



Integra Coal Operations Pty Ltd

ABN: 96 118 030 998

Glennies Creek Open Cut Coal Mine

Surface Water Assessment

Prepared by

PSM Australia Pty Ltd

October, 2007

**Specialist Consultant Studies Compendium:
Part 7**

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Surface Water Assessment

of the

Glennies Creek Open Cut Coal Mine

Prepared for: R.W. Corkery & Co. Pty. Limited
75 Kite Street
PO Box 80
ORANGE NSW 2800

On behalf of: Integra Coal Operations Pty Ltd
PMB 7
SINGLETON NSW 2330

Prepared by: PSM Australia Pty Ltd
175 Sunrise Drive
OCEAN VIEW QLD 4521

Tel: 07 3425 3600
Fax: 07 3425 3700
Email: wjcm@psm.com.au

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EXECUTIVE SUMMARY

The proposed Glennies Creek Open Cut development would involve the extraction of up to 7.7Mt of coal at a maximum extraction rate of 1.5Mt for a period of at least 6 years. The disturbed areas, for water management, cover approximately 1.9km². The Open Cut Project Area, that is those areas of the Project Site that would be disturbed by open cut mining, is within the Glennies Creek catchment which has an area of 512km². Glennies Creek joins the Hunter River at Maison Dieu. The Hunter River Catchment above the junction with Glennies Creek has an area of 14 500km².

The regional surface water environment is discussed and pertinent hydrometeorological data on quantity and quality presented.

The likely surface water impacts of the proposal include:

- a reduction in surface water runoff from the disturbed areas of the Project Site to Glennies Creek for a period of less than 10 years; and
- permanent removal of water that percolates to ground water within the disturbed areas.

The Integrated Dirty Water Management System is designed to:

- ensure total containment up to a prescribed ARI;
- prevent flooding of the portal;

and within these constraints:

- provide a reliable water supply for mining-related purposes.

Dirty water management for the proposed open cut may be incorporated into the existing Integrated Dirty Water Management System. The Camberwell North Pit sump is the lowest point in the system and the repository for net dirty water. Sump levels have been drawn down approximately 11m since September 2003. With conservative assumptions and export of 800m³/d to other mines it has been shown the Camberwell North Pit sump can be drawn down to any required level. Contracts and facilities are in place for assured export of up to 1 400m³/d with contracts for further increases to 3 900m³/d with the proposed new open cut in place, a sump maximum operating level of 39m AHD is recommended.

The substantial storage available within the Camberwell North Pit waste rock emplacement and sump provides for dirty water storage up to about an ARI 50a rainfall event without disruption to the operation of the Glennies Creek Underground Coal Mine, the Camberwell South Pit or the proposed open cut. For more extreme events, either the Camberwell South Pit or the proposed open cut will need to be used for temporary storage of dirty water.

Some runoff from the proposed new open cut waste emplacement is directed to Possum Skin Dam and the maximum filling level reduced to 87.5m AHD to accommodate this.

Existing electrical conductivities (a measurement of the salt concentrations) of the dirty water circuit vary between 6 000 and 14 000 $\mu\text{S}/\text{cm}$. Little change is anticipated as a result of the addition of the proposed open cut coal mine.

As part of open cut mine closure the void would be backfilled and the waste rock emplacement revegetated with deep rooted species. Once rehabilitation is complete all surface runoff would ultimately report to natural drainage. Deep percolation would dissipate to regional groundwater and the portal sump in the Camberwell North pit. A high permeability flow path between the backfilled new open cut final void and the portal sump may be required to prevent the ultimate development of a surface seep at the low point in the north wall of the proposed new open cut. Deep percolation rates and pillar conductivity needs to be assessed toward the end of mining and enhanced by fracturing as required.

The existing Glennies Creek – Camberwell surface operation and the proposed new open cut footprint all lie within the groundwater drawdown cone associated with the Glennies Creek Underground mine. The expected life of the underground operation is much longer than that of the proposed new open cut and its impacts overlie and outlast those of the proposed new open cut.

The Director General's specific requirements are addressed and a monitoring program recommended.

A conservative analysis has been undertaken which bias outcomes in favour of total containment of 'salty', dirty water under very wet conditions at the expense of water supply under drought conditions. Portal sump and Possum Skin Dam recommended operating levels should be reviewed as soon as adequate data is available from the monitoring program.

1 INTRODUCTION

1.1 Scope

This report has been prepared on behalf of Integra Coal Operations Pty Ltd (ICO) for the proposed Glennies Creek Open Cut Coal Mine (“the Project”). The proposed mine would be located within a 376ha Project Site, approximately 12km north of Singleton (**Figure 1**). The principal objectives of this report are to provide guidance to ICO on the most appropriate way in which to manage surface water and to examine the likely impacts of the Project on the surface water resources within and surrounding the Project Site.

The key potential surface water impacts arising from the Project would be increased surface water sediment and salinity concentrations, together with changes in stream flow and surface water runoff patterns downstream of the Project Site. These potential impacts are addressed in detail in this report.

1.2 Report Format

This report is structured as follows.

- Section 1 – defines the scope and format of this report.
- Section 2 – provides a brief overview of the Project with emphasis upon matters of importance for designing surface water controls and for assessing the surface water impacts of the Project.
- Section 3 – describes the regional and local drainage, runoff and water quality environment, as well as the available rainfall, evaporation and climatic data for the Project Site and surrounds.
- Section 4 – outlines the predicted site water balance, including an overview of the existing and proposed Camberwell and Glennies Creek Colliery integrated water management system, methods used to estimate the site water balance and a summary of the system inputs and outputs. The section concludes with an assessment of the anticipated surface water balance, ie. whether there is likely to be a surface water surplus or deficit during the operation of the open cut coal mine.
- Section 5 - explores the dirty water circuit salt balance.
- Section 6 - provides the analysis associated with the final void and its ultimate infilling.

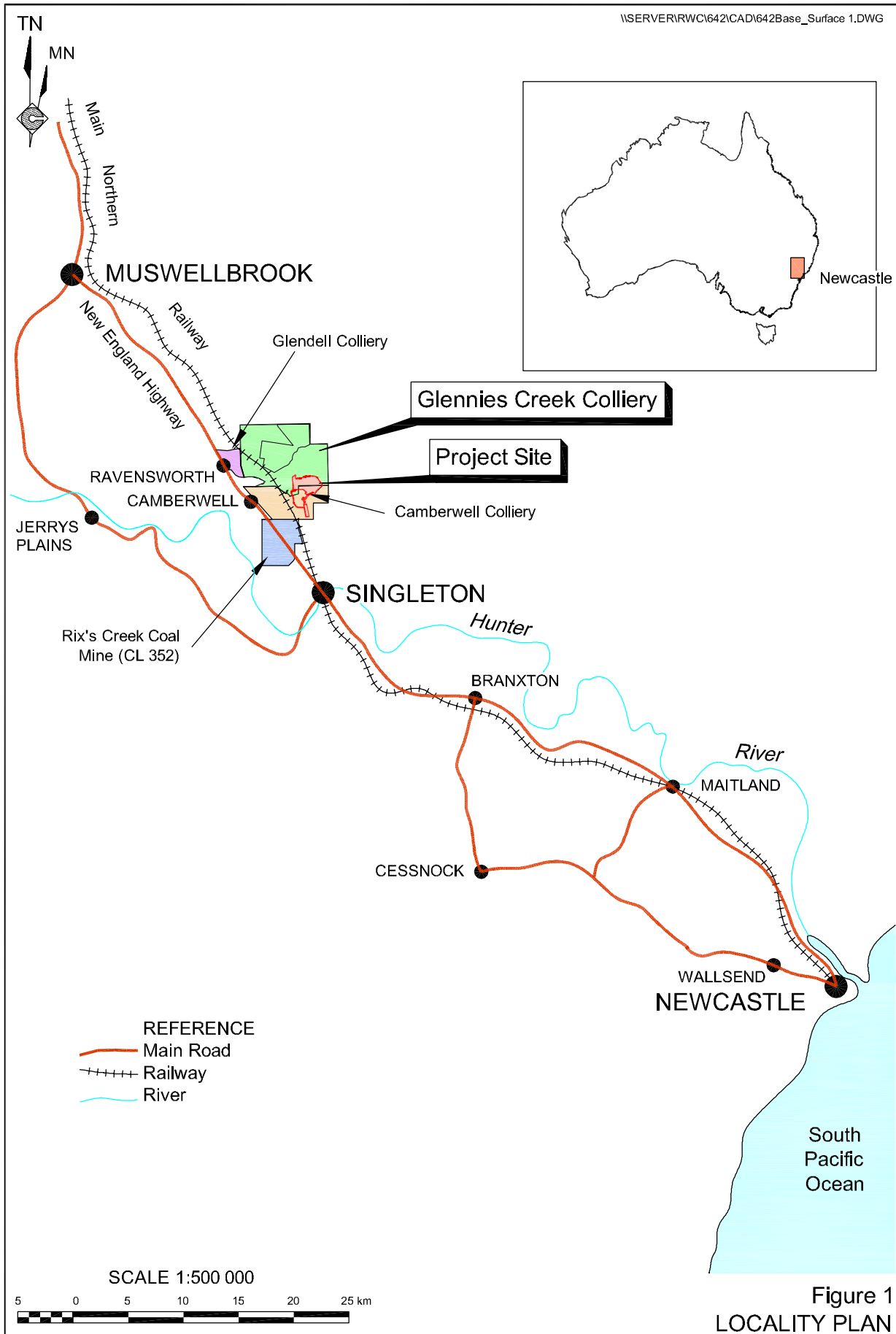


Figure 1
 LOCALITY PLAN

Note: A colour version of this figure is available on the project CD

- Section 7 – details the proposed surface water design and operational safeguards, including the surface water structures and operating procedures.
- Section 8 – provides an assessment of the likely impacts of the Project on the quality and quantity of surface water flows in the vicinity of the Project Site, and within the broader Hunter River Catchment.
- Section 9 – describes the proposed surface water monitoring program.
- Section 10 – details the Director-General's requirements and the section(s) of this report where each requirement is addressed.
- Section 12 – records the references used during the preparation of this report.
- Section 12 – presents a glossary of the technical terms used throughout this report.

2 PROJECT OVERVIEW

2.1 Mine Layout and Operations

The Project would involve the following activities (**Figure 2**).

- Construction of a site access road off Middle Falbrook Road.
- Construction of the open cut facilities area (including transportable offices, a bathhouse, a crib room, a report room, first aid facilities and stores; as well as a workshop, lay-down areas, parking facilities and associated infrastructure).
- Construction of two Dirty Water Containment Dams to the east of the out-of-pit waste rock emplacement and associated dirty water catch drains and clean water diversion drains.
- Coal mining by open cut methods within a pit shell covering approximately 90ha (7.7Mt reserve). Within this area, drilling has identified three principal coal seams amenable to mining by open cut methods, namely the:
 - Middle / Lower Liddell;
 - Barrett; and
 - Hebden seams.
- Transportation of run-of-mine (ROM) coal to the Camberwell Coal Handling and Preparation Plant (CHPP) via a combination of internal haul routes A to E (see **Figure 2**).
- When required, stockpiling of ROM coal at a temporary ROM coal stockpile area located at the top of the active open cut ramp (see Part B6.2) or at the existing RL100 Stockpile Area, with subsequent transportation to the Camberwell CHPP (see **Figure 2**).

- Highwall / auger mining. During the course of the open cut mining, there may be opportunities to undertake mining from the northern highwall using either highwall or auger mining methods to extract additional coal. These methods of mining would result in underground extraction for a maximum length of approximately 300m from the base of the highwall (see **Figure 2**). The final distance would depend on the type of mining undertaken. Highwall or auger mining would not occur outside the Project Site boundaries, nor would not result in subsidence of the ground surface. The coal that would be extracted by this method would be in addition to the 7.7Mt to be extracted by open cut mining methods.
- Programmed placement of waste rock materials from the open cut. Initially this would be to an out-of-pit emplacement, with subsequent placement out-of-pit as well as to in-pit in areas where mining has been completed. The proposed out-of-pit emplacement would have a disturbance footprint of approximately 43ha (see **Figure 2**).
- Progressive establishment of surface water control structures, including two dirty water detention dams (**Figure 2**).
- Storage and washing of ROM coal and dispatch of product coal from the Camberwell CHPP.
- Progressive reshaping and rehabilitation of all areas of mining-related disturbance. Overall, the total disturbed area to be rehabilitated would be approximately 139ha.
- Implementing and maintaining comprehensive systems to manage noise, vibration, air quality, visibility, surface water, groundwater, flora, fauna and Aboriginal heritage issues.

A related activity to the coal mining, transportation and washing would be the provision of various offsets in response to the clearing of approximately 70ha of native vegetation, and approximately 57ha of previously rehabilitated areas. These offset strategies include the protection and enhancement of:

- 122ha of properties owned by the parties to the Integra Coal Joint Venture to the north of Stony Creek Road (Northern Biodiversity Offset Area); and
- approximately 18ha of the parties to the Integra Coal Joint Venture property on the southern side of Glennies Creek (Glennies Creek Biodiversity Offset Area).

2.2 Final Landform

At Project completion, the final landform within the Open Cut Project Area (**Figure 3**) would comprise a single rehabilitated waste rock emplacement that would consist partly of an in-pit and partly of an out-of-pit emplacement. This emplacement would abut and blend into the existing Camberwell Colliery waste rock emplacement. Surface water contour drains would be removed. A decision regarding removal of the dirty water containment dams would be made in

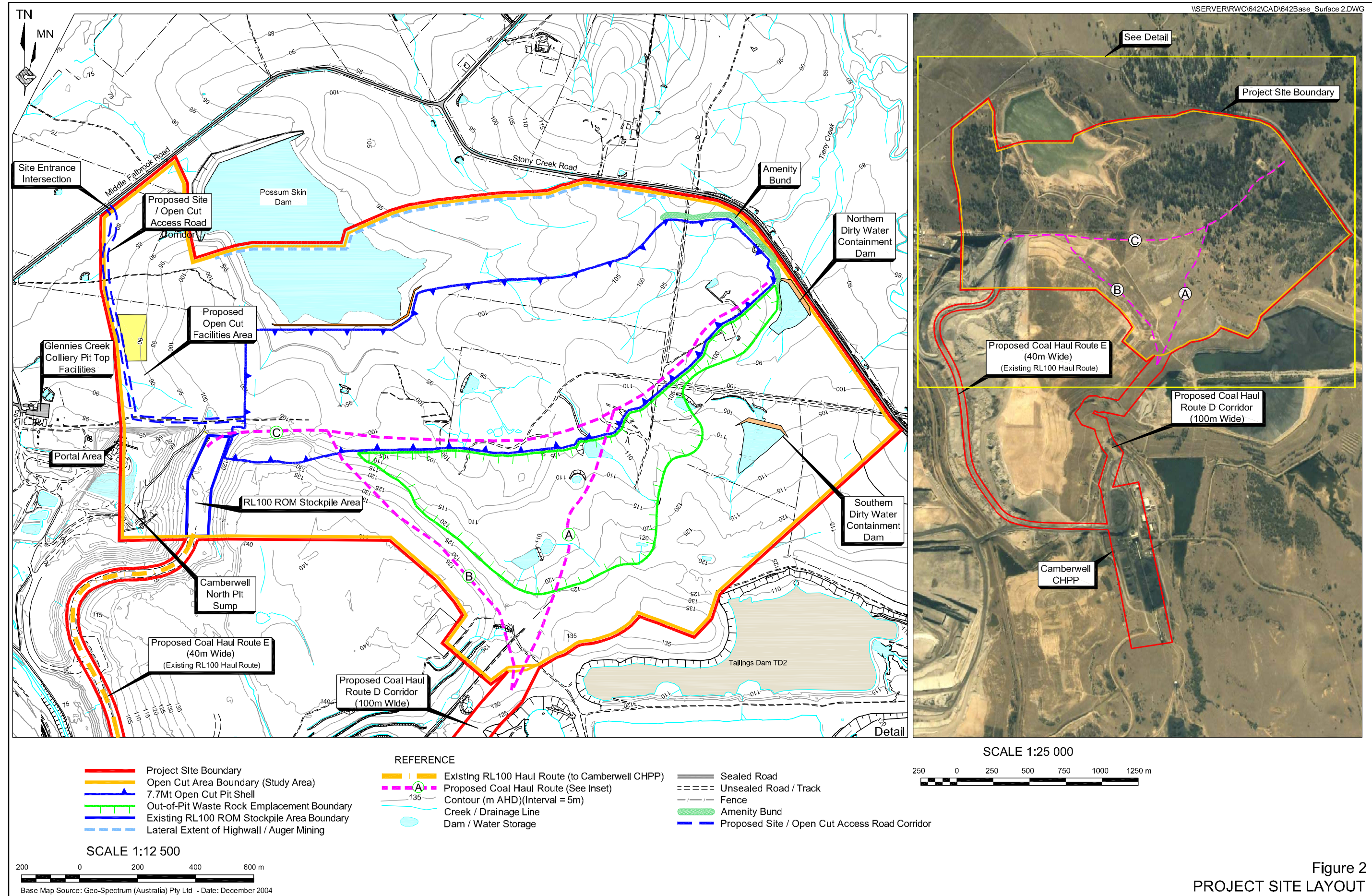
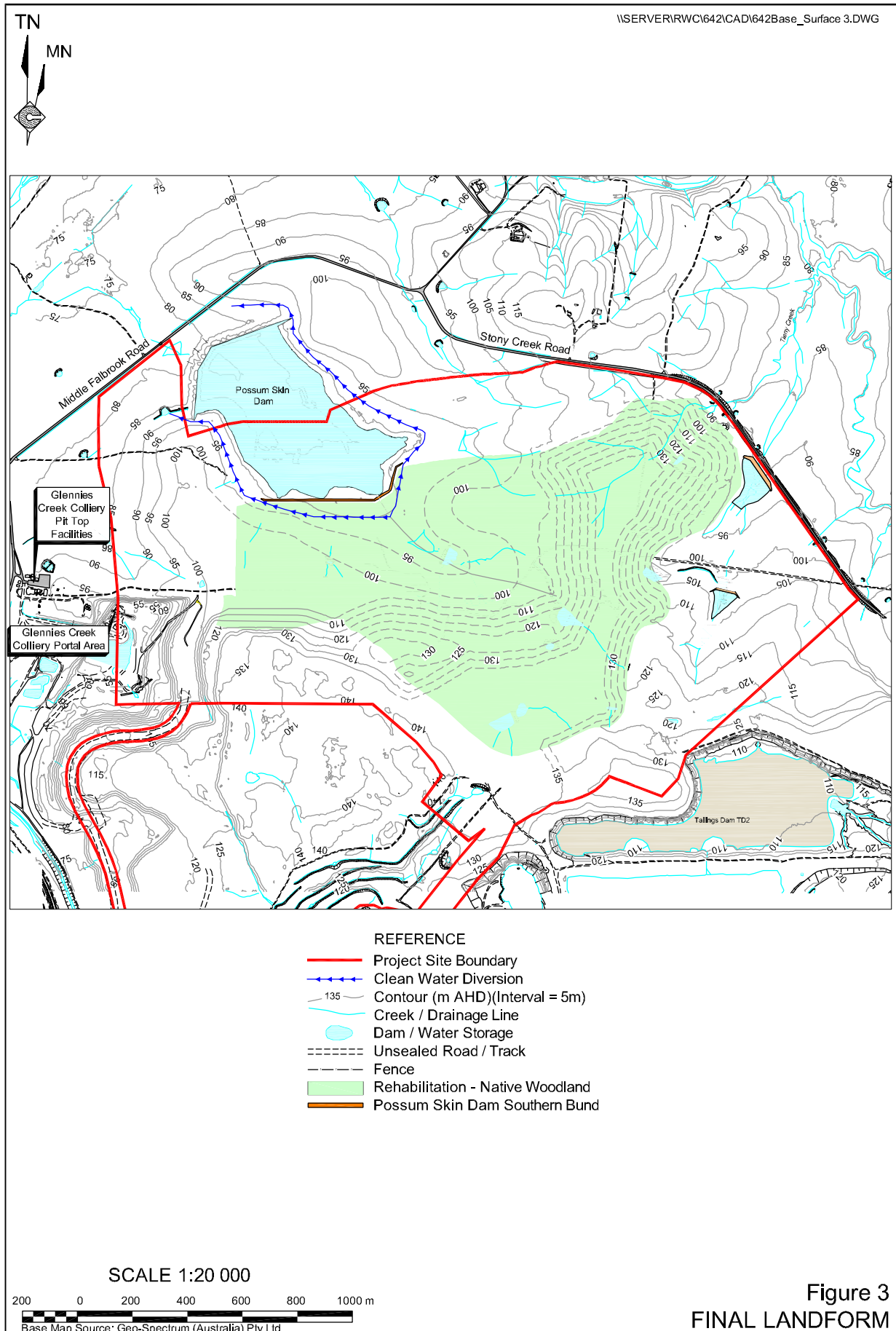


Figure 2
 PROJECT SITE LAYOUT



Note: A colour version of this figure is available on the project CD

consultation with an ecological consultant towards the end of mining operations. The void remaining at the completion of mining would be filled to the surface or slightly above through emplacement of tailings material from the Camberwell CHPP, and / or breaker stone from the Glennies Creek Underground Coal Mine pre-treatment plant. Final rehabilitation of the waste rock emplacement would involve reshaping, capping with inert materials (if required), spreading subsoil and topsoil and seeding / planting.

2.3 Current Water Management Strategy

The existing Glennies Creek Underground – Camberwell Colliery dirty water circuit is based on total containment of dirty water with inflows from seepage, direct rainfall and clean water dams (when required) balanced by evaporative loss and export in coal, as well as export to neighbouring mines (whenever possible).

Existing sources of dirty water include the following.

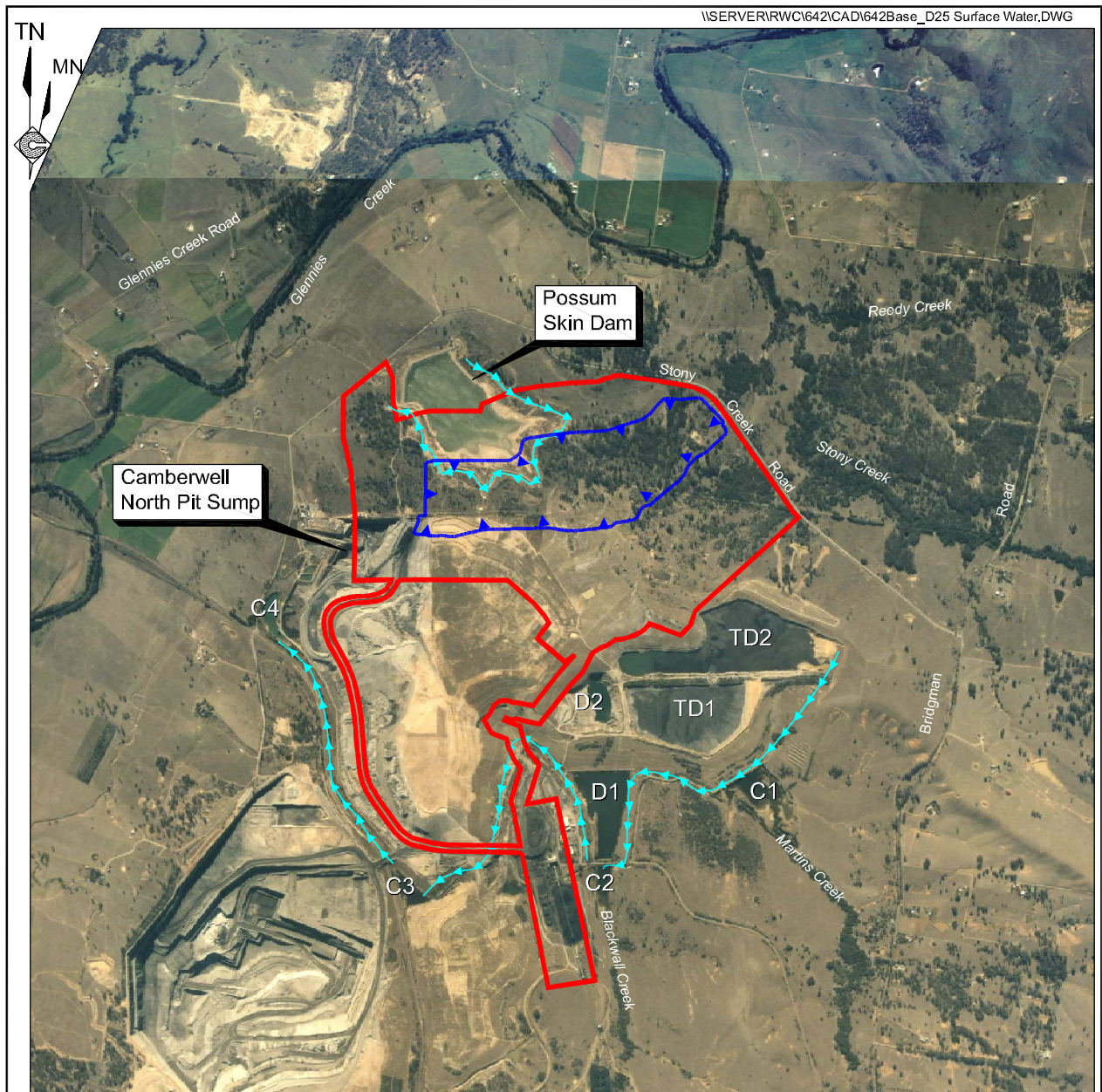
- Camberwell South Pit.
- Camberwell CHPP and stockpile area.
- Seepage from the Camberwell North Pit emplacement (including tailings dams).
- Groundwater seepage into the underground and existing mine voids.
- Direct rainfall on dirty water dam surfaces.

Dirty water losses include the following.

- Dust suppression within the Camberwell South Pit and all internal haul roads.
- Dust suppression within the Camberwell CHPP and stockpile areas.
- Dust suppression within the Glennies Creek Underground Coal Mine.
- Water added to the coal during processing and exported from site with that coal.
- Tailings interstitial water.
- Evaporation from impoundments.
- Export to neighbouring mines (see **Figure 4**).

The portal sump in the Camberwell North Pit is the lowest point in the dirty water circuit and the net repository of dirty water. If sump water levels are rising, the circuit is “making” water, whereas if they are falling the circuit is losing water.

Dirty water management for the proposed open cut would be incorporated into the existing Glennies Creek and Camberwell Colliery Surface Water Management System with all dirty water reporting directly or indirectly to the existing dirty water circuit.



REFERENCE

- Project Site Boundary
- 7.7Mt Open Cut Pit Shell
- Clean Water Diversion
- C1 Clean Water Dam
- D2 Dirty Water Dam
- TD2 Tailings Dam

SCALE 1:40 000

0.5 0 0.5 1.0 1.5 2.0 km

Base Photograph Source: Dept. of Lands - Date of Photograph: 11 October 2005

Figure 4
 EXISTING SURFACE WATER
 STRUCTURES

The proposed open cut has a life of approximately 6 years and the Camberwell South Pit is presently expected to be exhausted by late 2010. The Glennies Creek Underground Coal Mine is expected to continue for another 25 years.

This assessment assumes that the Camberwell South Pit, Glennies Creek Underground Coal Mine and the proposed Glennies Creek Open Cut Coal Mine are all operating concurrently. The Glennies Creek Underground Coal Mine operation is drawing down groundwater levels regionally and will continue to do so well beyond the life of the proposed new open cut (AGE, 2007⁽²⁾). Analysis of the existing dirty water circuit and the impacts of the proposed open cut are therefore evaluated in the context the ongoing regional groundwater draw down associated with the Glennies Creek Underground Coal Mine.

3 EXISTING ENVIRONMENT

3.1 Regional Setting

3.1.1 Drainage Network

The proposed Glennies Creek Open Cut Coal Mine lies wholly within the Glennies Creek catchment, a tributary of the Hunter River. The Hunter River discharges to the Pacific Ocean at Newcastle. **Figure 5** shows the entire Hunter River catchment and the Glennies Creek catchment within it together with the long term stream gauging stations. Glennies Creek enters the Hunter River just above the township of Maison Dieu. The Hunter River catchment above Maison Dieu has an area of 14 500km². Glennies Creek has a catchment area of approximately 512km².

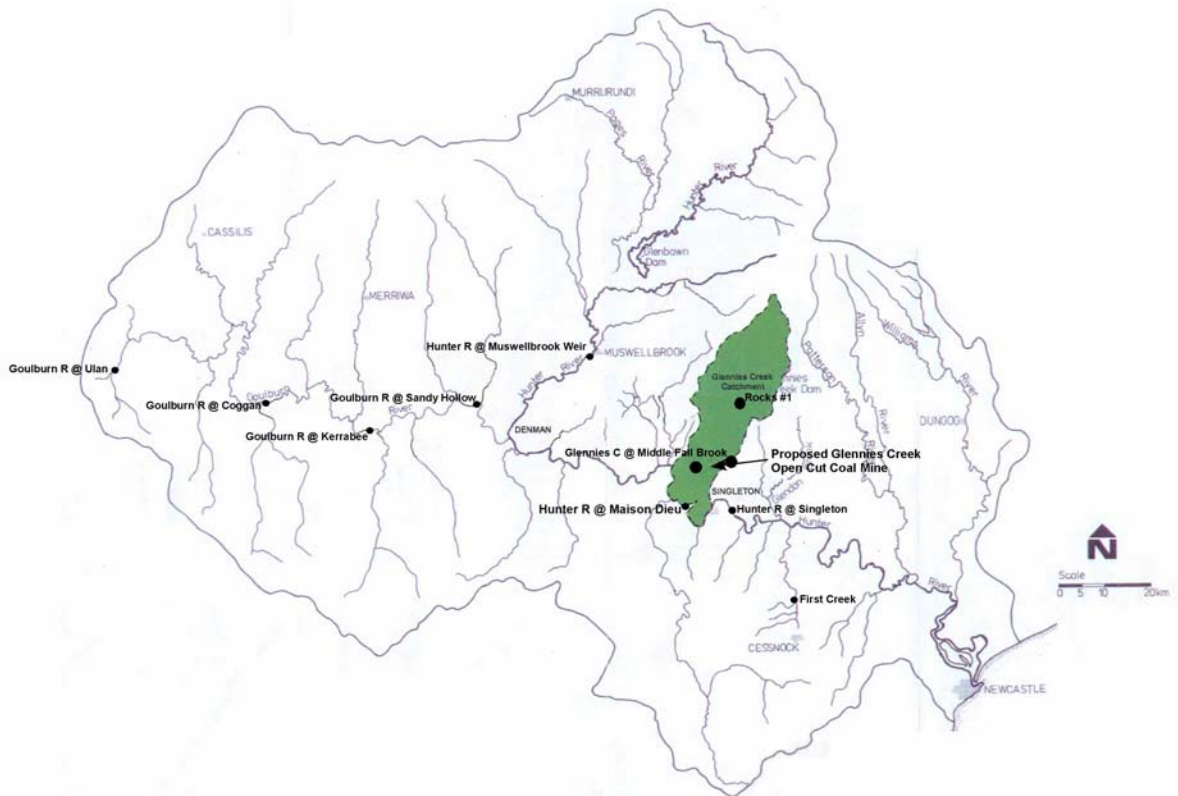


Figure 5
Hunter River Catchment and Stream Gauging Stations

3.1.2 Catchment Management Plan, Blueprint and Targets

The *Integrated Catchment Management Plan for the Hunter Catchment* (Hunter Catchment Management Trust 2002)⁽³⁾ summarises the Hunter Valley as follows.

“The 22 000 square kilometres of the Hunter catchment is home to 350 000 people and has a unique diversity of soil types, geology and climate which influences its vegetation and landscapes. Vegetation in the Hunter ranges from estuarine wetlands and mangrove forests, rainforest and freshwater wetlands to open grasslands, woodlands and eucalypt forests.

Hunter landscapes vary from rich flats of alluvial floodplains through undulating foothills to the rugged Barrington Tops in the northeast and the dissected sandstone of the Great Dividing Range in the southwest”.

It is noted the *Integrated Catchment Management Plan for the Hunter Catchment* ⁽³⁾ salinity target is – “By 2012, salinity levels for the Hunter River at Greta not to exceed 670 μ S/cm for 50% of the time and 900 μ S/cm for 80% of the time”.

