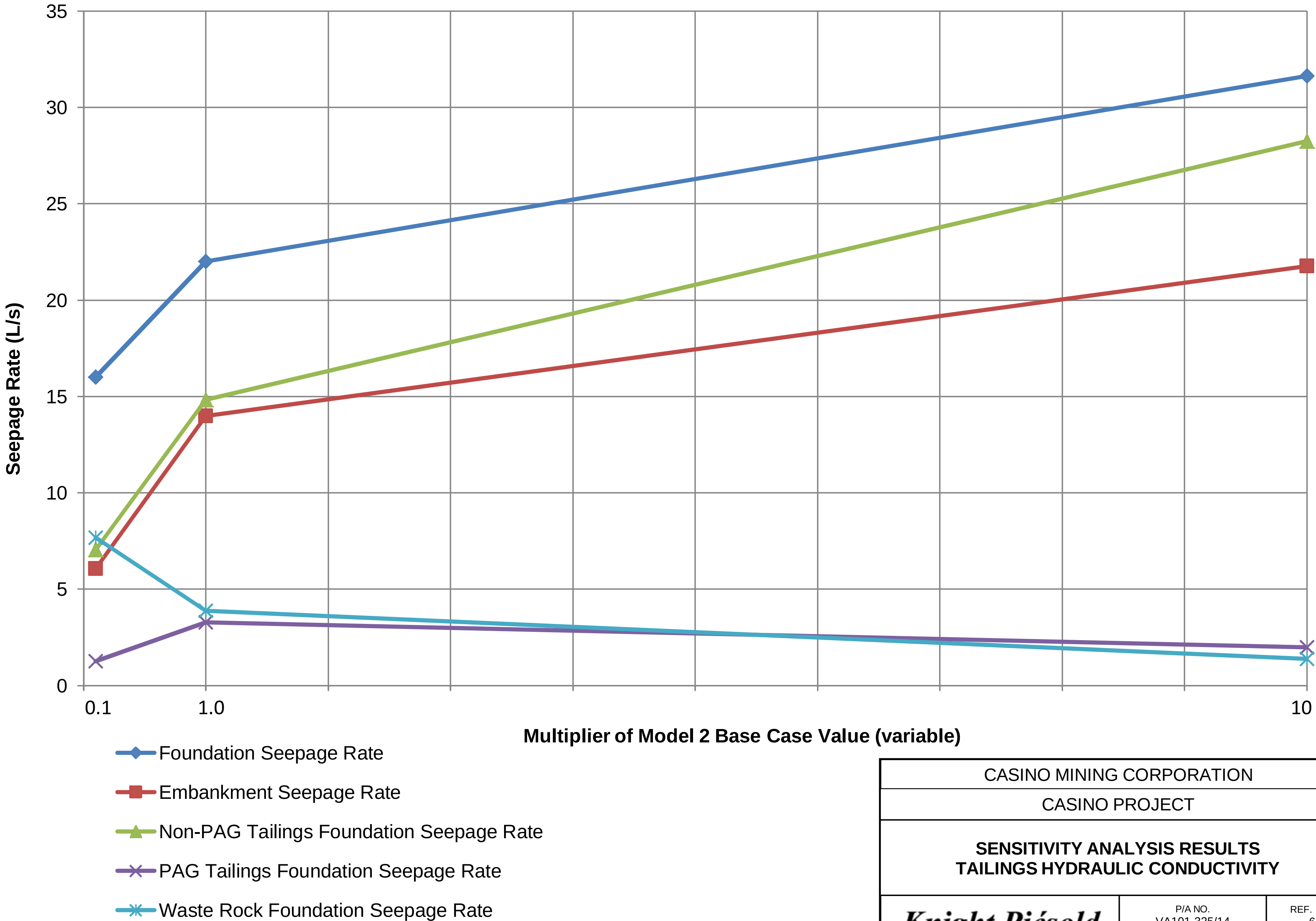
FIGURE B.6 REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	24OCT'13	ISSUED WITH REPORT	KTD	CAS	KJB

APPENDIX C

SENSITIVITY ANALYSIS RESULTS: TMF SEEPAGE ASSESSMENT

(Pages C-1 to C-4)



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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

