

Appendix E

Groundwater Report

Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development - Public Environmental Review



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42213762

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Section 1

Introduction

1.1 Background

Burnside Operations Pty Ltd (BOPL) plan to commence mining operations at North Point and Princess Louise deposits. Prior to mine development, a Public Environmental Review (PER) is required to obtain regulatory approval for the mines.

BOPL, as part of the project PER, requires an assessment of the environmental impacts of groundwater level lowering (drawdown) near the proposed mines, caused by pit dewatering.

To satisfy the guidelines for the PER, hydrogeological investigations comprised:

- (i) the installation of test production bores (for aquifer testing) and groundwater monitoring bores at North Point and Princess Louise deposits; and
- (ii) predictive groundwater flow modelling.

BOPL engaged URS Australia Pty Ltd (URS) to complete these assessments, as described in URS proposal 03036133, dated 6 September 2006.

1.2 Project Location

The Princess Louise and North Point deposits are located approximately 170 km southeast of Darwin and about 12 km northeast of Hayes Creek (Figure 1). This area occurs within the Burnside Project Area (BPA), a collection of mine sites all owned and operated by BOPL, and described as the area within a 30 km radius of the Brocks Creek Mine Site (Figure 2).

1.3 Mine Development

The proposed mine developments comprise conventional staged open pits, mined by a fleet of conventional rope shovels, hydraulic excavators and large haul trucks.

The proposed gold mining operations at Princess Louise and North Point mine sites are relatively small scale and short term, with the two open pit operations proposed to be completed within approximately 4 months.

It is anticipated that the Princess Louise pit will extend to approximately 35 m depth and produce 112,638 t of ore, while the North Point pit will be 25 m deep with 323,024 t ore extracted. Mining will intersect the water table at both sites and therefore pit dewatering will be required to ensure relatively dry and efficient mining.

1.4 PER Guidelines

Based on the Northern Territory EPA guidelines for the North Point and Princess Louise PER, the hydrogeological components of the PER need to include the following:

- Description of the site and the regional groundwater systems;
- Discuss the existing uses, beneficial uses and quality;
- Describe the impacts associated with mining and pit dewatering on groundwater; and
- Management of groundwater and groundwater monitoring.

Section 2

Scope of Work and Proposed Approach

2.1 Scope of Work

The scope of work for this project was outlined in URS proposal 03036133 and is summarised below.

- Data Review, Model Conceptualisation and Liaison;
- Groundwater Drilling and Testing Programs;
- Groundwater Model Construction and Features;
- Groundwater Model Calibration;
- Predictive Simulations – Dewatering and Environmental Impacts, and
- PER Groundwater Model Reporting.

2.2 Proposed Approach

The proposed approach (as described in our proposal) to complete the scope of work is outlined below.

2.2.1 Task 1 – Data Review, Model Conceptualisation and Liaison

In order to form a conceptual model of the mining areas and surrounding region, it will be necessary to review geological and hydrogeological data. Additional information is required for the local stratigraphy and hydrogeological parameters.

We will liaise with BOPL geologists to ensure that we fully understand the geology of the deposits and then form a conceptual groundwater model of each deposit prior to commencing model construction. This would require a visit to the Brocks Creek site office to review existing datasets and log core.

2.2.2 Task 2 – Groundwater Drilling and Testing Programs

Based on our conceptual model and known geology, we will design and complete a program of groundwater drilling and testing to assist in preliminary dewatering design and allow the quantification of environmental impacts.

Based on our hydrogeological interpretation, we will locate prospective groundwater targets and specify bore drilling methods and locations. One aquifer test bore will be located at each prospect, located outside the pit perimeter at each deposit if suitable data are available. Most of these locations will be sited in order that successful bores can be used for dewatering. Groundwater monitoring bores will also be constructed to measure groundwater quality down-gradient of the mine and will be used during aquifer testing to determine aquifer parameters.

Our hydrogeologists will visit site during the groundwater drilling and testing programs and liaise often with BOPL during the programs.

Our proposed field activities comprise the following groundwater exploration and testing programmes for PER completion.

North Point

- One test dewatering bore located outside the pit perimeter if available data allow this.
- Two groundwater monitoring bores to assist in the determination of aquifer properties through aquifer testing of production bores. We would locate these bores in long-term positions suitable for inclusion in a groundwater monitoring network.

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- Completion of aquifer tests and collection of groundwater samples for analysis.

Princess Louise

- One test dewatering bore located outside the pit perimeter if available data allow this.
- Two groundwater monitoring bores to assist in the determination of aquifer properties through aquifer testing of production bores. We would locate these bores in long-term positions suitable for inclusion in a groundwater monitoring network.
- Completion of aquifer tests and collection of groundwater samples for analysis.

2.2.3 Task 3 - Groundwater Model Construction and Features

Our proposed model will be constructed using commercially available software such as Visual MODFLOW (finite-difference). URS proposes to use MODFLOW-SURFACT with Visual MODFLOW Pro Version 4 as the pre- and post-processors. MODFLOW-SURFACT contains several flow packages which complement/supplement the widely used USGS MODFLOW by enhancing the schemes for performing unconfined simulations to rigorously model desaturation/resaturation of aquifers.

The modelled area will be discretised into different material types and layers in order to simulate the interpreted geology and hydrogeology as closely as possible. The model will take into account such features as:

- The geometry and properties of known aquifer systems;
- The geology and structural geology of the site and the impact of these structures on groundwater flow;
- The layout of the mining areas and the proposed open-pits;
- The relationship between groundwater and surface water – both flows and levels, and
- Groundwater and surface water recharge-discharge mechanisms.

The model will be designed to incorporate additional groundwater drilling and testing information as it becomes available and this will lead to gradual model refinement as the mining operations commence. In this manner, the model can be used to refine, predict and quantify the required dewatering system for mining and also the potential environmental impacts associated with dewatering.

2.2.4 Task 4 - Groundwater Model Calibration

The calibration of the model will occur in two steps:

- **Steady-State** – during this calibration stage, groundwater levels generated by the model will be matched to known groundwater levels and flow directions across the mining region. This will be achieved by small variations in model parameters, especially hydraulic parameters such as permeability and storativity. A successful steady-state calibration is a necessary precursor to the next stage of model development.
- **Transient** – this is the most difficult and time-consuming stage of model calibration. During this work, known aquifer response to pumping by bores is matched by simulating this pumping in the model. This can be difficult to achieve. Model parameters are varied until a satisfactory drawdown response to actual pumping is achieved. The model is then ready to be used for predictive simulations to forecast available groundwater supply and assess potential environmental impacts.

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Scope of Work and Proposed Approach

2.2.5 Task 5 - Predictive Simulations – Dewatering Design, Environmental Impacts and Closure

2.2.5.1 Preliminary Pit Dewatering Design

The calibrated model will be used to calculate groundwater inflows to the pits. These inflows will give a preliminary indication of the amount of groundwater that has to be pumped to maintain efficient and relatively dry mining conditions. These results can be used to describe the required dewatering system for each pit.

Once the necessary abstraction rates have been established, these rates will be used to simulate pit dewatering and determine the regional drawdown of the water table around the mining area.

2.2.5.2 Environmental Impacts

The main potential groundwater-related environmental impacts resulting from the proposed mining are associated with groundwater level lowering near the pits. Groundwater lowering may result in vegetation stress, and have impacts on the ecological water requirements that are needed to sustain flora and fauna associated with drainages of the area.

The model will be constructed to simulate the interaction of groundwater and surface water in the major drainages of the area. Specialised model cells, which represent potential points of leakage from surface water to groundwater, will be included in the model. These cells will occur in drainages, and floodplains of these drainages. This will allow modelled leakage to occur during wet season.

Drawdown predictions from the groundwater modelling will be used to evaluate the impacts of pit dewatering. Thus, the groundwater/surface water modelling will allow a quantification of environmental impacts and therefore assist in planning the mitigation of such impacts. This will be an important aspect of regulatory approval for the proposed mine development.

2.2.5.3 Mine Closure

We consider the development of a groundwater model to also be important in mine closure planning. As with environmental impacts, studies of final void water levels will be an important aspect of obtaining regulatory approval for the mine development.

2.2.6 Task 6 – PER Groundwater Reporting

The report will describe the field program completed, the hydrogeology of the mining area, the conceptual hydrogeological model for each deposit, the modelling results at the PER stage (dewatering and closure) and will also describe the potential environmental impacts associated with groundwater abstraction for pit dewatering. Results from this report can be directly imported into the PER document or be presented as an Appendix.

Section 3

Drilling and Testing Program

3.1 Groundwater Drilling

One test production bore and 2 groundwater monitoring bores were installed at the North Point and Princess Louise deposits (Figures 3 and 4) during December 2006 and January 2007. Drilling was completed by Bores NT with a truck-mounted drilling rig using air-hammer methods.

A 146 mm diameter pilot hole was drilled at each location. All holes were lithologically logged and sampled.

Bore construction details are summarised in Table 1 and discussed below.

Table 3-1 Bore Construction Details

Bore	Mine Grid			MGA			Depth (m)	Screened Interval (mbgl)	Groundwater Depth (mbtoc)
	Easting	Northing	RL	Easting	Northing	RL			
North Point									
NPPB1	9646.63	9974.06	1112.67	8507303.87	775723.03	112.67	61	25-61	14.18
NPMB1	9734.50	9990.09	1113.22	8507391.73	775738.83	113.22	61	55-61	14.70
NPMB2	9403.15	10031.47	1123.36	8507060.67	775781.01	123.36	67	62-67	24.26
Princess Louise									
PLPB1	9746	7100	-	8504750.83	775495.74	-	78	22-78	26.60
PLMB1	7092.82	9740.30	1146.06	-	-	114.6	73	67-73	22.37
PLMB2	9694	6950	-	-	-	-	66	60-66	16.10

Notes: mbgl = metres below ground level
mbtoc = metres below top of collar

Bore logs, showing descriptions of strata and graphical well construction details, are presented in Appendix A.

3.1.1 Test Production Bores

3.1.1.1 North Point

One test production bore (NPPB1, Figure 3) was constructed and cased with 203 mm internal diameter casing and slotted steel bore screens.

The bore was drilled using air-hammer techniques and encountered fractured greywacke and tuff between the depths 24-28, 40-42, 47-48, 54-56 and 60-61.

Bore development was by air-lifting and surging, using compressed air to force groundwater into and out of the screened section, and discharge groundwater from the bore. The bore was developed by this method until silt-free groundwater returns were obtained.

3.1.1.2 Princess Louise

One test production bore (PLPW1, Figure 4) was constructed and cased with 203 mm internal diameter casing and slotted steel bore screens.

The bore was drilled using air-hammer techniques and encountered fractured greywacke and tuff between the depths 36-37m and 59-59m.

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Drilling and Testing Program

Bore development was by air-lifting and surging, using compressed air to force groundwater into and out of the screened section, and discharge groundwater from the bore. The bore was developed by this method until silt-free groundwater returns were obtained.

3.1.2 Groundwater Monitoring Bores

Two groundwater monitoring bores were drilled at each deposit and constructed using 50 mm nominal diameter uPVC casing. Machine-slotted uPVC casing (1 mm aperture slots) was used for the screened section. Details of the bore constructions are presented in Appendix A.

3.1.2.1 North Point

Two groundwater monitoring bores were installed at North Point (NPMW1 and 2, Figure 3) to assist with the determination of groundwater drawdown response from aquifer testing. The bores intersected siltstone, mudstone and greywacke.

3.1.2.2 Princess Louise

Two monitoring bores were installed at Princess Louise (PLMW1 and 2, Figure 4) to assist with the determination of groundwater drawdown response from aquifer testing. Both bores intersected siltstone, mudstone and greywacke.

3.2 Bore and Aquifer Testing

A program of bore and aquifer testing was completed in each of the test production bores to determine bore and aquifer properties.

Three types of tests were undertaken:

- Step-drawdown tests;
- Constant-discharge tests; and
- Recovery tests.

3.2.1 Step-Drawdown Tests

The step-drawdown tests were used to determine bore pumping characteristics and estimate a pumping rate suitable for the constant-discharge test. These tests comprised pumping the bore at rates that were increased incrementally ("steps"). The steps were generally of 60 minutes duration. Analyses of these results were used to determine well and formation loss factors and to select a suitable rate for the constant-discharge test.

Plots of the step-rate tests for North Point and Princess Louise are presented in Figures 5 and 6.

3.2.2 Constant Discharge and Recovery Tests

The constant-discharge test in each production bore was commenced following the step-drawdown test and after groundwater levels had recovered to near-initial static levels. Upon completion of each constant-discharge test, recovering groundwater levels were also measured and analysed.

The test pumping was undertaken by the drilling contractors using electric submersible pumps. Pumping rates were measured through an orifice weir. Electric contact meters (dip meters) were used to measure groundwater levels in both the pumped bore and the groundwater monitoring bores.

Section 3

Drilling and Testing Program

The constant-discharge test results enable the hydraulic characteristics of the aquifers intersected by each test production bore to be determined. These parameters quantify the storage and transmission of groundwater in the aquifer.

The results of the constant-rate tests and the calculated hydraulic parameters are shown on Table 3-2, with drawdown plots presented in Figures 7 and 8.

Table 3-2 Constant Discharge Test Results

Pumping Bore	Date of Test	Pumping Rate (kL/day)	Final Drawdown (m)	Observation Bores		Transmissivity (m ² /day)		Storativity
				Bore No	Dist. (m)	Theis	Cooper-Jacob	(-)
North Point								
NPPB1	22/1/2007	1,640	5.44	NPPB1 (e)	0	500		-
				NPPB1 (l)		100		-
				NPMB1 (e)	243	430		3E-05
				NPMB1 (l)		115		4E-04
				NPMB2 (e)	332	740		1E-04
				NPMB2 (l)		100	110	5E-04
Princess Louise								
PLPB1	18/1/2007	490	9.97	PLPB1 (r)	0	35		-
				PLMB1 (l)	70	20	22	5E-06
				PLMB1 (r)		190		-
				PLMB2 (l)	92	20	21	1E-03
				PLMB2 (r)		150		-

Notes: (e) – Early Time
(l) – Late Time
(r) – Recovery

Section 4

Geology and Hydrogeology

4.1 Geological Setting

4.1.1 Regional Geology

Previous mining operations in the vicinity of the project area have extracted gold, tin and the base metals, lead, zinc and copper. Gold mineralisation occurs in all units of the South Alligator Group and Burrell Creek Formation (Figure 9); a sequence of regionally metamorphosed greenschist facies, fine grained volcano-metasedimentary and mafic intrusive rocks. All gold prospects are associated with regional anticlinal structures that trend around the Burnside Granite pluton, in the core of the project area.

The largest gold deposits are located on the Howley Anticline, which hosts a series of deposits along its length and which has been the major source of gold in this area. Significant gold deposits have also been discovered and periodically mined over the last century in the East Burnside area. These prospects are hosted within large anticline structures and are spatially related to the regional northwest striking Pine Creek Shear Zone, which trends northwest between the Burnside and Margaret Granite plutons (BOPL, 2006).

4.1.2 Local Geology

The North Point and Princess Louise Deposits are hosted within the Mount Bonnie Formation of the South Alligator Group that comprises of a sequence of shale, mudstone, phyllite, siltstone, feldspathic greywacke and minor tuffaceous chert, tuff, argillite with rare banded iron formation and dolomite.

Gold mineralisation at the North Point and Princess Louise deposits is associated with quartz veining and centralised shear zones, located on the western limb of a north-south trending anticline. Both the North Point and Princess Louise deposits are located within the northwest-trending Pine Creek Shear Zone that forms part of a wrench fault system (NTGS, 1993).

4.2 Hydrogeology

Aquifers at North Point and Princess Louise occur primarily (from surface) within fractured greywacke, vuggy quartz veining and weathered greywacke and tuff in the bedrock. The most significant aquifer occurs within greywacke, which appears to have a moderate permeability at Princess Louise and high permeability at North Point.

Faults and shear zones that intersect the deposits also probably transmissive and will contribute groundwater inflow to the proposed pits where they intersect the walls.

Groundwater levels are relatively flat at both deposits with slight increases associated with topography. North Point groundwater levels are approximately 14 metres below ground surface and between 16 and 26 metres below ground surface at Princess Louise, depending on the topography.

Groundwater within each of the prospects is fresh with total dissolved solids ranging between 130 and 210 mg/L, and elevated iron and arsenic concentrations, especially at the North Point deposit. Groundwater is not considered potable at either site as it exceeds NHMRC Drinking water guidelines for arsenic of 0.007 mg/L (0.392 mg/L North Point, 0.053 mg/L Princess Louise) and aesthetic iron values of 0.3 mg/L (0.48 mg/L, North Point).

Detailed chemical analyses are presented in Table 4-1.

Section 4

Geology and Hydrogeology

Table 4-1 Detailed Chemical Analyses

Analyte	Unit	NPPB1	PLPB1
pH	pH Unit	6.43	7.09
TDS	mg/L	132	206
Hydroxide Alkalinity as CaCO ₃	mg/L	<1	<1
Carbonate Alkalinity as CaCO ₃	mg/L	<1	<1
Bicarbonate Alkalinity as CaCO ₃	mg/L	67	101
Total Alkalinity as CaCO ₃	mg/L	67	101
Sulphate as SO ₄ ²⁻	mg/L	14	7
Sulphur as S	mg/L	5	2
Chloride	mg/L	2.1	10.2
Calcium	mg/L	4	3
Magnesium	mg/L	11	19
Sodium	mg/L	12	17
Potassium	mg/L	3	4
Arsenic (dissolved)	mg/L	0.392	0.053
Cadmium (dissolved)	mg/L	0.0002	<0.0001
Chromium (dissolved)	mg/L	<0.001	<0.001
Copper (dissolved)	mg/L	<0.001	<0.001
Lead (dissolved)	mg/L	<0.001	<0.001
Nickel (dissolved)	mg/L	<0.001	<0.001
Zinc (dissolved)	mg/L	0.017	0.012
Iron (dissolved)	mg/L	0.48	0.29

Section 5

Groundwater Modelling Methodology

5.1 Conceptual Hydrogeology Model

Interpretations of conceptual hydrogeology models for North Point and Princess Louise pits are described below.

