# Report

## Long Term Void Water Storage and Quality

21 SEPTEMBER

Prepared for

BMA Coal Pty Ltd

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# Abbreviations

| Abbreviation | Description |
|---|---|
| m AHD | metres above Australian Height Datum |
| BMA | BHP Billiton Mitsubishi Alliance |
| C | Runoff coefficient |
| CLIMARC | Computerising the Australian Climate Archives |
| DERM | Department of Environment and Resource Management |
| EC | Electrical conductivity |
| EIS | Environmental impact statement |
| K | Hydraulic conductivity (m/day) |
| km | kilometres |
| m/day | metres per day |
| MODHMS | Integrated modelling software package |
| PEST | Parameter estimation |
| PWB | PW Baker & Associates Pty Ltd |
| Q | Discharge rate |
| TDS | Total dissolved solids |
| URS | URS Australia Pty Ltd |

# Executive Summary


URS were appointed to conduct an assessment of the hydrological and salinity performance on a range of final void scenarios for the proposed Caval Ridge Mine. A scope of work was envisaged by Peter Baker & Associates, which included integrated modelling to address the long-term water and salt balances for three final void configurations. The modelling aimed at assessing decant and flooding risks, connections to groundwater resources, and water quality parameters in the long term.

The three final void configurations includes a base case, the void at the end of mining ~ 156 m deep; a 25% regrade (25p) resulting in a shallower final void (~ 123 m) and reduced low and high walls; and a 10% regrade (10p) final void with a shallow final void (~ 55 m) and gentle slopes.

An integrated (surface water and groundwater) modelling approach was adopted to simulate groundwater ingress or outflow, surface water contributions, and climate influences. This allowed for the prediction of void equilibrium water level and estimates of salt accumulation for each of the three void configurations. In order to provide representative scenarios the input into the modelling included two different surface water catchment areas and three different long term rainfall predictions. A sensitivity analysis was included during modelling with regards to aquifer hydraulic parameters and a verification process, using a rainfall-runoff model, to determine representative surface water runoff volumes.

A nine layer (based on site geology) model comprised a 100 m x 100 m grid across a 74.4 $km^2$ area was constructed. The model extent was deemed sufficiently large to assign constant head boundaries (based on extrapolated groundwater level data) in predicting long term groundwater trends. The 100 year mean annual rainfall and evaporation data and representative aquifer hydraulic parameters were used as input into the model set up.

A steady state model, using MODHMS software, was constructed based on the available data and represented envisaged groundwater flow conditions after 30 years of mine dewatering. The steady state model outcome was used as initial conditions for the transient model, which undertook the predictive scenarios.

The transient model was constructed, based on representative model parameters, and was verified through sensitivity analyses and review of model water budgets. It was used to predict resulting water levels and salt concentration in various final void configurations due to groundwater rebound and changes in runoff and climate (rainfall and evaporation) conditions. The final void equilibrium water levels were estimated for the three void configurations and were compared to the pre-mining groundwater levels. A salt balance for each of the final void configurations was calculated to predict long-term water quality trends.

The shallow final void, which included higher than average rainfall and a larger catchment area, is recognised to have the lowest long term impacts on final void water quality. Final void water is, however, recognised to deteriorate with time for all scenarios considered.

Due to low rainfall, high evaporation, and limited groundwater ingress the final void (irrelevant of configuration) does not contain significant volumes of water after void water equilibrium is reached. The remaining large void storage space is sufficient such that the risk of decant is negligible.

Consideration of flood protection is being considered by URS in their flood study for the Caval Ridge EIS supplementary submission.

# Introduction

BHP Billiton Mitsubishi Alliance (BMA) are investigating and considering stable, sustainable outcomes and void footprint minimisation strategies for the envisaged final voids at Caval Ridge Mine. To demonstrate this BMA have appointed URS to conduct an assessment of the hydrological and salinity performance on a range of void scenarios.

PW Baker & Associates Pty Ltd (PWB) will, on behalf of BMA, be compiling the necessary final void report. PWB have developed a scope of work which includes integrated (surface water and groundwater) modelling to address the long-term water and salt balances in the envisaged void configurations. The modelling aims at assessing decant and flooding risks, connections to groundwater resources, and water quality parameters in the long term.

URS were asked to prepare a brief report of the modelling to indicate methodology, data sources, and model limitations.

## 1.1 Available data

To assist in selecting and setting up the necessary numerical integrated model, the following information was considered:

- The project site, comprising the Horse Pit, is approximately 10 km x 5 km;
- The coal dips at ~6º to the east;
- The final pit depth will be ~ 200 m;
- The geology within the pit comprises Quaternary alluvial, Tertiary sediments, and Permian coal measures;
- Only the Horse Pit final void is to be modelled;
- The surface water diversions, around the Horse Pit, will remain after closure;
- No major faults or intrusions are located within the Horse Pit mining void;
- Bore logs and hydrogeological data for 16 monitoring bores across the site;
- 5 sets of groundwater monitoring, water levels and quality, data;
- Shape files for the topography, alluvium, tertiary, and coal seams; and
- Surface water data from the EIS.

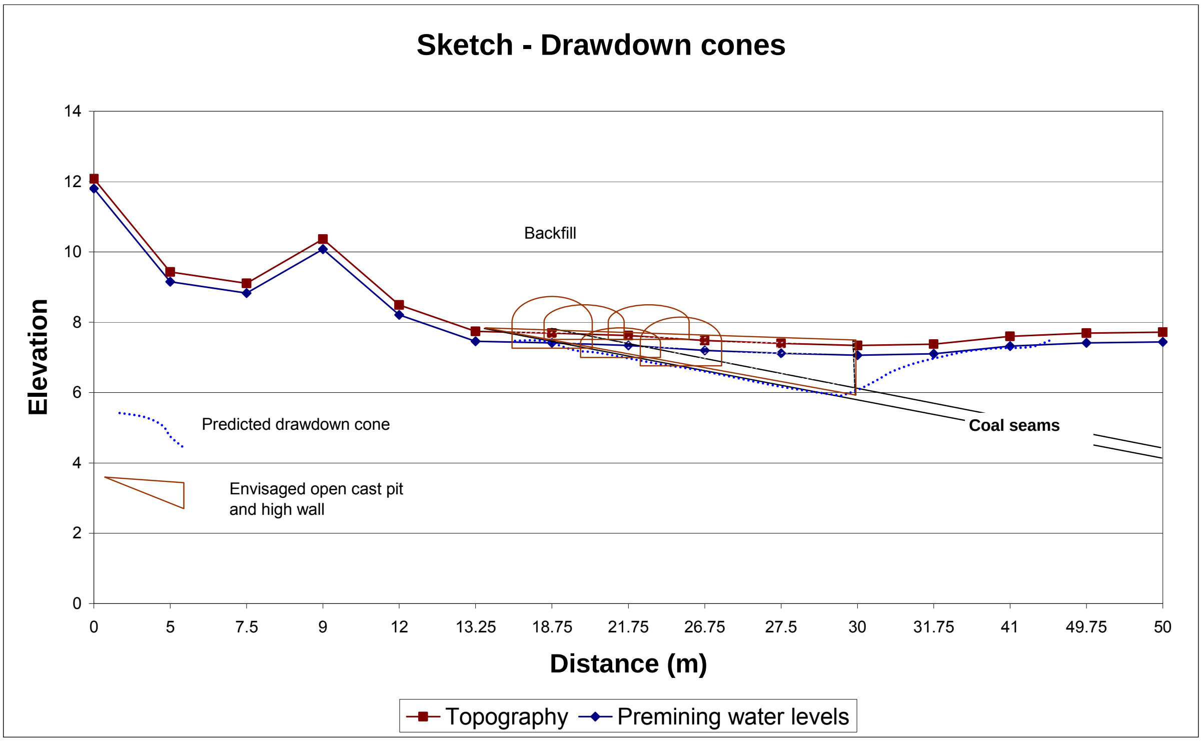
## 1.2 Background

Current available data, groundwater levels and ambient hydrochemistry, are based on pre-mining conditions. Therefore it is important to relate the available data to the aquifer conditions when dewatering ceases such that suitable starting conditions can be established for the purpose of long-term model predictions.

Pumping of water (groundwater ingress, runoff and direct rainfall) will result in the dewatering of the hanging wall sediments, ahead of mining and along strike. Drawing 1-1 indicates a typical dewatering cone which develops ahead of surface mining.

# 1 Introduction

## Drawing 1-1 Typical drawdown cone




The extent of the drawdown cones, as calculated in the EIS groundwater section, around the voids was less than 1 km (839 m in the interburden).

The size distribution of coal overburden spoil material is highly variable based on geology, dumping method, and placement (dragline or truck). This can result in variable permeability across the backfill area and over time. Increased recharge and alteration, due to increased total dissolved solids, to the groundwater quality is envisaged to occur within the backfill. Based on limited data it is assumed that the hydraulic conductivity, runoff and TDS contribution from the spoil pile remains constant through out the modelled scenarios.

The lower hydraulic conductivity (K) of the foot wall sediments and the base of the spoil having higher K reduces the impacts of dewatering within the foot wall sediments.

These impacts were considered when setting up the model and conducting scenario predictions, such as groundwater rebound and salt balances.

# Model scenarios

Three final void configurations have been provided for inclusion in the modelling. These include:

- Base case, the 30 year mine configuration with standing highwall and steep ramps and lowwalls;
- 25p regrade case, the pits and ramps have been reshaped to approximately 25%; and
- 10p regrade case, the pit and ramps have been reshaped to 10%.

**Appendix A** includes the three mine void configurations.

The modelling simulates groundwater ingress or outflow, surface water contributions, climate influences, and resultant salt balances for each of the three void configurations.

Each of the three configurations will result in markedly different storage volumes based on predicted equilibrium void water levels. Modelling is also required to allow for two different surface water ingress scenarios when considering the void water levels. These two surface water scenarios include:

- Limited catchment area, surface water inflow is limited to direct rainfall and runoff into the void without any modifications (min); and
- Maximum catchment area, as above but with the runoff from the backfill spoils piles being captured in a drainage system and redirected into the void (max).

In order to provide representative long term simulations three different climate scenarios were considered. The modelling allowed for the consideration of the following rainfall scenarios:

- Dry case, the mean annual precipitation reduced by 10%;
- Median case, the mean annual precipitation based on 100 years of data; and
- Wet case, the mean annual precipitation increased by 10%.

A sensitivity analysis was included with regards to aquifer hydraulic parameters. The aquifer hydraulic parameters utilised for the model were estimated based on the EIS groundwater study, the drilling and testing of 16 monitoring bores. The parameters were varied within expected ranges to determine sensitivity. The parameters which were varied were:

- Hydraulic conductivity values, low, medium, and high; and
- Runoff coefficients for the backfill spoil areas, low, medium, and high.

## 2.1 Model Approach

URS utilised the MODHMS groundwater modelling package to construct the required groundwater model. MODHMS was selected as it allowed for:

- The modelling of variable saturation conditions, allowing for unsaturated and saturated conditions thus avoiding dry-cell problems;
- Coupled flow and mass transport simulations;
- The inclusion of discrete features, such as the backfill area; and
- Integrated groundwater and surface water modelling.

A steady state model was constructed based on the available data and represented envisaged groundwater flow conditions at the end of the 30 years life of mine. The steady state model outcome (drawdown extent) was used as initial conditions for the transient model, which undertook predictive scenarios. The modelling approach comprised the following:

## 2 Model scenarios

- Simulations of dewatering cones and extent at the end of mining (after 30 years and final void depth to ~ 160 m below surface);
- Groundwater ingress volumes with time and void water level rebound to an equilibrium level (some 40 to 50 years after mining); and
- Salt balance assessment through the integrated modelling of surface water and groundwater input and climate effects.

A rainfall-runoff model was compiled, which utilised the daily rainfall and evaporation data for the 100 year dataset, to estimate the volume of water within the final void after 100 years. This allowed for an accurate estimate of the runoff volume for inclusion in the rational formula. Using the rational formula an estimation of the runoff coefficient was calculated for inclusion in the integrated model. The estimated runoff was then used as an input into the model, which allowed for the determination of equilibrium water levels in the final void, allowing for different catchment sizes and rainfall scenarios.

# Model Conceptualisation

The approach presented includes the steps and plans needed to construct a suitable groundwater numerical model.

## 3.1 Data review

Geological and hydrogeological data compiled from the groundwater studies for the study area have been compiled and reviewed. The majority of the data is compiled in Chapter 7 of the Caval Ridge Environmental Site Assessment report (URS, 2009), which included bore logs, aquifer tests, and hydrochemistry. Available groundwater data from the Department of Environment and Resource Management (DERM) bore database have been obtained and reviewed.

Three main data requirements have been identified as crucial to the construction of the envisaged numerical groundwater model, these data requirements include:

- Dependent variables (head and concentration data);
- Boundary conditions; and
- Aquifer properties.

### 3.1.1 Head and concentration data

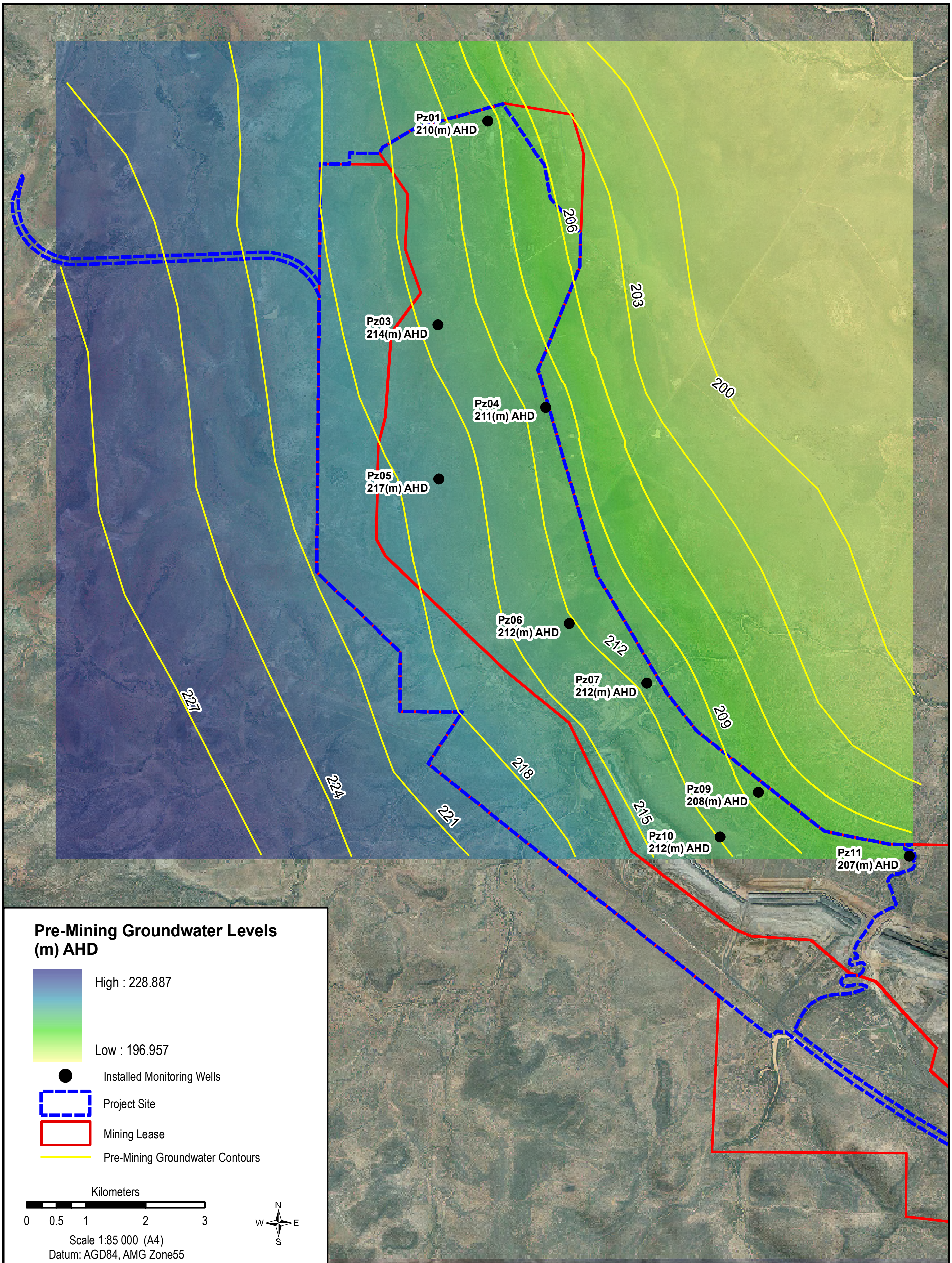
Groundwater level and hydrochemical data from bores within the weathered and fractured rock aquifers were compiled, verified, and analysed. The groundwater level data has been contoured in order to evaluate the pre-mining groundwater flow patterns, gradients, and direction(s) on the site. The groundwater level contours are presented in Figure 3-1 and serve as regional flow trends for generating model initial conditions.

### 3.1.2 Boundary conditions

Model boundaries are based on available information and site data limitations. The boundaries include:

- **Top inflow boundary** comprising recharge and evaporation. Available precipitation and evaporation data was reviewed / verified;
- **Horizontal inflow boundary** based on groundwater level data, which is used to determine the sites' east, west, north, and south boundary conditions. Geological log data and groundwater level information was used to set up representative constant head boundaries, sufficiently far from the mine; and
- **Bottom inflow boundary** considered below the site. Model bottom elevations were determined from floor and roof elevation data supplied by the client. The no-flow boundary was assumed sufficiently far below the Layer 9 floor elevation based on available geological data.

**NOTE**: As the modelling was limited to only the Horse Pit final void a constant head boundary has been included along the southern boundary of the model grid. This approach removes the cumulative impacts of the Heyford Pit, which is to be constructed along strike of the Horse Pit.

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| Client: BMA BHP Billiton Mitsubishi Alliance / URS | Project: CAVAL RIDGE PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT LONG TERM VOID WATER STORAGE AND QUALITY | Title: **PRE-MINING GROUNDWATER LEVELS** |
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| Job No: **4262 6420**/6158 | File No.: 42626158-g-1502.mxd | Figure: **3-1** |
| | Rev. A | A4 |

### 3.1.3 Aquifer properties

Limited site specific aquifer hydraulic parameters are available for the various geological and hydrogeological units mapped on site. In order to assist with the construction of groundwater model layers the following aquifer properties are evaluated:

- Hydraulic conductivity (K), derived from slug tests conducted in order to obtain aquifer hydraulic parameters; and
- Storage properties of aquifers (unconfined and confined), obtained from literature values.

The aquifer parameters utilised for the initial model set-up are summarised in Table 4-1.

**Table 3-1 Model Layer assigned values**

| Unit | K (m/day) | Specific yield | Specific storage (/m) |
|---|---|---|---|
| Coal seams | 0.17 | 0.03 | 0.00001 |
| Inter/Overburden | 0.03 | 0.03 | 0.00001 |
| Backfill | 0.22 | 0.10 | - |

# Model Input Data

## 4.1 Rainfall

Recorded site specific data, from the Moranbah weather station, is available for the period 1972 to 2007. For an extended period (100 years) a statistical analysis of climate data from surrounding weather stations was compiled based on the DERM Data Drill system.

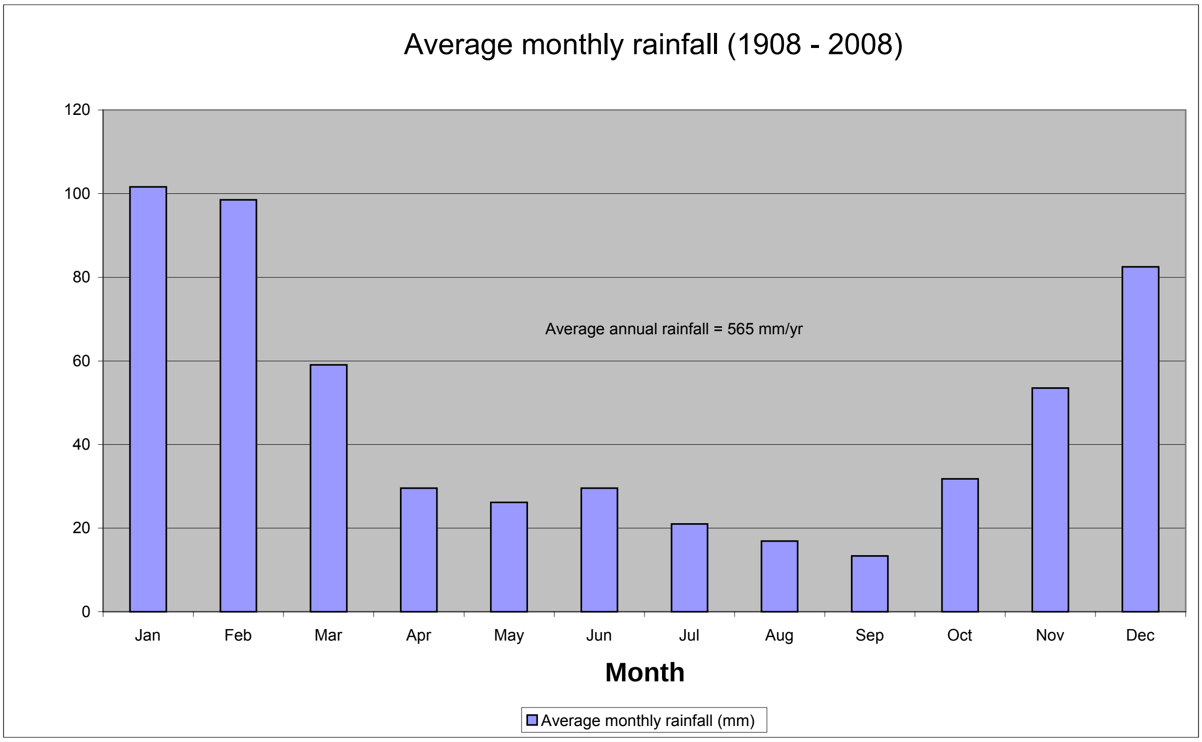
The rainfall and evaporation data for a selected point, 22º15'S 148º12'E, within the mine site was interpolated from 25 daily observations using anomaly interpolation method for CLIMARC[1] data.

The Data Drill rainfall data for the period 13/11/1908 to 13/11/2008 provided the following:

- Average daily rainfall (over 100 years) 1.55 mm; and
- Average daily rainfall for each year.

Figure 4-1 shows the average monthly rainfall data for the 100 years of data.