CASINO MINING CORPORATION

CASINO PROJECT

SENSITIVITY ANALYSIS RESULTS
TAILINGS HYDRAULIC CONDUCTIVITY

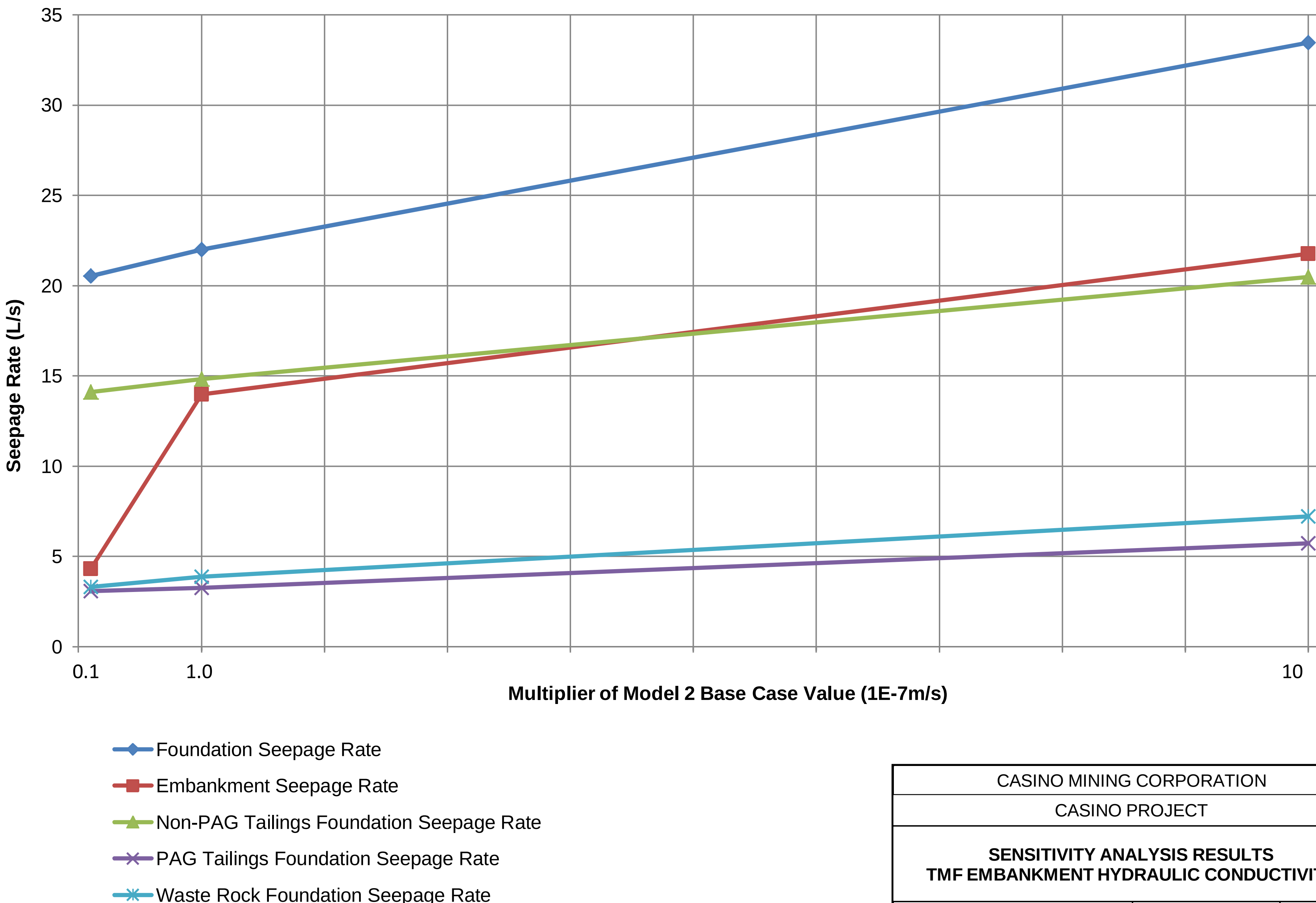
Knight Piésold CONSULTING

P/A NO. VA101-325/14

REF. NO. 6

FIGURE C.1

REV 0



0	24OCT'13	ISSUED WITH REPORT	KTD	CAS	KJB
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

CASINO MINING CORPORATION

CASINO PROJECT

SENSITIVITY ANALYSIS RESULTS
TMF EMBANKMENT HYDRAULIC CONDUCTIVITY

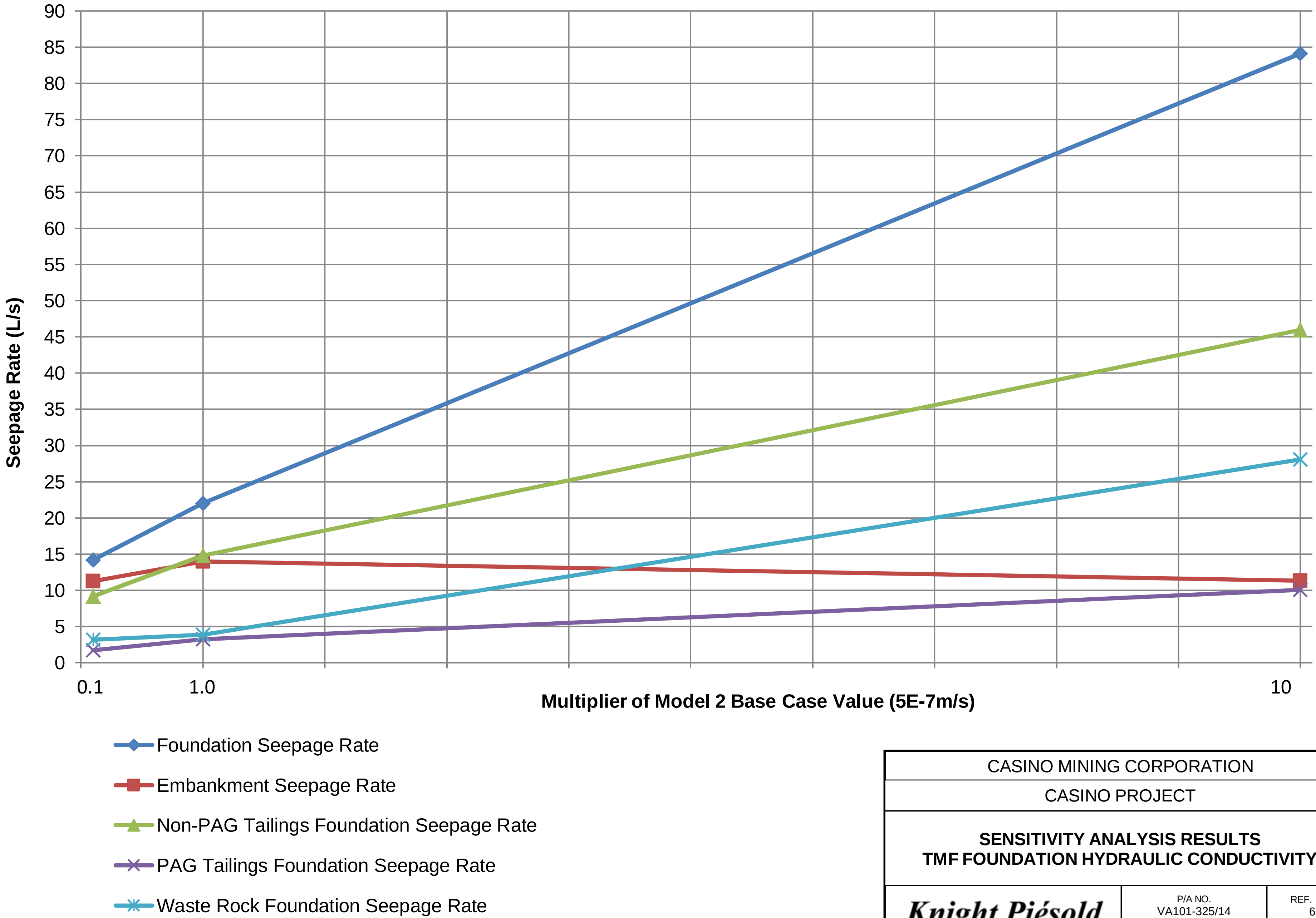
Knight Piésold CONSULTING

P/A NO. VA101-325/14

REF. NO. 6

FIGURE C.2

REV 0



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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