5.1.1 North Point

- The local groundwater flow direction is towards the north-west and regionally towards the north, following topography and the associated drainages to the north.
- Groundwater levels are generally 14 metres below ground surface.
- Surficial cover is generally thin or non-existent near the pit and does not contain significant aquifer zones.
- The bedrock comprises a 25 metre wide shear/fracture zone through the pit, associated with the mineralisation and vuggy quartz fracturing.
- The bedrock weathering profile deepens in the vicinity of the pit, associated with the shear zone.
- The detailed geology beyond the mining area is generally unknown. Therefore, the modelled geology in regional areas is based on large-scale mapping.

5.1.2 Princess Louise

- The deposit is located on a groundwater divide and local groundwater flow direction is to the south west and regionally towards the north, following topography and associated drainages to the north.
- Groundwater levels are generally 25 metres below ground surface, depending on topography.
- Surficial cover is generally thin or non-existent in the vicinity of the pit and does not contain significant aquifer zones.
- The bedrock comprises a 15 metre wide shear/fracture zone through the pit, associated with the mineralisation and vuggy quartz fracturing.
- The weathering profile deepens throughout the pit area, associated with the shear zones.
- The detailed geology beyond the mining area is generally unknown. Therefore, the modelled geology in regional areas is based on large-scale mapping.

5.2 Groundwater Flow Model Details

5.2.1 Model Code

The model code selected was MODFLOW. MODFLOW is a three-dimensional block-centred finite-difference code developed by the USGS to simulate groundwater flow in the saturated subsurface. Visual MODFLOW Pro Version 4 was used as the pre- and post-processors.

5.2.2 Model Domain

5.2.2.1 North Point

Section 5

Groundwater Modelling Methodology

The model domain measures 2 km east-west and 2 km north-south (Figure 10), and was discretised into 6512 model cells (88 columns x 74 rows x 2 layers) with variable grid sizes. Each cell block represents a homogeneous hydrogeologic sub-unit of the hydrostratigraphic unit. Finer grids (6.5 m x 10 m) were used around the proposed open-pit and in areas of specific interest (Figure 10).

5.2.2.2 Princess Louise

The model domain measures 5.5 km east-west and 6 km north-south (Figure 11), and was discretised into 12412 model cells (107 columns x 116 rows x 2 layers) with variable grid sizes. Each cell block represents a homogeneous hydrogeologic sub-unit of the hydrostratigraphic unit. Finer grids (5 m x 5 m) were used around the proposed open-pit and in areas of specific interest.

5.2.3 Model Setup and Layering

In order to capture the regional and local flow of groundwater and physical changes caused by mining, the numerical models were designed to include the groundwater flow domains. Two layers identified in the conceptual model, were modelled as individual layers (Table 5-1).

Table 5-1 Model Layers

Layer	Descriptions
North Point	
1	Weathered Bedrock/Weathered Shear
2	Bedrock/Fresh Shear
Princess Louise	
1	Weathered Bedrock/Weathered shear
2	Bedrock/Fresh Shear

5.2.4 Distribution of Hydraulic Properties

Uniform hydraulic conductivities (permeabilities) were assigned to layers 1 and 2, but were sub-zoned, based on the interpreted distributions of: (i) weathered bedrock; (ii) shear/fracture units. Figure 12 shows the distribution of permeability in the model for North Point and Figure 13 shows the distribution for Princess Louise.

For all shear/fracture units modelled, the horizontal permeability was made anisotropic (K_y , north-south $\neq$ K_x , east-west).

5.2.5 Boundary Conditions

Since the presence of physical boundaries to groundwater flow within the model domain is largely unknown, the hydraulic boundaries were arbitrarily selected at the model perimeter, a significant distance from the areas where groundwater is removed from the model to simulate open-pit dewatering.

No recharge has been defined, as the mining is planned during the dry season at both deposits.

Section 5

Groundwater Modelling Methodology

To simulate groundwater abstraction for pit dewatering, production bores were used in each model. Scheduling the flow rates and the number of bores at each pit allowed for the determination of dewatering rates.

5.2.6 Simplifying Assumptions for Modelling

Simplifying assumptions were made in order to discretise the groundwater flow conditions into a manageable package, without sacrificing the ability to simulate features which significantly contribute to the groundwater flow regime. The assumptions used are summarised below:

Aquifer Base

The bedrock below -500 mRL (North Point) and -100 mRL (Princess Louise) does not yield water and is impermeable to groundwater flow.

Top of Model

The top of the model is the current topography (Figures 3 and 4), with the uppermost layer being unconfined.

Hydraulic Parameters and Material Types

- The calibrated hydraulic parameters are representative beyond the calibrated domain of the model;
- The permeability zoning, which is based on the published bedrock geology of the area, broadly represents the hydrogeology; and
- Only major shear and permeable fracture zones of weathered bedrock are represented in the model. In general, the fresh bedrock in the mine area has a small permeability and contains limited aquifers.

Mine Development

The mining schedule for both deposits is equally sub-divided into monthly schedules.

Model Code

MODFLOW is a groundwater flow model code for fully saturated conditions. Hydraulic conductivity does not change with the change in water content. The reduction in hydraulic conductivity in unsaturated conditions is approximated by correcting the transmissivity for changes in the saturated thickness.

5.2.7 Limitations of the Models

The developed groundwater flow model has limitations. These limitations result from generalisations, interpretations and assumptions made in attempting to simulate the interpreted hydrogeology. The model limitations include:

- MODFLOW is a fully saturated groundwater flow model code, which can lead to an overestimation of the dewatered areas;
- The area occurs within a fractured rock environment, where the only major aquifers in the bedrock are secondary structures, such as faults and shear zones in the weathered zones. The models only represent the major secondary structures (faults and shear zones) in the area; and
- The limited data surrounding the deposits and the complexities of the hydrogeological regime mean that these models should only be used as a guide to determine impact areas and the likely groundwater abstraction rates required for dewatering. The interpretation of predictive simulations should be based on the assumptions made.

Section 5

Groundwater Modelling Methodology

5.3 Model Calibration

Model calibration is used to establish that the model can reproduce measured groundwater levels and flows, both regionally and during aquifer tests.

Calibration of the model occurs in two steps and these are described below.

5.3.1 Steady State Calibration

A steady state calibration was completed by:

- Assigning estimated hydraulic properties to the various material types in the model;
- Assigning assumed groundwater levels to the model boundaries, based on topography and known groundwater levels in the modelled area; and
- Running the model under current known hydraulic conditions for an infinite time (i.e., steady-state) to establish the regional groundwater flow gradient, flow pattern and groundwater elevations in the area.
- For both North Point and Princess Louise, a flat groundwater table was applied.

5.3.2 Transient Calibration

The groundwater elevations resulting from the steady-state calibration were used as initial conditions for all transient simulations.

During the transient calibration process, the hydraulic parameters were varied in order to get the best fit of modelled drawdown to the actual drawdown measured in observation bores during aquifer tests. The transient calibration was repeated for each of the aquifer tests (North Point and Princess Louise) in the test production bores with simulated groundwater levels tracked at the observation bore locations.

Steady state calibration is presented in Figures 14 and 15 and Table 5-2 shows that observed and simulated groundwater levels are comparable for North Point and Princess Louise.

Table 5-2 Transient Calibration Results

Observation Bore	Observed Drawdown (m)	Simulated Drawdown (m)
North Point		
NPMB1	3.43	3.42
NPMB2	2.82	2.84
Princess Louise		
PLMB1	4.62	4.51
PLMB2	4.40	4.56

5.4 Predictive Simulations

With the calibrated model, simulations of the open-pit dewatering system were completed to help assess the potential impacts of dewatering on regional groundwater levels and the hydrological environment and to determine the pit dewatering requirements.

Section 5

Groundwater Modelling Methodology

In order to model the dewatering of the open-pit and to assess the environmental impacts, the model was run in transient mode, with bores used to simulate the dewatering requirements, based on the mining schedules (elevation versus time).

The dewatering scenarios investigated used a staged mining schedule (*BOPL, 2005*), in order to quantify dewatering rates in line with proposed mining schedule.

Dewatering bores were placed along the shear/fracture zones to simulate groundwater abstraction from each pit. Dewatering rates of each bore were varied in order to achieve the drawdown required during the mining schedule at each deposit.

5.5 Derived Hydraulic Parameters

One hundred transient calibration runs were completed at North Point in order to match simulated aquifer test drawdown to actual. A total of thirty five transient calibration runs were completed at Princess Louise. Table 5-3 summarises the hydraulic parameters derived from the calibrated models that broadly correspond with the values derived from the aquifer tests.

Table 5-3 Hydraulic Parameters Derived from the Calibrated Models

Material Type	Model Layer	Descriptions	Hydraulic Conductivity (Permeability)			Specific Storage	Specific Yield
			Kx	Ky	Kz		
			(m/d)	(m/d)	(m/d)	(1/m)	(-)
North Point							
1	1	Weathered Bedrock	5	5	1	2E-04	0.05
2	1	Weathered Shear	20	60	20	5E-04	0.1
3	2	Fresh Shear	20	60	20	1E-05	0.015
4	2	Bedrock	0.01	0.01	0.001	5E-06	0.007
Princess Louise							
1	1	Weathered Bedrock	0.5	0.5	0.05	5E-05	0.004
2	1	Weathered Shear	10	20	10	6E-05	0.1
3	2	Fresh Shear	2.5	4	1.4	6E-06	0.01
4	2	Bedrock	0.01	0.01	0.001	1E-06	0.001

Section 6

Groundwater Modelling Results

6.1 Estimated Dewatering Rates

Estimated dewatering rates for the North Point and Princess Louise deposits are presented in Figure 16. The rates have been estimated for both deposits using the completed depths of mining after four months, and by comparing this to the simulated drawdown observed (Section 6.3). Each production bore simulated was screened to at least 5 metres below the anticipated depth of mining.

6.1.1 North Point

Three production bores was used to simulate the required drawdown based on the mining schedule at North Point. Each bore was pumped at a rate of 692 kL/day (8 L/sec) for 120 days (4 months).

The estimated dewatering rates at North Point are 2,074 kL/day (24 L/sec), sustained throughout the anticipated mining duration of 3 months with a one month lead time prior to mining.

The long-term dewatering rates will decrease as the aquifer interval is progressively dewatered.

6.1.2 Princess Louise

One production bore was used to simulate the required drawdown based on the mining schedule at Princess Louise. The bore was initially pumped at 425 kL/day (4.9 L/sec), sustained throughout the anticipated mining duration of 3 months with a one month lead time prior to mining.

The long-term dewatering rates will decrease as the aquifer interval is progressively dewatered.

6.2 Simulated Drawdown from Open Pit Development

Figures 17 and 18 show the simulated extent of drawdown for North Point and Princess Louise after 120 days (4 months) of groundwater abstraction at the anticipated dewatering rates (Section 6.1).

6.2.1 North Point

The extent of drawdown after 4 months of abstraction at 2,074 kL/day from three production bores indicated 1 metre reductions in groundwater level between 680 and 810 m to the north and south of the planned pit, and between 360 and 425 m to the east and west. Most of the abstraction will occur from within the shear zone, weathered bedrock and permeable zones within the bedrock. By the end of mining, the groundwater level within the pit will be 15 m below the original static groundwater level or approximately 30 m below ground level.

6.2.2 Princess Louise

The extent of drawdown after 4 months of pumpage at 425 kL/day from one production bore indicated 1 metre reductions in groundwater level between 1.1 km and 2.1 km to the north and south of the planned pit, and between 700 m and 720 m to the east and west. Most of the abstraction will occur from within the shear zone, weathered bedrock and permeable zones within the bedrock.

6.3 Potential Impacts from Mine Dewatering

Based on the simulated drawdown in the groundwater modelling, bedrock/shear zone groundwater levels will be lowered in the immediate area of the open pits because of the groundwater abstraction required for mine dewatering.

Groundwater lowering associated with dewatering of the proposed pits can cause drawdown in groundwater supply bores/stock wells if these are in close proximity to the proposed pits. Based on

Section 6

Groundwater Modelling Results

current knowledge, no existing users are located within the predicted cone of depression for both North Point and Princess Louise.

Groundwater lowering associated with dewatering of the proposed pits can also impact:

- Groundwater dependent ecosystems (GDEs) such as wetlands and swamps, features that are largely supported by groundwater and the position of the water table. We are unaware of any such features near the mining developments.
- Stream flows in surface drainages, although most of the pit dewatering will occur during the dry season, when such drainages are dry.

Our preliminary assessment indicates that dewatering of the two open-pits will have little impact on the groundwater resources of the region or features that are supported by groundwater. Both of these mining developments require only minor dewatering for a relatively short period of time, which will minimise potential impacts on groundwater.

The proponent will incorporate the existing groundwater monitoring bores into a groundwater monitoring system to ensure that any groundwater-related impacts are recognised and can therefore be mitigated.

Section 7

Conclusions and Recommendations

Based on the results of the drilling and testing programmes and groundwater modelling, the following conclusions and recommendations are summarised below.

7.1 Conclusions

- Drilling and testing programmes were undertaken at both North Point and Princess Louise deposits to assist with pit dewatering design and predict groundwater drawdown associated with dewatering, through the use of a groundwater flow model.
- The hydrogeology away from the mining areas is generally unknown. The regional hydrogeology is based on regional geological maps and structures, but the groundwater model does not take all of these into account.
- The modelled areas occur in a fractured rock environment. As such, the occurrence of aquifers is structurally controlled and quite complex. We feel that the main aquifers in each deposit comprise a central shear zone in both the weathered and fresh bedrock zones. Away from the central shears we believe that only minor aquifers occur and these are mainly located in the weathered zone.
- As a result, the groundwater models are approximate but can be used to assess order of magnitude variations in groundwater level as a result of pit dewatering and the required abstraction rates to meet dewatering requirements. Calibration of both models is only based on one pumping test at each deposit.
- No wetlands or swamps are present in the vicinity the drawdown predicted by the modelling.
- Dewatering will occur during the dry season when streams in proximity to the pits are not flowing.
- Dewatering discharge at Princess Louise is to be used for dust suppression purposes during the life of mining. Water quality is fresh, however the groundwater is slightly elevated in arsenic and iron concentrations.
- Due to the dewatering rates required at North Point, not all of the dewatering discharge can be used for dust suppression. Therefore, other water disposal options will need to be considered, such as evaporation ponds or irrigation. Water quality is fresh, however the groundwater has elevated arsenic concentrations and slightly elevated iron concentrations.

7.2 Recommendations

- Due to the likely excessive water requirements at North Point, the preferred water disposal options need to be determined.
- Incorporate the existing monitoring and production bores at the deposits into a groundwater monitoring programme and monitor throughout the life of the mining.
- As part of licensing requirements, it will probably be necessary to regularly monitor the performance of the dewatering systems (abstraction rates, groundwater levels) and the groundwater monitoring network for environmental reasons. This monitoring is recommended because it will also be advantageous to maintain relatively dry and efficient mining conditions by optimising dewatering system performance.
- At this stage, the design of the dewatering systems is preliminary. As mining schedules and mine designs become more definitive, it is recommended that the dewatering designs are refined.

Section 8

References

Burnside Operation Pty Ltd (BOPL) (2006), Mine Management Plan – Cosmo Project Area, July 2006

Burnside Operations Pty Ltd (BOPL) (2005), Brocks Creek and Cosmo Open Pit Mining Study April 2005.

Northern Territory Geological Survey (NTGS), (2006), Pine Creek SD 52-8, Metallogenic Map Series Explanatory Notes and Mineral Deposit Data Sheets, Department of Mines and Energy, Northern Territory Government, 1993.

Section 9

Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of GBS Australia Pty Ltd and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 6 September 2006 (3036133).

