

FINAL REPORT

Simulation of Proposed Tailings Storage Facility to Assess Potential Seepage Impacts

McArthur River Mine

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Xstrata Plc

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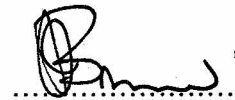
Project Manager:



Chris MacHunter
Associate Hydrogeologist/Geophysicist

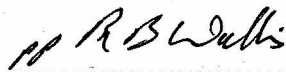
URS Australia Pty Ltd
Level 3,
93 Mitchell Street
GPO Box 2005,
Darwin, NT, 0801 Australia
Tel: 61 8 8980 2900
Fax: 61 8 8941 3920

Project Director:



Ian Brunner
Senior Principal Hydrogeologist

Authors:



Chris MacHunter
Associate Hydrogeologist/Geophysicist

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.....
Ian Brunner
Senior Principal Hydrogeologist



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Gary Brophy
Project Hydrogeologist

Contents

Executive Summary -----	ES-1
1 Introduction -----	1-1
1.1 Background	1-1
1.2 Previous Work	1-1
2 Geology and Hydrogeology -----	2-1
2.1 Geological Setting	2-1
2.1.1 Regional Setting	2-1
2.1.2 Geology of the Mine Area	2-1
2.1.3 Geology Beneath the TSF	2-1
2.2 Hydrogeology	2-2
2.2.1 Regional Hydrogeology	2-2
2.2.2 Local TSF Hydrogeology	2-3
2.2.3 Conceptual Hydrogeology Model	2-4
2.3 Groundwater Chemistry	2-5
3 TSF Characterisation -----	3-1
3.1 TSF History	3-1
3.1.1 Initial Design and Construction	3-1
3.1.2 Initial Operation	3-1
3.1.3 Initial Seepage and Remedial Works	3-1
3.1.4 Embankment Raise	3-2
3.1.5 Proposed Operations	3-2
3.2 Seepage pathways	3-2
3.3 Impacted Areas	3-3
3.3.1 Mounding of the Water Table	3-3
3.3.2 Transport of Contaminants	3-3
3.4 Mitigation Control Measures	3-3
4 Groundwater Modelling -----	4-1
4.1 Groundwater Flow Model Details	4-1
4.1.1 Model Code	4-1
4.1.2 Model Domain	4-1
4.1.3 Model Setup and Layering	4-1
4.1.4 Distribution of Hydraulic Properties	4-1
4.1.5 Boundary Conditions	4-2
4.1.6 Assumptions for Modelling	4-2
4.1.7 Limitations of the Model	4-3
4.2 Groundwater Model Calibration	4-3
4.2.1 Steady State Calibration	4-3
4.2.2 Transient Calibration	4-4
4.2.3 TSF Water Balance	4-4
4.3 Predictive Simulations	4-5
4.3.1 Scenario 1 - No Mitigation Measures	4-6
4.3.2 Scenario 2 – Borefield Recovery System	4-6
4.3.3 Scenario 3 – Interceptor Drains	4-7

Contents

4.3.4	Scenario 4 – Low Permeable Wall	4-7
4.4	Potential Environmental Impacts Associated with TSF Seepage Recovery	4-8
4.4.1	Operational	4-8
4.4.2	Scenario 1 - No Mitigation Measures	4-8
4.4.3	Scenario 2 – Borefield Recovery System	4-8
4.4.4	Scenario 3 – Interceptor Drains	4-8
4.4.5	Scenario 4 – Barrier Wall	4-8
4.4.6	Closure	4-9
4.4.7	Scenario 1 - No Mitigation Measures	4-9
4.4.8	Scenario 2 – Borefield Recovery System	4-9
4.4.9	Scenario 3 – Interceptor Drains	4-9
4.4.10	Scenario 4 – Barrier Wall	4-9
5	Conclusions and Recommendations -----	5-1
5.1	Conclusions	5-1
5.2	Recommendations	5-1
6	References -----	6-1
7	Limitations -----	7-1

List of Tables and Figures

Tables

Table 1	Summary of Interpreted Hydraulic Conductivity Values	2-3
Table 2	Model Layers.....	4-1
Table 3	Hydraulic Parameters Derived from the Calibrated Model.....	4-2

Figures

Figure 1	Location Map
Figure 2	Regional Bore Location Map
Figure 3	TSF Bore Location Map
Figure 4	Regional Groundwater Levels - (mAHD End of Dry Season 2005)
Figure 5	TSF Groundwater Levels – (mAHD End of Wet Season 1998)
Figure 6	TSF Groundwater Levels – (mAHD End of Dry Season 1997)
Figure 7	TSF Groundwater Levels – (mAHD End of Wet Season 2005)
Figure 8	TSF Groundwater Levels - (mAHD End of Dry Season 2005)
Figure 9	TSF Electrical Conductivity – (uS/cm – End of Wet Season 1998)
Figure 10	TSF Sulphate – (mg/L – End of West Season 1998)
Figure 11	TSF Electrical Conductivity – (uS/cm – End of Wet Season 2006)
Figure 12	TSF Sulphate – (mg/L – End of Wet Season 2006)
Figure 13	Layout of Expanded Tailings Storage Facility
Figure 14	TSF Groundwater Level Change – (mAHD - Dry Season 1997 to 2005)
Figure 15	TSF Groundwater Level Change – (mAHD Wet Season 1998 to 2005)
Figure 16	TSF Electrical Conductivity Change – (uS/cm – Wet Season 1998 to 2006)
Figure 17	TSF Sulphate Change – (mg/L – Wet Season 1998 to 2006)
Figure 18	Model Grid
Figure 19	Conceptual Model
Figure 20	Model Cross Section

List of Tables and Figures

Figure 21	Steady State Groundwater Levels
Figure 22	Transient Calibration Statistics – Calibrated Heads vs. Observed Heads
Figure 23	Scenario 2 – Modelled Borefield Recovery System
Figure 24	Scenario 3 – Modelled Interceptor Drains
Figure 25	Scenario 4 – Modelled Barrier Wall
Figure 26	Scenario 1 - Simulated Groundwater Level Change - 10 Years of Operation
Figure 27	Scenario 1 - Simulated Groundwater Level Change - 25 Years of Operation
Figure 28	Scenario 1 - Simulated Groundwater Level Change- 10 Year Post Closure
Figure 29	Scenario 1 - Simulated Groundwater Level Change- 25 Years Post Closure
Figure 30	Scenario 2 - Simulated Groundwater Level Change, 10 Years of Operation
Figure 31	Scenario 2 - Simulated Groundwater Level Change, 25 Years of Operation
Figure 32	Scenario 2 - Simulated Groundwater Level Change, 10 Year Post Closure
Figure 33	Scenario 2 - Simulated Groundwater Level Change, 25 Years Post Closure
Figure 34	Scenario 3 - Simulated Groundwater Level Change, 10 Years of Operation
Figure 35	Scenario 3 - Simulated Groundwater Level Change, 25 Years of Operation
Figure 36	Scenario 3 - Simulated Groundwater Level Change, 10 Year Post Closure
Figure 37	Scenario 3 - Simulated Groundwater Level Change, 25 Years Post Closure
Figure 38	Scenario 4 - Simulated Groundwater Level Change, 10 Years of Operation
Figure 39	Scenario 4 - Simulated Groundwater Level Change, 25 Years of Operation
Figure 40	Scenario 4 - Simulated Groundwater Level Change, 10 Year Post Closure
Figure 41	Scenario 4 - Simulated Groundwater Level Change, 25 Years Post Closure

Executive Summary

Draft guidelines issued by the Northern Territory Government, Department of Natural Resources, Environment and the Arts (NRETA), Section 7, Tailings Storage Facility (TSF) request Xstrata demonstrate that seepage from the existing and proposed TSF will not adversely impact on the receiving environment and discuss methods of seepage control. One of the preferred seepage control methods is by groundwater recovery systems and as requested by the draft guidelines, the proponent should consider the possible drawdown impacts for such a groundwater recovery system and potential follow on-effects.

A groundwater model was constructed using MODFLOW-SURFACT with Visual MODFLOW Pro to undertake predictive scenario modelling to demonstrate the potential seepage mitigation systems can manage seepage. Four scenarios were undertaken, Scenario 1 with no mitigation measures in place, Scenario 2 utilising a borefield recovery system, Scenario 3, an interceptor drain surrounding the TSF and Scenario 4, a low permeability wall installed to 12 m depth.

The groundwater modelling and the predictive results demonstrate that all of the potential seepage mitigation systems can manage seepage. The production bores and low permeability wall scenarios are not seen as effective stand-alone seepage mitigation systems; both would require support from local trenches. The production bores would have limited effectiveness in profiles of comparatively low transmissivity. The low permeability wall would be compromised once the mounding inside the wall propagates to the ground surface and consequently must be supported by a seepage recovery system.

All seepage mitigation options would be enhanced by recovery of the seepage from beneath the TSF. The mounding associated with seepage is greatest beneath the TSF and this aspect offers opportunities for enhanced rates of local recovery together with interception of seepage near the source. Drains beneath the TSF would offer a comparatively efficient system. Production bores on the TSF embankment would also provide a benefit, albeit of a lesser order.

The developed model has shortfalls in that it only investigates the saturated profile linked to the water table environment. As such, the entire seepage flow path is not simulated. Consequently, the model does not represent seepage from the embankment walls, or the potential expression of seepage at the toe of the TSF from flow in the unsaturated profile.

It is recommended that groundwater drilling and testing programmes be undertaken to quantify groundwater parameters locally near the TSF, the hydrostratigraphy, establish baseline groundwater conditions and refine the groundwater model. To determine the effectiveness of the low permeability wall, a trial recovery bore and trench should be installed near the existing trial geopolymer barrier near the existing Cell 1. The information gained will assist with the detailed design of the seepage recovery systems for the proposed new Cells 1 and Cell 2.

1.1 Background

McArthur River Mine is located 45 km southwest of Borroloola in the Northern Territory, adjacent to the McArthur River (Figure 1). URS Australia Pty Ltd (URS) has been engaged by Xstrata Plc (Xstrata) to prepare a Public Environmental Report (PER) for the proposed McArthur River Mine Expansion. The proposed expansion includes upgrade of the existing Tailings Storage Facility (TSF), including both enhancement of seepage controls and enlargement through new cells.

The Northern Territory Government, Department of Natural Resources, Environment and the Arts (NRETA), has prepared draft guidelines for TSFs. Section 7, of the draft guidelines requests Xstrata discuss methods of seepage control and demonstrate that seepage from the existing and proposed additional cells TSF will not adversely impact on the local receiving environments.

One of the preferred control methods is a seepage recovery system. This report presents the results of predictive groundwater modelling of seepage from the existing and proposed TSF cells and the application of seepage recovery systems to mitigate potential impacts on the water table and shallow groundwater environments.

1.2 Previous Work

Previous investigations of the existing TSF include a rehabilitation concept design and installation of additional groundwater monitoring facilities (URS, 2004). Recently, the installation by Preservation and Maintenance Engineering Soilcon Systems (2006) of a geopolymer barrier wall near the northern perimeter of the TSF has been completed to limit known seepage impacts adjacent to the Surprise Creek watercourse.

2.1 Geological Setting

The geological setting of the McArthur River Mine and surrounds has been described previously (URS, 2005a). A short summary is provided below.

2.1.1 Regional Setting

The McArthur Basin comprises Carpentarian and Adelaidean rocks extending from the Alligator River in the Northern Territory to the Queensland border and includes a large part of Arnhem Land and the Gulf of Carpentaria drainage region.

The topographical relief is dominated by low escarpments, plateaus and ridges. Limestone and dolomitic rocks of Palaeozoic age or older occur in the western part of the McArthur River catchment, upstream of the project site. Sandstone and conglomeratic rocks occur in the eastern sub-catchments, including those of the rivers Kilgour and Glyde.

2.1.2 Geology of the Mine Area

The sediment-hosted stratiform HYC ore deposits of the McArthur River Mine have similarities with ore-bodies at Mount Isa and Hilton in Queensland. The ore deposits are about 1.5 km long and 1.0 km wide, with an average thickness of 55 m.

The HYC ore deposits occur near the base of the HYC pyritic shale member, within the Middle Proterozoic McArthur Group. The shale member comprises a sequence of inter-bedded pyritic bituminous dolomitic siltstones, sedimentary breccias and volcanic tuffs.

The HYC ore deposits have been folded and eroded along the western margin, which is covered by about 30 m of alluvium and soil. The western margin contains the Hinge Ore Zone, which is sub-vertical over a strike length of 1.0 km and vertical height of 200 m. The northern margins inter-finger with sedimentary breccias and the southern margin grades into thin nodular barren pyritic siltstone. On the eastern margin, the ore-body thickens and is folded to form the Fold Zone, which has a strike length of at least 600 m. The south-eastern corner of the orebody is down-faulted by about 110 m, along the north-easterly trending Woyzbun Fault.

2.1.3 Geology Beneath the TSF

The geology of the near-surface profile beneath the TSF has previously been categorised by Allan Watson Associates (2003). The geology is discretised into:

- superficial alluvial and abandoned watercourse deposits;
- a middle succession of sandy clay and silty clay; and

- a lower succession of weathered bedrock.

The superficial succession is formed of alluvial sandy silt/silty sand and gravel deposits that range in thickness from 0.1 to 0.6 m. In localised areas, fluvial clayey sand and gravel beds range in thickness from 0.2 and 1.7 m. The fluvial beds are interpreted to represent abandoned watercourses of the Surprise Creek.

The middle succession is comprised of sandy clay and silty clay, with thicknesses from 0.8 to 4.5 m.

The lower succession comprises weathered siltstone, sandstone and dolomite, extending to depths of about 12 m from the ground surface. The lower succession represents the bedrock weathering profile and grades vertical to fresh Reward Dolomite bedrock.

2.2 Hydrogeology

The detailed hydrogeology of the area has been described previously (URS, 2005) and is summarised below.

2.2.1 Regional Hydrogeology

Groundwater Geology and Aquifer Occurrence

Aquifers in the mining area occur in both the near-surface alluvial profiles and bedrock. These aquifers are characterised by both intergranular and secondary porosity and transmissivity.

The alluvial deposits near the proposed open pit occur predominantly in the channel of the McArthur River and associated floodplain. The alluvium predominantly comprises low-transmissivity silts, clays, and fine-grained sands. However, a higher transmissivity basal section of coarse-grained sands, gravels and cobbles/boulders occurs along the deepest portions of the channel.

Aquifers also occur locally in both the weathered and partially weathered bedrock. The near-surface geology east of the pit is predominantly weathered Cooley Dolomite, and to the west, dolomitic siltstones, shale and Teena Dolomite. The most significant aquifer occurs within the weathered dolomite, which appears to have a low to moderate transmissivity.

Faults that intersect the weathered and partially weathered zones of the bedrock are probably comparatively transmissive. These will potentially contribute groundwater flows to the proposed open pit, where they intersect the pit wall.

Groundwater occurs in vuggs or solution channels (collectively referred to as karst and weathered/vuggy dolomite), fractures, joints and faults within the fresh bedrock. The underground mine water balance provided by Xstrata in May 2003 indicates that groundwater inflows to the underground mine from fresh bedrock sources is about 2,420 kL/day (28 L/sec).

Groundwater Levels and Flow

Since 1995, a network of monitoring bores (both regional and local) has been established by Xstrata to enable assessment of potential impacts of the current mining operations on the groundwater resources of the area (Figure 2 and 3).

Groundwater levels across the mining area show an easterly flow from high elevations near the TSF (38 mRL) to lower elevations near the McArthur River (22 mRL).

Groundwater levels for the end of dry season 2005 are presented on Figure 4. The regional groundwater flow is towards the McArthur River. A cone of depression is locally situated over the base of the McArthur River, likely associated with groundwater inflows into the underground mine from sands and gravels along the base of the watercourse.

2.2.2 Local TSF Hydrogeology

Groundwater Geology and Aquifer Occurrence

Aquifers that underlie the TSF occur within superficial deposits and the underlying weathered and fresh bedrock. Groundwater appears to be hosted predominantly within the weathered bedrock and potentially in vugs or structures within the dolomitic siltstone.

Hydraulic conductivity values for the stratigraphic successions identified in the geological model were developed from design data presented in previous reports by Alan Watson and Associates and Golder Associates; and by calibration of the seepage model to observed behaviour at the site. A summary of interpreted hydraulic conductivity values is presented in Table 1.

**Table 1
Summary of Interpreted Hydraulic Conductivity Values**

Material Description	Horizontal Hydraulic Conductivity (m/day)	kh/kv Ratio¹
TSF Perimeter Embankment	0.001 – 0.01	2
Tailings - Current Condition	0.01	2
Tailings – Long-Term Condition	0.01 - 0.001	2
Sandy Clay	0.01 - 0.001	2
Sand and Gravel	0.1 – 4	2 – 10
Dolomitic Siltstone	0.1 – 2	2 – 10
Clay Cut off Key	0.001	2

Notes:

1. kh = horizontal hydraulic conductivity, kv = vertical hydraulic conductivity

Groundwater Levels and Flow

Based on the information described previously (URS, 2005), the groundwater levels prior to construction of the Existing TSF were set at approximately 31 mRL, about 9 m below the ground surface. Groundwater flow is towards the southeast and the McArthur River.

Wet season groundwater levels in 1998 are generally 2 m higher than the 1997 dry season (Figure 5). Dry season groundwater levels in 1997 (Figure 6) show groundwater levels lower than the 2005 levels generally about 2 m lower than in 2005 (note that the groundwater levels are influenced by the TSF, however no data were available on the height of the TSF at that time). Groundwater levels at the end of the dry season 2005 (Figure 7) show a water table mound centred below the TSF. End of wet season groundwater levels in 2005 (Figure 8) similarly show water table mounding below the TSF.

2.2.3 Conceptual Hydrogeology Model

The conceptual hydrogeological model of the area comprises the following features:

- The groundwater flow direction is towards the southeast, from the higher topography near the TSF into the valley associated with the McArthur River.
- Baseline groundwater levels were within about 9 m of the ground surface.
- Watercourses in the area, including Surprise Creek, drain towards the southeast. Stream flow in these watercourses is non-perennial.
- The conceptual hydrogeological model incorporates alluvial successions of sandy silt/silty sand and gravel underlain by sandy and silty clay and weathered bedrock. The alluvial successions locally include clayey sand and gravel deposits in abandoned watercourses.
- Transmissivity is greatest within the sand beds of the alluvial deposits and vugs, joints or fractures in the weathered bedrock. Within the bedrock, transmissivity occurs where faults, shear zones and fractures occur.
- The superficial deposits are generally thin and do not form significant aquifer zones except in proximity to watercourses.
- The geology beyond the TSF area is only broadly defined. Therefore, the conceptual hydrogeology in regional areas is based on large-scale mapping.
- Seepage from the TSF is interpreted to predominantly occur through the alluvium and weathered bedrock profiles. The potential for seepage is enhanced in profiles or zones of comparatively high transmissivity.

2.3 Groundwater Chemistry

Initial groundwater sampling of bores was undertaken in 1997, nearly three years after commissioning of the TSF. Although not representative of baseline conditions, monitoring results indicate the groundwater (mainly in weathered bedrock) around and beneath the TSF is of (Na-Mg-Ca)-(SO₄-Cl) type with a TDS concentrations of 1,000 to 8,000 mg/L. Groundwater quality in other monitoring bores around the TSF is similar, although the combination of cations and anions varies and the TDS shows considerable variation. Since 1997, Electrical Conductivity and SO₄ concentrations have both increased.

Electrical Conductivity values at the end of wet season 1998 (Figure 9) are elevated near GW10 and GW11, coinciding with tailings emplacement during that time. Sulphate concentrations at the same time (Figure 10) are elevated only in GW10 and GW14. Electrical Conductivity sampled in 2006 (Figure 11) is elevated near GW14, GW 17 and GW18. Similarly, sulphate concentrations are also elevated in GW17 and GW18, being generally greater than 3,000 mg/L (Figure 12).

3.1 TSF History

A detailed description of the TSF history is provided previously (URS, 2004). Figure 13 presents the layout of the Existing Cell 1 and proposed Cell 1 and Cell 2. A summary is provided below.

3.1.1 Initial Design and Construction

MPA Williams and Associates Pty Ltd completed a study of disposal options for the McArthur River Mine tailings in 1992. This study used the results of preliminary site investigations by Golder Associates. When operational, the Existing Cell 1 received disposed thickened tailings from an elevated, central location to form a conical-shaped stack. The profile of the stack was expected to form 1% beach-slopes.

The site developed for tailings impoundment is located about 4 km west of the current process plant, and covers an area of about 330 ha. The southern portion comprises an area allocated for proposed Cell 1 and Cell 2. The area encompassing proposed Cell 1 and Cell 2 and the water management dam is formed by a perimeter bund.

3.1.2 Initial Operation

Tailings deposition into the Existing Cell 1 occurred initially by discharge from the centrally located vertical riser until the tailings approached the outfall level. Flexible pipe extensions were subsequently used to continue the depositional process. During operation, tailings water and surface stormwater runoff was reported to collect along the perimeter embankment. As a result of continual ponding, the tailings beach adjacent to the perimeter embankment becomes saturated.

3.1.3 Initial Seepage and Remedial Works

Seepage from the TSF is evident was observed in Surprise Creek adjacent to the TSF. Regular monitoring of water in Surprise Creek one to two years after the commencement of tailings disposal detected only background concentrations of lead and zinc. Regular pumping of water from the creek back into the TSF was undertaken to minimise the impacts of the seepage. Other seepage remediation works included thickening of the tailings to reduce water content and the installation of a three metre deep cut-off trench between the creek and the impoundment in an effort to intercept the seepage. Additionally, during operation of the Existing Cell 1, the tailings discharge was shifted further from the embankment to limit ponding of supernatant water. To monitor the effects of these remedial actions, additional groundwater monitoring bores were installed.

Preservation and Maintenance Engineering Soilcon Systems (2006) drilled closely spaced holes lined with injection tubes along the northern TSF embankment. Geopolymer solutions were subsequently injected into the holes to generate an in-ground barrier wall. As a result of the installation of the barrier wall, monitoring bores GW10, GW11, GW12 and GW13 are no longer in service.

3.1.4 Embankment Raise

In 1999, the initial TSF impoundment was becoming full and Maunsell was engaged to undertake a review of future tailings disposal options. On completion of the review, there was a decision to raise the embankment of the Existing Cell 1 and to continue to use this cell as the sole TSF.

3.1.5 Proposed Operations

A detailed description of the proposed TSF operations is provided previously (URS, 2006) and is summarised below.

Existing Cell 1 will be utilised for the open cut operations. Thereafter, tailings placement will shift to the west, to the area currently used for the evaporation pond, the dirty water dam and the clean water dam. This will enable Existing Cell 1 to be decommissioned and rehabilitated. The proposed layout of the new TSF is given in Figure 13.

3.2 Seepage pathways

Seepage pathways that may allow the transport of contaminants from the TSF include:

- Transmissive sandy alluvial profiles beneath the TSF and water management dams.
- Transmissive horizons in the TSF embankments.
- Weathered bedrock.
- Fractures, vugs or faults within the fresh bedrock.

Seepage from the TSF can migrate vertically through the disposed tailings, directly to the water table, and laterally through embankments. The vertical component is the most significant aspect of seepage as it provides the shortest flow path to the natural environment.

Once seepage from the TSF has entered the water table, it can migrate further both laterally and vertically. Sandy alluvial profiles beneath the TSF or water containment dams, will over time become saturated and propagate the seepage in a radial direction, outward from the source. Where these strata intersect watercourses, groundwater discharge will occur. Surprise Creek is a natural groundwater discharge zone during the wet season. The discharge rapidly diminishes after the wet season once the short-term bank storage is depleted and the water table falls below the base of the watercourse. When an artificial source of water creates a water table mound, prolonged discharge into local watercourses, such as Surprise Creek, may occur.

An interpretation of the groundwater velocity (Darcy Flux) is determined by the hydraulic conductivity and porosity of the porous media in the flow path and the hydraulic gradient:

$$DarcyFlux = \frac{K \times i}{n}$$

where:

K = Hydraulic Conductivity, in the range 0.1 to 4 m/day

n = porosity, in the range from 0.25 to 0.4 (dimensionless)

i = Hydraulic gradient about 0.042 (dimensionless)

Based on adopted hydraulic conductivity of 0.1 to 4 m/day for the superficial alluvial deposits, an estimated porosity of 0.25 to 0.4 (dimensionless) and an interpreted average hydraulic gradient of 0.042 (dimensionless), the groundwater flux is approximated in the range 0.01 to 0.7 m/day, or 4 to 245 m/year. As the TSF has been in operation for ten years, it would be anticipated that seepage indicators may now be transported more than several hundred of metres downgradient from the TSF and water management dams.

3.3 Impacted Areas

3.3.1 Mounding of the Water Table

Water table mounding has occurred beneath the TSF and the water management dam. Dry season groundwater level changes near GW17 and GW13 are in order of 5 m between 1997 and 2005 (Figure 14). GW7, however, shows an uncharacteristic rise of 3.5 m during the same period and this aspect suggests that seasonal variations in the comparative measurement may influence the interpretations of water table mounding associated with the TSF. Groundwater level changes for the wet season (Figure 15) show similar rises between the 1998 and 2005. However, there are limited comparable observation points.

3.3.2 Transport of Contaminants

Groundwater quality data from monitoring bores located southeast of the water management dam show rises in Electrical Conductivity up to 10,000 $\mu\text{S}/\text{cm}$ between 1998 and 2006 wet seasons (Figure 16). Similarly, sulphate concentrations have increased up to 3,600 mg/L near the vicinity of GW17 and GW9 (Figure 17).