The ‘*Hunter Catchment Blueprint*’⁽³⁾ for natural resource management identified four key problem areas.

1. Degradation of the riparian zone including channel structure decline, sedimentation, loss of vegetation and stream bank erosion.
2. Degradation, loss and fragmentation of native vegetation cover and terrestrial, riverine, estuarine and wetland habitat and biodiversity.
3. High levels of induced salinity in rivers, groundwater and soil.
4. Soil degradation including rill, sheet and gully erosion, mass movement and exposed acid sulfate soils.

Management targets ‘to improve water quality by 2012’ include:

- improving stream bank stability and vegetation along 125km of streams in the Wollombi, Goulburn, Doyles, Martindale, Wallis/Fishery, Pages, Dart and Rouchel catchments and along the Hunter River;
- protecting an additional 60km of streams in areas with already stable and well vegetated river systems in the Williams, Paterson/Allyn, Wallis/Fishery, upper Glennies and upper Wollombi catchments and key sections of the Goulburn catchment;
- managing river salinity levels and salt loads consistent with the NSW Salinity Strategy; and
- minimising the impacts of development on in-stream health.

3.1.3 Catchment Runoff

In the dry temperate environment of the Hunter Valley, catchment runoff is highly variable and generally represents only a small fraction of rainfall. Tables A4 and A5 (**Appendix A**) were assembled from data supplied directly by the Department of Planning (DoP) and extracted from the Pineena Database⁽⁴⁾ which summarise the duration and quality of available runoff data. The Pineena Database⁽⁴⁾ is DoP's hydrometeorological database for gauged streams in New South Wales. The database, supplied on DVD, is regularly updated and provides streamflow data from long term averages down to instantaneous flows and individual rating curves. The quality of data and length of record varies from station to station.

The quality of a continuous flow record, from which annual runoff and other statistics are derived, depends on the stability of the flow control and the accuracy of the rating curves. The flow control is **ideally** a rock bar, or similar feature across the river, that would ensure that for a particular water level upstream of the bar, there was only one flow rate, irrespective of water levels downstream or the rate of rise of the flood. "Ideal" rockbars seldom exist and the most stable river section at the location of interest must be used. Changes over time in the "control" are accommodated by constructing a new 'rating curve' for the new (changed) control. Rating curve is the term used to describe the relationship between water level upstream of the control and the flow rate over the control.

The rating curve in turn is established by simultaneously measuring the flow rate (termed gauging) and the upstream water level repeatedly to establish a curve of flow rate versus upstream level.

Short of having several independent gauging stations nearby on the same stream there is no way of confirming the accuracy of a particular rating curve or the overall accuracy of long term statistics from a particular gauging station. Standardized procedures exist for gauging flows that, with well maintained equipment, minimize errors from a particular gauging, however, rating curves must be formed from a limited number of gaugings and errors are introduced through fitting, interpolation and extrapolating of this curve. The difficulty in this is distinguishing rating errors from real differences in catchment hydrological response associated with geology, topography and land use.

For this reason, it is important to use data from a range of stations to establish a consistent pattern considering:

- different periods of record;
- differences in catchment size and stream transmission loss;
- different soil types, vegetative cover and land use;
- different geology and catchment morphology;
- different long-term mean rainfall;
- rating curve bias/errors; and
- water storage and extraction.

This has been done firstly considering the Greater Hunter catchment above Maison Dieu (catchment area $\approx 14\,500\text{km}^2$) and for Glennies Creek at its junction with the Hunter River. See **Tables A4** and **A5** (Appendix A).

For the Hunter River Catchment, mean annual runoff varies from 257mm for Glennies Creek at the Rocks # 1 to 9.1mm for First Creek a wide range that needs to be considered in the context of the dot points in the preceding paragraph. The effect of Lake St Clair is to moderate peak flows and increase base flows. Total runoff is only marginally impacted by changes in actual evaporation/evapotranspiration within the storage area footprint.

For the more reliable stations in the western part of the Greater Hunter catchment, mean annual runoff is in the range of 20-40mm, **Table 1**. Further east, runoff increases due to the somewhat wetter climate and different geology to around 50-100mm. For subcatchments within Glennies Creek and catchments about the proposed development, a mean annual runoff of around 80mm is indicated. (See Table A4, Appendix A).

Table 1
Goulburn-Hunter Rivers - Mean Annual Runoff

| Station | Catchment Area(km²) | MAR (mm) |
|----------------------------------|---------------------------------------|-----------------|
| Goulburn River @ Ulan | 159 | 24.4 |
| Goulburn River @ Coggan | 3 445 | 19.4 |
| Goulburn River @ Kerrabee | 5 043 | 24.5 |
| Goulburn River @ Sandy Hollow | 6 895 | 26.1 |
| Hunter River @ Muswellbrook Weir | 4 220 | 87.2 |
| Hunter River @ Maison Dieu | 14 500 | 21.8 |
| Hunter River @ Singleton | 16 400 | 32.45 |
| MAR = Mean Annual Runoff | | *See Figure 5 |

3.1.4 Water Quality

The notion of water quality encompasses a very wide range of physical, chemical and biological parameters, however, as highlighted in the Hunter Catchment Management Trust reports^{(5), (6)}, the pertinent water quality parameters are sediment and salinity. Of these, salinity is the more insidious and accordingly background information is developed in some detail in this section.

Electrical conductivity, as a surrogate for total dissolved salts, has been measured at several locations in the Greater Hunter catchment. Historically, only spot sampling for water quality was done, however, over the last few years continuous monitoring of electrical conductivity has been progressively implemented at a number of locations.

Figure 5 shows the location of the stream gauging stations operated by the Department of Natural Resources discussed in this text.

The Goulburn River and Upper Hunter River join just downstream of Denman to form the Hunter River. Salinity conditions in these two tributaries largely define conditions at Maison Dieu (downstream of their junction and just upstream of the junction with Glennies Creek). To understand the salinity response, it is useful to consider the individual tributaries. For illustration, the Goulburn River at Kerrabee and the Hunter River at Muswellbrook are used.

Figure 6 shows the interrelationship between conductivity and flow rate at Kerrabee on the Goulburn River. The declining conductivity with increasing discharge being consistent with the notion of high conductivity baseflow/groundwater inflow diluted by surface runoff.

Figure 7, again for the Goulburn River at Kerrabee, illustrates the typical catchment response to an individual flood event, i.e. initially there is a high conductivity baseflow and high conductivity initial surface runoff (surface rinse) followed by low conductivity ongoing surface runoff. Finally, conductivity increases as baseflow becomes an increasing fraction of total flow. The fluctuations in conductivity on the rising limb represent the effects of subcatchment inflows with higher quality (lower conductivity) runoff. As catchments become larger both flows and EC traces become more complex and represent the temporal sum of all subcatchment contributions. Careful detailed modelling is required to define the contribution of a particular subcatchment. **Figure 8** and **Figure 9** are similar plots for the Hunter River at Muswellbrook.

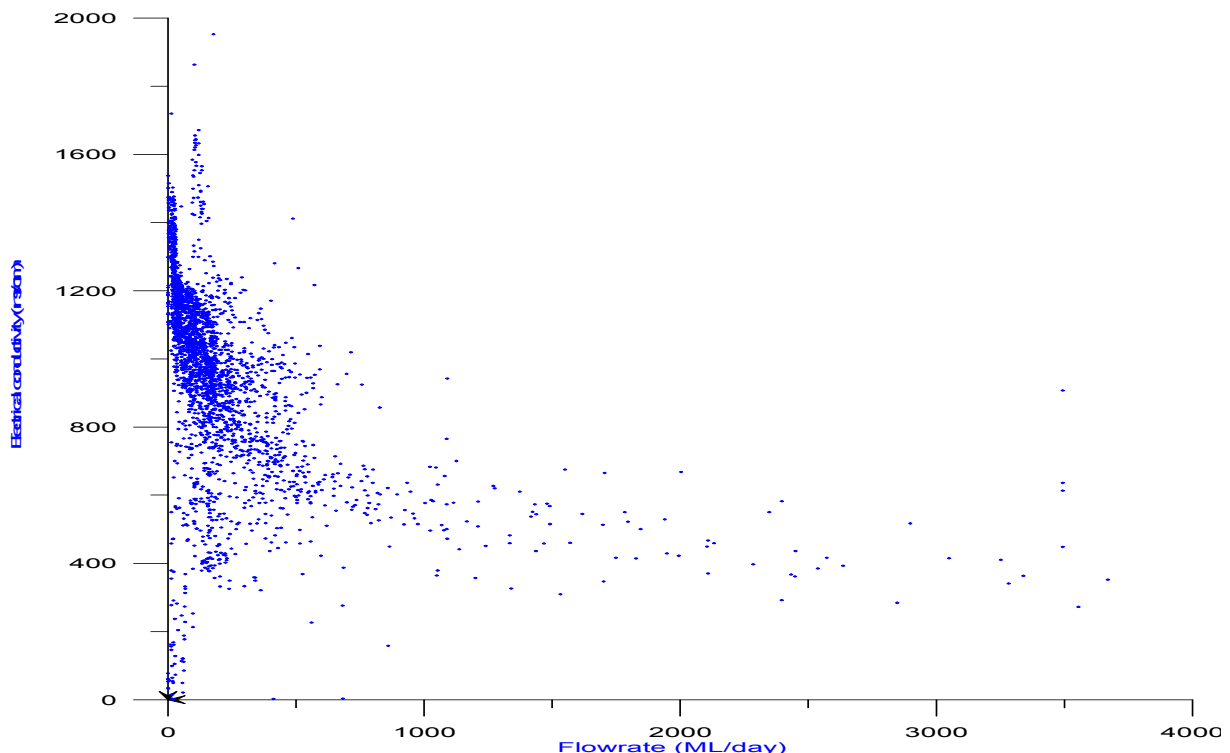


Figure 6
Conductivity @ 25°C Versus Flowrate, All Data Goulburn River at Kerrabee

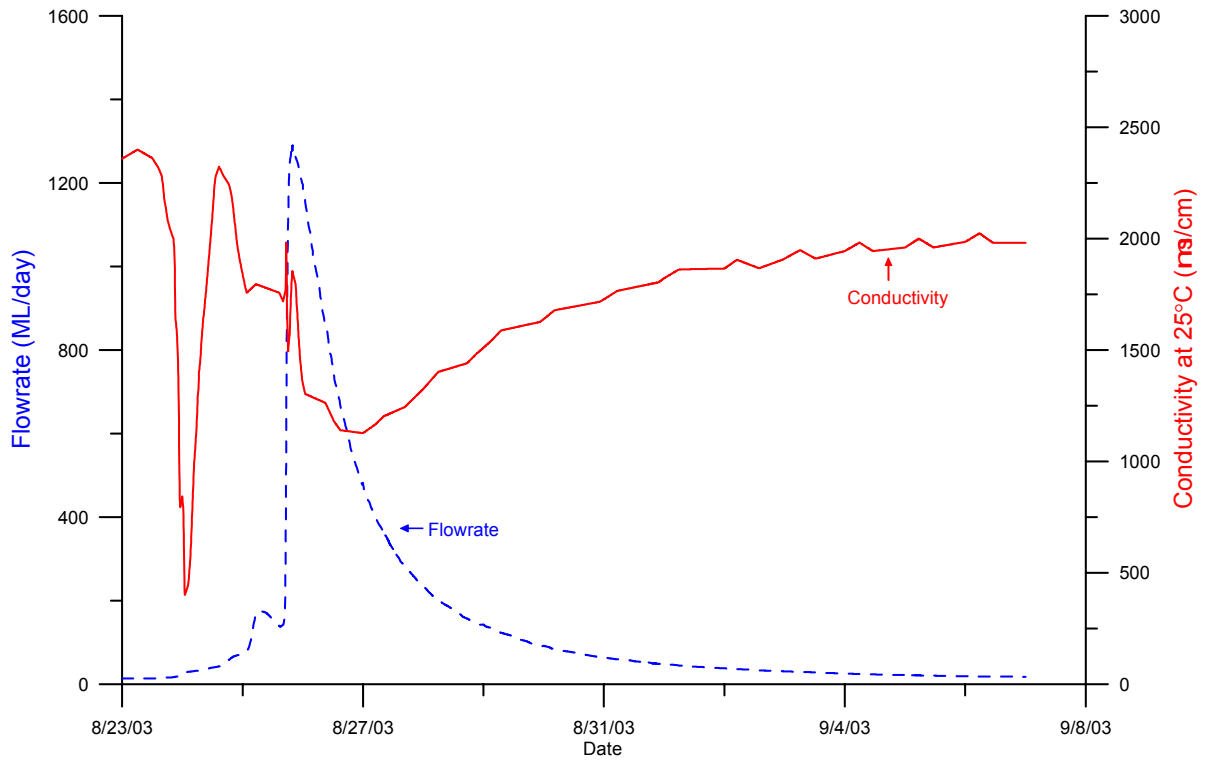


Figure 7
Interrelationship Between Conductivity and Flow Rate During the Passage of an Individual Flood Goulburn River at Kerrabee

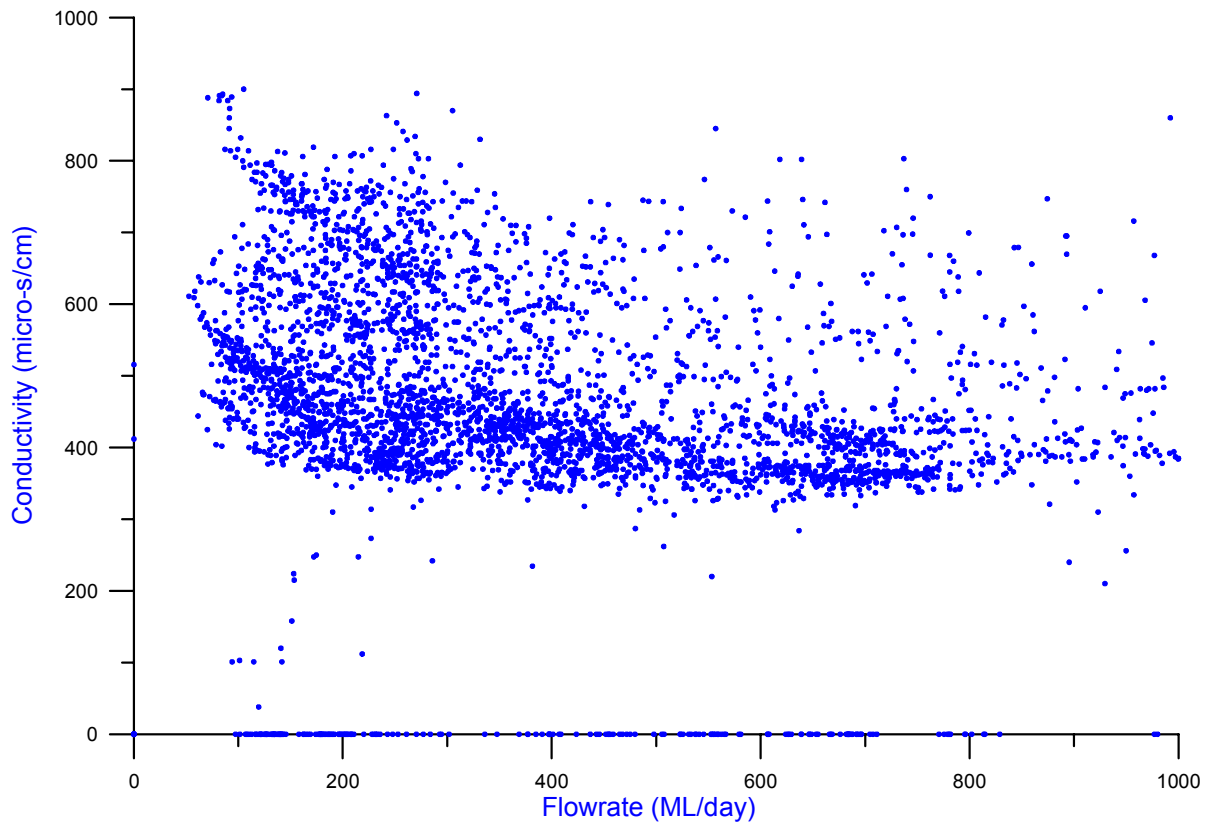


Figure 8
Conductivity @ 25°C Versus Flowrate, All Data Hunter River @ Muswellbrook

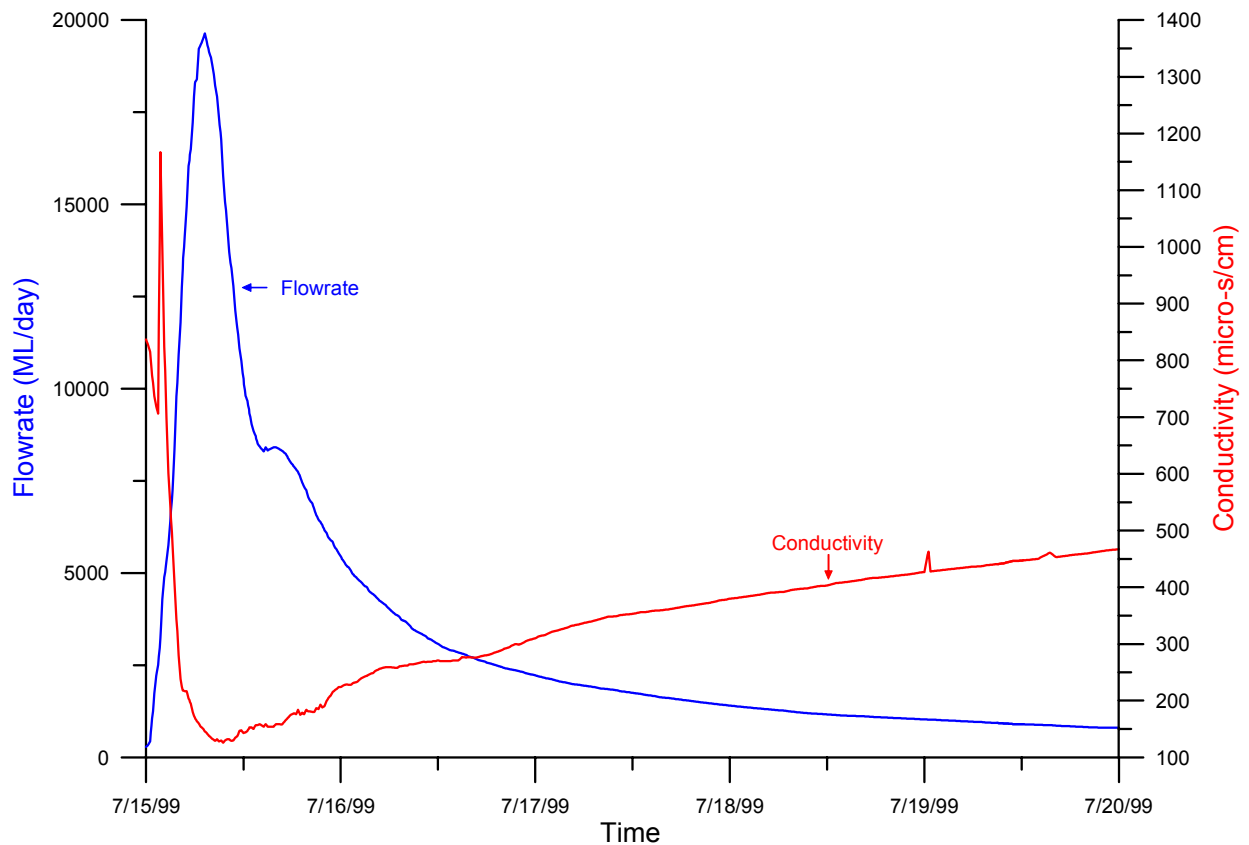


Figure 9

Interrelationship Between Conductivity and Flow Rate During the Passage of an Individual Flood, Hunter River @ Muswellbrook

3.2 Local Setting

3.2.1 Background

For the purposes of this assessment, the local setting relates to the entire Glennies Creek catchment. The catchment boundary and drainage network within the Glennies Creek catchment is shown on **Figure 5**.

Subsequent to the *Hunter Catchment Blueprint*⁽³⁾ referred to in **Section 3.1.2**, a *Status of Natural Resources Report*⁽⁵⁾ (the "Status Report"), consistent with the key problem areas identified in the *Blueprint*⁽³⁾, was prepared in 2003 for the Glennies Creek Catchment by the Hunter Catchment Management Trust.

"The Glennies Creek Catchment is located in the centre of the Hunter Valley and is situated near Singleton about 80km north-west of Newcastle, NSW. The Glennies Creek catchment has an area of 51 200ha and lies fully within the Singleton local government area.

The main waterways within the catchment include Lake St. Clair, the body of water impounded by Lake St Clair, as well as many tributaries within the catchment, including Goorangoola Creek, Campbell's Creek, Cross Creek, Carrow Creek and Fall Brook. Glennies Creek has a regulated flow, though many of the small tributaries do not.

Glennies Creek has its headwaters in the Mount Royal Range, the southern most part of the Barrington Plateau. Carrow Brook and Fall Brook flow from the Mount Royal Range into Lake St. Clair. Glennies Creek continues below the dam and meets the Hunter River at Maison Dieu.

Approximately 500 people live in the Glennies Creek catchment, largely in the localities of Camberwell and Mount Olive. Singleton is the closest major population centre and is located just south of the catchment”.

“The main land uses within the catchment are nature conservation, agriculture, mining, cropping, water supply catchment, tourism and recreation, and quarrying. The upper forested section of the catchment is contained within the Mount Royal National Park and some privately owned land managed for conservation. Large sections of the remaining areas of the catchment are used for agriculture. Agricultural land uses include beef cattle grazing, dairying, cropping and other livestock industries. Mining and quarrying activities are also present in the lower section of the catchment, with several mining leases still undeveloped”⁽⁵⁾.

The report provides details on existing conditions within the catchment particularly as they relate to:

- salinity;
- erosion, sedimentation; and
- land use, and land capability.

The report also provides detailed recommendations relating to:

- land use planning and legislation;
- water quality planning and legislation;
- biodiversity planning and legislation; and
- integrated land management.

With regard to the area of the Project Site the Status Report⁽⁵⁾ shows that the area:

- lies within a zone that has been substantially cleared of natural vegetation;
- has sparse riparian vegetation;
- land use is grazing;

- has highly erodible soils;
- has a land capability Class IV to Class V; and
- has not been evaluated for dry land salinity.

Following the *Status Report*⁽⁵⁾, the Hunter Central Rivers Catchment Management Authority published a *Management Report*⁽⁶⁾ in March 2004. This report presents ten priority actions and an implementation schedule. The ten priority actions are:

1. *Undertake a water-quality-monitoring program on Goorangoola Creek and its tributaries. Complete a community water-quality survey in which landholders provide a sample of water to be tested to gather initial data and raise awareness of water-quality issues. Encourage the formation of a Waterwatch group within the catchment to sample water quality and aquatic life.*
2. *Undertake programs to raise the community's awareness of:*
 - *threatened species identified within the catchment and key threatening processes relevant to the catchment; and*
 - *the importance of understorey and dead tree trunks as habitat for native birds, animals and reptile species.*
3. *Encourage the management of livestock to reduce grazing pressure on riverbanks and gullies by assisting landholders to complete riverbank revegetation and erosion rehabilitation projects where the creekbank or creekbed is degraded.*
4. *Encourage landholders to establish biodiversity corridors as shown in Map 2 (page 30).*
5. *Raise awareness of land managers' responsibilities in relation to various natural resource management legislation and how it relates to the management of their land.*
6. *Encourage a property-management-planning program in the catchment.*
7. *Identify major gully erosion and landslips within the catchment. Encourage landholders to undertake appropriate revegetation and stabilization works giving priority to sites where sediment is entering waterways.*
8. *Encourage and assist landholders to consider their land both economically and environmentally.*
9. *Incorporate biodiversity-planning principles into the **Singleton Local Environment plan 1996** (SC 1996), development control plans and development assessment process.*
10. *For future subdivision development within the catchment, implement a series of regulations to assist in the conservation and regeneration of native vegetation and habitat, and incorporate into planning instruments, such as the **Singleton Local Environment Plan 1996**, development control plans and the development assessment process.*

Further, the Status Report⁽⁵⁾, also outlines the biodiversity corridors within the Glennies Creek Catchment. There are no existing or proposed corridors shown within the boundaries of the Project Site.

The Glennies Creek catchment constitutes Zone 3 of the *Water Sharing Plan for the Hunter Regulated River Water Source*⁽⁷⁾. The plan aims to limit long term extractions to approximately 20% of long term average flow and releases from Glenbawn and Glennies Creek storages (Figures 5 and 6) are designed to ensure flows at the reference sites of Liddell and Greta exceed minimums that vary through the year. At the start of each water year, 20 000 megalitres in Glenbawn and Glennies Creek storages is to be reserved as an environmental contingency. Lake St Clair has a capacity of 283 000ML with 1 070ML of dead storage. On 21 November 2006, the storage was at 35% of capacity.

3.2.2 Catchment Runoff

Catchment and gauging station data for the Middle Hunter and Glennies Creek are summarised in **Table A4**. As discussed in **Section 3.1.3**, an indicative yield or long term annual flow for an ungauged subcatchment in the Glennies Creek Catchment is estimated 80mm/a with significant uncertainty associated with land use, geology and topography.

3.2.3 Water Quality

Figure 10 presents spot conductivity data for Glennies Creek at Middle Fall Brook. The Middle Fall Brook Station is due north of the proposed Glennies Creek Open Cut Coal Mine. The plot illustrates the roll of the Lake St Clair in moderating high salinity low flows by dilution.

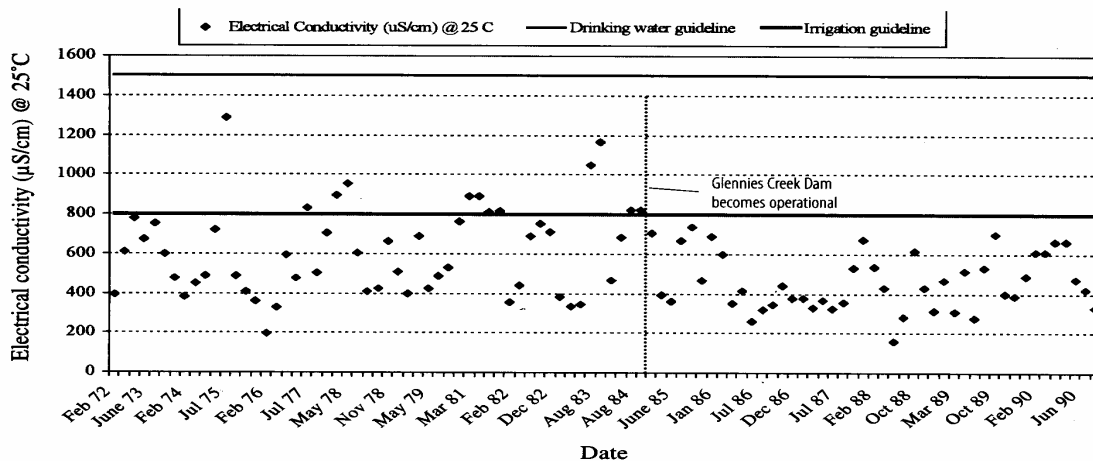


Figure 10
Spot Conductivity Data Glennies Creek at Middle Fall Brook

Table 2 drawn from the *Status Report*⁽⁵⁾ presents predicted electrical conductivity (EC) (as a surrogate for Total Dissolved Salts) probability percentiles for Glennies Creek at Middle Fall Brook and the Hunter River at Singleton. The increases, well into the future, reflect the anticipated long term impacts of land use change. The basis of these numbers is presented in Department of Land and Water Conservation (2001)⁽⁵⁰⁾.

Table 2
Preliminary Predicted Future Salinity for Glennies Creek and the Hunter River at Singleton*

| Site | Percentile | Predicted EC (μ S/cm) | | | | |
|--|------------------|----------------------------|------|------|------|------|
| | | 2000 | 2010 | 2020 | 2050 | 2100 |
| Glennies Creek at Middle Fall Brook | 50 th | 445 | 450 | 450 | 455 | 455 |
| | 80 th | 570 | 575 | 575 | 585 | 585 |
| Hunter River at Singleton | 50 th | 670 | 680 | 685 | 705 | 715 |
| | 80 th | 925 | 935 | 945 | 970 | 980 |

* From Status Report ⁽⁵⁾

3.3 Open Cut Area and Surrounding Area

3.3.1 Catchment Area

Figure 3 presents an aerial photograph of the area surrounding the Open Cut Area. For the purposes of assessing the impacts of the Project upon the local area, water resources surrounding the Open Cut Area, the Camberwell North Pit area covered by the integrated Surface Water Management System including the Glennies Creek Underground Coal Mine, Camberwell South Pit and associated Camberwell CHPP and the Open Cut Area.

The Open Cut Area lies immediately north of the Camberwell North Pit and east and southeast of the Glennies Creek Underground Coal Mine, the portal of which is located within the Camberwell North Pit. The existing infrastructure is shown (**Figure 4**). Note that dam labelling in **Figure 4** follows simple nomenclature C = clean, D = dirty, T = tailings, so for example C2 = clean water storage dam 2, D1 = dirty water storage dam 1 and TD2 = tailings dam 2. Dirty water means contaminated by sediment, salt or both.

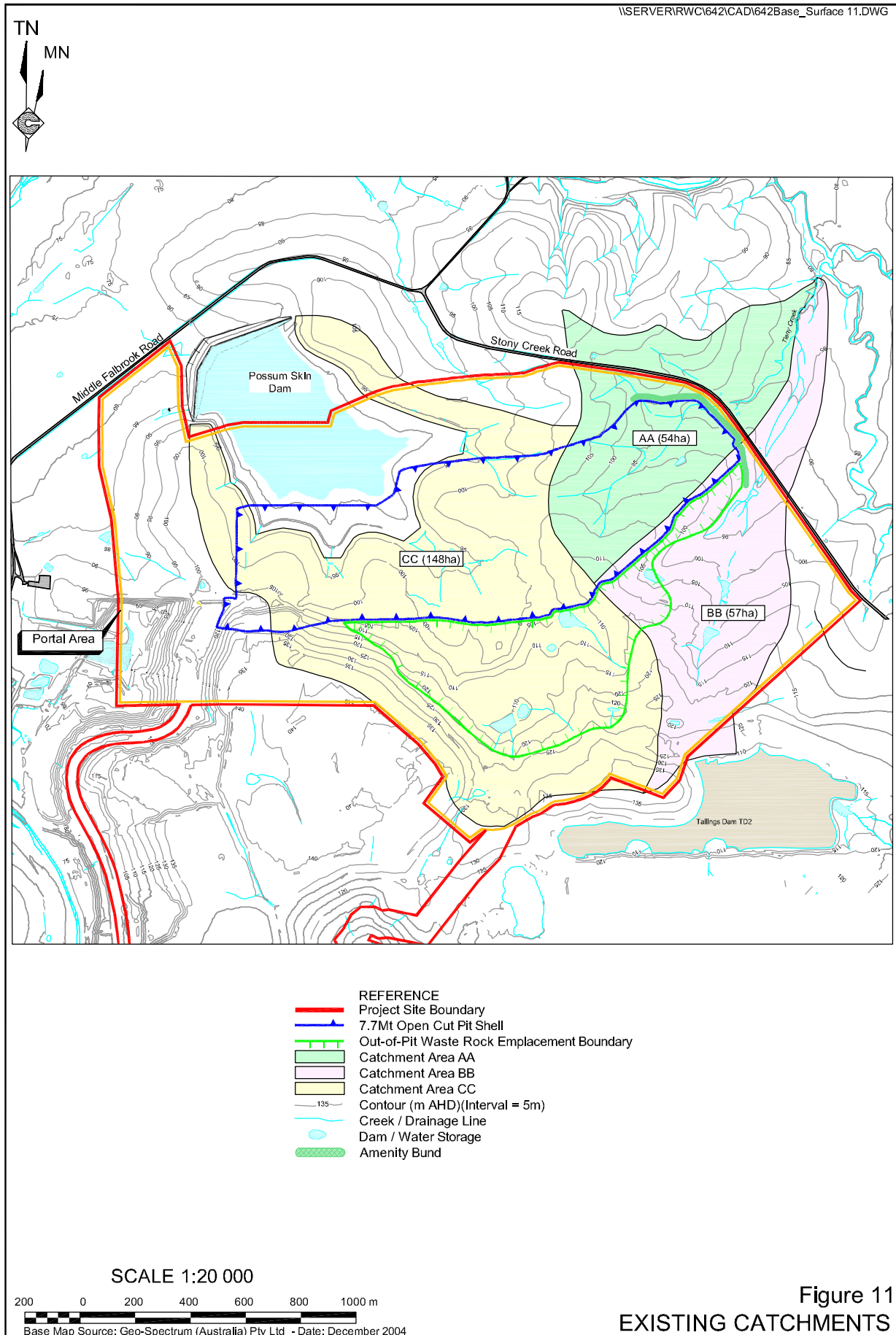
Historically, development of the Camberwell North Pit required interception and diversion of Station Creek drainage south of the pit. Martins and Blackwall Creeks were tributaries of Station Creek.