CASINO MINING CORPORATION

CASINO PROJECT

SENSITIVITY ANALYSIS RESULTS
TMF FOUNDATION HYDRAULIC CONDUCTIVITY

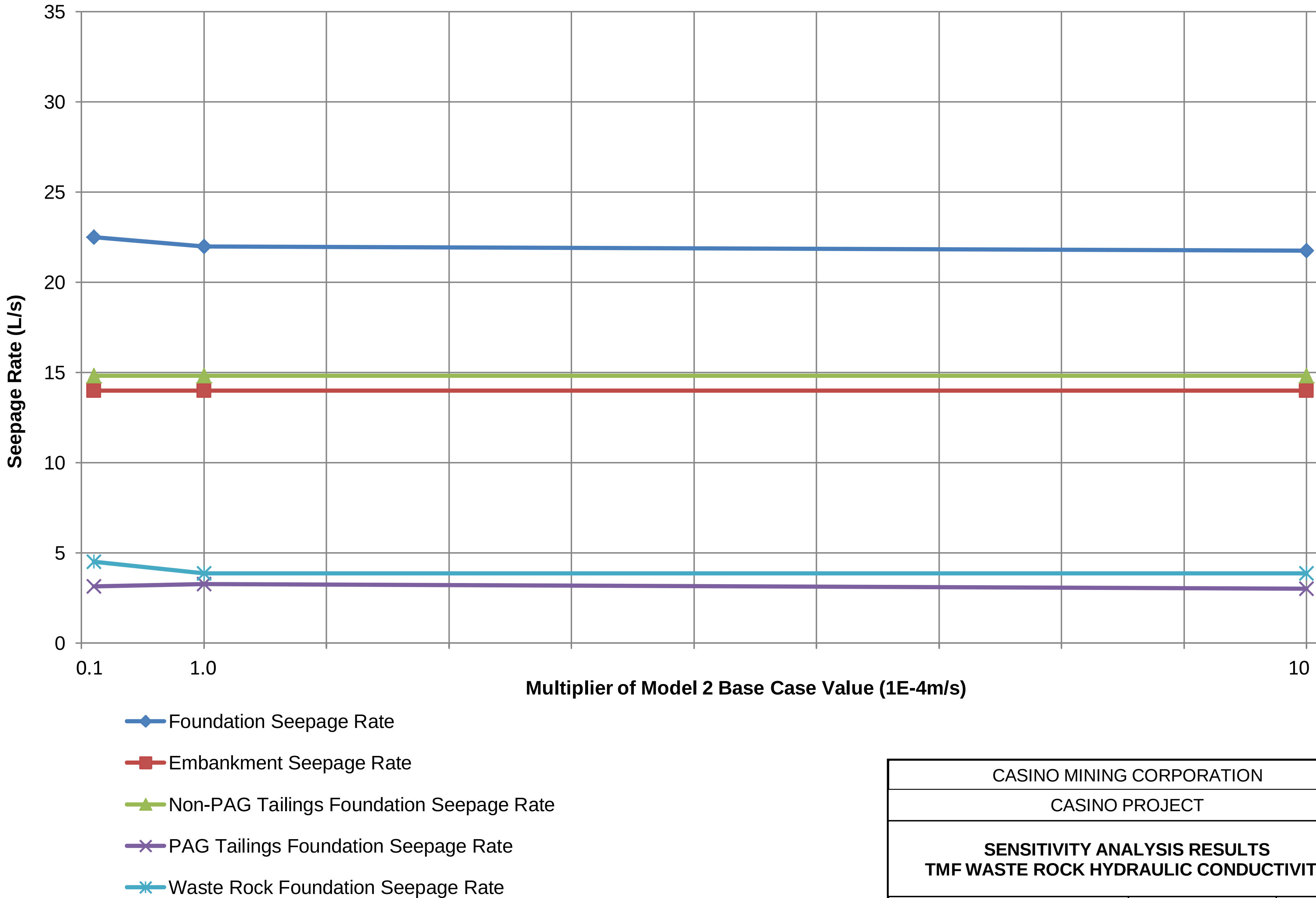
Knight Piésold CONSULTING

P/A NO. VA101-325/14

REF. NO. 6

FIGURE C.3

REV 0



CASINO MINING CORPORATION

CASINO PROJECT

SENSITIVITY ANALYSIS RESULTS