3.4 Mitigation Control Measures

Control measures to mitigate the seepage from the TSF, include:

- Groundwater recovery bores surrounding the TSF.

-
- Cut-off trenches or drains on the perimeter of the TSF.
 - Low transmissivity barrier wall on the perimeter of the TSF.

The feasibility and effectiveness of each seepage mitigation control measure will depend on the seepage flow paths, hydraulic conductivity of the porous media beneath the TSF and groundwater flow characteristics in the water table and shallow groundwater environments near the TSF.

4.1 Groundwater Flow Model Details

4.1.1 Model Code

The model code selected was MODFLOW-SURFACT. MODFLOW-SURFACT (Hydrogeologic Inc, 1996) is an enhanced version of the 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-processor.

4.1.2 Model Domain

The model domain measures 10 km east-west and 10 km north-south (Figure 18), and was discretised into 97,955 cells (143 columns x 137 rows x 5 layers) of variable sizes. Each cell represents a homogeneous hydrogeological unit. Finer cells (14 m x 14 m) were used around the TSF.

4.1.3 Model Setup and Layering

The groundwater flow model is compatible with the conceptual hydrogeological model and includes a layer form based on the interpreted geological profiles and known aquifer systems (Figure 19). The model layers are shown in Table 2.

Table 2
Model Layers

Layer	Descriptions
1	Tailings
2	Alluvium
3	Weathered Bedrock
4	Bedrock

4.1.4 Distribution of Hydraulic Properties

Uniform hydraulic conductivities were assigned to all layers. Table 3 summarises the hydraulic parameters applied to the model. Figure 19 and 20 shows the distribution of hydraulic conductivity in the model.

Table 3
Hydraulic Parameters Derived from the Calibrated Model

Material Type	Model Layer	Description	Hydraulic Conductivity (m/day)			Specific Storage (1/m)	Specific Yield (dimensionless)
			Kx	Ky	Kz		
1	1	Tailings	0.01	0.01	0.005	1.00E-06	0.001
3	2	Alluvium	4	4	2	1.00E-04	0.1
4	3	Weathered Bedrock	2	2	0.2	3.00E-04	0.05
5	4	Bedrock	0.001	0.001	0.0005	5.00E-06	0.001
2	5	TSF Embankment Walls	0.001	0.001	0.0005	1.00E-06	0.001

4.1.5 Boundary Conditions

Constant-head boundary conditions were used to represent interpreted groundwater level elevations at the up-gradient and down-gradient boundaries of the model. Internal drain boundaries were used to represent watercourses and their function in the discharge of groundwater.

Recharge to the TSF has been defined using an average rate of 200 mm/year. On decommissioning of the TSF, a nominal recharge of 50 mm/yr has been applied, comparable with the findings from previous predictive seepage modelling simulations (URS, 2004).

4.1.6 Assumptions for Modelling

Assumptions were made in order to discretise the interpreted groundwater flow and seepage from the TSF. The assumptions used are summarised below.

Aquifer Base

The bedrock below -20 mRL is interpreted to be of low transmissivity, does not yield significant groundwater flows and limits the vertical transport of seepage from the TSF.

Top of Model

The top of the model is the ground surface topography as interpolated from available digital elevation models.

Hydraulic Parameters and Material Types

- The model layers, hydraulic conductivity and hydrostratigraphy are compatible with the conceptual hydrogeological model and broadly represent the known hydrogeology.

-
- The alluvial superficial deposits are relatively uniform in thickness beyond the immediate mining area and cover the entire model domain except the areas of known bedrock outcrop.

TSF Development Schedules

The model incorporates development, operating and closure schedules for the existing and proposed TSF.

The recharge on the TSF causes mounding of the local water table. The recharge is simulated to represent mostly water balances that incorporate seasonal climatic influences.

Model Code

MODFLOW-SURFACT is a groundwater flow model code for fully saturated conditions. The reduction in hydraulic conductivity in unsaturated conditions is approximated by correcting the transmissivity for changes in the saturated thickness.

4.1.7 Limitations of the Model

The developed groundwater flow model has limitations due to generalisations and assumptions made in the interpreted hydrogeology.

The model is intended to be used as a guide to the potential impacts of seepage from the TSF and likely groundwater abstraction rates required for mitigation of seepage impacts. The interpretations of the predictive simulations should be cognisant of the assumptions made.

The developed groundwater model simulates the permanent water table environment, not the perched saturated profiles within the TSF. That is, the groundwater model provides potential seepage directly to the water table and does not simulate the entire seepage flow path from the saturated tailings through the underlying unsaturated profile.

4.2 Groundwater Model Calibration

The purpose of calibration is to establish that the model can simulate interpreted groundwater levels and flows, providing broad representation of seepage from the TSF.

Calibration of the model occurred in two steps as described below.

4.2.1 Steady State Calibration

A steady state calibration was completed by:

- Assigning interpreted hydraulic properties to the various material types in the model.

-
- Assigning groundwater levels to the model boundaries, based on topography, known groundwater levels in the modelled domain and interpreted distributions of recharge and discharge zones.
 - Running the model for an infinite time (i.e., steady-state) to establish the regional groundwater flow gradients, baseline water table elevations in the area of the TSF, and both recharge and discharge characteristics.

The calibrated steady-state groundwater levels are presented on Figure 20.

4.2.2 Transient Calibration

The water table elevations resulting from the steady-state calibration were used as initial conditions for all transient simulations. Whenever the transient calibration involved changes to the hydraulic conductivity, the steady-state calibration was repeated with the new set of hydraulic conductivity values to obtain a revised set of initial conditions.

During the transient calibration process, the hydraulic parameters were varied slightly in order to get the best fit of water table mounding associated with the TSF. A plot of simulated and interpreted heads is presented on Figure 21.

4.2.3 TSF Water Balance

A conceptual water balance was derived from Alan Watson & Associates (2004) and was used to determine the likely groundwater recharge from the existing and proposed cells of the TSF.

Existing Cell 1

Tailings were disposed into the Existing Cell 1 at a rate of 1.6 Mtpa. With an assumed solids concentration of 60%, the disposed tailings incorporated about 1.07 million kL of water each year, a consumptive water use of about 2,930 kL/day. It has been estimated (Allan Watson & Associates, 2004) that 65% of the water in the tailings would be initially retained; 35% would be lost by evaporation. Based on the estimate, about 1,900 kL/day would initially remain in storage. Subsequently, it is assumed that 80% of the available storage (about 1,520 kL/day) would be progressively released, during drainage and consolidation process and potentially yield as seepage. Embankment seepage rates of 240 L/day/m have been estimated (Allan Watson & Associates, 2004) for the proposed Cell 1 and Cell 2 and have been adopted for the Existing Cell 1 embankment. The Existing Cell 1 embankment has a perimeter of 3.7 km, therefore the total seepage through the embankment is estimated to be 890 kL/day. The remaining 630 kL/day would infiltrate to the water table. As the Existing Cell 1 has an area of approximately 800,000 m², the anticipated recharge rate to the underlying water table is about 290 mm/yr. Underdrains installed in the Existing Cell 1 may reduce the anticipated recharge.

Proposed Cell 1 and Cell 2

The proposed Cell 1 and Cell 2 will have a tailings emplacement rate of 1.8 Mtpa. Using similar assumptions made above, the total tailings water input is expected to be 1.2 million kL each year (3,290 kL/day). With an initial tailings water retention of 65%, approximately 2,140 kL/day will remain in storage, of which 1,710 kL/day is assumed to yield as seepage. Using an embankment seepage rate of 240 L/day/m and a perimeter of 4.7 km, lateral seepage may ultimately be up to 1,130 kL/day. Seepage infiltrating to the water table may range from 580 to 1,130 kL/day, potentially changing over time as the height of the disposed tailings increases. The proposed Cell 1 and Cell 2 have an area of 2,100,000 m², therefore the anticipated recharge rate over the area is estimated at 100 to 200 mm/yr.

4.3 Predictive Simulations

Four scenarios were simulated to assess the effectiveness and potential impacts of alternative seepage mitigation systems. The model scenarios were each run for 25 years and subsequently another 25 years post-operation to demonstrate the long-term response after closure. The four predictive scenarios included:

- Scenario 1, no mitigation of seepage.
- Scenario 2, a borefield seepage recovery system.
- Scenario 3, an interceptor drain seepage recovery system.
- Scenario 4, a barrier wall limiting seepage transport.

Each scenario is described below.

Scenario 1 – No Seepage Mitigation

Recharge applied to the no mitigation scenario was 200 mm/yr to the water table beneath the proposed Cell 1 and Cell 2 and 50 mm/yr recharge on Existing Cell 1. The simulation incorporates the TFS and no seepage mitigation measures. As such, this scenario represents a worst-case in terms of water table mounding and seepage impacts. After 25 years of operation, both the proposed Cell 1 and Cell 2 are decommissioned and recharge is reduced to 50 mm/yr to simulate the long-term post operational conditions.

Scenario 2 – Borefield Seepage Recovery

The TFS simulations include a borefield recovery system incorporating 32 shallow pumping bores, up to 30 m in depth, with a combined abstraction of 1,980 kL/day (Figure 23). Several model runs were undertaken to identify the most effective number of pumping bores, their individual abstraction rates and time(s) of pumping. Recharge rates applied to the TFS are similar to Scenario 1.

The final simulations indicated a three-phase timing for operation of the pumping bores would provide the most effective seepage recovery strategy. Bores located adjacent to Surprise Creek were only pumped at 20 kL/day for the 25 year duration of TSF operation. This provided adequate drawdown to capture seepage without significant environmental impacts.

For the 10-year period after decommissioning of the TSF, total abstraction of 390 kL/day was identified as the most effective to intercept seepage without significant drawdown impacts. Thereafter, the simulated abstraction was further reduced to 290 kL/day.

Scenario 3 – Seepage Interceptor Drain

A partially penetrating interceptor drain was installed to 5 m depth along the perimeter of the TSF to evaluate the effectiveness of a trench for interception of seepage (Figure 24). Recharge rates applied to the TSF are similar to Scenario 1.

Scenario 4 – Seepage Barrier Wall

A 12 m depth fully penetrating low hydraulic conductivity (0.0001 m/day) barrier wall is simulated along the perimeter of Existing Cell 1, the proposed Cell 1, and Cell 2 (Figure 25). Recharge rates applied to the TSF are similar to Scenario 1.

4.3.1 Scenario 1 - No Mitigation Measures

Initial model runs indicated mounding of the water table to and occurrences of seepage on the ground surface outside the eastern TSF embankment, where shallow, low transmissivity bedrock is present. This seepage was captured using drain boundaries in subsequent model runs. The water balance output from this scenario indicated possible seepage of 80 kL/day from surface expression of the water table, about 13% of the simulated seepage.

Figure 26 shows water table mounding beneath the proposed Cell 1 and Cell 2 after 10 years of operation. Mounding of the water table radiates outward from the TSF, with 1 m groundwater rises extending up to 1.5 km from the TSF. The mounding to the northeast of the TSF is limited. In this area, the water table intersects Surprise Creek and discharge occurs. Figure 27 shows the water table mounding after 25 years of operation. The mounding extends up to 2 km from the TSF. Figures 28 and 29 show a gradual decline of groundwater levels, 10 and 25 years after the decommissioning of the TSF.

4.3.2 Scenario 2 – Borefield Recovery System

Figure 30 shows the simulated groundwater level change utilising the borefield recovery system after 10 years of operation. The results indicate that a total abstraction rate of 1,980 kL/day is effective in promoting drawdown of the mounded water table near the Existing Cell 1. Although groundwater mounding to the south of the TSF is evident, it is constrained to within about 1 km of the impoundment.

This mounding may be controlled by refining individual pumping rates from pumping bores. Figure 31 shows the simulated groundwater level changes after 25 years of operation. Minor mounding of the water table exists to the south of the TSF.

Figure 32 shows the simulated groundwater level change 10 years after decommissioning of the TSF, with abstraction of 390 kL/day. Results indicate residual groundwater mounding to the north is constrained within the TSF perimeter. This demonstrates that the borefield recovery is effective in that area of the TSF. To the southwest of the TSF, the borefield recovery system is effective in promoting drawdown adjacent to the TSF embankments. However, residual mounding of the water table is evident beyond the southern TSF boundary. As rates of seepage reduce after closure, groundwater monitoring will enable adaptive borefield management to mitigate residual mounding and limit drawdown impacts outside the TSF perimeter.

Figure 33 shows the simulated groundwater level change, 25 years after decommissioning at an abstraction rate of 290 kL/day. Mounding continues to be excessive to the south of the TSF under this scenario. Residual mounding of 1 m can be seen extending up to 2 km from the TSF towards Barney Creek. This scenario demonstrates the effectiveness of recovery using pumping bores, however simulated pumping rates and/or periods of pumping need to be limited to reduce residual mounding away from the TSF perimeter or drawdown impacts.

4.3.3 Scenario 3 – Interceptor Drains

Figure 34 shows the simulated groundwater level changes after 10 years of TSF operation and interceptor drains in use. To the southwest, groundwater mounding of 1 m extends up to 1 km from the TSF. This indicates the interceptor drains are not fully capturing the entire seepage flow paths because the drains do not fully penetrate the flow system. Figure 35 shows the results after 25 years of operation. Groundwater mounding of 1 m is shown up to 2 km southeast of the TSF, indicating that the drains are not effective in capturing seepage in this area.

Figures 36 and 37 show the dissipation and decay of the water table mound 10 and 25 years after decommissioning of the TSF.

4.3.4 Scenario 4 – Low Permeable Wall

Figure 38 shows the water table mounding after 10 years TSF operation with a seepage barrier wall in use. Mounding occurs to the northwest and southwest of the TSF embankments. After 25 years of operation (Figure 39), the mounding has propagated up to 1 km to the northwest of the TSF. The mounding of the water table indicates that the barrier wall is effective in limiting the seepage from the TSF, but provides a horizontal barrier to the natural groundwater flow system.

Figure 40 shows the water table mounding progressively increasing, 10 years after decommissioning of the TSF. Figure 41 shows the groundwater mounding occurring at distances up to 1 km northeast of the

TSF, 25 years after decommissioning, likely to be due to the barrier wall limiting the natural groundwater throughflow.

4.4 Potential Environmental Impacts Associated with TSF Seepage Recovery

4.4.1 Operational

During both the operational and closure phases of the proposed TSF, seepage recovery systems may cause drawdown impacts on the local groundwater resources.

4.4.2 Scenario 1 - No Mitigation Measures

With no mitigation, seepage from the TSF would continue to discharge into Surprise Creek. After 10 years of TSF operation, water table mounding may propagate to Barney Creek to the south. Mounding in the vicinity of and subsequent discharge into Barney Creek is predicted to progressively increase during the operating life of the TSF. The existing cone of depression to the east of the McArthur River forms a groundwater sink, drawing the mounding in an easterly direction.

4.4.3 Scenario 2 – Borefield Recovery System

Borefield recovery systems will mitigate groundwater seepage from the TSF. Under the modelled scenario small-scale mounding of the water table was evident. However, more closely spaced pumping bores may rectify this. Groundwater drawdown impacts would be limited by the transmissivity of the local stratigraphy, periods of pumping and the abstraction rates. During operation groundwater monitoring and adaptive borefield management would limit the extent of drawdown from the TSF.

4.4.4 Scenario 3 – Interceptor Drains

The simulated interceptor drains provide effective drawdown to the northeast of the TSF. However, the simulated drawdown extends to unacceptable distances from the TSF. The simulated drain depth of 5 m may be locally reduced to limit the drawdown near Surprise Creek. Conversely, the interceptor drains do not effectively mitigate the seepage impacts to the southwest of the TSF, where mounding of the water table is evident.

4.4.5 Scenario 4 – Barrier Wall

The barrier wall mitigates the impacts of seepage from the TSF. However, it does form a barrier to the natural groundwater flow and consequently causes mounding of the water table upstream and to the northwest of the TSF. To mitigate this impact, an inceptor drain could be installed to intercept the

groundwater throughflow, or the barrier wall might be combined with a borefield recovery system to abstract groundwater from sensitive areas.

4.4.6 Closure

4.4.7 Scenario 1 - No Mitigation Measures

Similar to when in operation, with no mitigation, seepage from the TSF would continue to discharge into Surprise Creek during closure. After 10 years of closure, water table mounding may continue to propagate to Barney Creek to the south. Mounding in the vicinity of and subsequent discharge into Barney Creek is predicted to progressively decline naturally, however at a significantly slower rate than if some form of recovery systems was implemented.

4.4.8 Scenario 2 – Borefield Recovery System

After closure, a borefield recovery system can effectively capture the seepage from the TSF. Drawdown impacts from pumping bores will be limited by the transmissivity of the superficial deposits and weathered bedrock, periods of pumping and the abstraction rates. As rates of seepage reduced after closure, groundwater monitoring will enable adaptive borefield management to limit potential impacts.

4.4.9 Scenario 3 – Interceptor Drains

Interceptor drains show mitigation of seepage post closure. The simulated scenario demonstrates extensive drawdown beyond the TSF after closure. This characteristic indicates that the simulated drain depth of 5 m might be reduced. Under this scenario, drawdowns would be monitored and abstraction subsequently constrained to limit drawdown impacts to the immediate vicinity of the TSF.

4.4.10 Scenario 4 – Barrier Wall

The simulated barrier wall causes mounding of the water table on the upstream side of the TSF. Operational and post closure applications of barrier walls would need to be supported by pumping bores and/or interceptor drains to mitigate the mounding.

5.1 Conclusions

- The predictive simulations demonstrate that seepage mitigation systems can provide benefits. The production bores, interception trenches and barrier wall scenarios are not seen as effective stand-alone seepage mitigation systems; each would require support. The production bores would have limited effectiveness in profiles of comparatively low transmissivity. The interceptor drains do not fully penetrate the flow system and consequently might be supported on a local scale by pumping bores. The barrier wall would be compromised once the mounding outside the TSF embankment propagates to the ground surface and consequently must be supported by a seepage recovery system.
- All seepage mitigation options would be enhanced by recovery of the seepage from beneath the TSF. The mounding associated with seepage is greatest beneath the TSF and this aspect offers opportunities for interception of seepage near the source enhanced rates of local recovery and limiting of impacts beyond the TSF. Drains beneath the TSF would offer a comparatively efficient system. Production bores on the TSF embankment would also provide a benefit, albeit of a lesser order.
- The developed model investigates the groundwater environment below the permanent water table. It does not simulate the unsaturated profile nor specifically the saturated tailings. As such, the entire seepage flow path is not simulated. Consequently, the model does not represent seepage from the embankment walls, or the potential expression of seepage at the toe of the TSF from flows in the unsaturated profile.

5.2 Recommendations

- Re-installation of monitoring bores GW10, GW11, GW12 and GW13 to enable assessment of the effects of the barrier wall on seepage from the TSF.
- Ongoing measurement of recovered volumes and quality of water within Surprise Creek to determine the effects of the barrier wall on seepage paths.
- Installation of groundwater monitoring bores within the area of and adjacent to the proposed new Cell 1 and Cell 2 of the TSF.
- Undertake groundwater exploration drilling and aquifer testing programmes to quantify the hydrostratigraphy and groundwater parameters locally near the TSF, establish current baseline groundwater conditions beneath the proposed Cell 1 and Cell 2 and subsequently refine and verify the groundwater flow and seepage model of the TSF.
- Installation of a test recovery bore and trench near the vicinity of the Existing Cell 1 to assess the impacts and effectiveness of the existing barrier wall in terms of seepage mitigation.

-
- Consolidate the knowledge gained from the groundwater flow modelling and recommended site investigations and apply it to detailed design of effective seepage recovery systems for the proposed Cell 1 and Cell 2. The detailed designs should incorporate additional predictive modelling to define the preferred seepage recovery methods. Where practical the seepage recovery systems should extend beneath the TSF.

Allan Watson Associates (2003) *Draft Report - Concept Design and Pre-Feasibility Study for Tailings Storage Facility*. Prepared on behalf of Ausenco Limited.

Preservation and Maintenance Engineering Soil Con Systems (2006) - *Case Study, Tailings Storage Facility, McArthur River Mine, Insitu Barrier Wall Placement*. Prepared for McArthur River Mining.

URS (2004) *McArthur River Mine Tailings Storage Facility Rehabilitation – Cell 1 Concept Design*. Prepared for Xstrata McArthur River Mines.

URS (2005a) *MRM Expansion EIS – Groundwater Investigations to Determine the Potential Impacts of Dewatering*. Prepared for Xstrata Plc.

URS (2005b) *Groundwater and Surface Water Investigations of the McArthur River*. Prepared for Xstrata Plc.

URS (2005c) *McArthur River Mine Open Cut Project – Draft Environmental Impact Statement*. Prepared for Xstrata Plc.

URS (2005d) *McArthur River Mine Open Cut Project – Environmental Impact Statement Supplement*. Prepared for Xstrata Plc.

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 Xstrata Plc 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.

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 1 May and 20 June 2006 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.

Figures



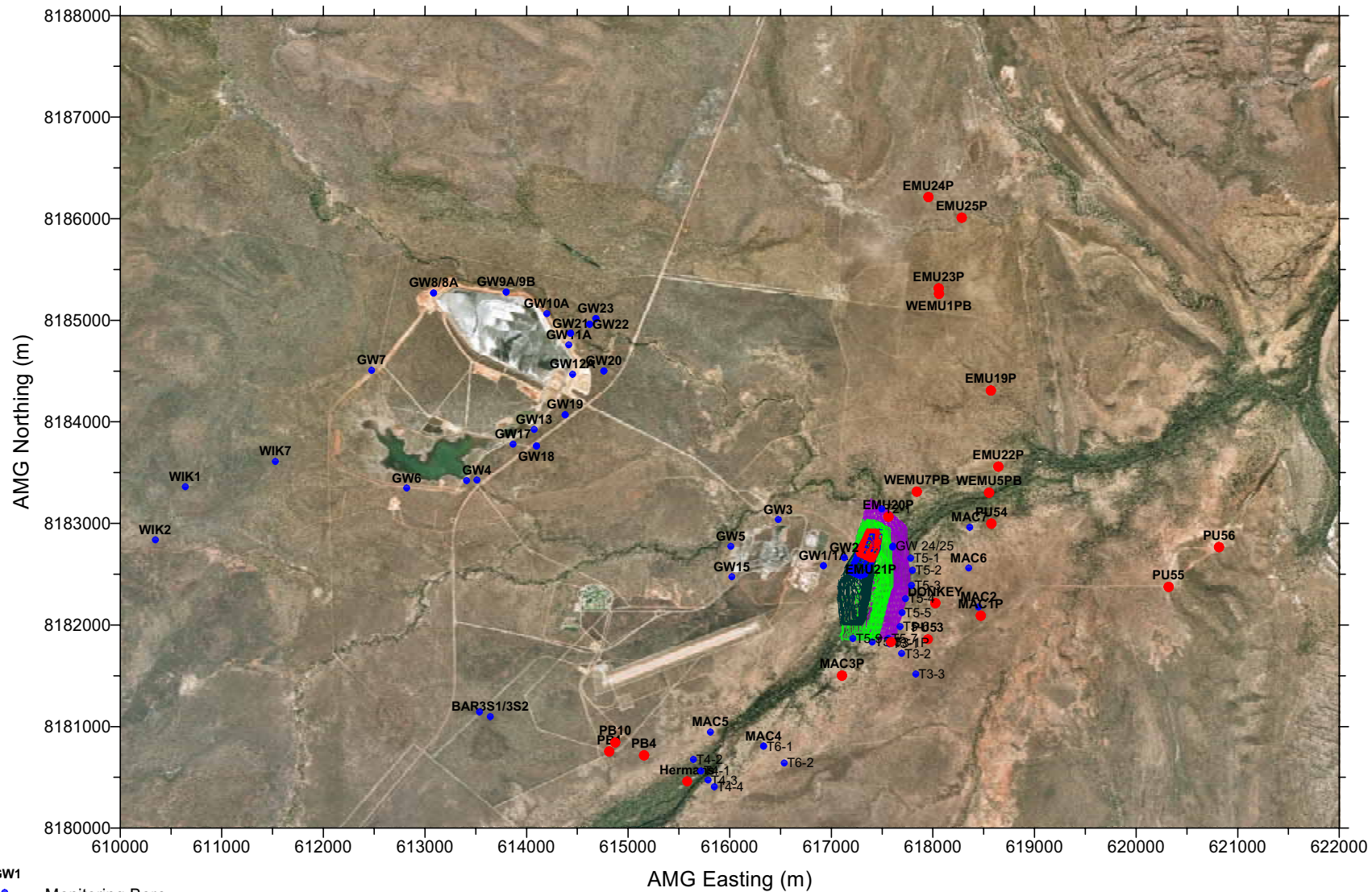
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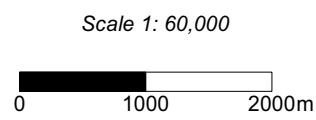
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**SIMULATION OF
 PROPOSED TAILINGS STORAGE FACILITY TO ASSESS
 POTENTIAL SEEPAGE IMPACTS**
REGIONAL LOCALITY PLAN