3.3.2 Catchments About the Open Cut Area

The following text/tables relate to more than the existing Open Cut Area catchments.

The Camberwell North Pit has been progressively backfilled and the in-pit waste rock emplacement now creates the headwater / topographical catchment boundary within the Project Site. The proposed mine and emplacement footprint encompasses three small headwater catchment areas labelled AA through CC in **Figure 11**. Some pertinent statistics for each catchment are presented in **Table 3**. Catchments AA and BB drain northeast across Stony Creek Road to Reedy Creek and then towards Glennies Creek, catchment CC drains north around Possum Skin Dam and then via an ill-defined drainage across the floodplain to Glennies Creek.

\\SERVER\RW\642\CAD\642Base_Surface 11.DWG



Note: A Colour Version of this figure is available on the project CD

Figure 12 indicates the areas of Catchments AA to CC that are presently impacted, would be impacted by the Project or would remain undisturbed. The area of proposed catchment impact is 67ha.

Table 3
Project Site Catchments

| Areas | Catchment | | |
|--|----------------------------------|----------------------------------|---|
| | AA | BB | CC |
| Total Area (ha) | 53 | 58 | 143 |
| Area within proposed open cut pit footprint (ha) | 25.8 | 2.2 | 50.6 |
| Out of Pit Emplacement Footprint (ha) | 0 | 6.9 | 35.7 |
| Area with sub-surface drainage to portal (ha) | 27.2 | 0 | 96 |
| Strahler Order(-) | 1 | 1 | 1 |
| Downstream Drainage | Reedy Ck then Glennies Ck | Reedy Ck then Glennies Ck | Possum Skin Dam Catchment Drain then Glennies Ck |

3.3.3 Water Quality

Table 4 presents monthly water quality monitoring data for Clean Water Dam 2 (C2), Dirty Water Dam 1 (D1) and Bore 2 (see Figure 4).

Table 4
Monthly Monitoring Data for C2, D1 and Bore 2

| Month Sampled | W17: Dam C2 | | | | W19: Dam D1 | | | | Bore 2 | | | |
|---------------|-------------|----------|----------|----------|-------------|----------|----------|----------|--------|----------|----------|-------------|
| | pH | EC uS/cm | TSS mg/L | TDS mg/L | pH | EC uS/cm | TSS mg/L | TDS mg/L | pH | EC uS/cm | TDS mg/L | level TOC m |
| Sep-05 | 8.0 | 2370 | 9 | 1164 | 8.2 | 7740 | 7 | 5196 | 6.8 | 10110 | 7028 | 14.29 |
| Oct-05 | 8.6 | 2880 | 8 | 1390 | 8.4 | 8150 | 14 | 5322 | 6.9 | 10510 | 7188 | 14.20 |
| Nov-05 | 7.9 | 2000 | 19 | ns | 8.8 | 6000 | 23 | ns | 7.0 | 10000 | 7556 | 14.16 |
| Dec-05 | 8.2 | 2150 | 17 | 1406 | 8.8 | 5800 | 20 | 3696 | 7.0 | 9670 | 7146 | 13.26 |
| Jan-06 | 9.2 | 2630 | 8 | 1652 | 8.6 | 8390 | 8 | 5128 | 6.8 | 10660 | 7166 | 13.26 |
| Feb-06 | 9.5 | 2780 | 4 | 1646 | 8.9 | 8870 | 12 | 5800 | 6.8 | 10520 | 8040 | 13.45 |
| Mar-06 | 9.5 | 3160 | 12 | 1844 | 8.8 | 9640 | 12 | 5160 | 7.0 | 10680 | 7392 | 12.72 |
| Apr-06 | 9.5 | 3180 | 14 | 1626 | 8.4 | 9400 | 24 | 4888 | 6.8 | 10760 | 7170 | 12.85 |
| May-06 | 10.9 | 3210 | 7 | 1750 | 9.2 | 10020 | 67 | 5705 | 7.0 | 10625 | 6132 | 12.90 |
| Jun-06 | 9.8 | 3720 | 2 | 1980 | 8.8 | 11730 | 12 | 6074 | 7.1 | 11810 | 6600 | 12.93 |
| Jul-06 | 9.9 | 3790 | 6 | 1850 | 8.8 | 12030 | 16 | 6940 | 7.1 | 11990 | 6500 | 12.33 |
| Aug-06 | 9.7 | 4030 | 6 | 1865 | 8.9 | 13500 | 36 | 6900 | 7.1 | 12870 | 6940 | 12.07 |
| MEAN | 9.2 | 2992 | 9 | 1652 | 8.7 | 9273 | 21 | 5528 | 7 | 10850 | 7072 | 13.20 |
| Min | 7.9 | 2000 | 2 | 1164 | 8.2 | 5800 | 7.0 | 3696 | 6.8 | 9670 | 6132 | 12.1 |
| Max | 10.9 | 4030 | 19 | 1980 | 9.2 | 13500 | 67.0 | 6940 | 7.1 | 12870 | 8040 | 14.3 |

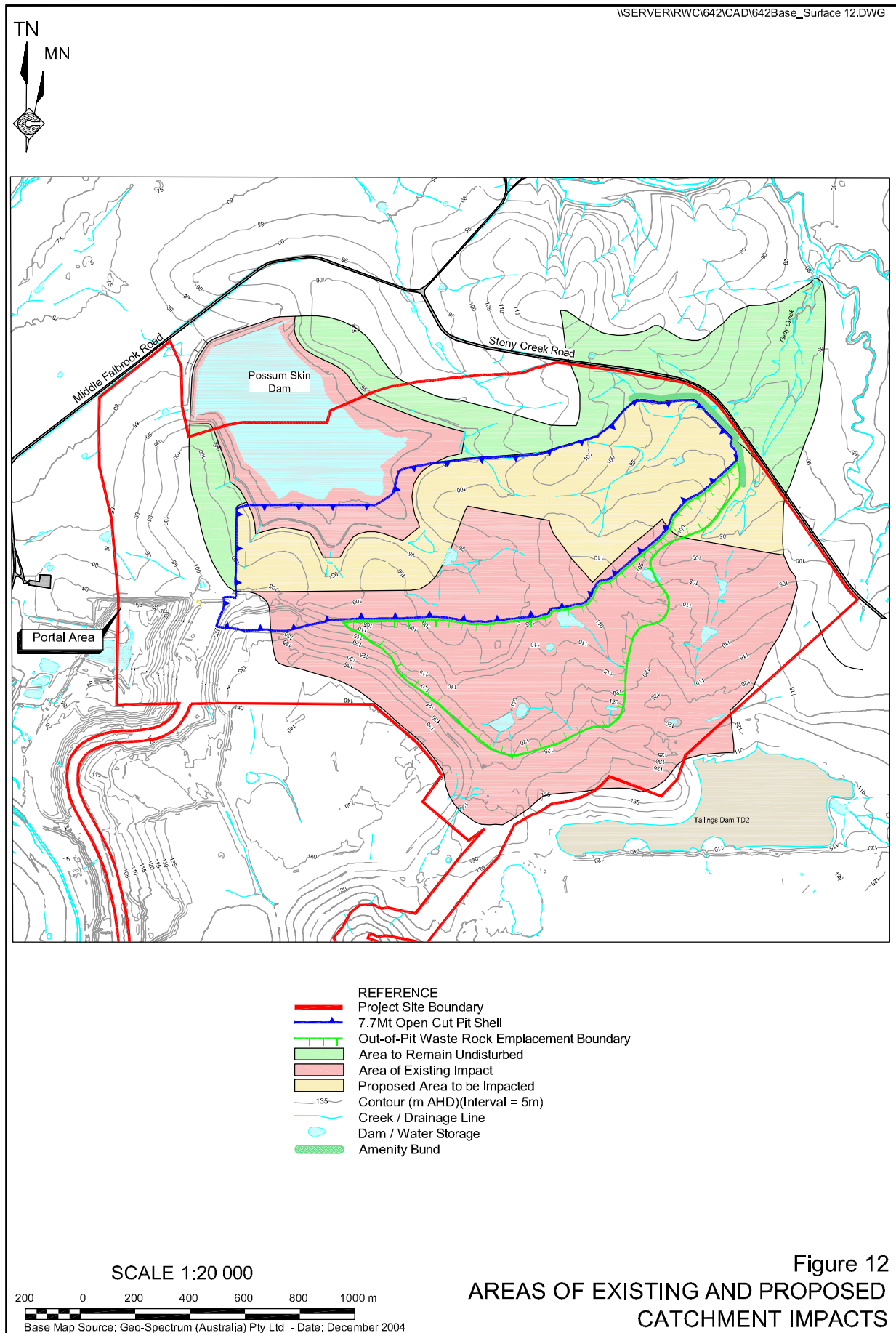


Table 5 presents spot electrical conductivity data for a number of sites about the mine (for location see **Figure 3**).

Table 5
Spot Electrical Conductivity Data Glennies Creek – Camberwell Site

| Location | Electrical Conductivity | Source |
|---|-------------------------|--------------|
| Portal Sump | 8 500 – 9 000 | Ken Barry |
| Possum Skin Dam | ~11 000 | Ken Barry |
| C1 | 5 200 | Colin Davies |
| TD2 | 12 000 | Colin Davies |
| TD1/TD2 Seepage ⁽¹⁾ | 13 000 | Colin Davies |
| ⁽¹⁾ Seep areas south of dams | | |

Table 6 presents water quality data assembled by AGE Consultants as part of the groundwater assessment for the Project. This data is discussed more fully in AGE Consultants (2007)²⁰ and bore locations shown therein.

Table 6
Borehole Water Quality Data[#]

| Bore Name | Coordinates (GDA94) | | Total Hole Depth (mbGL) | EC (µS/cm) | pH | Temp (°C) | Aquifer |
|---|---------------------|----------------------|-------------------------|-----------------------------------|------------|-----------|-----------------------------------|
| | Easting | Northing | | | | | |
| GC01 | 325124 | 6406664 | 108 | 10280 [†] | 8.46 | 21.3 | Permian Coal Seam |
| GC02 | 325160 | 6406490 | 105 | 7610 [†] | 8.77 | 19.8 | Permian Coal Seam |
| GC05 | 324337 | 6406203 | 108 | 7280 [†] | 8.47 | 20.4 | Permian Coal Seam |
| GC06 | 324941 | 6406784 | 126 | 9270 [†] | 8.33 | 21.1 | Permian Coal Seam |
| GC07 | 325864 | 6407071 | 120 | 8250 [†] | 7.01 | 22.3 | Permian Interburden and Coal Seam |
| GC08 | 326332 | 6407214 | 120 | 7610 [†] | 8.29 | 20.1 | Permian Coal Seam |
| GC09 | 323259 | 6407315 | 9 | 500 | 7.07 | 21.5 | Quaternary alluvium |
| GC10 | 324414 | 6408030 | 11.5 | 540 | 7.05 | 19.7 | Quaternary alluvium |
| GC13 | 326169 | 6406745 | 66 | - | - | - | Permian Coal Seam |
| GC14 | 325774 | 6407042 | 123 | 9560 [†] | 8.28 | 21.1 | Permian Coal Seam |
| GC15 | 325912 | 6406961 | 114 | 8170 [†] | 8.46 | 19.8 | Permian Coal Seam |
| GC16 | 326029 | 6407077 | 120 | 7760 [†] | 8.41 | 20.1 | Permian Coal Seam |
| GCTB | 325149 | 6406572 | 90 | 9930 [†] | 8.03 | 17.2 | Permian Coal Seam |
| GCP1 | 322080 ^a | 6406090 ^a | NA | 3110 to 3720 | NA | NA | Glennies Creek alluvium |
| GCP2 | 323447 | 6409344 | 2.7 | 340 to 578 | 6.3 to 6.8 | NA | Main Creek alluvium |
| GCP3 (alluvium) | 320945 | 6408387 | 5.5 | 14800 | 7.28 | NA | Betties Creek alluvium |
| GCP3 (Permian) | 230924 | 6408389 | 49.2 | 12840 | 7.54 | NA | Permian Sandstone |
| GCP4 (alluvium) | 320838 | 6409804 | 6.0 | 8610 | 6.68 | NA | Betties Creek alluvium |
| GCP4 (Permian) | 320838 | 6409600 | 36.0 | 20900 | 7.24 | NA | Permian Sandstone |
| Used to determine groundwater inflow mean concentrations. | | | | # Source: AGE Consultants (2007). | | | |

3.4 Hydrometeorological Data

3.4.1 Introduction

In this section, available hydrometeorological data is assembled and analysed in an engineering hydrology context to provide baseline data to assess existing hydrometeorological conditions and to design and evaluate environmental controls for the Project.

Even without the added uncertainties of climate change, it is inevitable there would be floods larger than any recorded so far and droughts longer and dryer than any recorded.

Part of engineering hydrology is the estimation of long term averages and the magnitude of deviations from these long term averages, from historic records, in particular, historic rainfall and streamflow records.

As the consequences of failure of a man-made structure for hydrological reason to human life, the environment, infrastructure etc increase, the hydrologic design is for greater deviations from the mean. Thus street curbs and gutters, in an urban environment where the consequences of overflow are nuisance only, are typically designed for the worst event in five to 20 years, whereas a major water supply dam upstream of a city, where failure would likely result in loss of life, is designed for the Probable Maximum Flood (PMF). However, the higher the design standard the higher the cost. If a particular hydraulic structure, say a culvert on a secondary road, is designed in error for the 100 year event rather than the 10 year event, then it will be larger and more expensive, consuming public funds that might be better used elsewhere.

Reliable estimation of the basic hydrometeorological statistics is necessary to ensure appropriate design and minimize misallocation of resources.

3.4.2 Rainfall

There are several rain gauges within 60km of the Project Site, some with records dating back to the 1870's. **Table 7** lists daily rainfall stations used to establish the Glennies Creek area composite record continuous from 1881. Mean annual rainfall from this composite record is estimated at approximately 725mm.

Table A1 (Appendix A) presents monthly data for the composite record period 1874-2003 (some missing months). The wettest calendar year was 1893 with 1 266mm, the next wettest was 1887 with 1 264mm. The driest year was 1957 with 351mm, however, this followed three wetter than average years. The driest consecutive pair of years was 1918 – 1919 with 406 and 420mm. The next driest pair of consecutive years is 1965-1966 with 421 and 476mm.

Table 7
Regional Rainfall Stations

| Station Name | Code | Period of Record | Adjustment |
|----------------------------|--------|------------------|------------|
| Singleton Post Office | 061070 | 1881-1969 | Index Stn |
| Singleton Pitt Street | 061232 | 1964-1975 | 0.987306 |
| Mitchell's Flat | 061044 | 1937-1976 | 0.995606 |
| Sedgefield | 061050 | 1903- | 0.952042 |
| Elderslie (Elderslie Farm) | 061092 | 1927- | 0.99884 |
| Branxton Post Office | 061005 | 1886-1969 | 0.971919 |
| Goorangoola | 061021 | 1885-1967 | 0.865952 |
| Scone (Philip Street) | 061069 | 1873-1992 | 1.11398 |
| Broke (Harrowby) | 061100 | 1887 | 1.1756 |
| Doyles Creek (Wood Park) | 061130 | 1920- | 1.08437 |
| Muswellbrook (Edderton) | 061018 | 1911-1985 | 1.24629 |
| Singleton Water Board | 061371 | 1991-2002 | 1.06983 |
| Singleton Army | 061275 | 1969-1990 | 1.04816 |

Table 8 presents monthly mean and maximum rainfall data from the composite record.

Table 8
Mean Monthly Rainfall (mm) Glennies Creek Composite

| | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Annual |
|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|-------|--------|
| Mean | 79.8 | 80.4 | 76.1 | 73.0 | 49.0 | 52.3 | 47.5 | 38.6 | 44.7 | 51.9 | 59.8 | 72.4 | 725 |
| Max | 313.8 | 360.4 | 333.7 | 244.2 | 246.5 | 354.6 | 245.6 | 200.6 | 166.6 | 285.8 | 190 | 216.9 | 1 266 |
| Min | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 | 0.3 | 0.3 | 0.4 | 0.0 | 0.5 | 0.8 | 0.0 | 351 |

Calculations related to total containment of dirty water up to a prescribed average recurrence interval is required as part of the surface water management for the Project. Total containment is related to storage (volume) capacity rather than channel or pipe flow rate capacity and is therefore affected by prolonged wet periods of several days (multiday) rather than an individual storm event.

Table 9 presents some historic maximum observed multiday rainfall event totals while **Figure 13** presents multiday smoothed historic rainfall curves. Note that all maxima relate to the 1892-93 summer period. This single summer period is easily the wettest on record and by definition its ARI is the length of the record but its actual ARI could be larger. By way of example from **Figure 13** the 90 day 50 year ARI wet period has a total of 575mm.

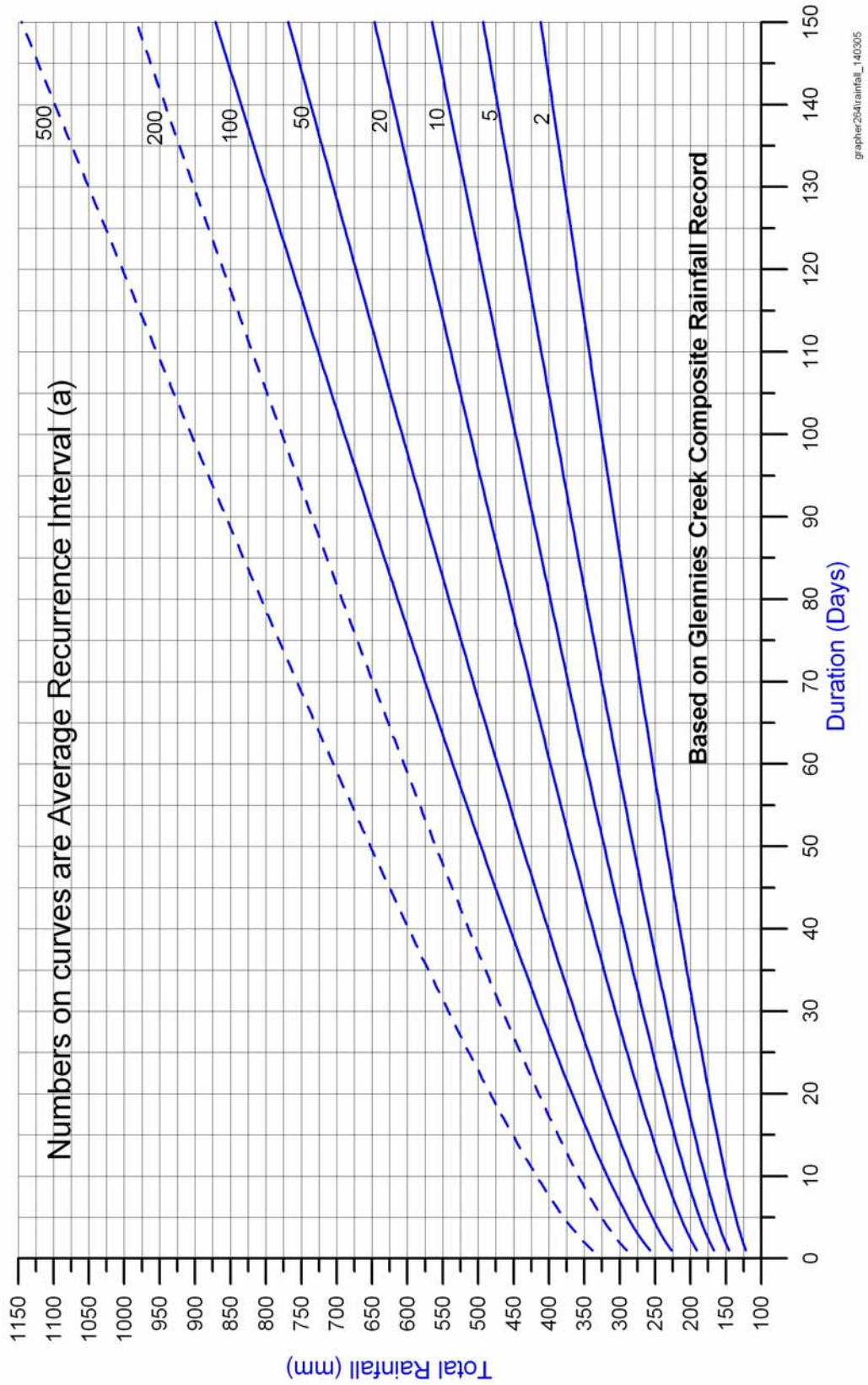


Figure 13
Smoothed Historic Multiday Rainfall

Table 9
Significant (Rank 1, ARI = 132a) Historic Multiday Rainfall Sequences 1881-2003 Glennies Creek Composite

| Days | Start Date | Antecedent Totals | | | Temporal Distribution of Rainfall | | | |
|------|------------|----------------------|------------------------|-------------|-----------------------------------|-----|-----|-----|
| | | Multiday Totals (mm) | Multiday Rainfall (mm) | 30 day (mm) | Fraction of Total Duration | | | |
| | | | | | 0.2 | 0.4 | 0.6 | 0.8 |
| 1.00 | 09.03.1893 | 250.20 | 23.100 | 145.80 | 20 | 40 | 60 | 80 |
| 2.00 | 09.03.1893 | 302.50 | 23.100 | 145.80 | 33 | 66 | 86 | 93 |
| 3.00 | 08.03.1893 | 325.40 | 0.00 | 122.70 | 4 | 22 | 69 | 90 |
| 5.00 | 06.03.1893 | 325.40 | 0.00 | 122.70 | 0 | 0 | 7 | 84 |
| 7.00 | 04.03.1893 | 325.40 | 0.00 | 136.70 | 0 | 0 | 1 | 53 |
| 10.0 | 01.03.1893 | 325.40 | 55.60 | 147.60 | 0 | 0 | 0 | 7 |
| 15.0 | 06.03.1893 | 326.50 | 55.60 | 122.70 | 7 | 100 | 100 | 100 |
| 20.0 | 19.02.1893 | 381.00 | 92.00 | 132.60 | 14 | 15 | 15 | 15 |
| 25.0 | 14.02.1893 | 391.20 | 122.40 | 160.20 | 3 | 17 | 17 | 17 |
| 30.0 | 09.02.1893 | 448.10 | 118.80 | 118.80 | 13 | 22 | 27 | 27 |
| 40.0 | 30.01.1893 | 473.00 | 156.80 | 147.90 | 5 | 17 | 30 | 31 |
| 50.0 | 20.01.1893 | 513.60 | 210.40 | 116.20 | 8 | 13 | 26 | 37 |
| 60.0 | 10.01.1893 | 566.90 | 231.50 | 118.00 | 9 | 21 | 31 | 43 |
| 80.0 | 21.12.1892 | 629.80 | 247.10 | 95.00 | 8 | 18 | 29 | 48 |
| 100 | 01.12.1892 | 724.00 | 307.00 | 82.00 | 13 | 22 | 35 | 47 |
| 120 | 11.11.1892 | 798.40 | 291.90 | 74.50 | 13 | 22 | 36 | 51 |
| 150 | 12.10.1892 | 872.90 | 285.60 | 116.30 | 9 | 22 | 35 | 49 |

3.4.3 Evaporation and Evapotranspiration

Evaporation and associated evapotranspiration is a major component of any water balance. For example, for a natural catchment in the Glennies Creek area, mean annual rainfall is approximately 725mm while mean annual runoff only around 80mm. The remainder (725 – 80 = 645mm) is lost as evapotranspiration.

Evaporation is also important in terms of dirty water containment and management. To ensure no discharge of dirty water, evaporation and water use must exceed direct rainfall and runoff. Reliable estimates of evaporation and evapotranspiration are central to the design and evaluation of dirty water containment systems.

Initially in Australia, evaporation was measured in the “Australia Sunken Tank”. In the 1960s the defacto world standard of the American Class A pan was adopted. Unfortunately even regionally pan measurements are noted for their variability rather than consistency. This variability is illustrated in the assembled data in **Table A2 (Appendix A)**.

The Bureau of Meteorology has recently prepared Australia wide contours of point and areal potential evapotranspiration. Annual totals for these in the vicinity of the Project Site are 1 800 and 1 300mm respectively. The distinction between point and areal evapotranspiration relates to the fact that evapotranspiration effects the ground level climate and therefore evapotranspiration. Areal estimates are assumed to apply to areas greater than 1km². Evapotranspiration and open water evaporation differ due to differences in absorbed global

radiation, surface roughness and stomatal control. Open water absorbs more radiation but is smooth, stomata close at night preventing transpiration. The net effect being that open water evaporation is typically about 15% to 25% more than potential evapotranspiration.

A compromise value for the Project Site, between the alternate estimates, but weighted toward the more recent Australia Wide estimate, is 1 600mm/yr (4.39mm/d). The corresponding monthly values are presented in **Table 10**.

Table 10
Adopted Monthly Mean Open Water Gross and Net Evaporation Rates at the Project Site

| Month | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Ann |
|--|-----|-----|-----|-----|-----|------|------|-----|------|-----|-----|-----|------|
| Mean Open Water Gross Evaporation (mm) | 216 | 168 | 162 | 108 | 78 | 60 | 60 | 78 | 114 | 168 | 186 | 204 | 1602 |
| Rainfall (mm) | 80 | 80 | 76 | 73 | 49 | 52 | 48 | 39 | 45 | 52 | 60 | 72 | 725 |
| Net Evap. (mm) | 136 | 88 | 86 | 35 | 29 | 8 | 12 | 38 | 69 | 116 | 126 | 132 | 877 |

3.4.4 Regional Climatic Data

General regional climatic data is presented in **Table A3 (Appendix A)** for six stations within approximately 50km of the Project Site namely Lostock Dam, Paterson (Tocal AWS), Jerry's Plains Post Office, Scone (Philip Street), Singleton Army and Cessnock (Nulkaba). Quantities are consistent across the six locations. By way of example, Jerry's Plains data is presented in **Table 11**.

4 WATER BALANCE AND MANAGEMENT

4.1 Introduction

An understanding of the dirty water balance and its management is provided in this section for the catchment areas and activities within the areas covered by the integrated Water Management Systems (**Section 3.3**). In **Figure 4**, key existing water management features are labelled. D signifies dirty water so D1 is Dirty Water Dam 1. C Signifies clean water so C2 is clean water dam 2 and so on; similarly TD1 is tailings dam 1, etc. The individual components considered in the overall water balance are as follows (see **Figure 4**).

1. Camberwell (CHPP), stockpile area and Dirty Water Dam 1.
2. Camberwell South Pit.
3. Camberwell North Pit waste rock emplacements including Tailing Dams and the portal sump.

Table 11
Jerry's Plains Post Office – General Climatic Data

| | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | ANN | NO. YRS | % COMP |
|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------|--------|
| Mean Daily Max Temp °C | 31.8 | 30.9 | 29.0 | 25.3 | 21.2 | 17.9 | 17.3 | 19.4 | 22.8 | 26.2 | 29.3 | 31.4 | 25.2 | 92.7 | 95 |
| Highest Max Temp °C | 44.4 | 45.3 | 42.8 | 38.9 | 30.0 | 26.1 | 25.6 | 31.0 | 36.2 | 39.4 | 44.9 | 45.6 | 45.6 | 43.2 | 91 |
| Mean Daily Min Temp °C | 17.1 | 17.1 | 15.0 | 10.8 | 7.4 | 5.2 | 3.7 | 4.4 | 6.9 | 10.2 | 13.1 | 15.7 | 10.5 | 92.9 | 95 |
| Lowest Min Temp °C | 7.7 | 8.7 | 4.5 | 0.6 | -1.6 | -2.8 | -4.5 | -3.0 | -0.6 | 1.0 | 4.4 | 5.0 | -4.5 | 43.2 | 90 |
| Mean 9am Relative Humidity (%) | 67 | 72 | 71 | 71 | 77 | 79 | 78 | 72 | 65 | 60 | 59 | 60 | 69 | 54.9 | 86 |
| Mean 9am Wind Speed (km/hr) | 10.2 | 9.5 | 9.4 | 9.0 | 9.4 | 9.8 | 10.9 | 11.1 | 12.2 | 11.3 | 10.9 | 10.3 | 10.3 | 42.8 | 90 |
| Mean 3pm Relative Humidity (%) | 46 | 50 | 50 | 47 | 51 | 53 | 50 | 45 | 43 | 43 | 41 | 42 | 47 | 40.6 | 86 |
| Mean 3pm Wind Speed (km/hr) | 13.7 | 13.7 | 13.0 | 11.8 | 11.7 | 11.8 | 13.5 | 14.6 | 15.4 | 14.4 | 14.9 | 14.6 | 13.6 | 42.6 | 90 |
| Mean Rainfall (mm) | 78.2 | 71.7 | 58.2 | 44.7 | 41.3 | 45.3 | 44.3 | 36.6 | 41.3 | 51.9 | 58.2 | 67.3 | 638.8 | 118.7 | 99 |
| Mean No. Rain days | 7.9 | 7.3 | 7.3 | 6.3 | 6.6 | 7.3 | 7.0 | 7.0 | 6.6 | 7.5 | 7.6 | 7.5 | 86.0 | 118.4 | 99 |
| Highest Monthly Rainfall (mm) | 226.3 | 340.4 | 264.3 | 172.2 | 314.3 | 288.4 | 231.6 | 206.9 | 156.1 | 170.0 | 217.8 | 233.1 | | 118.7 | 99 |
| Lowest Monthly Rainfall (mm) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.3 | 0.3 | 0.0 | 0.0 | 1.4 | 1.0 | 0.0 | | 118.7 | 99 |
| Highest Recorded Daily Rain (mm) | 97.3 | 139.7 | 132.1 | 86.6 | 99.1 | 190.8 | 137.2 | 65.3 | 67.3 | 68.6 | 67.1 | 108.0 | 190.8 | 118.5 | 99 |
| Mean No. of Clear Days | 7.0 | 5.3 | 7.4 | 9.3 | 8.6 | 8.4 | 10.8 | 11.9 | 10.7 | 8.3 | 7.2 | 7.6 | 102.6 | 45.4 | 96 |
| Mean No. of Cloudy Days | 11.8 | 12.1 | 11.0 | 9.5 | 10.8 | 11.0 | 8.5 | 8.1 | 8.2 | 11.0 | 11.0 | 11.3 | 124.3 | 45.4 | 96 |

4. Glennies Creek Underground Coal Mine.
5. Possum Skin Dam.
6. Proposed Glennies Creek Open Cut.
7. Export to other mining operations.

Existing dirty water management for the Glennies Creek Underground Coal Mine has involved a complex relationship with the Camberwell South Pit and shared Camberwell CHPP with physical, operational and management links.

Even with the development of the proposed Glennies Creek Open Cut Coal Mine and the integration of the operations through the Integra Coal Joint Venture, the Glennies Creek Underground Coal Mine would remain the central focus of the operations (R. Corbett per comm.). While dirty water management must consider the entire operation within the constraint of total containment, the primary objective is to preserve production from the underground operation.

Since Glennies Creek Underground Coal Mine is accessed through a portal in the Camberwell North Pit highwall, the water management system must:

- ensure total containment up to a prescribed ARI;
- prevent flooding of the portal;

and within these constraints

- provide a reliable water supply for mining-related purposes.

The Proponent proposes to contain all dirty water on site within the Integrated Surface Water Management System. This would involve the following.