TMF WASTE ROCK HYDRAULIC CONDUCTIVITY

Knight Piésold CONSULTING

P/A NO. VA101-325/14 | REF. NO. 6

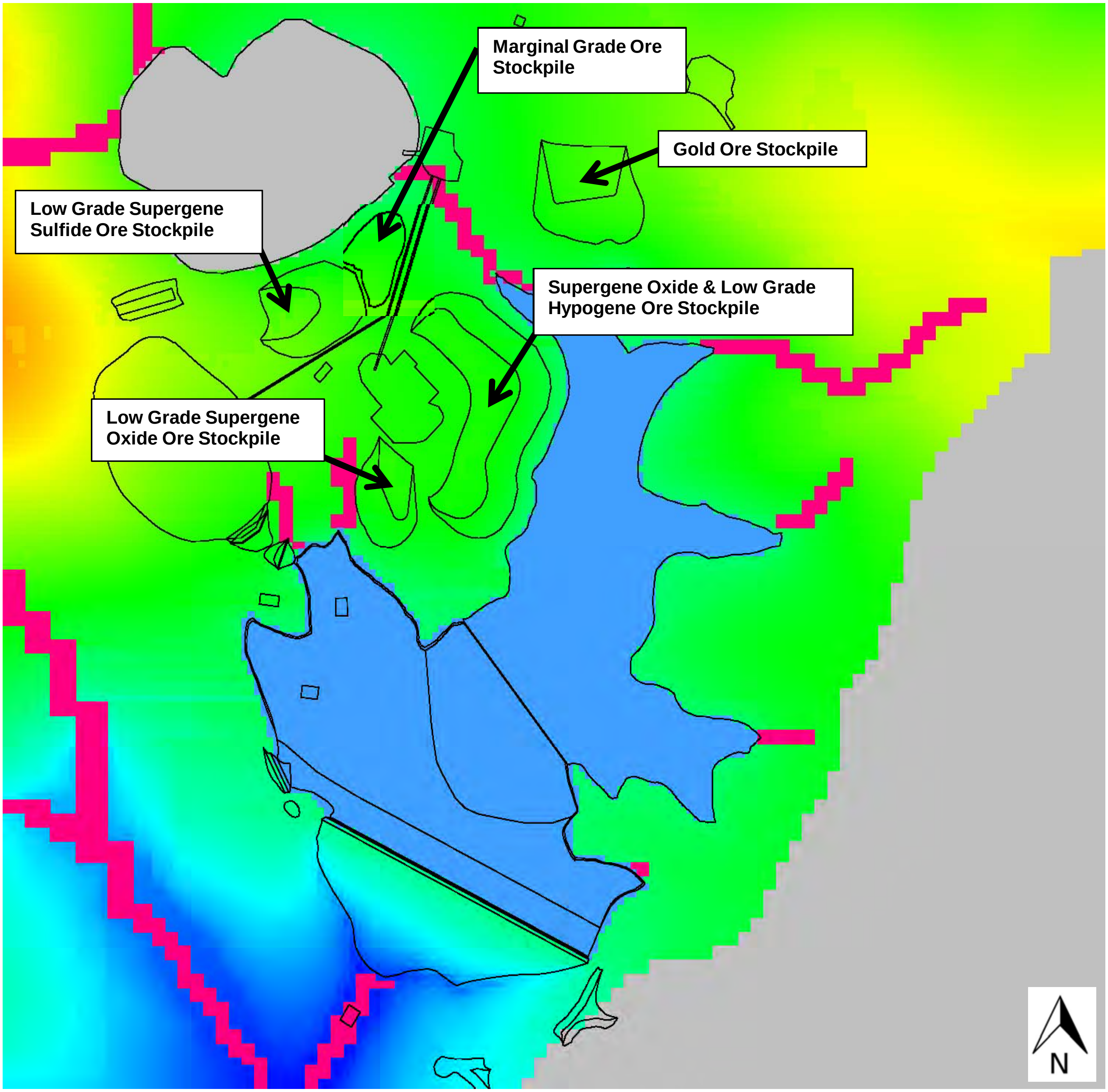
FIGURE C.4 | REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	24OCT'13	ISSUED WITH REPORT	KTD	CAS	KJB

APPENDIX D

ORE STOCKPILE SEEPAGE PATHWAY ANALYSIS

(Pages D-1 to D-6)