Figure 1

Figure 1.srf



- GW1** ● Monitoring Bore
- PB1** ● Production bore

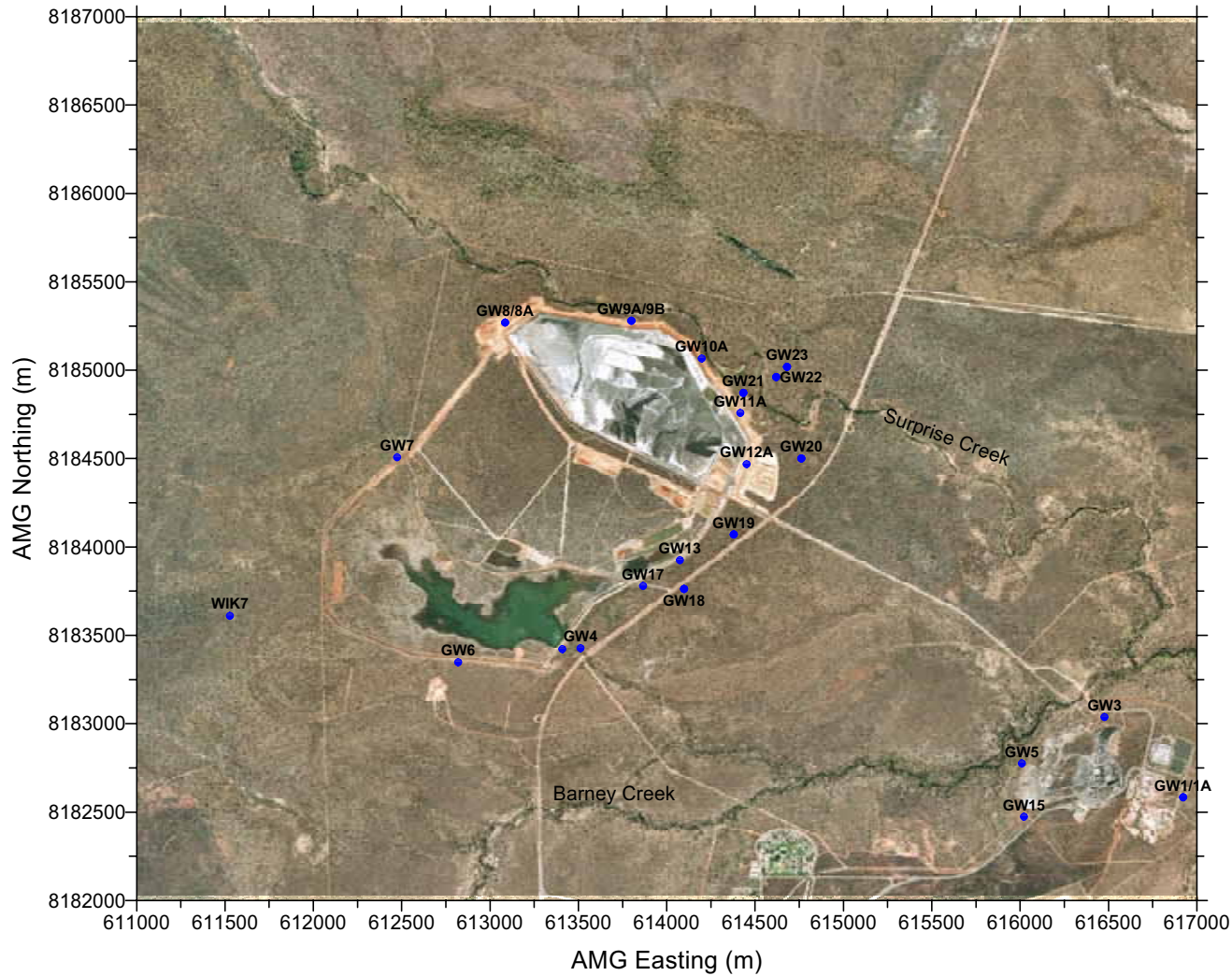


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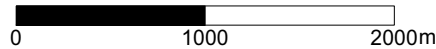
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SIMULATION OF
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POTENTIAL SEEPAGE IMPACTS
REGIONAL BORE LOCATION MAP

Figure 2

Figure 2.srf



GW1
• Monitoring Bore



Scale 1: 40,000

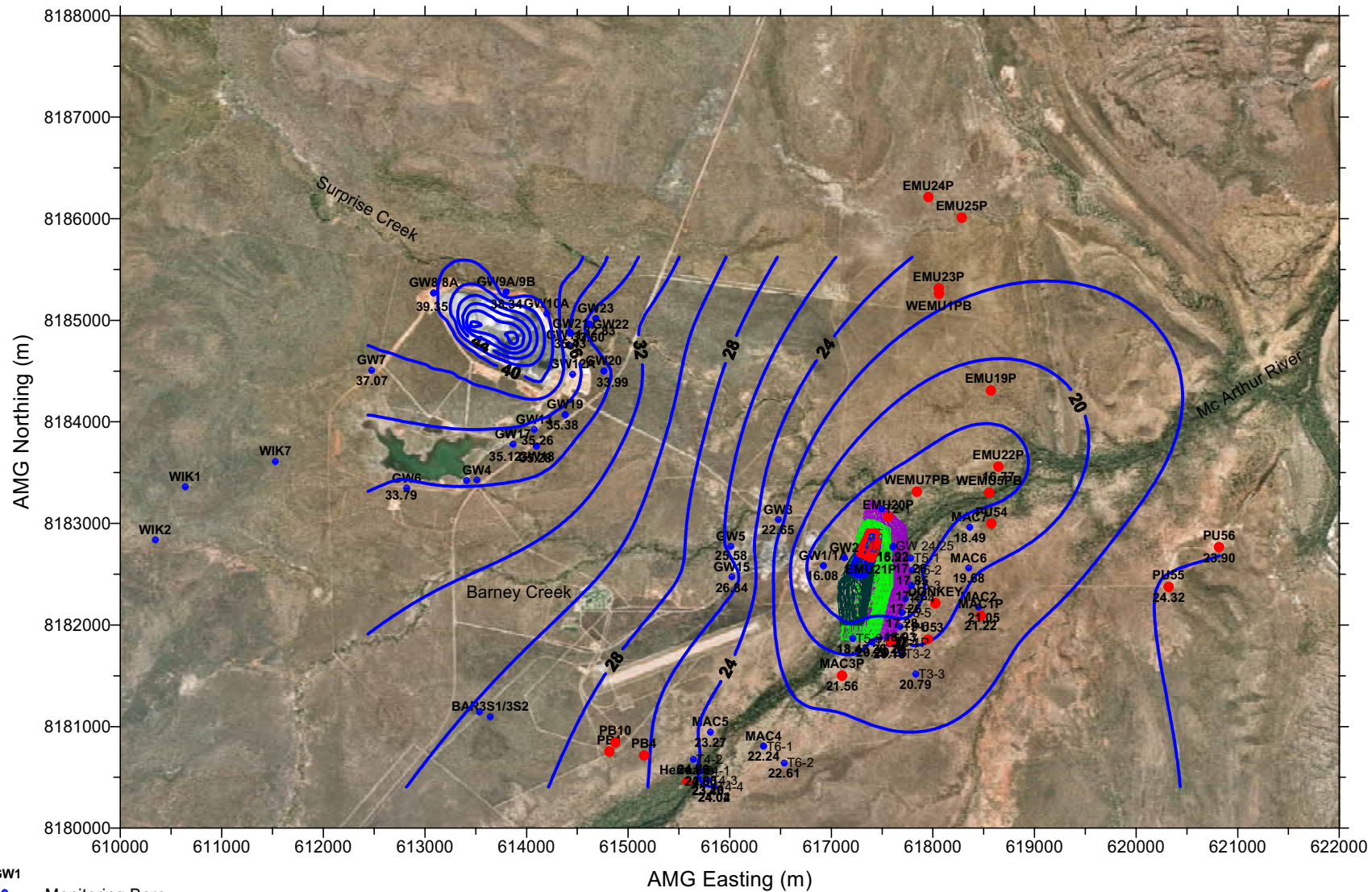
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POTENTIAL SEEPAGE IMPACTS
TSF BORE LOCATION MAP

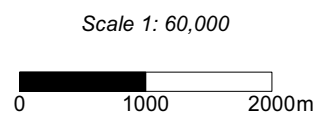
Figure 3



Figure 3.srf



- GW1 ● Monitoring Bore
- PB1 ● Production bore



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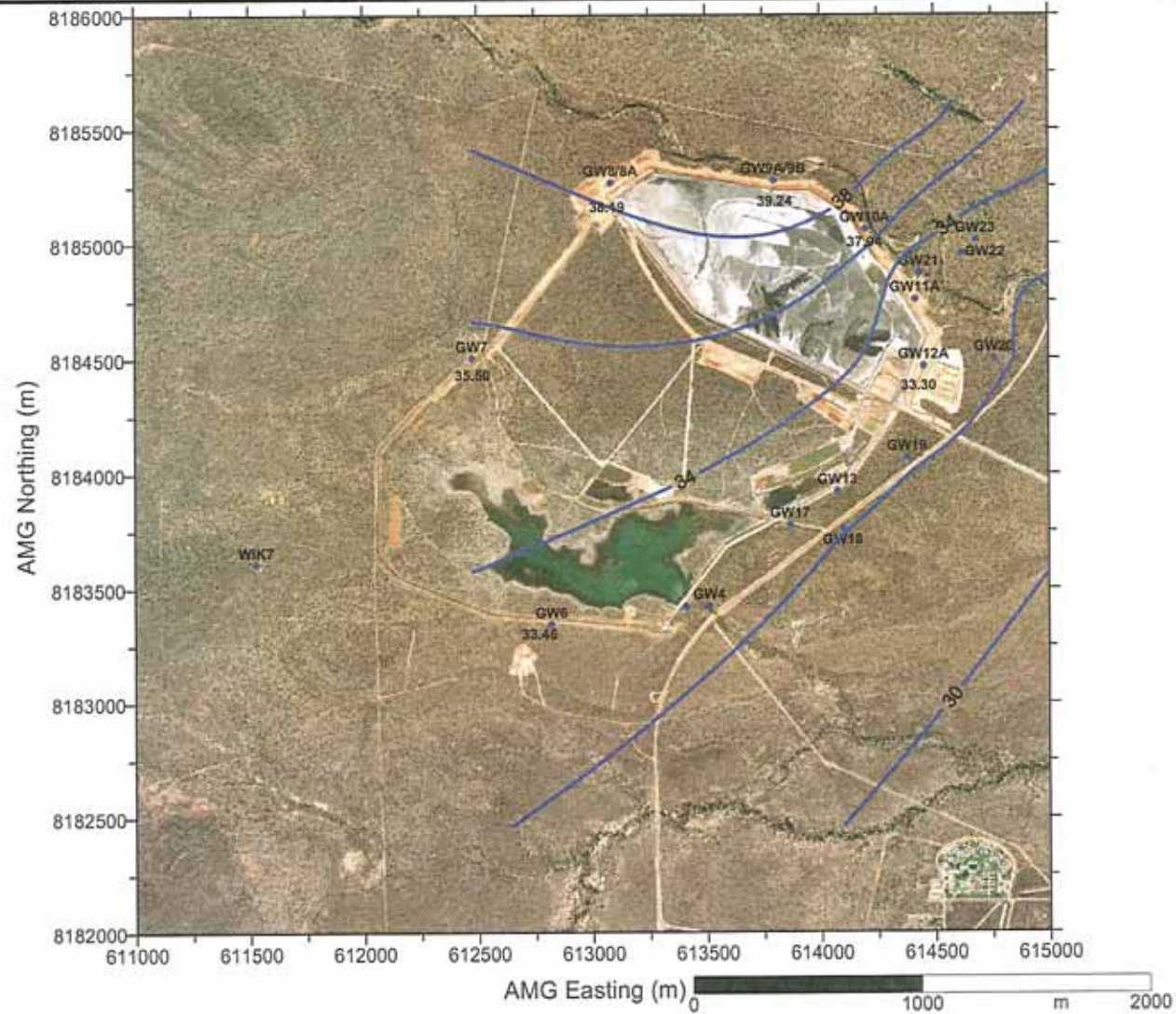
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SIMULATION OF PROPOSED TAILINGS STORAGE FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS

REGIONAL GROUNDWATER LEVELS (mAH - END OF DRY SEASON 2005)

Figure 4

Figure 4.srf



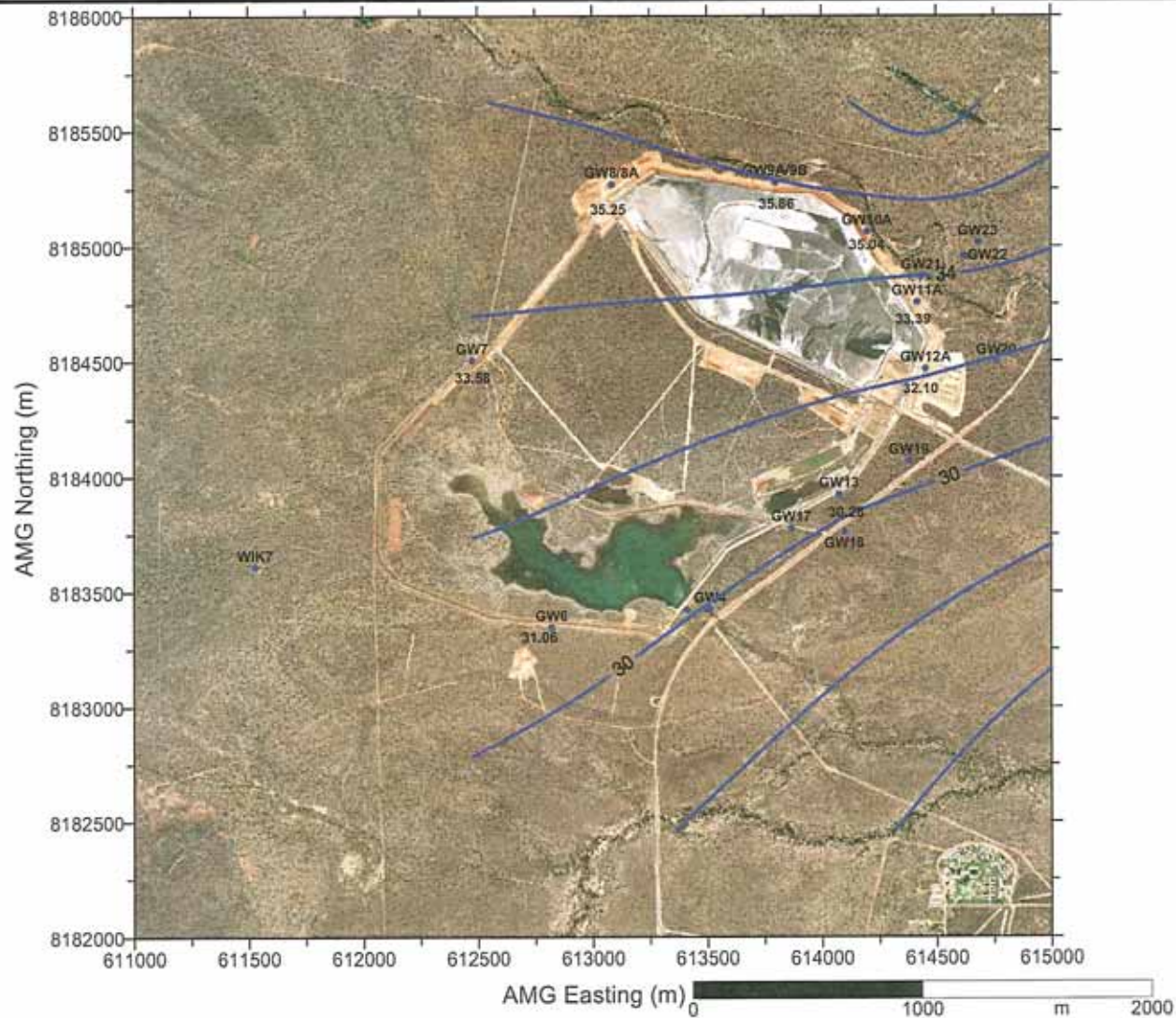
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TSF GROUNDWATER LEVELS
 (mAHD - END OF WET SEASON 1998)

Figure 5



Figure 8.srf



GW1
• Monitoring Bore

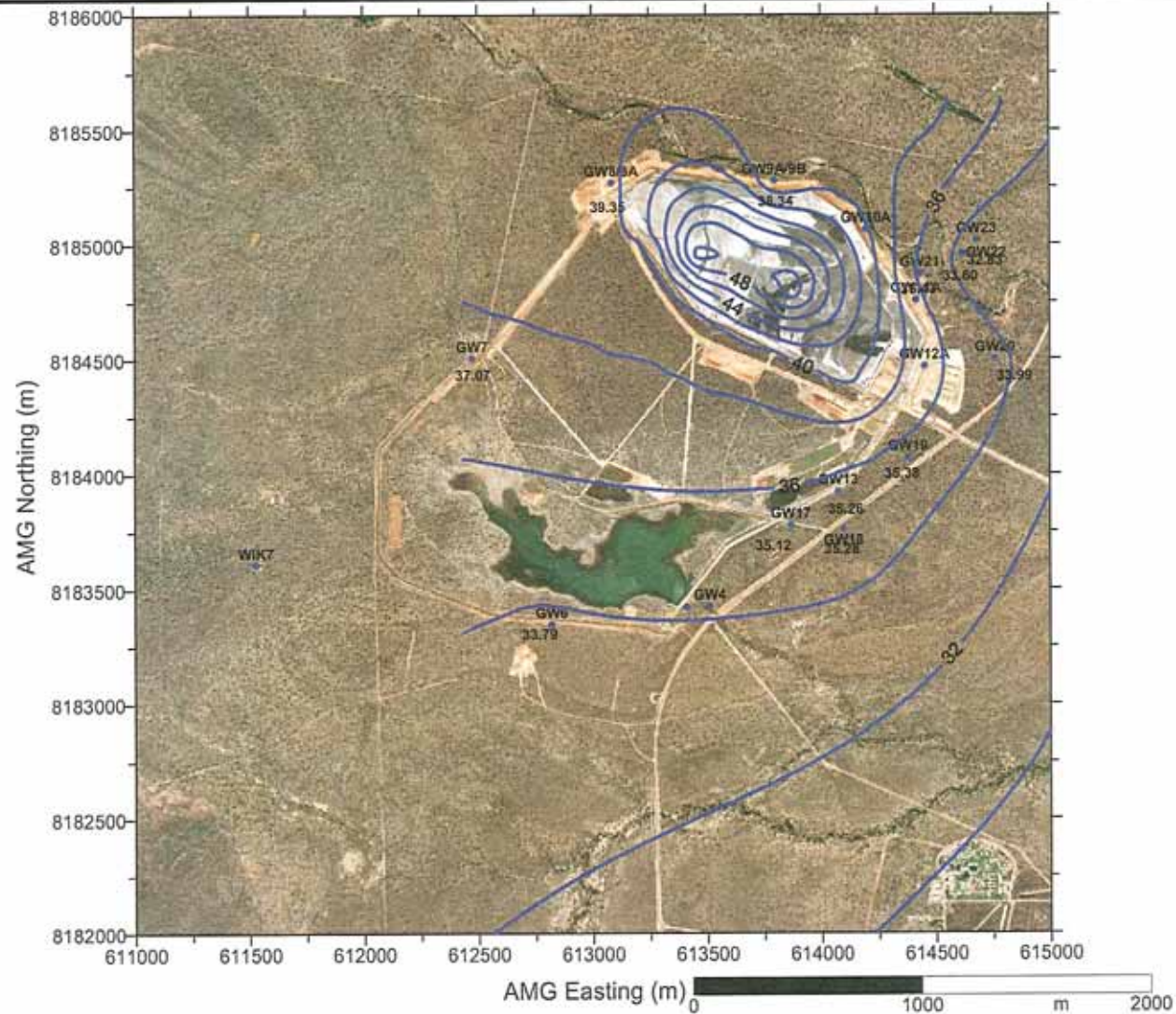
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TSF GROUNDWATER LEVELS
(mAHD - END OF DRY SEASON 1997)

Figure 6



Figure 7.srf



GW1
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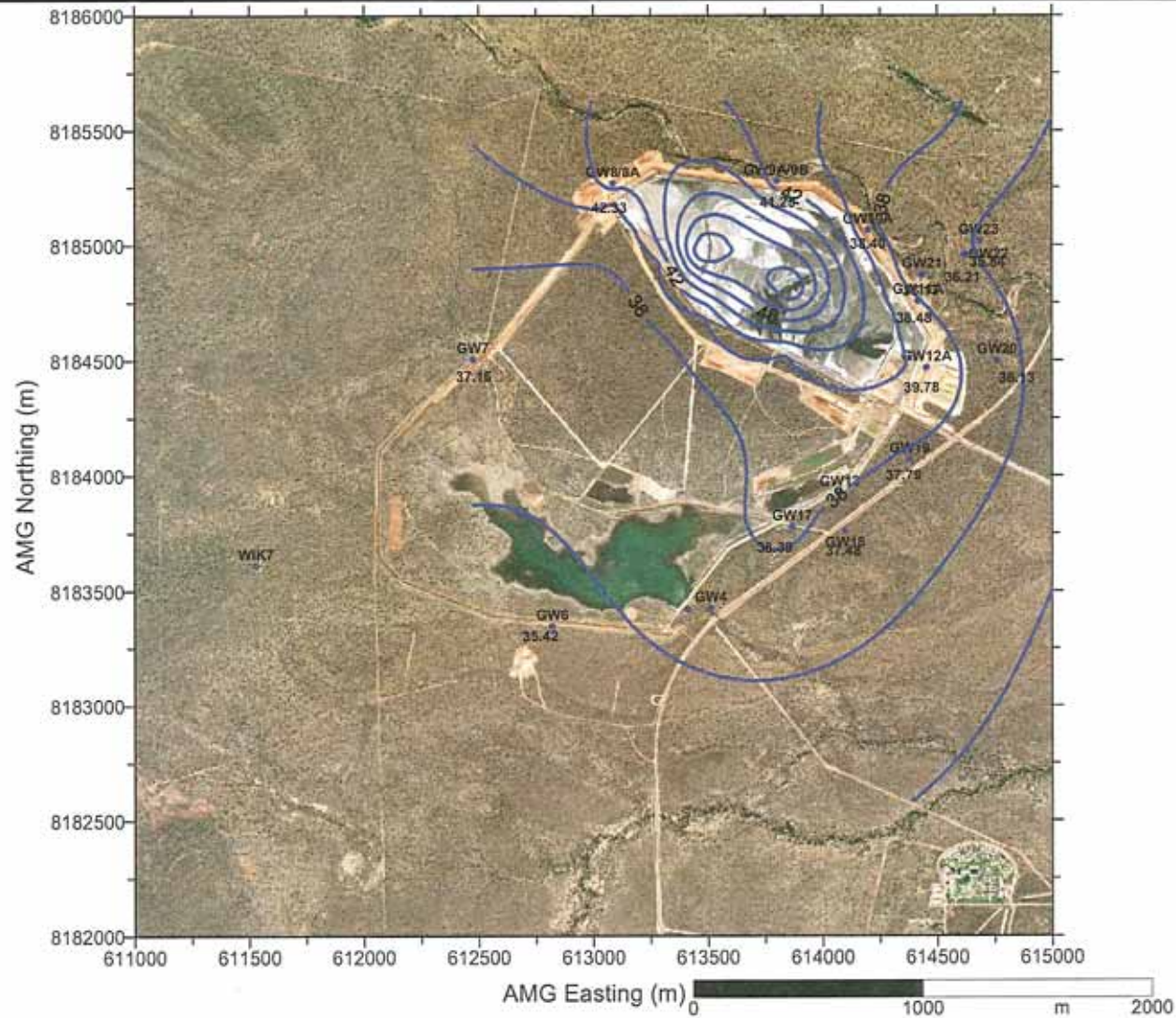
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TSF GROUNDWATER LEVELS
(mAHD - END OF DRY SEASON 2005)

Figure 7



Figure 7.srf



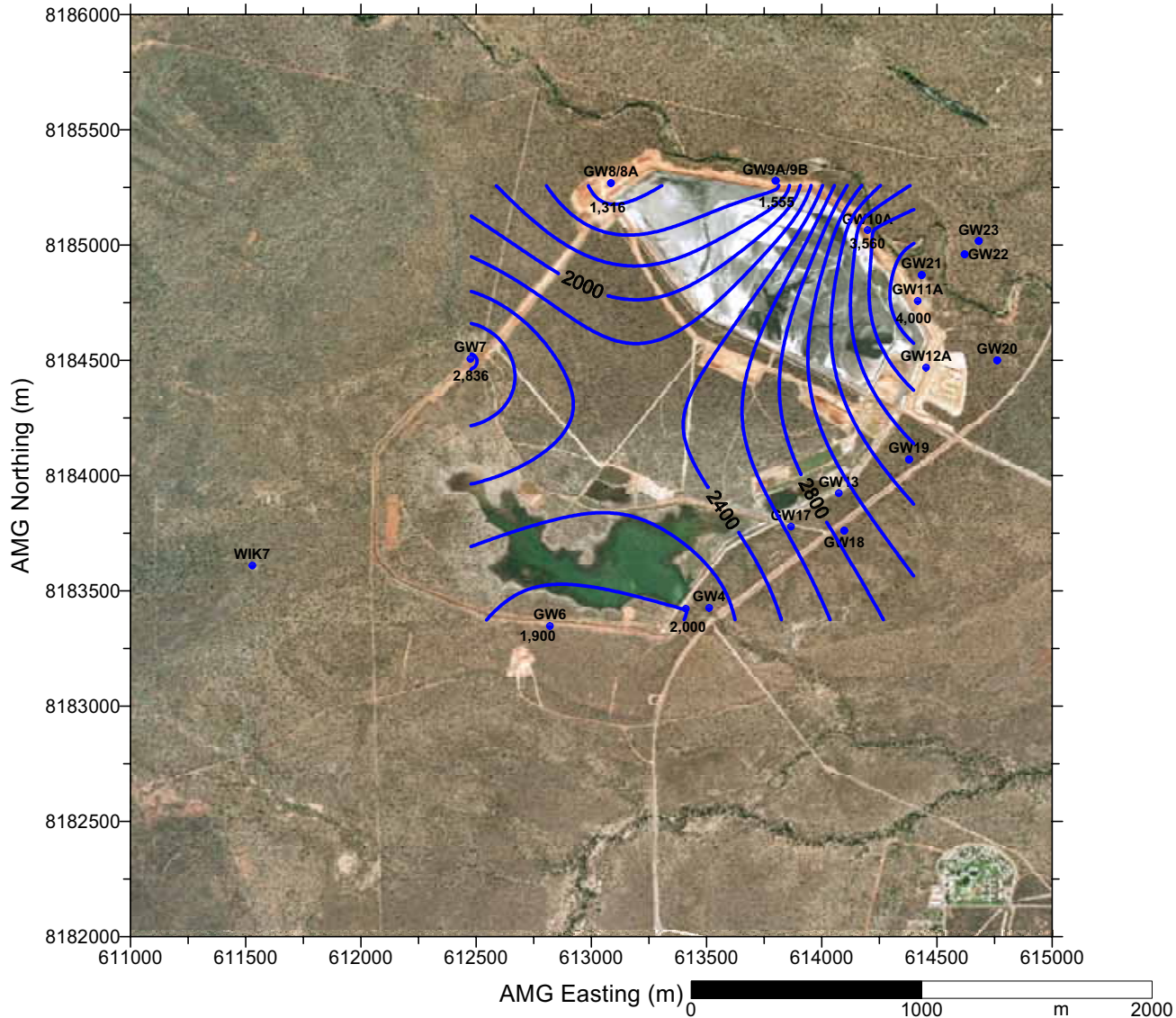
GW1
• Monitoring Bore

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FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
TSF GROUNDWATER LEVELS
(mAHD - END OF WET SEASON 2005)