**Figure 4-1 Average monthly rainfall (100 years)**




The daily rainfall data for 100 years included the most significant rainfall events recorded within the area. Table 4-1 present the most significant rainfall events, which indicates the nature of the intense storms and cyclonic rain within the study area.

[1] CLIMARC – Computerising the Australian Climate Archives

# 4 Model Input Data

### Table 4-1 Significant rainfall events on record

| Date | Volume (mm) | Duration (days) |
|---|---|---|
| Highest recorded rainfall | | |
| 08/01/1991 | 385.1 | 15 |
| 12/02/1954 | 326.7 | 13 |
| 22/03/1910 | 318.8 | 18 |
| 07/04/1958 | 309.8 | 11 |
| 06/01/1917 | 296.5 | 12 |
| Longest rainfall duration | | |
| 17/02/1947 | 201.6 | 19 |
| 24/01/1946 | 106.1 | 19 |
| 22/03/1910 | 318.8 | 18 |
| 06/04/1963 | 179.3 | 17 |
| 08/05/2000 | 158.7 | 17 |

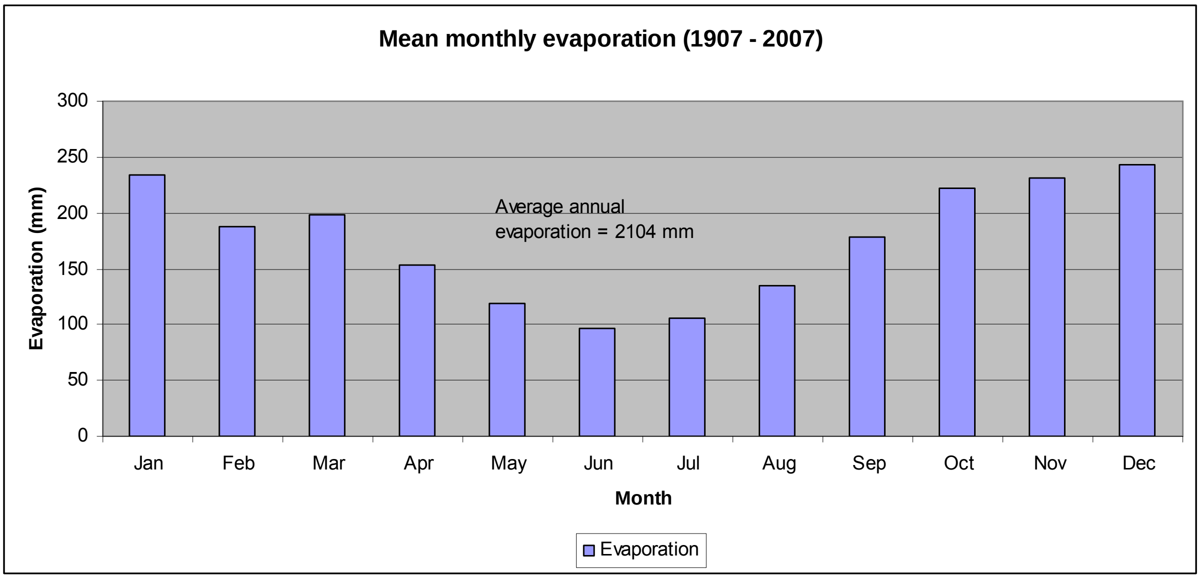
The mean annual rainfall, for the 100 years, was calculated and used as input into the model. In order to assess the impacts of climate fluctuations a 10% variation (dry and wet) to the mean annual rainfall was simulated in the model to determine variations in the equilibrium water levels of the three final void configurations.

## 4.2 Evaporation

The evaporation data was determined, based on the Data Drill system, for the 100 years of most recent data, 31/12/1907 to 31/12/2007. The average daily evaporation, over 100 years, was calculated to be 5.77 mm.

Figure 4-2 shows the average monthly evaporation data for the 100 year data.

### Figure 4-2 Evaporation data



The average annual rainfall and evaporation data indicates a negative water balance for the study area with evaporation exceeding rainfall for all months of the year.

## 4.3 Aquifer parameters

An evaluation of the data presented in the Groundwater Section of the EIS allowed for the selection of representative aquifer parameters. The parameters are presented in Table 4-2.

**Table 4-2 Aquifer parameters**

| Lithology | Parameter | Minimum | Maximum | Selected |
|---|---|---|---|---|
| Coal seams | K (m/day) | 0.017 | 1.7 | 0.17 |
| | Specific yield | 1% | 5% | 5% |
| | Storage Coefficient | 0.0001 | 0.001 | 0.001 |
| Inter/Overburden | K (m/day) | 0.003 | 0.3 | 0.03 |
| | Specific yield | 1% | 5% | 3% |
| | Storage Coefficient | 0.00001 | 0.001 | 0.001 |
| Backfill | K (m/day) | 0.022 | 2.2 | 0.22 |
| | Specific yield | 5% | 15% | 15% |

## 4.4 Runoff

Runoff is subjected to rainfall intensity and antecedent moisture conditions of the soil. A low total runoff was envisaged for the study area due to mostly drier soil conditions (bare land and high evaporation rate) and areas of higher infiltration (backfill areas). In addition, the intensity of most rainfall events may not be high enough to produce significant runoff.

The rainfall data used in the model was not generated from intensity-duration-frequency curves; instead it was a calculated 100-year mean annual rainfall value (565 mm/year). The use of a mean annual rainfall value meant runoff was generated daily and cumulated for 100 years. It was envisaged that this runoff volume (generated from mean rainfall) was in the same order or close to volume that would be generated from significant rainfall events (rainfall events with sufficient intensity and duration to allow runoff).

The integrated model, comprising nine layers, was simplified to reduce model running time and allow for a conservative estimate of void water volumes over time based on a mean annual rainfall of 565 mm/year. The simplified model approach allowed for net recharge to be added directly to the groundwater system taking into consideration high evaporation, high infiltration in the spoil area and most rainfall events may not have sufficient intensity to generate runoff.

The water budget generated in the model was assessed to determine if the model converged, i.e. parameters were altered (within appropriate boundaries) to reduce the discrepancy between input volume to and output volumes from the system.

### 4.4.1 Verification

In order to assess the validity of estimated surface water runoff component of the water budget the integrated model was utilised to conduct a rainfall-runoff simulation. The mean annual rainfall value of

1.54 mm/day was determined from the 100 year dataset. The 100 year daily and monthly rainfall and evaporation data sets were entered into the model to verify the model runs with estimated runoff from the rational formula.

Through the verification it was concluded that a runoff coefficient of 10% could be utilised to estimate runoff into the final void, as verified based on the 100 year daily rainfall-runoff modelling. This is recognised to be more representative of the water volume in the void after 100 years.

### 4.4.2 Input into model

The runoff volume was then simulated in the model by injecting water along the boundary of the catchment (both max and min), which allowed for the simulation of overland flow. The parameters considered for overland flow include:

- Daily rainfall data for 100 year dataset;
- Daily evaporation data for 100 year dataset;
- A Manning coefficient of 0.15 or less (bare ground)after a sensitivity analysis;
- Rill height of 1 mm (highly sensitive parameter which resulted in large range of volumes reporting to the void); and
- Obstruction height was negligible (not a typical feature in this case).

This allowed for a more accurate volume of water, reporting to the final void over time, to be estimated. The runoff volumes entering the void were included in the calculation of the salt balance, as the runoff across the spoil was assumed to contain a TDS of 450 mg/L (Section 4.5).

## 4.5 Hydrochemistry

The field measurements recorded during the EIS groundwater study and during subsequent monitoring rounds were used to determine representative groundwater water quality inputs, in terms of salinity, for each of the lithological units modelled on site.

The recorded electrical conductivity data and calculated Total Dissolved Solids[2] (TDS) data is presented in Table 4-3.

**Table 4-3 EC and TDS data**

| Monitoring | Unit | EC readings (µS/cm) | | | Average EC | Calculated TDS (mg/L) |
|---|---|---|---|---|---|---|
| Bore | | June 2008 | September 2008 | February 2009 | | |
| Pz03-D | Coal seam D04 | 19 970 | 21 450 | 16 570 | 19 330 | 12 371 |
| Pz04 | Coal seam Q | 1 529 | 1 107 | 1 111 | 1 249 | 800 |
| Pz06-D | Coal seam P02 | 1 691 | 1 981 | 1 813 | 1 828 | 1 170 |
| Pz07-S | Alluvium | - | 351 | 443 | 397 | 250 |
| Pz07-D | Coal seam Q01 | - | 3 890 | 3 960 | 3 925 | 2 510 |
| Pz08-S | Alluvium | - | 1 861 | 2 129 | 1 995 | 1 280 |
| Pz08-D | Interburden | - | 12 510 | 11 380 | 11 950 | 7 640 |

[2] TDS (mg/L) = EC (µS/cm *A), where A is between 5.5 and 9 depending on the chemical composition of the sample. A = 0.64 was utilised for the calculated TDS.

| | | | | | | |
|---|---|---|---|---|---|---|
| Pz09 | Coal seam P08 | - | 12 510 | 9 790 | 11 150 | 7 140 |
| Pz10 | Coal seam H08 | - | 9 090 | - | 9 090 | 5 820 |
| Pz11-D | Coal seam P08 | - | 8 650 | 7 220 | 7 940 | 5 080 |

Previous studies within the area plus an evaluation of the data presented in Table 4-2 allowed for the selection of representative TDS (salinity) inputs into the salt balance for the modelling. These data are compiled in Table 4-4.

**Table 4-4 Representative salinity data**

| Water source | Electrical conductivity (µS/cm) | TDS (mg/L) |
|---|---|---|
| Alluvium groundwater | 390 to 2 000 | 250 to 1 280 |
| Inter / overburden groundwater | 12 000 | 7 500 |
| Coal groundwater | 16 000 | 10 000 |
| Rain | 16 | 10 |
| Runoff from disturbed areas | 700 | 450 |
| Runoff from undisturbed areas | 300 | 170 |

In order to calculate a first approximation of the salt balance based on relative contributions the following assumptions have been made:

- An average TDS value of 9 000 mg/L has been assigned for the groundwater ingress. This is based on a 60% contribution from coal (10 000 mg/L TDS) and 40% from the inter/overburden units (7 500 mg/L); and
- All runoff modelled is derived from disturbed areas, thus a TDS value of 450 mg/L was utilised in the model.

# Model Set-up

## 5.1 Grid Extent

Based on the drawdown radius of influence envisaged in the EIS groundwater chapter (Section 2) the model grid was constructed to extend over an area of 74.4 $km^2$ to envelope the final void. The grid extends 6.2 km from west to east and 12 km from north to south. The grid cell size is 100 m x 100 m.

The distances to the boundaries are sufficiently far away from the void that constant head boundaries could be assigned based on the pre-mining groundwater level data (Figure 3-1).

Figure 5-1 shows the final grid extent and configuration across the study area.

## 5.2 Model layers

Nine layers, representing the different lithological units across the site, were included in the model. The layers were constructed based on the roof and floor contours of the coal seams and the topography supplied by the client. These units were extrapolated to the east to the boundary of the model.

Figure 5-2 presents a west-east cross-section through the centre of the model, illustrating the model layers. The model layers are as follows:

Layer 1: Unconfined weathered overburden aquifer

Layer 2: Coal

Layer 3: Interburden

Layer 4: Coal

Layer 5: Interburden

Layer 6: Coal

Layer 7: Interburden

Layer 8: Coal

Layer 9: Interburden

## 5.3 Boundaries

Section 3.1.2 discusses the boundaries included in the model.

## 5.4 Parameterisation

### 5.4.1 Hydraulic conductivity (K)

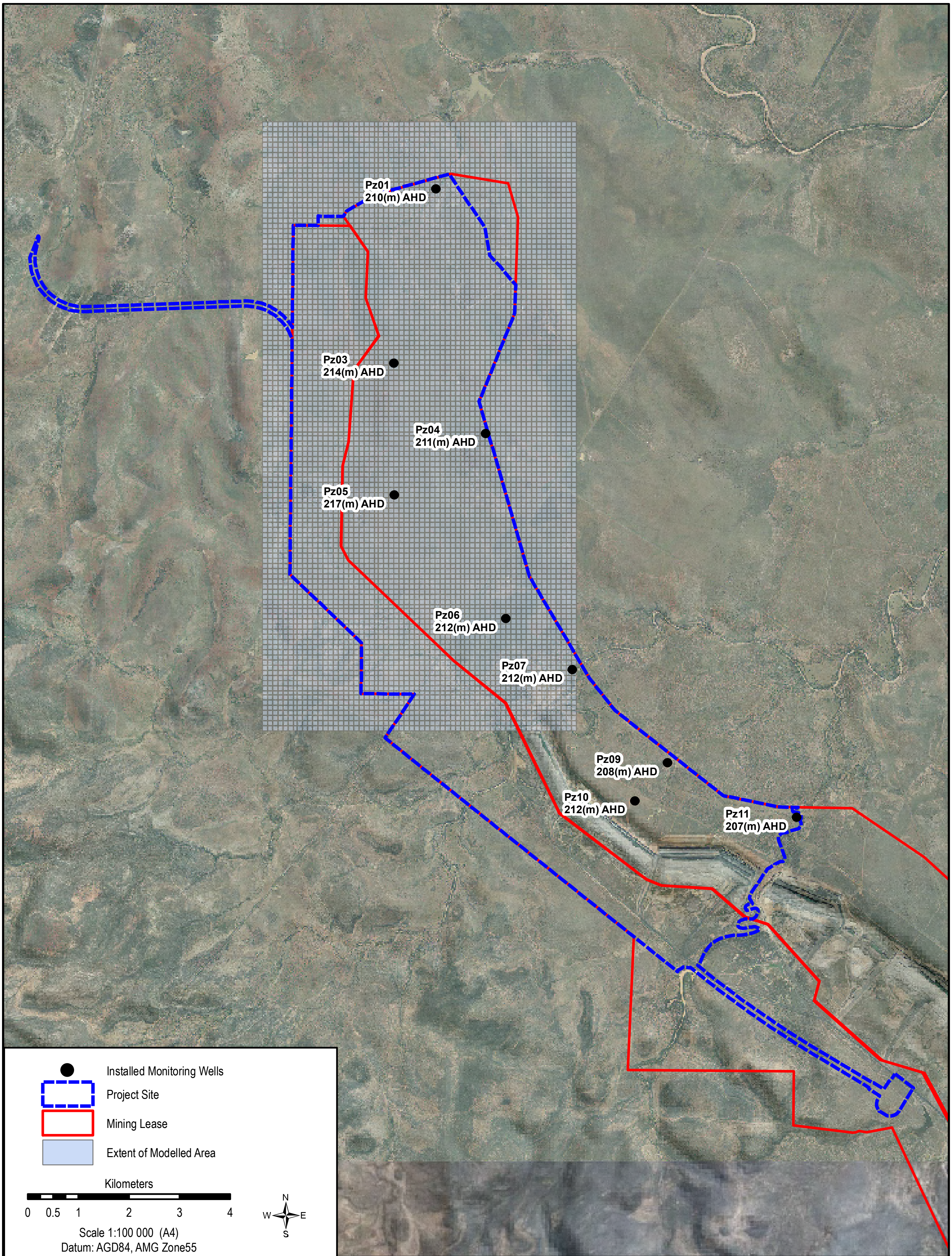
In order to obtain an initial assessment of the final void water the aquifer hydraulic parameters, hydraulic conductivity and storativity, were assumed to be homogeneous within each model layer.

Representative K data was based on site specific data compiled during the variable (slug) head tests conducted across the study area. The K data, as determined during the EIS compilation, is presented in Table 5-1.

# 5 Model Set-up

**Table 5-1 Hydraulic conductivity data**

| Monitoring well | Unit | Hydraulic Conductivity (K) (m/day) | |
|---|---|---|---|
| | | Bouwer & Rice Method | Hvorslev Method |
| Pz01 | Coal seam D04 | 0.1 | 0.13 |
| Pz02 | Basalt | 0.005 | 0.006 |
| Pz03-S | Basalt | 0.08 | 0.1 |
| Pz03-D | Coal seam D04 | 0.5 | 0.6 |
| Pz04 | Coal seam Q | 0.3 | 0.3 |
| Pz05 | Coal seam D04 | 0.02 | 0.03 |
| Pz06-S | Basalt | 0.1 | 0.2 |
| Pz06-D | Coal seam P02 | 0.06 | 0.08 |
| Pz07-S | Alluvium | 0.3 | 0.4 |
| Pz07-D | Coal seam Q01 | 0.3 | 0.3 |
| Pz08-S | Alluvium | 0.09 | 0.1 |
| Pz08-D | Sandstone interburden | 0.03 | 0.03 |
| Pz09 | Coal seam P08 | 0.1 | 0.2 |
| Pz10 | Coal seam H08 | 0.03 | 0.04 |
| Pz11-S | Alluvium | Dry | Dry |
| Pz11-D | Coal seam P08 | 0.03 | 0.04 |

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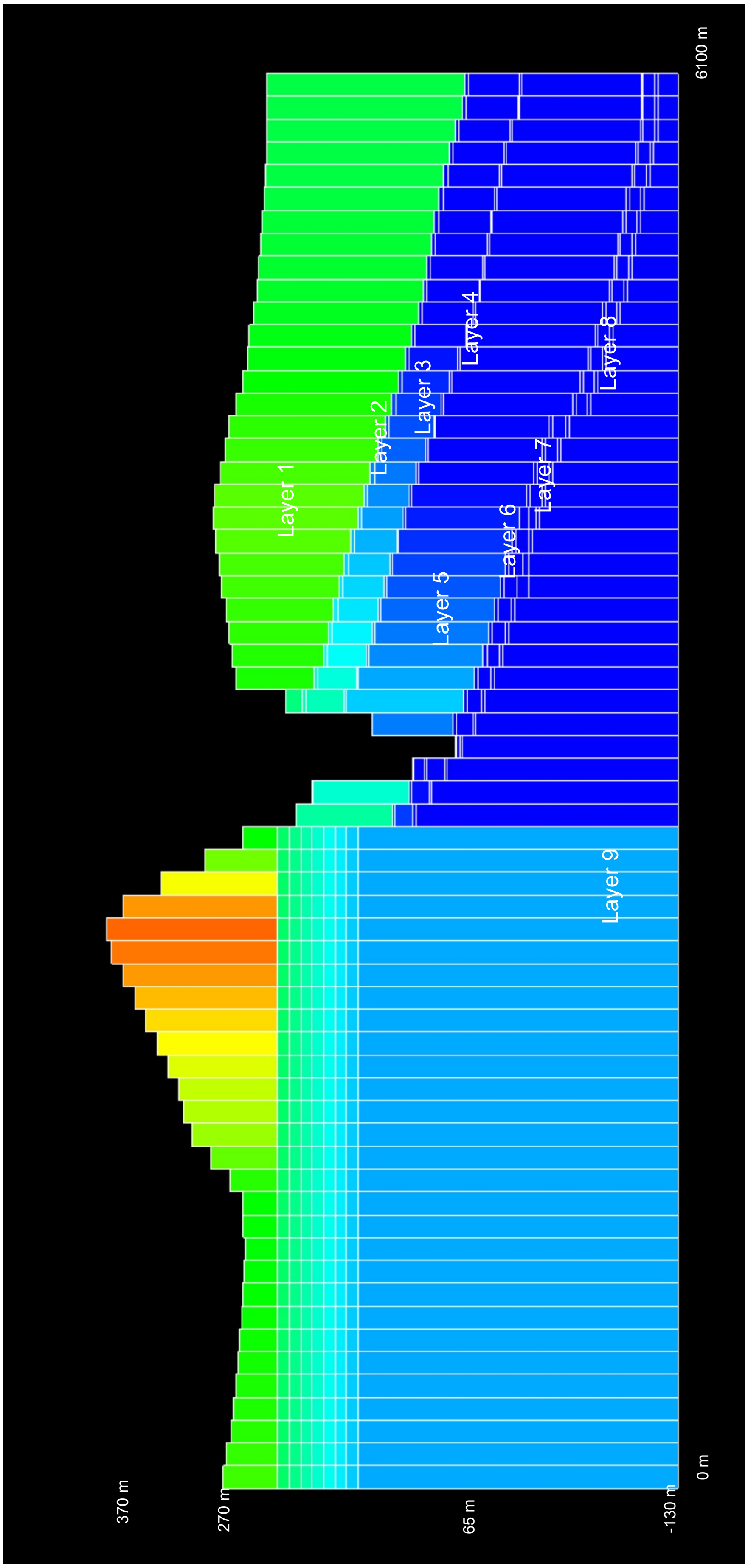
| Client: BMA – BHP Billiton Mitsubishi Alliance; URS | Project: CAVAL RIDGE PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT LONG TERM VOID WATER STORAGE AND QUALITY | Title: **GRID EXTENT AND SITE LAYOUT** |
| Drawn: MG | Approved: MST | Date: 22-09-2009 |
| Job No: **4262 6420**/6158 | File No.: 42626158-g-1503.mxd | Figure: **5-1** |
| Rev. A | A4 | |




N E S W

Horizontal Axis -
1 Block width = 100m

0 490 980 Meters

Vertical Axis: Horizontal Axis
5:1

## LEGEND

**Top Elevation of Layer (mAHD)**

100.000
130.000
160.000
190.000
220.000
250.000
280.000
310.000
340.000
370.000
400.000

Source:

| Client | Project | Title |
|---|---|---|
| BMA<br>BHP Billiton Mitsubishi Alliance<br>URS | CAVAL RIDGE PROJECT<br>ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT<br>LONG TERM VOID WATER STORAGE AND QUALITY | **SCHEMATIC CROSS SECTION W-E - ELEVATIONS OF MODEL LAYERS IN GRID** |
| | Drawn: MG · Approved: MST · Date: 22-09-2009 | Figure: **5-2** · Rev. A |
| | Job No: **4262 6420**/6158 · File No.: 42626158-g-1504.mxd | A4 |

### 5.4.2 Recharge and Evaporation

Rainfall recharge to the undisturbed Tertiary sediments and Permian coal seams is recognised to be low, < 5% of mean annual precipitation within the study area. Recharge zones were classified based on the rock types across the site, with the highest recharge being allocated to the backfill spoil pile area.

The recharge was refined through a review of the model water budget. Evaporation was estimated from the same process.