- Total containment of dirty water within the Camberwell North Pit sump, Possum Skin Dam, Dirty Water Dams and Tailings Dams up to a prescribed Average Recurrence Interval (ARI) rainfall event.
- In the event of rainfall in excess of the prescribed ARI event, release of dirty water off site would be prevented through the use of either the proposed Glennies Creek Open Cut Coal Mine or Camberwell South Pit for additional water storage.

4.2 Background

Between November 1998 and November 2003, the Camberwell North Pit Sump level rose from 9m AHD to 50m AHD simply because inputs exceeded outputs. Both the Camberwell and Glennies Creek operations impacted the sump water balance. In response to the high water levels and threat to the Glennies Creek Underground Coal Mine, Possum Skin Dam was constructed and measurement and water management progressively implemented.

Recent water management has been focused on minimizing unnecessary discharges to the Camberwell North Pit Sump and maximizing water export. Notwithstanding the expansion of the Camberwell CHPP from 800tph to 1 200tph and some increased South Pit catchment since November 2003, the sump has been drawn down to ~ 41m AHD (February 2007) and Possum Skin Dam levels reduced. The upgrade of the Camberwell CHPP has resulted in a reduction in wet tailings production as a proportion of ROM (from probably greater than 20% to about 10%), the key changes being reduced dirty water discharge to D2, reduced seepage below tailings dams TD1 and TD2 due to less tailings, tailings beaching, tailings return water pumps and export to Rixs Creek and Ashton Mines.

4.3 Objectives of the Analysis

The combined Camberwell-Glennies Creek dirty water circuit can be analysed in total and in segments. The Camberwell CHPP, tailings dam, North Pit waste rock emplacement, portal sump and underground is analysed in detail first. Additional components, including the Camberwell South Pit and the proposed open cut are then considered to show their impact on the water balance.

It is important to emphasise again that the Camberwell North Pit Sump is the ultimate repository of all excess dirty water. When the sump level is falling, there is net consumption of dirty water. When it is rising, there is excess dirty water.

In a hydrological sense, the combined dirty water system is unusual, if not unique, with very large storage compared to its contributing catchment area. This large storage heavily dampens the response to rainfall with critical conditions being wet periods of the order of weeks to months, rather than individual storm events. The modelling and analysis methodology developed is consistent with this form of response.

The analysis developed here is directed towards:

- establishing the requirements for a long term water balance and the capacity to draw down the portal sump to any prescribed level;
- defining the surcharge storage necessary to ensure total containment up to a prescribed ARI rainfall event without impacting on the operation of the existing or proposed operation; and
- total containment of dirty water during extreme wet periods

4.3.1 Overall Water Balance

At a macro scale or systems level, the Integrated Surface Water Management System can be represented as an open system receiving inputs, having storage and discharging outputs. This open system includes open pits, the Camberwell CHPP, tailings dam, waste rock emplacements, Possum Skin Dam and the Camberwell North Pit.

Inputs to the system include rainfall over the entire system footprint, clean water drawn from local dams, and groundwater from the surrounding coal seam aquifers and dewatering flows from underground.

Outputs include direct evaporation from water surfaces including Possum Skin Dam, tailings and dirty water dams and pit floors, as well as water lost to coal through the washing process, water used for dust suppression and water exported to other mines.

Storage is associated with each of the dams, the capillary space of tailings and weathered waste rock emplacement material, and the void within the space of the waste rock emplacement within the Camberwell North Pit.

Figure 14 illustrates schematically the existing primary internal and external linkages for the Integrated Surface Water Management System. **Figure 15** similarly illustrates the Integrated Surface Water Management System including the proposed open cut.

The proposed Glennies Creek Open Cut Coal Mine and associated waste rock emplacement has a total footprint of 1.89km², some of which overlies the existing historic Camberwell North Pit waste rock emplacement. The “new” catchment area adds rainfall input and evaporative output.

Mining operations, particularly open cut operations, have an ever changing landscape and this, in conjunction with the heavily dampened response of the waste rock emplacement-sump system, suggests a macro rather than microscopic approach should be used in the analysis of the water balance.

The nature of the dirty water management system is such that the difference between total inputs and outputs manifests itself as a change in sump storage. If sump water levels are rising, then inputs exceed outputs and vice versa. A review of sump level history provides an indication of the requirements for a water balance.

4.3.2 Camberwell Coal Handling and Processing Plant Water Circuit

Figure 16 provides a simplified schematic of the Camberwell CHPP water circuit. This is the innermost component of the larger schematics of the overall water balance in **Figure 15**. The deficit generated by this circuit represents the maximum total of ‘other’ inflows to the Camberwell North Sump that can be absorbed without causing an increase in water level. These ‘other’ inflows are dewatering from the underground, rainfall deep percolation on the Camberwell North Pit waste rock emplacement and so on.

Tailings disposal for Camberwell was reviewed by Australian Tailings Consultants in May 2005 as part of the Camberwell CHPP upgrade investigations⁽¹¹⁾. This independent report, together with direct measurements by PSM, has been used as the source for tailings quantities and characteristics.

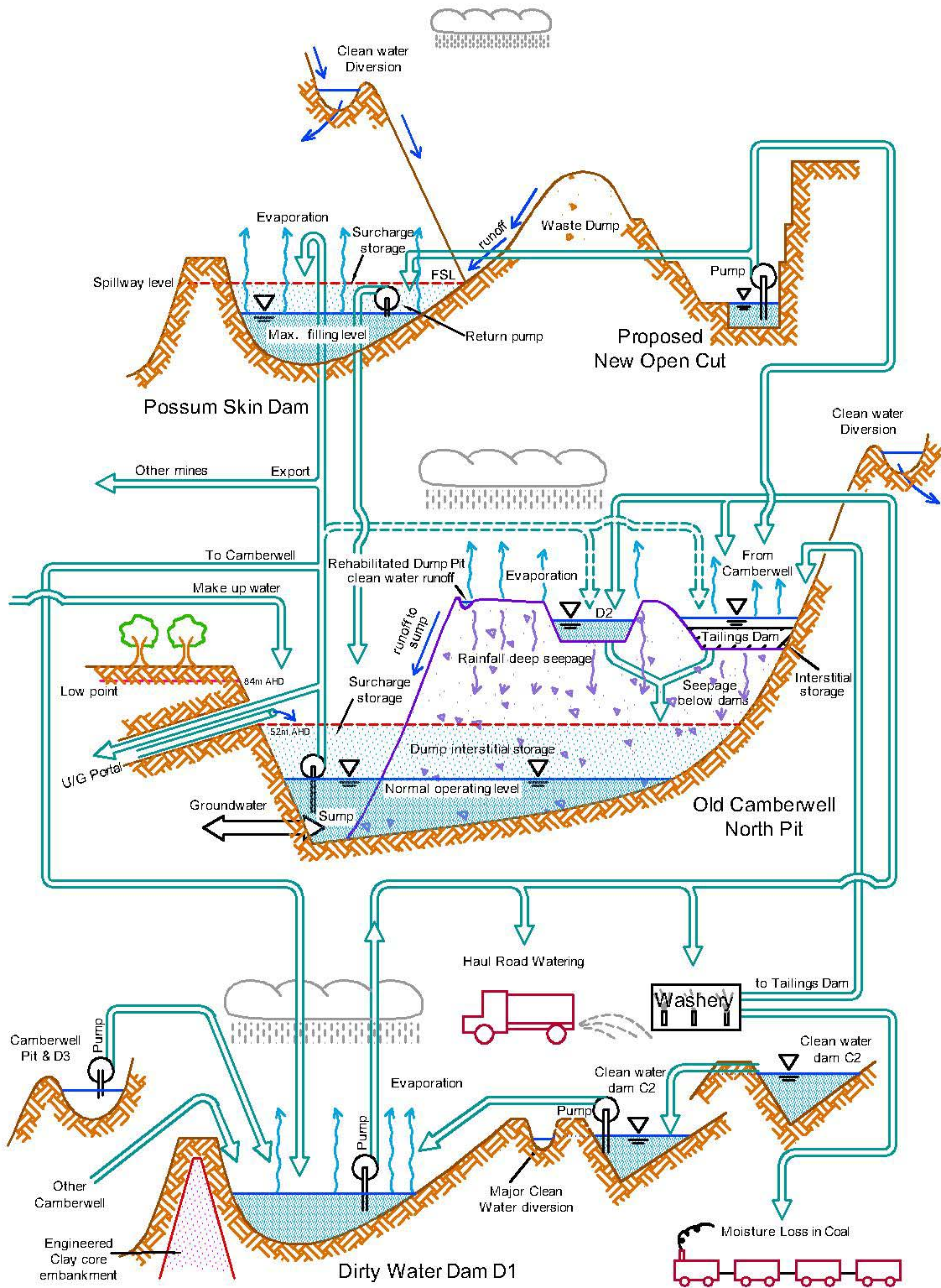


Figure 15
Proposed Dirty Water Management Schematic with New Open Cut

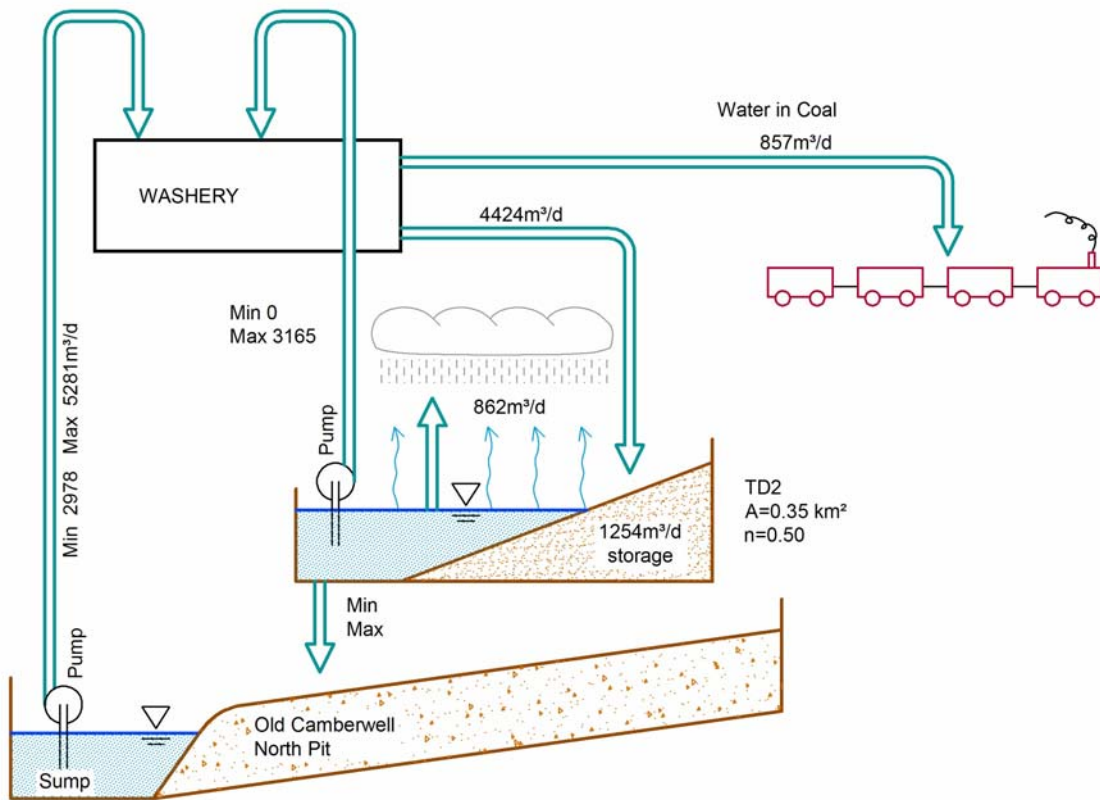


Figure 16
Coal Handling and Processing Plant Dirty Water Circuit Schematic

The report indicates an annual CHPP throughput of 8.7Mtpa with a 10% tailings yield and tailings slurry with a 30 to 40% solids concentration. Tailings dam sampling by PSM in March 2005 indicated highly variable in situ porosities with an average of 0.61. With better tailings management, porosities of 0.5 ought to be achievable. While this reduces the interstitial storage, it increases the solids capacity of the tailings dam and therefore the expected management objective.

Table 12 provides an analysis of a managed CHPP water circuit assuming 10% tailings yield (with sensitivities of 7.5 and 12.5%), with 35% slurry solids density (sensitivities 30% and 40%) and deposited tailings in situ porosities of 0.5 (sensitivities 0.4 and 0.6).

The right hand column in the table is the CHPP circuit water deficit i.e. the volume of water that must be drawn from sump storage or elsewhere. A deficit within the range 2 550 to 3 600m³/d is indicated. For the purposes of this assessment, a deficit of 3 000m³ / day has been assumed.

The numbers in **Figure 16** represent the managed CHPP water supply circuit with best estimate parameters. If losses from this circuit are entirely supplied from the sump then 3 000m³/d could be extracted. The figure shows the CHPP water sourced from sump and tailings supernatant pond. The overall balance is unaffected by the proportion.

Table 12
Coal Handling and Processing Plant Circuit Water Balance

| Tailings | | Slurry | | Deposited Tailings | | | | Water in Coal | Circuit Deficit | |
|--------------|--------------|----------|-----------------|--------------------|-------------------------|------------------|------------------|---------------|-----------------|-------------------|
| Fraction (%) | Tonnes Mtpa | % Solids | Contained Water | Porosity | Interstitial Water Mtpa | Supernatant Mtpa | Evaporation Mtpa | Mtpa | Mtpa | m ³ /d |
| 7.5 | 0.653 | 35 | 1.213 | 0.5 | 0.344 | 0.869 | 0.315 | 0.322 | 0.981 | 2 686 |
| 10 | 0.870 | 30 | 2.03 | 0.4 | 0.305 | 1.725 | 0.315 | 0.313 | 0.933 | 2 554 |
| 10 | 0.870 | 30 | 2.03 | 0.5 | 0.458 | 1.572 | 0.315 | 0.313 | 1.086 | 2 973 |
| 10 | 0.870 | 30 | 2.03 | 0.6 | 0.687 | 1.343 | 0.315 | 0.313 | 1.315 | 3 600 |
| 10 | 0.870 | 35 | 1.616 | 0.4 | 0.305 | 1.311 | 0.315 | 0.313 | 0.933 | 2 554 |
| 10 | 0.870 | 35 | 1.616 | 0.5 | 0.458 | 1.158 | 0.315 | 0.313 | 1.086 | 2 973 |
| 10 | 0.870 | 35 | 1.616 | 0.6 | 0.687 | 0.929 | 0.315 | 0.313 | 1.315 | 3 600 |
| 10 | 0.870 | 40 | 1.305 | 0.4 | 0.305 | 1.000 | 0.315 | 0.313 | 0.933 | 2 554 |
| 10 | 0.870 | 40 | 1.305 | 0.5 | 0.458 | 0.847 | 0.315 | 0.313 | 1.086 | 2 973 |
| 10 | 0.8070 | 40 | 1.305 | 0.6 | 0.687 | 0.618 | 0.315 | 0.313 | 1.315 | 3 600 |
| 12.5 | 1.088 | 35 | 2.021 | 0.5 | 0.573 | 1.448 | 0.315 | 0.304 | 1.192 | 3 264 |

Note 1: Bold = best estimate parameter.

It is important to note that at a practical level, tailings seepage and sump pumping to the Camberwell North Pit are linked. If tailings water management is poor then seepage is large but the CHPP makeup water requirement is also proportionally larger. Other than unnecessary pumping costs, a problem only arises when the extra makeup water is drawn from outside the pit sump system, for example, if there is inadequate sump pump capacity.

If the sump provides the total water supply for the CHPP then there is a significant deficit ($\approx 3\,000\text{m}^3/\text{d}$) resulting in drawdown of the sump.

This deficit is composed of:

- added water in coal (typically about 4% increase by weight) $860\text{m}^3/\text{d}$;
- tailings dam interstitial water $1\,250\text{m}^3/\text{d}$; and
- net evaporation loss from tailings dam $860\text{m}^3/\text{d}$.

Therefore, for a managed CHPP circuit the Camberwell North Pit sump's level can be reduced provided other inflows (underground, coal seam aquifers and rainfall deep percolation), less export to other mining operations, on average do not exceed $3\,000\text{m}^3/\text{d}$.

4.3.3 Camberwell North Pit Sump Water Balance

The water balance equation for the Camberwell North Pit Sump is:

$$\text{Inflow Rate} - \text{Outflow Rate} = \text{Rate of Change of Storage.}$$

In subsequent sections, component inflows and outflows, both actual and proposed, are discussed and quantified within the constraints of the available data. Where uncertainty is significant sensitivity limits are established. The storage capacity of the Pit Sump system is then provided and estimates of waste rock emplacement drainable porosity presented. Storage characteristics for Possum Skin Dam are also provided.

4.3.4 Inputs

Inputs to the Integrated Dirty Water Management System currently include the following.

- Tailings dam seepage.
- Direct rainfall and surface runoff.
- Rainfall deep percolation.
- Regional groundwater.
- Underground mine dewatering.
- South Pit (Managed).
- Camberwell South Pit.

4.3.4.1 Tailings Dam Seepage

Under worst case conditions (surfeit of water), tailings dam seepage is limited by the permeability of the underlying material. More generally it is limited by water management. For TD2, see **Figure 4**, the northwest end of the dam abuts highly permeable waste rock. If tailings is beached at this end and the supernatant pond is forced to the east seepage would be low. Conversely if tailings is beached from the east and the supernatant pond forced to the west adjacent to the permeable waste rock, and there is no attempt to recover tailings water, then seepage would be high.

Tailings dam seepage was considered and quantified in the context of CHPP circuit section in **Section 4.3.2** and is not repeated here.

4.3.4.2 Direct Rainfall and Surface Runoff

The water surface of the portal sump is comparatively small, of the order of 50 x 50m or less. Based on surface topography, around 0.5km² of catchment drains directly to the sump. Because, as is demonstrated below, the temporal response of the system is large, it is immaterial for this small area if rainfall excess enters the system quickly as direct runoff more, or slowly by percolating through the waste rock. For simplicity of analysis, all direct rainfall and surface runoff inputs have been included with the Rainfall Deep Percolation inputs discussed below.

4.3.4.3 Rainfall Deep Percolation

Rainfall Deep Percolation is a highly transient quantity and is both important and difficult to quantify. This is the primary uncontrolled or nature driven input to the historic Camberwell North Pit Sump system. The other is coal seam aquifer inflows and outflows.

To put this in perspective, the catchment area of the historic Camberwell North Pit Sump system excluding tailings dams is 3.7km². Mean annual rainfall averages a little less than 2mm/d. If 20% of this 2mm/d was deep percolation then the inflow would be 1 280m³/d.

Since regular measurement of sump levels and flows has begun, there have been no major rainfall events which might be used to obtain a direct indication of percolation amounts.

For a macro balance, the average fraction of incident rainfall that becomes deep percolation and the time this takes to reach the sump are critical variables. Without direct measurement, these must be estimated indirectly. Two approaches are adopted for this: one the extrapolation of natural catchment data and the other agricultural type point source modelling.

Extrapolation of Natural Catchment Data

It is now widely argued in the hydrologic literature that vegetation on natural catchments adjusts species type and densities so as to maximize biomass production^{(12). (13)}. For dry catchments (evaporation exceeds rainfall) this results in minimum runoff.

The effect of man's intervention primarily through vegetation change (deforestation) is to increase runoff. Regional gauged catchments indicate a mean annual runoff of around 80mm/a⁽¹⁴⁾. This 80mm/a is the sum of both direct and baseflow runoff. Proportioning the total runoff between direct and baseflow is difficult, however, the Australian Water Balance Model^{(15), (16)} Base Flow Index is a useful indication. Based on this published data an average value for the baseflow fraction of around 0.34 with a standard deviation of 0.14 is indicated.

Based on this, what is likely response of the bare and vegetated waste rock emplacements. For natural catchments within a few metres of the surface the vertical profile consists of vegetated topsoil, subsoil and basement, with the latter typically being of low permeability. When the soil profile is saturated, the propensity is for surface water runoff rather than deep percolation. By contrast, for waste rock emplacements, there is no low permeability basement to slow deep percolation and promote baseflow, or to "pond" water within the profile for later loss by evapotranspiration. When the soil profile is saturated following significant rainfall, the propensity would be for deep percolation rather than surface runoff. A natural catchment baseflow fraction mean +1 standard deviation is considered reasonable for a re-vegetated overburden emplacement. For a bare overburden emplacement the higher runoff is associated with surface sealing and reduced evapotranspiration. The surface sealing that promotes surface runoff at the same time reduces the opportunity for deep percolation. A deep percolation fraction similar to natural catchments, 0.34 seems reasonable.

Annual runoff is the small difference between rainfall and actual evapotranspiration. Actual evapotranspiration is, in addition to rainfall, strongly affected by the moisture holding capacity of the root zone, which in turn is a function of soil type and rooting depth. If average annual actual evapotranspiration is reduced by 50mm, while rainfall remains the same, then average annual runoff is increased by 50mm and vice versa.

Based on an analysis of Hunter Valley and Glennies Creek gauged catchments mean annual runoff is around 80mm, (**Section 3.2.2**). These are termed "natural" but in reality are mostly impacted by man.

For these natural catchments there is a well developed soil profile both in terms of fertility and moisture holding capacity. For a revegetated waste dump with shallow topsoiling moisture holding capacity is expected to be less than for a 'natural' catchment leading to less actual evapotranspirations and proportionally higher rainfall excess. Actual evapotranspiration is assumed to be 40mm / a less, and rainfall excess 40mm more.

For a bare waste rock emplacement profile effective storage capacity is further reduced by the absence of extracting roots at depth. Further surface sealing reduces infiltration. The combined effect of these is estimated to reduce actual evapotranspiration by 80mm and increase rainfall excess by 80mm over 'natural'.

These are indicative figures only and it is noted that over time weathering of dump surface material occurs, improving 'soil' structure and water holding capacity.

Table 13 presents mean annual rainfall excess and baseflow estimates for waste rock emplacement based on extrapolation of natural catchment data.

Table 13
Mean Annual Rainfall Excess and Baseflow Estimates for
Waste rock Emplacements Based on Natural Catchment Data

| Quantity | Catchment Type | | |
|----------------------------------|----------------|---|-----------------------------------|
| | Natural | Re-vegetated Waste rock emplacement | Bare Waste rock emplacement |
| Mean Annual Rainfall Excess (mm) | 80 | 120 | 160 |
| Baseflow fraction (-) | 0.34 | 0.48 | 0.34 |
| Deep Percolation (mm) | 27 | 58 | 54 |

In rounded figures, this indicates approximately 60mm/a average deep percolation for both re-vegetated and bare waste rock emplacements. Diversion of much of surface runoff from re-vegetated waste rock emplacements out of the dirty water circuit is both possible and advisable. However, as this is yet to be implemented it is assumed all waste rock emplacement runoff continues to report to the dirty water circuit either by direct percolation to the sump or surface runoff to D1. The North Camberwell Pit emplacement is composed of 1.45km² of re-vegetated waste rock emplacement and 2.25km² (See **Figure 4**) of bare waste rock emplacement. Applying the runoff rates from **Table 13**, average mean annual runoff is 144mm/a which corresponds to 1 460m³/d average inflow to the sump. This inflow is a composite of deep percolation, direct surface runoff and 'sink hole' percolation of surface runoff.

Simple Model

Intuitive extrapolation of 'natural' catchment response to very unnatural waste rock emplacements is inherently unreliable. It is therefore useful to approach the rainfall excess (runoff) estimation problem from basic hydrological principals as well.

A simple single store model with a falling rate evaporation/evapotranspiration algorithm is used. Inspection of the waste rock emplacement shows runoff may occur in isolated spots and some of this may pond on the waste rock emplacement to later infiltrate. During a significant storm in 2004 Dr. Pells of PSM and Peter Brennan of Glennies Creek Coal Management at one location observed ponded water disappearing down a sink hole in the waste rock emplacement.

The model has two parameters - the single store capacity (mm) and an evaporation resistance parameter (*k*). The evaporation resistance parameter, defines how hard it is for water to move from within the soil / rock mass to the effective evaporation site (the ground surface for a bare waste rock emplacement or a root hair for well vegetated surfaces). For vegetation there is an additional resistance moving through the plant and stomata.

The falling rate evapotranspiration function^{(17), (18)} is of the form

$$A_{et} = Pet \left(\frac{S}{S_{max}} \right)^{k.Pet} \quad (1)$$

where S is the current soil moisture, S_{max} the maximum or field capacity soil mixture, P_{et} the potential evapotranspiration, A_{et} the actual evapotranspiration and k the evaporation resistance parameter. For a self mulching clay soil with vigorous, extensively rooted annual summer crop $k \approx 0.1mm^{-1}$. For poorer soils flow resistance (k) becomes larger due to lesser root development. For evaporation solely from the surface flow resistance (k) is again larger primarily because the average flow path is longer. For the Glennies Creek waste rock emplacement flow resistance (k) is estimated at 0.4, within the likely range 0.2 to 0.8.

Again, for a self mulching agricultural clay soil, soil water holding capacity is typically in the range 150 to 200mm per metre depth of soil. For a partially weathered but un-reactive waste rock emplacement, the range is probably 30 to 60mm per metre depth.

Because of the blocky nature of the waste rock material it is anticipated that little water would migrate to the surface by capillary action from below 1m and certainly very little from below 2m. Thus the soils store capacity ranges from an upper limit of $2 \times 60 = 120mm$ to $1 \times 30 = 30mm$.

The albedo of the bare waste rock emplacements is likely in the range 0.2 to 0.4, with a best estimate of 0.3. Accordingly energy limited potential evaporation is taken to be 0.7 of the open water value of 4.39mm/d that is 3.07mm/d, say 3.0mm/d.

Table 14 presents estimated mean annual rainfall excess (the sum of surface runoff and deep percolation) for limiting cases and the best estimate established by simulation using a 121 year historic daily rainfall record⁽¹⁴⁾. Best estimate rainfall excess based on the simple model is 207mm per year with a range from 77mm per year to 295mm/a. For about 2.25km² of bare waste rock emplacement and total containment this 207mm/a corresponds to a mean inflow of 1 275m³/d within the range 474m³/d to 1 817m³/d.

Table 14
Estimated Mean Annual Bare Waste Rock Emplacement Rainfall Excess (mm)
for a Range of Simple Model Parameters

| Parameter Range | Evaporation Resistance mm ⁻¹ | Soil Storage Capacity (mm) | | |
|-----------------|---|----------------------------|--------------------------|-------------------------|
| | | Lower Limit 30 (1m) | Best Estimate 45 (1m) | Upper Limit 120 (2m) |
| Low | 0.2 | 212 | 168 | 77 |
| Best Estimate | 0.4 | 248 | 207 | 114 |
| High | 0.8 | 295 | 256 | 162 |

For re-vegetated waste rock emplacements, root development compared with evaporation solely from the surface reduces the resistance to moisture flow primarily by reducing the flow length and increasing the depth of the moisture storage zone. Evapotranspiration resistance is taken as half that of bare soil. Full vegetative development, especially for trees, takes many years. Here accessible "soil" depths are considered in the range 1.5 to 3.0m with the same 30 to 60mm/m moisture holding capacity. **Table 15** presents estimated mean annual rainfall excess based on the simple model.

Table 15
Estimated Mean Annual Rainfall Excess for Re-vegetated
Waste Rock emplacement Based on Simple Model

| Parameter Range | Evapotranspiration Resistance | Soil Store Capacity (mm) | | |
|-----------------|-------------------------------|--------------------------|------------|----------|
| | | 45 (1.5m) | 90 | 180 (3m) |
| Low | 0.1 | 146 | 78 | 31 |
| Best Estimate | 0.2 | 168 | 101 | 50 |
| High | 0.4 | 207 | 139 | 82 |

A representative rainfall excess value of 101mm within the range 31 to 207 is indicated. With 48% deep percolation over 1.45km² of revegetated emplacement this computes to 401m³/d within the range 123 to 822m³/d.

Combining re-vegetated and bare waste rock emplacement areas the simple model estimate of rainfall excess driven inflow is 1 676m³/d within the range 600 to 2 600m³/d.

In summary, the natural catchment extrapolation indicates around 1 460 m³/d of rainfall excess driven inflow while the simple model indicates around 1 676m³/d. A prudent value of 1 700m³/d is adopted as the long term mean rainfall excess inflow to the portal sump from the North Camberwell waste rock emplacement. The associated rounded bare and revegetated waste rock dump mean annual rainfall excesses are 210 and 100mm respectively.

Historic Data

There is some historic information on sump levels and, consequently, changes in storage within the pit between these levels and corresponding dates may be established for an assumed porosity. However, no periods, coincident with heavy rainfall, could be established in which there was either no pumping in or out of the pit, or for which the pumping rate was known. Consequently, and unfortunately, there is no historic basis for validating the rainfall driven emplacement inflows.

With pump flow rates now available and CHPP tailings flow rates likely available in the near future, rainfall deep percolation would likely become the largest unknown within the circuit.

Because deep percolation is disproportionately associated with significant wet periods a long period of monitoring would be required to define “mean” rates.

4.3.4.4 Underground Mine Dewatering

With the initial underground development, there were significant groundwater inflows around 2 000m³/d. Over time, these have continued to decline such that total inflows of around 1 000m³/d now about match water supplied to the underground for operational purposes.

Actual net groundwater seepage is likely to be in the range -300 to +300m³/d. While the possibility of underground expansion intersecting stronger seepage sources remains, the more extensive the underground openings become the less likely that a significant new source would be encountered due to the dewatering of the surrounding material that has already occurred.

For water balance analysis it is conservatively assumed 200m³/d of 'new' seepage water is produced by the Glennies Creek Underground Coal Mine.

4.3.4.5 Proposed Glennies Creek Open Cut Coal Mine

The proposed Glennies Creek Open Cut Coal Mine footprint overlays natural ground, existing waste emplacements, the north pit subcrop and the original Station Creek topographical divide. As a result the rainfall percolation paths are complex. **Figure 17** illustrates some differences between natural catchments and mine area ones.

Figure 18(a) provides surface runoff areas by destination while **Figure 18(b)** shows percolation areas by destination. **Figure 19** further subdivides the footprint such that each area has a unique surface runoff destination and deep percolation destination.

This figure has been used to prepare **Table 18** which estimates runoff and percolation for each of the sub areas A through M for the last day of mining when total runoff potential is approximately at its maximum. [It is noted that since preparation of this figure and table the footprint has been decreased somewhat – the runoff numbers are therefore conservative].

At the completion of mining operations, the footprint of the proposed Glennies Creek Open Cut Coal Mine would be approximately 1.89km², composed of a final void of 0.16km², 0.74km² of associated in pit waste rock emplacement, 0.86km² of out of pit emplacement and 0.14km² of natural catchment. Of this total area, approximately 1.14km² would drain towards the final void and 0.42km² would drain externally. Deep percolation would drain to the proposed Open Cut and the Camberwell North Pit. There would be negligible deep percolation to natural drainage.

Following completion of mining operations, the void would be progressively backfilled and the disturbed area revegetated with grasses and trees. As backfilling and revegetation progress, clean surface runoff would be diverted to natural drainage. However in the context of dirty water management the last day of mining represents a sensible worst case, that is the "make" of dirty water, is at its greatest.

The internally draining area is also at a maximum at the end of mining operations and is conservatively used to evaluate the dirty water balance.

For the final proposed open cut footprint for some areas both the surface runoff and deep percolation is to the proposed open pit. For others deep percolation continues to report to the old Camberwell Pit while surface runoff reports to the proposed open pit.