Figure 8





GW1
• Monitoring Bore

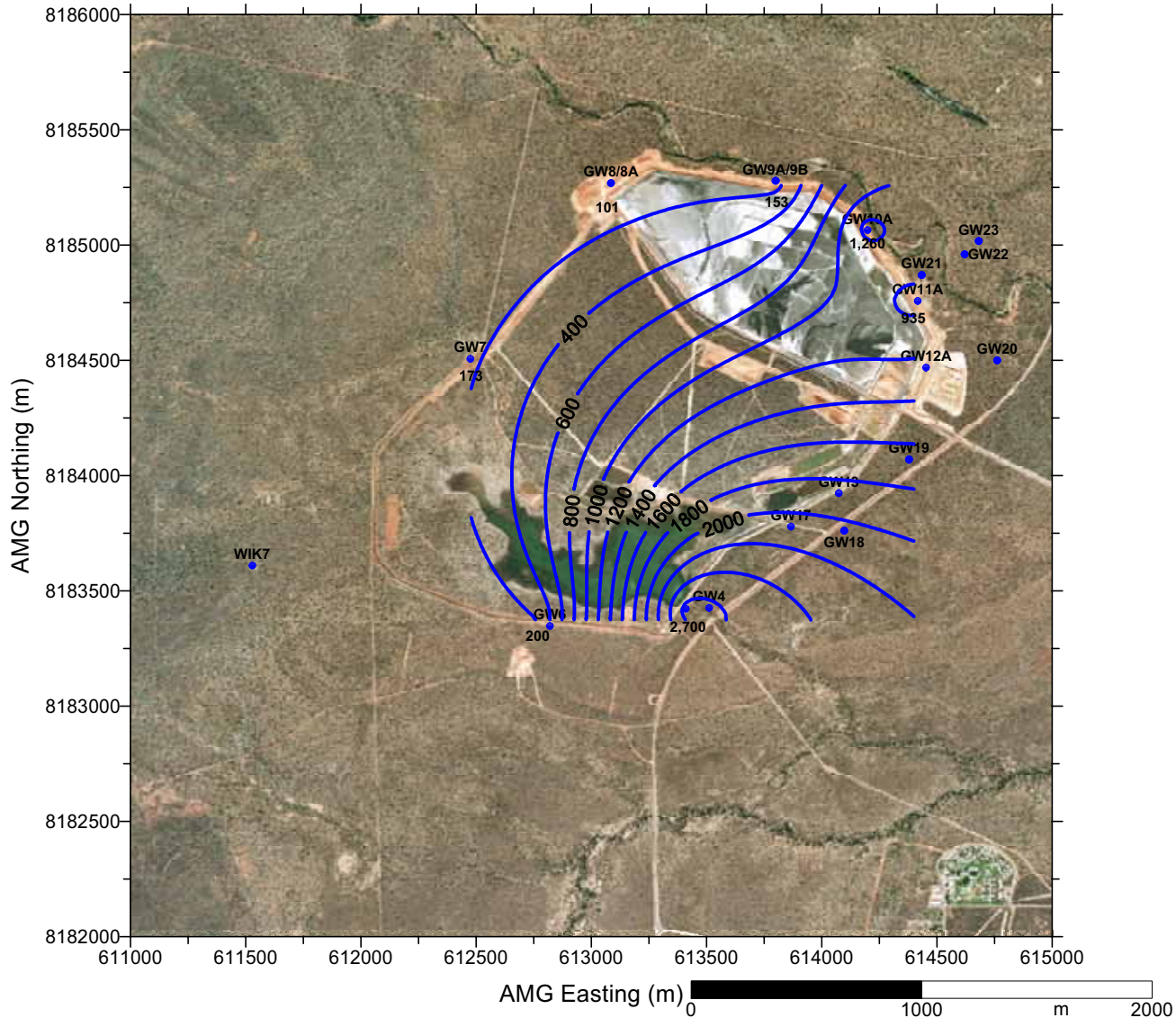
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TSF ELECTRICAL CONDUCTIVITY
(uS/cm - END OF WET SEASON 1998)

Figure 9



Figure 9.srf



GW1
• Monitoring Bore

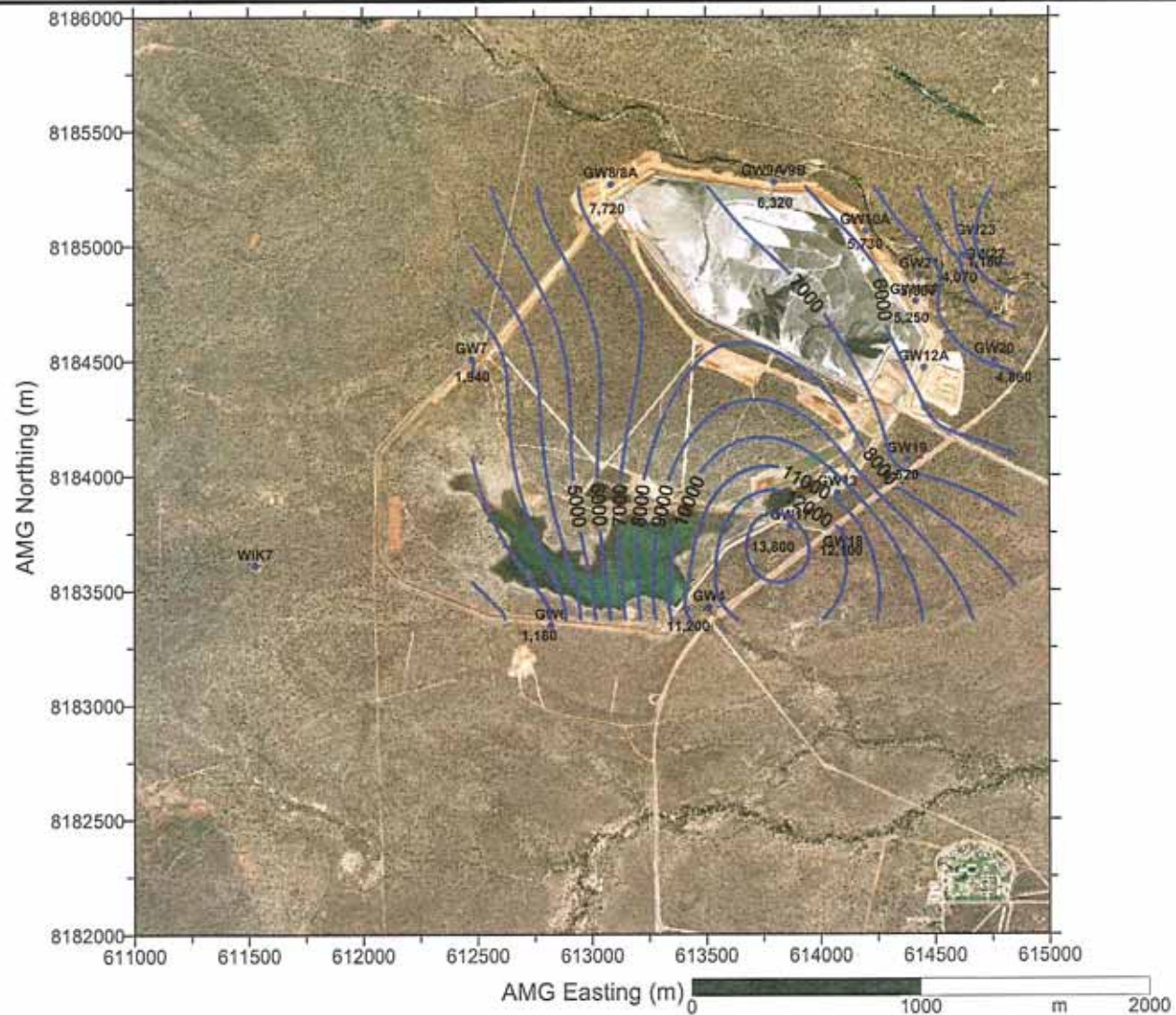
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FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
TSF SULPHATE
(mg/L - END OF WET SEASON 1998)

Figure 10



Figure 10.srf



GW1
• Monitoring Bore

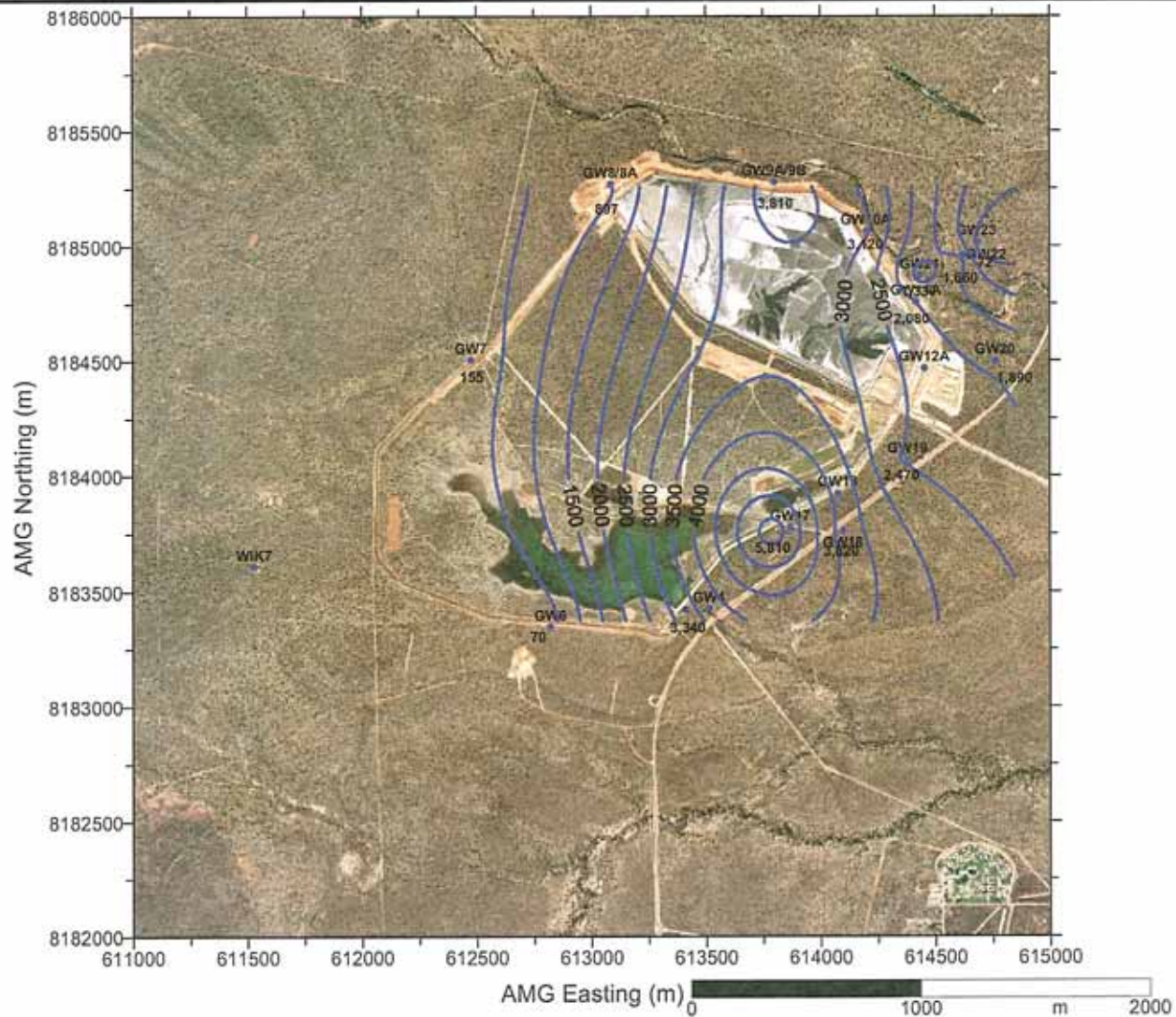
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FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
TSF ELECTRICAL CONDUCTIVITY
(uS/cm - END OF WET SEASON 2006)

Figure 11



Figure 9.srf



GW1
• Monitoring Bore

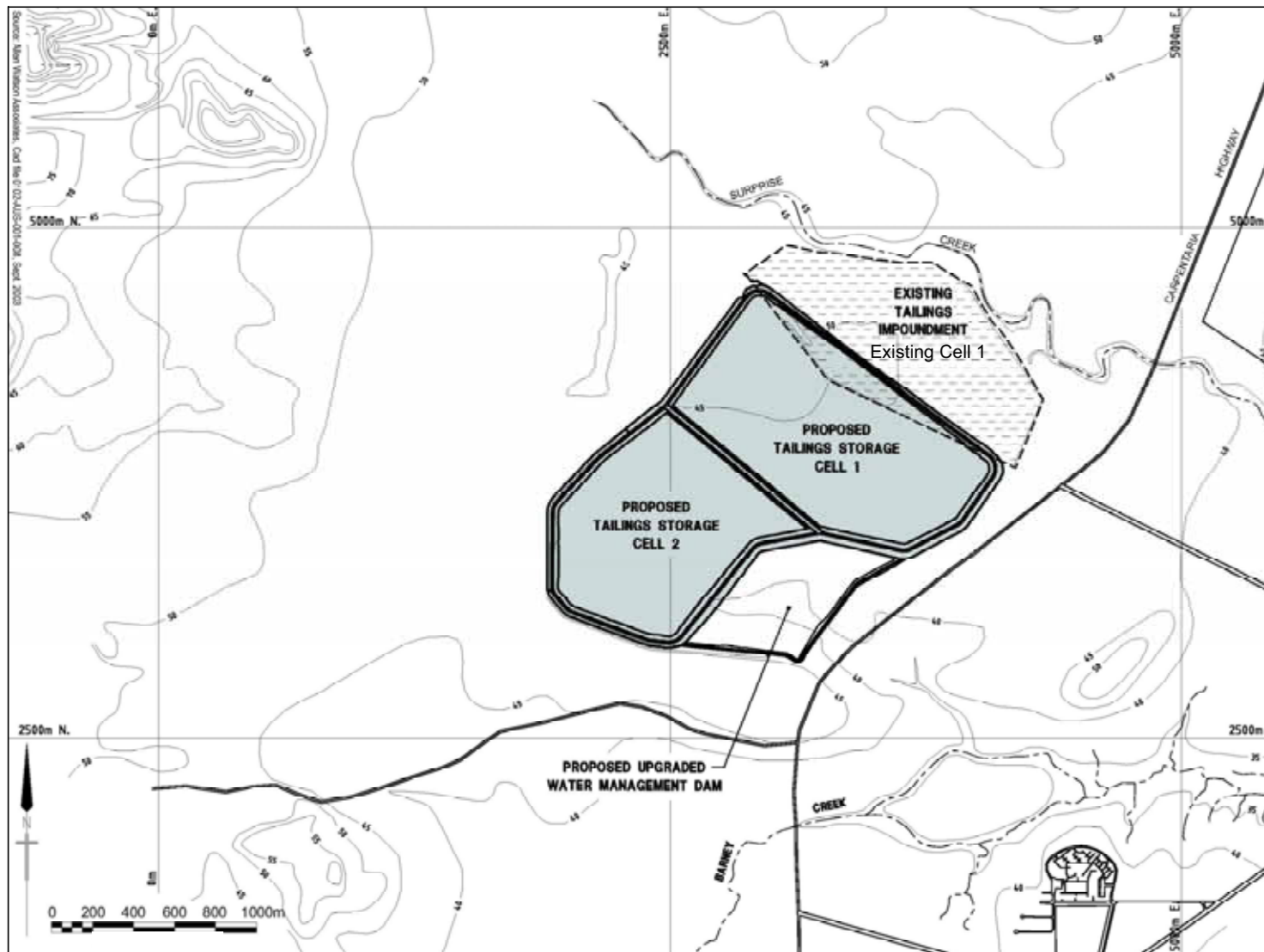
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FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
TSF SULPHATE
(mg/L - END OF WET SEASON 2006)

Figure 12



Figure 10.srf



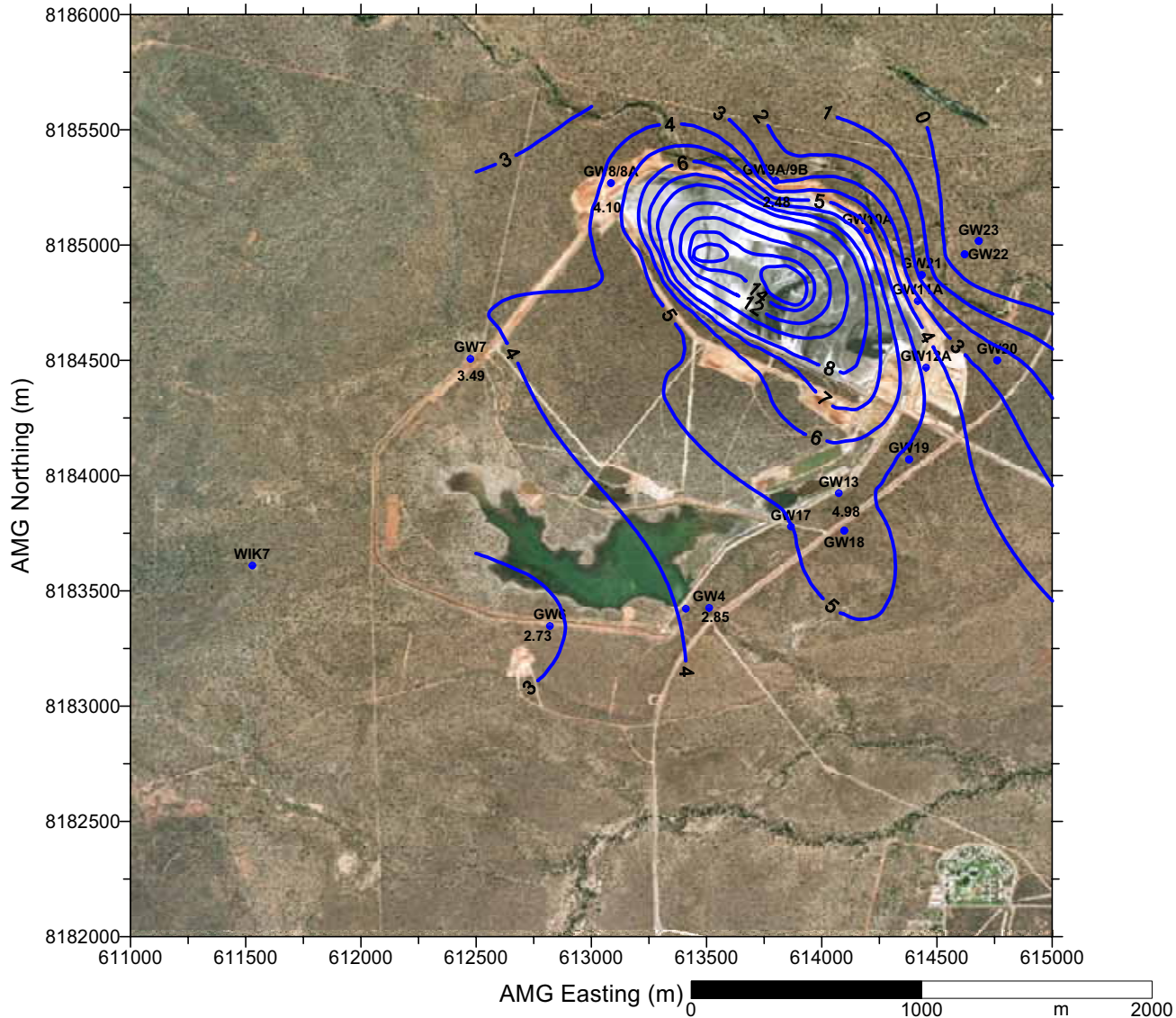
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 SIMULATION OF PROPOSED TAILINGS STORAGE FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
LAYOUT OF EXPANDED TAILINGS STORAGE FACILITY

Figure 13



Figure 13.srf



GW1
• Monitoring Bore

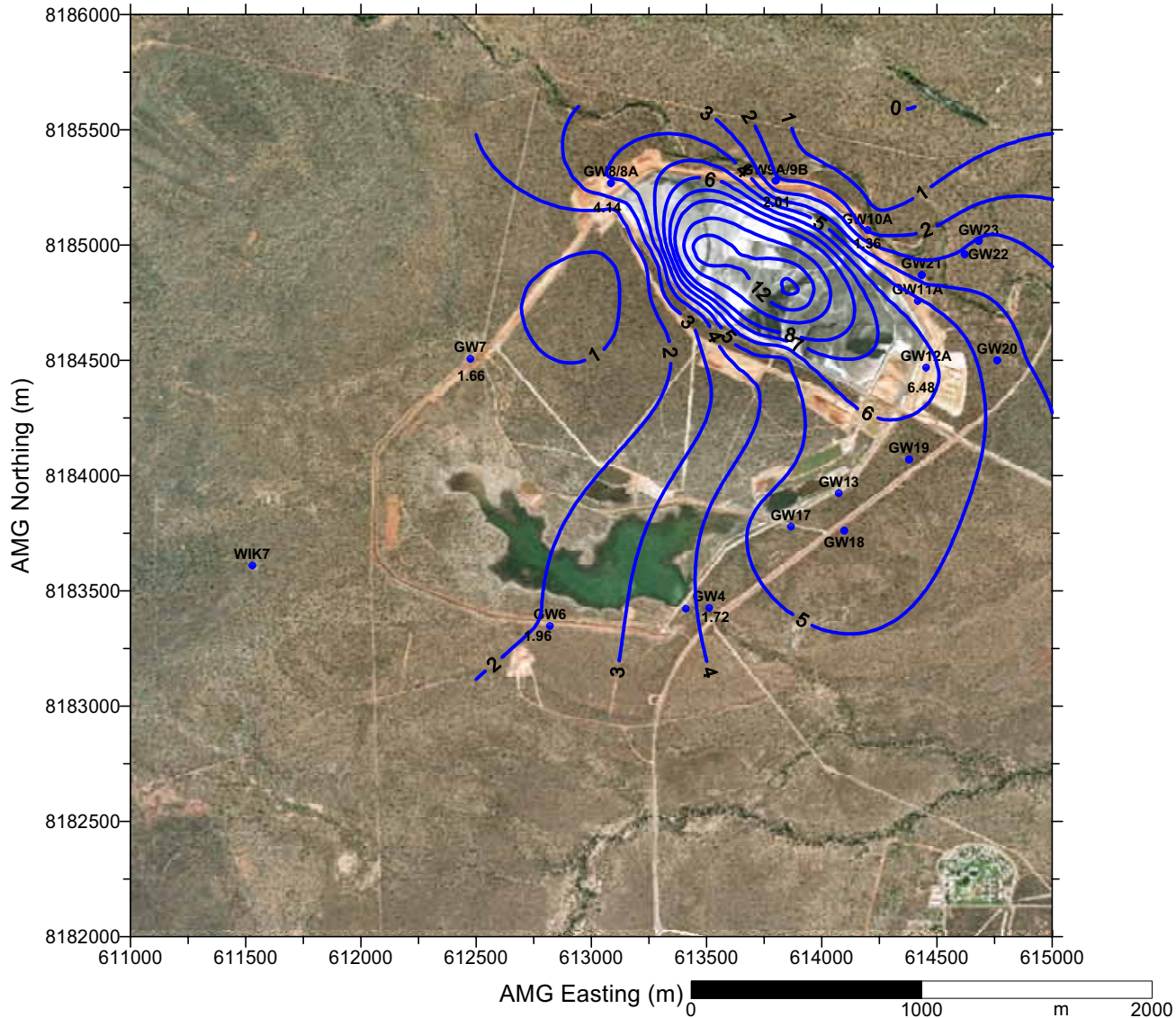
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FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
**TSF GROUNDWATER LEVEL CHANGE
(mAHD - DRY SEASON 1997 to 2005)**