## 5.5 Assumptions

The following assumptions were made when constructing and running the integrated model:

- The physical and chemical properties of the spoil pile remain constant through out the modelled period;
- The Heyford Pit was not included in the simulations and thus cumulative impacts of drawdown cones from the Horse and Heyford voids was excluded from the modelling;
- Groundwater levels used to set constant head boundaries were derived from the extrapolation of groundwater data recorded within the middle of the model grid;
- Model layer elevations were interpolated based on available roof and floor elevation data. Uniform layer thickness was extended to the model boundaries for the areas where no data was available;
- The numerical errors resulting from the dipping angles of the model layers were assumed to be negligible. The possible discrepancy can be reduced by including the effect into hydraulic conductivity;
- Groundwater levels are relatively deep below surface. Evaporation and transpiration impacts on groundwater are therefore recognised to be of limited significance. Evaporation and transpiration are, however, considered and combined into recharge as net recharge for the areas outside the mining area. Evaporation from land surface is considered only in the mining area, which accounts the major contribution from the void;
- Hydraulic conductivity and storativity are assumed to be homogeneous within each model layer;
- Head boundaries were extrapolated based on water level data in 2009 and were assumed to keep constant during the simulation period;
- Groundwater levels were assumed to be uniformly distributed across all layers, i.e. the same groundwater level was assigned to each layer;
- Net recharge was considered to be 2 to 3 percent of mean annual rainfall outside the mining area. No net recharge was applied within the mining area (maximum or minimum catchment area); and
- The integrated model has an overland flow domain, which simulates runoff, interactions with groundwater, and direct evaporation from surface. Since 100 year mean annual precipitation was adopted in the simulation, runoff can not be sufficiently generated, so rainfall-runoff simulation was not conducted explicitly and was approximated by the rational formula.

# Modelling Results

Once the groundwater model was set-up based on the pre-mining groundwater levels the model was used to simulate the predicted groundwater level drawdown around the final void after 30 years of mining, to simulate the gradients expected based on the base case final void configuration. The simulated drawdown around the mine is presented in Figure 6-1.

Using this model the following outputs were compiled:

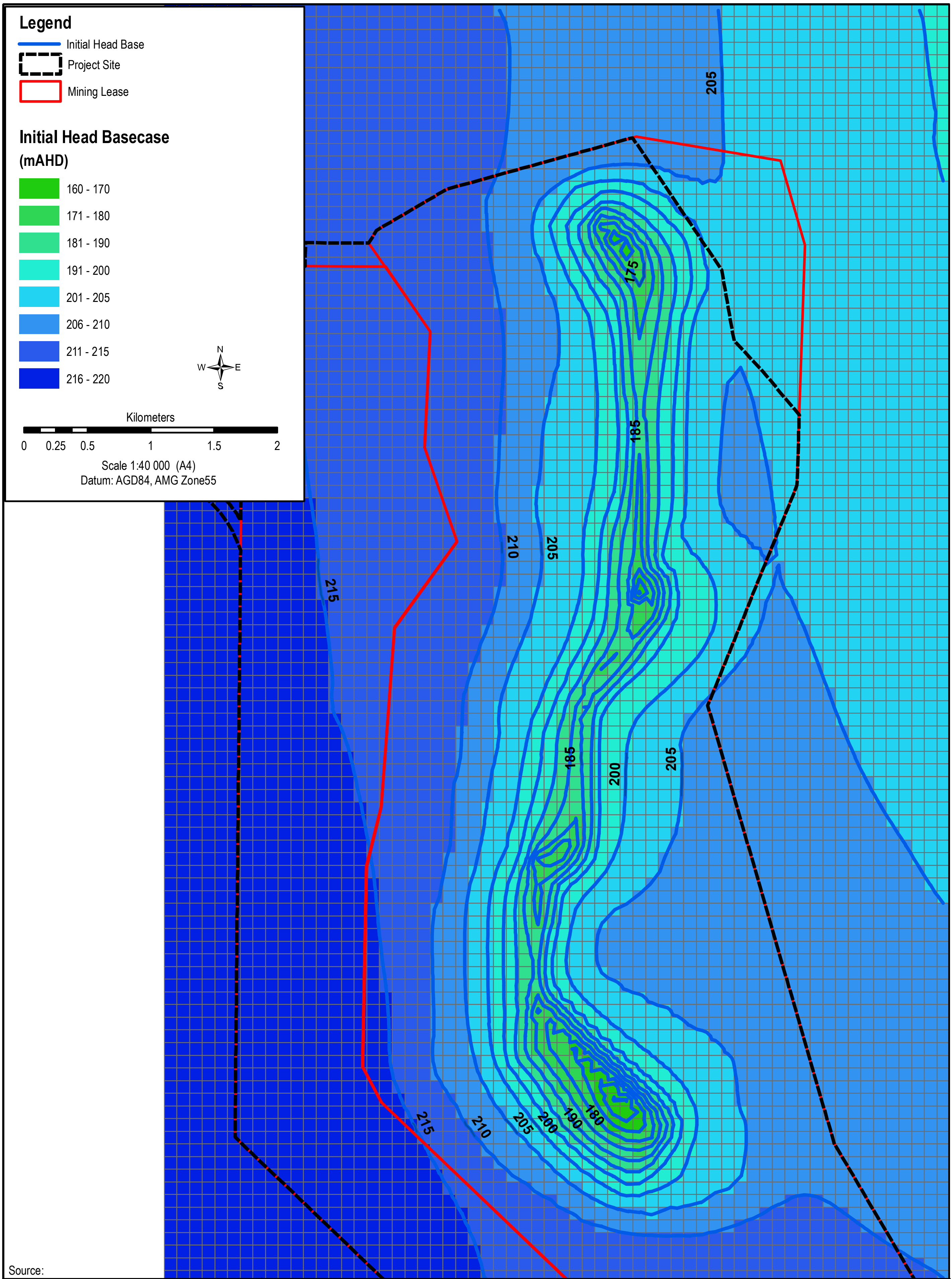
- Final void water level simulations for each of the three void configurations (base, 25p regrade, and 10p regrade), using two catchment configurations (minimum and maximum), three climate conditions (mean annual rainfall, + 10%, and – 10%), as discussed in Section 3;
- A comparison of predicted equilibrium void water levels to pre-mining groundwater levels;
- A salt balance for each of the final void configurations based on predicted groundwater ingress, variable climate data, and different catchment sizes, for 100 years; and
- An estimate of void space within each of the three void configurations after equilibrium is reached, which allowed for an evaluation of probability of spill risk.

In addition, URS were asked for input regarding flood risk and stratification within the final void.

## 6.1 Sensitivity analysis

Table 6-1 shows the Modelling Runs conducted to perform Analysis and Sensitivity Results for the envisaged scenarios presented above.

The sensitivity analysis allowed for the selection of the optimum parameters to conduct the model simulations.






| Client | Project | Title |
|---|---|---|
| BMA BHP Billiton Mitsubishi Alliance | CAVAL RIDGE PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT LONG TERM VOID WATER STORAGE AND QUALITY | **DRAWDOWN SIMULATION (BASE CASE) AT END OF MINING** |
| URS | Drawn: MG / Approved: MST / Date: 22-09-2009 | Figure: **6-1** / Rev. A |
| | Job No: **4262 6420**/6158 / File No.: 42626158-g-1505.mxd | A4 |

# 6 Modelling Results

**Table 6-1 Modelling Scenarios**

| | Contour Grading | Contributing Area | Rainfall | K Value | Runoff Coefficient |
|---|---|---|---|---|---|
| Analysis | Base | maximum | median | Base Scenario | 0.1 |
| | | | +10% | Base Scenario | 0.1 |
| | | | -10% | Base Scenario | 0.1 |
| | | minimum | median | Base Scenario | 0.1 |
| | | | +10% | Base Scenario | 0.1 |
| | | | -10% | Base Scenario | 0.1 |
| | 10p regrade | maximum | median | Base Scenario | 0.1 |
| | | | +10% | Base Scenario | 0.1 |
| | | | -10% | Base Scenario | 0.1 |
| | | minimum | median | Base Scenario | 0.1 |
| | | | +10% | Base Scenario | 0.1 |
| | | | -10% | Base Scenario | 0.1 |
| | 25p regrade | maximum | median | Base Scenario | 0.1 |
| | | | +10% | Base Scenario | 0.1 |
| | | | -10% | Base Scenario | 0.1 |
| | | minimum | median | Base Scenario | 0.1 |
| | | | +10% | Base Scenario | 0.1 |
| | | | -10% | Base Scenario | 0.1 |
| Sensitivity | Base | minimum | median | Base Scenario | 0.1 |
| | | | | Base Scenario | 0.1 |
| | | | | +10% | 0.1 |
| | | | | -10% | 0.1 |

Note: Base Scenario K values= Coal 0.17, Inter/Overburden 0.03, Backfill 0.22

## 6.2 Simulations

Final void volumes were calculated using modelling results, these are shown in **Appendix B**. Selected observation locations were chosen at grid cells listed below and displayed in Figures B4-B6. Water level rebound graphs for these observations are also shown in **Appendix B**.

| Observation locations | Row | Column |
|---|---|---|
| Obs1 | 48 | 76 |
| Obs2 | 91 | 78 |

A summary of the equilibrium final void water level elevations are presented in Table 6-2.

## 6 Modelling Results

**Table 6-2 Final void equilibrium water levels (based on mean annual rainfall)**

| Final void configuration | Pre-mining groundwater level at selected point | Bottom elevation of pit (m AHD) | Void equilibrium water level (m AHD) | Lowest surface elevation (m AHD) | Void equilibrium depth (m below surface[3]) | Time to reach equilibrium (years) |
|---|---|---|---|---|---|---|
| Base case min | 208.07 | 68.92 | 91.703 | 220 | 128 | 45 |
| Base case max | | | 91.739 | | 128 | 50 |
| 25p regrade min | 208.07 | 127.12 | 140.68 | | 79 | 50 |
| 25p regrade max | | | 144.51 | | 75 | 40 |
| 10p regrade min | 208.07 | 184.66 | 194.39 | | 26 | 45 |
| 10p regrade max | | | 195.00 | | 25 | 30 |

The variation in the estimated equilibrium void water levels was calculated based on the variation in mean annual rainfall data. Table 6-3 presents the variations.

**Table 6-3 Equilibrium void water levels**

| Final void configuration | Pre-mining groundwater level at selected point | Bottom elevation of pit (m AHD) | Void equilibrium water level (m AHD) | | |
|---|---|---|---|---|---|
| | | | Average | +10% | -10% |
| Base case min | 208.07 | 68.92 | 91.703 | 91.707 | 80.18 |
| Base case max | | | 91.739 | 100.36 | 91.732 |
| 25p regrade min | 208.07 | 127.12 | 140.68 | 142.96 | 130.38 |
| 25p regrade max | | | 144.51 | 147.02 | 144.51 |
| 10p regrade min | 208.07 | 184.66 | 194.39 | 194.98 | 190.06 |
| 10p regrade max | | | 195.00 | 195.00 | 194.736 |

## 6.3 Salt balance

Predictions of salt accumulation in the final void, for the three void configurations, was estimated based on salt contributions from groundwater ingress and runoff. Salt balance estimates were calculated for mean annual rainfall, mean +10%, and mean – 10% for each scenario.

For the base case final void scenario void water is recognised to deteriorate with time due to increased salinity. An increase in rainfall (mean +10%) and the larger catchment area results in a reduced deterioration with time. Void water, in this instance, results in an increase from ~ 5 000 mg/L TDS to ~ 12 000 mg/L TDS over 100 years.

For the most likely base case scenario; minimum catchment and average rainfall, the TDS will increase from ~ 9 800 mg/L TDS to ~ 19 800 mg/L TDS over 100 years.

[3] Metres below lowest void surface elevation

The salt accumulation for the regrade scenarios indicates similar increases with time. However, the initial increases in TDS are lower as groundwater rebound is required before it can enter the void.

The resultant charts are presented in **Appendix C.** Included in Appendix C are the estimates of net volumes in the void over time. These graphs indicate the higher the total volumes the more reduced the impact. Consideration could, therefore, be given to possibly increasing the catchment area around the final void to allow for additional runoff.

## 6.4 Spill risks

The probability of decant from the final void was considered for each of the three final void configurations. Based on the equilibrium water level results of the large catchment scenarios (runoff from the backfill spoil piles collected and directed into the voids) an estimate of the void space in each of the final void configurations was calculated.

The void space was calculated based on the final void figures provided by the client, which indicates the lowest elevation at the final void is 220 m AHD. Thus the void area between the equilibrium void water level and the spill elevation (220 m AHD) was calculated. Table 6-4 indicates the remaining void volumes to spill level.

**Table 6-4 Void space data**

| Final void | Total void volume ($Mm^3$) | Volume of water in void at equilibrium with mean annual rainfall ($Mm^3$) | | Percentage of total void space (%) | | Void space remaining ($Mm^3$) | |
|---|---|---|---|---|---|---|---|
| | | min | max | min | max | min | max |
| Base | 288 | 2.4 | 5.4 | 0.8 | 1.9 | 285.6 | 282.6 |
| 25p | 248 | 1.6 | 3.25 | 2.2 | 4.4 | 246.4 | 244.75 |
| 10p | 73.5 | 1.06 | 1.9 | 0.4 | 0.8 | 72.44 | 71.6 |

The modelling indicates, based on low aquifer properties, low rainfall recharge, and high evaporation, that only a small percentage (< 6 %) of the final void will be filled with water. This results in large volumes of void space, for all three configurations, after equilibrium is reached.

An evaluation of historic climate data was conducted to determine the most significant rainfall events on record for the study area. These include:

- Largest rainfall event: 193.2 mm on 28/12/1916;
- Largest rainfall duration: 201.6 mm over 19 days recorded on 17/02/1947; and
- Largest rainfall volume: 385.1 mm over 15 days recorded on 08/01/1991.

Assuming all this water fell directly into void, i.e. 100% recharge / runoff, over the largest catchment (2 350 ha), the volumes of water reporting to the void would be:

- Largest rainfall event: 4.5 $Mm^3$;
- Largest rainfall duration: 4.7 $Mm^3$; and
- Largest rainfall volume: 9 $Mm^3$.

Based on the volumes remaining in the voids (Table 6-4) none of these extreme rainfall events would have been sufficient to cause any risk of decant from the final void.

## 6.5 Groundwater / Void Water Interaction

On completion of mining it is envisaged that all pumping from the final void will cease and that groundwater levels will begin to rebound. The groundwater level contours predicted for the end of mining are presented in Figure 6-1. These drawdown contours are generated such that groundwater is below the mining void to ensure a dry working area.

Groundwater rebound with time has been predicted using the numerical model. Groundwater levels will increase over time. This will result in groundwater ingress into the final void. Based on the negative water balance derived from the climate data for the area, water will be lost from the pit through evaporation such that the final void acts as a groundwater sink.

Modelling predicts final void equilibrium water levels, which are below the pre-mining groundwater levels. Thus groundwater levels will not rebound to pre-mining elevations and groundwater flow patterns will not revert back to pre-mining conditions. The mining void will, therefore, continue to impact on the local groundwater causing a localised drawdown cone around the final void.

**Appendix D** contains the drawdown cones predicted around each of the three final void configurations once final void equilibrium water levels (assuming mean rainfall and minimum catchment) are reached.

Data regarding neighbouring bores, presented in the Groundwater Chapter in the EIS submission, indicates that no existing bores are located within the model study area. Thus no existing users are identified within the envisaged drawdown cones resulting after equilibrium is reached in the void. It is therefore, recommended that in order to verify model predictions and to provide site specific groundwater level data away from the final void (to provide data for the constant head boundaries) additional monitoring bores be constructed outside the mine disturbed areas. Stephen Denner (URS) will be compiling an EIS supplementary response, which will include recommendations regarding suitable groundwater monitoring.

## 6.6 Flood Risk

The risk of flooding into the void was requested. It is considered that major flooding in the area could result in the flooding into the void. The creek diversion details were considered in terms of bank height. The required rainfall to overtop the bank was determined in terms of volume and probability (Section 7.3).

Discussions were held with Michel Raymond, Principal Water Engineer at URS, who confirmed that his department are remodelling the Caval Ridge hydrology to assess flooding. The flood scenario to be modelled will include a 1: 3000 flood event, based on 1% of the life of the mine (30 years). Based on these scenario recommendations regarding berms and flood protection measures along the north and east of the Horse Pit will be made.

Comments regarding backfill spoil pile runoff management and ramp modifications (to prevent flooding) will be included in the URS Flood Risk study.

## 6.7 Stratification

Water in the voids may become stratified, especially voids in arid regions as the voids may contain dense saline water after extended dry periods. Fresh water from occasional storm events will remain above this saline layer, based on density differences. Also a dense stable layer may form at the base of the void where water containing high concentrations of dissolved salts has flowed into the void.

The chemical and biological processes within the void water, which can influence the mobility and fate of solutes, are closely linked to stratification and destratification. Changes in speciation and solubility across oxic, suboxic, and anoxic boundaries control the solubilities of redox sensitive metals. Metals, such as chromium, lead, and selenium, are less soluble in the reduced state than in the oxidised state.

As only limited hydrology and geochemistry data is available for final voids in central Queensland, as most voids are still active components of both mining operations and mine water management systems, it will require extensive data collection through the life of the mine. These data can be modelled to assess geochemical reactions and water behaviour (particularly stratification) as part of a detailed mine-closure plan.

# Conclusions

- A groundwater numerical model was constructed to simulate mine related dewatering around Horse Pit after 30 years of mining. The drawdown cone was simulated to the bottom of the final void, some 160 m below surface. The resultant groundwater contours, gradients, and flow patterns were utilised to estimate groundwater ingress into the Horse Pit final void at mine closure. The groundwater drawdown simulation is, allowing for several assumptions, a suitable representation of the envisaged dewatering impacts;
- The conceptualisation and model set-up is a simplified model of actual mining conditions as it assumes constant aquifer hydraulic parameters, hydrochemistry, and no cumulative impacts of Heyford Pit;
- The use of a finite difference model to simulate the groundwater flow within and between layers is suitable for the study even though minor numerical errors may occur due to the dipping angle of the model layers;
- The use of mean annual climate data, based on 100 year data set, allowed for representative input into the scenarios;
- Sensitivity analysis of model parameters ensured that the input into the model were representative, allowing for representative simulations;
- The transient model was used to obtain void equilibrium water levels for various final void configurations and input scenarios. The results all indicate that limited water will be stored in the final void, irrelevant of the configuration, due to limited water input and high evaporation outflow from the model;
- Final void water will deteriorate with time, high and rapid salt accumulation is envisaged for the deep final void. The water in the shallower (regrade) void configurations will become more saline with time but a slower rate; and
- Large void space will be available in all three final void configurations after void equilibrium water level is achieved. This negates any risk of decant from the Horse Pit.

# 8 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 BMA and PW Baker 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 August 2009.

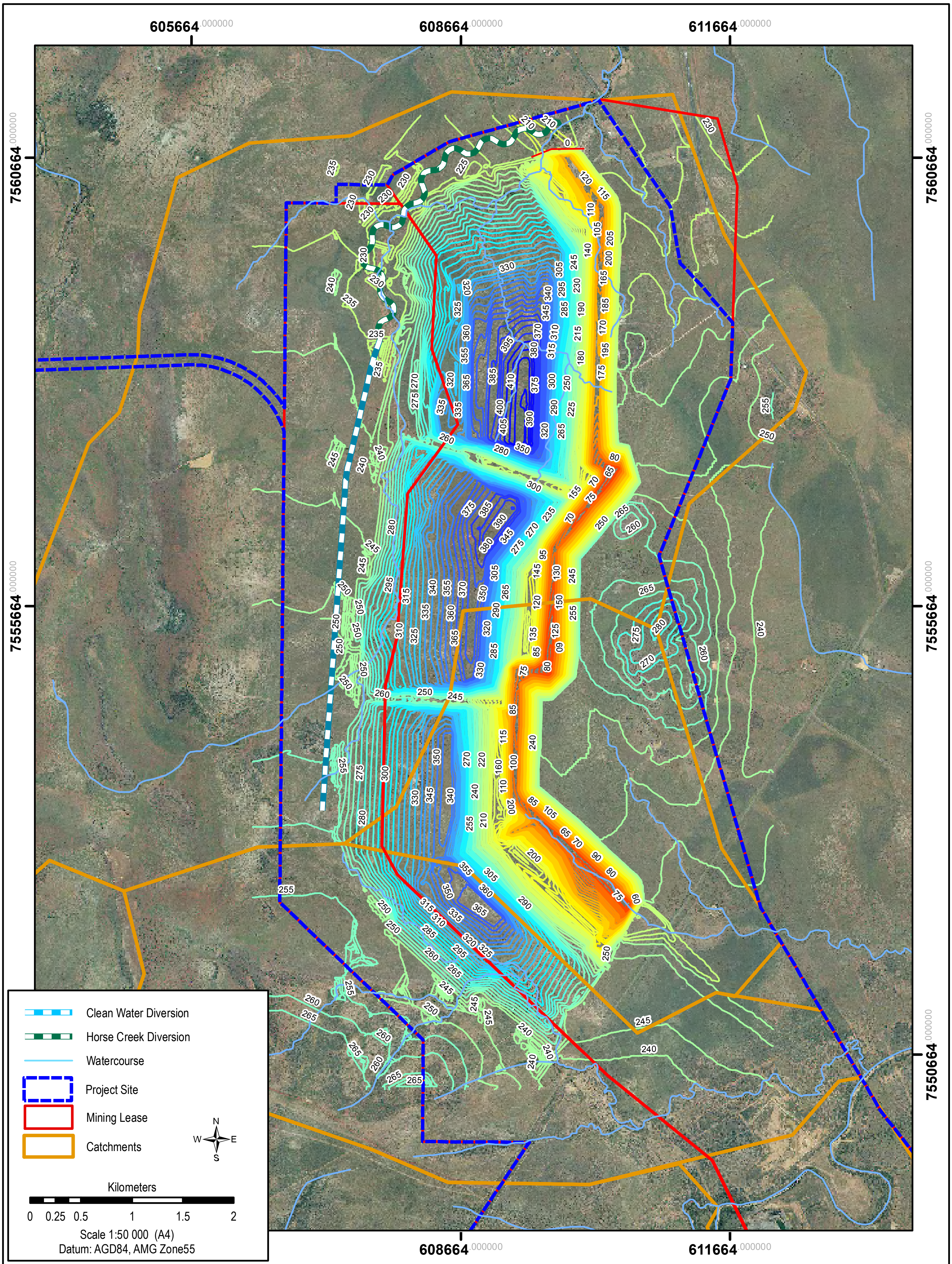
The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations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

This report was prepared during September 2009 and is based on the information available 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.