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 22 January 2007 and 23 February 2007 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing or other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. The borehole logs indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of conditions as constrained by the project budget limitations. The behaviour of groundwater and some aspects of contaminants in soil and groundwater are complex. Our conclusions are based upon the analytical data presented in this report and our experience. Future advances in regard to the understanding of chemicals and their behaviour, and changes in regulations affecting their management, could impact on our conclusions and recommendations regarding their potential presence on this site.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, URS must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

Appendix A

Bore Completion Diagrams

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MONITORING WELL NPPB1

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08 8980 2900
08 8941 3920

Project
No.: **42213762**

Project
Reference: **Burnside Operations**

ENVIRO_WELL_ADELAIDE_WCC_AUS.GDT J:\JOBS\42213762\BORE LOGS\LOGS NORTH POINT.GPJ 23/2/07

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airflow (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS	
			S	M	HR									
22	Hammer						GRYW							Pre-collar - 254mm
23							TUFF	TUFF: silt with gravel, dark grey, up to 5mm in diameter, angular to subangular	D/M					
24								decreased silt component, increased gravel component up to 25mm in diameter water cut at 24m bgl	W	10l/sec		24m bgl: 366 uS/cm 7.35 pH		
25														
26								decreasing silt component with depth	M					
27														203mm diameter slotted steel casing
28										8l/sec		28m bgl: 174.4 uS/cm 7.6 pH		
29														
30														
31														
32														
33								gravels up to 10mm in diameter, angular, well sorted, pale grey	W					

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Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS		
			S	M	HR										
34	Hammer						TUFF	gravels up to 15mm in diameter, angular, poorly to well sorted	W						
35															
36							GRYW	GRAYWACKE: silt with gravel, gravels up to 10mm in diameter, grey colour	W	2l/sec		36m bgl: 186.1 uS/cm 7.86 pH			
37								increased gravel component up to 20mm in diameter, dark grey colour	W						
38								decreased gravel component	W						
39								decreased gravel component up to 10mm in diameter	W						
40								pyrite crystals up to 3mm in diameter	W	2l/sec		40m bgl: 168.2 uS/cm 7.86 pH			
41								gravels up to 20mm in diameter, angular	W						
42								gravels up to 15mm in diameter, angular	W	8l/sec		42m bgl: 153.8 uS/cm 7.69 pH			
43															
44															
45															

203mm
diameter slotted
steel casing

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Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airflow (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS		
			S	M	HR										
46	Hammer						GRYW								
47															
48							MUDS	MUDSTONE: silt with gravel, quartz gravels up to 30mm in diameter, poorly sorted	W		16l/sec	48m bgl: 163.9 uS/cm 8.05 pH			
49								decreased quartz gravels	W						
50								gravels up to 5mm in diameter, well sorted	W						
51							TUFF	TUFF: silt with gravel, gravels up to 15mm in diameter, poorly sorted	W						
52															
53															
54								gravels up to 40mm in diameter	W		20l/sec	54m bgl: 153.4 uS/cm 7.39 pH			
55															
56								increase in gravel component	W						
57															

203mm diameter slotted steel casing

MONITORING WELL NPPB1

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Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS		
			S	M	HR										
58	Hammer						TUFF	decreased gravel component	W						
59								increase in gravel component, up to 15mm in diameter	W						
60								quartz vein, quartz gravel up to 100mm in diameter in fine silt, increased water production ~ 25 to 30 L/Sec	W						
61								End of Hole at 61m bgl							End Cap
62															
63															
64															
65															
66															
67															
68															
69															

[illegible]

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Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airflow (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS		
			S	M	HR										
34	Hammer						GRYW	fine to coarse grain sand, minor silt gravels up to 30mm in diameter, well sorted, higher percentage of gravels than sand	W	6l/sec		34m bgl: 98.8 uS/cm 6.07 pH			
35								foam injected at 34m bgl							
36										6l/sec		36m bgl: 26.8 uS/cm 6.5 pH			
37															
38															
39															
40															
41								fine to coarse grain sand, grey in color, gravels up to 15mm in diameter	W						
42										6l/sec		42m bgl: 125.6 uS/cm 7.33 pH			
43								increased sand component, decreased gravel component, minor silt	W						
44								increased gravel component (quartz), up to 50mm in diameter	W						
45								decreased gravel component, minor silt	W						

50mm diameter solid PVC casing.

Gravel - 5mm diameter rounded gravel pack

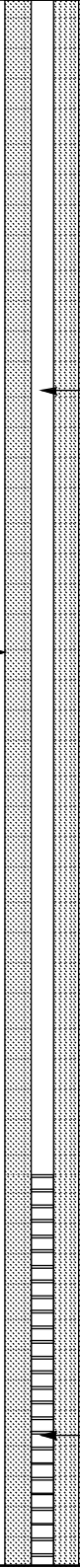
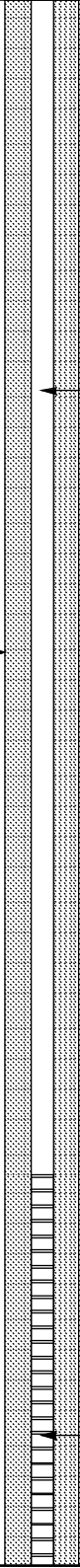
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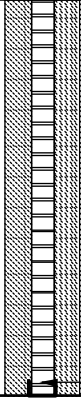
Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airflow (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS	
			S	M	HR									
46	Hammer						GRYW	increased gravel component	W				 50mm diameter solid PVC casing. Gravel - 5mm diameter rounded gravel pack 50mm diameter slotted PVC casing	
47								gravels up to 30mm in diameter	W					
48								decreased gravel component	W	6l/sec		48m bgl: 168.8 uS/cm 7.05 pH		
49														
50														
51														
52								approximately 20% gravels up to 15mm in diameter	W					
53								decreased gravel component	W					
54								fine to very coarse grain sand, some gravels up to 15mm in diameter, dark grey color	W	6l/sec		54m bgl: 133 uS/cm 7.25 pH	 50mm diameter slotted PVC casing	
55														
56								coarse grain gravel, pebbles up to 35mm in diameter	W					
57								increased gravel size, up to 70mm in diameter	W					

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Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airflow (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS
			S	M	HR								
58	Hammer						GRYW	reduced gravel component	W				
59													
60										6l/sec		60m bgl: 130.1 uS/cm 7.34 pH	
61								End of Hole at 61m bgl					
62													
63													
64													
65													
66													
67													
68													
69													

URS Australia Level 3, 93 Mitchell Street, Darwin	08 8980 2900 08 8941 3920	Project Reference: Burnside Operations	Client: Burnside Operations
Drilling Contractor: Bores NT		Project No.: 42213762	Location: North Point
Logged By: BMW	Bore Size: 146 mm	Relative Level: 123.36	Drill Type: Down hole hammer
Checked By: CMH	Total Depth: 67.00 m	Coordinates: 8507060.67 mN	Drill Model: MK6
Date Started: 10-12-06	Casing Size: mm	775781.01 mE	Drill Fluid: Foam
Date Finished: 11-12-06		Permit No: RN35484	

Depth (m)	Method	Casing	Penetration	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS
0			S M HR		ML	SILT with SAND: very fine grain sand, cream/ tan colour, minor gravels up to 5mm in diameter	D				Standpipe
1											PVC cap
2					TUFF	TUFF: silt and sand with gravel up to 20mm in diameter, grounded to sub rounded, dark grey in colour	D				Cement topseal
3					SILTS	SILTSTONE: minor gravels up to 10mm in diameter, grey colour	D				Pre-collar - 254mm
4											Gravel - 5mm diameter rounded gravel pack
5						silt grey/tan colour, minor gravels up to 5mm diameter, slightly friable	D				Bentonite plug
6					SILTS	SILTSTONE: silt grey/tan, minor gravels up to 5mm diameter	D				
7											
8						silt with sand and minor gravels up to 3mm in diameter, light brown/tan/red colour	D				50mm diameter solid PVC casing.
9					GRYW	GRAYWACKE: silt with gravel, gravels up to 10-15mm in diameter, well sorted, pale grey/tan colour	D				

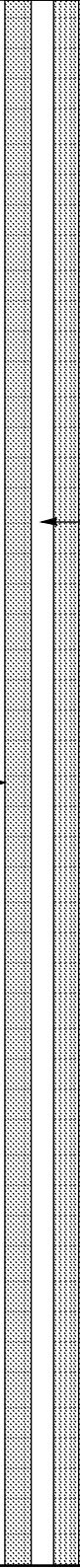
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No.: **42213762**

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Reference: **Burnside Operations**

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Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS	
			S	M	HR									
10	Hammer					x x x x x x x x x x	SILTS	SILTSTONE: silt, minor gravels up to 1mm in diameter, pale grey/tan	D/M					
11						x x x x x x x x x x								
12						x x x x x x x x x x	SILTS	SILTSTONE: silt, minor gravels up to 7mm in diameter, pale grey/, slightly friable	D/M					
13						x x x x x x x x x x								
14						x x x x x x x x x x	SILTS	SILTSTONE: silt with minor sand gravels up to 1mm in diameter, tan colour	D/M					
15						x x x x x x x x x x								
16						x x x x x x x x x x	SILTS	SILTSTONE: silt, minor gravels up to 2mm in diameter, grey colour	D/M					
17						x x x x x x x x x x								
18						x x x x x x x x x x		silt, minor gravels up to 2mm in diameter, dark grey colour	D/M					
19						x x x x x x x x x x		silt, minor gravels up to 2mm in diameter, lighter grey colour	D/M					
20						x x x x x x x x x x								
21						x x x x x x x x x x								

50mm diameter solid PVC casing.

Gravel - 5mm diameter rounded gravel pack

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Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS	
			S	M	HR									
34	Hammer						GRYW	increasing gravels up to 5mm diameter, well sorted, coarse sand	W					50mm diameter solid PVC casing.
35														
36							TUFF	TUFF: sand with silt and gravel, fine to coarse grain sand, minor gravels up to 4mm in diameter, dark grey colour	W					
37														
38								sand with silt and gravel, fine to coarse grain sand, minor gravels up to 2mm in diameter	W					
39	Hammer									7l/sec	40m bgl: 395 uS/cm 9.25 pH	Gravel - 5mm diameter rounded gravel pack		
40														
41							GRYW	GRAYWACKE: gravel and sand, fine to coarse grain sand, gravels up to 25mm in diameter	W					
42														
43														
44	Hammer							gravel and sand, fine to coarse grain sand, gravels up to 10mm in diameter	W					
45														

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08 8941 3920

Project
No.: **42213762**

Project
Reference: **Burnside Operations**

ENVIRO_WELL_ADELAIDE_WCC_AUS.GDT J:\JOBS\42213762\BORE LOGS\LOGS NORTH POINT.GPJ 23/2/07

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture		Water Depth (m)	Airflow (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS		
			S	M	HR											
46							GRYW				6l/sec		46m bgl 228 uS/cm 8.3 pH			
47							TUFF	TUFF: sand with gravels, very fine to medium grain sand, minor gravels up to 60mm in diameter, minor silt	W							
48																
49																
50																
51																
52							GRYW	GRAYWACKE: gravel with sand, minor silt component, gravels up to 25mm in diameter, well to poorly sorted	W		6l/sec		52m bgl: 176.2 8.22 pH	Gravel - 5mm diameter rounded gravel pack		
53																
54								gravel with sand, gravels well to poorly sorted, up to 10mm in diameter	W							
55								gravel with sand, gravels well to poorly sorted, up to 20mm in diameter	W							
56																
57																

50mm diameter solid PVC casing.

Drill Type: **Down hole hammer**
Drill Model: **MK6**
Drill Fluid: **Foam**

ENVIRO_WELL_ADELAIDE WCC_AUS.GDT J:\JOBS\42213762\BORE LOGS\GBS BORE LOGS.GPJ 23/2/07

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Project
No.: **42213762**

Project
Reference: **Burnside Operations**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS			
			S	M	HR											
10	Hammer						GRYW									
11								gravels up to 8mm in diameter, medium grey colour	D							Pre-collar - 254mm
12								increase in gravel component, up to 10mm in diameter	D							
13																
14																
15							TUFF	TUFF: silt with minor gravels up to 8mm in diameter, tan/cream/grey colour	D							
16							GRYW	GRAYWACKE: silt with gravels up to 8mm in diameter, pink colour	D							
17								gravels up to 6mm in diameter, grey/tan colour	D							203mm diameter solid steel casing
18							TUFF	TUFF: silt with minor gravels up to 5mm in diameter, pink/tan colour	D							
19								gravels up to 15mm in diameter, medium grey colour	D							
20								decreased gravel component	D							
21								decreased gravel component, up to 5mm in diameter	D							Packer at 21m bgl

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Project
No.: **42213762**

Project
Reference: **Burnside Operations**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS		
			S	M	HR										
22	Hammer						TUFF	decreased gravel component, up to 20mm in diameter, pale grey	D						
23															
24								decreased gravel component, up to 15mm in diameter	D						
25								gravels up to 8mm in diameter, pale grey colour	D						
26								decreased gravel component, up to 9mm in diameter, pale grey colour	D						
27															
28															
29								decreased gravel component, up to 7mm in diameter, pale grey colour	D/M						
30								decreased gravel component, up to 6mm in diameter, pale grey colour	M/W						
31								gravels up to 20mm in diameter water cut at 31m bgl	W						
32															
33								decreased silt component, gravels up to 17mm in diameter, well sorted	W						

Standing water level at 26.0m TOC at 18/1/07

203mm diameter slotted steel casing

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Project
No.: **42213762**

Project
Reference: **Burnside Operations**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS		
			S	M	HR										
34	Hammer						TUFF	gravels up to 20mm in diameter	W						
35															
36								decrease in gravel component, increased in silt component	W	2l/sec		36m bgl: 225 uS/cm 6.77 pH			
37							GRYW	GRAYWACKE: silt with gravel, gravels up to 15mm in diameter, grey colour	W						
38															
39								gravels up to 2mm in diameter, very fine to coarse grain sand, grey colour	W						
40								gravels up to 10mm in diameter	W						
41															
42										3l/sec		42m bgl: 224.4 uS/cm 6.99 pH			
43															
44															
45							TUFF	TUFF: silt with gravel and sand, gravels up to 18mm in diameter, well sorted	W						

203mm diameter slotted steel casing

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Project
No.: **42213762**

Project
Reference: **Burnside Operations**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airflow (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS		
			S	M	HR										
46	Hammer						TUFF								
47															
48							GRYW	GRAYWACKE: sand with silt and gravel, gravels up to 3mm in diameter	W			48m bgl			
49															
50								increase in gravel component, gravels up to 8mm in diameter	W						
51							MUDS	MUDSTONE: silt with sand and gravel, very fine to coarse grain sand, gravels up to 30mm in diameter	W						
52								decrease in gravel component, gravels up to 10mm in diameter	W						
53															
54												54m bgl			
55								gravels up to 15mm in diameter	W						
56															
57							GRYW	GRAYWACKE: silt with sand and gravel, gravels up to 8mm in diameter	W						

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Project
No.: **42213762**

Project
Reference: **Burnside Operations**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)		Sample Parameters	WELL CONSTRUCTION DETAILS		
			S	M	HR					Water Depth (m)	Airift (/sec)				
58	Hammer						GRYW								
59								evidence of oxidation	W						
60															
61															
62															
63															
64								minor oxidation	W						
65															
66								minor oxidation	W						
67															
68															
69								gravels up to 5mm diameter, evidence of oxidation	W						

☒ Foam 62m bgl

☒ 3l/sec 68m bgl:
400 uS/cm
7.3 pH

203mm
diameter slotted
steel casing

ENVIRO_WELL_ADELAIDE WCC_AUS.GDT J:\JOBS\42213762\BORE LOGS\GBS BORE LOGS.GPJ 23/2/07

MONITORING WELL PLMB1

URS Australia Level 3, 93 Mitchell Street, Darwin	08 8980 2900 08 8941 3920	Project Reference: Burnside Operations	Client: Burnside Operations
Drilling Contractor: Bores NT		Project No.: 42213762	Location: Princess Louise
Logged By: BMW	Bore Size: 146 mm	Relative Level: 146.06	Drill Type: Down hole hammer
Checked By: CMH	Total Depth: 73.00 m	Coordinates: 8504750.83 mN 775495.74 mE	Drill Model: MK6
Date Started: 1-5-07	Casing Size: mm	Permit No: RN35487	Drill Fluid: Foam
Date Finished: 1-6-07			

Depth (m)	Method	Casing	Penetration	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS
0			S M HR		SILTS	SILTSTONE: silt with gravels up to 30mm in diameter	D				Standpipe
1						gravels up to 20mm in diameter	D				PVC cap
2											Cement topseal
3											
4						gravels up to 30mm in diameter, grey colour	D				Gravel - 5mm diameter rounded gravel pack
5											Bentonite plug
6											
7											
8											
9	Hammer				TUFF	TUFF: silt with minor gravels, gravels up to 5mm in diameter, orange colour	D				50mm diameter solid PVC casing

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Project
No.: **42213762**

Project
Reference: **Burnside Operations**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS
			S	M	HR								
10	Hammer						TUFF	gravels up to 10mm in diameter, 80% gravels 1 to 5mm in diameter, grey colour	D				50mm diameter solid PVC casing. Gravel - 5mm diameter rounded gravel pack Standing water level at 21.45 m TOC at 18/1/07
11													
12							TUFF	TUFF: silt with gravel, gravels up to 5mm in diameter, pale brownish/red colour	D				
13								gravel up to 5mm in diameter, dark brown/red colour	D				
14													
15								very fine silt, minor gravels up to 3mm in diameter	D				
16													
17							GRYW	GRAYWACKE: silt with gravel, gravels up to 4mm in diameter, grey colour	D				
18													
19								increased gravel component, up to 15mm in diameter, grey colour	D				
20								gravels up to 5mm in diameter, tan/pink colour, well sorted, majority coarse grain sand up to 1mm in diameter	D				
21								majority coarse grain sand up to 3mm in diameter	D				

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Project
No.: **42213762**

Project
Reference: **Burnside Operations**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS	
			S	M	HR									
22	Hammer						GRYW							50mm diameter solid PVC casing. Gravel - 5mm diameter rounded gravel pack
23														
24								gravels up to 4mm in diameter, grey colour, majority silt	D					
25								increased gravel component, up to 5mm in diameter	D					
26								decreased gravel component, up to 4mm in diameter	D					
27								increased gravel component, up to 5mm in diameter	D					
28														
29														
30														
31														
32							SILTS	SILTSTONE: silt with minor gravels, gravels up to 10mm in diameter, pale grey	M/W					
33								silt with minor gravels, gravels up to 15mm in diameter, pale grey	W					

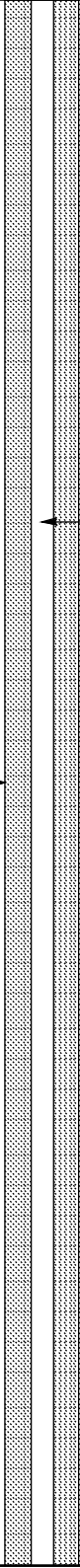
Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS	
			S	M	HR									
34	Hammer					x x								