Figure 14



Figure 14.srf



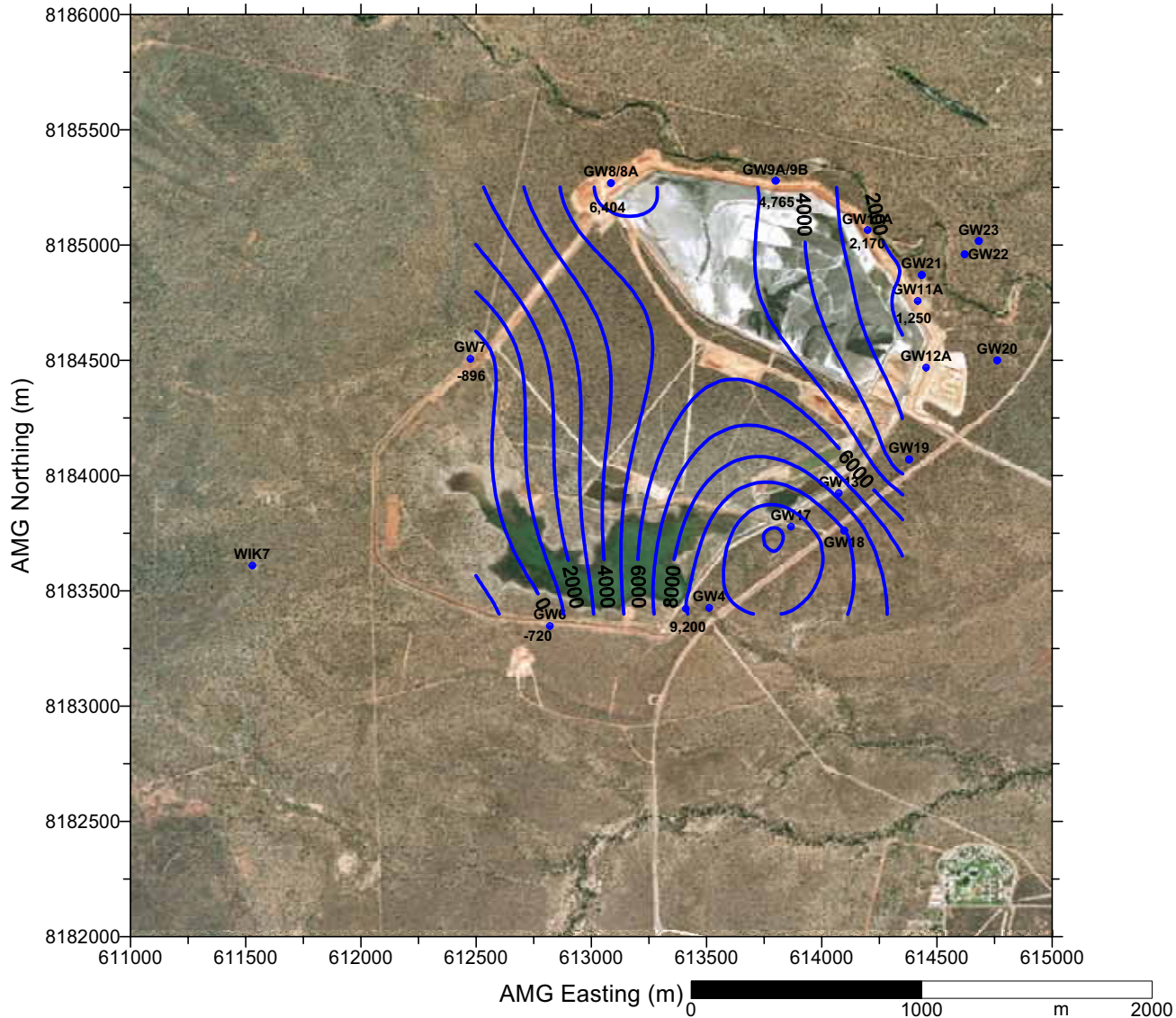
GW1
• Monitoring Bore

Job No.	42625552	
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Chk'd By	IGB	30 May '06
Revision No.	0	

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 SIMULATION OF PROPOSED TAILINGS STORAGE
 FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
TSF GROUNDWATER LEVEL CHANGE
(mAHD - WET SEASON 1998 to 2005)

Figure 15

Figure 15.srf



GW1
• Monitoring Bore

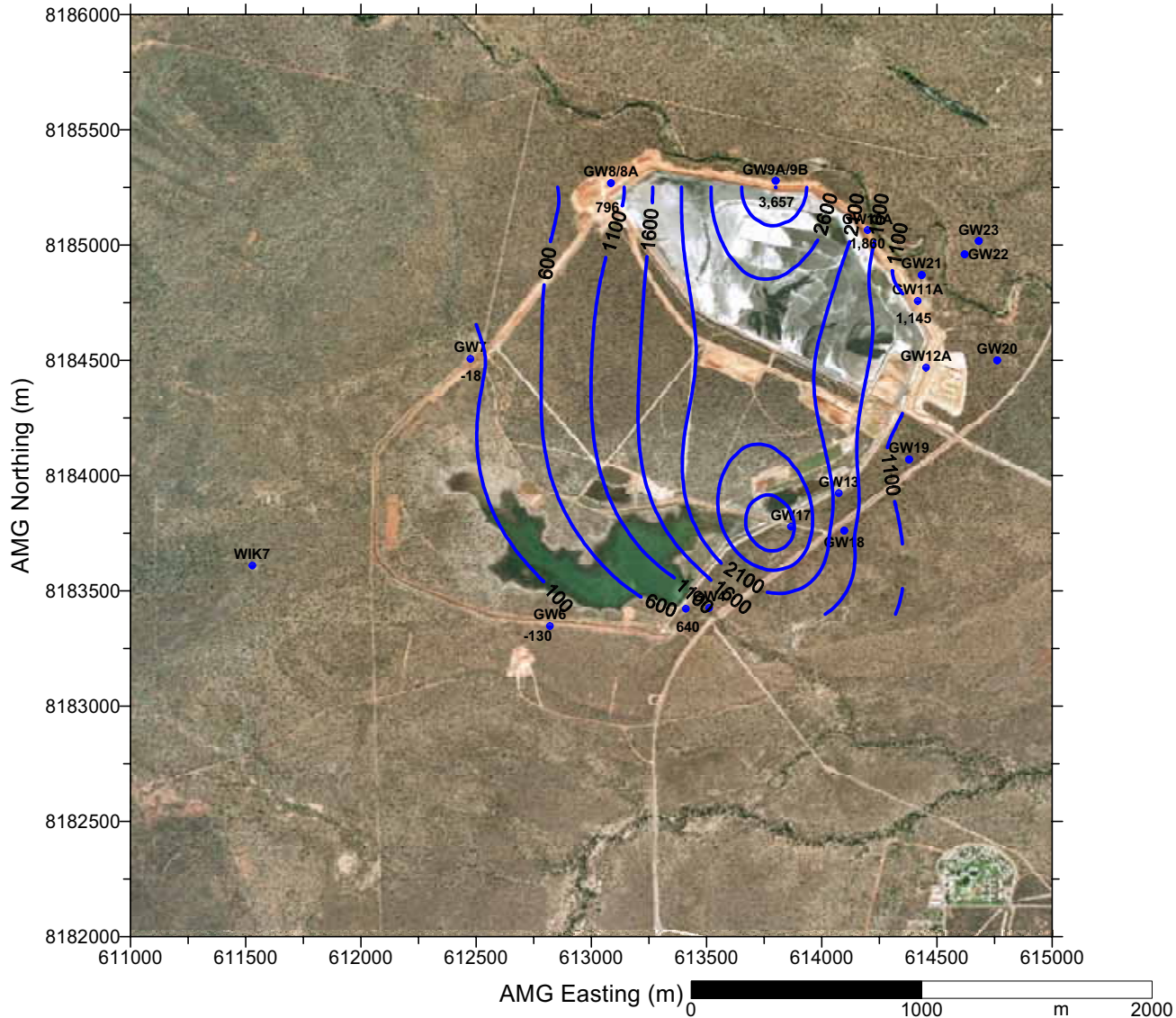
Job No.	42625552	
Prep. By	CMAC	24 May '06
Chk'd By	IGB	30 May '06
Revision No.	0	

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SIMULATION OF PROPOSED TAILINGS STORAGE
FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
TSF ELECTRICAL CONDUCTIVITY CHANGE
(uS/cm - WET SEASON 1998 to 2006)

Figure 16



Figure 16.srf



GW1
• Monitoring Bore

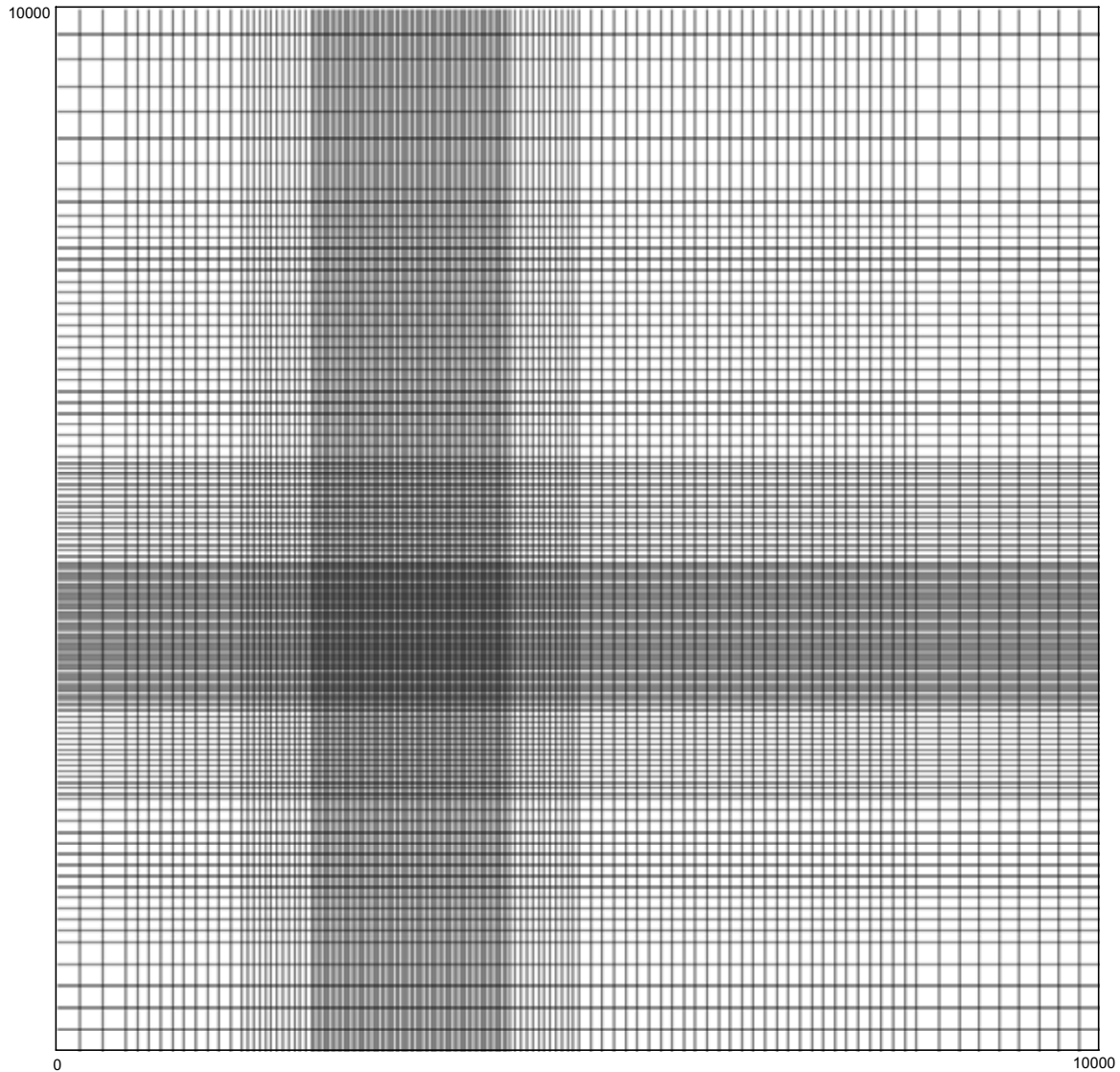
Job No.	42625552	
Prep. By	CMAC	24 May '06
Chk'd By	IGB	30 May '06
Revision No.	0	

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FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
TSF SULPHATE CHANGE
(mg/L - WET SEASON 1998 to 2006)

Figure 17



Figure 17.srf



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Chk'd By	IGB	30 May '06
Revision No.	0	

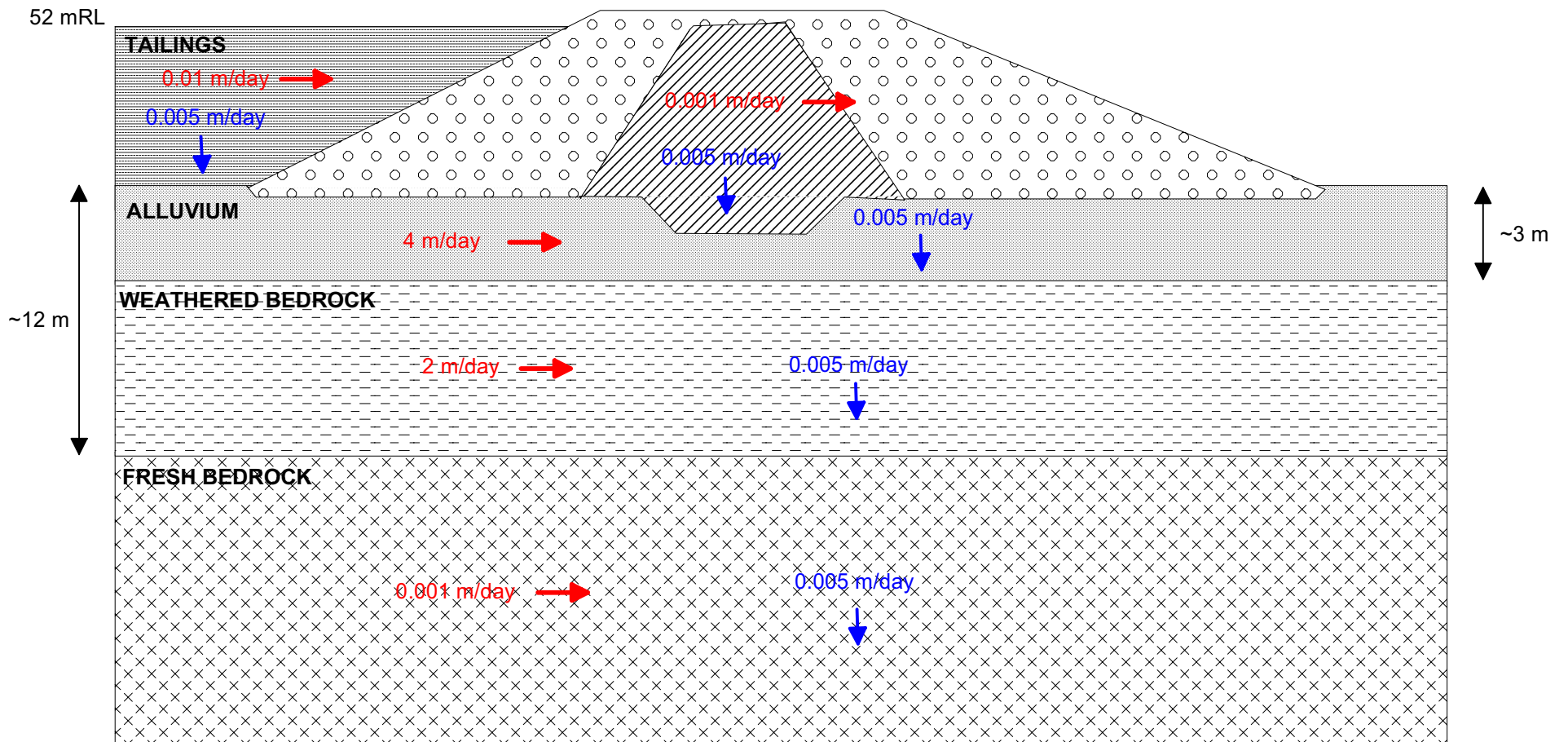
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 SIMULATION OF PROPOSED TAILINGS STORAGE
 FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS

MODEL GRID

Figure 18



Figure 18.srf



Modelled Parameters

- 0.001 m/day Horizontal Hydraulic Conductivity
- 0.005 m/day Vertical Hydraulic Conductivity

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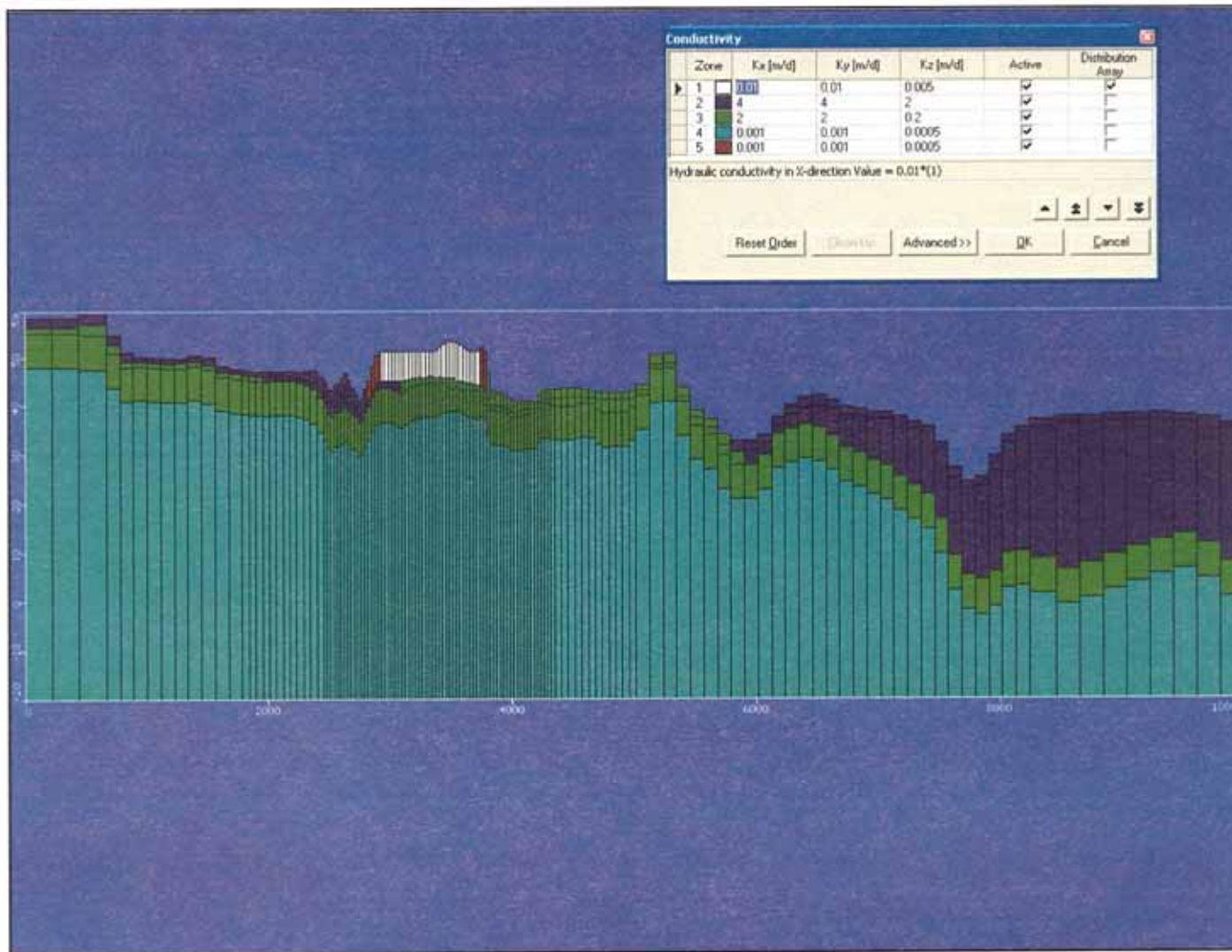
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SIMULATION OF PROPOSED TAILINGS STORAGE FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS

CONCEPTUAL MODEL

Figure 19



Figure 19.srf



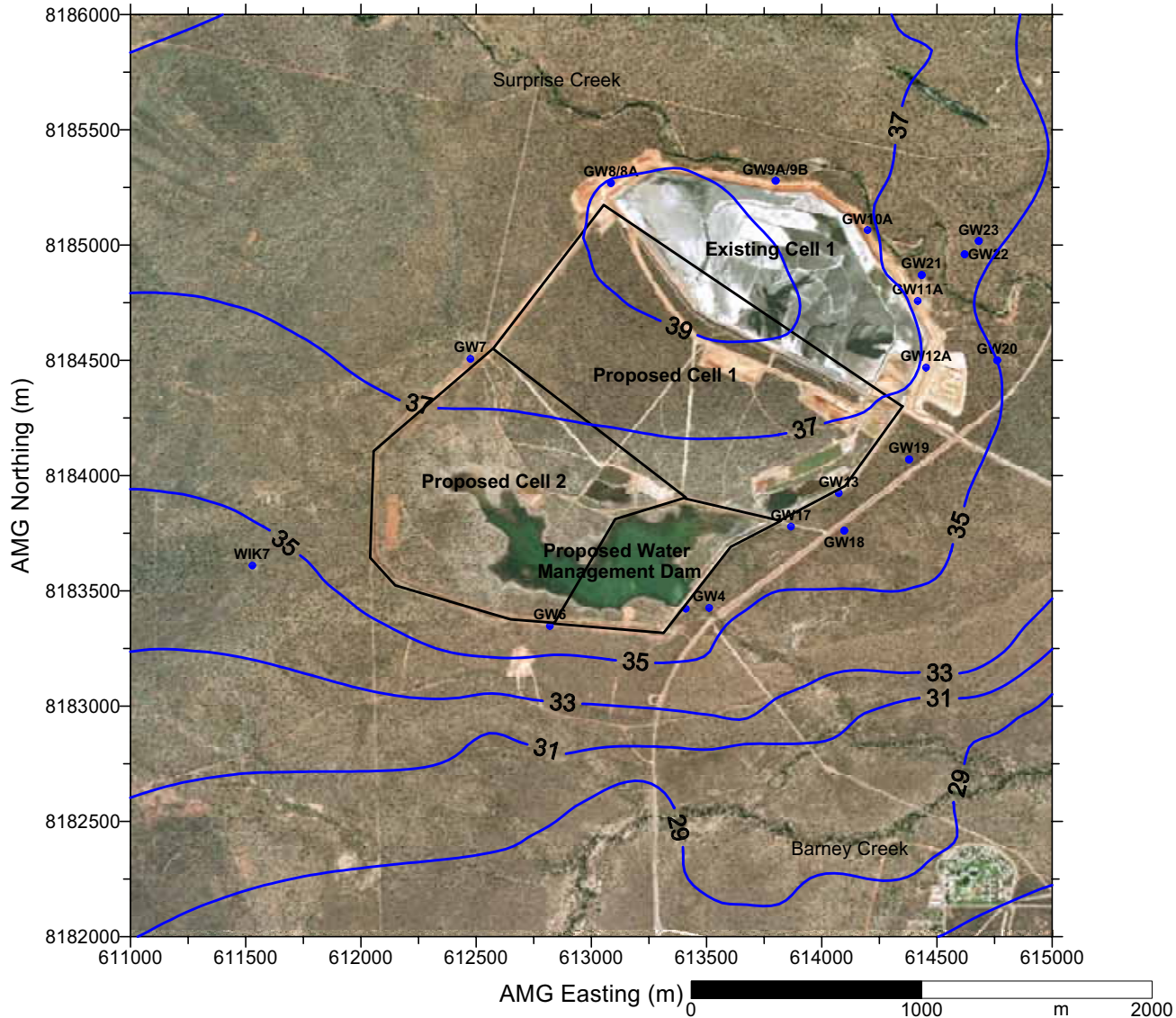
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 GROUNDWATER MODELLING OF PROPOSED TAILINGS STORAGE
 FACILITY TO ASSESS POTENTIAL GROUNDWATER RECOVERY IMPACTS