A

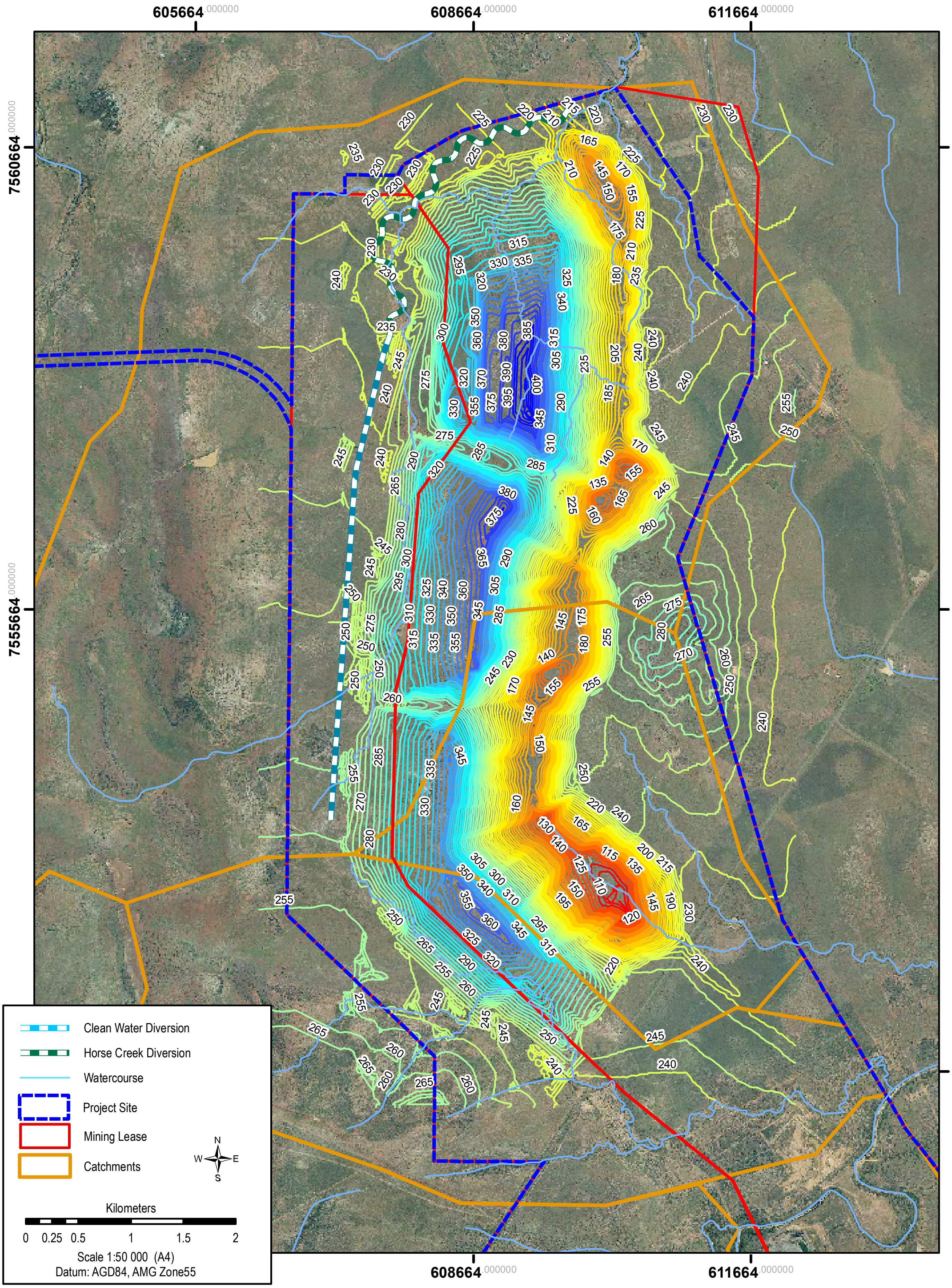
# Appendix A Final void configurations




Source:



| Client | Project | Title |
|---|---|---|
| BMA<br>BHP Billiton Mitsubishi Alliance | CAVAL RIDGE PROJECT<br>ENVIRONMENTAL IMPACT STATEMENT<br>SUPPLEMENT<br>LONG TERM VOID WATER STORAGE AND QUALITY | **FINAL VOID CONFIGURATION**<br>**BASE CASE** |
| URS | Drawn: MG / Approved: MST / Date: 22-09-2009 | Figure: **A1** / Rev. A |
| | Job No: **4262 6420**/6158 / File No.: 42626158-g-1506.mxd | A4 |

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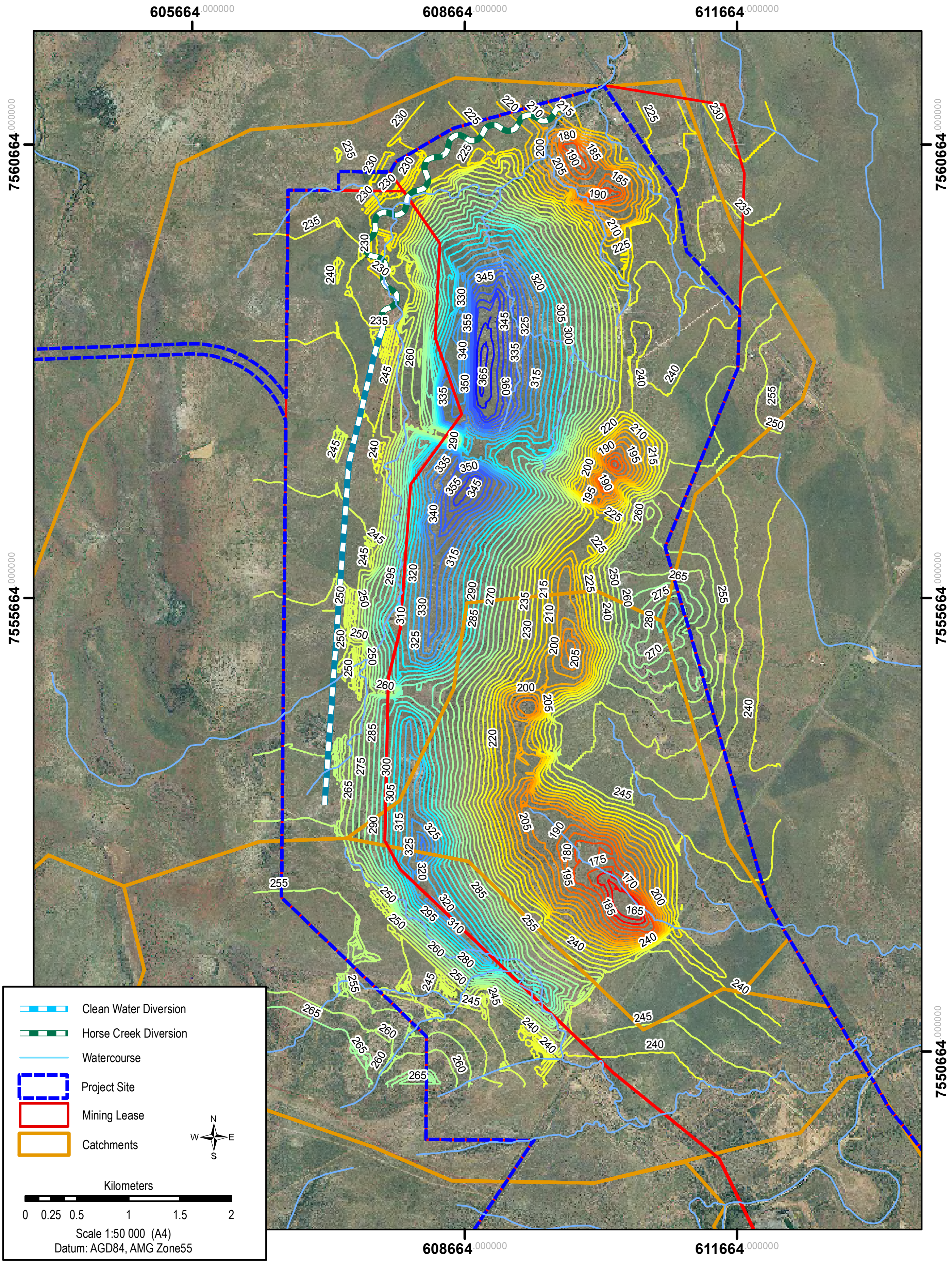
| Client | Project | Title |
|---|---|---|
| BMA BHP Billiton Mitsubishi Alliance | CAVAL RIDGE PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT LONG TERM VOID WATER STORAGE AND QUALITY | **FINAL VOID CONFIGURATION 25% CASE** |
| URS | Drawn: MG / Approved: MST / Date: 22-09-2009 | Figure: **A2** / Rev. A |
| | Job No: **4262 6420**/6158 / File No.: 42626158-g-1507.mxd | A4 |

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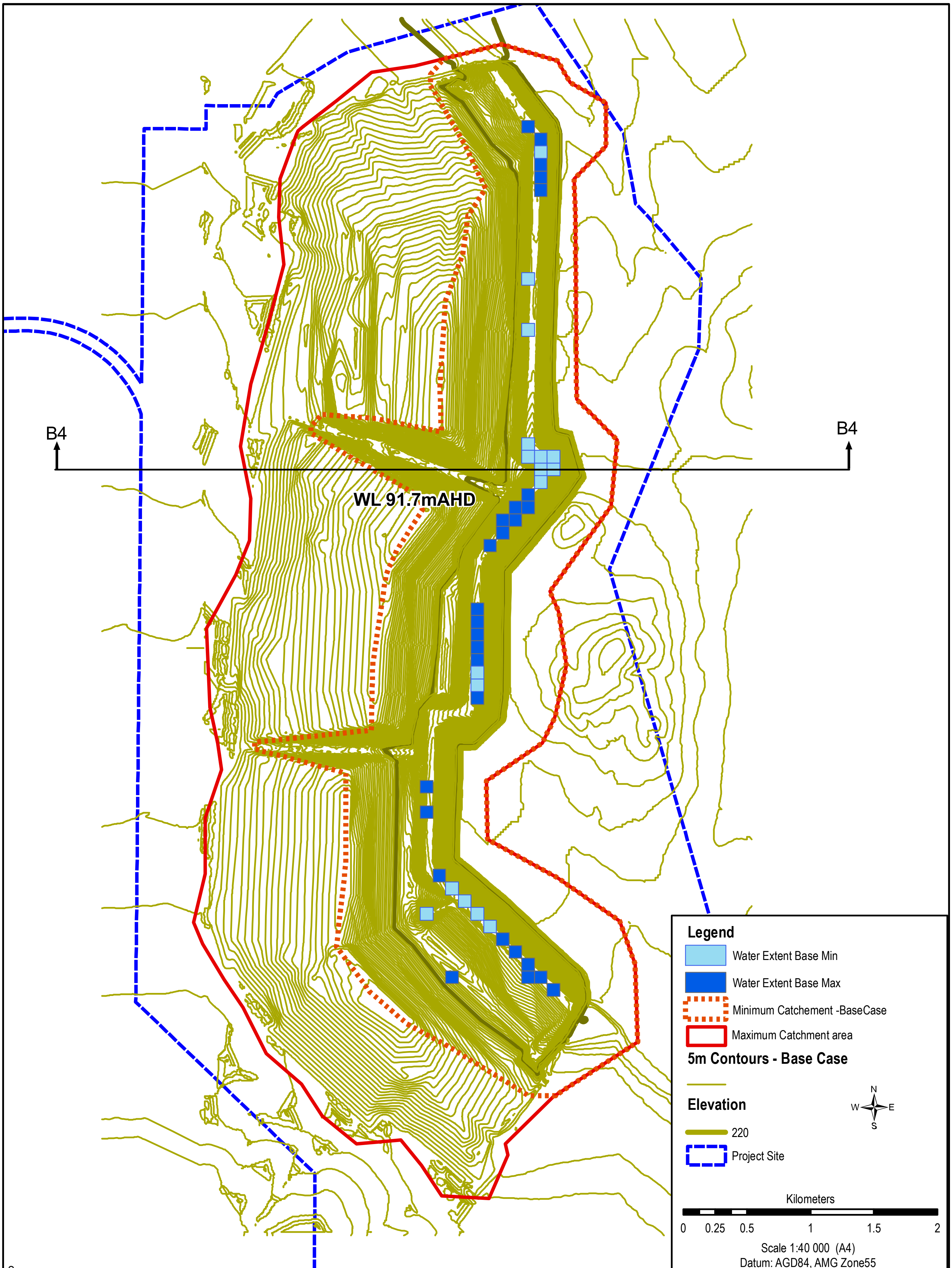
|---|---|---|
| BMA BHP Billiton Mitsubishi Alliance | CAVAL RIDGE PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT LONG TERM VOID WATER STORAGE AND QUALITY | **FINAL VOID CONFIGURATION 10% CASE** |
| URS | Drawn: MG · Approved: MST · Date: 22-09-2009 | Figure: **A3** · Rev. A |
| | Job No: **4262 6420**/6158 · File No.: 42626158-g-1508.mxd | A4 |

# Appendix B Final void water level figures

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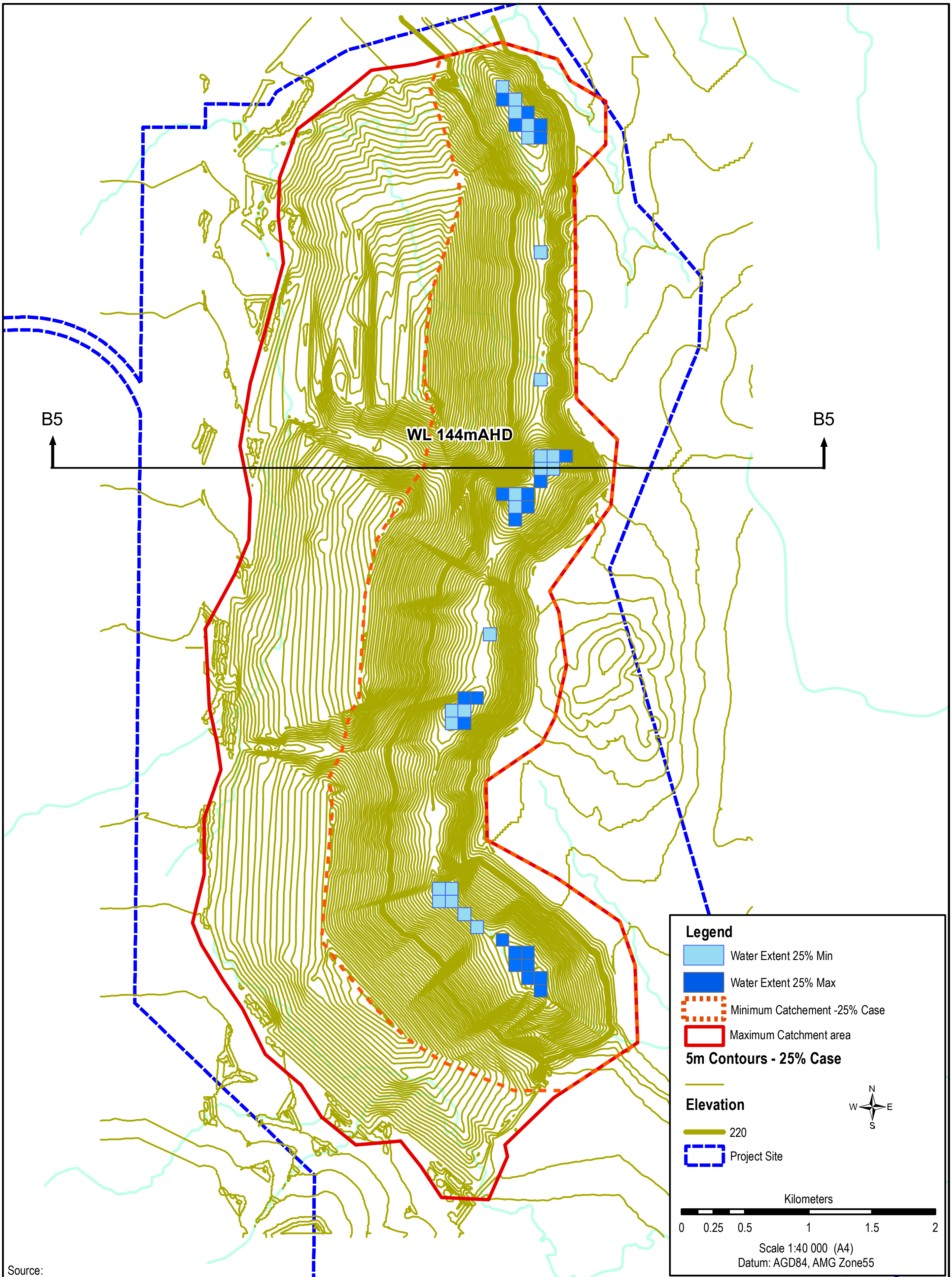
| Client | Project | Title |
|---|---|---|
| BMA BHP Billiton Mitsubishi Alliance | CAVAL RIDGE PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT LONG TERM VOID WATER STORAGE AND QUALITY | **BASE CASE FINAL CONTOURS EXTENT OF WATER IN VOID FROM MAX AND MIN CATCHMENT AREAS** |
| URS | Drawn: MG / Approved: MST / Date: 22-09-2009 | Figure: **B1** / Rev. A |
| | Job No: **4262 6420**/6158 / File No.: 42626158-g-1509.mxd | A4 |

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| Client | Project | Title |
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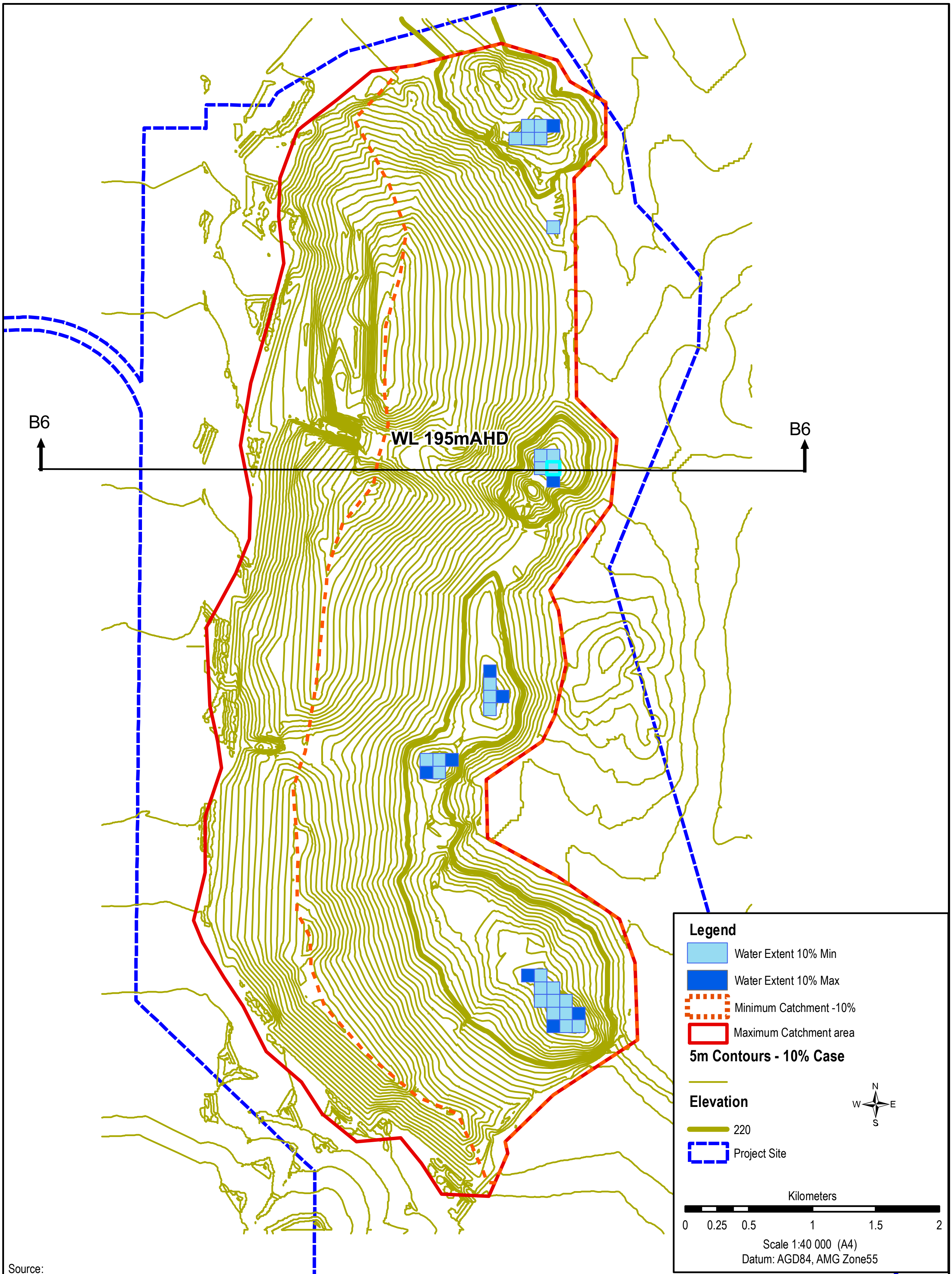
| BMA BHP Billiton Mitsubishi Alliance; URS | CAVAL RIDGE PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT LONG TERM VOID WATER STORAGE AND QUALITY | 25% CASE FINAL CONTOURS EXTENT OF WATER IN VOID FROM MAX AND MIN CATCHMENT AREAS |

| | | | | |
|---|---|---|---|---|
| Drawn: MG | Approved: MST | Date: 01-09-2009 | Figure: B2 | Rev. B |
| Job No: 4262 6420/6158 | File No.: 42626158-g-1510.mxd | | | A4 |