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Project
No.: **42213762**

Project
Reference: **Burnside Operations**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture		Water Depth (m)	Airflow (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS		
			S	M	HR											
46	Hammer						MUDS	reduced weathering and oxidation, increase in gravel diameter, minor pyrite crystals evident	W		21/sec		46m bgl: 341 uS/m 8.22 pH	 50mm diameter solid PVC casing. Gravel - 5mm diameter rounded gravel pack		
47																
48								decrease in gravel component, up to 10mm in diameter, increase in silt and fine to coarse grain sand	W							
49								increase in gravel component, up to 30mm in diameter foam injected at 49m	W							
50																
51																
52								decrease in gravel component	W							
53																
54																
55								increase in gravel component, up to 30mm in diameter, majority coarse grain sand up to 3mm in diameter	W							
56								decrease in gravel component, up to 15mm, evidence of oxidation	W							
57																

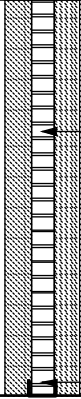
ENVIRO_WELL_ADELAIDE WCC_AUS.GDT J:\JOBS\42213762\BORE LOGS\GBS BORE LOGS.GPJ 23/2/07

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Project
No.: **42213762**

Project
Reference: **Burnside Operations**

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airift (/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS
			S	M	HR								
70	Hammer						MUDS	gravels up to 4mm in diameter	W				 50mm diameter slotted PVC casing End Cap
71								gravels up to 3mm in diameter, well sorted coarse sand with silt and very fine grain sand	W				
72								increase in gravel component, up to 25mm in diameter, evidence of oxidisation	W				
73								End of Hole at 73m bgl					
74													
75													
76													
77													
78													
79													
80													
81													

MONITORING WELL PLMB2

URS Australia Level 3, 93 Mitchell Street, Darwin	08 8980 2900 08 8941 3920	Project Reference: Burnside Operations	Client: Burnside Operations
Drilling Contractor: Bores NT		Project No.: 42213762	Location: Princess Louise
Logged By: BMW	Bore Size: 146 mm	Relative Level:	Drill Type: Down hole hammer
Checked By: CMH	Total Depth: 66.00 m	Coordinates: 6950.00 mN	Drill Model: MK6
Date Started: 1-4-07	Casing Size: mm	9694.00 mE	Drill Fluid: Foam
Date Finished: 1-8-07		Permit No: RN35489	

Depth (m)	Method	Casing	Penetration	Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS
0			S M HR		GRYW	GRAYWACKE: silt with gravel, pale tan gravels up to 30mm in diameter	D				Standpipe
1											PVC cap
2						gravels up to 13mm in diameter	D				Cement topseal
3						gravels up to 15mm in diameter	D				Gravel - 5mm diameter rounded gravel pack
4											
5											Bentonite plug
6					SILTS	SILTSTONE: silt with minor gravels, gravels up to 6mm in diameter, medium to dark grey	D				
7						gravels up to 20mm in diameter, pink/tan colour	D				
8											
9					GRYW	GRAYWACKE: silt with gravel, gravels up to 30mm in diameter, yellow/tan/orange colour	D				50mm diameter solid PVC casing

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airlift (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS
			S	M	HR								
10	Hammer					SILTS	SILTSTONE: silt with minor gravels, gravels up to 6mm in diameter, grey/pink colour	D					

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Project
No.: **42213762**

Project
Reference: **Burnside Operations**

ENVIRO_WELL_ADELAIDE_WCC_AUS.GDT J:\JOBS\42213762\BORE LOGS\GBS BORE LOGS.GPJ 23/2/07

Depth (m)	Method	Casing	Penetration			Legend	Classification	USC DESCRIPTION OF STRATA Type, plasticity / particle size, colour, secondary / minor components (e.g., "trace"), moisture content, consistency / density, and additional observations	Moisture	Water Depth (m)	Airflow (l/sec)	Sample Parameters	WELL CONSTRUCTION DETAILS		
			S	M	HR										
22	Hammer						GRYW	dark grey	D/M						
23															
24															
25							SILTS	SILTSTONE: sand with silt and minor gravels, very fine to medium grain sand, grey colour water cut at 25m bgl	W						
26															
27								gravels up to 5mm in diameter, very fine to coarse grain sand	W						
28								increase in gravel component, up to 20mm in diameter	W						
29								gravels up to 5mm in diameter	W						
30								gravels up to 10mm in diameter, minor oxidation	W		3l/sec	30m bgl: 300 uS/cm 7.5 pH			
31								gravels up to 15mm in diameter, increase in oxidation	W						
32															
33								gravels up to 8mm in diameter, evidence of oxidation, very fine to medium grain sand	W						

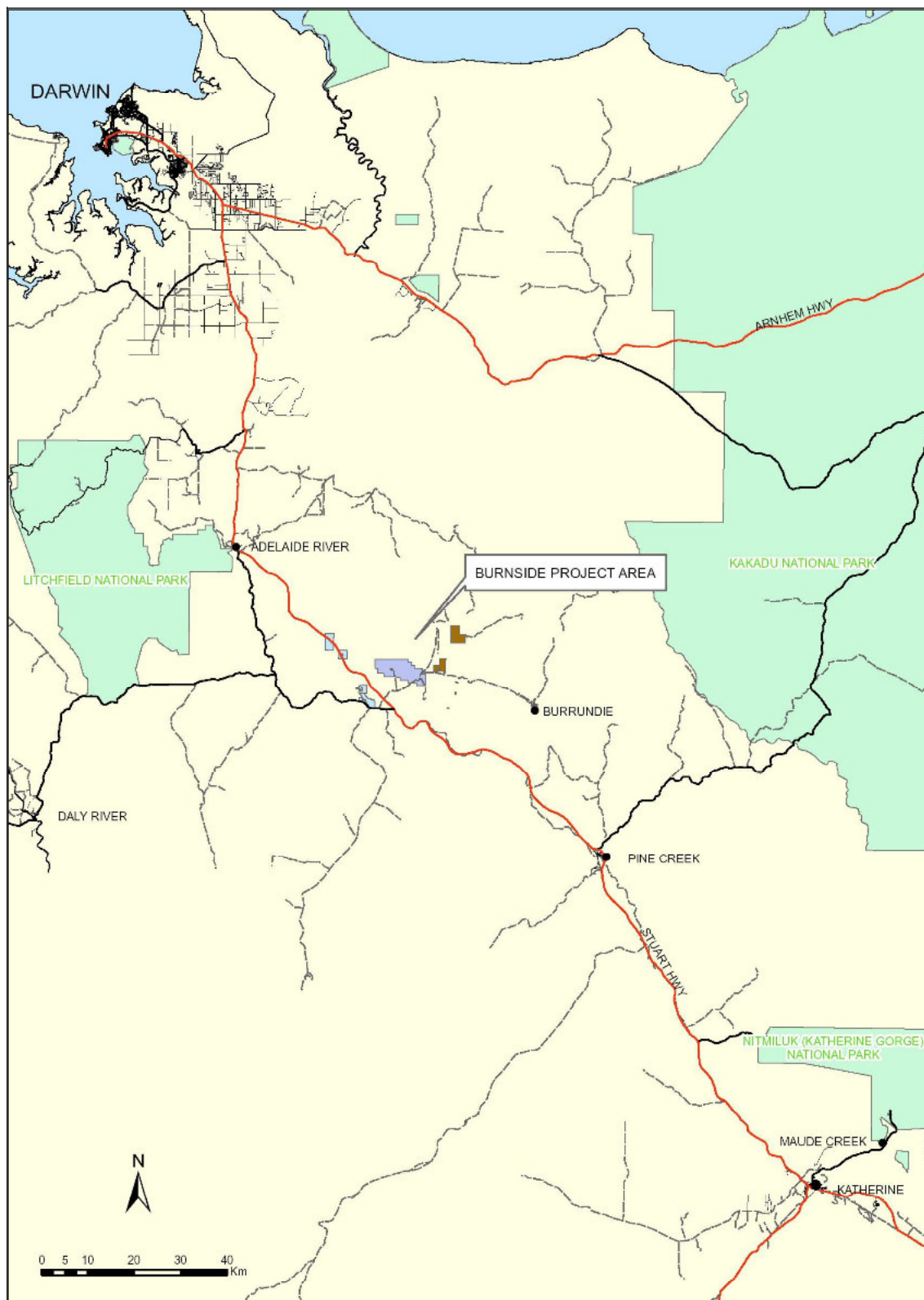
50mm diameter solid PVC casing.

Gravel - 5mm diameter rounded gravel pack

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Source: .

Client:

Burnside Operations Pty Ltd

Project:

Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development

Title:

Regional Locality Plan

URS

Drawn: CMAC

Approved: RIJV

Date: 19/1/2007

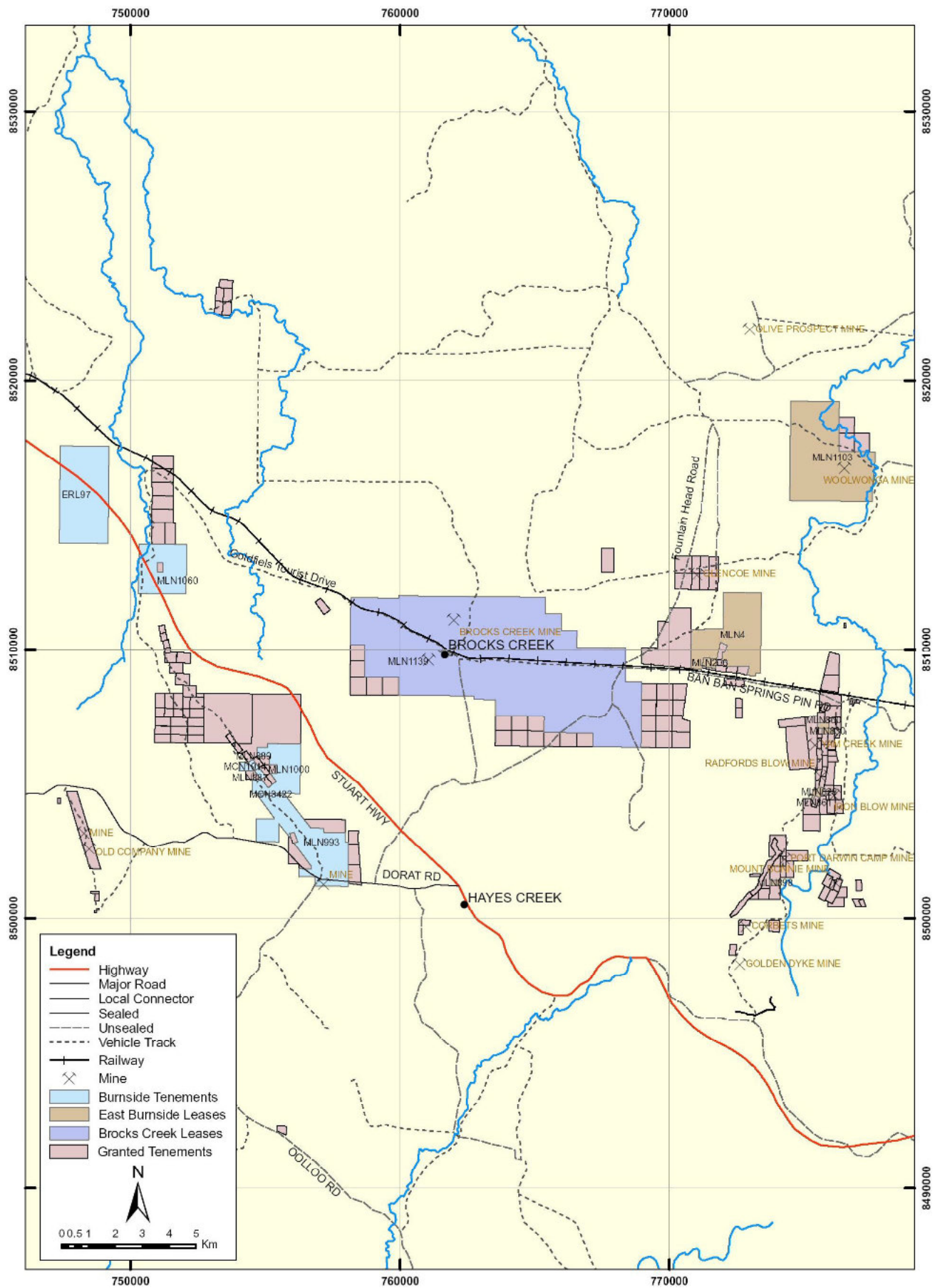
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File No: Figure 1.srf

Figure: 1

Rev A

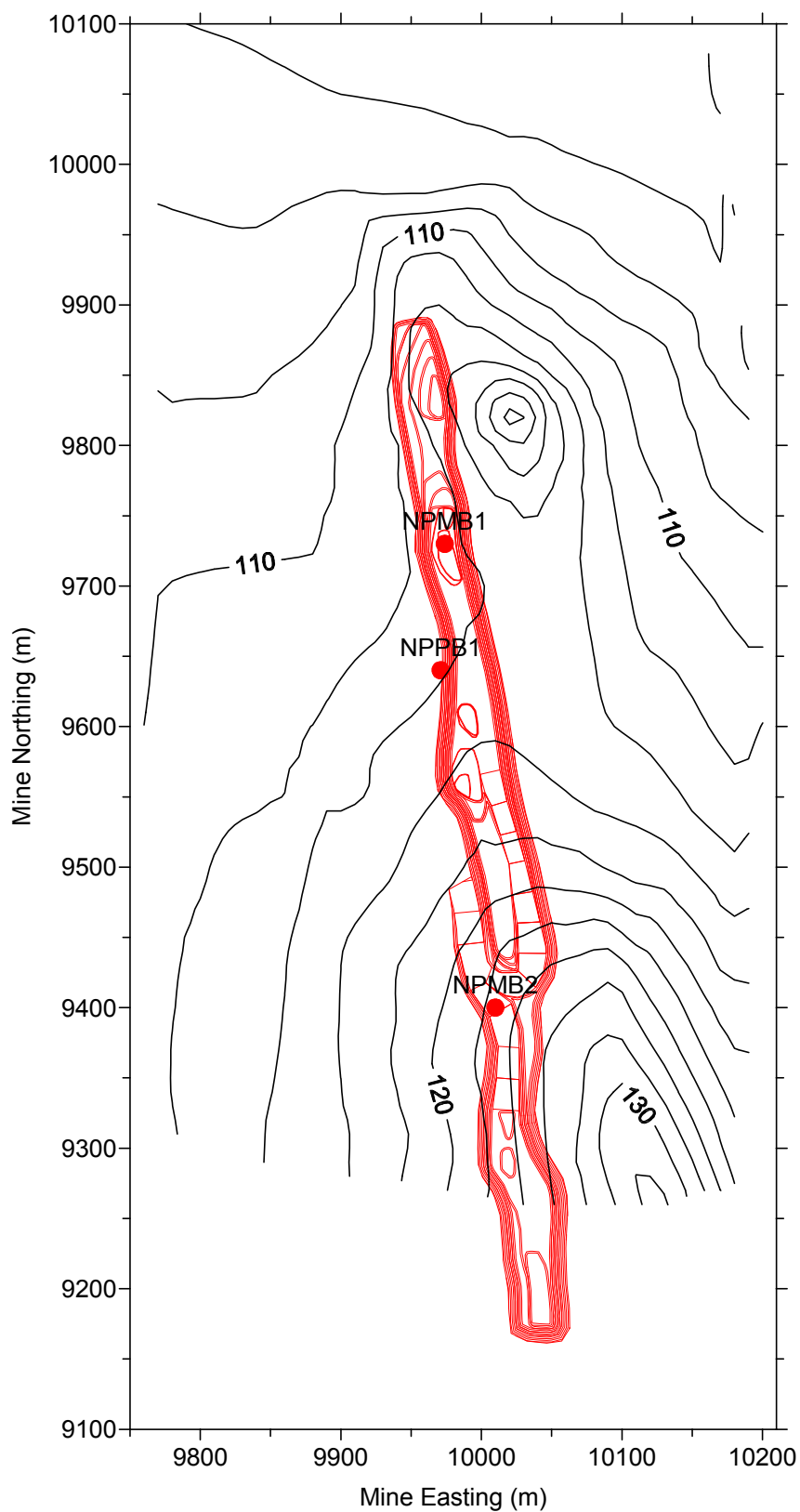
A4



Source: .

Client: Burnside Operations Pty Ltd	Project: Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development	Title: Sites and Surrounds		
	Drawn: CMAC Approved: RIJVV Date: 19/1/2007 Job No: 42213762 File No: Figure 2.srf	Figure: 2 Rev A A4		

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Source: .