MODEL CROSS SECTION

Figure 20





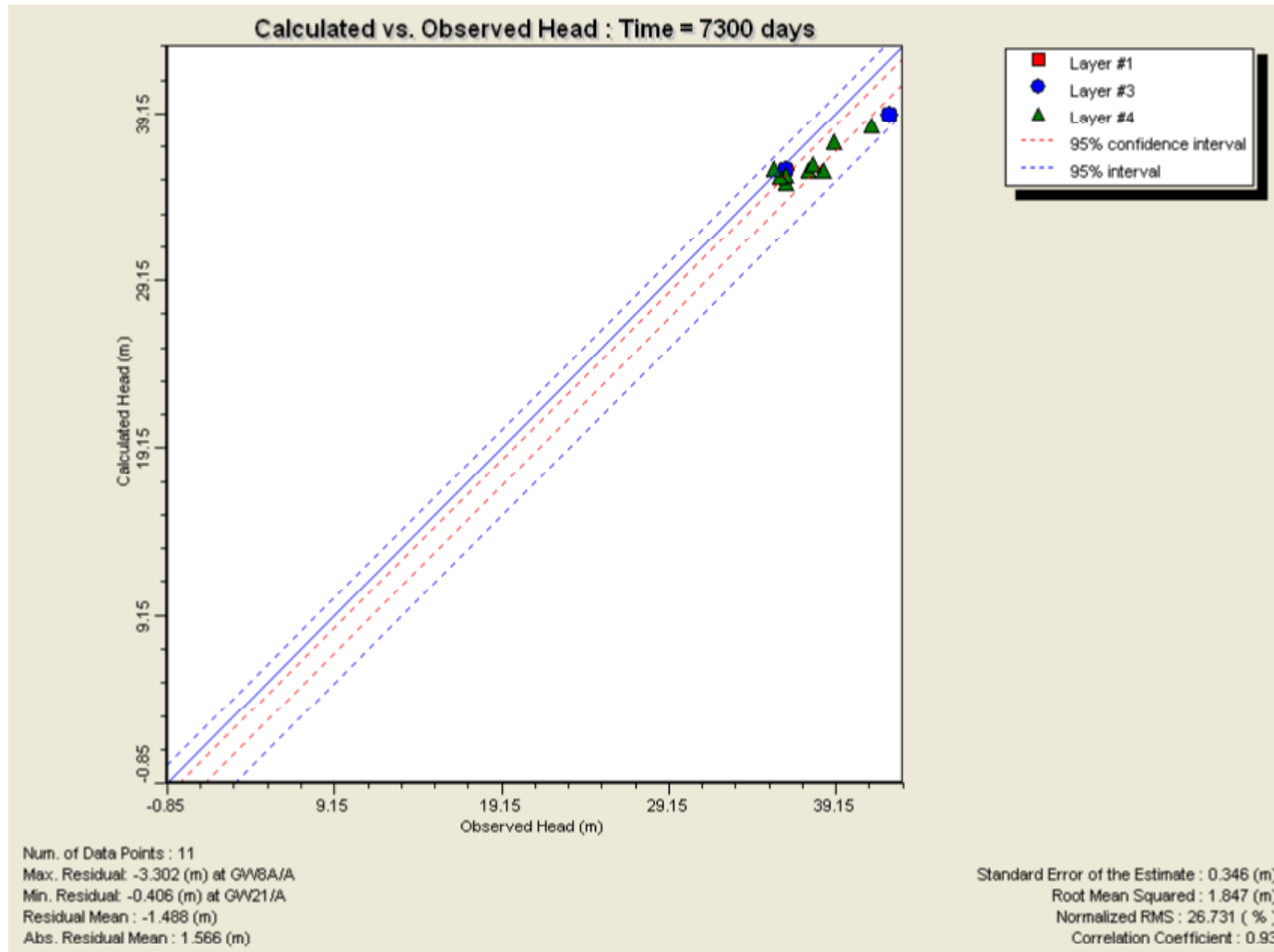
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 SIMULATION OF PROPOSED TAILINGS STORAGE FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
STEADY-STATE GROUNDWATER LEVELS

Figure 21

Figure 21.srf



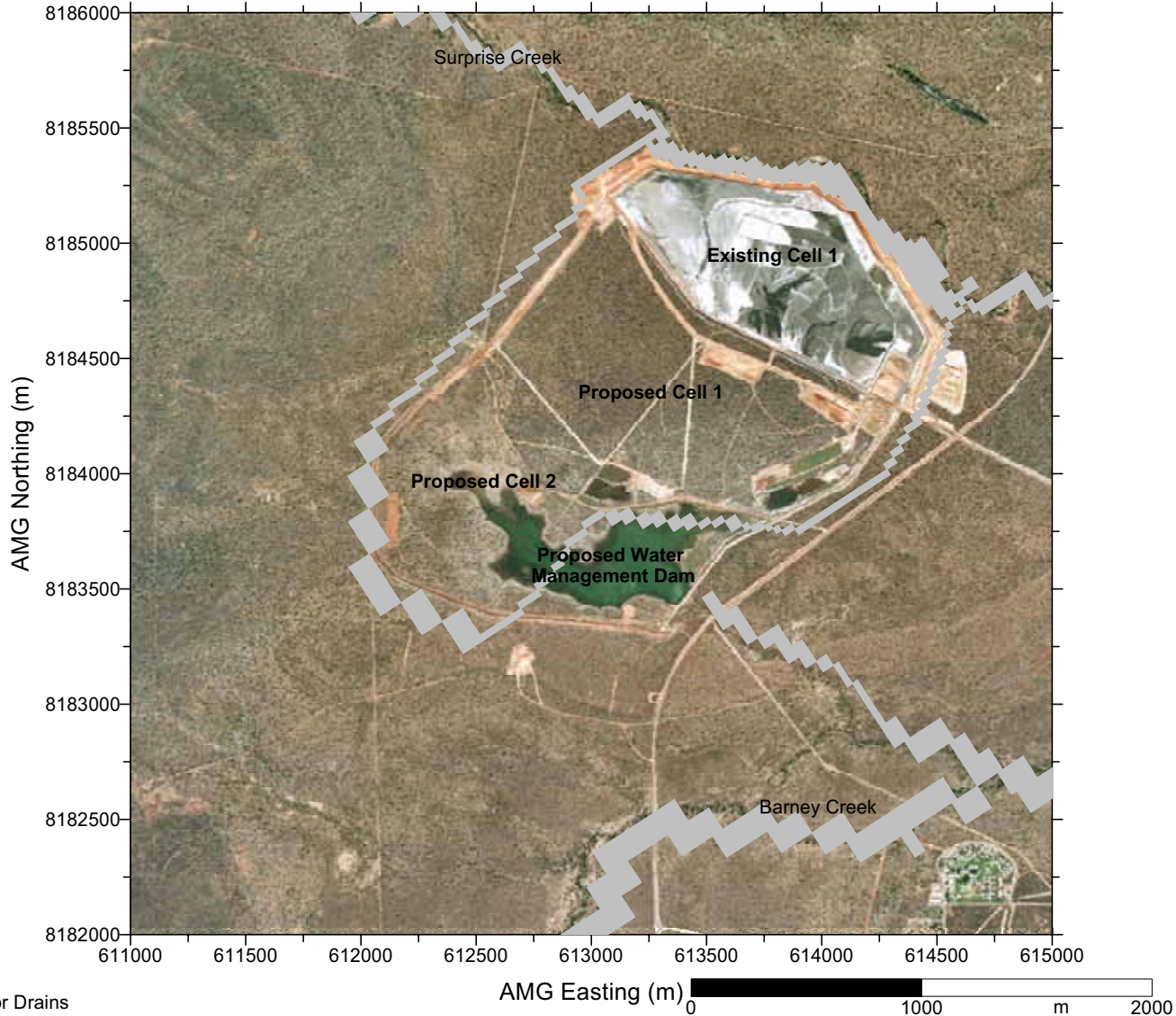
Job No.	42625552	
Prep. By	GRB	24 May '06
Chk'd By	CMAC	30 May '06
Revision No.	0	

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SIMULATION OF PROPOSED TAILINGS STORAGE
FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS

**TRANSIENT CALIBRATION STATISTICS
CALIBRATED VS OBSERVED HEADS**

Figure 22





■ Modelled Interceptor Drains

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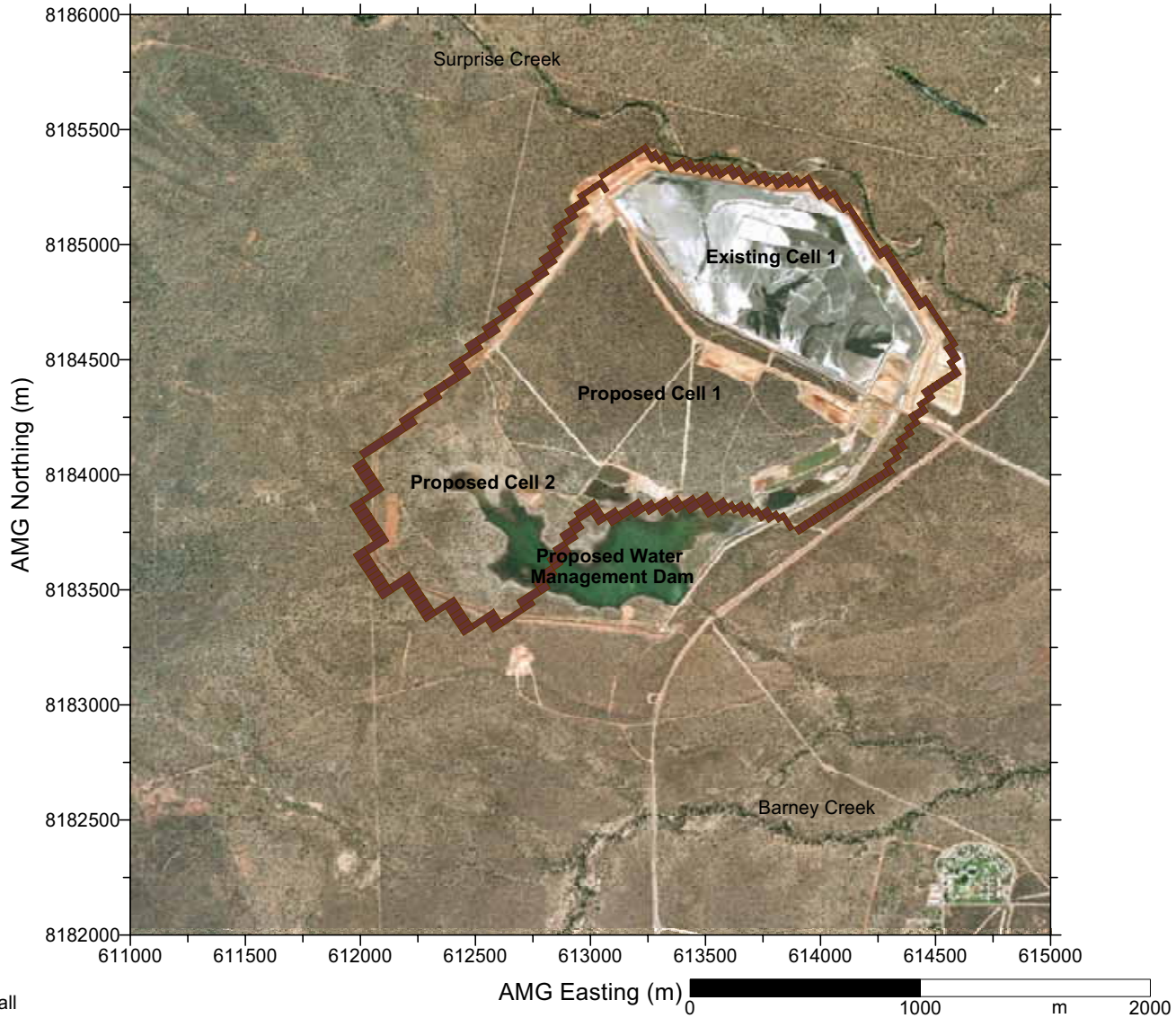
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 SIMULATION OF PROPOSED TAILINGS STORAGE
 FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS

**SCENARIO 3 -
 MODELLED INTERCEPTOR DRAINS**

Figure 24



Figure 24.srf



■ Modelled Barrier Wall

Job No.	42625552	
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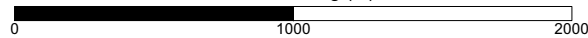
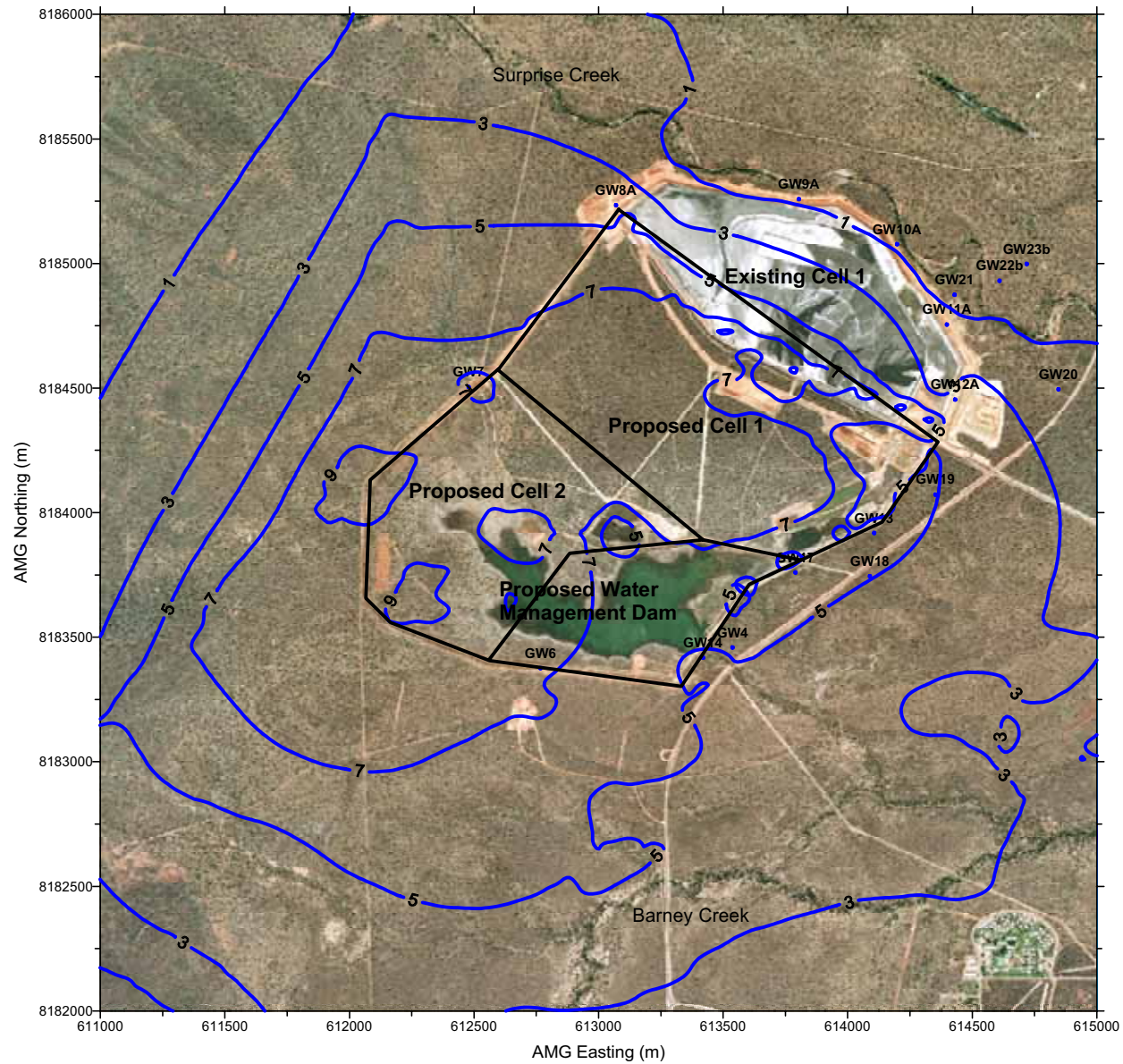
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 SIMULATION OF PROPOSED TAILINGS STORAGE
 FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS

**SCENARIO 3 -
 MODELLED BARRIER WALL**

Figure 25



Figure 25.srf



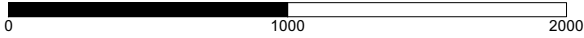
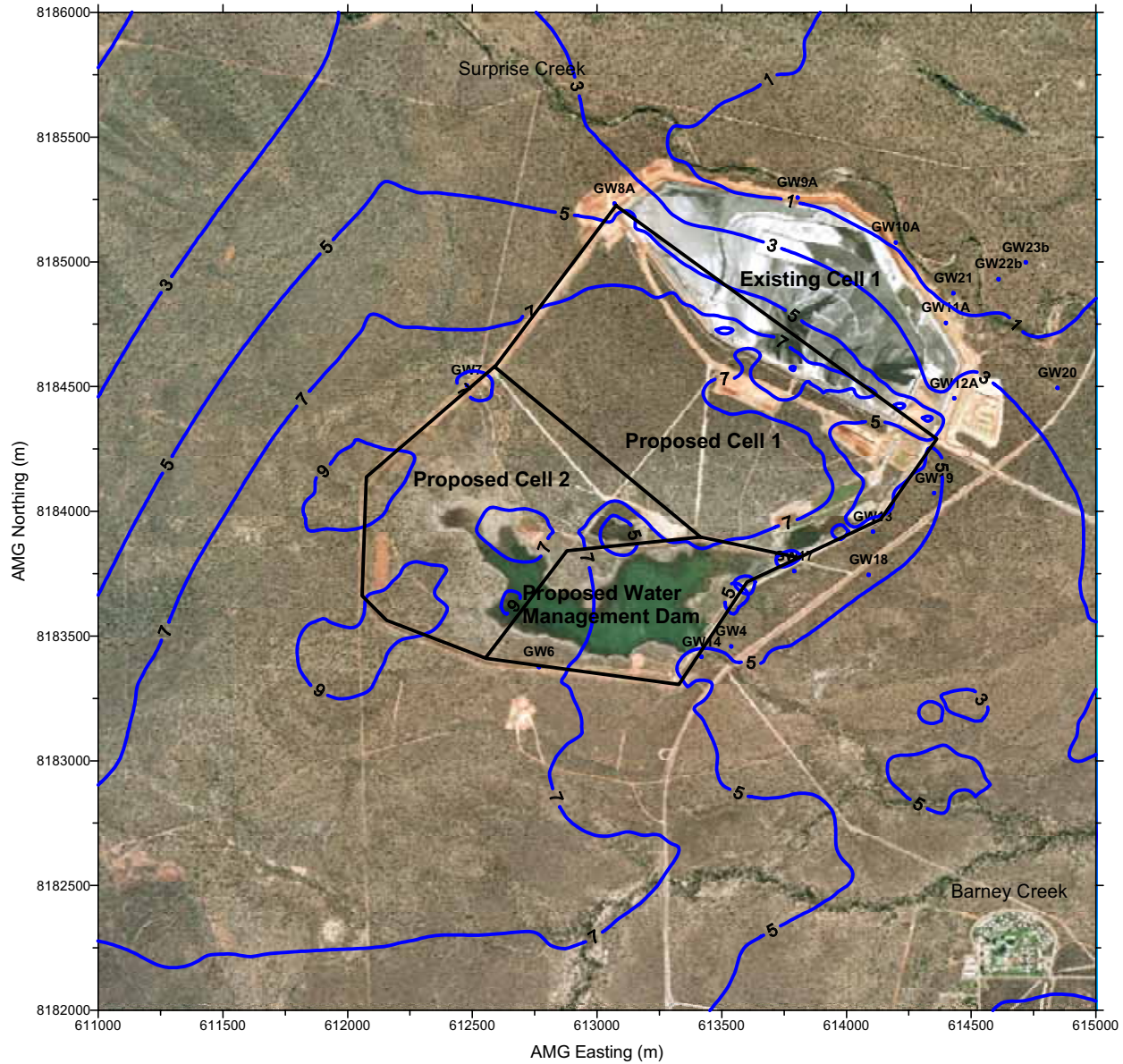
GW1
Monitoring Bore

Job No.	42625552
Prep. By	GRB 24 May '06
Chk'd By	CMAC 30 May '06
Revision No.	0

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SIMULATION OF PROPOSED TAILINGS STORAGE FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
SCENARIO 1 - SIMULATED GROUNDWATER LEVEL CHANGE - 10 YEARS OF OPERATION

Figure 26





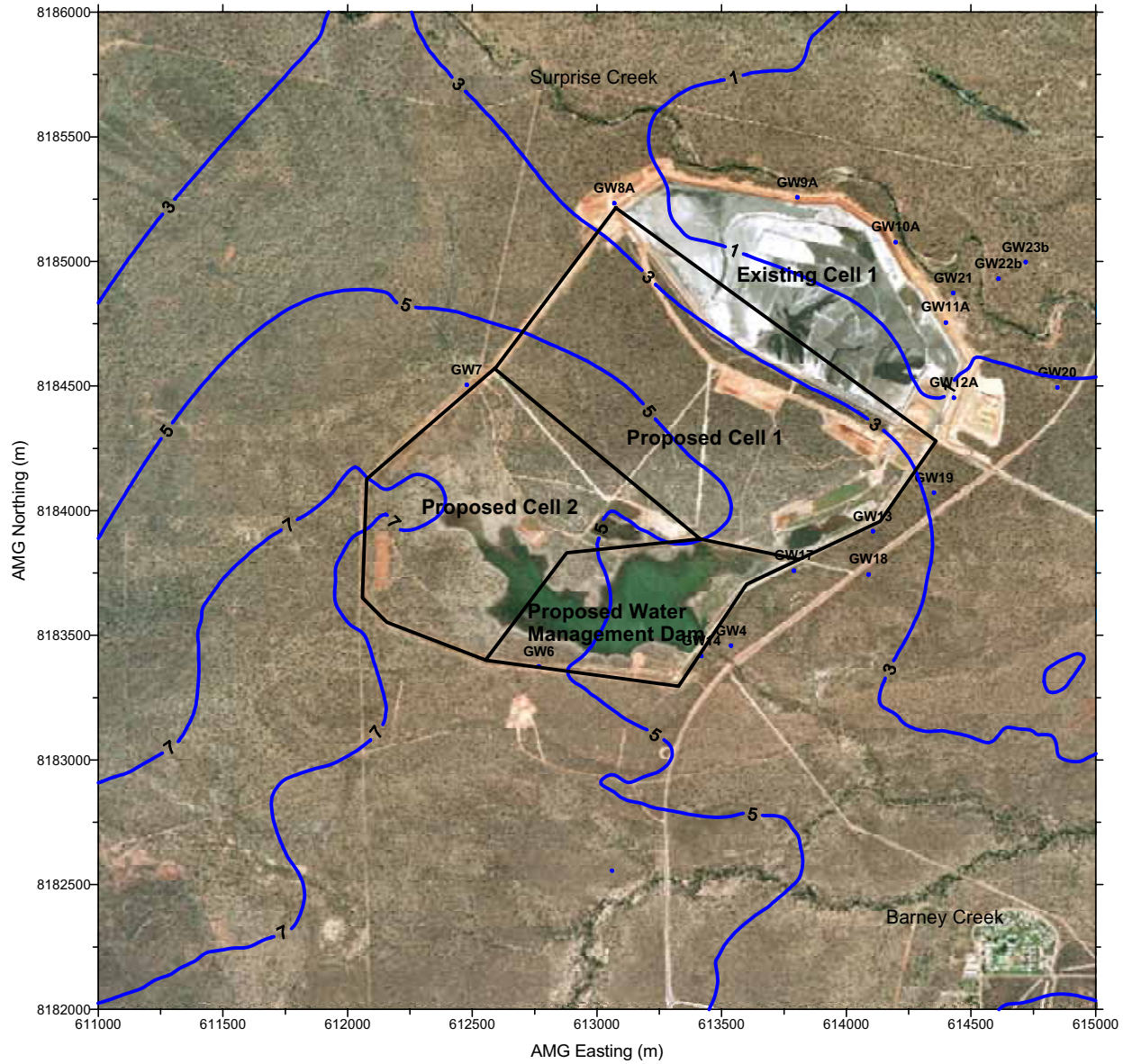
GW1
 • Monitoring Bore

Job No.	42625552	
Prep. By	GRB	24 May '06
Chk'd By	CMAC	30 May '06
Revision No.	0	

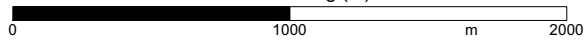
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 SIMULATION OF PROPOSED TAILINGS STORAGE FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
SCENARIO 1 - SIMULATED GROUNDWATER LEVEL CHANGE - 25 YEARS OF OPERATION

Figure 27





GW1
 • Monitoring Bore



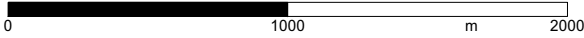
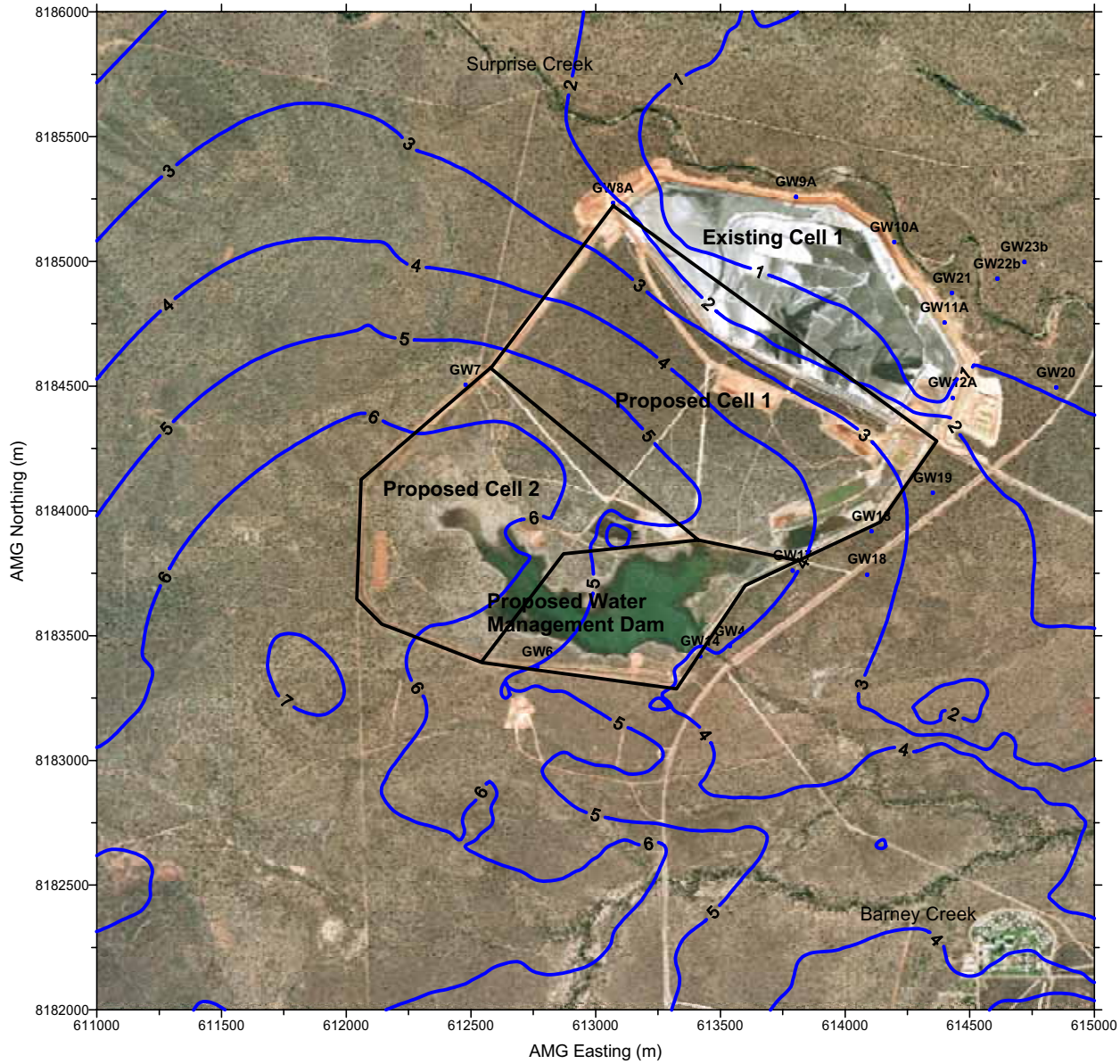
Job No.	42625552	
Prep. By	GRB	24 May '06
Chk'd By	CMAC	30 May '06
Revision No.	0	