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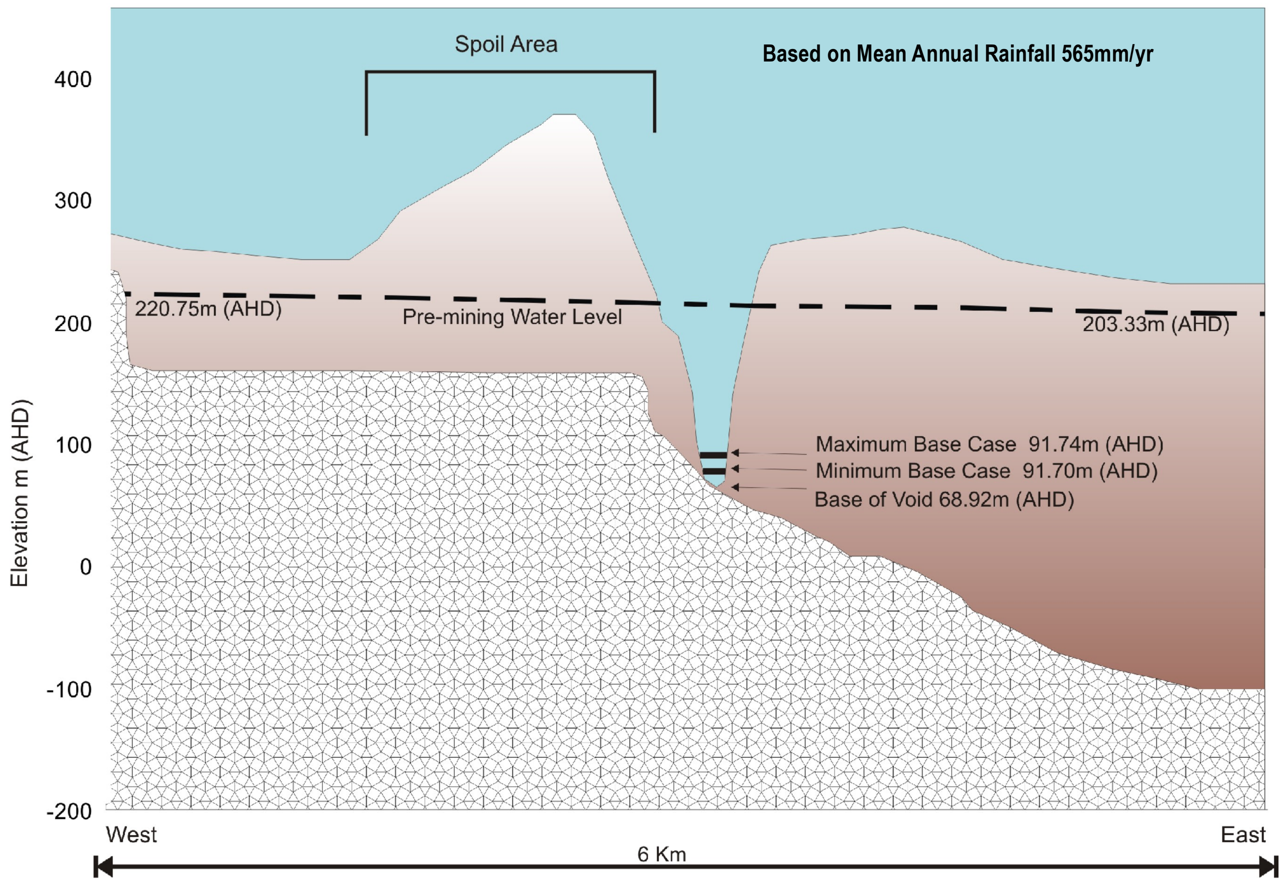
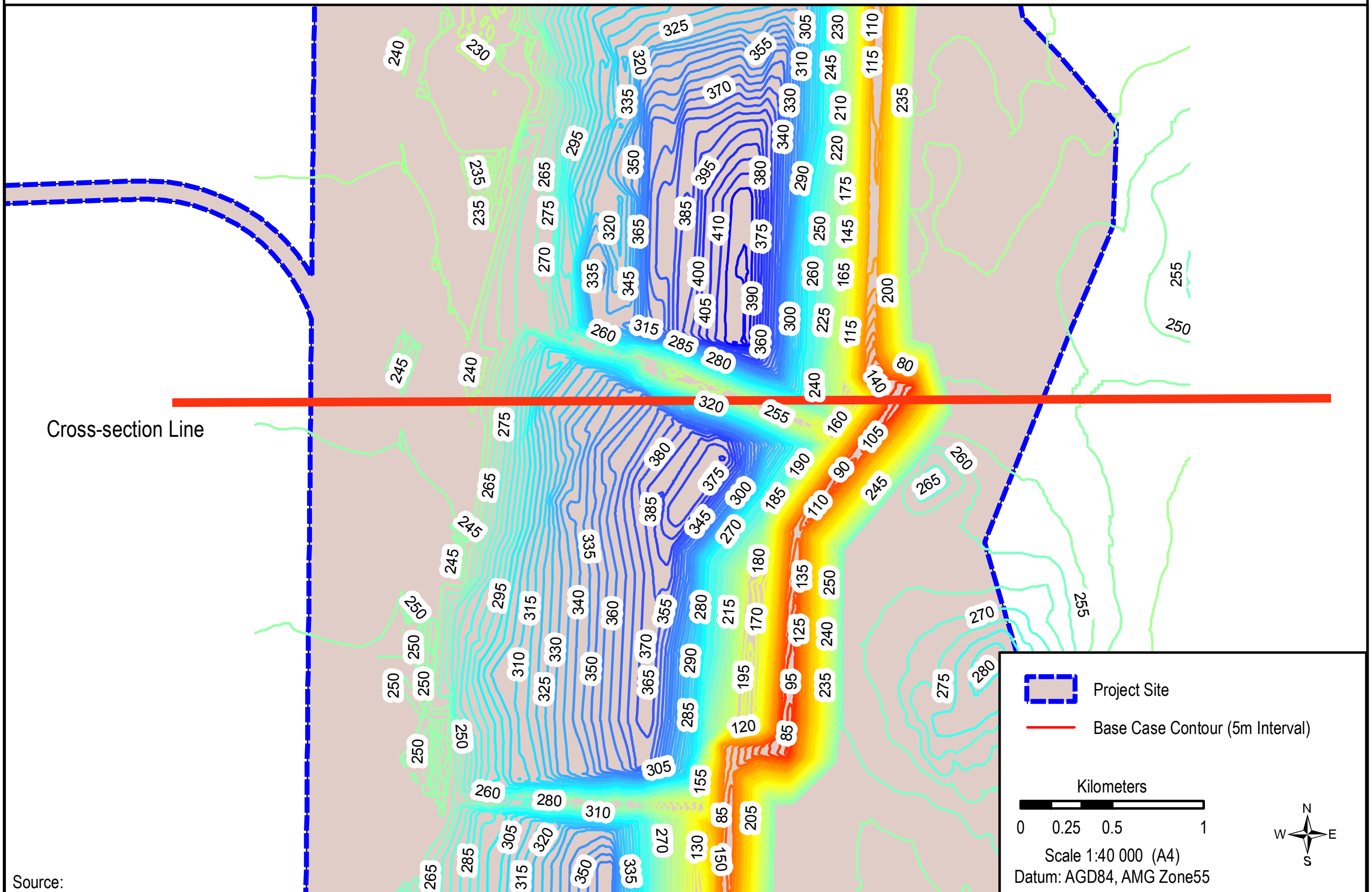
| Client | Project | Title |
|---|---|---|
| BMA BHP Billiton Mitsubishi Alliance | CAVAL RIDGE PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT LONG TERM VOID WATER STORAGE AND QUALITY | **10% CASE FINAL CONTOURS EXTENT OF WATER IN VOID FROM MAX AND MIN CATCHMENT AREAS** |
| URS | Drawn: MG / Approved: MST / Date: 22-09-2009 | Figure: **B3** / Rev. A |
| | Job No: **4262 6420**/6158 / File No.: 42626158-g-1511.mxd | A4 |




**Site Cross-Section m (AHD)**

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| Client | Project | Title |
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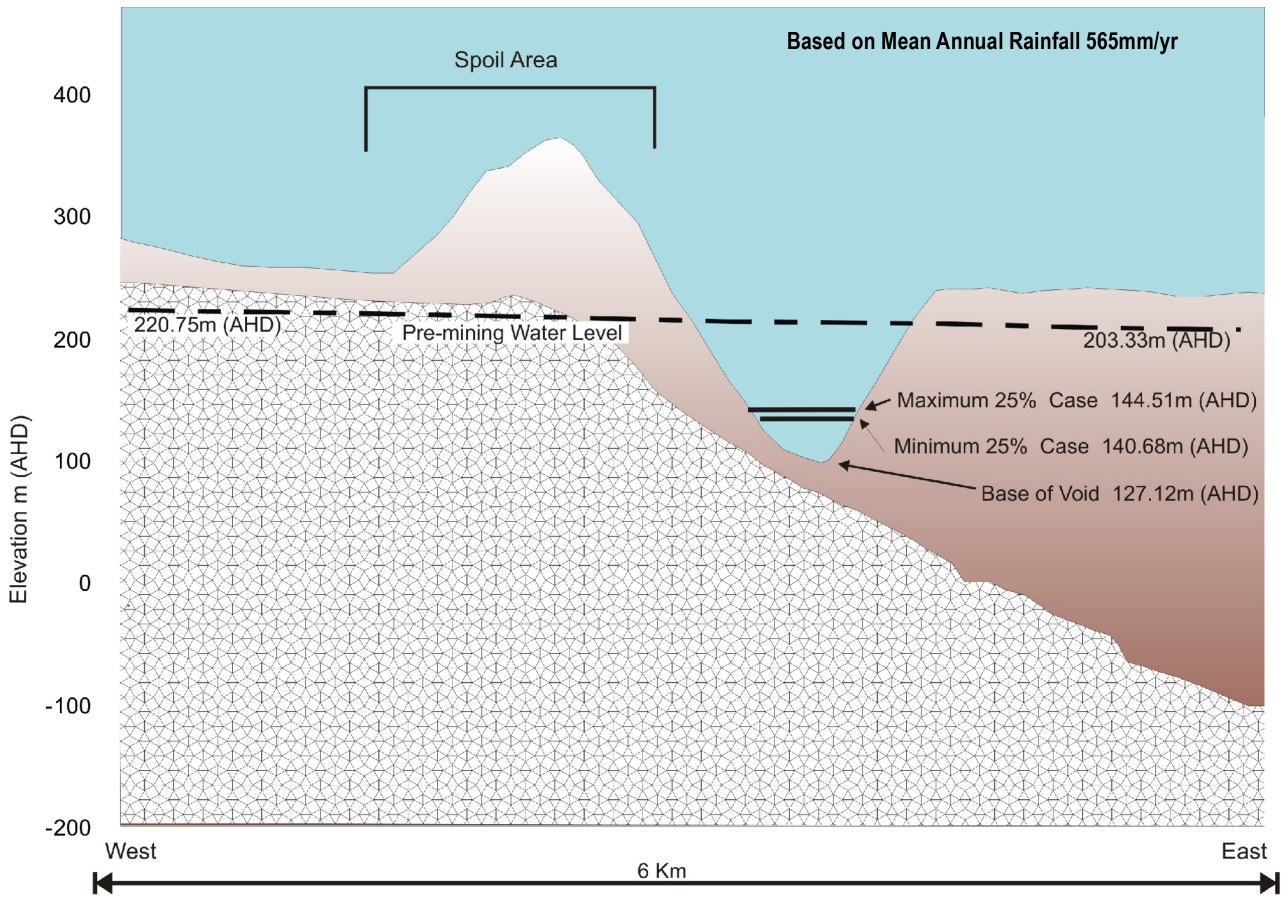
| BMA BHP Billiton Mitsubishi Alliance / URS | CAVAL RIDGE PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT LONG TERM VOID WATER STORAGE AND QUALITY | **BASE CASE AND CROSS SECTION** |
| | Drawn: MG / Approved: MST / Date: 22-09-2009 | Figure: **B4** / Rev. A |
| | Job No: **4262 6420**/6158 / File No.: 42626158-g-1512.mxd | A4 |

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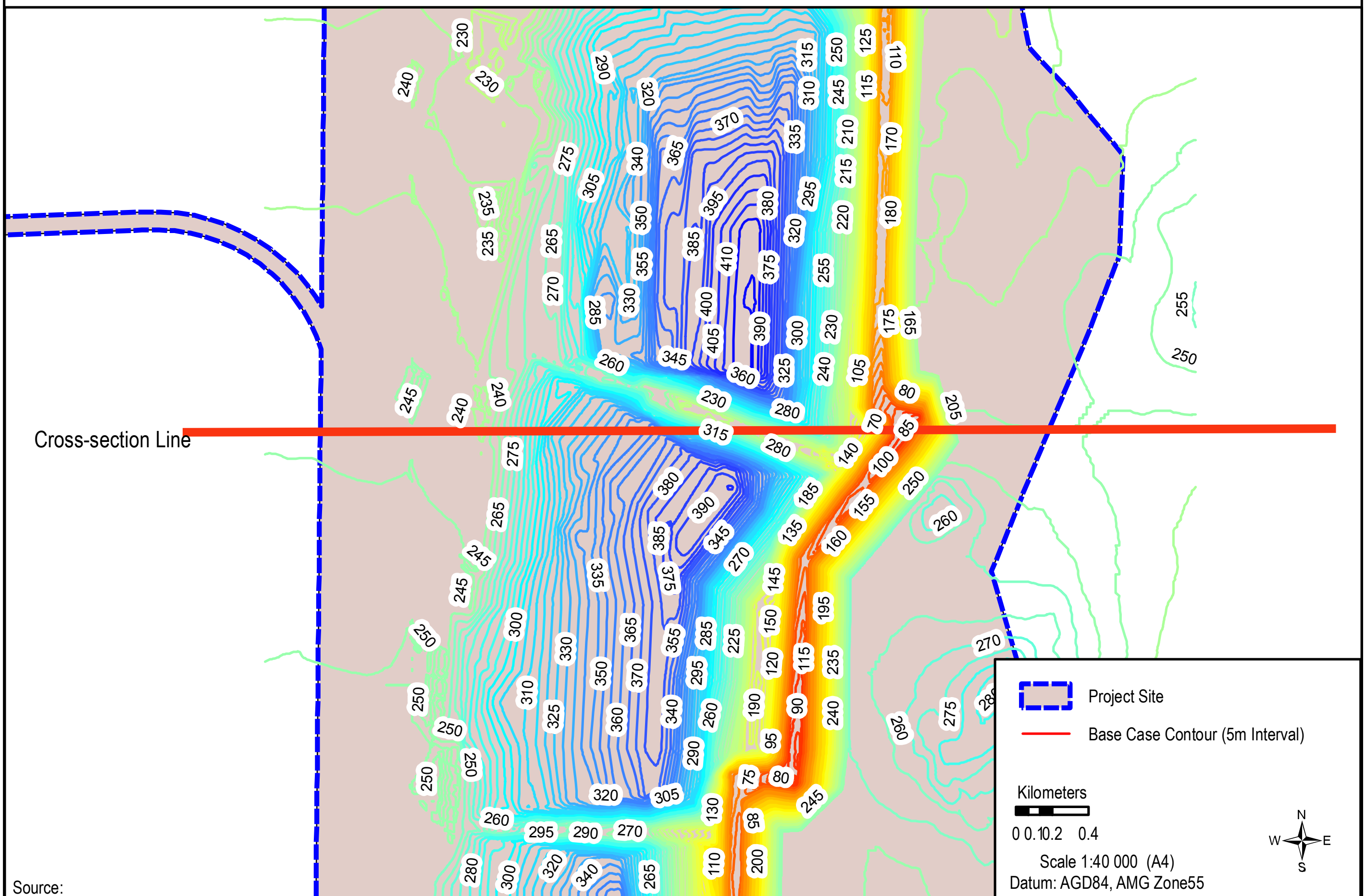




| Client | Project | Title |
|---|---|---|
| BMA BHP Billiton Mitsubishi Alliance / URS | CAVAL RIDGE PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT LONG TERM VOID WATER STORAGE AND QUALITY | **25% CASE AND CROSS SECTION** |

| Drawn: MG | Approved: MST | Date: 22-09-2009 | Figure: **B5** | Rev. A |
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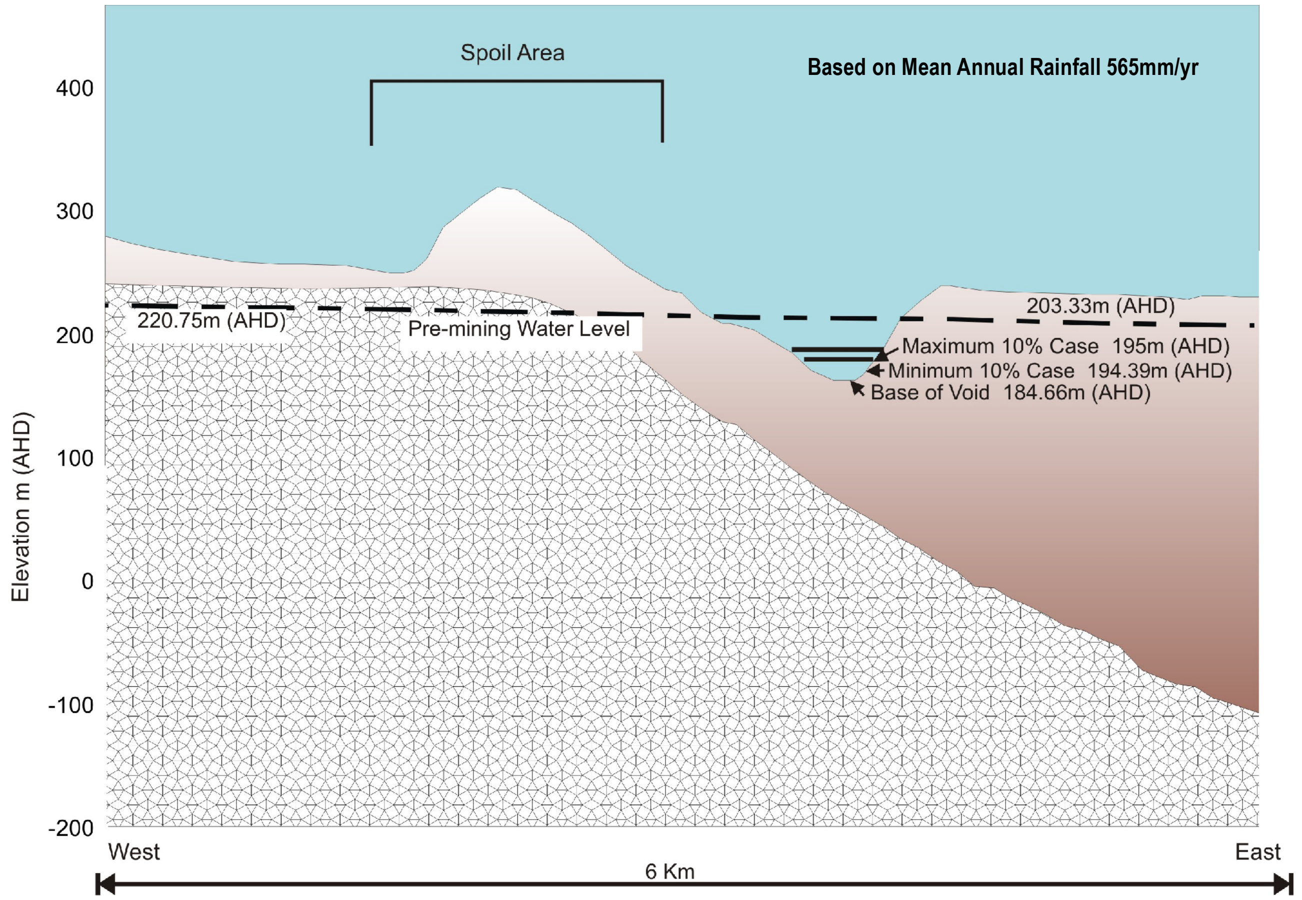


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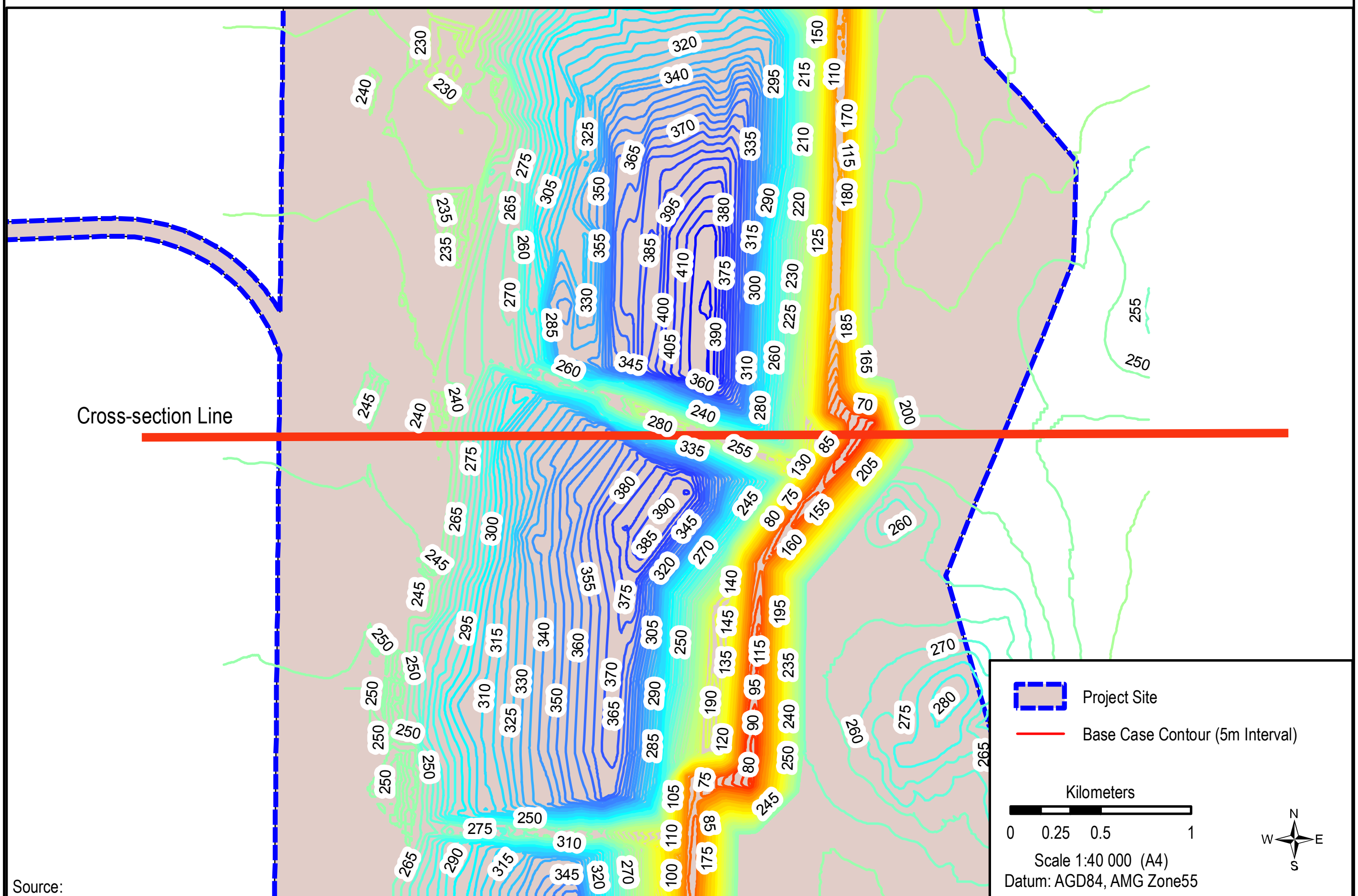