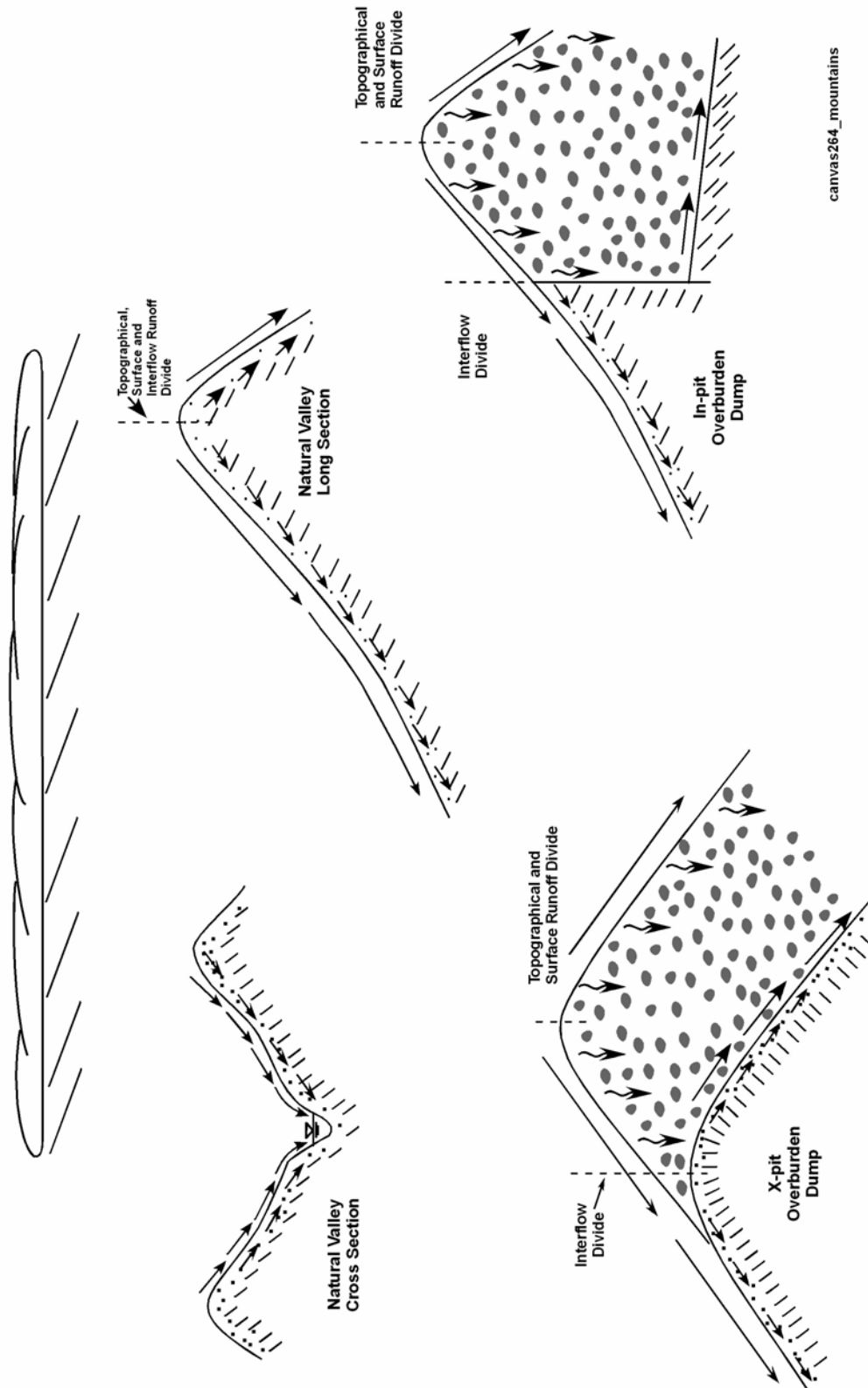


Figure 17
Interflow and Groundwater Flow Paths in Natural Valleys and In-pit and X-pit Waste Rock Dumps

Pit Floor Runoff

For the pit floor, runoff is estimated as rainfall total less ϕ mm of initial abstraction or wetting up. **Table 16** presents mean annual pit floor runoff for several values of ϕ .

Table 16
Mean Annual Pit Floor Rainfall Excess for a Range of Initial Abstractions

| Initial Abstraction (mm) | Runoff Fraction (-) | Mean Annual Runoff (mm) | 0.16km ² Pit Floor Runoff (m ³ /d) |
|--------------------------|---------------------|-------------------------|--|
| 1 | 0.89 | 629 | 276 |
| 2 | 0.80 | 566 | 248 |
| 3* | 0.73 | 514 | 225 |
| 4 | 0.66 | 470 | 206 |
| 5 | 0.61 | 431 | 189 |
| * Best estimate | | | |

Runoff/Percolation All Surfaces

Runoff and percolation characteristics for all surfaces used in assessing the proposed Glennies Creek Open Cut Coal Mine are summarized in **Table 17**. These factors were established in **Section 4.3.4.3**.

Table 17
Adopted Mean Annual Rainfall Excess Totals and Proportions by Catchment Type

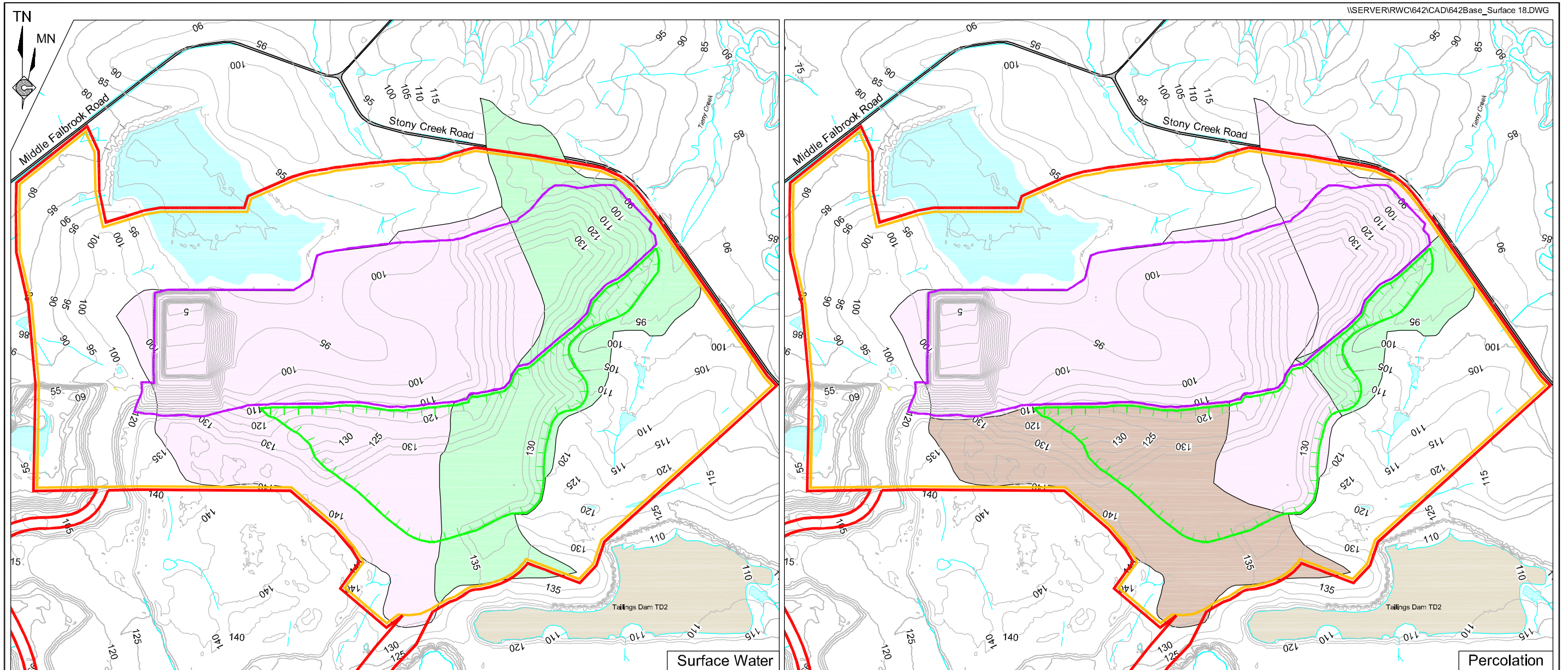
| Catchment Type | Rainfall Excess (mm/a) | Surface Runoff | | Baseflow/Deep Percolation | |
|-------------------------------------|------------------------|----------------|------|---------------------------|------|
| | | Fraction | mm/a | Fraction | mm/a |
| Natural Catchment | 80 | 0.66 | 53 | 0.34 | 27 |
| Re-vegetated Waste Rock emplacement | 100 | 0.42 | 42 | 0.58 | 58 |
| Bare Waste Rock emplacement | 210 | 0.66 | 139 | 0.34 | 71 |
| Pit Floor/Final Void | 514 | 1.00 | 514 | 0.00 | 0 |

Table 18, which needs to be considered in conjunction with **Figure 19** and **Table 17**, provides subcatchment rainfall excess quantities by surface, vegetative cover and deep percolation destinations.

Both surface runoff and deep percolation have three possible destinations – the proposed Glennies Creek Open Cut Coal Mine, the historic Camberwell North Pit or natural drainage.

The detail in **Table 18** is required to avoid double accounting of deep percolation in particular.

The estimated total of the proposed Glennies Creek Open Cut Coal Mine average ‘new water’ contribution to the portal sump by seepage and pumping on “the last day of mining” is 571m³/d (say 600m³/d) via the proposed open cut and 74m³/d directly by deep percolation. An additional 109m³/d reports to natural drainage downstream.



- REFERENCE
- Project Site Boundary
 - 7.7Mt Open Cut Pit Shell
 - Out-of-Pit Waste Rock Emplacement Boundary
 - Surface Water Flow to Dirty Water Management System
 - Surface Water Flow to Natural Drainage (Rehabilitation Complete)
 - 135 Contour (m AHD)(Interval = 5m)
 - Creek / Drainage Line
 - Dam / Water Storage

- REFERENCE
- Project Site Boundary
 - 7.7Mt Open Cut Pit Shell
 - Out-of-Pit Waste Rock Emplacement Boundary
 - Percolation to Glennies Creek Open Cut
 - Percolation to Natural Drainage
 - Percolation to Camberwell North Pit Sump
 - 135 Contour (m AHD)(Interval = 5m)
 - Creek / Drainage Line
 - Dam / Water Storage

SCALE 1:15 000
 250 0 250 500 750 m
 Base Map Source: Geo-Spectrum (Australia) Pty Ltd - Date: December 2004

Figure 18
 DESTINATION OF SURFACE WATER
 AND PERCOLATION BY CATCHMENT
 AT COMPLETION OF MINING

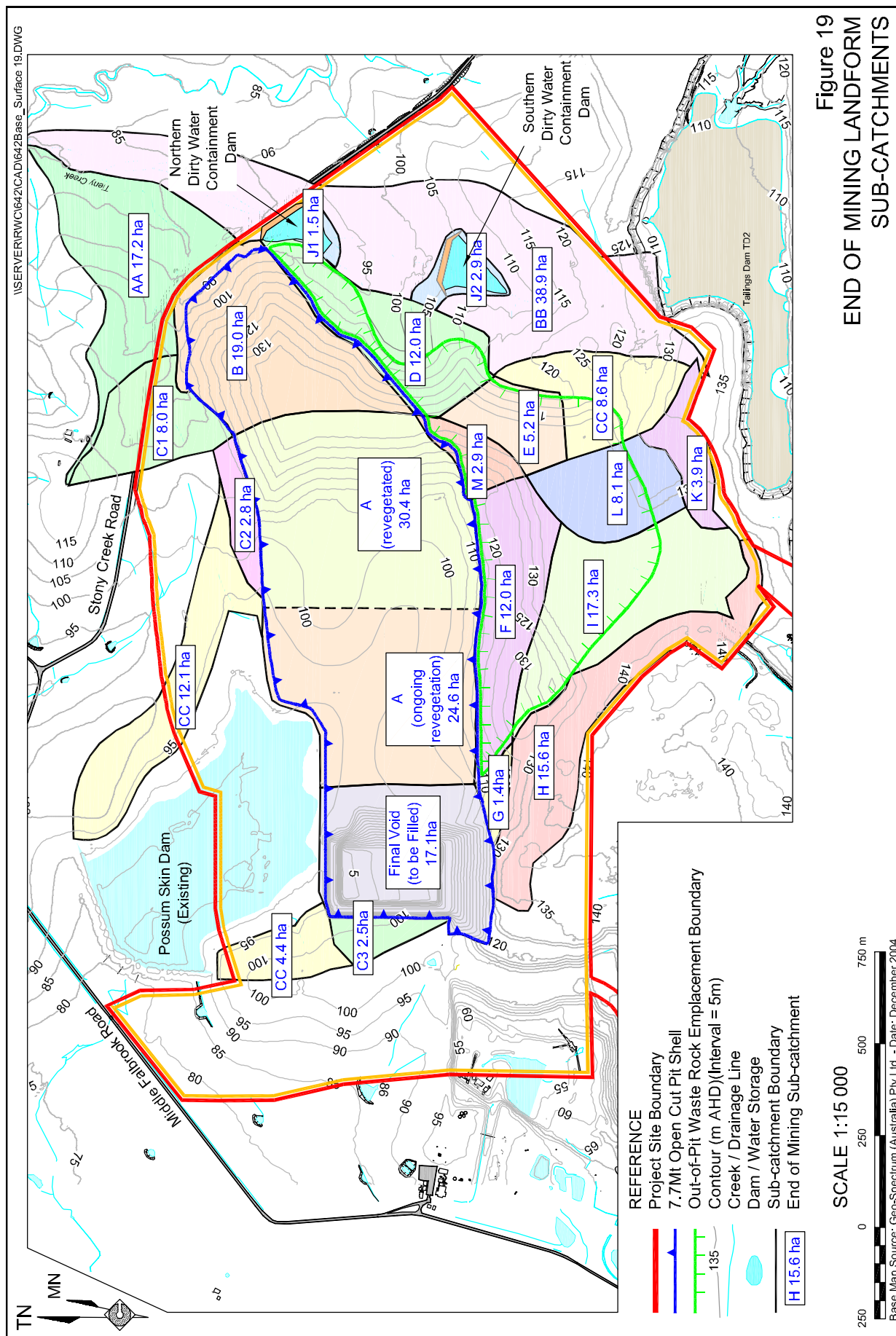


Figure 19
END OF MINING LANDFORM
SUB-CATCHMENTS

Note: A Colour Version of this figure is available on the project CD

Table 18
Proposed Glennies Creek Open Cut Coal Mine - Last Day of Mining Mean Annual Rainfall Excess
(Surface Runoff and Deep Percolation) and Destinations by Subcatchment

| Sub-Catchment | Area (km ²) | Type | Cover Status | Destination | | | | | | | | | |
|--------------------------------------|-------------------------|----------------------------------|--------------|------------------|------------|---------|--|------------------|------------|---------|------------|------------|------------|
| | | | | Surface Runoff | | | | Deep Percolation | | | | | |
| | | | | Natural Drainage | | New Pit | | Natural Drainage | | New Pit | | Camberwell | |
| | | | | Area | Runoff | Area | Runoff | Area | Runoff | Area | Runoff | Area | Runoff |
| Final Void | 0.16 | Pit Floor | Bare | | | 0.16 | 514 ⁽¹⁾ (225) ⁽²⁾ | | | 0.160 | 0 (0) | | |
| A 50% | 0.272 | In-pit Emplacement | Re-vegetated | | | 0.272 | 42 (31) | | | 0.272 | 58 (43) | | |
| A 50% | 0.272 | In-pit Emplacement | Bare | | | 0.272 | 139 (104) | | | 0.272 | 71 (53) | | |
| B | 0.192 | In-pit Emplacement | Re-vegetated | 0.192 | 42 (22) | | | | | 0.192 | 58 (30) | | |
| C1 | 0.083 | Natural | Natural | 0.083 | 53 (12) | | | 0.083 | 27 (6) | | | | |
| C2 | 0.027 | Natural | Natural | | | 0.027 | 53 (4) | | | 0.027 | 27 (2) | | |
| C3 | 0.026 | Natural | Natural | | | 0.026 | 53 (4) | | | 0.026 | 27 (2) | | |
| D | 0.116 | Outside Pit Emplacement | Re-vegetated | 0.116 | 42 (13) | | | 0.116 | 58 (18) | | | | |
| E | 0.066 | Outside Pit Emplacement | Re-vegetated | 0.066 | 42 (8) | | | | | 0.066 | 58 (10) | | |
| F | 0.11 | Overlay Outside Pit Emplacement | Re-vegetated | | | 0.110 | 42 (13) | | | 0.11 | 58 (17) | | |
| G | 0.012 | Camberwell North Pit Emplacement | Re-vegetated | | | 0.012 | 42 (1) | | | 0.012 | 58 (2) | | |
| H | 0.17 | Camberwell North Pit Emplacement | Re-vegetated | | | 0.170 | 42 (20) | | | | | 0.170 | 58 (27) |
| I | 0.167 | Overlay Outside Pit Emplacement | Re-vegetated | | | 0.167 | 42 (19) | | | | | 0.167 | 58 (27) |
| J1 & J2 | 0.04 | Camberwell North Pit Emplacement | Re-vegetated | 0.058 | 77 (9) | | | 0.040 | 39 (4) | | | | |
| K | 0.044 | Camberwell North Pit Emplacement | Re-vegetated | 0.044 | 42 (5) | | | | | | | 0.044 | 58 (7) |
| L | 0.083 | Overlay Outside Pit Emplacement | Re-vegetated | 0.083 | 42 (10) | | | | | | | 0.083 | 58 (13) |
| M | 0.054 | Outside Pit Emplacement | Re-vegetated | 0.054 | 42 (6) | | | | | 0.054 | 58 (9) | 0.054 | |
| Contributing Area (km ²) | | | | 0.678 | | 1.216 | | 0.239 | | 1.191 | | 0.518 | |
| Runoff (m ³ /d) | | | | | (85) | | (421) | | (28) | | (168) | | (74) |

⁽¹⁾ Unit area rate mm/a e.g. 514
⁽²⁾ Subcatchment rate m³/d e.g. (225)

Once the proposed Open Cut void has been backfilled and revegetated, the surface runoff component of void inflow (403m³/d) would be diverted to natural catchment downstream, leaving long term only deep percolation to be dissipated to groundwater and the portal sump.

Table 19 presents indicative responses for the 10% wet and dry years assuming runoff proportion to rainfall squared about mean rainfall.

Table 19
Indicative Annual Runoff/Deep Percolation Flows and 10% Wet and Dry Conditions

| Statistic | Annual Calendar Year Rainfall (mm) | Destination | | |
|--|------------------------------------|--|---|---|
| | | Proposed Open Cut ⁽²⁾ (m ³ /d) | Camberwell North Pit ⁽²⁾ (m ³ /d) | Natural Drainage ⁽²⁾ (m ³ /d) |
| Dry [Exceeded 90% of years] | 458 | 228 | 30 | 43 |
| Mean ⁽¹⁾ | 725 | 571 | 74 | 109 |
| Wet [Exceeded 10% of years] | 933 | 946 | 123 | 181 |
| (1) Based on period 1881 – 2003. | | | | |
| (2) Runoff proportional to P^2 about \bar{P} . | | | | |

4.3.4.6 Camberwell South Pit

The Camberwell South Pit has a footprint of approximately 2km². Based on the data in **Table 16**, the Camberwell South Pit floor mean annual runoff is 514mm which equates to 2 814m³/d (assume 2 800m³/d).

4.3.5 Outputs

Outputs from the Integrated Surface Water Management System include the following.

- CHPP water supply.
- Possum Skin Dam evaporation.
- Regional groundwater.
- Underground mine dust suppression.
- Surface dust suppression.
- Export to other mining operations.

4.3.5.1 Coal Handling and Processing Plant Water Supply

The CHPP circuit has been detailed in **Section 4.3.2**. Following recent upgrades, it is expected to consume about 3 000m³/d (**Section 4.3.2**). This is made up of tailing interstitial storage, tailings dam evaporation and water exported in coal.

4.3.5.2 Possum Skin Dam Evaporation

Possum Skin Dam was constructed to provide emergency dirty water storage when the portal was under threat of inundation. On an ongoing basis it provides evaporation loss. The level in the dam is maintained at the maximum safe no spill level to maximize net evaporation (evaporation – rainfall). This is estimated to have averaged 493m³/d.

It is proposed to divert some of the proposed new open cut waste emplacement runoff to the Possum Skin Dam. To do this within the original total containment to the 100 year ARI event design constraint requires the maximum filling level be lowered to RL 87.5m AHD with a smaller surface area. The associated reduced evaporation is estimated at 364m³/d.

Storage and surface area characteristics are presented in **Section 4.3.6.1**.

4.3.5.3 Regional Groundwater

Regional groundwater was assessed by AGE Consultants and their report is presented as Part 8 of the *Specialist Consultant Studies Compendium*. The proposed open cut would intersect Permian-aged coal seam aquifers and AGE Consultants note that there would be both groundwater inflows and outflows from the proposed open cut. However, flows are expected to be quite small. AGE Consultants⁽²⁰⁾ estimate an average inflow of 116.5m³/d flow to the proposed Glennies Creek Open Cut. This would stabilize at around 44m³/d by the completion of mining operations. For analysis, a net Groundwater inflow of 100m³/d has been conservatively assumed.

There is a hydraulic gradient in the Hebden Seam toward the portal sump. However, flows are expected to be small compared to those from the underground or the proposed open cut. (Ian Callow, AGE Consultants per comm).

4.3.5.4 Underground Mine Dust Suppression

Approximately 1 000m³/d is pumped to the underground mine for dust suppression while between 800 to 1 200m³/d is currently pumped from underground. A net gain of 200m³/d is conservatively assumed (see **Section 4.3.4.4**).

4.3.5.5 Surface Dust Suppression

Dust suppression water is required for haul roads and stockpiles and around the Camberwell CHPP. Requirements are higher in dry periods. Average annual values are based on area by net evaporation by efficiency.

4.3.5.6 Export to Other Mining Operations

- An agreement between the Proponent and Ashton Coal Operations Pty Ltd for the supply of up to 500 000m³ of water per year or 1 400m³/day prior to the commencement of longwall mining operations at the Ashton Coal Mine. Following commencement of longwall mining, the agreement is for supply of up to 900 000m³ per year, or approximately 2 500m³/day. It is understood longwall mining is programmed to commence in 2007. This agreement is subject to mine water availability. With the exception of some minor works underground which are due for completion in the latter part of 2006, all necessary infrastructure and approvals are currently in place for the supply of this water.
- An agreement between the Proponent and Resources Pacific Pty Ltd for the supply of up to 500 000m³ per year, or approximately 1 400m³/day, of mine water to the Newpac Colliery, although neither the infrastructure nor approvals are currently in place.

Therefore, under the existing, approved formal arrangements, the integrated Glennies Creek/Camberwell water balance currently has the facilities to export up to 1 400m³/day with increases to 3 900m³/d in the future.

Additionally, since 2003, the Proponent has periodically supplied mine water to the Rixs Creek Colliery at a rate of between approximately 200 000 and 350 000m³ per year or 500 to 1 000m³/day.

4.3.6 Storage

- Possum Skin Dam
- Camberwell North Pit
- Camberwell South Pit
- Proposed Open Cut

4.3.6.1 Possum Skin Dam

To date Possum Skin Dam has operated as a dirty water (salt) storage and evaporation dam in conjunction with Pit-Emplacement-Sump water management system in the Camberwell North Pit. The dam provides temporary storage and dissipates excess water through evaporation. The dam is located in an upland valley and has clean water diversion channels designed to carry upland clean water runoff around the storage. These channels are designed for a 100 year ARI event.

The embankment and spillway have been designed according to NSW Dam Safety Committee requirements, to pass the probable maximum flood (PMF).

Under normal operation the dirty water (salt) is to be contained up to the 100 year ARI event.

That is no discharge of dirty water up to the 100 year ARI event.

This total containment design requires that a maximum filling level (89.0m AHD) be specified such that the 100 year ARI multiday wet period does not cause spill. The spillway crest level is 90.5m AHD, that is, dirty water from mining operations would only be discharged to the dam when the water level was below the maximum filling level.

As part of the proposed new open cut development some of the in pit waste emplacement surface runoff will be directed to Possum Skin Dam.

To accommodate the increased inflows while meeting the total containment to the 100 year ARI design requirement the maximum filling level must be reduced to RL 87.5m AHD.

Operating Philosophy

During a major multiday wet period both the Possum Skin Dam and Camberwell North Pit would be filling: the dam from direct rainfall on the water surface and surface runoff from the existing small perimeter catchment and the proposed new open cut waste emplacement, and the Camberwell North Pit from direct rainfall, surface runoff and deep percolation.

During normal conditions, the Possum Skin Dam operates as an evaporation basin and the larger the water surface area the greater the water loss. For this reason, it is advantageous to have the normal water level as high as possible. Conversely for the Camberwell North Pit the great majority of the water is stored within the interstitial space of the waste rock emplacement within the pit and evaporation is negligible and the water level within the Camberwell North Pit can be kept as low as possible without materially changing the loss rate.

Accordingly, the overall operating philosophy adopted is to:

- maintain the dam at the highest safe level to maximise evaporation; and
- maintain the Pit-Emplacement-Sump at the lowest level possible to maximise available wet period storage and minimise the potential for portal flooding.

To maintain the dam at as high a level as possible requires that a maximum filling level be set. Pumping to the dam would stop whenever the water reached this maximum filling level. Also, to maximize evaporation, pumping would commence whenever the water fell measurably below this level.

This means that at the time of the multiday design event it would not be possible to pump a significant volume from the Camberwell North Pit to Possum Skin Dam.

Surface Area and Storage

Table 20 presents depths, surface area and stored volume as a function of level for Possum Skin Dam.

Table 20
Possum Skin Dam Surface Area and Storage Volume as a function of Level

| Elevation (m AHD) | Depth (m) | Area (m ² x 10 ⁶) | Volume (m ³ x 10 ⁶) |
|----------------------|--------------|---|---|
| 79 | 0 | 0 | 0 |
| 80 | 1 | 0.010 | .02 |
| 81 | 2 | 0.018 | 0.035 |
| 82 | 3 | 0.026 | 0.055 |
| 83 | 4 | 0.040 | 0.09 |
| 84 | 5 | 0.062 | 0.14 |
| 85 | 6 | 0.083 | 0.23 |
| 86 | 7 | 0.111 | 0.33 |
| 87 | 8 | 0.145 | 0.47 |
| 88 | 9 | 0.185 | 0.63 |
| 89 | 10 | 0.23 | 0.83 |
| 90 | 11 | 0.28 | 1.08 |
| 91 | 12 | 0.325 | 1.40 |
| 92 | 13 | 0.36 | 1.71 |

4.3.6.2 Camberwell North Pit

In the context of a water balance with inflows equalling outflows, storage is of no consequence. However, in reality assumptions about tailings dam seepage and rainfall deep percolation can only be tested with short period data during which sump water levels would be either rising or falling. Then

$$\text{Inflow Rate} - \text{Outflow Rate} = \text{Rate of Change of Storage}$$

Geoterra/Maunsells⁽²²⁾ used contour data for the Camberwell North Pit floor to establish an area elevation table for the pit at 10m intervals from *RL-15* to *RL65* (m). This data has been used to produce the curve (log-log-linear) in **Figure 20**. The relationship between area and elevation is closely defined by

$$A_{(m^2)} = 783(RL + 15)^{1.76} \quad (2)$$

This is readily integrated to produce a storage curve for the empty pit (no waste rock) viz

$$S_{(m^3)} = \int_0^H A.dH \quad (3)$$

where $H = RL + 15$

$$S_{(m^3)} = 284(RL + 15)^{2.76} \quad (4)$$

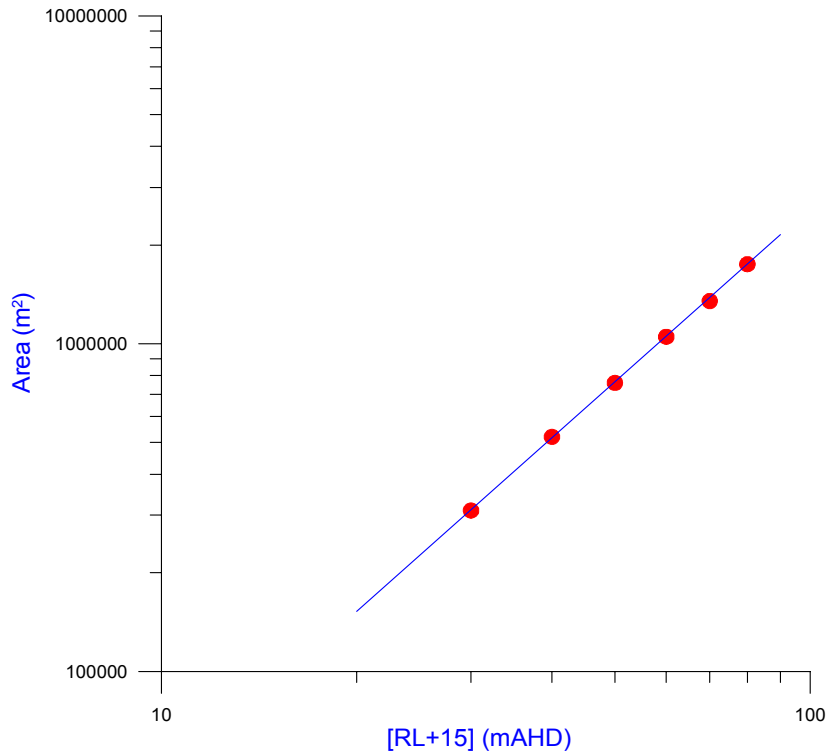


Figure 20
Surface Area Elevation Curve Camberwell North Pit

Storage at some key elevations are presented in **Table 21**.

Table 21
“Empty” or air space Pit Storage at Some Key Elevations

| Elevation m AHD | Storage (m ³) x 10 ⁶ |
|--------------------|---|
| -15 | 0 |
| 9 | 1.831 |
| 30 | 10.380 |
| 40 | 18.000 |
| 43 | 20.911 |
| 50 | 28.639 |
| 52 | 31.138 |
| 65 | 50.798 |
| 84 | 91.468* |
| *Extrapolated | |

Table 22 presents Camberwell North Pit water storage for a range of assumed porosities. Porosity is clearly important but difficult to estimate. Estimates are discussed in **Appendix B**.

4.3.6.3 Camberwell South Pit

The Camberwell South Pit footprint is currently approximately 2km².

Should an extreme wet period occur, this open cut, together with the proposed Open Cut, would be available for temporary storage of dirty water.

Table 22
Pit Waste rock emplacement Sump Water Storage (m³x10⁶) as a function of Elevation and Drainable Porosity

| Elevation (m AHD) | Drainable Porosity% | | | | | |
|----------------------|---------------------|-------|-------|-------|-------|-------|
| | 5.0 | 7.5 | 10.0 | 12.5 | 15.0 | 20.0 |
| 9 | 0.0915 | 0.137 | 0.183 | 0.229 | 0.275 | 0.366 |
| 30 | 0.519 | 0.778 | 1.038 | 1.297 | 1.557 | 2.076 |
| 40 | 0.9 | 1.35 | 1.8 | 2.25 | 2.7 | 3.6 |
| 43 | 1.05 | 1.568 | 2.091 | 2.614 | 3.14 | 4.182 |
| 45 | 1.148 | 1.722 | 2.296 | 2.870 | 3.444 | 4.592 |
| 50 | 1.432 | 2.148 | 2.864 | 3.580 | 4.296 | 5.728 |
| 52 | 1.557 | 2.335 | 3.114 | 3.892 | 4.671 | 6.228 |

4.3.6.4 Proposed Open Cut

The proposed Glennies Creek Open Cut Coal Mine, like the Camberwell South Pit, would provide dirty water storage during an extreme wet period to ensure the Proponent's commitment to nil discharge from the central dirty water circuit is achieved.

4.4 Pit-Sump-Waste Rock Emplacement Balance

Assembling the various component flows the Pit-Sump-Waste rock emplacement balance can be established for various scenarios. The objective here is to define what is required to ensure a balance and by association, what is required to ensure the portal sump, the net repository for the dirty water circuit, can over time be drawn down to any desired level.

This level being set low enough to ensure the portal is not flooded during an extended wet period and high enough to ensure water supply during drought. Portal flooding risk is assessed in **Section 4.5**.

This section focuses on the long term water balance and starts with a base case centred round the CHPP circuit and the tailings dam and portal sump within the Camberwell North Pit. Then additional inputs and outputs are progressively added and the balance re-evaluated at each stage.

Table 23 presents the Base Case i.e. no Camberwell South Pit, no proposed Open Cut and no export.

4.4.1 Base Case

For a sump level of 42m AHD and 10% porosity this corresponds to 16mm/d drawdown.

As a rule of thumb each 1 000m³/d deficit produces 10mm/d drawdown of the Camberwell North Pit Sump.