Client:

Burnside Operations Pty Ltd

Project:

Hydrogeological Assessments of the North Point
and Princess Louise Deposits for Mine Development

Title:

Bore Locations - North Point

URS

Drawn: CMAC

Approved: RIJV

Date: 19/1/2007

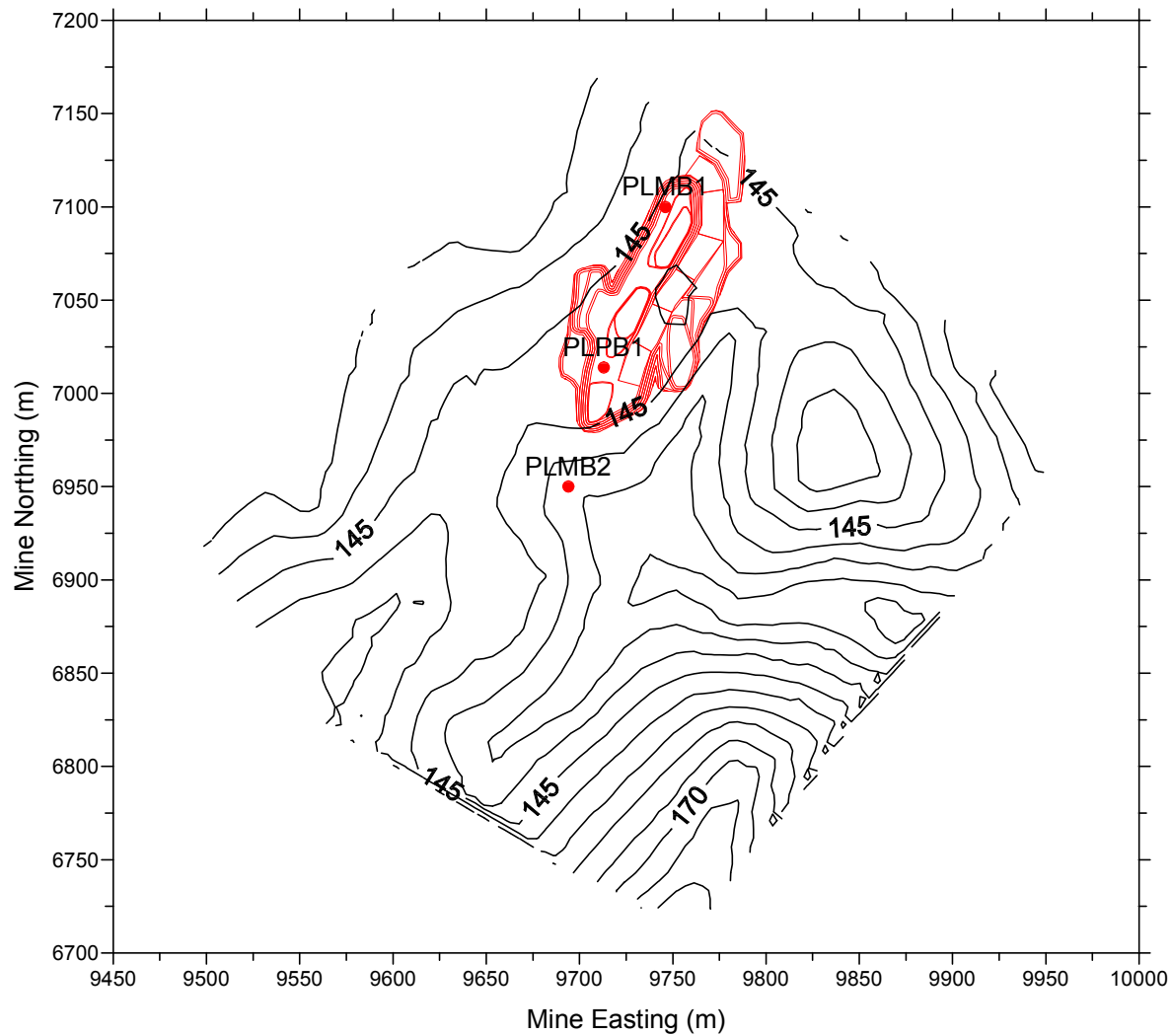
Job No: 42213762

File No: Figure 3.srf

Figure: 3

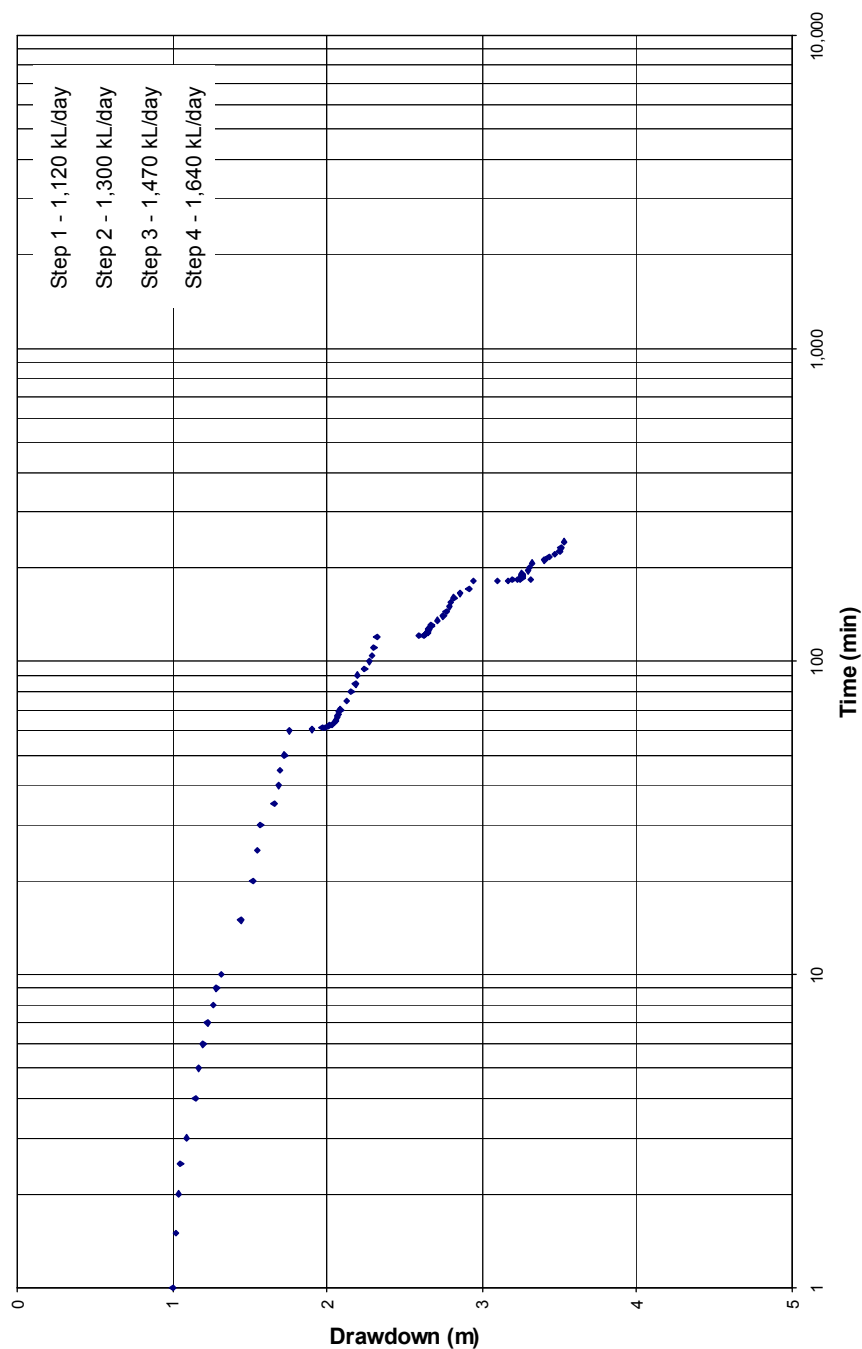
Rev A

A4



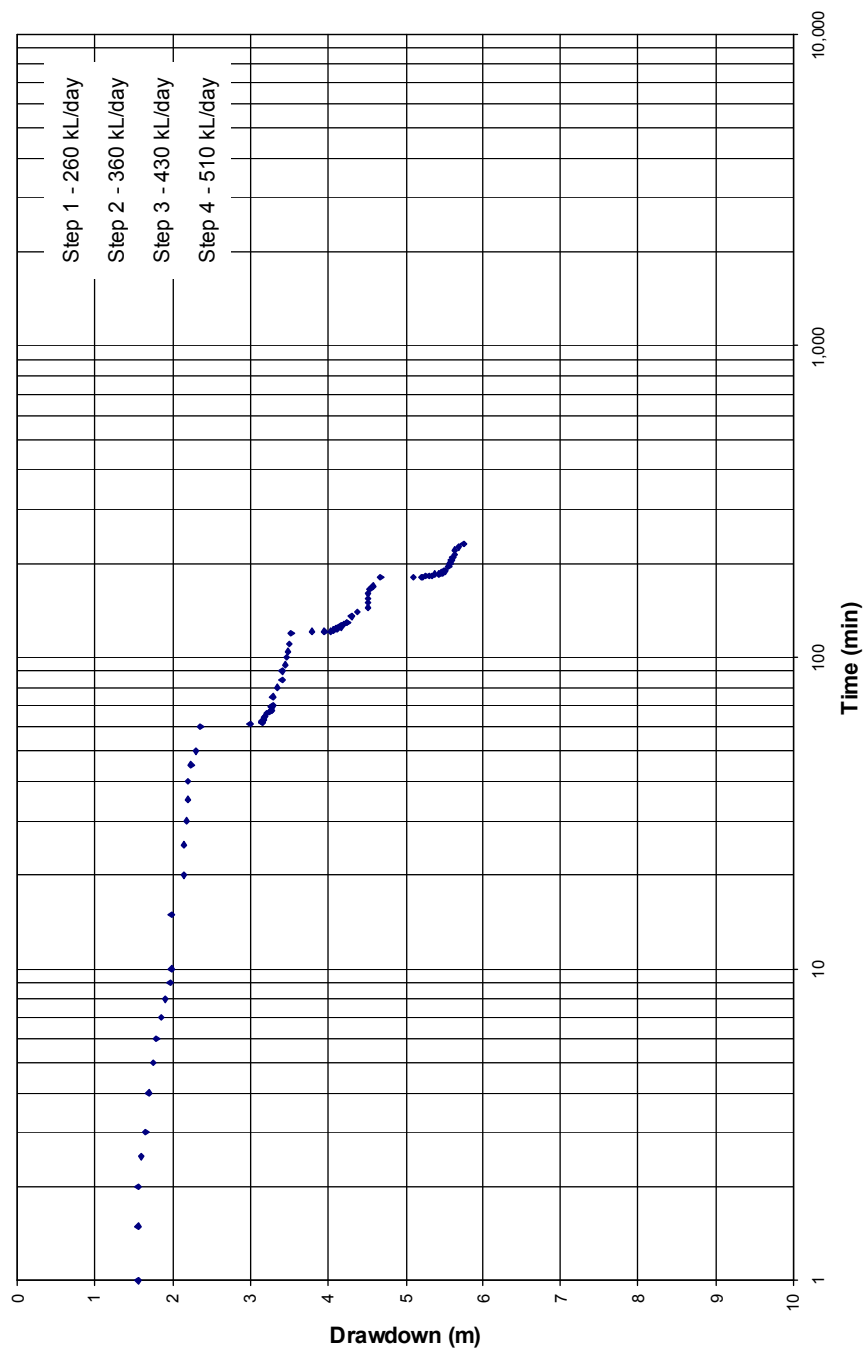
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Client: Burnside Operations Pty Ltd	Project: Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development	Title: Bore Locations - Princess Louise		
	Drawn: CMAC	Approved: RIJV	Date: 19/1/2007	Figure: 4
	Job No: 42213762	File No: Figure 4.srf		Rev A A4



Source: .

Client: Burnside Operations Pty Ltd	Project: Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development	Title: Production Bore NPPB1 Step-Rate Test		
	Drawn: CMAC	Approved: RIJV	Date: 31/1/2007	Figure: 5
	Job No: 42213762	File No: Figure 5.srf		Rev A A4



Source: .

Client:

Burnside Operations Pty Ltd

Project:

Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development

Title:

**Production Bore PLPB1
Step-Rate Test**

URS

Drawn: CMAC

Approved: RIJV

Date: 31/1/2007

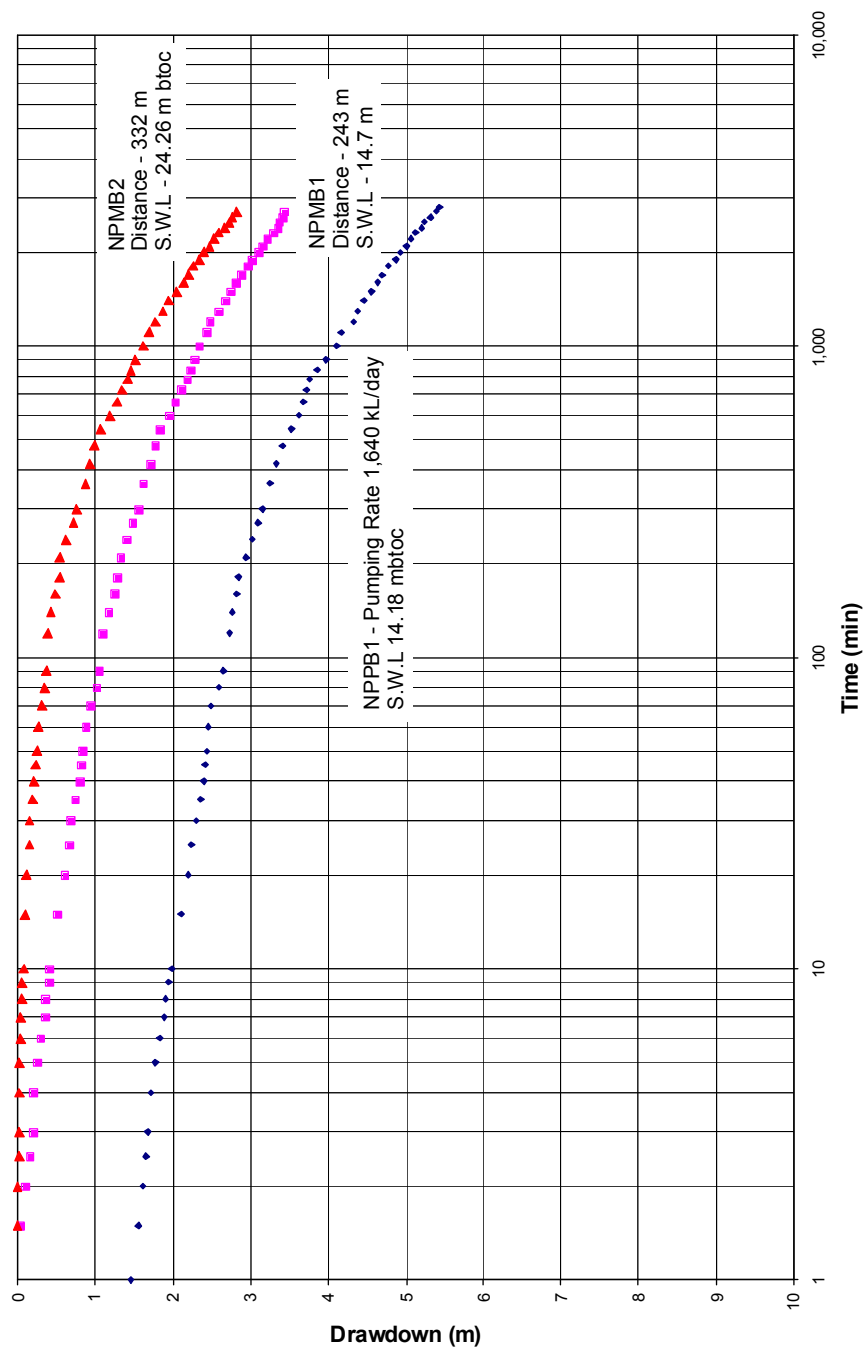
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File No: Figure 6.srf

Figure: 6

Rev A

A4



Source: .

Client:

Burnside Operations Pty Ltd

Project:

Hydrogeological Assessments of the North Point
and Princess Louise Deposits for Mine Development

Title:

**Production Bore NPPB1
Constant-Rate Test**

URS

Drawn: CMAC

Approved: RIJVV

Date: 31/1/2007

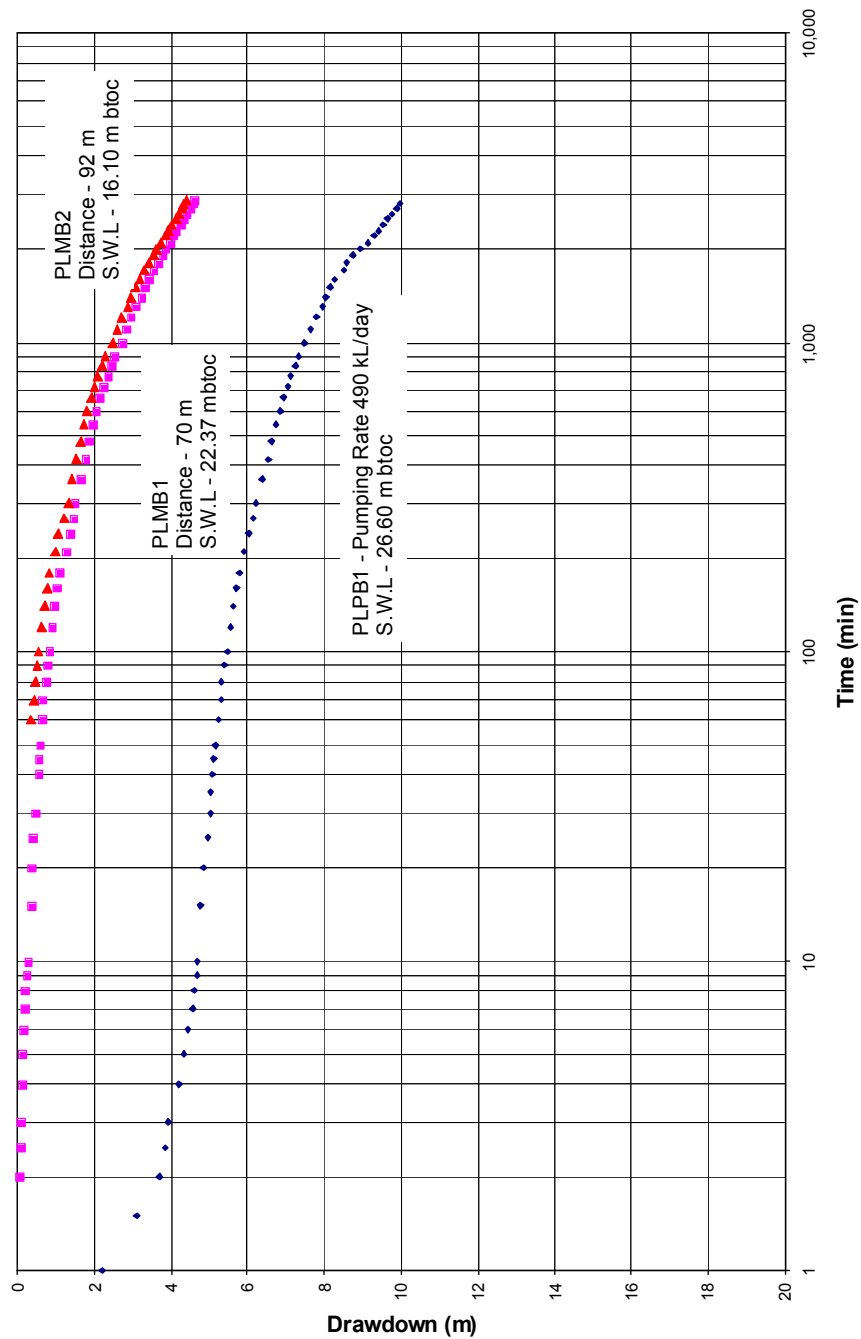
Job No: 42213762

File No: Figure 7.srf

Figure: 7

Rev A

A4



Source: .