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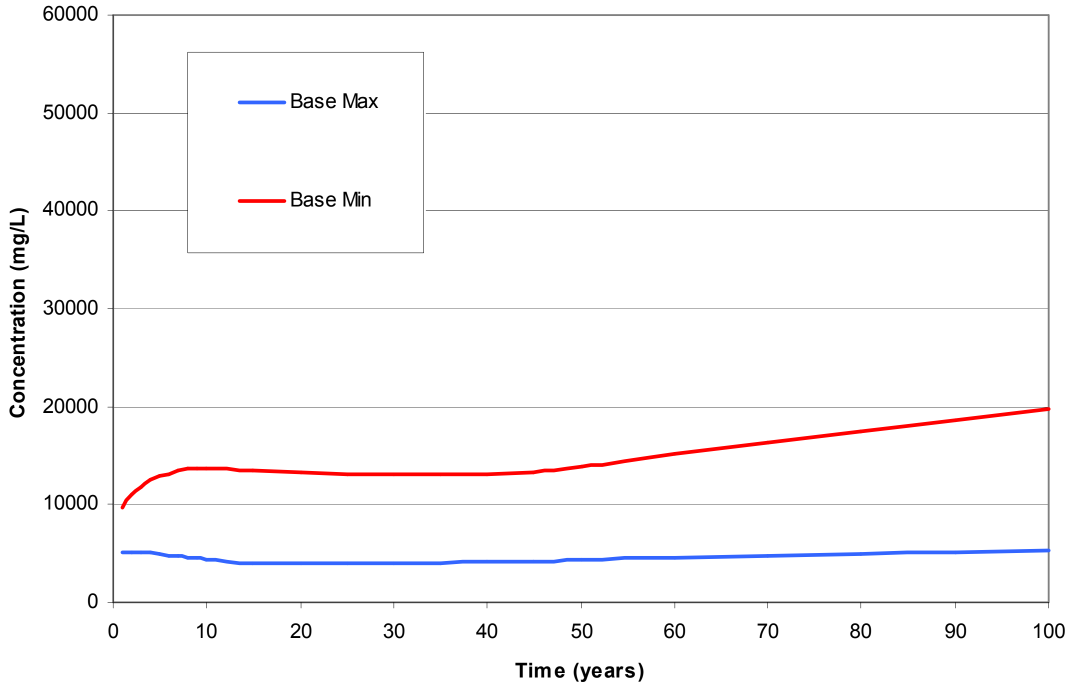
| URS | Drawn: MG / Approved: MST / Date: 22-09-2009 | Figure: **B6** / Rev. A |
| | Job No: **4262 6420**/6158 / File No.: 42626158-g-1514.mxd | A4 |

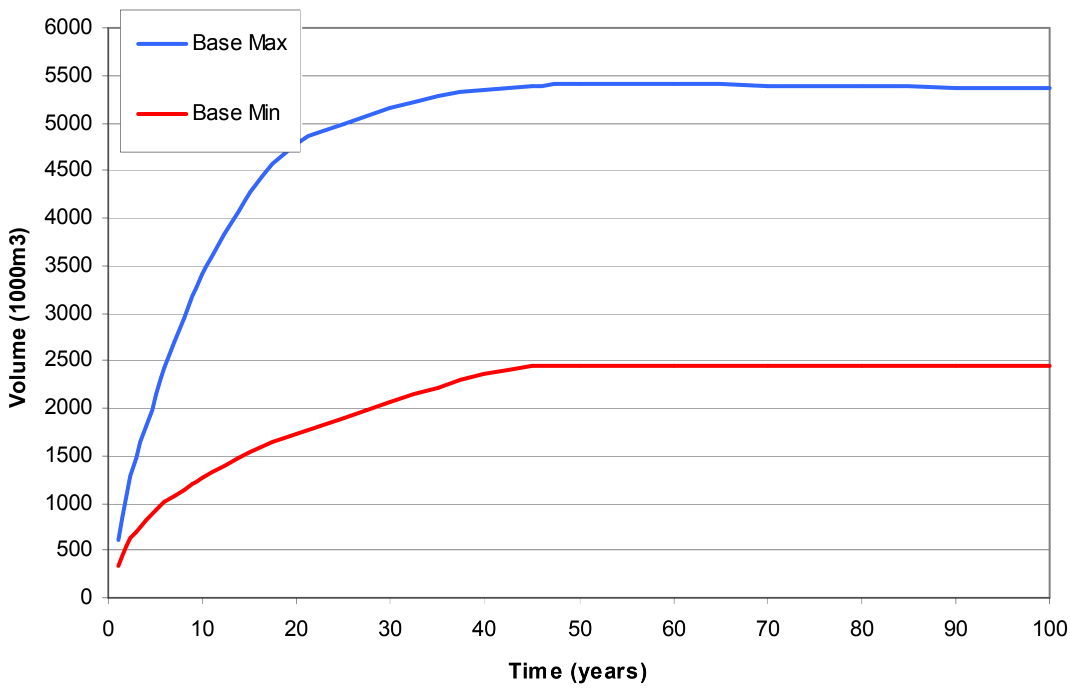
# Appendix C Salt balance and Void Volumes figures

## Appendix C

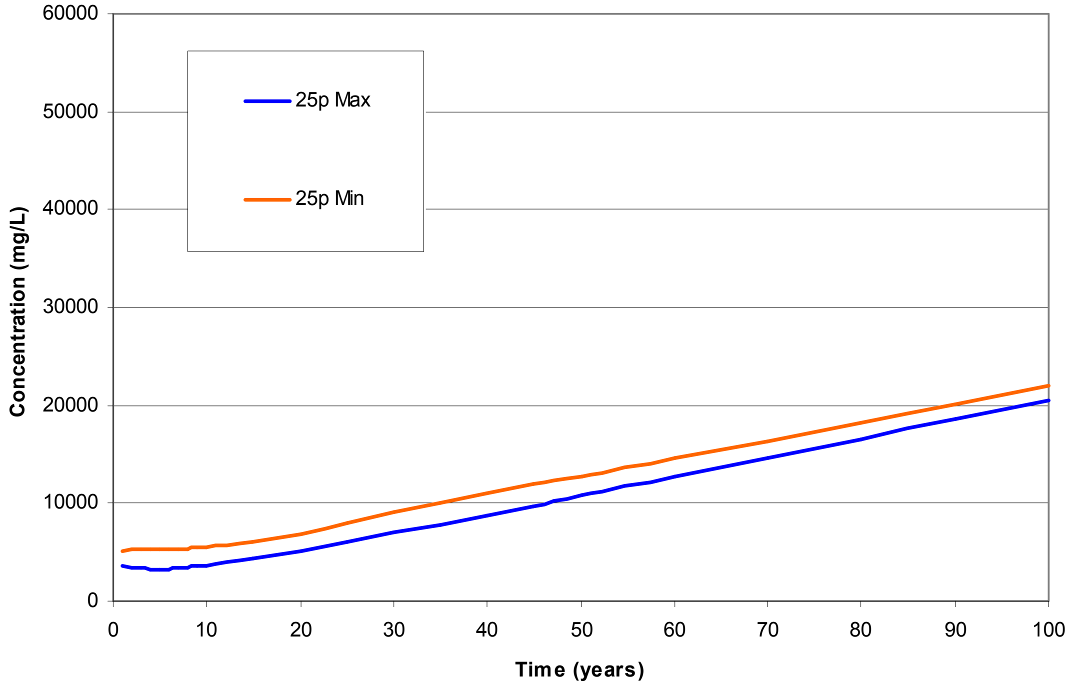
C1 Base case average rainfall salt accumulation



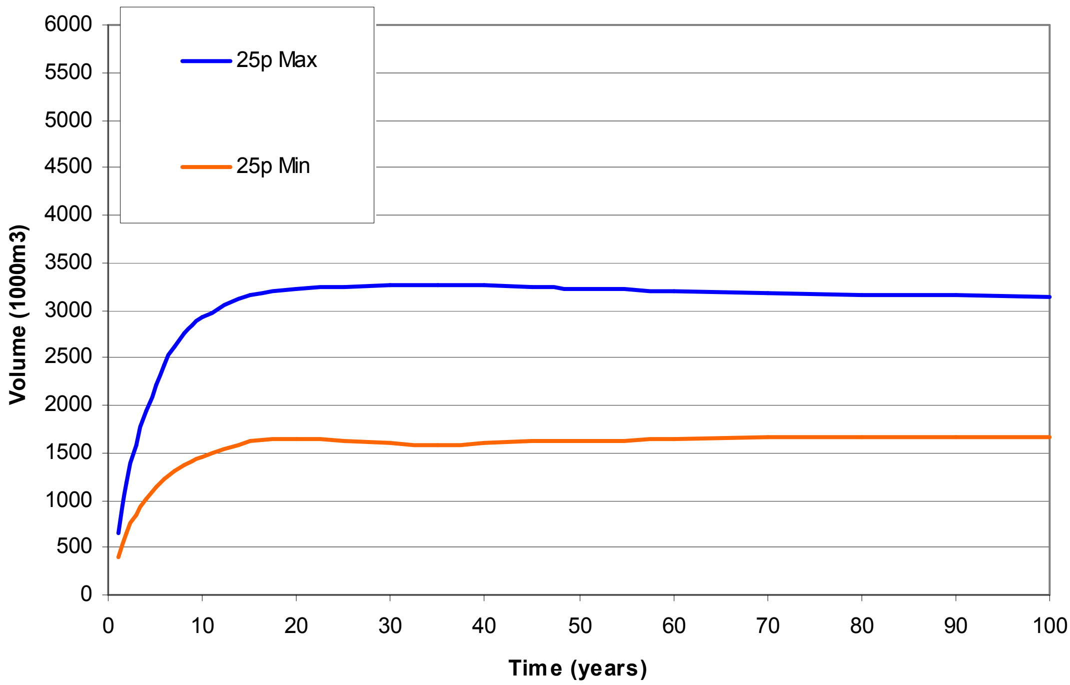

C2 Base case average rainfall estimated volumes



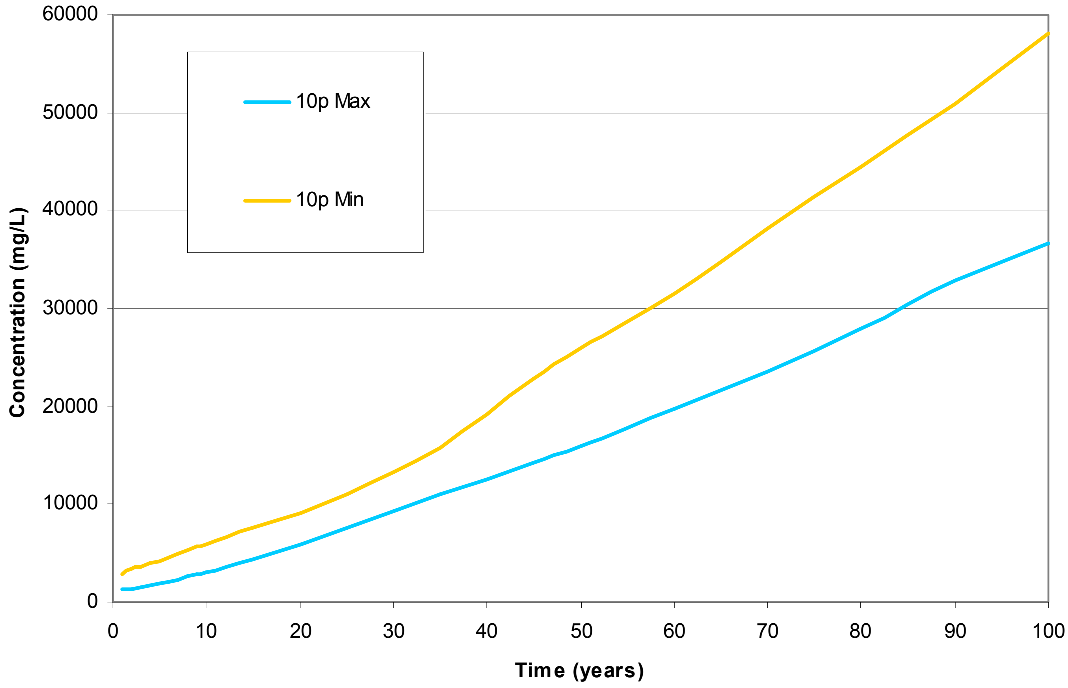
C3 25p average rainfall salt accumulation



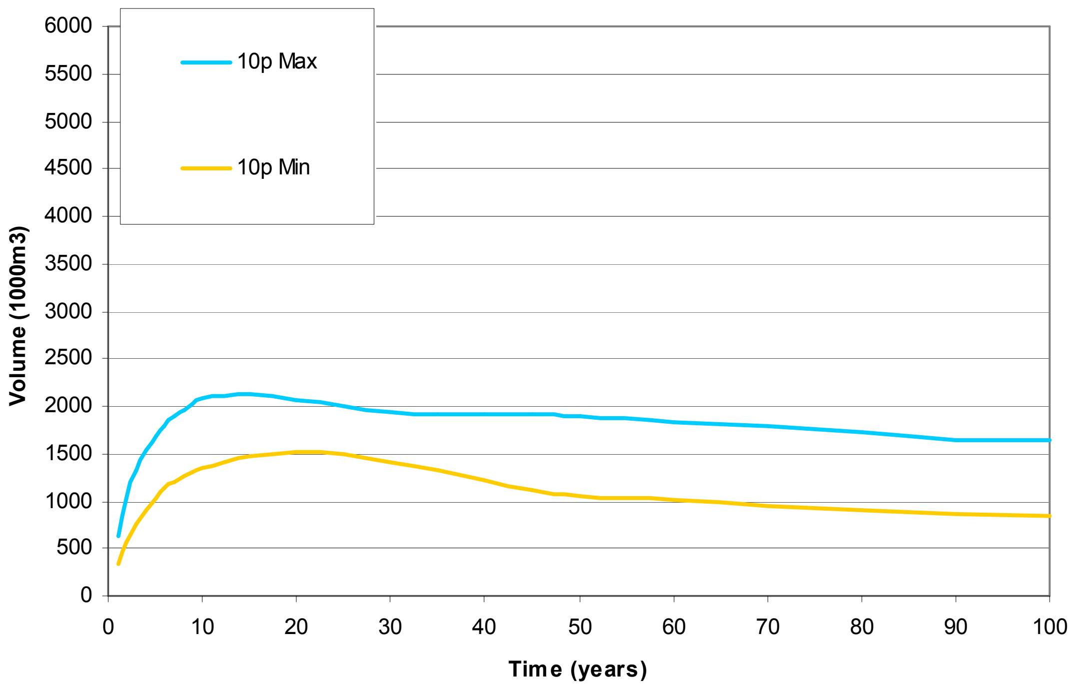

C4 25p average rainfall estimated volumes



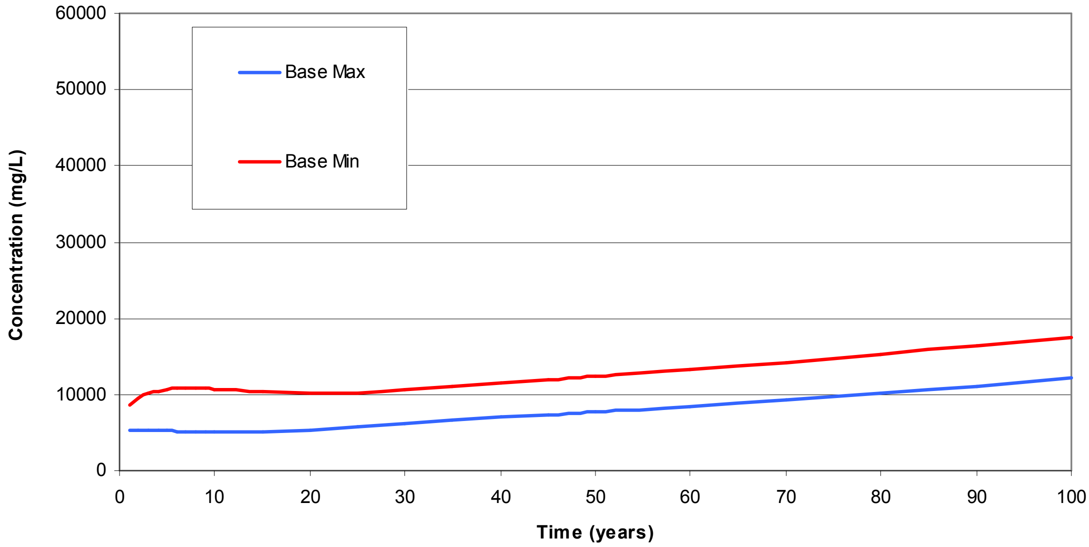
C5 10p average rainfall salt accumulation



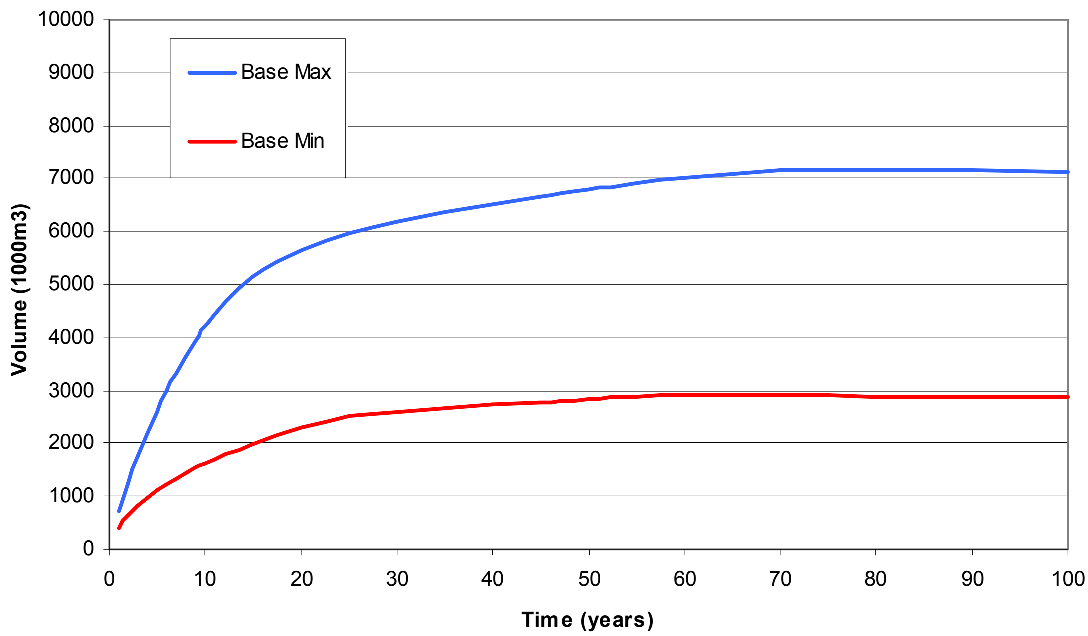

C6 10p average rainfall estimated volumes



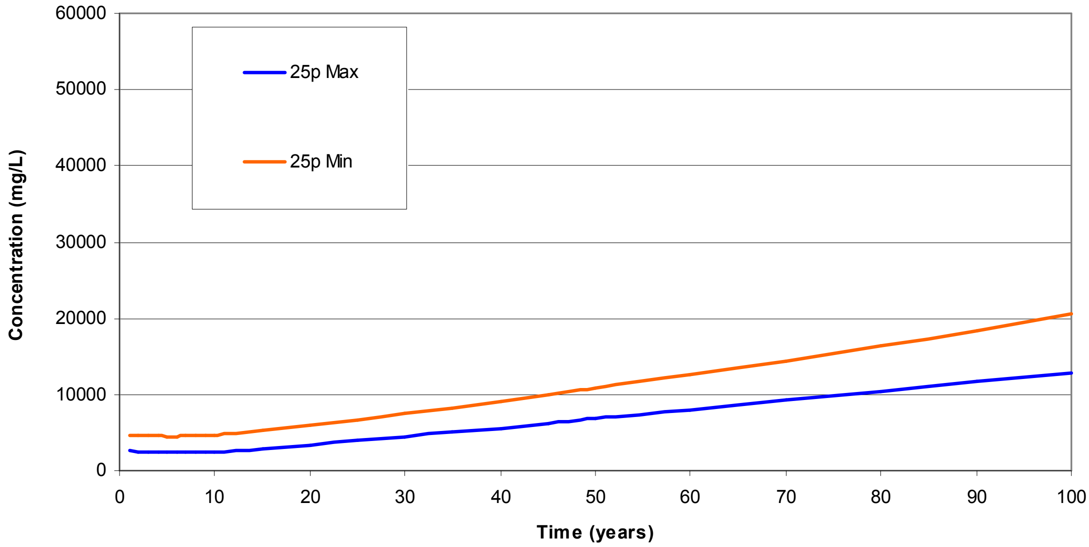
C7 Base case average rainfall +10% salt accumulation