CASINO MINING CORPORATION

CASINO PROJECT

MINE EFFECTS MODEL RESULTS
MODPATH PARTICLE ANALYSIS: STOCKPILE LOCATIONS

Knight Piésold CONSULTING

P/A NO. VA101-325/14 | REF. NO. 6

FIGURE D.1 | REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
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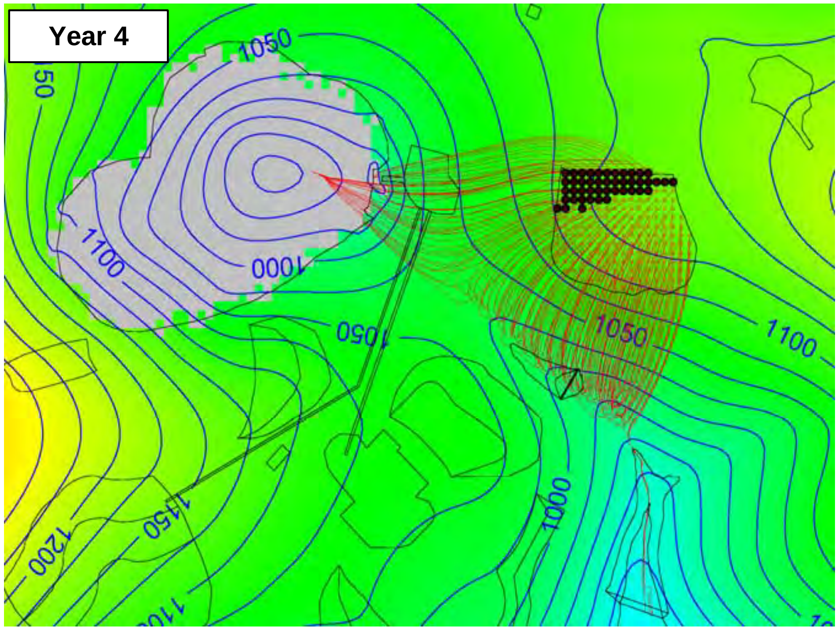
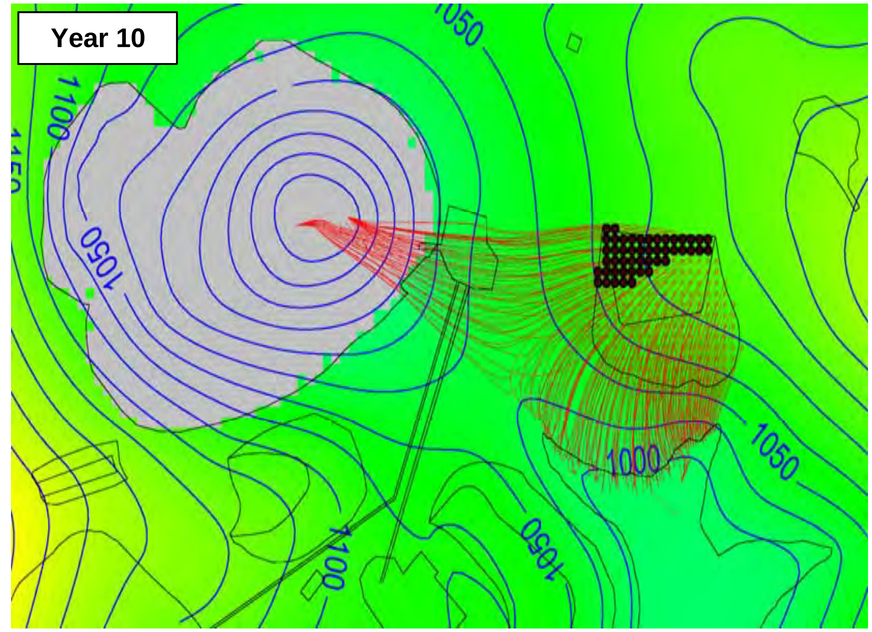
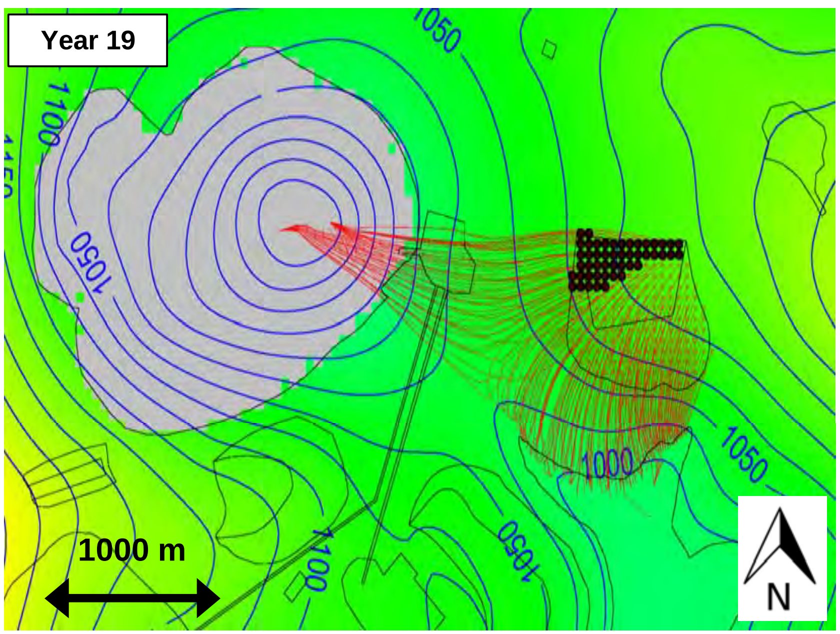






Legend

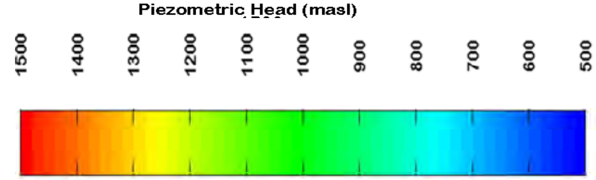
Piezometric Contours (masl)

1000

Particle Trace

Particle Trace Ending In Open Pit

Piezometric Head (masl)