Client:

Burnside Operations Pty Ltd

Project:

Hydrogeological Assessments of the North Point
and Princess Louise Deposits for Mine Development

Title:

**Production Bore PLPB1
Constant-Rate Test**

URS

Drawn: CMAC

Approved: RIJV

Date: 31/1/2007

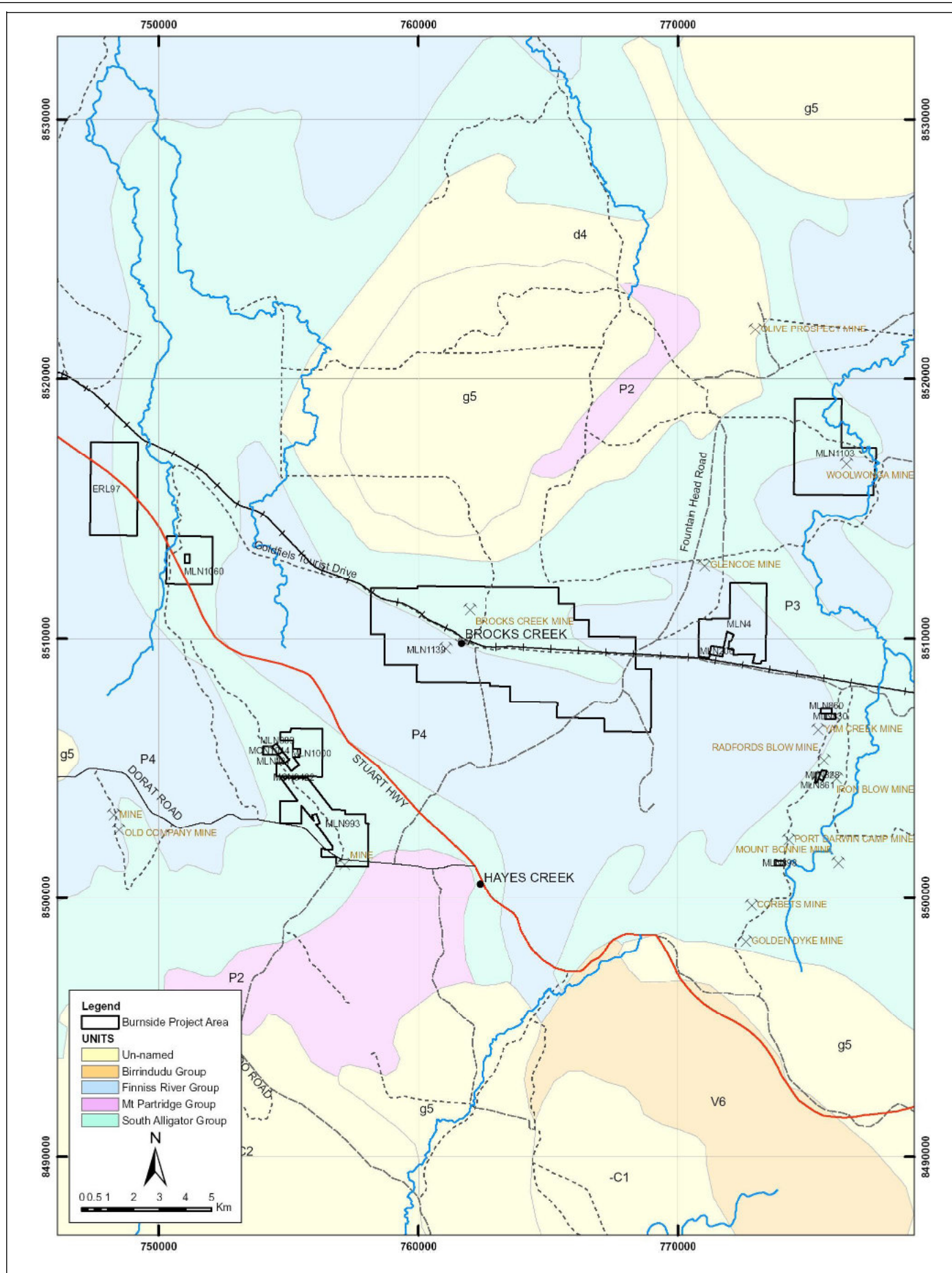
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File No: Figure 8.srf

Figure: 8

Rev A

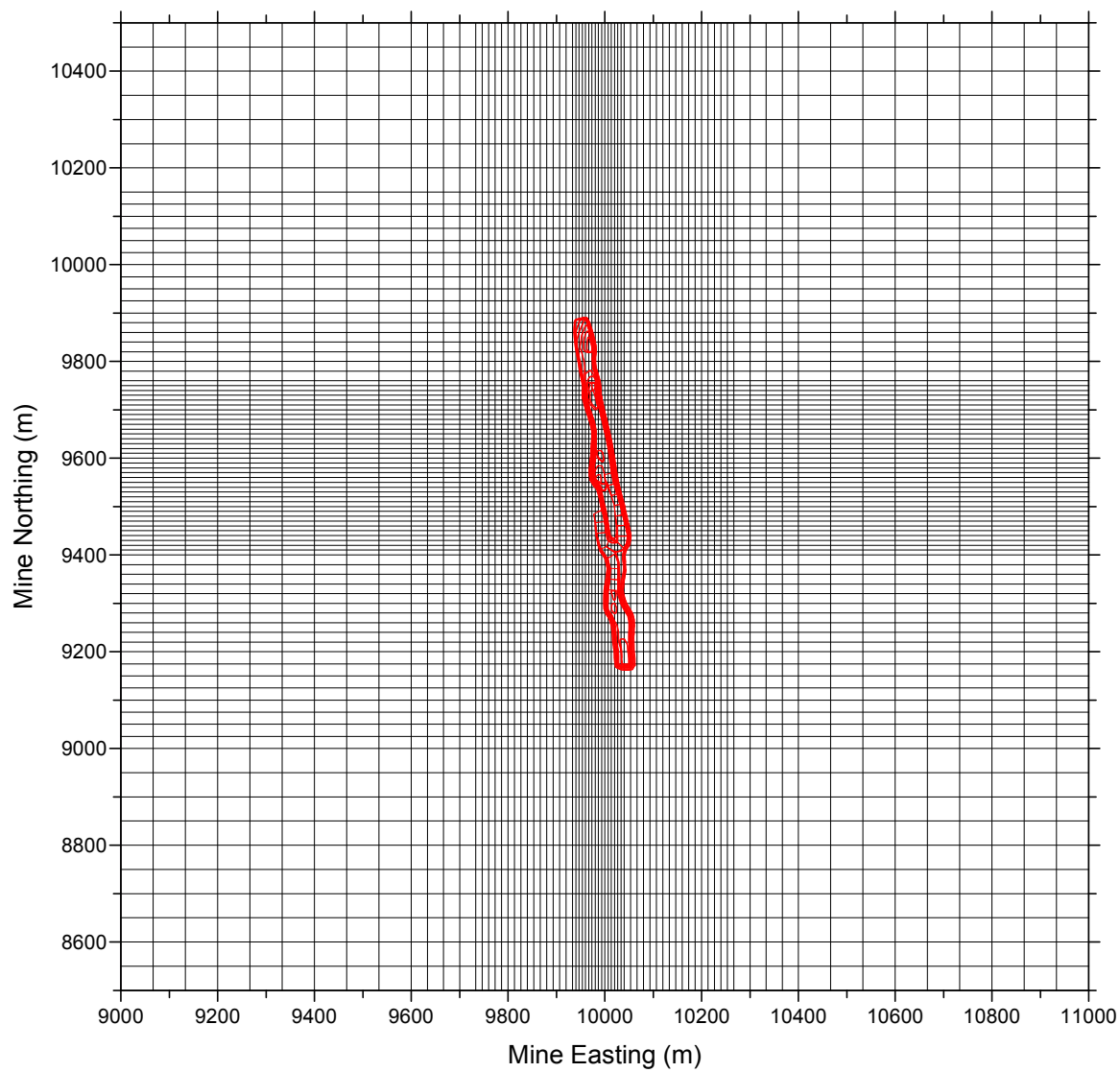
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Source: .

Client: Burnside Operations Pty Ltd	Project: Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development	Title: Regional Geology		
	Drawn: CMAC	Approved: RIJV	Date: 19/1/2007	Figure: 9 Rev A A4
	Job No: 42213762	File No: Figure 9.srf		

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Source: .

Client:

Burnside Operations Pty Ltd

Project:

Hydrogeological Assessments of the North Point
and Princess Louise Deposits for Mine Development

Title:

Model Grid - North Point

URS

Drawn: CMAC

Approved: RIJV

Date: 16/2/2007

Job No: 42213762

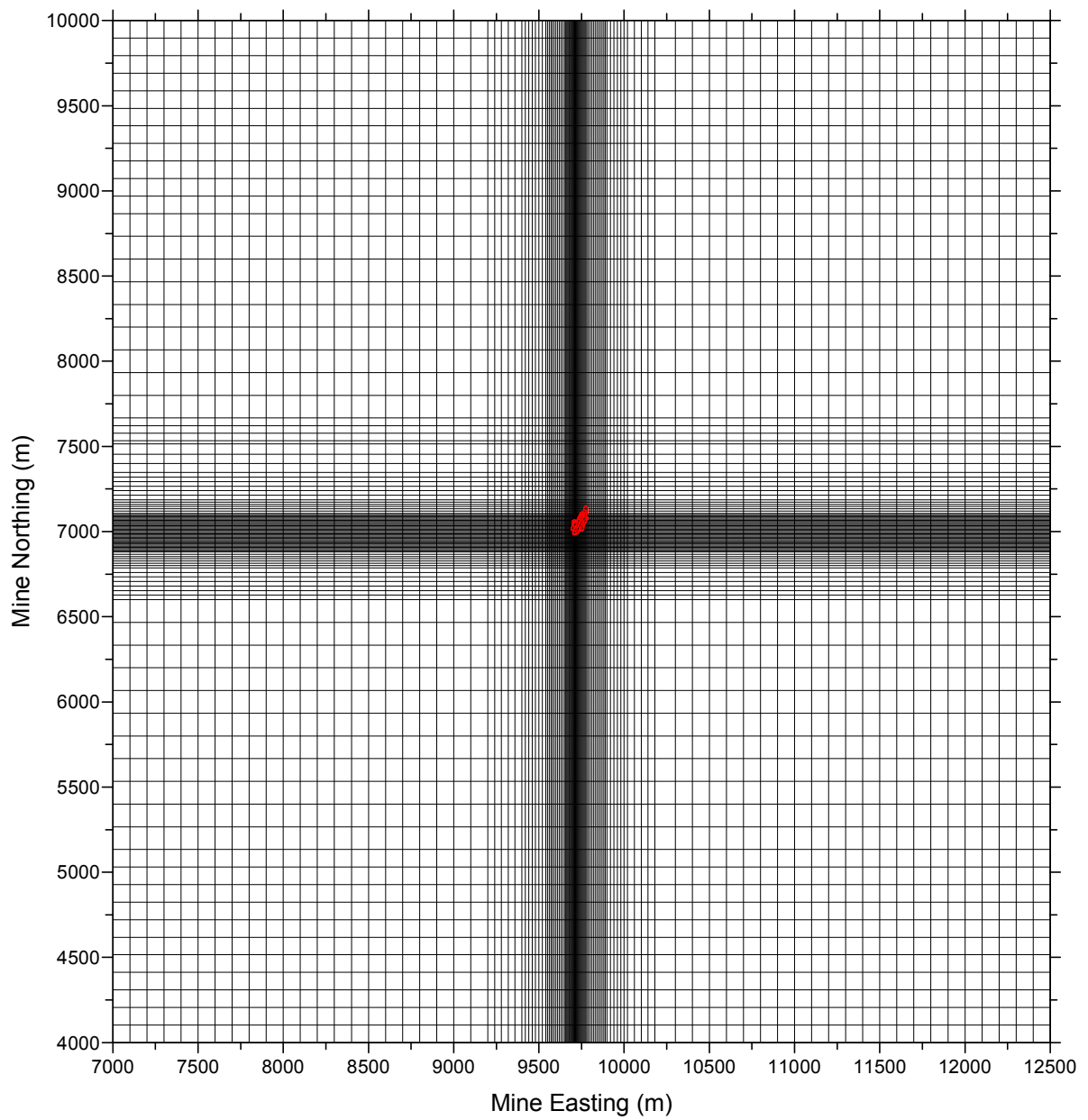
File No: Figure 10.srf

Figure: **10**

Rev A

A4

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Source: .

Client:

Burnside Operations Pty Ltd

Project:

Hydrogeological Assessments of the North Point
and Princess Louise Deposits for Mine Development

Title:

Model Grid - Princess Louise

URS

Drawn: CMAC

Approved: RIJV

Date: 16/2/2007

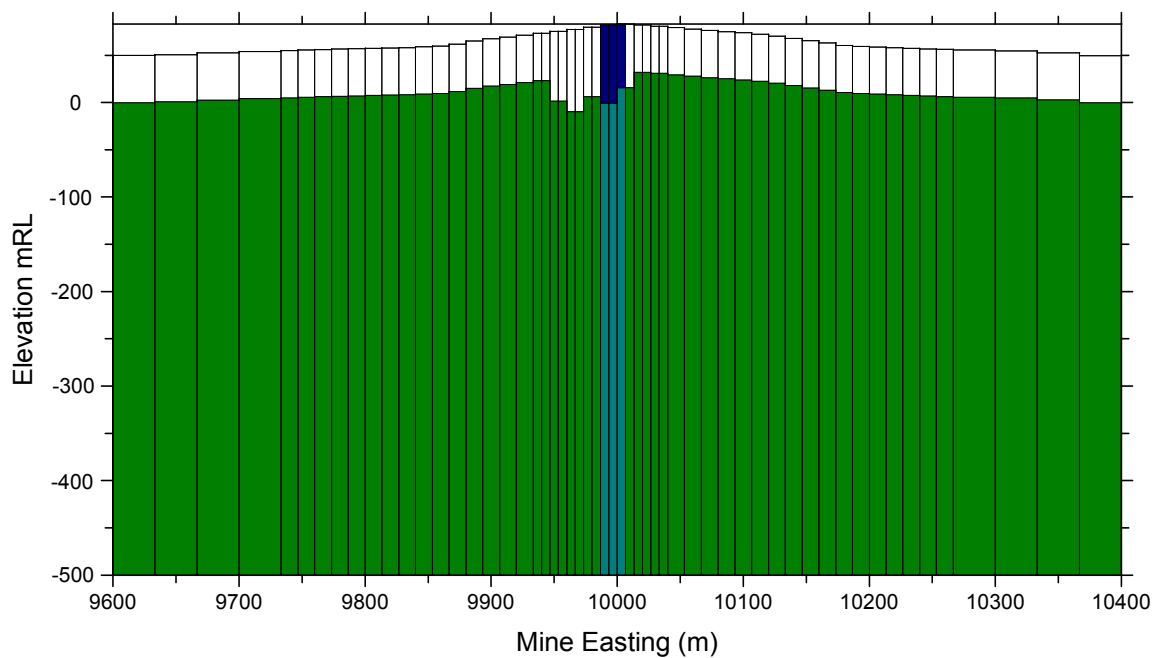
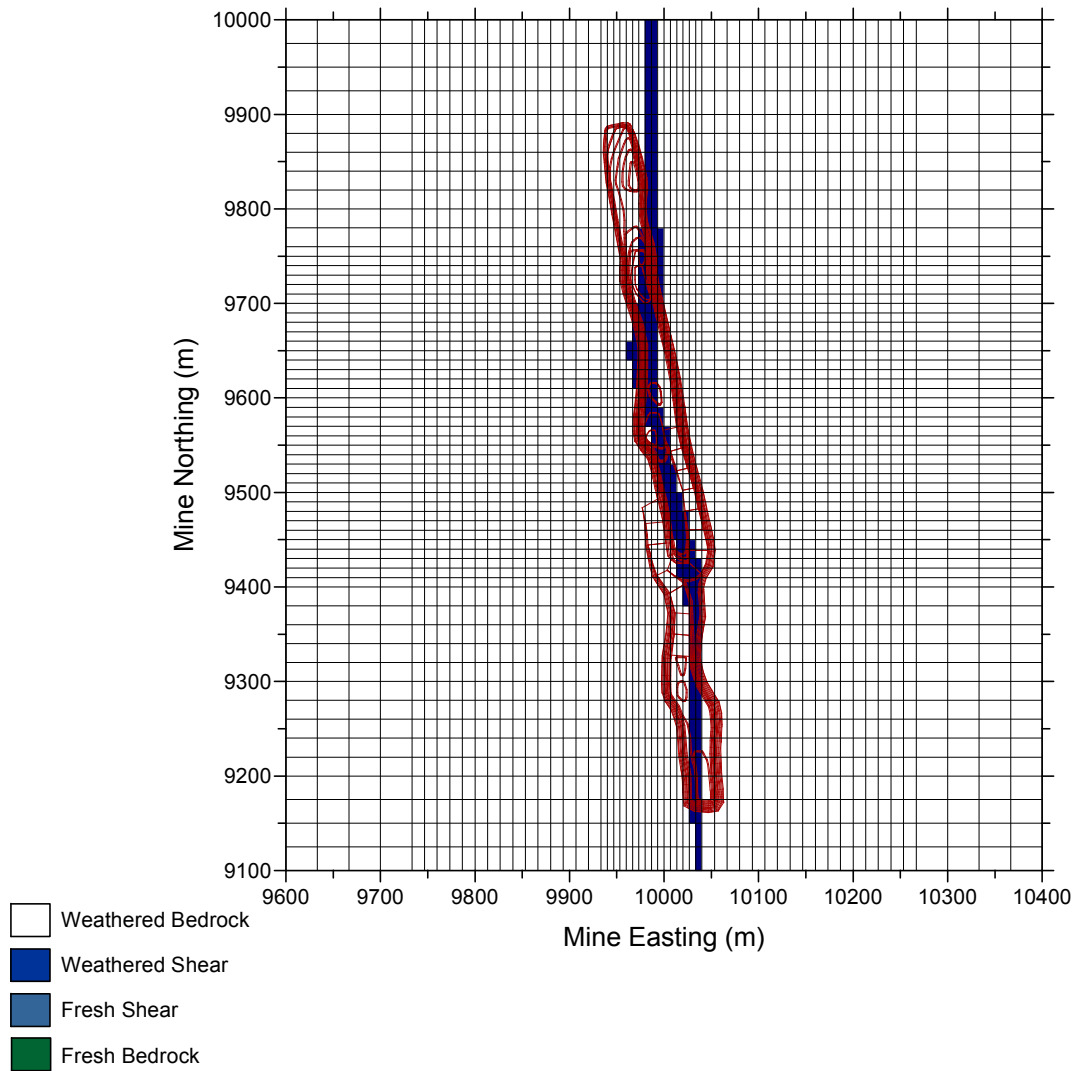
Job No: 42213762