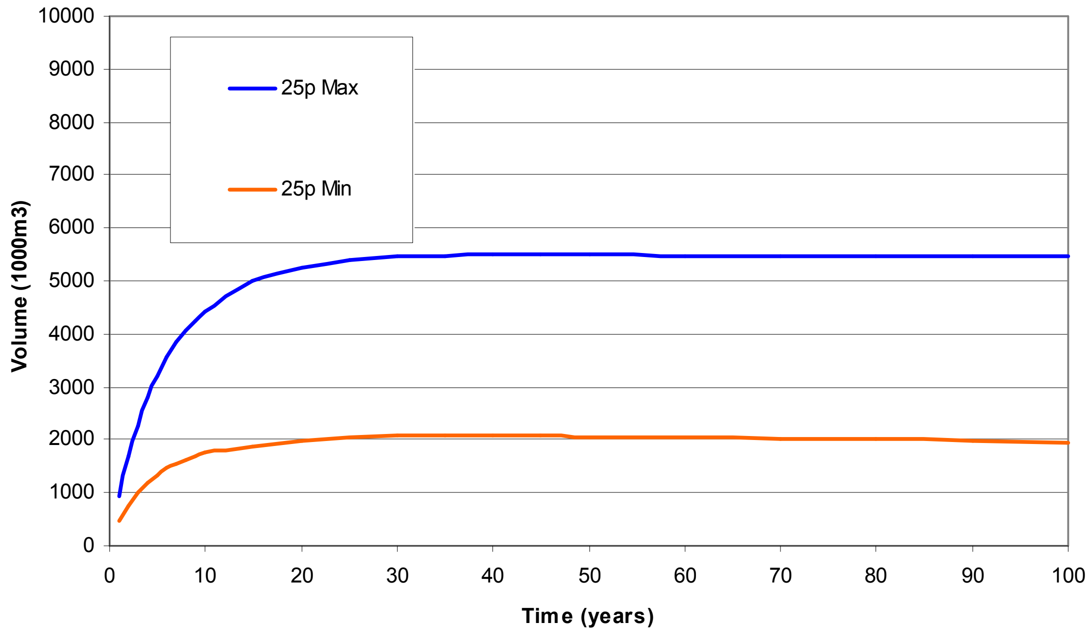

C8 Base case average rainfall +10% estimated volumes



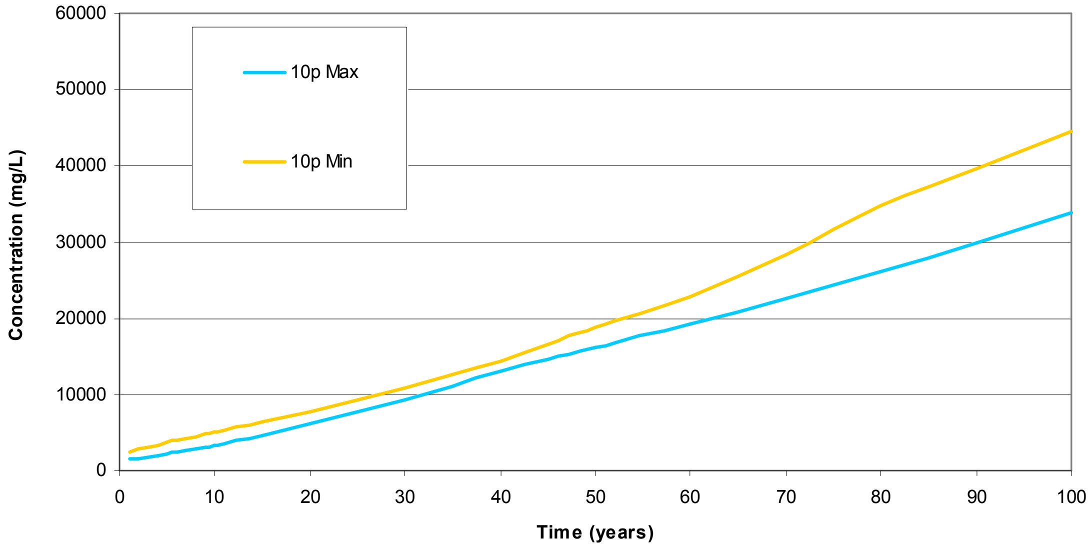
C9 25p average rainfall +10% salt accumulation



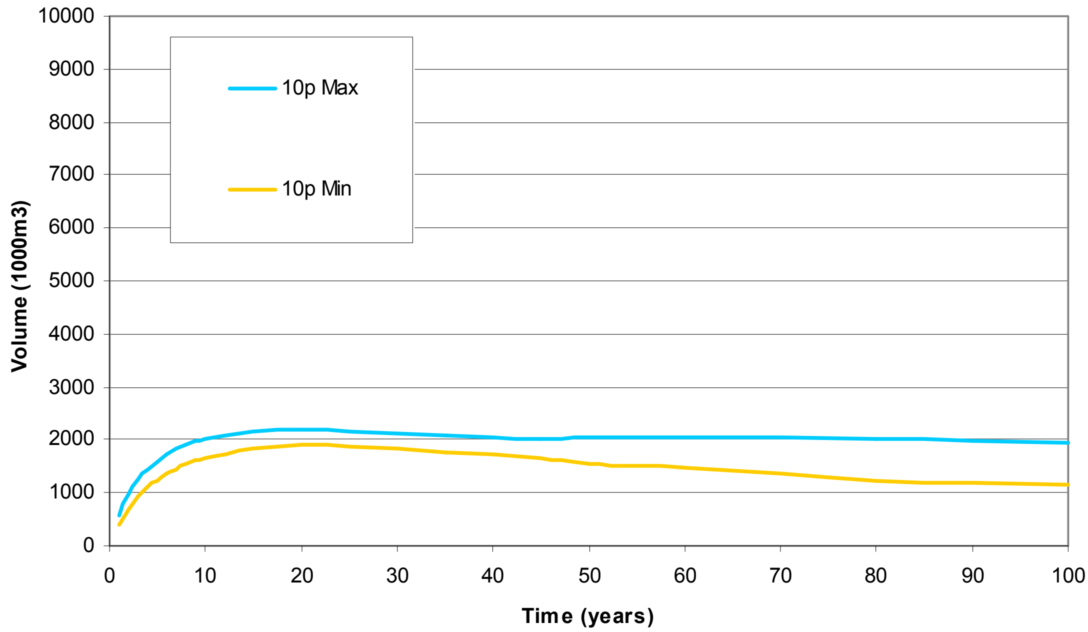

C10 25p average rainfall +10% estimated volumes



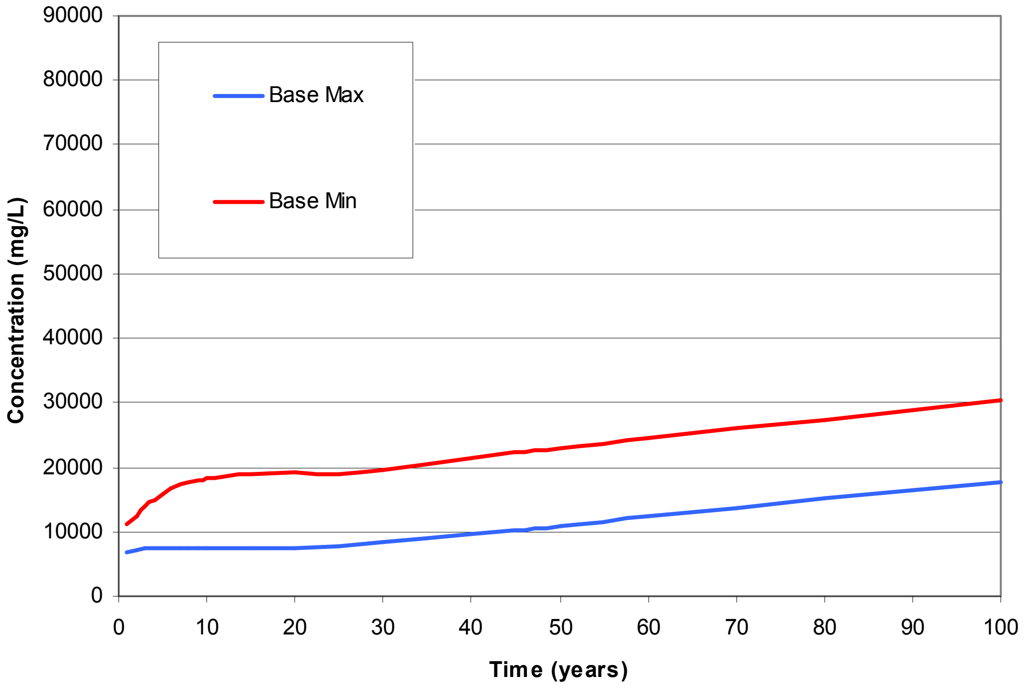
C11 10p average rainfall +10% salt accumulation



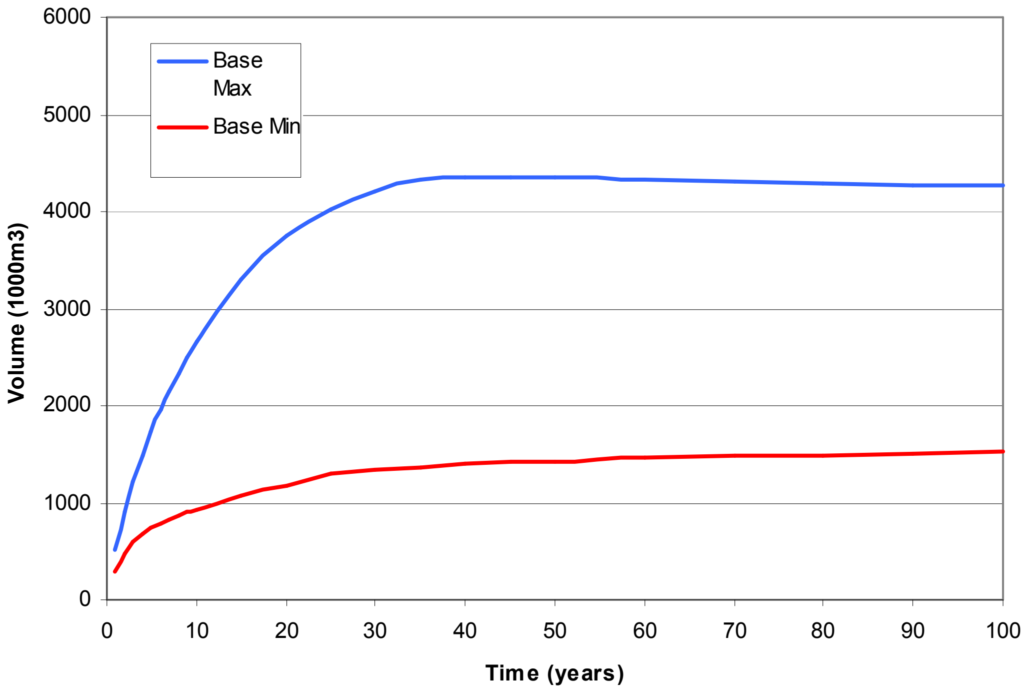

C12 10p average rainfall +10% estimated volumes



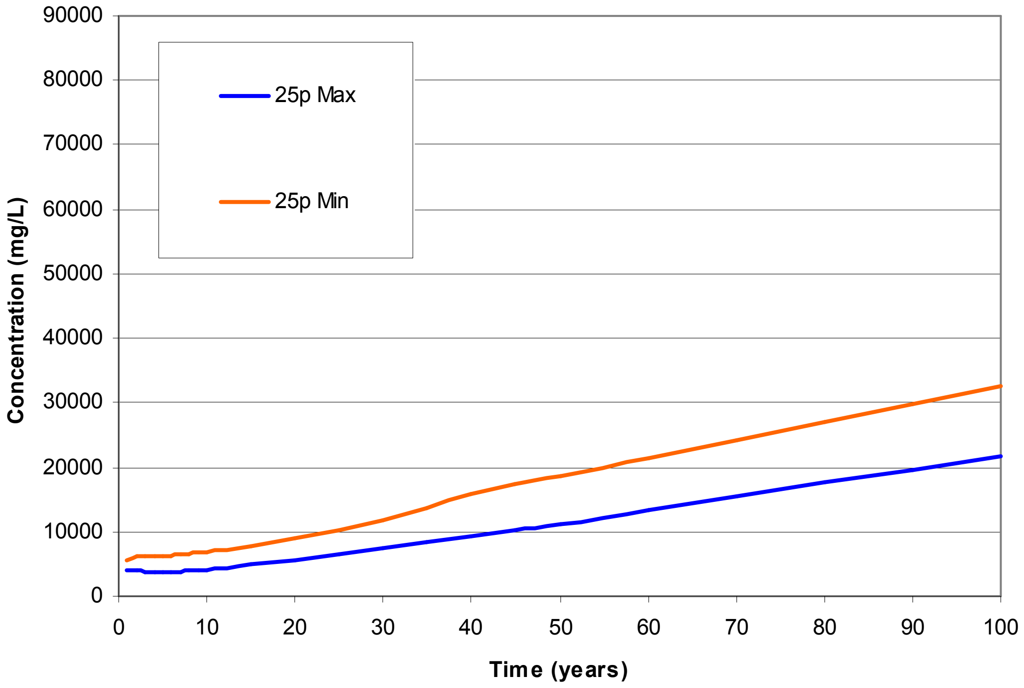
C13 Base case average rainfall -10% salt accumulation



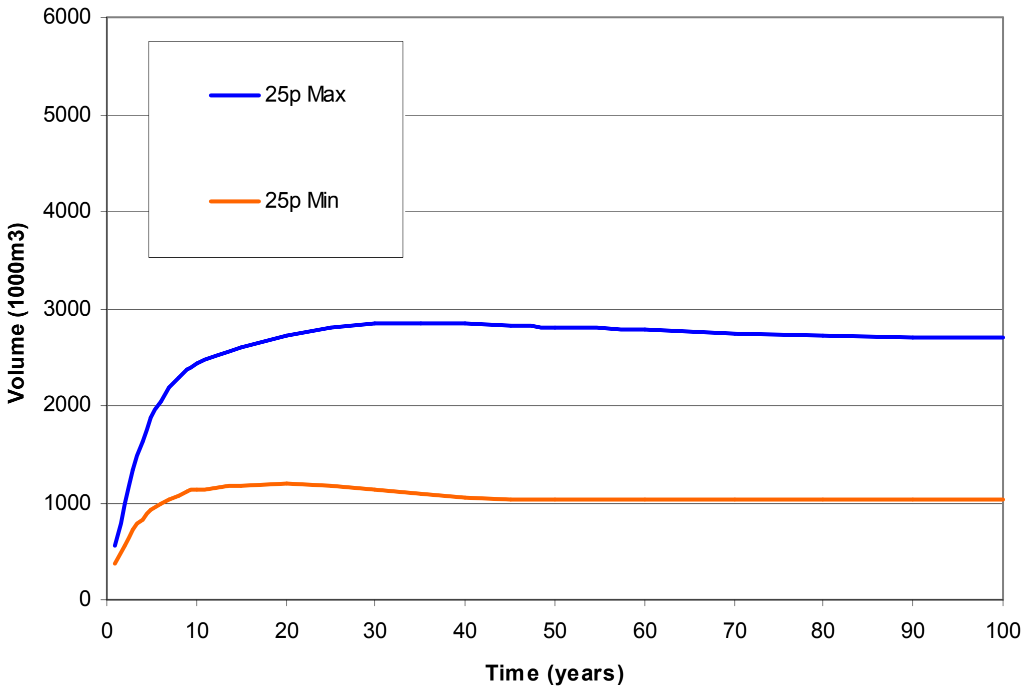

C14 Base case average rainfall -10% estimated volumes



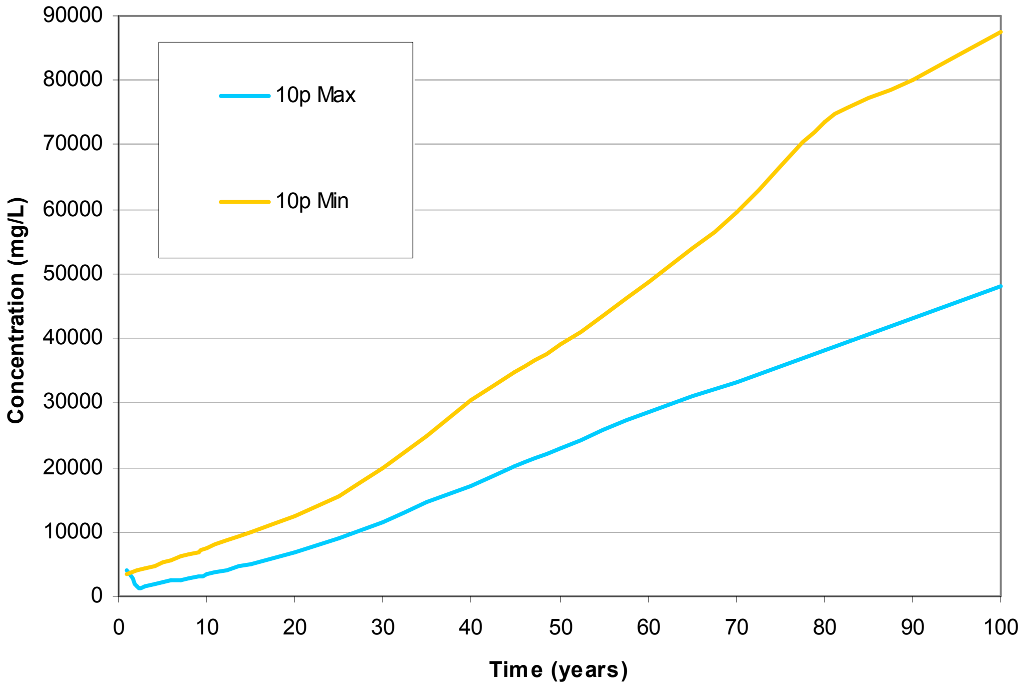
C15 25p average rainfall -10% salt accumulation



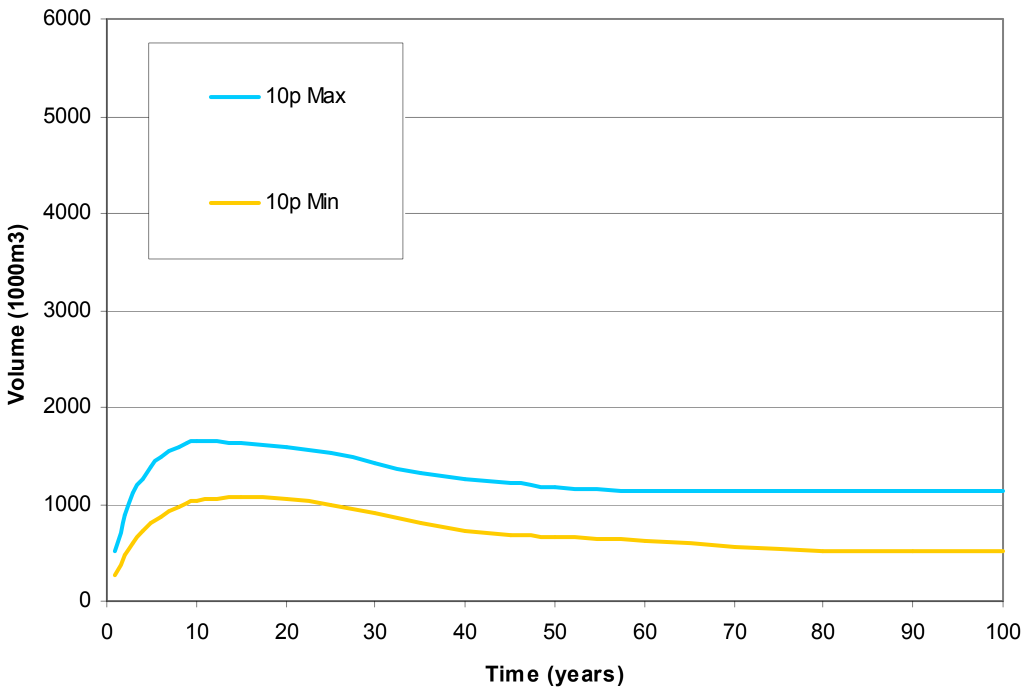

C16 25p average rainfall -10% estimated volumes



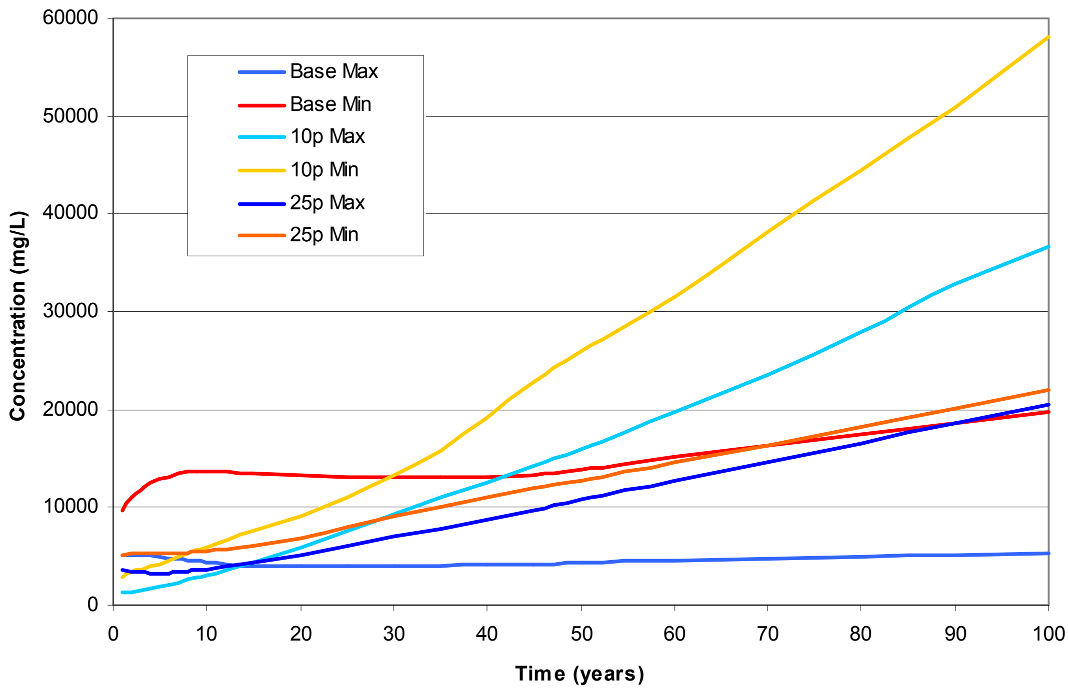
C17 10p average rainfall -10% salt accumulation