Table 23
Base Case – No Camberwell South Pit, no proposed open cut, no export

| Source | Inflow (m ³ /d) | Outflow (m ³ /d) |
|--|----------------------------|-----------------------------|
| CHPP Circuit (net) | - | 3 000 |
| Possum Skin Dam Evaporation | - | 364 |
| Rainfall Deep Percolation | 1 700 | |
| Underground (net) | 200 | |
| Regional Groundwater | <100 | |
| | | |
| Total | 2 000 | 3 364 |
| Storage depletion (3 364 – 2 000 = 1 364m ³ /d) say 1 400m ³ /d. | | |

These results should not be compared with recent experience because they include average rainfall deep percolation rates. In reality deep percolation occurs as infrequent major pulses following prolonged heavy rainfall not steady percolation.¹

For the December 2005 – March 2006 period there would have been negligible deep percolation inflow so the deficit, without export and without inflows from the South Pit, would be around 3 000m³/d with an expected Sump level decline rate of 30-35mm/d. For the period, available pumping data 22nd December 2003 to March 2006 the mean decline rate was 32mm/d.

4.4.2 Base Case + Camberwell South Pit

If the Camberwell South Pit is added to the base case, then the associated losses to haul road dust suppression and evaporation from the main Camberwell Dirty Water Dam needs to be included.

The Camberwell South Pit and CHPP footprint is approximately 2.3km², runoff from the area is conservatively estimated (all treated as pit floor, see **Table 16**) at 514mm/a, yielding 3 250m³/d.

Dust suppression requirements on haul road and stockpile areas are estimated to be 900mm/a over an area of 0.5km². This equated to a requirements for 1 233m³/d (assume 1 200m³/d). **Table 24** indicates a net water inflow for the CHPP circuit, tailings dams, dirty water dams and the Camberwell South Pit of around 300m³/d without export. This inflow rate is not inconsistent with recent experience when export to Rixs Creek is considered.

Table 24
Base Case + Camberwell South Pit

| Source | Inflow (m ³ /d) | Outflow (m ³ /d) |
|---|----------------------------|-----------------------------|
| Base Case | 2 000 | 3 364 |
| Camberwell South Pit + CHPP 2.3km ² Haul Road Dust Suppression | 3 250 | 1 200 |
| D1 Evaporation | | 250 |
| Totals | 5 250 | 4 814 |
| Storage Increase = 436m ³ /d | | |

¹ Also the current Possum Skin Dam operating level provides more evaporation loss (~500m³/d) than it would with the proposed lower maximum filling level.

4.4.3 Integrated Glennies Creek - Camberwell

The Integrated Base Case + Glennies Creek Open Cut Coal Mine + Camberwell South Pit balance is presented in **Table 25**.

Table 25
Integrated Glennies Creek - Camberwell

| Source | Inflow (m ³ /d) | Outflow (m ³ /d) |
|---|-------------------------------|--------------------------------|
| Base Case | 2 000 | 3 364 |
| Camberwell South Pit | 3 250 | 1 450 |
| Proposed Glennies Creek Open Cut Coal Mine | 590 | 200 ¹ |
| Total | 5 840 | 5 014 |
| Storage Increase = 826m ³ /d | 850m ³ /d | |
| ¹ Dust suppression ~ 100 000m ² . | | |

To balance this storage increase, guaranteed export of up to 850m³/d or about 300 000m³/a is required. Agreements with the Ashton and Newpac Collieries provide a total of 2 800m³/d or 1 000 000m³/a so both the portal sump and Possum Skin Dam can be drawn down over time.

4.5 Portal Flooding

4.5.1 Background

In **Section 4.4**, the requirements to ensure a dirty water circuit balance and the ability to draw down the portal sump to any desired level were established. In this section, portal flooding risk is evaluated so that an appropriate operating sump level can be prescribed.

Currently (February 2007) the Camberwell North Pit sump water level is at or below 41.0m AHD. The portal invert is at about 52m. This 11m provides 1.31 x 10⁶m³ of flood storage for an assumed porosity of 10%. In October 2003 PSM⁽²⁴⁾ recommended a sump flood surcharge capacity of 1 x 10⁶m³ to provide sufficient surcharge storage to protect the portal against ARI 100 flooding risk. In February 2004⁽²⁵⁾ this was revised upward to 1.22 x 10⁶m³. This section of the report reviews portal flooding risk in the light of both physical and operational changes in water management and improved understanding of component flows, based on measurement and observation.

Historically, dewatering of the sump has largely been managed by Camberwell. Observations over the 2003 – 2005 period indicated that during periods of even modest rainfall:

- portal sump dewatering to the CHPP ceased (they preferentially pump from the Camberwell South Pit);
- pumping to Rixs Creek and Ashton Mine ceased (they similarly use their own site runoff);

- the CHPP continues to operate and discharging tailings to the on waste rock emplacement tailings dams (TD1 and TD2), the seepage from which continues to flow to the portal sump;
- Camberwell South Pit, if D1 is full, would pump excess water to TD2 or D2; and
- on waste rock emplacement rainfall excess largely percolates through the waste rock emplacement to the sump. This as a result of direct infiltration and flow of local surface runoff to high infiltration capacity zones and sink holes.

It is also important to note thus far Possum Skin Dam has been maintained essentially at maximum level to maximize evaporative loss. With a surfeit of export capacity available, levels in the dam can also be drawn down to provide additional wet period storage. However, this should only be done after the portal sump is drawn down to the design level.

Following the integration of mining operations through the Integra Joint Venture, a comprehensive, site wide, dirty water management plan can be established for the first time, with thresholds, volumes/levels triggering control measures, etc.

Under these conditions, there are two scenarios to consider ie. the existing combined operation and existing combined operation with new open cut. The new open cut pit/waste rock emplacement footprint partially overlaps a portion of the existing historic Camberwell North Pit and care is required to avoid "double accounting".

Under rare extended wet periods runoff conditions are quite different to those used to estimate mean annual rates. For these conditions 90% runoff is assumed across all surfaces.

4.5.2 Analysis

Because of the large quantity of flood storage in the sump-waste rock emplacement system, critical portal flooding conditions are driven by multiday wet periods rather than an individual storm.

Figure 21 presents multiday design rainfall curves based on a 123 year composite daily rainfall record centred on Singleton (See **Section 3.4.2**).

For a prescribed probability of occurrence, as the multiday wet period gets longer the total rainfall increases but at a decreasing rate. For example, the 100 year ARI 30 day total is 412mm and the 60 day total 535mm. Doubling the wet period duration increases the total rainfall by only 30%.

For direct rainfall on the Camberwell North Pit waste rock emplacement, effective inflow to the sump ceases when evaporation matches rainfall. In the absence of any direct measurement, runoff generation from the existing Camberwell South Pit and the proposed Glennies Creek Open Cut might also be expected to cease under about the same conditions.

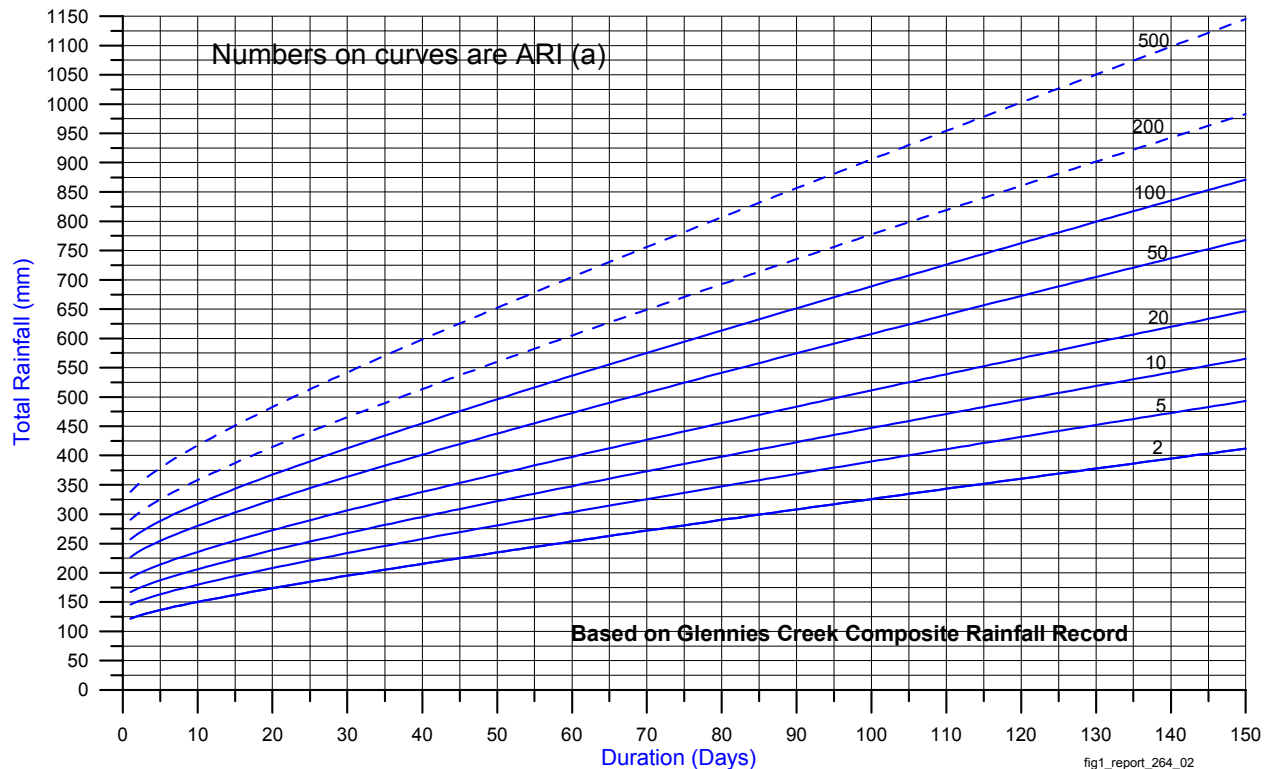


Figure 21
Smoothed Historic Multiday Rainfall

Current best estimates of average annual open water evaporation are 1 600mm, which equates to 4.4mm/d. A water body absorbs about 97% of incident solar radiation. Soil and vegetation reflect a greater proportion of the radiation with the result that evaporation is less. Further, during wet periods both cloud cover and humidity are higher reducing evaporation. Accordingly, a design evaporation rate of 3.5mm/d is adopted (1 278mm/a).

During a multiday wet period the Camberwell North Pit sump would continue to receive near steady inflows from the following sources:

- Glennies Creek Underground;
- groundwater coal seam aquifer inflows; and
- tailing dam seepage.

Near steady “outflows” include:

- water exported in coal;
- water stored in the interstitial tailing space;
- underground dust suppression; and
- export to other mines under agreement.

These inputs and outputs are approximately balanced and small compared with the design wet periods flow rates, and are not considered in this wet period analysis. For this design wet period analysis, the inputs considered include:

- direct percolation of incident rainfall on North Camberwell waste rock emplacement;
- additional Dam seepage associated with excess Camberwell South Pit water pumped to D2 and/or TD2, if permitted as part of the dirty water management system;
- direct dirty water discharge from the proposed Glennies Creek Open Cut Coal Mine if permitted as part of the dirty water management system; and
- direct rainfall on Possum Skin Dam if/while below maximum filling level.

For the purpose of this analysis, the sole output is evaporation/evapotranspiration from:

- Camberwell North Pit waste rock emplacement;
- Camberwell South Pit footprint;
- Proposed Glennies Creek Open Cut; and
- Possum Skin Dam if/while below maximum filling level.

If Possum Skin Dam is at or above its maximum filling level then no water may be pumped to it. With export available Possum Skin Dam may well be below the maximum filling level at the start of a wet period, however, it is conservatively assumed to be full for the purpose of analysis.

In hydrologic analysis, the duration of, for example, the ARI 100 design rainfall event for a culvert on a small creek is much shorter than for a bridge on a large river, even though they are both defined as ARI 100 events. In design, hydrologists use the notion of a critical duration to set the design rainfall duration⁽²⁶⁾. This is defined as the duration, at the prescribed frequency (i.e. ARI 100), that maximizes the hydrological response of interest (i.e. flow rate in the case of the culvert and bridge in this discussion). For a small culvert, the critical duration might be 30 minutes. For a large river the critical duration would be typically 15 to 30 hours. For total containment systems the critical duration can be as long as months.

For total containment systems, the critical duration at the prescribed design frequency is that which maximizes the water level of the storage (the Camberwell North Pit sump in this case). This occurs when the additional rainfall of an additional day just matches the day's evaporation i.e. 3.5mm. In this context it is important to note that in the 123 year historic rainfall record for Singleton the wettest year, 1893, recorded 1 266mm.

The next wettest, 1887, produced 1 264mm. For both of these years, rainfall about matches evaporation. It follows that it would be extremely difficult to provide evaporation dependent security against flooding greater than about 2% in any year. That is, should annual rainfall of

this magnitude ($\geq 1\,260$) occur then flooding of the Glennies Creek Underground Coal Mine might occur unless pumping to the Camberwell South Pit or proposed Open Cut was instigated. The historic record indicates about a 2% or one in 50 chance of this occurring in any year.

Adoption of a total containment dirty water management policy means flooding of the Camberwell and/or the proposed Glennies Creek Open Cut can be expected to occur under rare extended wet periods.

To illustrate the estimation of critical duration and storage requirements the ARI 20 curve from **Figure 21** has been re-plotted in **Figure 22**. Also plotted in **Figure 22** is the evaporation rate of 3.5mm/d represented by a straight line with a slope of 3.5mm/d. The point where the evaporation line is tangent to the rainfall curve is the critical duration. Twenty days in this example. For longer durations the rainfall rate is less than the potential evaporation while for shorter durations it is greater. Where the evaporation intersects the Y axis (rainfall) is the amount of storage (as mm of rainfall over the catchment) that is required in conjunction with the evaporation to just contain the event. **Table 26** presents the ten largest 20 day totals in the 1881-2003 historic record.

Table 26
Ten Largest 20 Day Totals in 123 Year Singleton Composite Record 1881-2003

| Rank | ARI (a) | Start Date | 20 Day Total (mm) | Rainfall in Preceding 20 days (mm) | Temporal Distribution | | | |
|------|---------|------------|-------------------|------------------------------------|-----------------------|----|----|----|
| | | | | | 20 | 40 | 60 | 80 |
| 1 | 124 | 19/02/1893 | 381.0 | 92.0 | 14 | 15 | 15 | 15 |
| 2 | 62 | 08/06/1950 | 337.9 | 41.0 | 31 | 41 | 71 | 85 |
| 3 | 41 | 17/06/1930 | 315.8 | 29.0 | 81 | 82 | 83 | 88 |
| 4 | 31 | 16/02/1955 | 301.1 | 16.6 | 21 | 22 | 98 | 98 |
| 5 | 25 | 08/02/1908 | 291.8 | 108.8 | 13 | 24 | 25 | 44 |
| 6 | 21 | 10/10/1985 | 285.8 | 12.0 | 64 | 72 | 77 | 81 |
| 7 | 18 | 12/03/1978 | 280.2 | 7.7 | 0 | 37 | 74 | 96 |
| 8 | 16 | 13/01/1971 | 274.4 | 57.4 | 1 | 34 | 48 | 49 |
| 9 | 14 | 30/01/1990 | 270.8 | 48.2 | 4 | 74 | 91 | 93 |
| 10 | 12 | 26/07/1952 | 270.0 | 16.8 | 32 | 34 | 55 | 79 |

Table 27 presents critical durations for a range of prescribed probabilities of wet period occurrence (expressed as ARI – Average Recurrence Interval) for the adopted evaporation rate of 3.5mm/d and the curves in **Figure 21**.

During a multiday rainfall evaporation occurs each day so the net percolated rainfall is the difference between the total and that lost by evaporation (assuming no surface runoff).

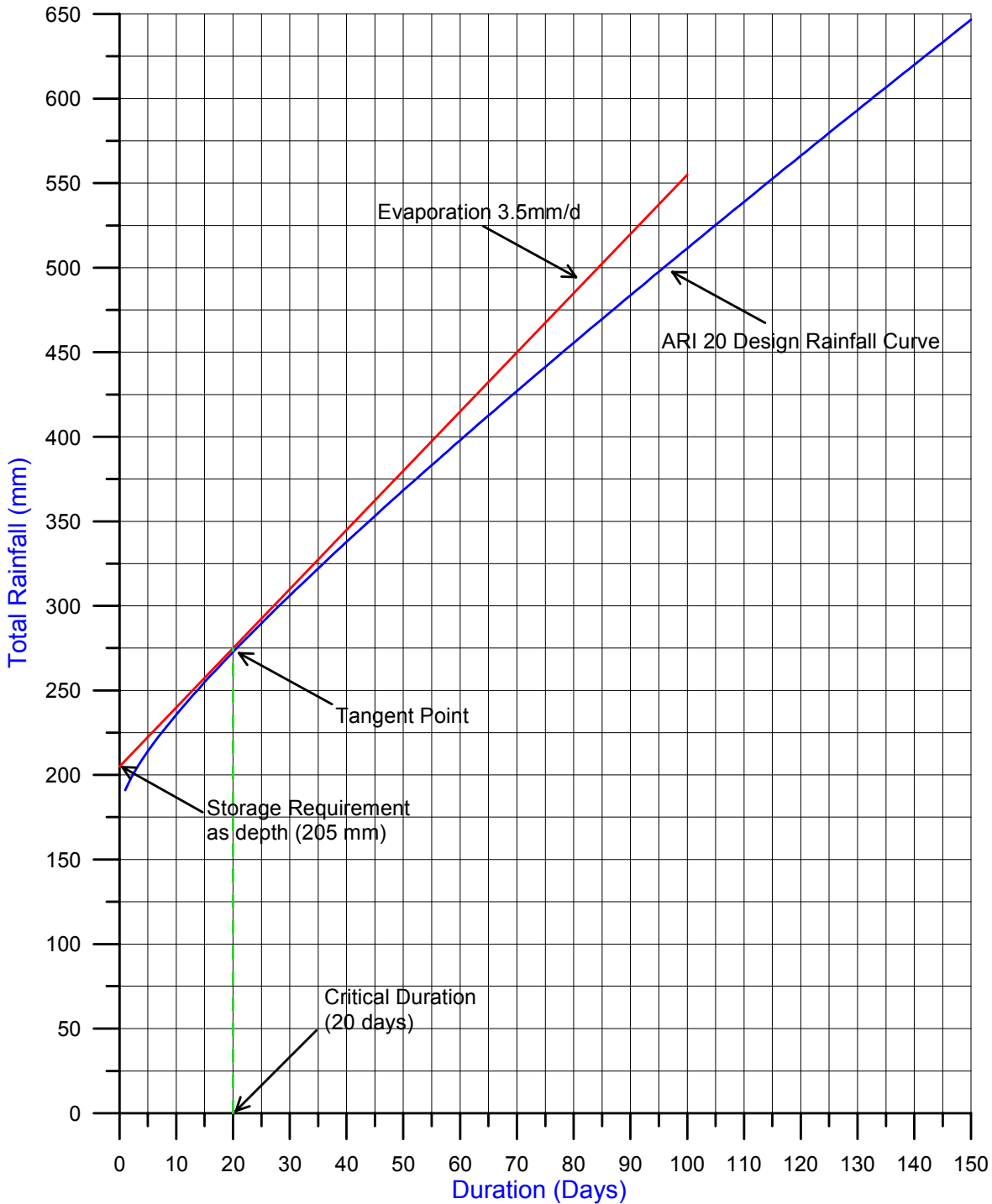


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Figure 22
Defining Critical Duration and Storage Requirement

Table 28 is an expansion of **Table 27** providing the associated storage requirement as both depth and volumes for individual contributing catchment areas. Also shown in the table are the volumes contributed by the steady inflows. This table is used to build total storage requirements for specific situations. For example, the current system is composed of the Camberwell South Pit and Camberwell North Pit Sump plus steady flows. For ARI 5 year protection total storage requirement is $0.6 + 0.36 + 0.03 = 0.99 \times 10^6 \text{m}^3$.

Table 27
Multiday Wet Period Critical Durations for
Portal Flooding as a Function of ARI

| ARI | Critical Duration (d) | Wet Period Total (mm) |
|-----|-----------------------|-----------------------|
| 2 | 3 | 136 |
| 5 | 10 | 165 |
| 10 | 12 | 210 |
| 20 | 20 | 272 |
| 50 | 60 | 472 |

Table 28
Sump-Waste Rock Emplacement Flood Storage Requirements Analysis

| Multiday Design Rainfall | | | Storage Requirement | | | |
|--------------------------|-----------------------|-----------------------|------------------------------|---|--|--|
| | | | By Catchment | | | |
| ARI (a) | Critical Duration (d) | Wet Period Total (mm) | As depth ⁽¹⁾ (mm) | Camberwell North Pit Sump ⁽²⁾ (m ³ x10 ⁶) | Camberwell South Pit ⁽³⁾ (m ³ x10 ⁶) | Proposed Glennies Creek Open Cut Coal Mine ⁽⁴⁾ (m ³ x10 ⁶) |
| 2 | 3 | 130 | 120 | 0.49 | 0.29 | 0.16 |
| 5 | 10 | 165 | 148 | 0.60 | 0.36 | 0.20 |
| 10 | 12 | 210 | 172 | 0.70 | 0.42 | 0.23 |
| 20 | 20 | 275 | 205 | 0.83 | 0.50 | 0.27 |
| 50 | 60 | 472 | 280 | 1.13 | 0.68 | 0.37 |

⁽¹⁾ Rainfall-Evapotranspiration.
⁽²⁾ 10% loss to surface runoff out of catchment (4.5 x 0.9 = 4.05km²).
⁽³⁾ South Pit + CHPP area 10% infiltration loss (2.7 x 0.9 = 2.43km²).
⁽⁴⁾ 10% loss by infiltration in new waste rock emplacement area, 10% pit floor (1.89 – 0.43) x 0.9 = 1.32.

The waste rock emplacement within the historic Camberwell North Pit, which also contains the sump, is of considerable depth and some of the emplacement has a silt and clay fraction and hence the ability to absorb and exude water. At the start of an especially wet period some of the percolating water would be absorbed by the silt and clay matrix, particularly near the surface where weathering has occurred. Some of this water is later carried to the surface by capillary action and lost through evaporation.

The absorbed water, in the context of the current analysis, represents a form of flood surcharge storage. The quantum of this storage is difficult to estimate. Experience with other large waste rock emplacements, field scale test waste rock emplacements and laboratory testing suggest that preferential flow paths develop quickly with depth such that a large fraction of waste rock emplacements above the water table have essentially constant moisture content. For the Camberwell North Pit waste rock emplacement “capillary” flood storage is guesstimated to be in the range of 25 to 100mm, say 50mm. Over the 4.5km² waste rock emplacement surface this 50mm corresponds to an equivalent sump flood storage of 0.23 x 10⁶m³. Thus the actual sump storage requirement is the total less this 0.23 x 10⁶m³. The Proposed Glennies Creek Open Cut waste rock emplacement would be expected to have similar storage capacity and also might, because it is fresh waste, still be “wetting up”.

However, as the design event might occur late in the new mine life, this storage is conservatively neglected.

Note also the analysis assumes the rainfall excess reports instantaneously to the portal sump. This is conservative since for example, the Camberwell South Pit, the rate of delivery is limited by pump capacity and for the Camberwell North Pit waste rock emplacement percolation through waste rock may take several days, perhaps even weeks.

4.5.3 Results

Table 29 presents available flood storage in the portal sump for a range of sump (and waste rock emplacement groundwater table levels) and a range of assumed porosities (see **Section 4.3.6.2**). Also shown are the underground mine portal freeboards.

Table 29
Surcharge Storage ($m^3 \times 10^6$) as a function of Camberwell North Pit Groundwater Table Level

| Groundwater Table Level (m AHD) | Portal Freeboard (m) | Drainable Porosity % | | | |
|---------------------------------|----------------------|----------------------|-------|-------|--------|
| | | 7.5% | 10% | 12.5% | 100% |
| 37 | 15 | 1.236 | 1.647 | 2.059 | 16.475 |
| 38 | 14 | 1.175 | 1.567 | 1.958 | 15.668 |
| 39 | 13 | 1.112 | 1.483 | 1.854 | 14.833 |
| 40 | 12 | 1.048 | 1.397 | 1.746 | 13.969 |
| 41 | 11 | 0.981 | 1.308 | 1.635 | 13.078 |
| 42 | 10 | 0.912 | 1.216 | 1.520 | 12.157 |
| 43 | 9 | 0.840 | 1.121 | 1.401 | 11.206 |
| 44 | 8 | 0.767 | 1.023 | 1.278 | 10.226 |
| 45 | 7 | 0.691 | 0.922 | 1.152 | 9.216 |
| 46 | 6 | 0.613 | 0.818 | 1.022 | 8.175 |
| 47 | 5 | 0.533 | 0.710 | 0.888 | 7.103 |
| 48 | 4 | 0.450 | 0.600 | 0.750 | 6.000 |
| 49 | 3 | 0.365 | 0.487 | 0.608 | 4.865 |
| 50 | 2 | 0.277 | 0.370 | 0.462 | 3.698 |
| 51 | 1 | 0.187 | 0.250 | 0.312 | 2.498 |
| 52 | 0 | 0.000 | 0.000 | 0.000 | 0.000 |

By way of illustration, currently (27 November 2006) the elevation of the water within the Camberwell North Pit sump is at or below 41.0m AHD. At 41m AHD and 10% porosity there is $1.31 \times 10^6 m^3$ of surcharge storage available without impacting on the operations of the Glennies Creek Underground Coal Mine. To this storage must be added the storage associated with capillary absorption in the waste rock emplacement of $0.23 \times 10^6 m^3$ for a total surcharge storage estimated at $1.54 \times 10^6 m^3$.

The protection afforded by the surcharge storage volume is assessed for the two cases namely:

- existing situation (Camberwell North Pit waste rock emplacement + Camberwell South Pit); and
- existing situation + proposed Glennies Creek Open Cut Coal Mine.

Flood surcharge storage requirements for these are presented in columns 2 and 3 in **Table 30**, for critical event ARI's from 2 to 50 years.

Table 30
Total Flood Surcharge Storage Requirement ($m^3 \times 10^6$)
for Various Contributing Catchment Combinations¹

| ARI (a) | Existing | Existing + Proposed Glennies Creek Open Cut |
|---------|----------|---|
| 2 | 0.79 | 0.94 |
| 5 | 0.99 | 1.17 |
| 10 | 1.16 | 1.37 |
| 20 | 1.39 | 1.64 |
| 50 | 2.00 | 2.34 |

For the existing situation, the available storage of 1.54×10^6 is just greater than the 20 year ARI event. For the existing situation with the proposed Glennies Creek Open Cut Coal Mine the available 1.54×10^6 lies a little below the 20 year ARI event.

Because critical flooding conditions are produced by extended wet periods there is no risk to human life however, given the value underground infrastructure and lost production, the consequence of flooding would be significant.

Table 31 and **Table 32** present the required surcharge flood storage and associated sump water level necessary to limit the risk of flooding in any year to 5% and 2% respectively.

Table 31
Flood Surcharge Storage Requirement ($m^3 \times 10^6$) to Secure an Annual
Flooding Risk of 5% (20a ARI)

| Storage | Existing | Existing + Proposed Glennies Creek Open Cut |
|--|----------|---|
| Total | 1.39 | 1.64 |
| Sump ⁽¹⁾ | 1.16 | 1.41 |
| Sump Elevation (m AHD) ⁽²⁾ | 41.60 | 38.90 |
| ⁽¹⁾ Assumes $0.23 \times 10^6 m^3$ of equivalent flood storage provided by capillary storage within the waste rock emplacement. | | |
| ⁽²⁾ Sump storage below 52m AHD. Assuming a drainable porosity of 10%. | | |

Table 32
Flood Surcharge Storage Requirement ($m^3 \times 10^6$) to Secure an Annual
Flooding Risk of 2% for Contributing Catchment Combinations

| Storage | Contributing Catchment Combinations | |
|--|-------------------------------------|---|
| | Existing | Existing + Proposed Glennies Creek Open Cut |
| Total | 2.00 | 2.34 |
| Sump ⁽¹⁾ | 1.77 | 2.11 |
| Sump Elevation 52m AHD ⁽²⁾ | 34.40 | 29.50 |
| ⁽¹⁾ Assumes $0.23 \times 10^6 m^3$ of equivalent flood storage provided by capillary storage within the waste rock emplacement. | | |
| ⁽²⁾ Sump storage below 52m AHD. Assuming a drainable porosity of 10%. | | |

This analysis assumes all design wet period storage is provided by the portal sump and associated waste rock interstitial space. With the surfeit of export capacity evaporation loss from Possum Skin Dam is less important and the dam might be drawn down to provide additional wet period storage in lieu of sump capacity provided transfer pump capacity remained in place.

Drawing down Possum Skin Dam would allow an increase in the ARI threshold at which flooding of one of the open cuts would have to be accepted.

4.5.4 Uncertainty and Recommendations

The greatest source of uncertainty in this analysis of portal flooding is the estimation of the drainable porosity of the waste rock emplacement below an elevation of 52m AHD in the historic Camberwell North Pit Sump system. The lower the porosity the lower the sump water level required to achieve a prescribed volume of surcharge storage.

The next most important source of uncertainty is the estimate of the additional water stored in the silt-clay matrix of the waste rock emplacement during a wet period. It is important to note the total amount of water stored in the matrix is not important, only the change or increase over the average or background storage capacity for a wetter than average period.

Because of the large spatial variability in waste rock characteristics it may only be possible, if at all, to estimate this from inflow-storage-outflow analysis of the system. On best guesstimate this represents about 25% of the surcharge storage requirement and therefore a significant component.

To allow investigation of both these uncertainties, it is recommended that sump water level be continuously monitored to ± 10 mm. This precision is necessary because of the very highly dampened nature of the hydrological response and the short time windows when conditions (inflows and outflows) remain constant.

5 DIRTY WATER CIRCUIT SALT BALANCE

In this section, the salt balance is explored and indicative equilibrium concentrations and the salt levels at the completion of mining activities are estimated.

Dominant salt inflows include:

- groundwater inflows to the Glennies Creek Underground Coal Mine;
- groundwater inflows to the North Camberwell Pit;
- rainfall percolation through waste rock emplacements (Camberwell North Pit and proposed Glennies Creek Open Cut waste rock emplacements); and

Dominant salt outflows or losses from the circuit include salt losses related to:

- tailing interstitial space;
- export in coal*;
- storage within Possum Skin Dam;
- export to other mines; and
- dust suppression underground.

* The CHPP may be both a source (washing process) of salt and a user of salt (exported with coal).

Active salt storage locations are those of the dirty water itself, namely:

- a) Dirty Water Dam D1; and
- b) Camberwell North Pit sump and emplacement interstitial space.

Possum Skin Dam may be interpreted to be a site for salt outflow or storage or both. In the current analysis, it is assumed its primary role is as an evaporimeter. That is, dirty water (with its contained salts) is pumped from the active portal sump storage to makeup evaporation loss, never to return. As such, it represents a salt outflow.

The salt conservation equation is: -

Salt Inflow Rate – Salt Outflow Rate = Rate of change of Storage

In algebraic terms

$$g_{in} - Q.C_{out} = \frac{d}{dt}(V.C_{STOR}) \left[\frac{t}{d} \right] \quad (5)$$

This is a simple first order differential equation where:

- g_{in} is the salt inflow rate (t/d),
- Q is the salt carrying water outflow rate (m³/d),
- V is the dirty water storage volume (m³),
- C_{out} is mean salt concentration of salt outflow water (t/m³),
- \bar{C}_{STOR} is the mean concentration of dirty water in storage.

Provided there is adequate mixing, the outflow and storage concentrations are identical VIZ

$$C = C_{out} = C_{STOR} \quad (6)$$

At equilibrium when salt inflow equals salt outflow

$$C_e = \left(\frac{g_{in}}{Q} \right) \left[\frac{t}{m^3} \right] \quad (7)$$

and

$$g_e = Q.C_e \quad (8)$$

The solution of (5) is

$$g(t) = g_e \left(1 - e^{-\left(\frac{t+t_0}{K}\right)} \right) \quad [t/d] \quad (9)$$

where K is the storage constant or lag of the circuit defined by

$$K = \left(\frac{V}{Q} \right) \quad [d] \quad (10)$$

and

$$t_o = -K.Ln \left(1 - \frac{C_o}{C_e} \right) \quad [d] \quad (11)$$

To apply (9) requires estimates of only 3 quantities g_{in} , Q , V and starting concentration $C(o)$. The most difficult to estimate and the source of greatest uncertainty is the salt inflow g_{in} .