CASINO MINING CORPORATION

CASINO PROJECT

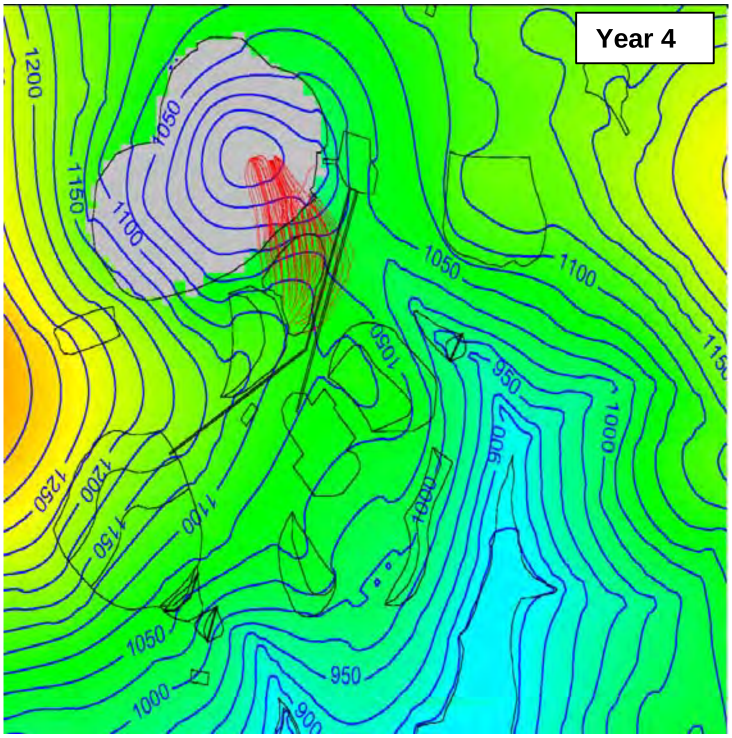
MINE EFFECTS MODEL RESULTS
MODPATH PARTICLE ANALYSIS
GOLD ORE STOCKPILE

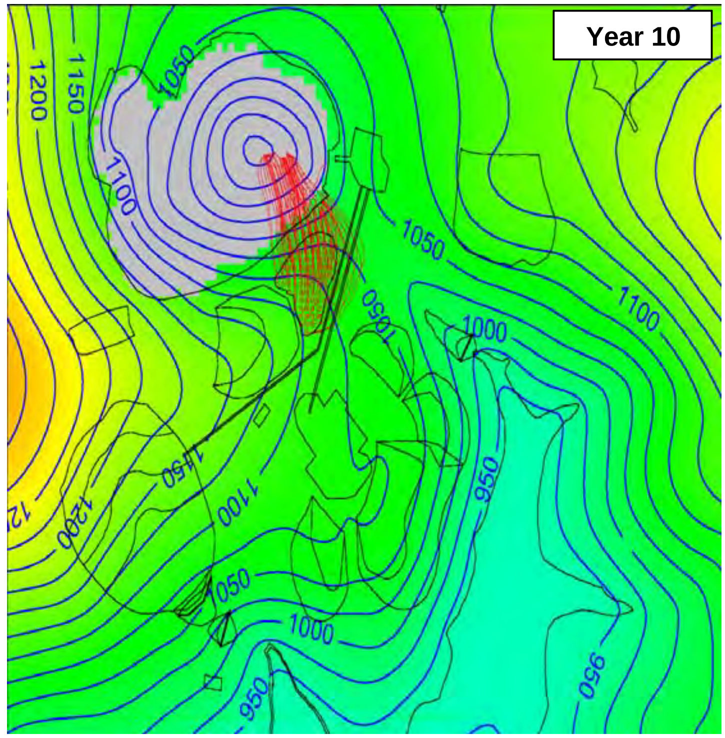
Knight Piésold CONSULTING

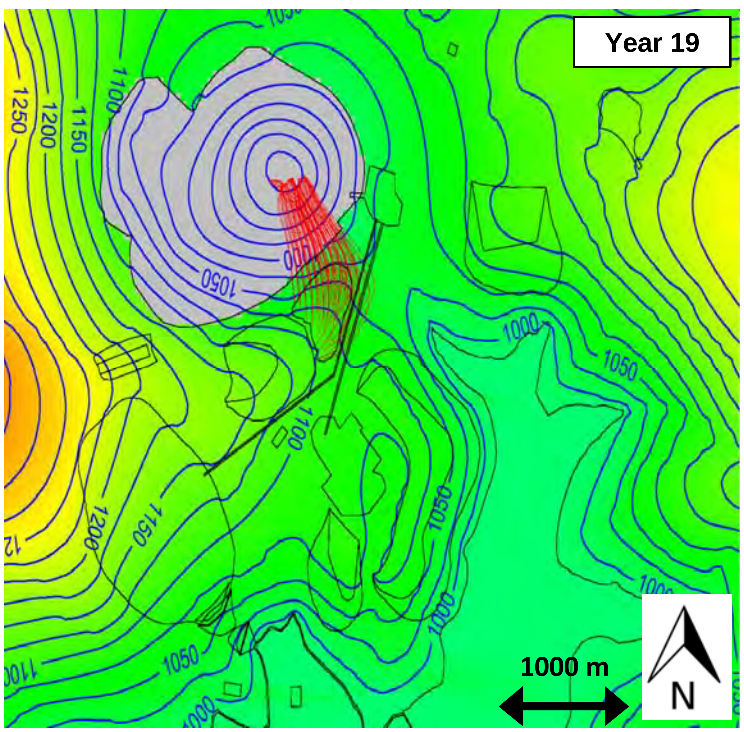
P/A NO.	REF. NO.
VA101-325/14	6

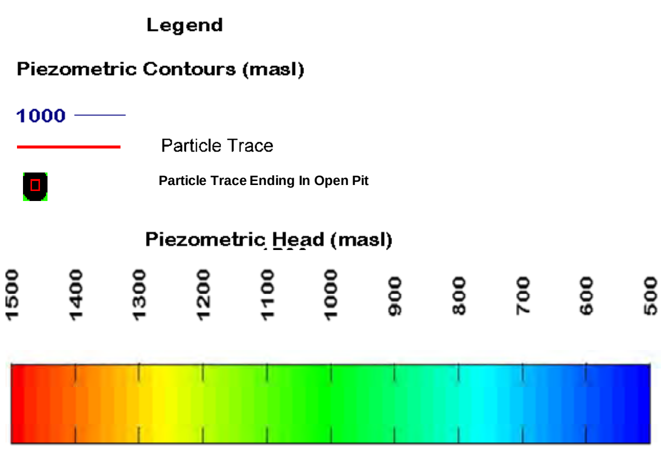
FIGURE D.2 REV 0

0	24OCT'13	ISSUED WITH REPORT	KTD	CAS	KJB
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D