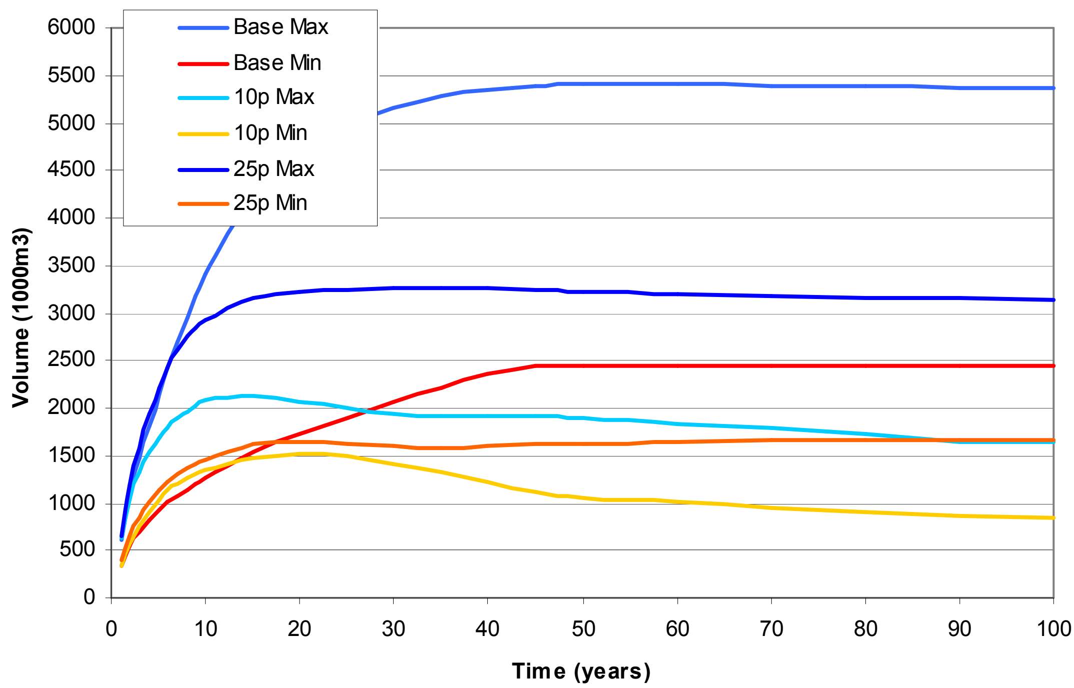

C16 10p average rainfall -10% estimated volumes



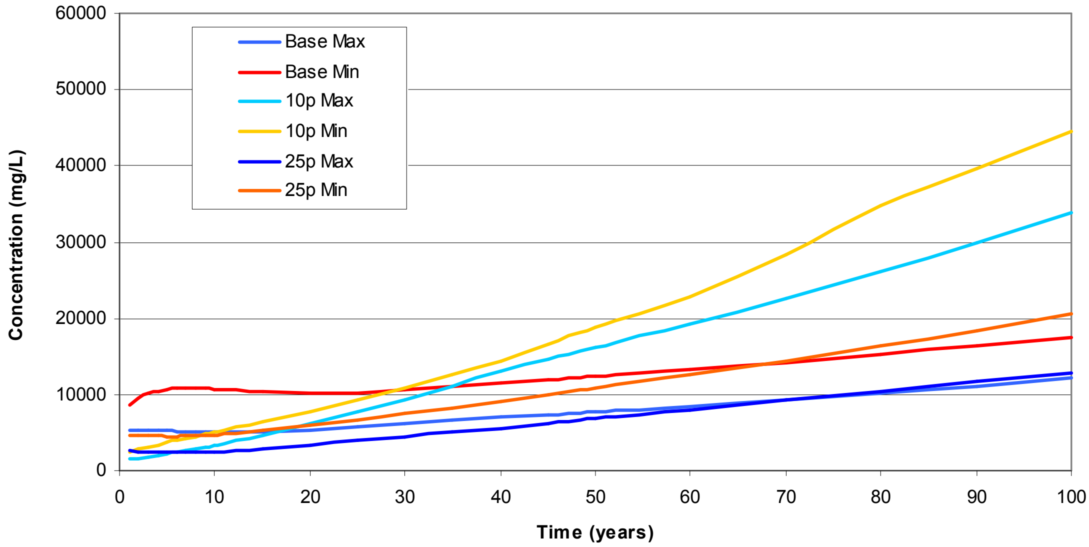
C17 Base case average rainfall salt accumulation (combined)



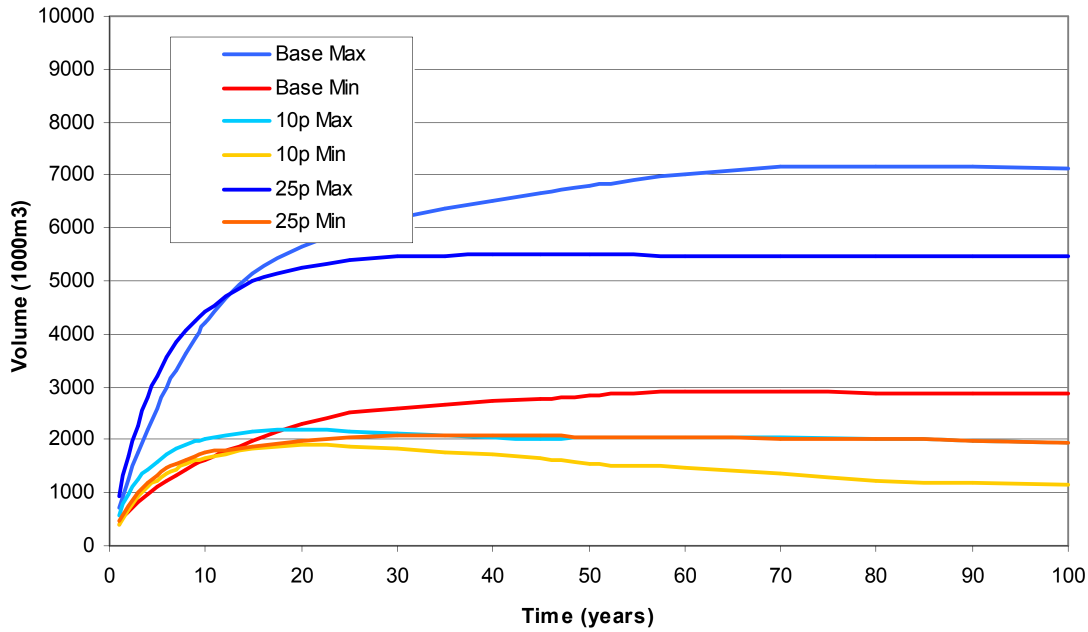

C18 Base case average rainfall estimated volumes (combined)



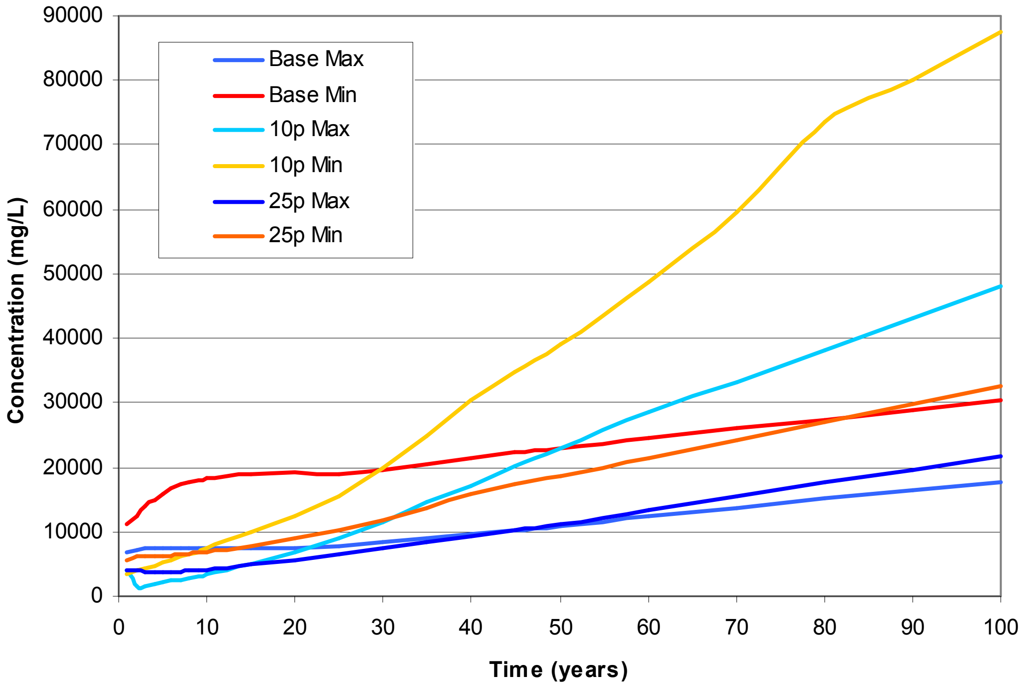
C19 Base case average rainfall +10% salt accumulation (combined)



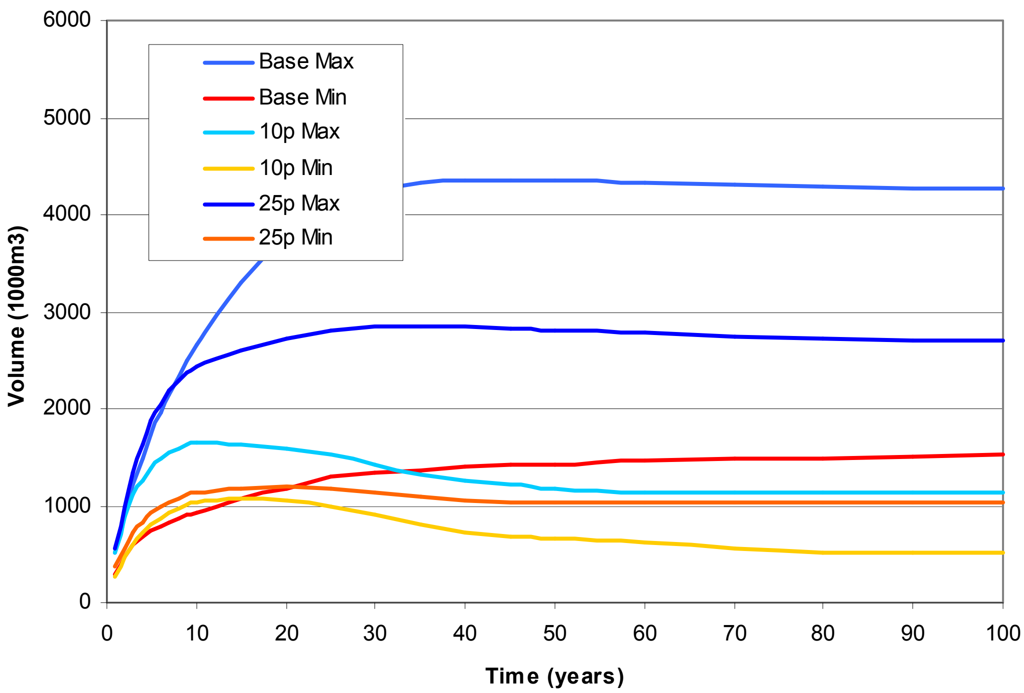

C20 Base case average rainfall +10% estimated volumes (combined)



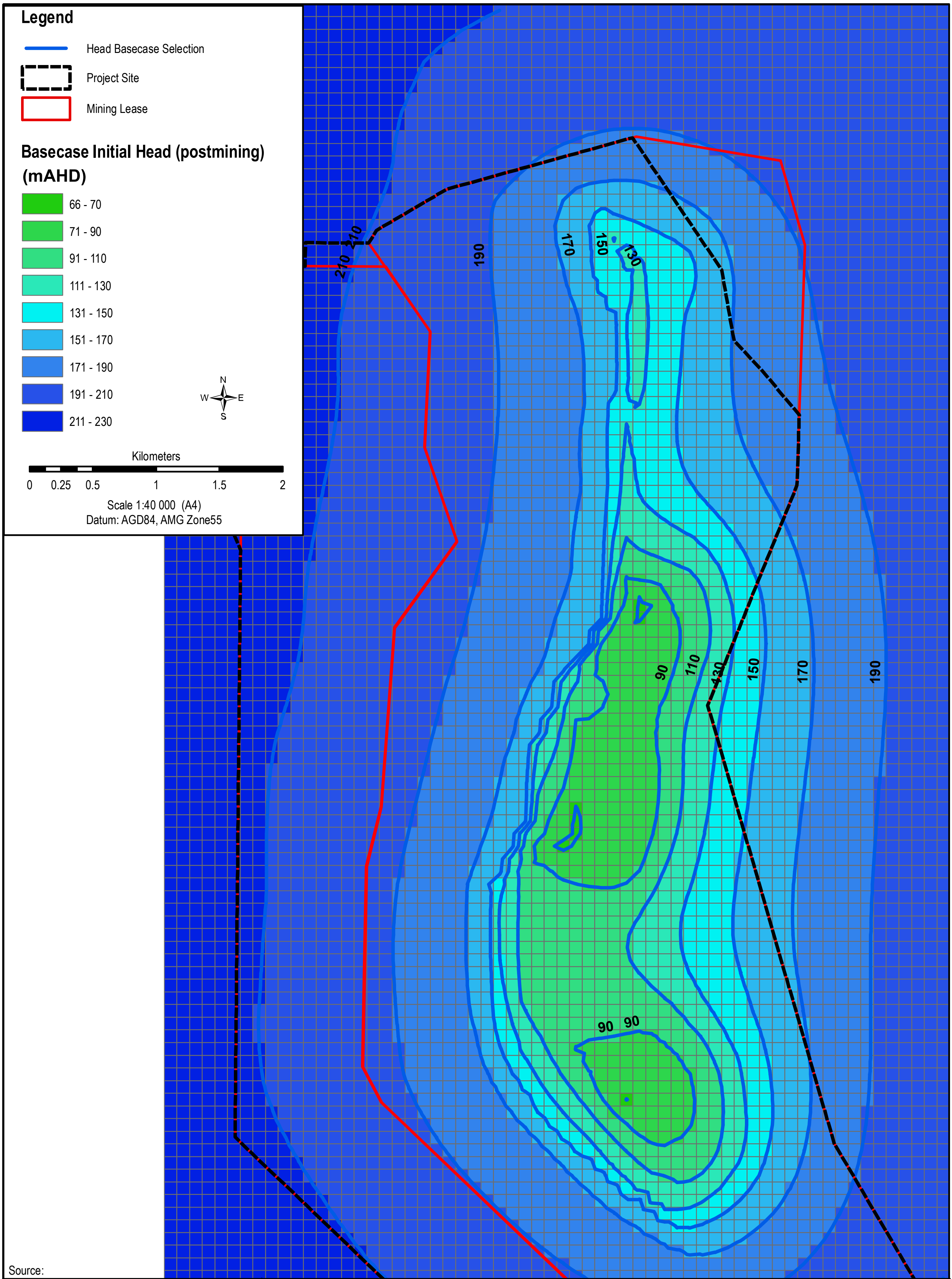
C21 Base case average rainfall -10% salt accumulation (combined)




C22 Base case average rainfall -10% estimated volumes (combined)



# Appendix D Drawdown cone predictions

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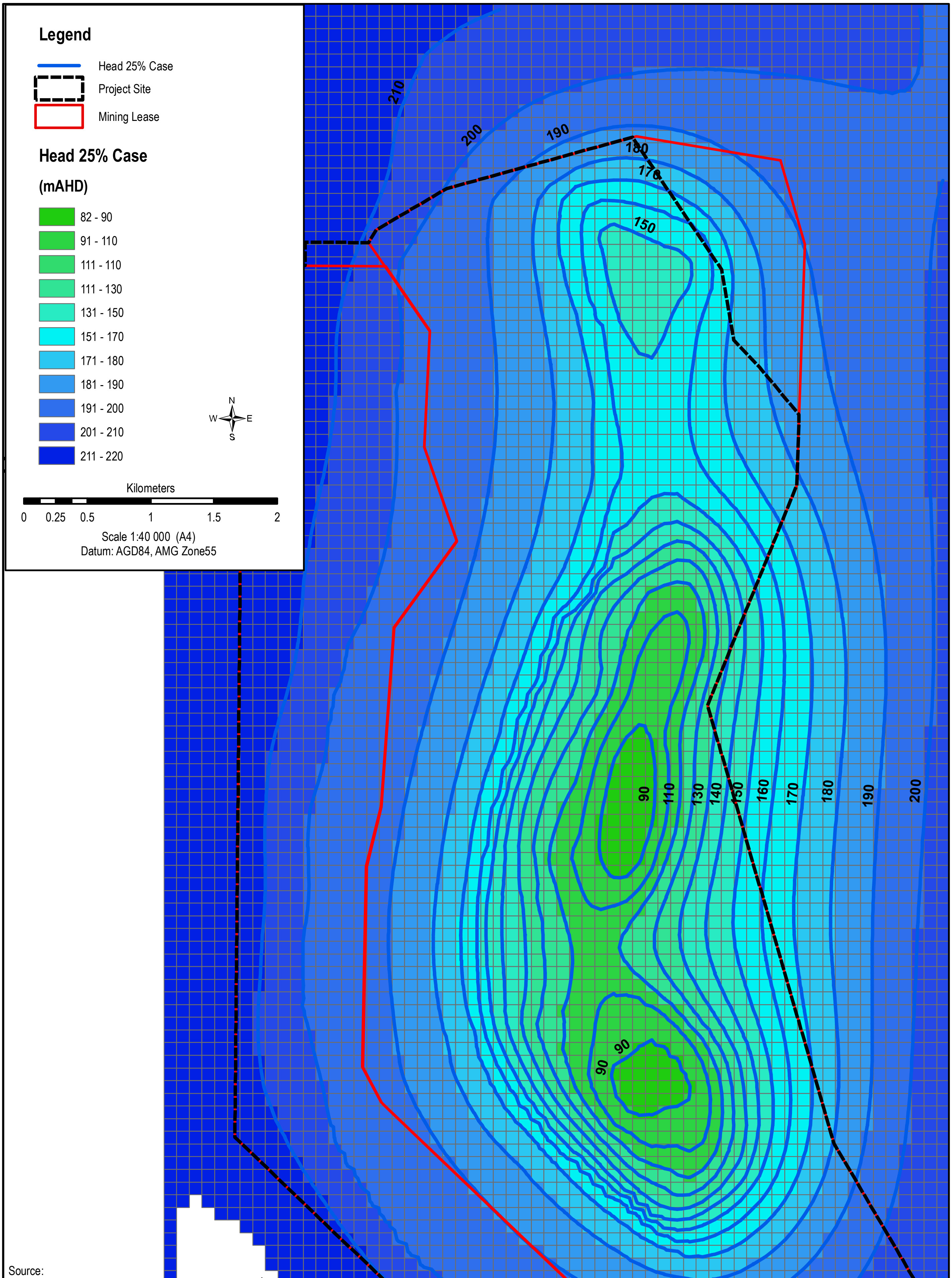
| BMA BHP Billiton Mitsubishi Alliance | CAVAL RIDGE PROJECT<br>ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT<br>LONG TERM VOID WATER STORAGE AND QUALITY | **DRAWDOWN SIMULATION (BASE CASE) AT EQUILIBRIUM (~40YRS)** |
| URS | Drawn: VE · Approved: MST · Date: 22-09-2009 | Figure: **D1** · Rev. A |
| | Job No: **4262 6420**/6158 · File No.: 42626158-g-1515.mxd | A4 |

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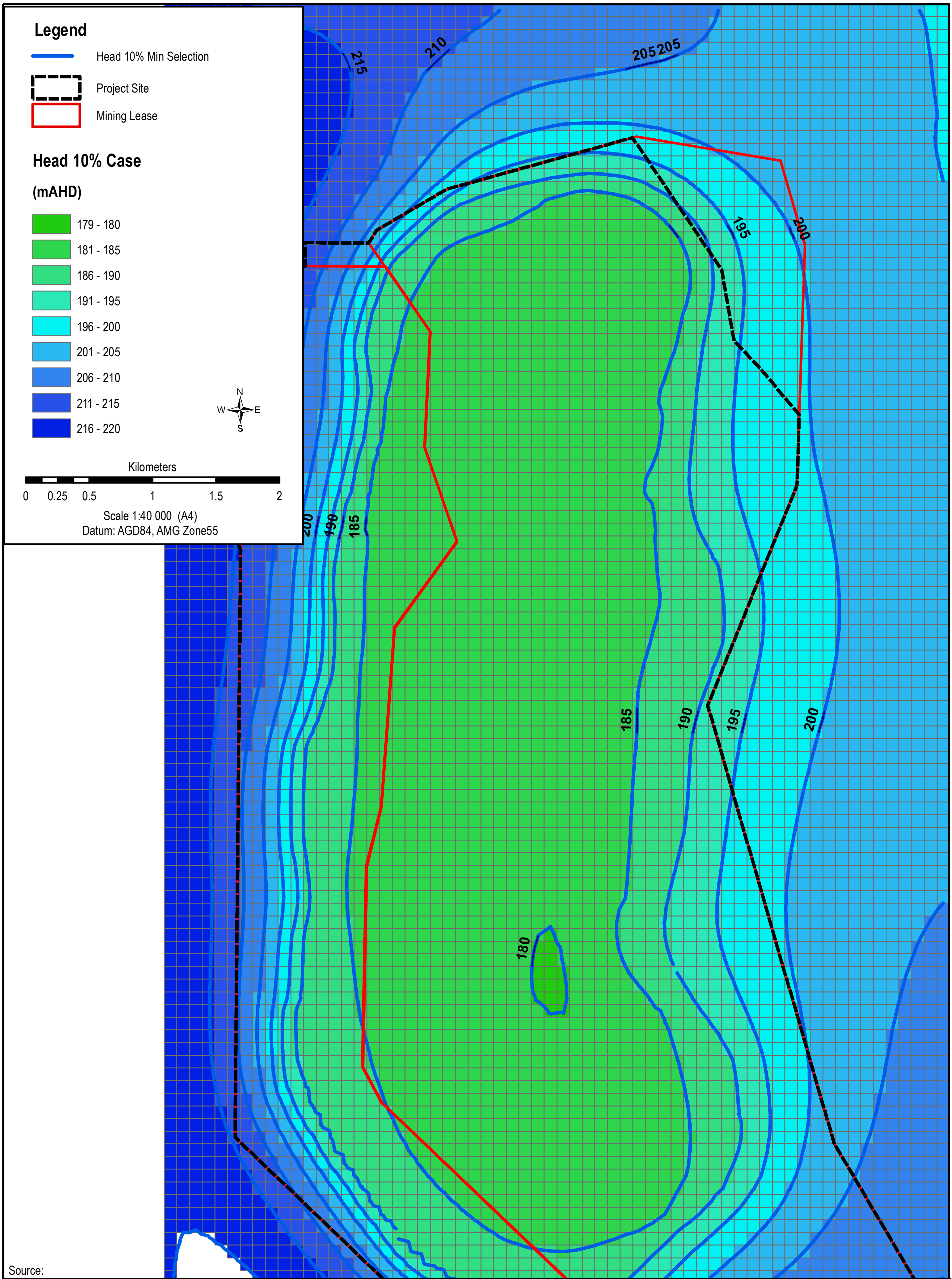
| URS | Drawn: VE · Approved: MST · Date: 22-09-2009 | Figure: D2 · Rev. A |
| | Job No: 4262 6420/6158 · File No.: 42626158-g-1516.mxd | A4 |






| Client | Project | Title |
|---|---|---|
| BMA BHP Billiton Mitsubishi Alliance / URS | CAVAL RIDGE PROJECT ENVIRONMENTAL IMPACT STATEMENT SUPPLEMENT LONG TERM VOID WATER STORAGE AND QUALITY | **DRAWDOWN SIMULATION (10 PERCENT REGRADE CASE) AT EQUILIBRIUM (~40YRS)** |
| | Drawn: VE / Approved: MST / Date: 22-09-2009 | Figure: **D3** / Rev. A |
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