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SIMULATION OF PROPOSED TAILINGS STORAGE FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS

SCENARIO 1 - SIMULATED GROUNDWATER LEVEL CHANGE - 10 YEARS POST CLOSURE

Figure 28



GW1
 • Monitoring Bore

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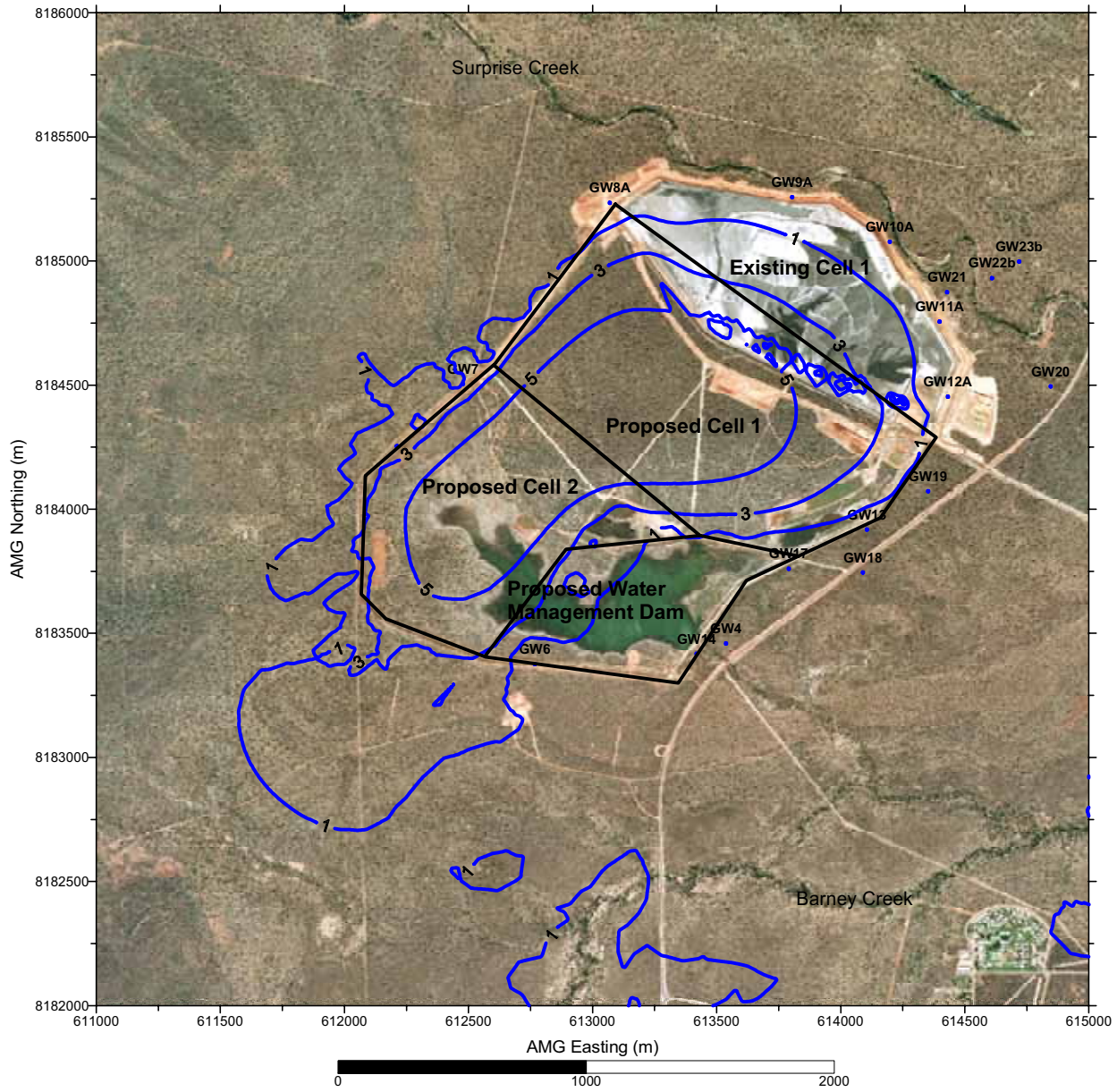
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SIMULATION OF PROPOSED TAILINGS STORAGE
 FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS

**SCENARIO 1 - SIMULATED GROUNDWATER
 LEVEL CHANGE - 25 YEARS POST CLOSURE**

Figure 29

URS



GW1
 • Monitoring Bore

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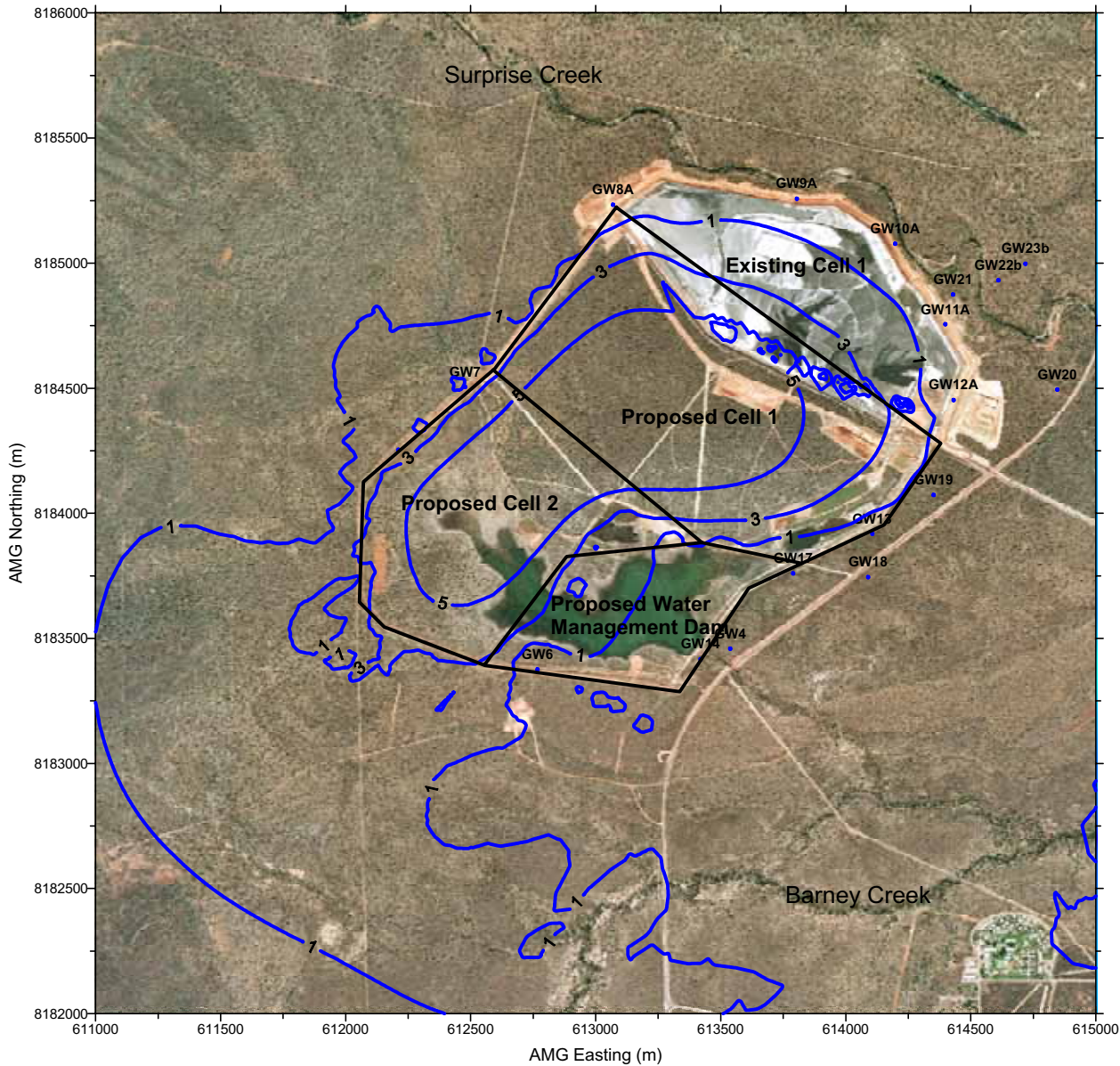
Xstrata Plc

SIMULATION OF PROPOSED TAILINGS STORAGE
 FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS

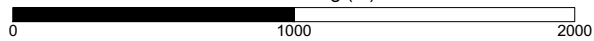
**SCENARIO 2 - SIMULATED GROUNDWATER
 LEVEL CHANGE - 10 YEARS OF OPERATION**

Figure 30





GW1
 • Monitoring Bore



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Prep. By	GRB	24 May '06
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Revision No.	0	

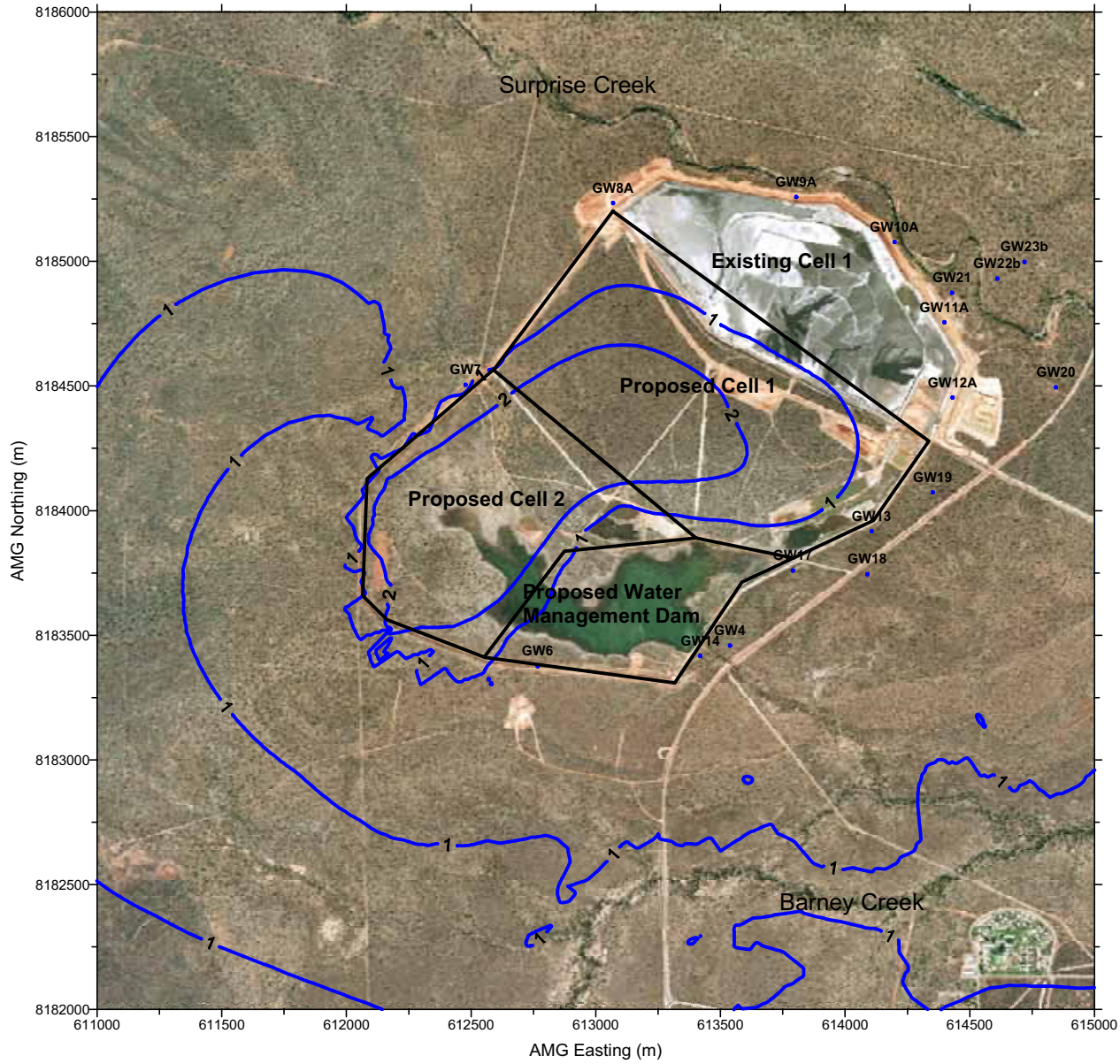
Xstrata Plc

SIMULATION OF PROPOSED TAILINGS STORAGE
 FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS

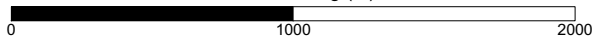
**SCENARIO 2 - SIMULATED GROUNDWATER
 LEVEL CHANGE - 25 YEARS OF OPERATION**

Figure 31





GW1
 ● Monitoring Bore

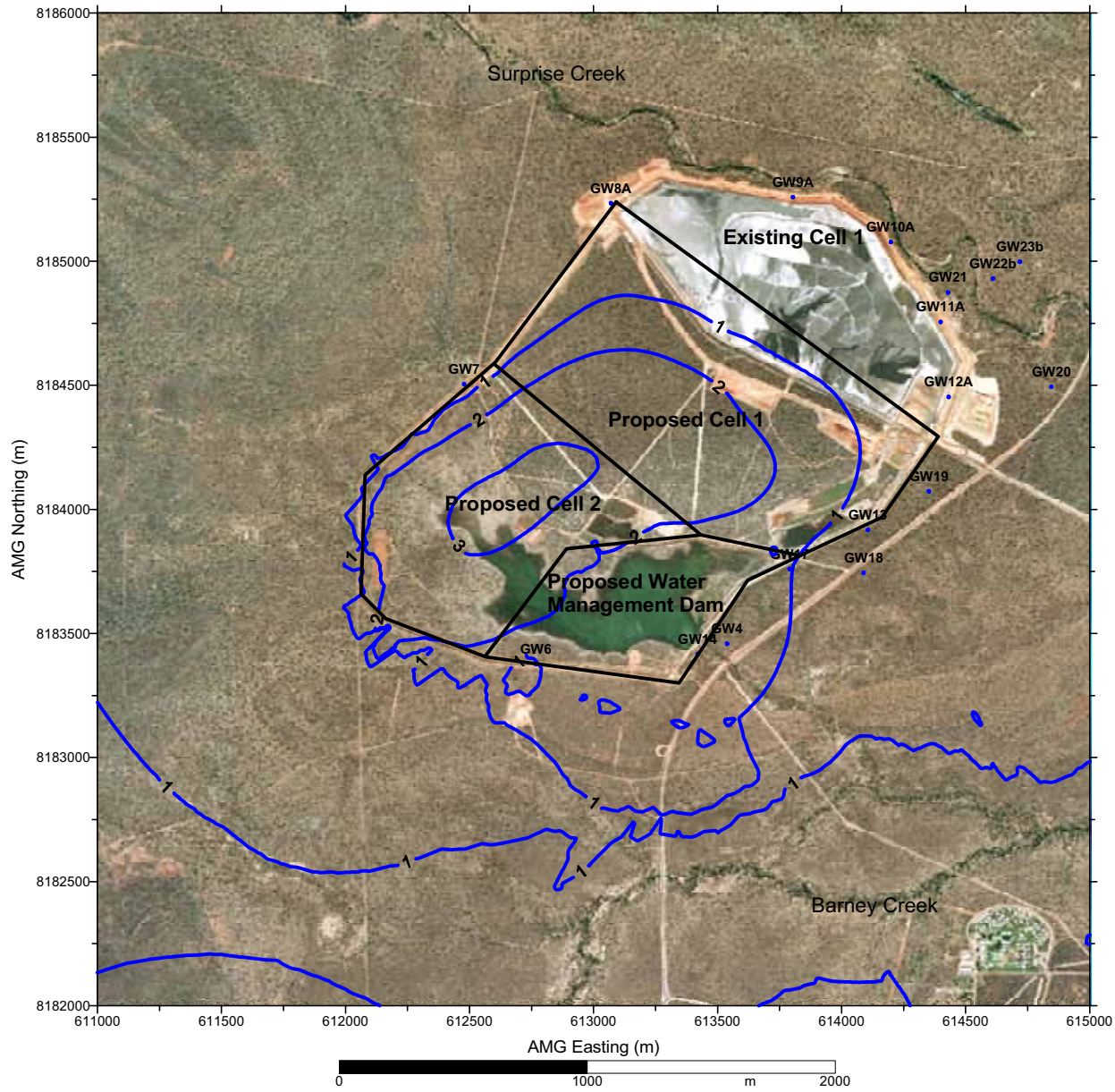


Job No.	42625552
Prep. By	GRB 24 May '06
Chk'd By	CMAC 30 May '06
Revision No.	0

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 SIMULATION OF PROPOSED TAILINGS STORAGE FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
SCENARIO 2 - SIMULATED GROUNDWATER LEVEL CHANGE - 10 YEARS POST CLOSURE

Figure 32





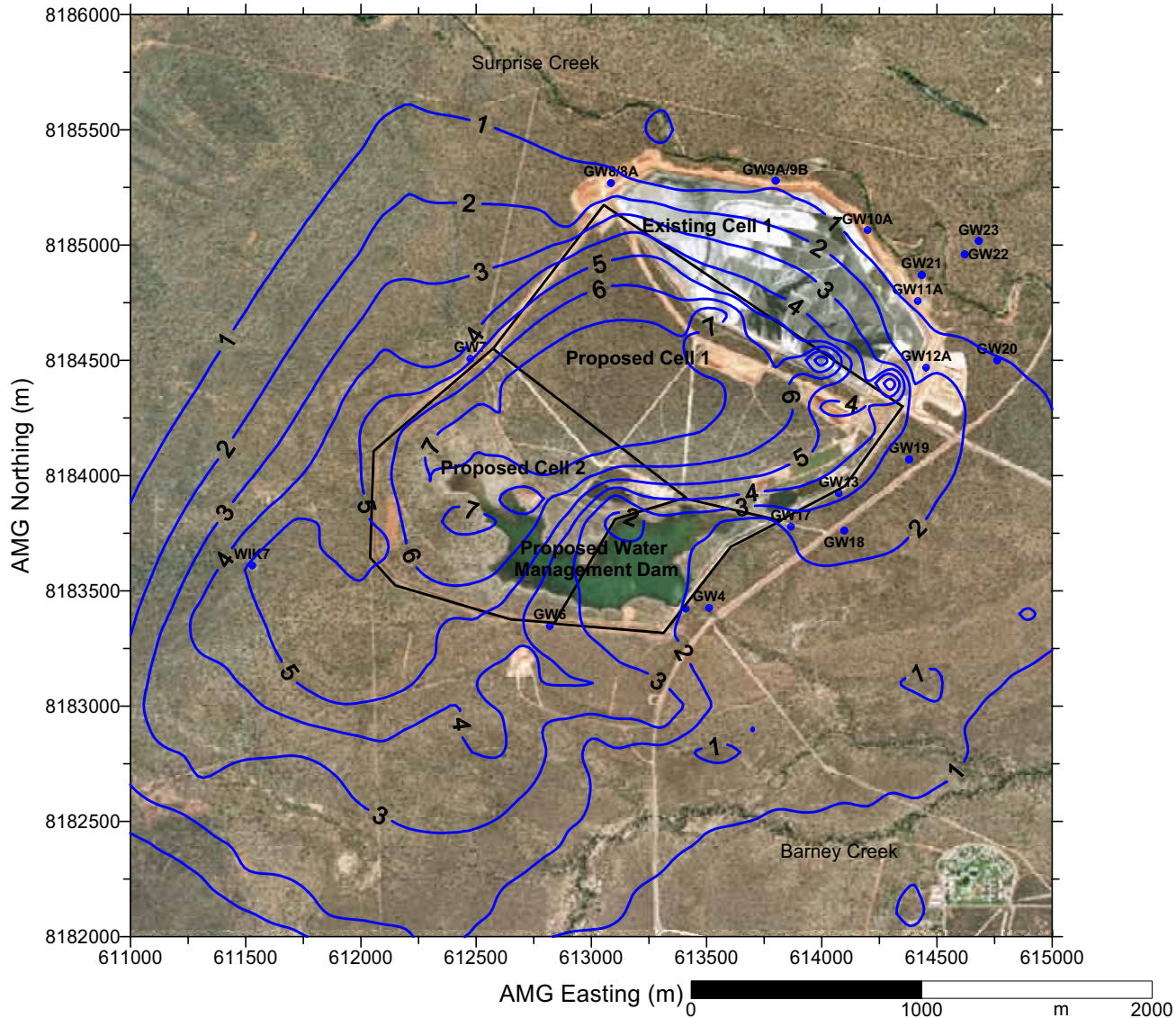
GW1
 • Monitoring Bore

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Prep. By	GRB	24 May '06
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 FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
**SCENARIO 2 - SIMULATED GROUNDWATER
 LEVEL CHANGE - 25 YEARS POST CLOSURE**

Figure 33





GW1
• Monitoring Bore

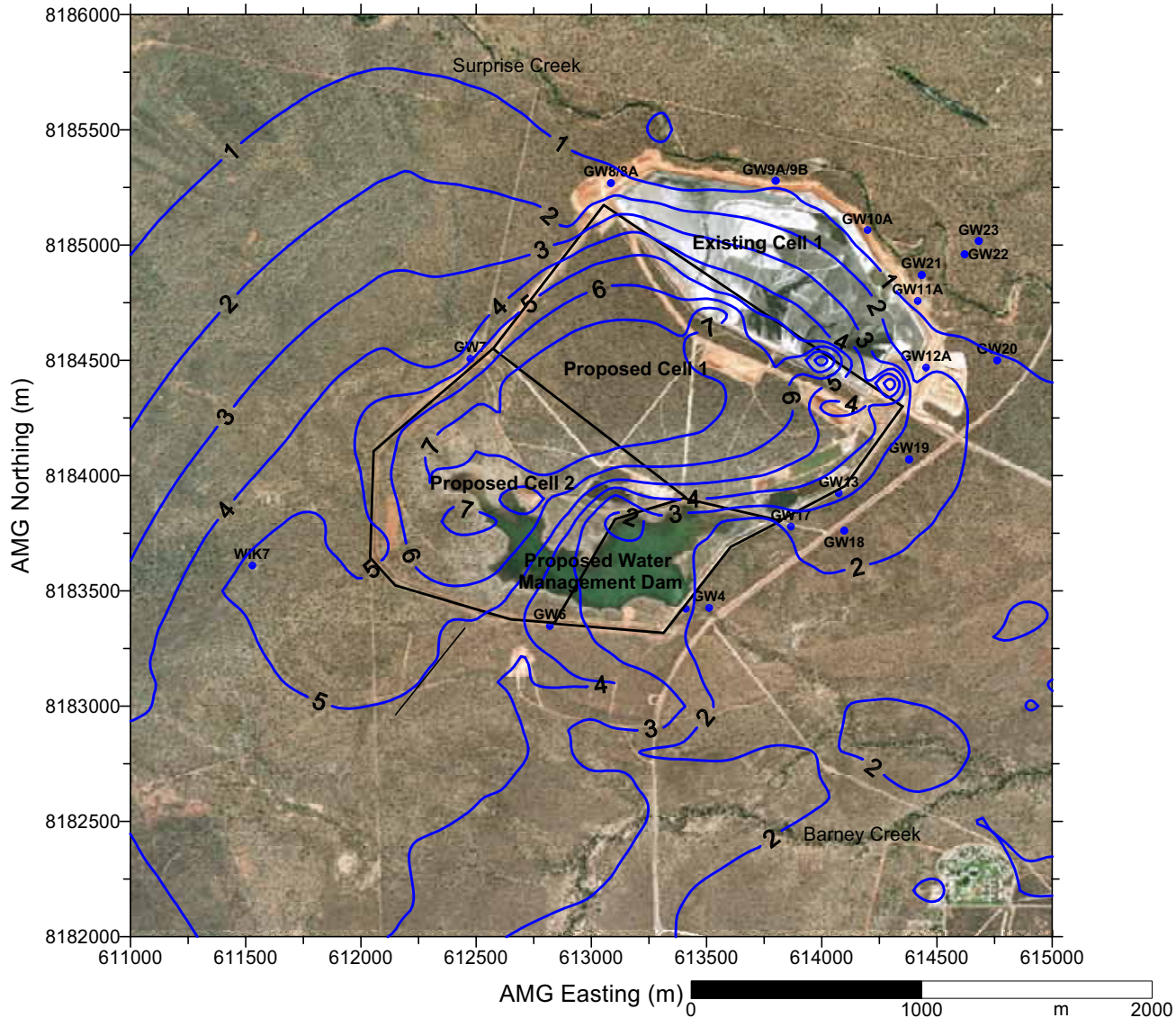
Job No.	42625552	
Prep. By	CMAC	24 May '06
Chk'd By	IGB	30 May '06
Revision No.	0	