CASINO MINING CORPORATION

CASINO PROJECT

MINE EFFECTS MODEL RESULTS
MODPATH PARTICLE ANALYSIS
MARGINAL GRADE ORE STOCKPILE

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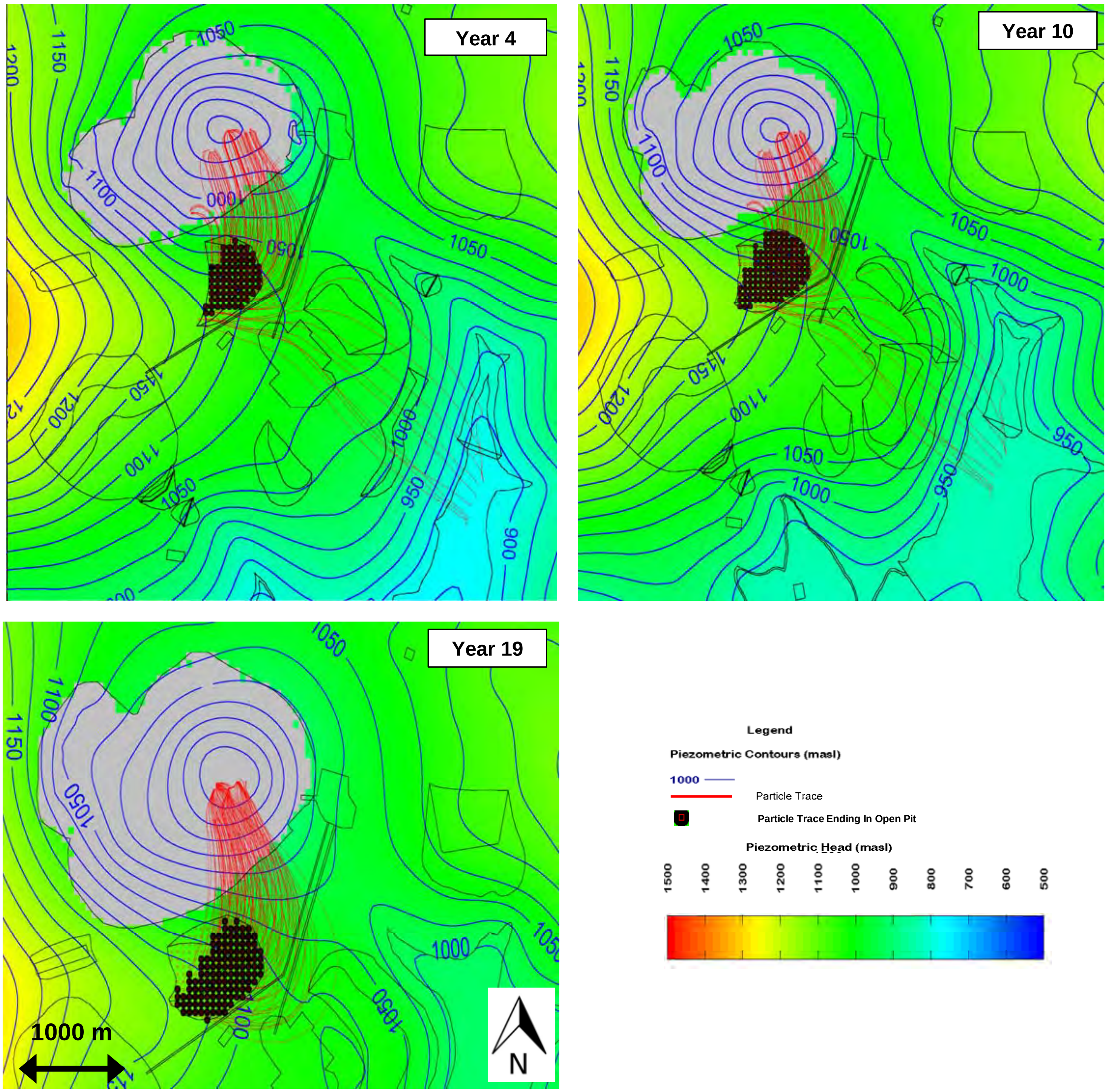
P/A NO.	REF. NO.
VA101-325/14	6

FIGURE D.3 REV 0

0	24OCT'13	ISSUED WITH REPORT	KTD	CAS	KJB
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



0	24OCT'13	ISSUED WITH REPORT	KTD	CAS	KJB
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

CASINO MINING CORPORATION

CASINO PROJECT

MINE EFFECTS MODEL RESULTS
MODPATH PARTICLE ANALYSIS
LOW GRADE SUPERGENE SULFIDE ORE STOCKPILE

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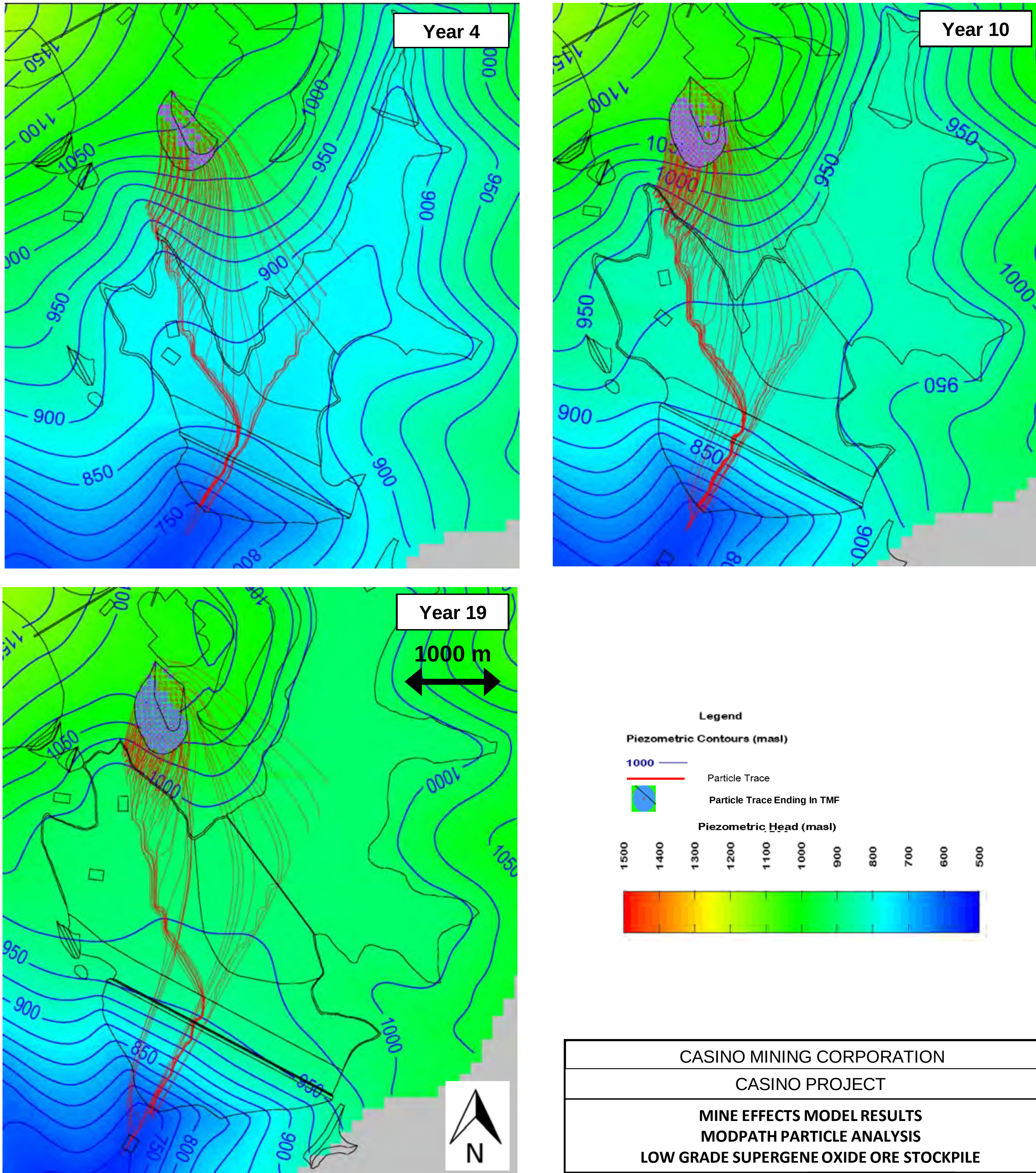
P/A NO. VA101-325/14	REF. NO. 6	
FIGURE D.4		REV 0