File No: Figure 11.srf

Figure: **11**

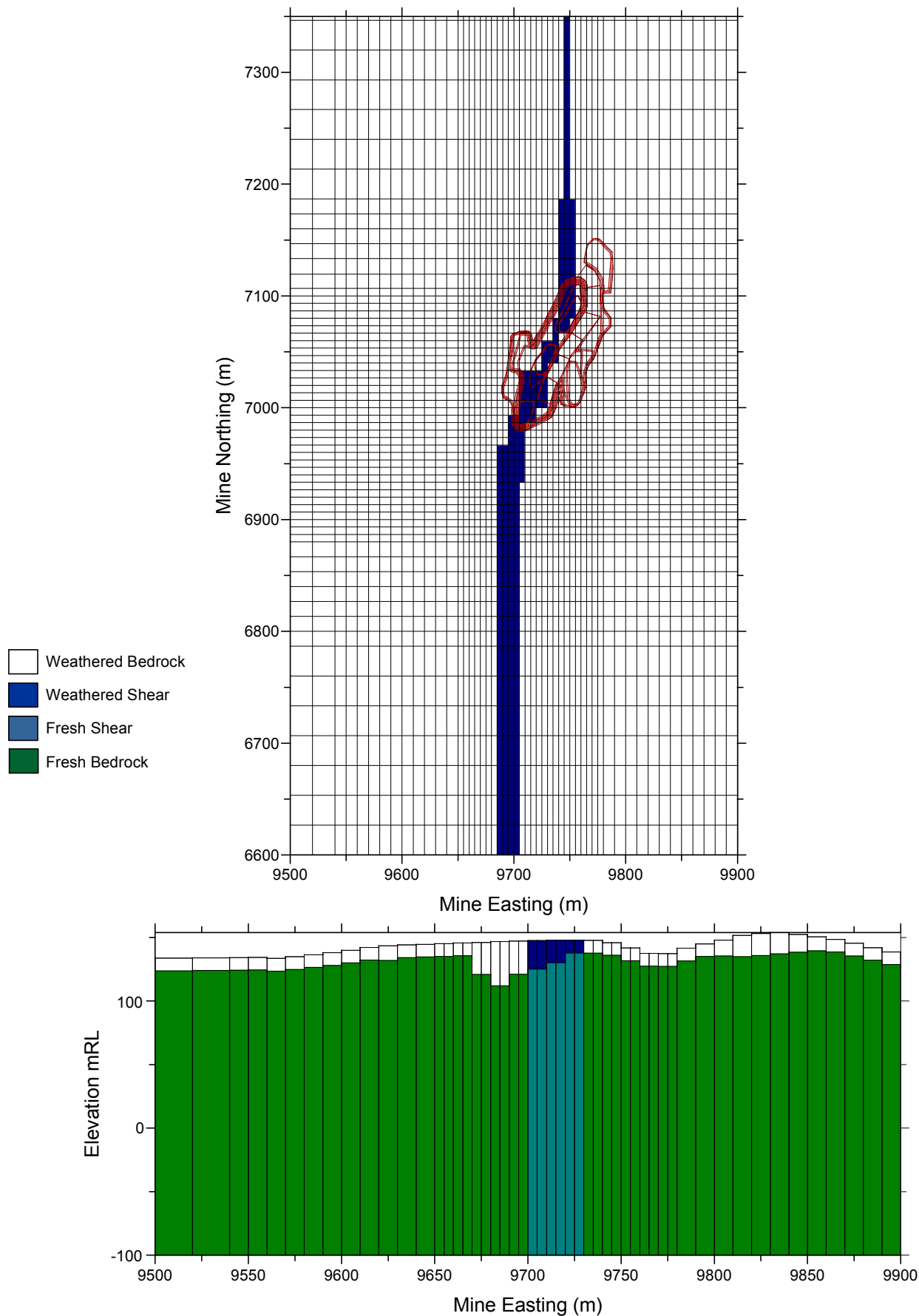
Rev A

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Source: .		Project:		Title:	
Client:		Burnside Operations Pty Ltd		Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development	
URN		Drawn: CMAC		Approved: RIJVV	
		Job No: 42213762		Date: 16/2/2007	
		File No: Figure 12.srf		Figure: 12	
				Rev A	
				A4	



Source: .

Client:

Burnside Operations Pty Ltd

Project:

Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development

Title:

Distribution of Hydraulic Parameters - Princess Louise

URS

Drawn: CMAC

Approved: RIJV

Date: 16/2/2007

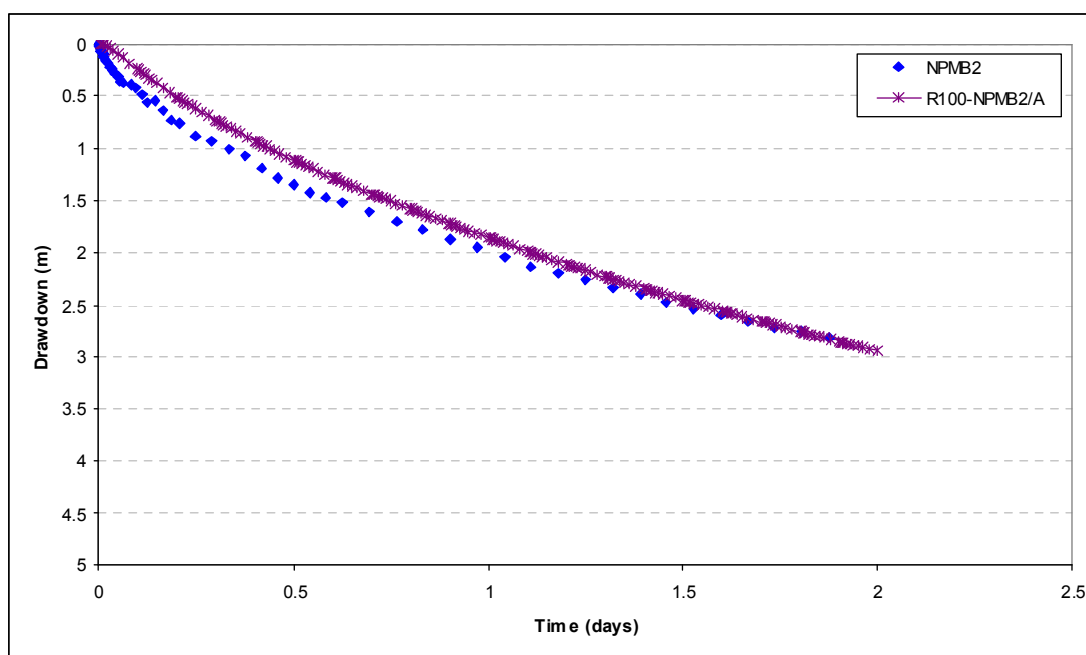
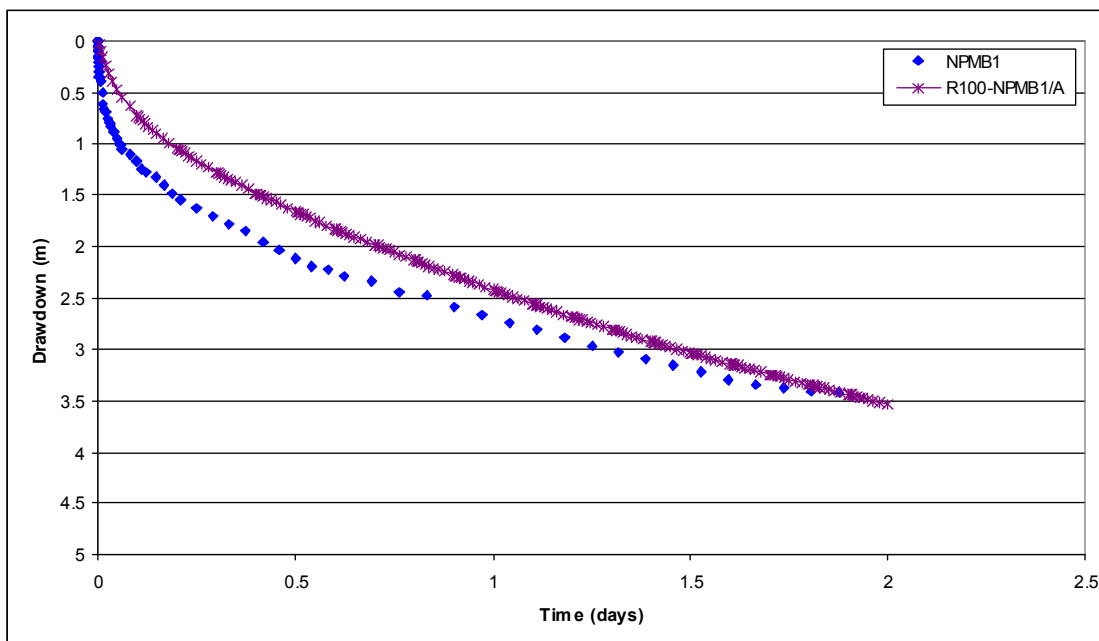
Job No: 42213762

File No: Figure 13.srf

Figure: **13**

Rev A

A4



Source: _

Client:

Burnside Operations Pty Ltd

Project:

Hydrogeological Assessments of the North Point
and Princess Louise Deposits for Mine Development

Title:

Transient Calibration - North Point

URS

Drawn: CMAC

Approved: RIJV

Date: 16/2/2007

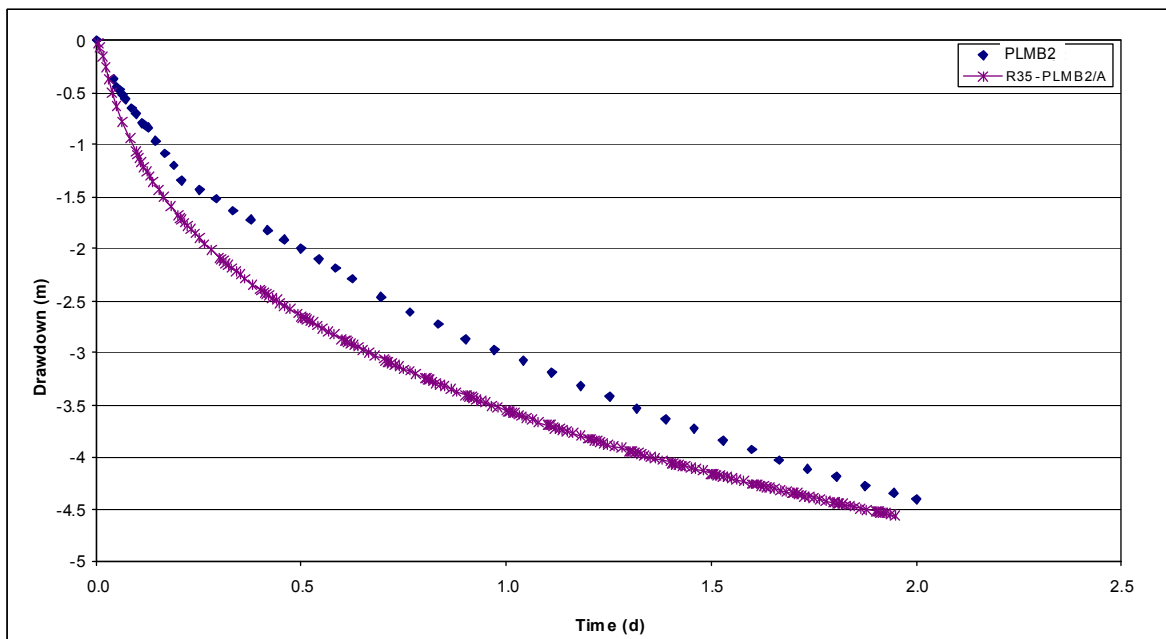
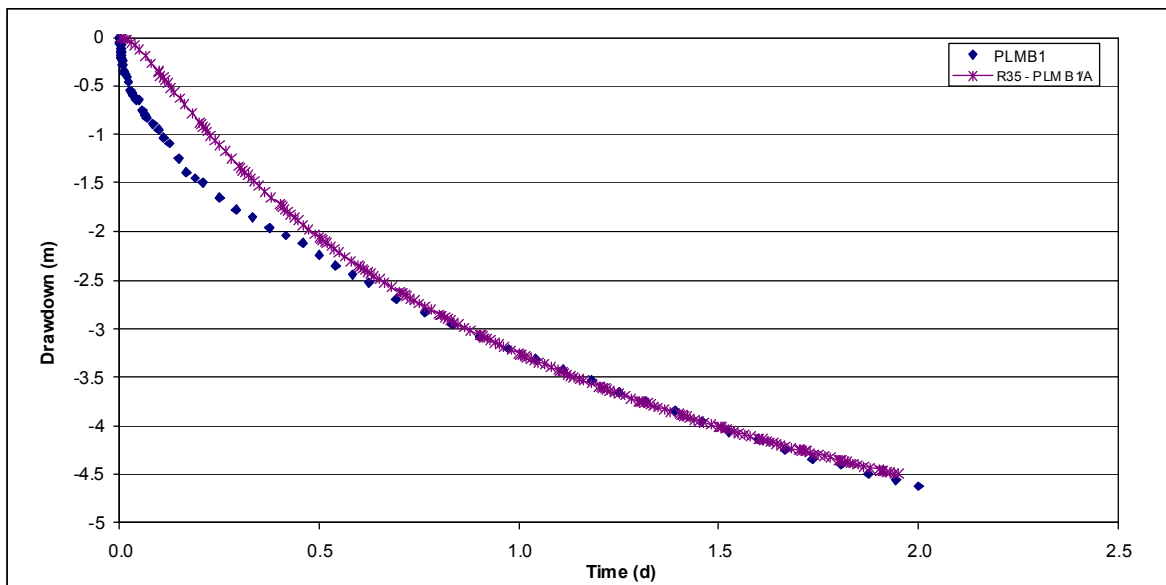
Job No: 42213762

File No: Figure 14.srf

Figure: **14**

Rev A

A4



Source: _

Client:

Burnside Operations Pty Ltd

Project:

Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development

Title:

Transient Calibration - Princess Louise

URS

Drawn: CMAC

Approved: RIJV

Date: 16/2/2007

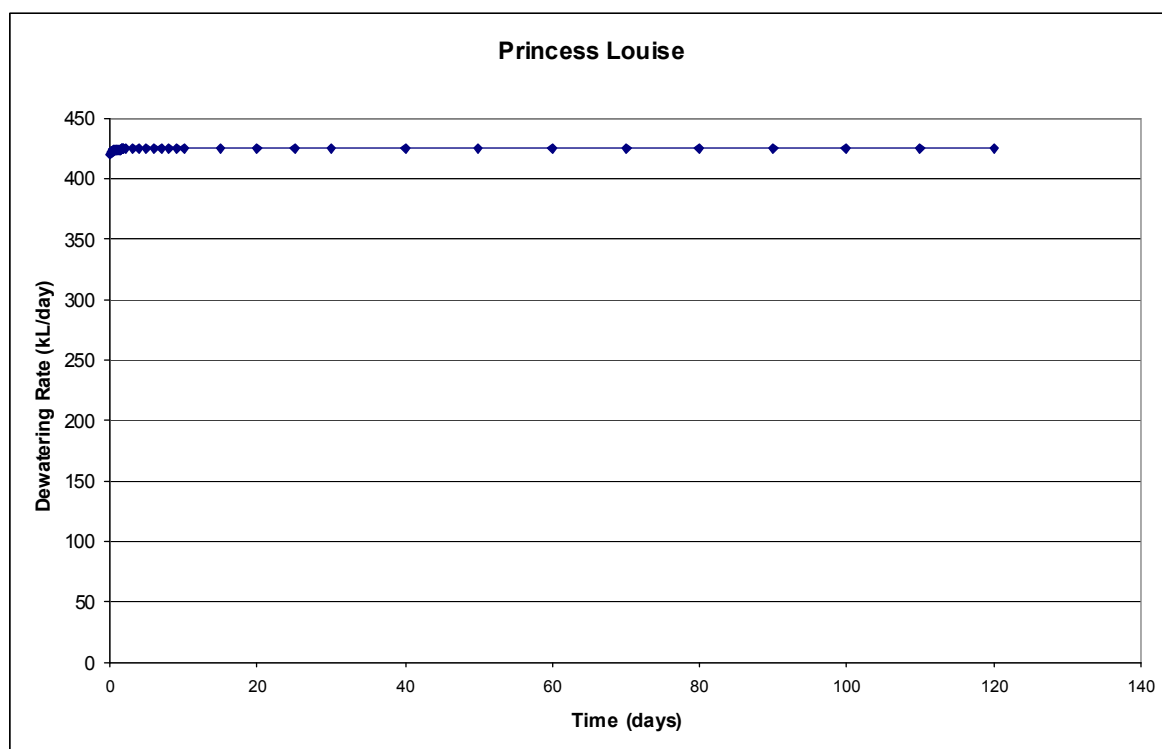
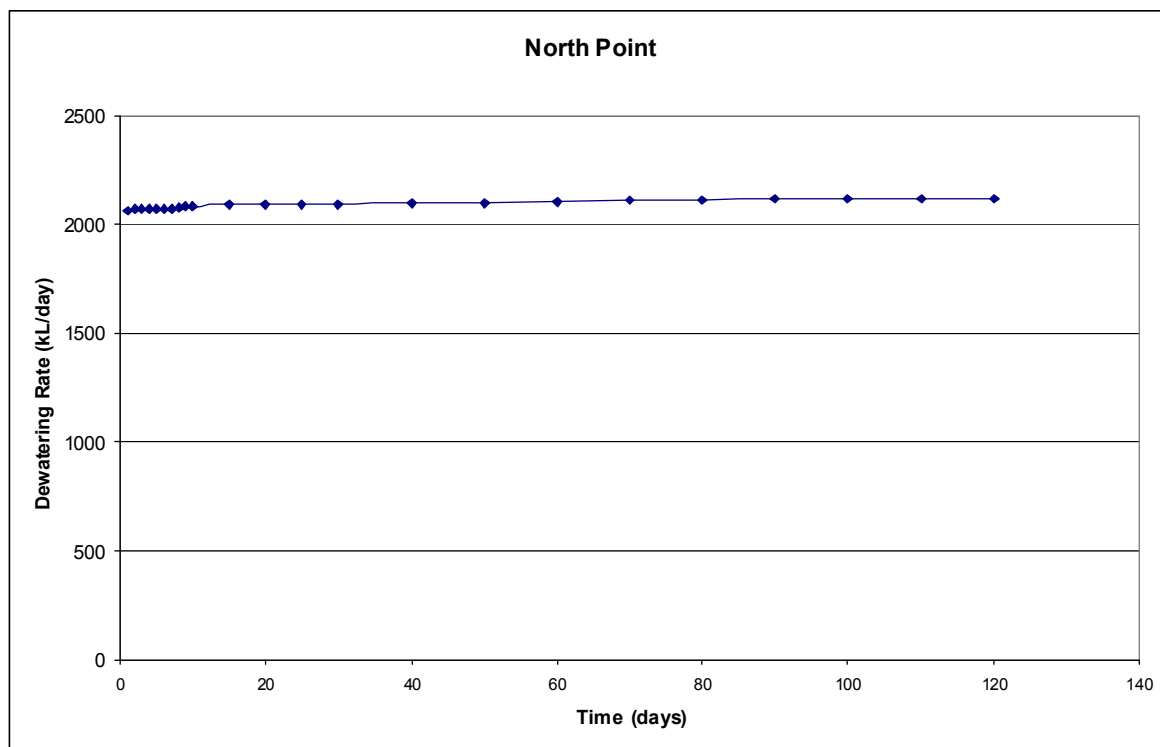
Job No: 42213762

File No: Figure 15.srf

Figure: **15**

Rev A

A4



Source: _

Client:

Burnside Operations Pty Ltd

Project:

Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development

Title:

**Estimated Groundwater Pumpage
North Point & Princess Louise**



Drawn: CMAC

Approved: RIJV

Date: 16/2/2007

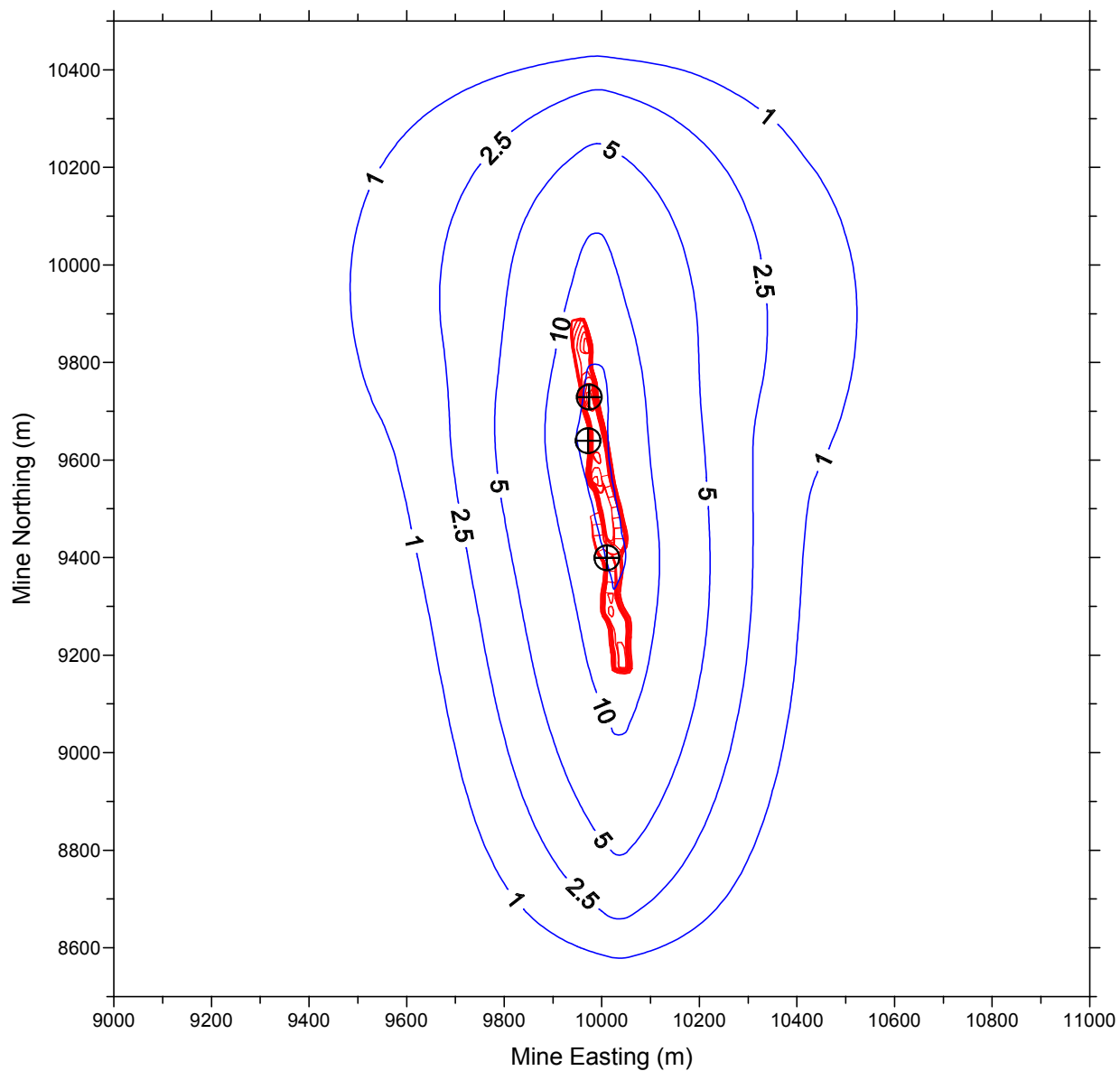
Job No: 42213762

File No: Figure 16.srf

Figure: **16**

Rev A

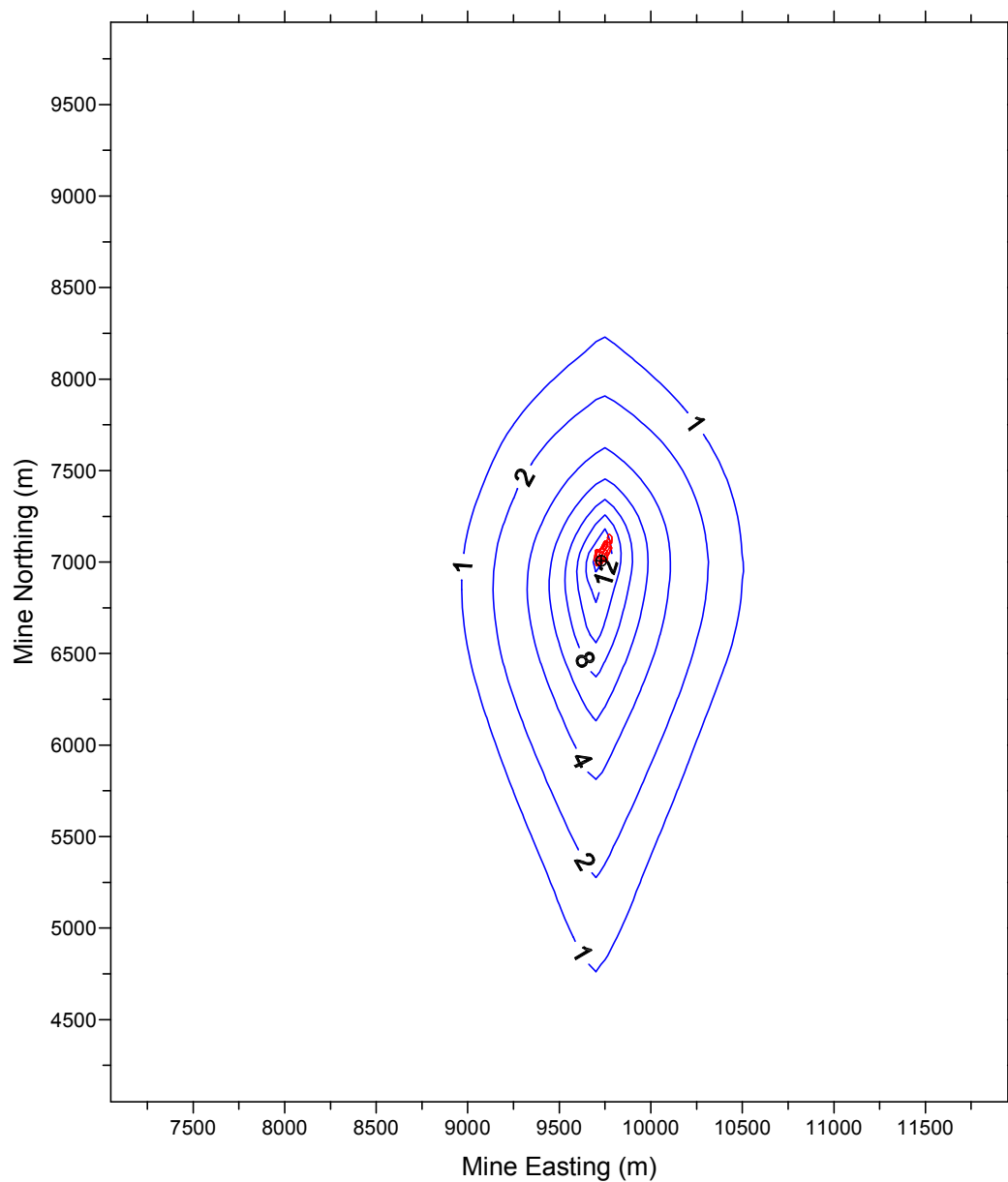
A4



⊕ Simulated Production Bore
 — Simulated Drawdown

Source: .

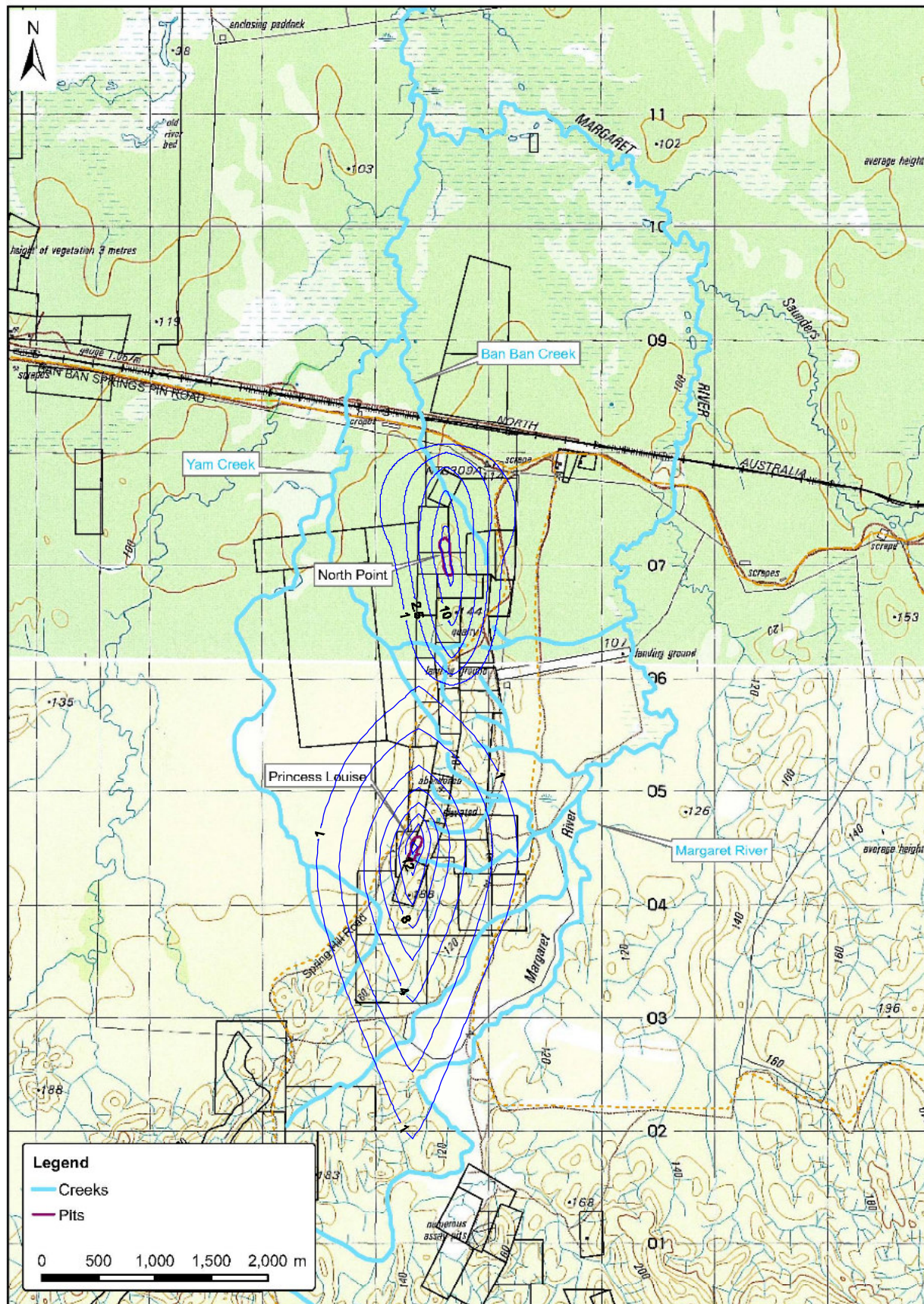
Client: Burnside Operations Pty Ltd	Project: Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development	Title: Predicted Drawdown - North Point 120 Days Pumpage at 2,073 kL/day		
	Drawn: CMAC	Approved: RIJV	Date: 16/2/2007	Figure: 17
	Job No: 42213762	File No: Figure 17.srf		Rev A A4



⊕ Simulated Production Bore
 — Simulated Drawdown

Source: .

Client: Burnside Operations Pty Ltd	Project: Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development			Title: Predicted Drawdown - Princess Louise 120 Days Pumpage at 425 kL/day	
	Drawn: CMAC	Approved: RIJV	Date: 16/2/2007	Figure: 18	Rev A
	Job No: 42213762	File No: Figure 18.srf			A4



Source: .

Client:

Burnside Operations Pty Ltd

Project:

Hydrogeological Assessments of the North Point and Princess Louise Deposits for Mine Development

Title:

Predicted Extent of Drawdown

URS

Drawn: CMAC

Approved: RIJIV

Date: 16/2/2007

Job No: 42213762

File No: Figure 19.srf

Figure: **19**

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A4