The mean salt inflow is difficult to measure because the sources are diverse, and the rainfall driven sources may be intermittent. However, if the circuit has reached a dynamic equilibrium then salt inflows approximately equal salt outflows, and more importantly the circuit salt concentration is approximately stabilised. The term dynamic equilibrium is used because inflows and outflows are not steady. During dry periods there is little diluting surface runoff and concentrations would tend to increase. Conversely, during wet periods concentrations would tend to decrease.

The solute lag, K , in the dirty water circuit is the mean time a molecule of solute spends in storage in the system. The notional time to equilibrium⁽⁴⁹⁾, t_e , is twice this lag, thus

$$t_e = \frac{2V}{Q} \quad (12)$$

Estimated post CHPP upgrade salt carrying water outflows are: -

| | |
|-------------------------------------|---------------------------|
| Water in Coal | 857m ³ /d |
| Water to interstitial tailing space | 1 254m ³ /d |
| Export to other mines | 300m ³ /d |
| Possum Skin Dam | <u>493m³/d</u> |

Thus $Q = \underline{2\,904\text{m}^3/\text{d}}$ say 3 000m³/d.

The estimated portal sump volume below an elevation of 41m AHD is around 1.9Mm³ while D1 has a capacity of 0.4Mm³ for a total of 2.3Mm³. The storage constant or lag of the salt circuit is thus around $(2.3 \times 10^6 / 3\,000)$ days ≈ 770 days ≈ 2 years. With notional time to equilibrium of 4 years.

The Glennies Creek underground has been operating for > 4 years, therefore very crudely, salt inflow and outflow rates ought to be approximately equal and salt concentrations be approximately equilibrated.

Mining operations and the CHPP have not been constant over the last 4 years but the denominator in (12) has likely to have declined over time with the effect that earlier periods had a smaller time to equilibrium. Recent circuit salt concentrations are therefore a crude indication of dynamic equilibrium concentrations.

The available dirty water circuit water quality data (see **Section 3.3.3**) suggest electrical conductivity in the range 6 000 – 14 000µS/cm, with lower values associated with wetter periods or infusions of clean makeup water and the higher values associated with dry periods.

With the proposed new open cut, CHPP throughput would be unchanged and export of salt would remain a function only of salt concentration. The proposed new open pit represents an additional source of water and salt. This additional water requires additional export to other mines to balance (with an associated export of salt). The proposed new open cut would therefore decrease or increase salt concentration of the water within the Integrated Surface Water Management System depending on whether the “new” water has higher or lower salt concentration than the current sources. The magnitude of this change is not expected to be significant.

6 INFILLING OF FINAL VOID

The Department of Primary Industries (DPI) requires a conceptual analysis of the proposed open cut final void water quantity and quality as part of the proposed Glennies Creek Open Cut Coal Mine *Environmental Assessment*. Accordingly an analysis of final void salt and water dynamics was made by PSM Australia Pty Ltd. Significant salt accumulation in the void due to evaporation was anticipated with potential discharge to ground and surface waters. The proponent therefore elected to infill the final void to prevent evaporative concentration.

It is understood that, *"It is the Proponent's current intention that the final void would ultimately be filled to the surface or slightly above through the emplacement of reject material from the Camberwell CHPP, and/or breaker stone from the Glennies Creek Underground Coal Mine pre-treatment plant, with final rehabilitation involving reshaping, capping with inert materials (if required), spreading of topsoil and seeding/planting."*

Water in the interstitial space of the backfilled void material is not subject to evaporation and the associated concentrating of salts and consequently dissipation of this water to regional groundwater will not adversely impact regional groundwater quality. However, if a seep is not to ultimately form where the pit (infilled) intersect the highwall at the lowest point in the natural topography then the dissipation capacity to regional groundwater and flow to the portal sump through the pillar must exceed supply.

Toward the end of mining the hydraulic conductivity of the pillar and seepage inflow rates will need to be assessed and if required pillar conductivity increased by fracturing.

7 DESIGN AND OPERATIONAL SAFEGUARDS

7.1 Objectives

The primary design objective is total on-site containment of salt dominated dirty water in the central circuit for the Glennies Creek – Camberwell operation.

For the proposed new open cut, objectives are maximization of clean water diversion, total containment of salt laden dirty water up to ARI 100 events, and containment of high sediment, low salt dirty water up to the 50a ARI event

Open cut mining produces a continuously changing landscape such that within the overall objectives there is also a need to maximize the rehabilitated area at any time and therefore clean water diversion.

The main dirty water circuit is detailed in Section 4. This section provides a conceptual level overview of the various drainage structures with indicative sizing and design criteria.

7.2 Design Criteria

As demonstrated in Section 4, the operation of the Glennies Creek Camberwell main dirty water circuit allows total containment of the main circuit dirty water without the requirement to pump water to either the Camberwell South Pit or the proposed open cut up to the ARI 50 event. For larger events open cut temporary storage is required. In this circuit the primary contaminant is salt.

Possum Skin Dam which has operated as a storage and an evaporation pond was designed for and operated to ensure no spill up to the ARI 100 event. Again the principal contaminant is salt.

For the proposed Glennies Creek Open Cut dirty water is of two types: - sediment dominated runoff from bare dumps and salt dominated deep percolation to the new void and Camberwell North Pit waste rock emplacement. The latter, more insidious, dirty water reports to the main Glennies Creek – Camberwell dirty water circuit and would be totally contained irrespective of ARI. The high sediment low salt surface runoff would be collected in detention dams or the existing Possum Skin Dam and pumped to the main dirty water circuit.

The detention dam – pump systems for control of sediment-laden water are designed for the ARI 50 event. For the proposed detention dams' events greater than ARI 50 some of the partially settled low salt water would overflow to Reedy Creek and then Glennies Creek.

For Possum Skin Dam the design event remains ARI 100 years.

7.3 Structures and Controls

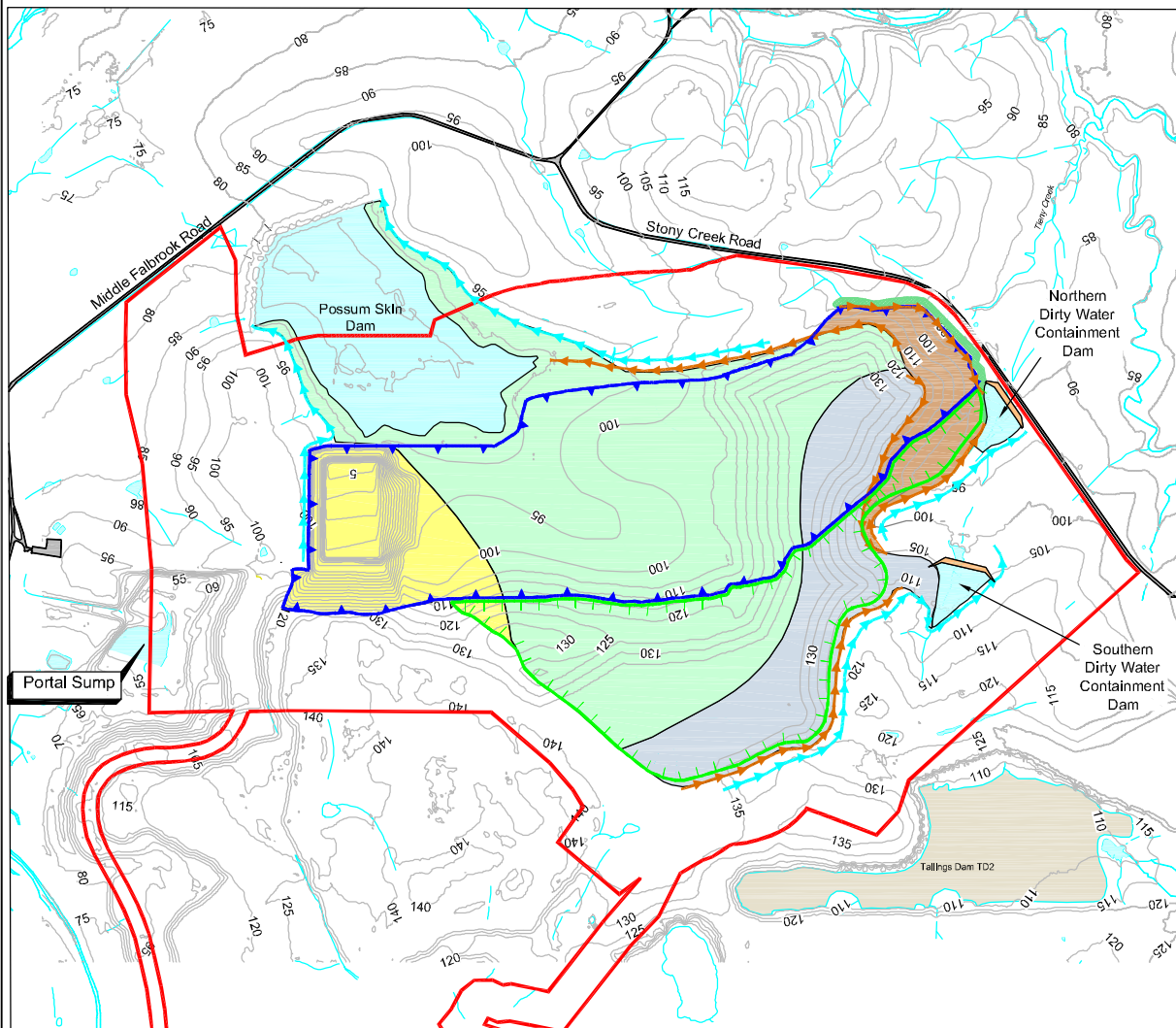
Figure 23 provides a generalized sketch level layout of the various drainage structures as at Year 3 of the Project. These structures are used to maximize clean water diversion and ensure high sediment, low salt, dirty water is totally contained up to the design ARI (50 years) and partially settle prior to discharge for events rarer than ARI 50. The waste rock emplacement configuration has been deliberately designed to keep it within the ridgeline that runs roughly southwest to northeast. To the southeast waste emplacement runoff is directed to one or other of two dirty water dams. From these, dirty water is pumped to the tailing dam for use in the dirty water circuit. Total containment up to the 50 year ARI is achieved by a combination of pump capacity and sump (dam) capacity as illustrated in **Figure 24**. For the upper dam a 30 000m³ sump in conjunction with a 21L/s pump is recommended. For the lower a 10 000m³ sump and 50L/s pump.

Each of the dirty water dams has an associated clean water diversion channel to prevent contamination by dirty water, **Figure 23**.

A clean water interception and diversion channel is also required to carry clean water south around the eastern edge of the pit/waste emplacement, **Figure 23**.

The dual dam system has been implemented to preserve wild life habitat.

\\SERVER\RW\642\CAD\642Base_Surface 23.DWG



- REFERENCE
- Project Site Boundary
- ▲ 7.7Mt Open Cut Pit Shell
- Out-of-Pit Waste Rock Emplacement Boundary
- Surface Water Runoff to Possum Skin Dam
- Surface Water Runoff to Southern Dirty Water Containment Dam
- Surface Water Runoff to Northern Dirty Water Containment Dam
- Surface Water Runoff to Open Cut
- Contour (m AHD)(Interval = 5m)
- 135 Creek / Drainage Line
- Dam / Water Storage
- Amenity Bund
- Clean Water Diversion
- ▲ Dirty Water Catch Drain
- ▲

SCALE 1:20 000

200 0 200 400 600 800 1000 m

Base Map Source: Geo-Spectrum (Australia) Pty Ltd - Date: December 2004

Figure 23
 DIRTY WATER DETENTION
 DAM CATCHMENTS

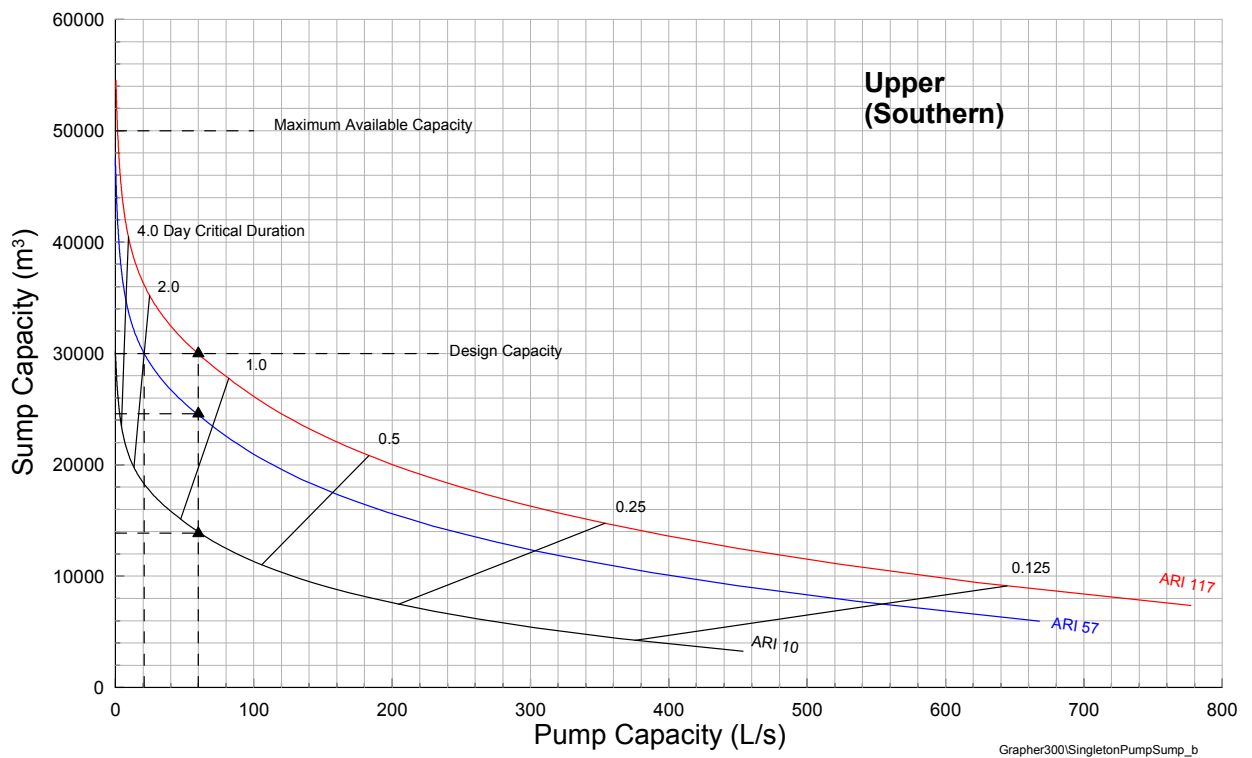
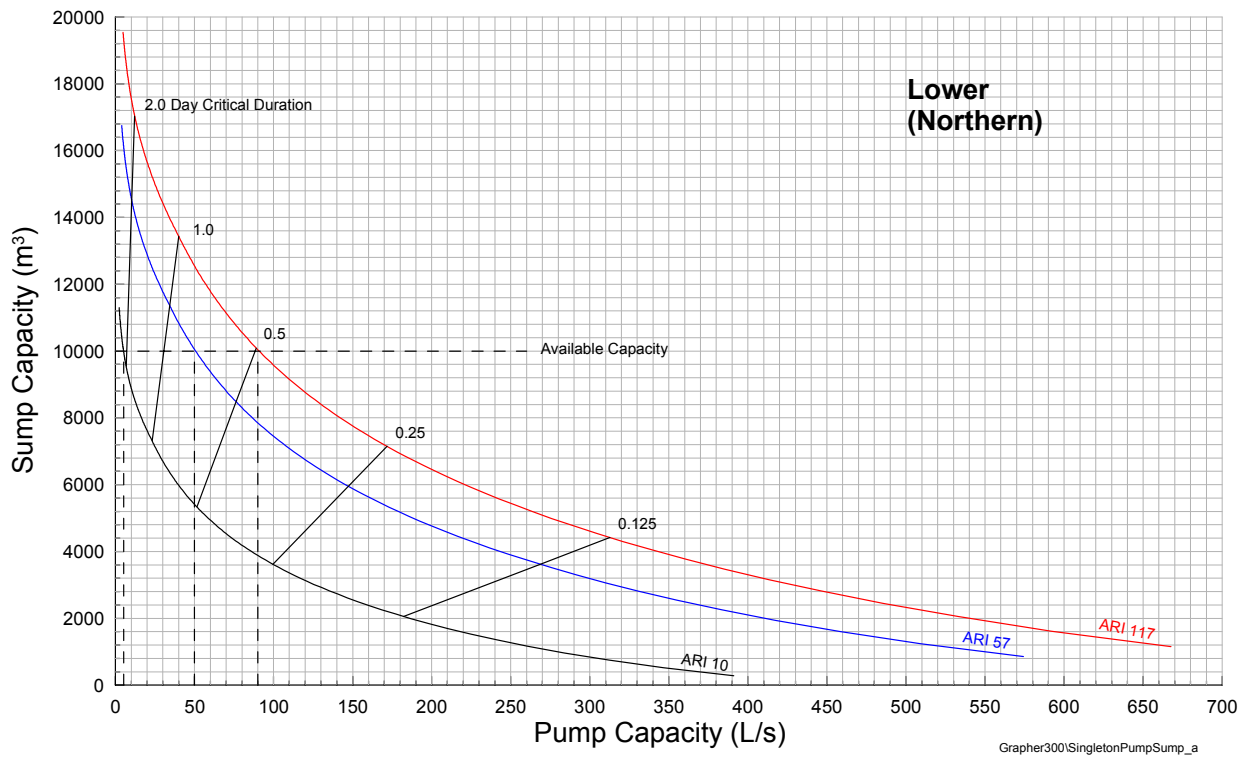


Figure 24 Detention Dam Pump Capacity-Storage Capacity Curves

On the northwestern side emplacement surface runoff drains either to the operating pit or Possum Skin Dam. During operations, drainage to Possum Skin Dam will be maximized. Near the end of mining at its maximum 90ha of waste emplacement will be draining to Possum Skin Dam.

Currently Possum Skin Dam is operated as both a storage and evaporation pond for 'salt' dirty water with total containment up to the 100 year ARI. That is a maximum filling level (89m AHD) has been established so that the 100 year ARI incident rainfall and peripheral catchment runoff is contained below spillway level.

Draining the northwest side of the waste emplacement to Possum Skin Dam increases the catchment area requiring a larger buffer storage and associated lower maximum filling level. The new larger catchment is composed of approximately 90ha of waste emplacement and approximately 37ha of water surface. For the waste emplacement catchment only the surface runoff component drains to Possum Skin Dam the percolation reports to the pit.

For this configuration the critical 100 year ARI event is of 17 days duration with 355mm of rainfall and producing ~ 350 000m³ of runoff to be contained in Possum Skin Dam.

This requires that a lower maximum filling level be set and a means, be established, to drawdown the dam level promptly when this maximum level is exceeded due to runoff. The alternative to prompt drawdown is to set an even lower maximum filling level and allow the slow attrition of excess by evaporation.

Adopting this latter more robust alternative, the new maximum filling level is established by containing the 100 year event followed by the 10 year event. For this a total of 550 000m³ of storage is required. The corresponding maximum filling level is 87.5m AHD. This lower level means potential evaporation basin performance is reduced by approximately 30%.

Revised clean water channels are also required to divert clean water about the dam:

The Possum Skin Dam clean water diversion on the eastern side must be extended south to the proposed new open cut and the flow direction reversed to carry water north about the embankment.

Similarly the Possum Skin Dam clean water diversion on the western side must be extended south to border the western edge of the proposed new open cut, **Figure 23**.

8 ASSESSMENT OF IMPACTS

8.1 Surface Water Flows

8.1.1 Local Mine Area

For the purpose of water management the proposed Glennies Creek Open Cut conservatively has a total footprint of < 1.89km². [This footprint is larger than defined solely by pit and dump outline due to the inclusion of additional undivertible contributing catchment area.] Of this 1.9km² area 0.4 km² overlies existing mine impacted land (Camberwell North Pit waste rock emplacement).

Surface runoff from the footprint, while dirty, would be totally contained up to the prescribed design ARI within the Integrated Site Dirty Water Management System. As rehabilitation progresses, runoff would be redirected to natural downstream drainage.

The effects of deforestation and reforestation on runoff are variable^(33 - 48), however, it is well recognised that the type of vegetation affects the hydrological response. Trees and particular by deep rooted species intercept and transpire more water than grasses with the result that runoff is less: both surface and deep percolation.

To minimise deep percolation, deep rooted tree species will be used in rehabilitation and this will reduce surface runoff. Compared with naturally forested Glennies Creek catchment, rehabilitated area runoff will be the same, less the residual deep percolation that ultimately reports to the portal sump. For the likely conservative values in **Table 17**, runoff to downstream may be reduced by up to 60%.

When naturally forested land is converted to grassland or farmland, runoff is typically about doubled. So compared with rural (largely deforested) Glennies Creek catchment runoff (from 1.9km²) to downstream will be reduced by up to 75%.

8.1.2 Glennies Creek Catchment

The maximum impact on Glennies Creek is a maximum reduction of 1.9km² of contributing catchment area which at its junction with the Hunter has an area of about 512km². For the period of mine operation and rehabilitation, surface runoff in Glennies Creek at this junction would be reduced by a maximum of 0.4%.

8.1.3 Hunter River Catchment

At the junction with Glennies Creek the Hunter River has an area of 14 500km². Much of this drains dryer western areas with the result that impacts cannot be simply proportional on catchment area.

If the entire Hunter (14 500km²) above the junction is conservatively attributed mean annual runoff in the range 20mm/a to 40mm/a then the impact of totally containing the proposed Glennies Creek Open Cut runoff on Hunter River flows at the Glennies Creek junction is to reduce them by between 0.015% and 0.030%.

8.2 Surface Water Quality

In this section surface water quality impacts are considered at local, Glennies Creek and Hunter River scales. All are considered in terms of the "Hunter River Water Quality Objectives"⁽⁵¹⁾.

8.2.1 Hunter River Water Quality Objectives

The eleven Hunter River Water Quality Objectives provide guidelines to assist water quality planning and management for both rivers and estuaries. Of particular relevance to the current study are the objectives for aquatic ecosystems.

As noted in “Hunter River Water Quality Objectives Explained” report, local ecosystems water quality requirements provides a basis for protecting the water for other uses people make of it.

Table 33 presents numerical criteria or trigger values for aquatic ecosystems for NSW rivers, for key parameters relevant to the current project.

Table 33
ANZECC (2000) Surface Water Quality Trigger Values for Protection of Aquatic Ecosystems

| Indicator | Upland Rivers (> 150m altitude) | Lowland Rivers |
|--|------------------------------------|---------------------------------------|
| Total Phosphorous (µg/L) | 20µg/L | Coastal – 25µg/L Inland – 50µg/L |
| Total Nitrogen (µg/L) | 250µg/L | Coastal – 350µg/L Inland – 500µg/L |
| Dissolved Oxygen (% saturation) | 90 – 110 | 85 – 110 |
| pH | 6.5 – 8.0 | 6.5 – 8.5 |
| Specific Electrical Conductivity (µg/L) | 30 – 350 | 125 – 2200 |
| Turbidity (NTU) | 2 – 25 | 6 – 50 |

For these three quantities in a mining environment, sediment and salt are the dominant contaminants and when pyrite oxidation occurs its impact on runoff acidity / alkalinity as indicated by pH is also important. Turbidity (NTU) is an indication of the suspended sediment load and Specific Electrical Conductivity a measure of salt content.

The relevant values and ranges in **Table 33** are highlighted. These are guidelines and for lowland rivers indicate for some parameters (e.g. electrical conductivity and turbidity) quite wide ranges.

For the proposed new open cut, the key water quality question is, “when is runoff from rehabilitated land suitable for discharge to natural drainage”? On the one hand, it is important to return the “water” to natural drainage as soon as possible due to its general scarcity while on the other to retain it so as to not adversely affect water quality downstream.

It is recommended that water only be diverted to natural drainage following rehabilitation when the year on year water quality has stabilised within the ANZECC based guidelines (**Table 33**) and that water quality has stabilise year on year.

8.2.2 Local Mine Area

Surface runoff would be totally contained up to the 50 year ARI until its quality in terms of all measures in **Table 33**, but in particular sediment, salt and pH is acceptable for discharge.

As demonstrated in **Section 3.1.4**, the salt load in natural streams is largely derived from the base flow or deep percolation component and qualitatively a similar response is expected for catchments in waste rock material. Percolation from all of the proposed new open cut in pit and out of pit waste emplacements reports directly or indirectly to portal sump and the “totally contained” part of the dirty water circuit.

The associated salt is therefore removed from runoff that reports downstream with the result that downstream water quality is improved by dilution. However because the contributing area is small the downstream benefit is small.

Drainage or deep percolation through waste rock largely reports to either the proposed new open cut pit or the Camberwell North Pit waste rock emplacement and ultimately the portal sump. This is expected to continue until the drawdown associated with Glennies Creek Underground development has recovered. The timing of this is not defined. The Glennies Creek Underground Coal Mine is expected to continue for another 25 years and the groundwater recovery will continue for many, many years after mine closure.

During this extended period, only the surface runoff component of total runoff would report to natural drainage downstream and therefore salt loads would be expected to be acceptable and declining over time as weathering continues.

8.2.3 Glennies Creek Catchment

Current and expected future water quality at Middle Fallbrook is presented in **Section 3.2.3** for 50% and 80% percentiles ie. Without runoff from the open cut mine area. The initial quality of surface runoff from the proposed Glennies Creek Open Cut is unknown, but the values in **Table 2** and **Table 33** provide a guide as to when discharge might be acceptable. The predicted future 2020 50th percentile for Glennies Creek and the Hunter in **Table 2** are EC's 450 and 685 respectively which are within the guidelines in **Table 33**. Given runoff quality would be expected to improve over time discharge, once EC averages less than 685, is recommended. At or below these levels the impact of discharging water would be insignificant.

8.2.4 Hunter River Catchment

As noted in **Section 8.1.3**, runoff from the proposed Glennies Creek Open Cut footprint represents 0.015% to 0.030% of the total Hunter River Catchment. The impact in terms of salt load would be of the same order and therefore insignificant.

9 MONITORING

9.1 Quantity

The Integrated Surface Water Management System is, and would continue to be, managed to strike a balance between portal flooding risk and drought water supply risk.

Using conservative assumptions, it has been shown that the portal sump can be drawn down to any required level. These conservative assumptions bias the operation toward drought exposure so as to ensure total containment and protection of the regional environment during wet periods.

Reliable data would allow closer analysis and a more balanced approach to risk and better assessment of any future developments. Of particular interest, are deep percolation rates from the waste rock emplacements and further assessment of the porosities of these emplacements.

To facilitate this all of the following must be measured and recorded. It is recognised many are already being measured.

1. If not already in place, portal sump levels to be continuously monitored to $\pm 10\text{mm}$ (30 min).
2. Daily flows to and from the Glennies Creek Underground Coal Mine to be measured and recorded.
3. Volumes exported to other mines to be measured and recorded daily.
4. Daily rainfall measured near the centroid of the inpit waste emplacements.
5. All water flows to/from CHPP and Tailings Dams by source.
6. D1 water level (daily) ($\pm 5\text{mm}$).
7. All flows to / from D1 by source.
8. Biannual photographic record of proposed new open cut waste rock emplacement and associated rehabilitation

9.2 Quality

Sources of salt within the dirty water circuit need to be more accurately quantified, in particular: -

- a) the quality of salt added or removed during the coal processing operations;
- b) salt sourced from deep percolation through the waste rock emplacements;
- c) salt loss associated with dust suppression both underground and surface mining;
and
- d) wash water added salt exported in coal.

Probably the most important of these (largest source) is that added by the washing process. The CHPP water inflow and outflow streams need to be sampled in parallel to determine this.

To assess the salt return from dust suppression, a salt balance is required for the individual locations. For the underground, continuous sampling of inflow and outflow water quantity and quality for a 14 day period should suffice.

Defining components of the salt balance is probably best achieved by a campaign or snapshot approach rather than continuous monitoring.

It is recommended this be done as soon as practicable and then repeated whenever there is a significant change in mining operations.

It is recommended that monitoring of rehabilitated area runoff to test for suitability for offsite discharge against the ANZECC guidelines involve a minimum of 5 runoff events and not less than 40mm of cumulative runoff proportionally sampled.

10 DIRECTOR-GENERAL'S REQUIREMENTS

Table 34 lists where each of the Director-General's requirements relating to surface water issues are addressed in this document.