CASINO MINING CORPORATION

CASINO PROJECT

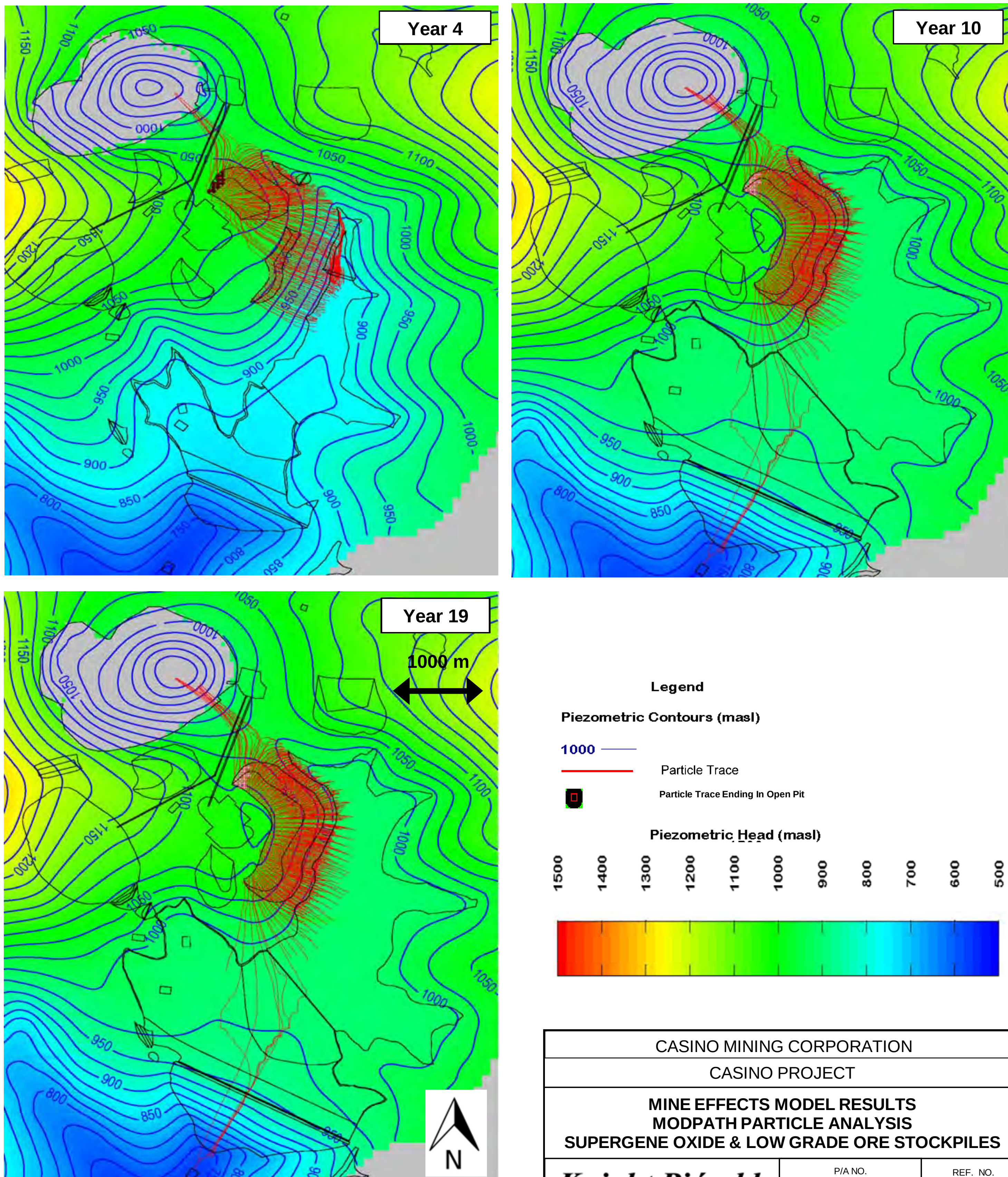
MINE EFFECTS MODEL RESULTS
MODPATH PARTICLE ANALYSIS
LOW GRADE SUPERGENE OXIDE ORE STOCKPILE

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-325/14	6

FIGURE D.5 — REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	24OCT'13	ISSUED WITH REPORT	KTD	CAS	KJB



CASINO MINING CORPORATION

CASINO PROJECT

MINE EFFECTS MODEL RESULTS
MODPATH PARTICLE ANALYSIS
SUPERGENE OXIDE & LOW GRADE ORE STOCKPILES

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P/A NO.	REF. NO.	FIGURE	REV
VA101-325/14	6	**FIGURE D.6**	0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	24OCT'13	ISSUED WITH REPORT	KTD	CAS	KJB