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 FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
**SCENARIO 3 - SIMULATED GROUNDWATER
 LEVEL CHANGE - 10 YEARS OF OPERATION**

Figure 34



Figure 34.srf



GW1
 ● Monitoring Bore

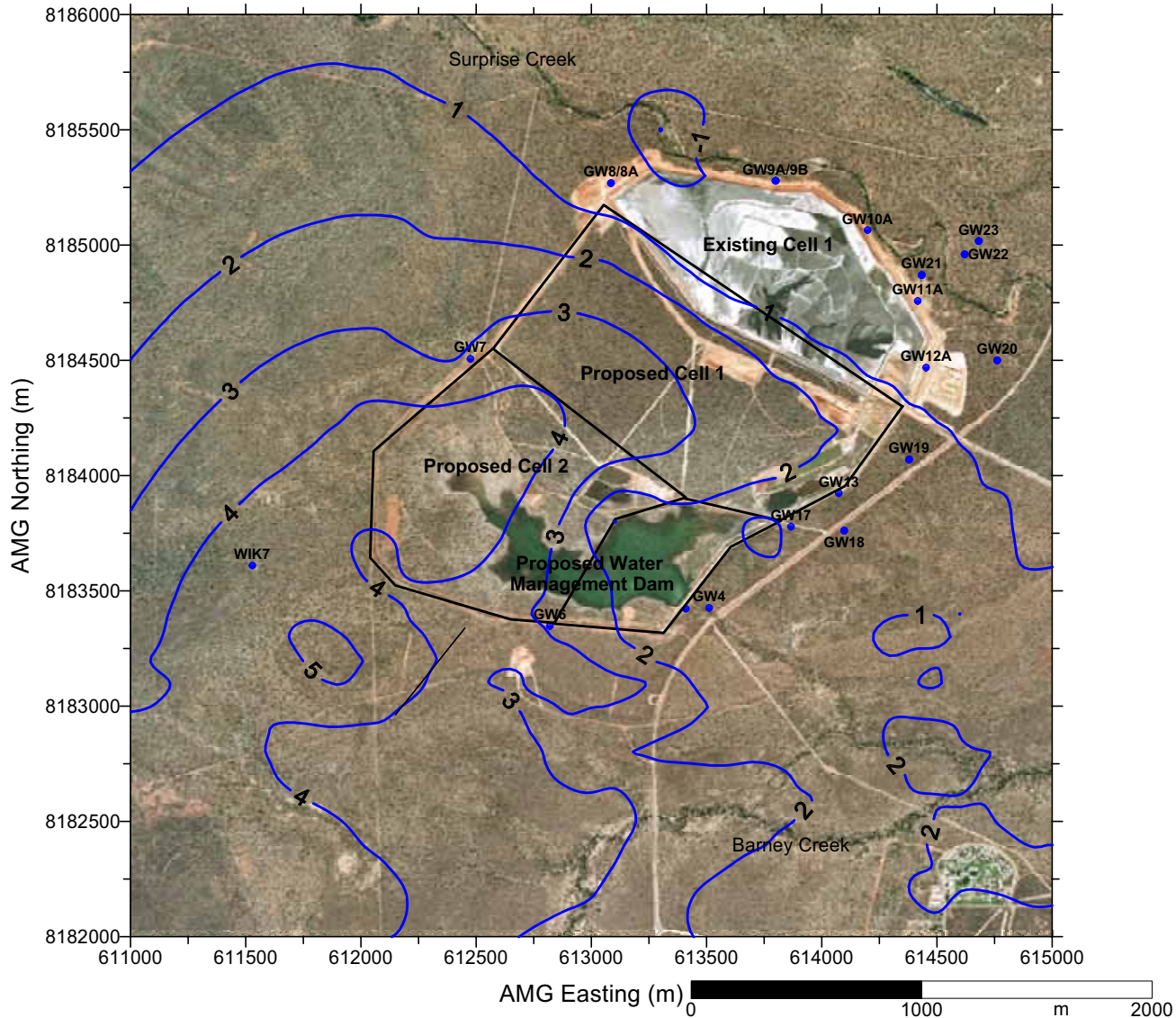
Job No.	4262552	
Prep. By	CMAC	24 May '06
Chk'd By	IGB	30 May '06
Revision No.	0	

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 SIMULATION OF PROPOSED TAILINGS STORAGE FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
SCENARIO 3 - SIMULATED GROUNDWATER LEVEL CHANGE - 25 YEARS OF OPERATION

Figure 35



Figure 35.srf



GW1
 ● Monitoring Bore

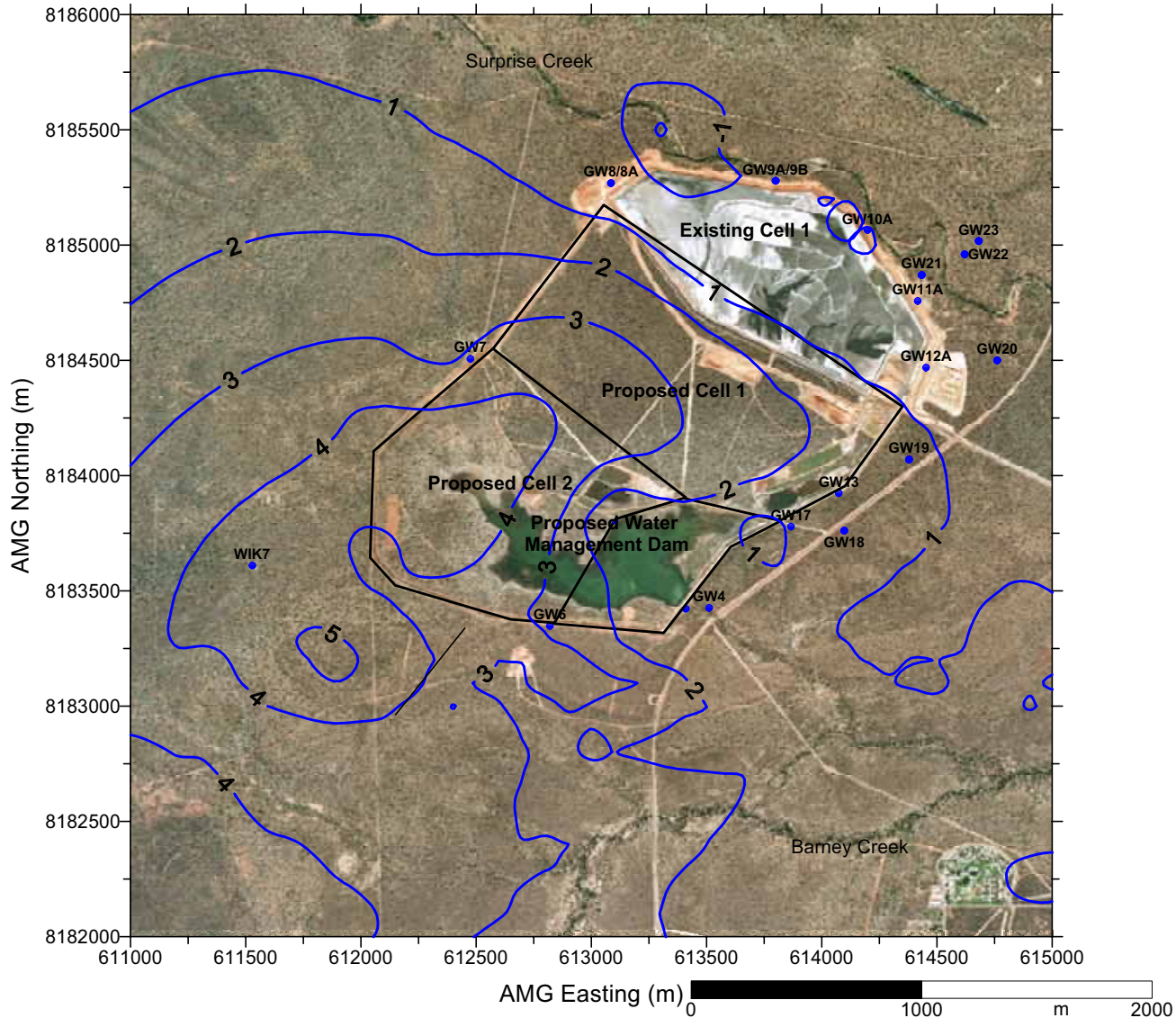
Job No.	42625552	
Prep. By	CMAC	24 May '06
Chk'd By	IGB	30 May '06
Revision No.	0	

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 SIMULATION OF PROPOSED TAILINGS STORAGE
 FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
**SCENARIO 3 - SIMULATED GROUNDWATER
 LEVEL CHANGE - 10 YEARS POST CLOSURE**

Figure 36



Figure 36.srf



GW1
• Monitoring Bore

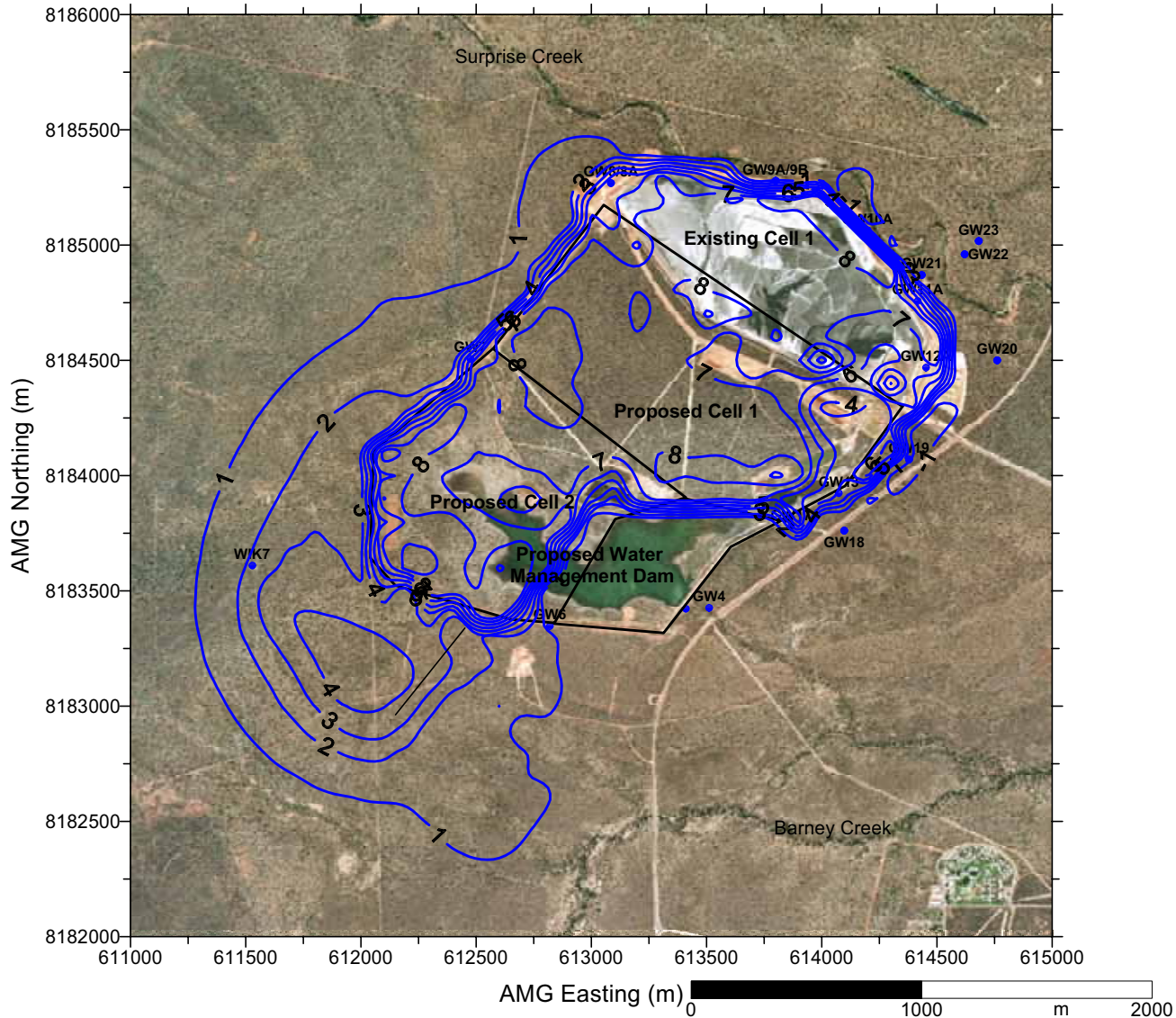
Job No.	42625552	
Prep. By	CMAC	24 May '06
Chk'd By	IGB	30 May '06
Revision No.	0	

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 SIMULATION OF PROPOSED TAILINGS STORAGE
 FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
**SCENARIO 3 - SIMULATED GROUNDWATER
 LEVEL CHANGE - 25 YEARS POST CLOSURE**

Figure 37



Figure 37.srf



GW1
• Monitoring Bore

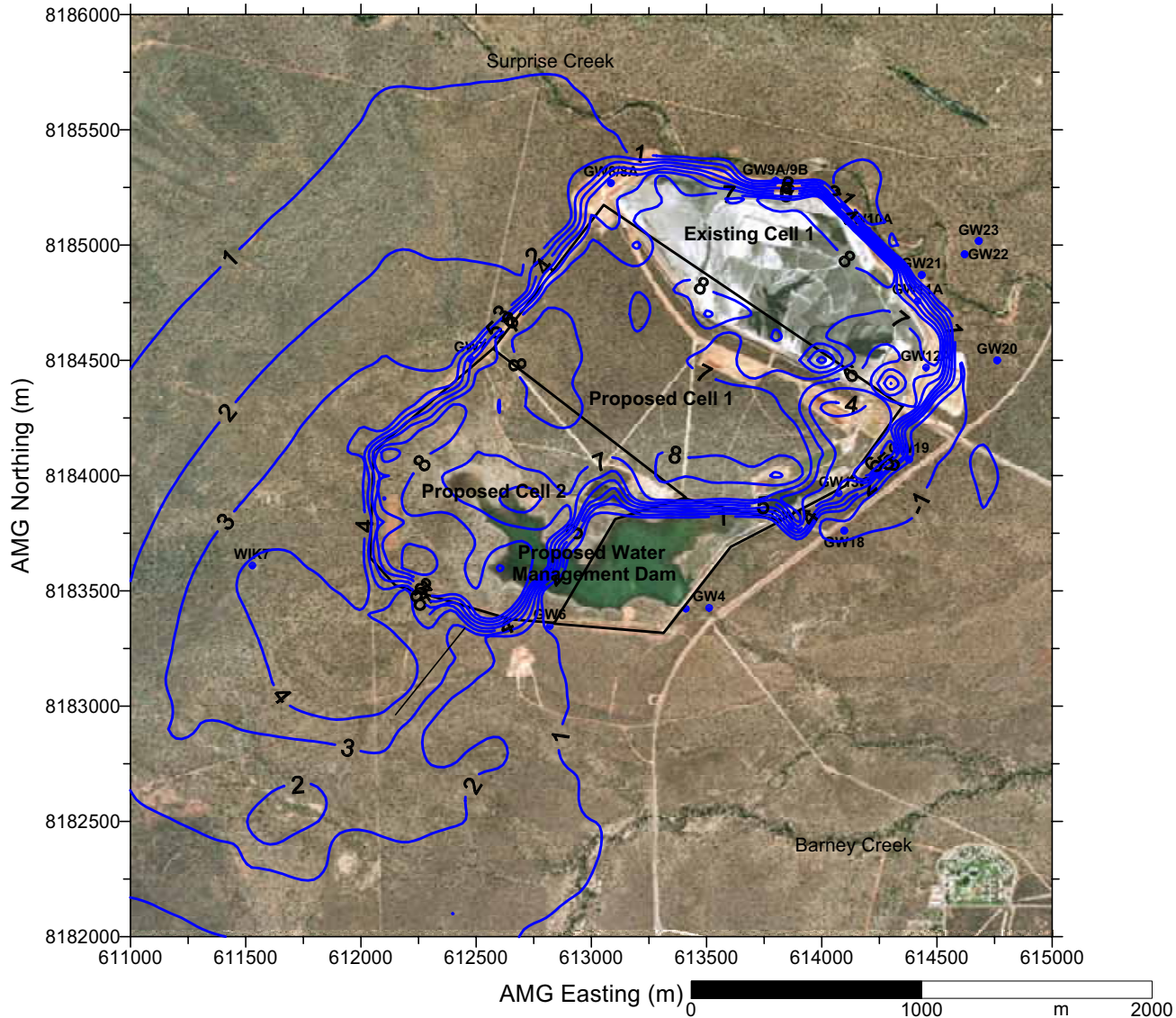
Job No.	42625552	
Prep. By	CMAC	24 May '06
Chk'd By	IGB	30 May '06
Revision No.	0	

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SIMULATION OF PROPOSED TAILINGS STORAGE FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
SCENARIO 4 - SIMULATED GROUNDWATER LEVEL CHANGE - 10 YEARS OF OPERATION

Figure 38



Figure 38.srf



GW1
• Monitoring Bore

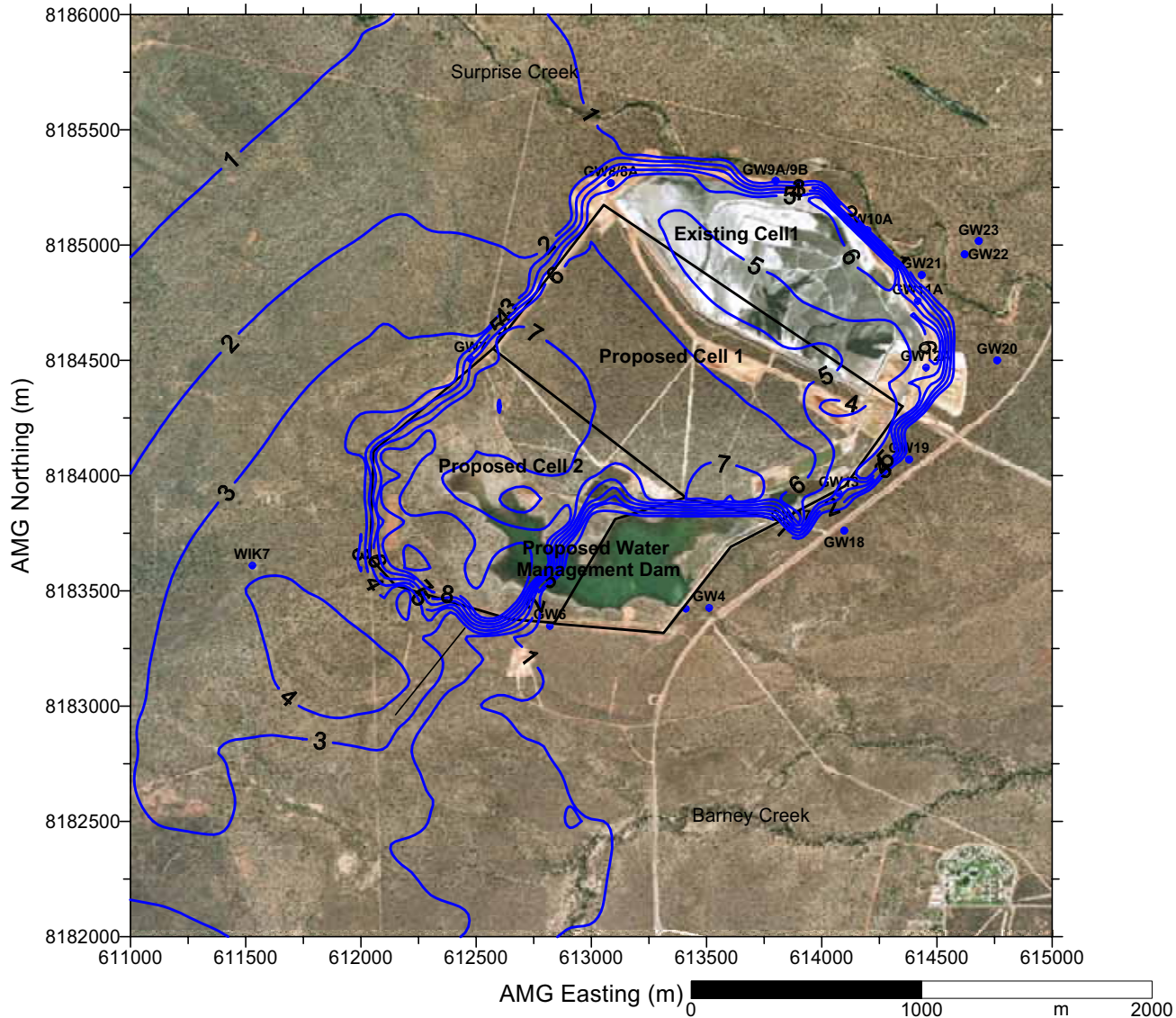
Job No.	42625552	
Prep. By	CMAC	24 May '06
Chk'd By	IGB	30 May '06
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SIMULATION OF PROPOSED TAILINGS STORAGE FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
SCENARIO 4 - SIMULATED GROUNDWATER LEVEL CHANGE - 25 YEARS OF OPERATION

Figure 39



Figure 39.srf



GW1
 • Monitoring Bore

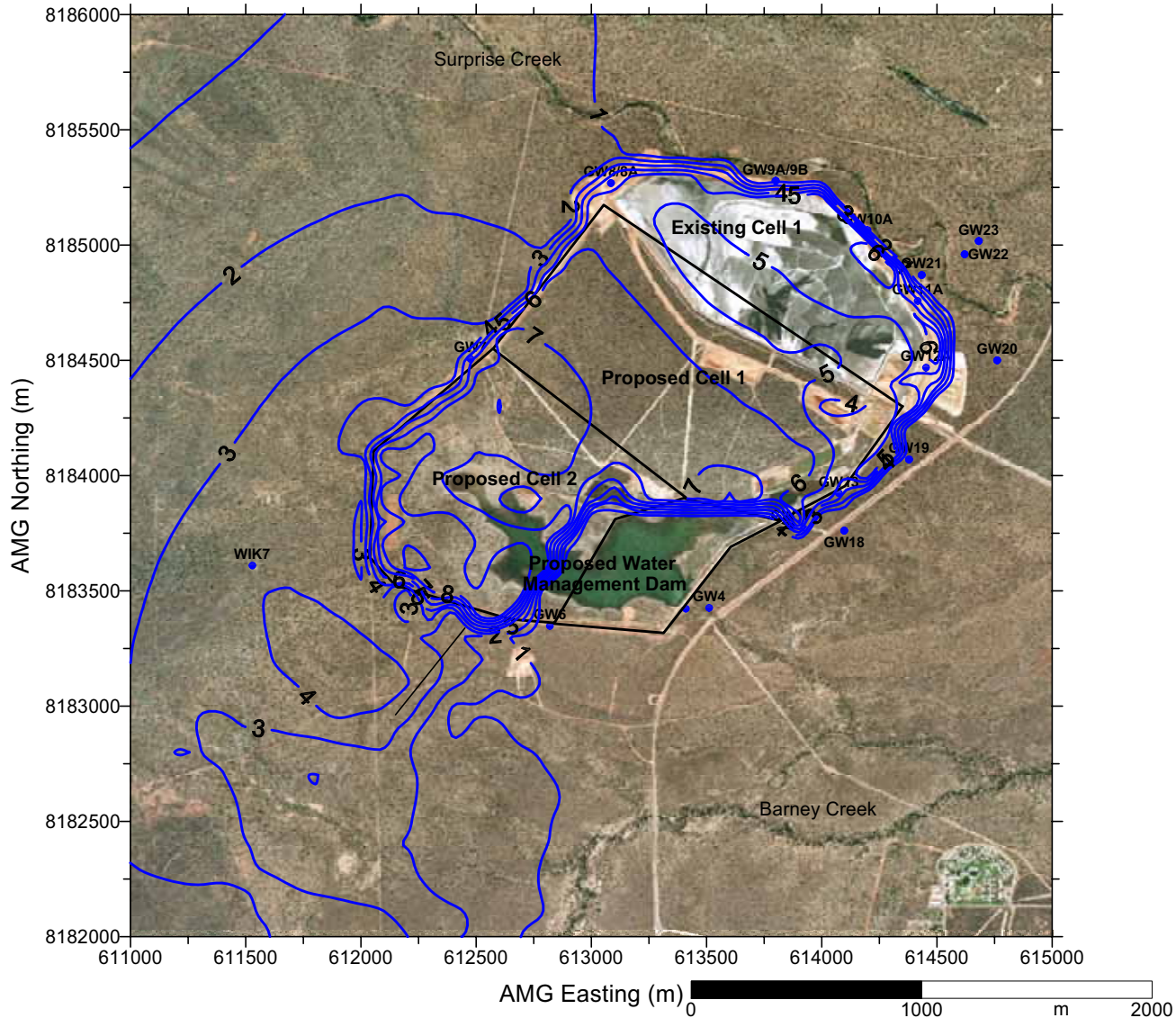
Job No.	42625552	
Prep. By	CMAC	24 May '06
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 FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
**SCENARIO 4 - SIMULATED GROUNDWATER
 LEVEL CHANGE - 10 YEARS POST CLOSURE**

Figure 40



Figure 40.srf



GW1
 • Monitoring Bore

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 FACILITY TO ASSESS POTENTIAL SEEPAGE IMPACTS
**SCENARIO 4 - SIMULATED GROUNDWATER
 LEVEL CHANGE - 25 YEARS POST CLOSURE**

Figure 41



Figure 41.srf