Table 34
Coverage of Environmental Assessment Requirements and Environmental Issues in the Surface Water Report

Page 1 of 5

| ENVIRONMENTAL REQUIREMENTS RAISED BY THE DIRECTOR-GENERAL RELATING TO SURFACE WATER (25.01.07) | | |
|--|------------------------------------|--|
| | Relevant Section(s) | Comment |
| Key Assessment Requirements , namely: <ul style="list-style-type: none"> • <i>Surface Water</i> <ul style="list-style-type: none"> – Include detailed modelling of potential surface and groundwater impacts, a site water balance, and a detailed description of any proposed creek diversion. – Include a surface and groundwater contingency strategy as part of the mitigation measures which detail the measures proposed to protect the water supply to landowners in the region and the environment. | <p>4</p> <p>4.3.6.1</p> <p>4.3</p> | <p>Glennies Creek – Camberwell dirty water circuit balance – total containment. Portal flooding.</p> <p>Possum Skin Dam containment Proposed open pit.</p> <p>No Creek diversions. Contingency – temporary dirty water accumulation in open pit ARI > 50a</p> |

Table 34 (Cont'd)
Coverage of Environmental Assessment Requirements and Environmental Issues in the Surface Water Report

| ENVIRONMENTAL REQUIREMENTS RAISED BY THE DIRECTOR-GENERAL RELATING TO SURFACE WATER (25.01.07) | | |
|--|---------------------|---------|
| | Relevant Section(s) | Comment |
| References <ul style="list-style-type: none"> Managing Urban Stormwater: Soils and Construction Volume 14th Edition (Landcom). Guidelines for Fresh and Marine Water Quality and Guidelines for Water Quality Monitoring and Reporting (ANZECC). Rehabilitation Manual for Australian Streams (Land and Water Resources Research and Development Corporation). NSW State Rivers and Estuaries Policy – NSW Sand and Gravel Extraction Policy for Non Tidal Rivers (DNR). Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DEC). Environmental Guidelines: Use of Effluent by Irrigation (DEC). | | |

| ENVIRONMENTAL REQUIREMENTS RAISED BY GOVERNMENT AGENCIES RELATING SURFACE WATER | | | |
|--|---|---------------------|---|
| Government Agency | Paraphrased Requirement | Relevant Section(s) | Comment |
| Department of Natural Resources (10/04/06) | Detail proposed method of disposal of any tailings or waste water. | 4.3 | Use of existing facilities. Total containment of dirty water circuit. |
| | Detail of the results of any models or predictive tools used, including inputs, limitations for models used and any sensitivity analyses conducted. | 4.3 4.5 | Dirty water balance portal flooding. |
| | Interaction of this Project with other existing and proposed mining operations in the catchment. | 4.3 | Export of dirty water. |
| | Provide a site-specific water balance including: <ul style="list-style-type: none"> sources of water supply; location and design specifications for all clean water diversion; details of internal drainage of the contaminated water circuit; | 4 NA | Site runoff, underground and pit groundwater inflows existing clean water dams. |

Table 34 (Cont'd)
Coverage of Environmental Assessment Requirements and Environmental Issues in the Surface Water Report

| ENVIRONMENTAL REQUIREMENTS RAISED BY GOVERNMENT AGENCIES RELATING SURFACE WATER | | | |
|--|---|------------------------------------|---|
| Government Agency | Paraphrased Requirement | Relevant Section(s) | Comment |
| Department of Natural Resources (10/04/06) (Cont'd) | <ul style="list-style-type: none"> details in regard to any mine water storage proposed for the development; discussion of proposed monitoring programs and reporting procedures; description of integrated water management system, including an assessment of the water management system under a range of conditions. | 9 4.3 | No addition storage proposed. Flows and quality monitoring. Total containment design. |
| | <p>The Environmental Assessment must address the following.</p> <ul style="list-style-type: none"> Details of existing groundwater interception and management on site. Details of any anticipated increase in groundwater interception. Details of the location of all existing and proposed groundwater monitoring bores. Details of any additional dewatering and water management facilities. | See Groundwater Consultants Report | See Groundwater Consultants report (AGE). |
| Department of Environment and Conservation (22/12/04) | Demonstrate compliance with <i>Protection of the Environment Operations Act (1997)</i> , including <u>the protection of water quality</u> . | 7, 8, 9 | Application of ANZECC (2000) guidelines. |
| | Document and justify the methodology, data and assumptions used to design any pollution control works and assess the potential impact of the Project on water quality. | 4, 5, 8, 9 | Total containment rehabilitated land runoff quality impacts only. |
| | If a wastewater discharge is proposed it must be justified and it must be demonstrated that controlled discharges can be managed in compliance with the requirements of the Hunter River Salinity Trading Scheme. | NA | No wastewater discharge anticipated. |
| | <p>If a discharge under the Hunter River Salinity Trading Scheme is found to be necessary and the discharge would be via a tributary of the Hunter River, the EA must include a tributary impact assessment that addresses the following:</p> <ul style="list-style-type: none"> Impacts on downstream landholders: <ul style="list-style-type: none"> A list of downstream landholder/tenants including a record of permanent or seasonal activities; | | Not applicable. |

Table 34 (Cont'd)
Coverage of Environmental Assessment Requirements and Environmental Issues in the Surface Water Report

| ENVIRONMENTAL REQUIREMENTS RAISED BY GOVERNMENT AGENCIES RELATING SURFACE WATER | | | |
|--|--|---------------------|--|
| Government Agency | Paraphrased Requirement | Relevant Section(s) | Comment |
| Department of Environment and Conservation (22/12/04) (Cont'd) | <ul style="list-style-type: none"> - A description and list of all crossings, culverts and other in-stream structures. • Physical and biological impacts: <ul style="list-style-type: none"> - existing flow and stream characteristics, including current bank and bed profiles, potential flow volumes at key points of inflection within the stream course, stability of stream banks and beds and an assessment of soil types. - Assessment of likely impacts of proposed discharge including impacts on flow characteristics, potential for erosion of banks, bed or damage to riparian vegetation. • Proposed measures to: <ul style="list-style-type: none"> - minimise the impacts of discharge on downstream landholders, including a discharge notification procedure; - reduce potential erosion hazards at vulnerable points in the stream banks, protect and maintain riparian vegetation and bank stability, and provisions for energy dissipation of discharge waters where necessary. | 4 | Total containment of dirty water. Headwater catchment areas not significantly different to natural. |
| | | 7, 8 | Post mine catchment areas similar to pre-mine runoff the same or less. |
| | In cases where more than one mine discharges to a tributary, the EA must also address the collective impacts of discharge to that tributary. | NA | Not applicable. |
| Department of Primary Industries (Agriculture) (9 December 2004) | Possible changes to surface and groundwater flows and quality that could affect other water users and the environment. | 7, 8 | Headwater catchment < 2km ² surface runoff. Quarantined for < 10 years. Project lies within drawdown cone of Glennies Creek underground dewatering. |

Table 34 (Cont'd)
Coverage of Environmental Assessment Requirements and Environmental Issues in the Surface Water Report

| ENVIRONMENTAL REQUIREMENTS RAISED BY GOVERNMENT AGENCIES RELATING SURFACE WATER | | | |
|--|---|----------------------------|---|
| Government Agency | Paraphrased Requirement | Relevant Section(s) | Comment |
| Department of Primary Industries (Agriculture) (9 December 2004) (Cont'd) | Saline and wastewater management, and the changes the development will have on saline water generation, including controls to prevent the saline water storage structure 'Possum Skin Dam' from discharging water into Glennies Creek because of a run off event. | 4, 5 4,3,6,1 | Total containment of dirty water main circuit. Possum Skin Dam ARI 100 design. |

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12 GLOSSARY OF TECHNICAL TERMS

Baseflow

Baseflow comprises a combination of interflow (i.e. rainfall which infiltrates the ground surface and moves sub-surface through the soil mantle and other relatively shallow permeable materials e.g. alluvial/colluvial soils before entering a stream), underflow (i.e. flow in streambed alluvium) and groundwater which may discharge to a stream from deeper groundwater aquifers (under artesian conditions).

Baseflow Index

Ratio of baseflow volume to total flow volume in a stream averaged over a long period of time.

Baseflow Recession

The gradual reduction of baseflow in a stream during periods with no surface runoff. Baseflow recession is caused by gradual depletion of baseflow storage.

Baseflow Recession Constant

Rate of baseflow recession measured as the ratio of baseflow volume on one day to that on the previous day (linear model).

Baseflow Storage

Storage of water beneath the ground from where baseflow is derived.

CHPP

Coal Handling and Processing Plant.

Drawdown

Decline in groundwater level due to net loss of groundwater in storage (e.g. due to pumping or groundwater discharge during dry periods).

Evaporation

Loss of volume of a liquid (water) by conversion into vapour.

Evapotranspiration

Loss of water by evaporation and transpiration of plants.

Potential Evapotranspiration

Potential Evapotranspiration is the Evapotranspiration rate when moisture supply is not limiting. This rate is defined by climatic conditions.

Flow Duration Curve

A curve or relationship between streamflow and the percentage of proportion of time that flow is exceeded on average.

Gauging

Measurement of flow in a stream. Measurements are typically undertaken using a current meter or other flow velocity measuring device.

Gauging Station (Gauge)

A streamflow monitoring station that records surface water level in a stream at regular intervals.

Groundwater

Water that occurs beneath the ground surface in pores and other voids in the soil/rock mass.

Hydrograph (Flow)

Graphical plot of flow rate versus time.

Infiltration

Process of water movement into the ground surface (i.e. soil) from rainfall or irrigation water application.

Interflow

A component of baseflow (see Baseflow).

Interstices

The openings or pore spaces in a soil/rock mass.

Mean Annual Flow

The arithmetic mean of annual flows (usually expressed in megalitres/year).

Megalitre

Measurement of volume. Equal to one million litres or one thousand cubic metres.

Mine Water

Water that accumulates in Project operational areas (e.g. active open cuts, inactive open cuts, tailing disposal areas, CHPP water supply storage, coal washing and handling areas).

Orographic Effects

Effects that are caused by the physical geography of mountains and mountain ranges.

Overland Flow

Overland flow is water that travels over the surface of the catchment. It comprises both sheet flow and channel flow. Also known as quick flow.

Permeability

A measure of the rate at which water would flow into or through soil or rocks.

Rainfall Excess

All rainfall on a catchment that is not lost by evapotranspiration. The sum of surface runoff, interflow and deep percolation.

Recession (Flow)

The recession is the decrease in flow rate in a stream, which occurs following a rainfall event.

Recharge

Addition of water to baseflow storage from the surface (by infiltration).

Runoff

The volume of flow that passes an observation point on a stream. Runoff is normally measured as a depth by dividing total flow volume by the area of catchment contributing to flow upstream of that point. It is usually expressed as a depth per unit time such as millimetres per day or millimetres per year.

Seeps/Seepage (diffuse flow)

Expression of baseflow to the ground surface (small amount).

Sheet Flow

Overland flow which travels in a dispersed form rather than within a defined channel.

Spring (concentrated flow)

Expression of baseflow to the ground surface. This term is often applied to situations where the rate of groundwater discharge is sufficient to generate a measurable or visible surface flow.

Strahler Order

Starting at the top of a catchment, any watercourse which has no other watercourses flowing into it is classed as a 1st order watercourse; where two 1st order watercourses join, the watercourse becomes a 2nd order watercourse; if a 2nd order watercourse is joined by a 1st order watercourse – it remains a 2nd order watercourse; when two or more 2nd order watercourses join they form a 3rd order watercourse; a 3rd order watercourse does not become a 4th order watercourse until it is joined by another 3rd order watercourse; and so on.

Streamflow Variability

Variability of annual flows or coefficient of variation is the ratio of the standard deviation over the mean of annual flows. It is a statistical measure of the amount annual flows vary relative to the average.

Stressors

Physical, chemical or biological factors that may cause degradation of aquatic ecosystems when ambient values are too high/low (e.g. nutrients, biodegradable organic matter, dissolved oxygen, turbidity, suspended particulate matter, temperature, salinity, pH, ammonia, cyanide, heavy metals, biocides and other toxic organic compounds).

Supernatant

The layer of water above settled solids.

Surface Runoff

The proportion of runoff that was derived from overland flow. Variably expressed as either a volume (ML) or as an equivalent depth (mm) by dividing by catchment area (see Runoff).

Tailings

Finely ground residue (fine rejects and slimes) from processing and extraction of product (e.g. coal) from ore.

Toxicants

As defined in the ANZECC (2000) Guidelines *“toxicants is a term used for chemical contaminants that have the potential to exert toxic effects at concentrations that might be encountered in the environment.”*

Transmission Loss

Transmission loss is the loss of flow from a stream. It can be caused by seepage of water out of the stream channel through its bed and banks or loss of water to evapotranspiration in vegetated or ponded areas of a stream channel.

Turbidity

State of water clarity. Increased turbidity is accompanied by reduced light penetration into a water body and is measured by the proportion of light scattered as it moves through a given depth of water.

Underflow

A component of baseflow (see Baseflow).

Volumetric Water Supply Reliability

Expressed as a volume of water supplied divided by volume required.

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Appendices

Appendix A Additional Hydrometeorological Data
Tables

Appendix B Estimation of the Drainable Porosity of
the Camberwell North Pit Waste
Emplacement

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Appendix A

Additional Hydrometeorological Data Tables

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Table A1
Historic Monthly Rainfall Data Glennies Creek Composite

| Year | January | February | March | April | May | June | July | August | September | October | November | December | Annual |
|------|---------|----------|-------|-------|-------|-------|-------|--------|-----------|---------|----------|----------|--------|
| 1874 | 313.8 | 95.20 | 33.40 | 29.40 | 23.10 | 34.30 | 95.70 | 14.10 | 68.70 | 6.500 | 22.30 | 0.000 | 736.5 |
| 1875 | 54.40 | 237.6 | 44.10 | 25.20 | 55.10 | 98.80 | 20.10 | 13.60 | 26.00 | 30.00 | 29.10 | 10.80 | 644.8 |
| 1876 | -1.00 | 68.50 | 44.10 | 37.80 | 82.20 | 49.60 | 45.20 | 18.40 | 37.10 | 70.80 | 65.30 | 65.40 | -1.00 |
| 1877 | 44.20 | 1.100 | 18.90 | 4.600 | 32.80 | 13.00 | 84.10 | -1.00 | 22.20 | 49.00 | 18.20 | 62.30 | -1.00 |
| 1878 | 0.000 | 189.3 | 84.90 | 0.000 | 0.000 | 53.80 | 97.90 | 24.30 | 89.20 | 44.40 | 86.30 | 45.90 | 716.0 |
| 1879 | 29.50 | 126.0 | 43.60 | 53.50 | 118.2 | 32.30 | 48.80 | 130.7 | 74.10 | 14.50 | 163.0 | -1.00 | -1.00 |
| 1880 | 59.90 | 8.500 | -1.00 | 50.10 | 13.40 | 13.00 | 6.200 | 8.700 | 106.2 | 44.40 | 36.50 | 30.90 | -1.00 |
| 1881 | 37.90 | 194.3 | 16.20 | 7.900 | 35.30 | 0.300 | 8.400 | 72.90 | 56.10 | 64.50 | 13.90 | 2.800 | 510.5 |
| 1882 | 18.80 | 20.60 | 16.30 | 21.90 | 37.50 | 47.00 | 23.40 | 19.80 | 2.300 | 91.20 | 86.40 | 46.10 | 431.3 |
| 1883 | 85.40 | 135.5 | 1.700 | 80.30 | 75.80 | 11.90 | 9.700 | 80.60 | 113.2 | 64.40 | 41.70 | 33.30 | 733.5 |
| 1884 | 9.200 | 4.200 | 17.80 | 71.50 | 46.60 | 44.30 | 156.8 | 7.700 | 36.20 | 23.80 | 61.20 | 20.70 | 500.0 |
| 1885 | 61.00 | 74.10 | 47.60 | 78.00 | 29.50 | 109.9 | 10.00 | 2.800 | 41.40 | 48.00 | 52.60 | 69.70 | 624.6 |
| 1886 | 115.1 | 14.50 | 52.60 | 78.10 | 94.20 | 39.00 | 61.50 | 81.50 | 41.60 | 33.90 | 94.50 | 35.50 | 742.0 |
| 1887 | 145.6 | 163.8 | 73.20 | 135.3 | 67.70 | 41.80 | 92.00 | 126.9 | 30.80 | 25.30 | 161.2 | 200.3 | 1264 |
| 1888 | 12.90 | 103.2 | 21.00 | 11.90 | 10.70 | 38.20 | 28.20 | 6.300 | 59.70 | 29.00 | 29.70 | 53.30 | 404.1 |
| 1889 | 62.30 | 112.4 | 10.10 | 49.90 | 166.3 | 34.00 | 112.7 | 57.10 | 65.90 | 86.30 | 94.40 | 103.4 | 954.8 |
| 1890 | 111.5 | 247.4 | 208.0 | 28.80 | 106.5 | 88.80 | 99.60 | 24.20 | 26.10 | 28.70 | 79.80 | 70.10 | 1120 |
| 1891 | 83.00 | 30.80 | 85.20 | 32.50 | 26.20 | 119.3 | 33.30 | 30.00 | 88.30 | 48.70 | 105.3 | 38.40 | 721.0 |
| 1892 | 85.10 | 91.40 | 191.6 | 148.7 | 42.60 | 34.80 | 53.80 | 45.70 | 129.9 | 70.90 | 82.00 | 129.3 | 1106 |
| 1893 | 121.7 | 147.6 | 333.7 | 65.30 | 43.30 | 194.9 | 62.70 | 81.80 | 20.60 | 95.30 | 68.50 | 30.50 | 1266 |
| 1894 | 84.60 | 44.40 | 263.1 | 29.90 | 7.600 | 38.90 | 14.90 | 12.00 | 59.90 | 89.60 | 8.200 | 52.60 | 705.7 |
| 1895 | 276.9 | 73.10 | 1.300 | 20.90 | 22.50 | 25.20 | 6.300 | 24.00 | 32.00 | 18.80 | 97.80 | 124.0 | 722.8 |
| 1896 | 56.20 | 153.8 | 121.4 | 10.70 | 48.80 | 102.5 | 31.10 | 56.40 | 4.800 | 65.10 | 56.10 | 61.20 | 768.1 |
| 1897 | 45.70 | 9.900 | 38.80 | 62.10 | 36.60 | 84.30 | 120.9 | 35.50 | 27.70 | 90.60 | 6.400 | 73.50 | 632.0 |
| 1898 | 143.1 | 131.8 | 31.70 | 11.10 | 70.50 | 108.5 | 23.90 | 51.80 | 145.8 | 52.60 | 3.800 | 92.50 | 867.1 |
| 1899 | 23.60 | 1.000 | 30.90 | 133.7 | 20.40 | 41.40 | 73.10 | 200.6 | 65.50 | 55.60 | 50.80 | 40.60 | 737.2 |
| 1900 | 40.10 | 9.000 | 54.50 | 71.30 | 80.10 | 184.7 | 121.7 | 31.40 | 37.70 | 12.40 | 70.30 | 92.50 | 805.7 |
| 1901 | 69.10 | 8.700 | 83.70 | 82.90 | 25.50 | 36.50 | 18.30 | 56.00 | 30.20 | 45.50 | 39.70 | 60.20 | 556.9 |
| 1902 | 43.60 | 8.400 | 27.50 | 9.900 | 7.100 | 13.40 | 48.60 | 31.80 | 31.00 | 128.1 | 95.00 | 77.30 | 521.7 |
| 1903 | 4.100 | 2.300 | 134.9 | 53.40 | 34.50 | 27.00 | 79.00 | 74.40 | 166.6 | 119.9 | 122.2 | 119.3 | 937.6 |
| 1904 | 17.40 | 173.1 | 126.2 | 124.7 | 3.300 | 13.70 | 245.6 | 27.40 | 13.00 | 63.90 | 13.70 | 23.90 | 845.9 |
| 1905 | 6.900 | 2.800 | 120.4 | 88.20 | 13.00 | 33.30 | 20.10 | 39.30 | 22.60 | 31.10 | 57.00 | 11.40 | 446.1 |
| 1906 | 38.30 | 38.10 | 103.0 | 23.60 | 61.20 | 19.90 | 6.600 | 91.60 | 22.90 | 68.60 | 57.00 | 49.10 | 579.9 |
| 1907 | 88.10 | 37.80 | 124.7 | 33.30 | 23.60 | 42.90 | 3.800 | 12.40 | 10.60 | 3.100 | 77.30 | 83.30 | 540.9 |
| 1908 | 43.70 | 360.4 | 107.1 | 47.00 | 6.600 | 17.80 | 35.20 | 62.10 | 43.00 | 8.200 | 27.60 | 13.00 | 771.7 |
| 1909 | 28.20 | 115.9 | 11.90 | 32.30 | 11.50 | 72.50 | 8.200 | 52.50 | 87.00 | 42.30 | 66.30 | 216.9 | 745.5 |
| 1910 | 149.6 | 10.10 | 91.00 | 9.100 | 18.30 | 69.10 | 56.30 | 9.600 | 21.60 | 75.40 | 8.600 | 107.5 | 626.2 |
| 1911 | 147.7 | 79.80 | 142.2 | 33.00 | 13.40 | 12.00 | 121.5 | 67.00 | 49.00 | 34.40 | 53.40 | 43.70 | 797.1 |
| 1912 | 47.50 | 87.20 | 96.50 | 62.70 | 58.50 | 45.00 | 155.3 | 20.90 | 8.100 | 49.40 | 33.60 | 14.70 | 679.4 |
| 1913 | 69.40 | 28.50 | 87.30 | 117.7 | 246.5 | 88.30 | 53.40 | 12.20 | 37.10 | 28.70 | 17.70 | 17.70 | 804.5 |
| 1914 | 61.50 | 47.20 | 100.9 | 23.40 | 38.20 | 52.60 | 39.00 | 5.700 | 63.60 | 83.50 | 127.0 | 126.7 | 769.3 |
| 1915 | 27.20 | 62.70 | 25.10 | 44.20 | 130.0 | 13.10 | 35.00 | 9.500 | 39.40 | 18.00 | 0.800 | 83.80 | 488.8 |
| 1916 | 12.50 | 59.20 | 24.60 | 61.50 | 17.00 | 68.20 | 26.80 | 26.20 | 41.70 | 122.4 | 115.8 | 96.10 | 672.0 |
| 1917 | 95.40 | 45.20 | 21.30 | 49.40 | 10.00 | 12.70 | 13.70 | 29.80 | 132.4 | 46.70 | 119.2 | 62.90 | 638.7 |
| 1918 | 123.7 | 43.50 | 7.100 | 29.70 | 2.800 | 30.50 | 78.30 | 34.70 | 21.00 | 18.30 | 10.50 | 5.600 | 405.7 |
| 1919 | 45.30 | 41.20 | 29.90 | 28.90 | 77.70 | 5.600 | 20.10 | 5.100 | 72.90 | 15.50 | 20.50 | 56.80 | 419.5 |
| 1920 | 101.6 | 60.50 | 20.60 | 14.50 | 3.100 | 101.7 | 91.70 | 34.40 | 31.20 | 6.400 | 57.00 | 175.7 | 698.4 |
| 1921 | 68.10 | 40.10 | 122.5 | 201.2 | 175.1 | 94.60 | 115.9 | 12.20 | 22.10 | 58.40 | 99.60 | 90.10 | 1100 |
| 1922 | 80.80 | 47.70 | 23.40 | 8.300 | 24.60 | 28.00 | 164.9 | 3.300 | 69.70 | 39.80 | 2.800 | 50.60 | 543.9 |
| 1923 | 52.70 | 0.000 | 24.40 | 71.10 | 2.300 | 98.40 | 60.80 | 36.20 | 72.90 | 13.20 | 37.00 | 167.6 | 636.6 |
| 1924 | 117.6 | 62.70 | 11.10 | 106.6 | 30.10 | 36.60 | 55.90 | 21.60 | 81.20 | 21.00 | 169.8 | 109.5 | 823.7 |
| 1925 | 156.7 | 36.80 | 55.30 | 7.400 | 71.80 | 64.10 | 15.50 | 55.20 | 4.900 | 35.20 | 57.40 | 42.70 | 603.0 |
| 1926 | 25.40 | 21.50 | 249.2 | 118.5 | 56.40 | 25.60 | 64.30 | 25.90 | 31.00 | 10.50 | 10.70 | 223.6 | 862.6 |
| 1927 | 131.5 | 2.000 | 28.70 | 210.4 | 19.00 | 11.20 | 6.300 | 5.300 | 8.700 | 6.400 | 190.0 | 53.10 | 672.6 |
| 1928 | 112.3 | 104.6 | 107.5 | 64.80 | 12.50 | 75.00 | 87.20 | 11.90 | 2.800 | 38.00 | 19.00 | 15.30 | 650.9 |
| 1929 | 6.400 | 193.1 | 5.900 | 59.10 | 2.100 | 24.10 | 54.40 | 45.80 | 89.20 | 134.1 | 98.10 | 21.00 | 733.3 |
| 1930 | 64.00 | 32.30 | 86.40 | 16.20 | 32.00 | 305.7 | 47.90 | 26.20 | 3.100 | 68.80 | 28.70 | 94.50 | 805.8 |
| 1931 | 71.90 | 38.70 | 44.40 | 244.2 | 97.70 | 41.60 | 74.10 | 15.00 | 40.90 | 27.90 | 33.10 | 92.20 | 821.7 |
| 1932 | 4.400 | 120.7 | 100.3 | 19.60 | 8.100 | 15.10 | 17.30 | 18.60 | 116.0 | 15.70 | 85.90 | 37.20 | 558.9 |
| 1933 | 46.70 | 11.20 | 22.20 | 64.80 | 31.70 | 27.20 | 94.80 | 0.800 | 78.50 | 81.40 | 66.30 | 69.50 | 595.1 |
| 1934 | 56.10 | 183.1 | 15.60 | 62.60 | 21.20 | 22.40 | 98.70 | 59.10 | 115.4 | 50.30 | 39.70 | 83.40 | 807.6 |
| 1935 | 56.40 | 56.40 | 41.90 | 23.20 | 3.100 | 2.600 | 48.90 | 6.800 | 55.40 | 66.10 | 21.90 | 50.50 | 433.2 |
| 1936 | 56.30 | 52.70 | 110.3 | 18.00 | 42.50 | 27.70 | 52.40 | 30.00 | 10.40 | 8.100 | 6.300 | 166.7 | 581.4 |
| 1937 | 163.8 | 32.40 | 82.40 | 24.20 | 10.40 | 61.20 | 21.60 | 49.60 | 14.00 | 51.60 | 87.80 | 166.8 | 765.8 |
| 1938 | 85.10 | 33.70 | 24.70 | 42.20 | 74.50 | 17.30 | 21.40 | 59.50 | 18.80 | 46.30 | 42.00 | 2.300 | 467.8 |
| 1939 | 95.20 | 0.000 | 147.7 | 29.10 | 12.00 | 11.50 | 7.200 | 24.50 | 35.70 | 72.10 | 59.00 | 16.60 | 510.6 |
| 1940 | 35.90 | 2.000 | 19.00 | 75.20 | 12.50 | 11.00 | 3.000 | 45.50 | 30.70 | 31.80 | 81.80 | 118.4 | 466.8 |
| 1941 | 67.80 | 40.90 | 67.00 | 12.20 | 15.30 | 38.70 | 15.20 | 32.80 | 20.50 | 80.20 | 40.90 | 18.30 | 449.8 |
| 1942 | 13.90 | 87.10 | 160.2 | 9.700 | 16.10 | 28.10 | 82.70 | 17.80 | 28.00 | 99.40 | 102.4 | 60.70 | 706.1 |
| 1943 | 87.30 | 25.10 | 26.70 | 25.10 | 174.2 | 12.80 | 11.50 | 51.80 | 83.50 | 53.00 | 96.60 | 56.80 | 704.4 |
| 1944 | 50.50 | 36.60 | 30.30 | 33.50 | 58.90 | 6.600 | 38.30 | 67.90 | 23.90 | 8.000 | 9.700 | 16.80 | 381.0 |
| 1945 | 61.10 | 44.70 | 21.40 | 50.60 | 66.30 | 173.0 | 68.90 | 39.10 | 0.000 | 67.10 | 31.60 | 57.40 | 681.2 |
| 1946 | 78.30 | 54.30 | 106.0 | 170.5 | 4.800 | 51.60 | 7.100 | 0.800 | 18.90 | 14.70 | 25.70 | 48.20 | 580.9 |
| 1947 | 25.10 | 103.4 | 37.10 | 57.90 | 31.80 | 16.30 | 15.10 | 15.30 | 28.50 | 28.60 | 86.00 | 178.1 | 623.2 |
| 1948 | 72.00 | 96.30 | 72.90 | 24.20 | 72.00 | 100.1 | 5.300 | 13.20 | 122.0 | 4.400 | 28.60 | 84.20 | 695.2 |
| 1949 | 82.80 | 169.1 | 95.60 | 74.20 | 34.00 | 191.0 | 49.60 | 42.60 | 110.2 | 41.40 | 50.40 | 79.30 | 1020 |
| 1950 | 69.70 | 180.6 | 24.60 | 82.50 | 45.00 | 354.6 | 120.1 | 65.80 | 31.80 | 104.1 | 138.3 | 3.600 | 1221 |
| 1951 | 251.5 | 37.10 | 71.60 | 17.70 | 15.80 | 120.9 | 67.60 | 26.80 | 31.70 | 12.70 | 14.20 | 32.80 | 700.4 |
| 1952 | 7.600 | 47.00 | 86.10 | 54.50 | 24.50 | 51.00 | 103.2 | 196.6 | 11.20 | 87.90 | 16.90 | 66.00 | 752.5 |
| 1953 | 99.30 | 120.1 | 28.70 | 23.70 | 152.4 | 2.000 | 25.00 | 48.30 | 21.10 | 35.50 | 47.20 | 18.30 | 621.6 |
| 1954 | 93.30 | 228.0 | 5.500 | 8.200 | 15.60 | 29.60 | 101.0 | 21.60 | 55.80 | 103.9 | 116.7 | 53.40 | 832.6 |
| 1955 | 71.30 | 297.3 | 57.00 | 62.30 | 51.50 | 17.90 | 4.800 | 29.10 | 37.60 | 47.40 | 115.3 | 126.3 | 917.8 |
| 1956 | 82.60 | 120.3 | 155.7 | 51.70 | 77.70 | 76.50 | 35.40 | 35.70 | 4.600 | 42.40 | 10.10 | 73.50 | 766.2 |
| 1957 | 38.70 | 43.60 | 41.30 | 27.20 | 0.000 | 6.200 | | | | | | | |

Table A1 (Cont'd)
Historic Monthly Rainfall Data Glennies Creek Composite

| Year | January | February | March | April | May | June | July | August | September | October | November | December | Annual |
|-----------|---------|----------|-------|-------|-------|-------|-------|--------|-----------|---------|----------|----------|---------|
| 1962 | 122.6 | 130.5 | 22.50 | 47.60 | 182.0 | 11.20 | 54.70 | 46.80 | 36.60 | 33.30 | 43.70 | 111.0 | 842.5 |
| 1963 | 152.7 | 34.80 | 143.7 | 77.20 | 146.8 | 72.20 | 15.30 | 68.70 | 59.80 | 24.80 | 67.70 | 81.30 | 945.0 |
| 1964 | 77.70 | 22.90 | 19.10 | 152.2 | 40.90 | 175.1 | 10.50 | 20.90 | 42.10 | 79.80 | 11.20 | 31.20 | 683.6 |
| 1965 | 18.30 | 12.90 | 1.000 | 33.90 | 10.40 | 23.20 | 100.5 | 14.80 | 16.70 | 93.00 | 11.40 | 84.60 | 420.7 |
| 1966 | 14.60 | 54.00 | 46.30 | 13.70 | 32.20 | 37.40 | 2.400 | 46.80 | 20.90 | 59.80 | 94.80 | 53.00 | 475.9 |
| 1967 | 38.10 | 58.10 | 113.8 | 28.50 | 31.30 | 109.3 | 19.90 | 115.6 | 62.20 | 59.40 | 19.00 | 26.70 | 681.9 |
| 1968 | 266.8 | 43.00 | 68.50 | 7.700 | 97.40 | 9.100 | 15.80 | 53.70 | 16.20 | 10.40 | 19.30 | 102.8 | 710.7 |
| 1969 | 14.20 | 100.1 | 101.6 | 71.70 | 43.20 | 102.7 | 32.50 | 49.90 | 41.20 | 107.1 | 123.3 | 81.10 | 868.6 |
| 1970 | 165.5 | 26.40 | 46.20 | 34.90 | 15.30 | 9.400 | 0.300 | 16.40 | 96.30 | 33.70 | 51.70 | 171.3 | 667.4 |
| 1971 | 221.5 | 200.8 | 54.50 | 30.10 | 50.20 | 7.200 | 26.10 | 35.40 | 26.90 | 12.60 | 35.00 | 161.4 | 861.7 |
| 1972 | 158.7 | 24.90 | 73.40 | 101.9 | 30.50 | 27.50 | 1.100 | 46.30 | 26.10 | 179.9 | 64.00 | 29.20 | 763.5 |
| 1973 | 57.30 | 165.6 | 22.60 | 17.10 | 20.80 | 31.00 | 41.60 | 46.80 | 38.00 | 105.5 | 115.5 | 56.00 | 717.8 |
| 1974 | 151.1 | 48.80 | 28.80 | 92.20 | 82.00 | 83.10 | 9.300 | 25.90 | 15.40 | 56.30 | 111.8 | 6.700 | 711.4 |
| 1975 | 42.50 | 163.4 | 31.80 | 51.90 | 6.500 | 99.30 | 30.60 | 12.40 | 52.70 | 26.70 | 48.20 | 47.00 | 613.0 |
| 1976 | 188.2 | 206.9 | 175.4 | 30.50 | 24.60 | 56.00 | 64.20 | 9.600 | 21.50 | 68.70 | 39.00 | 18.30 | 902.9 |
| 1977 | 55.60 | 84.30 | 204.2 | 23.20 | 218.0 | 19.50 | 12.90 | 19.00 | 73.70 | 10.00 | 30.20 | 33.30 | 783.9 |
| 1978 | 183.8 | 15.20 | 280.3 | 66.60 | 39.40 | 94.20 | 20.80 | 21.10 | 44.30 | 30.10 | 81.80 | 101.5 | 979.1 |
| 1979 | 40.90 | 10.50 | 92.20 | 53.70 | 193.6 | 58.60 | 12.20 | 2.900 | 27.10 | 15.40 | 11.10 | 5.300 | 523.5 |
| 1980 | 72.70 | 44.20 | 32.90 | 0.800 | 55.90 | 29.90 | 20.00 | 2.500 | 0.000 | 45.50 | 3.800 | 130.4 | 438.6 |
| 1981 | 34.70 | 221.9 | 1.900 | 40.70 | 112.9 | 35.40 | 56.10 | 4.700 | 12.90 | 121.2 | 110.4 | 98.80 | 851.6 |
| 1982 | 50.30 | 92.30 | 185.1 | 12.20 | 10.10 | 21.30 | 20.30 | 0.400 | 67.10 | 31.10 | 21.90 | 17.30 | 529.4 |
| 1983 | 32.20 | 38.70 | 32.00 | 109.9 | 56.80 | 24.60 | 20.30 | 17.80 | 14.70 | 76.90 | 41.80 | 96.90 | 562.6 |
| 1984 | 171.9 | 100.7 | 94.60 | 72.90 | 30.70 | 27.00 | 70.80 | 9.700 | 27.00 | 58.60 | 141.3 | 66.50 | 871.7 |
| 1985 | 0.400 | 36.00 | 60.20 | 95.90 | 76.50 | 26.70 | 56.00 | 28.30 | 43.60 | 285.8 | 56.40 | 45.70 | 811.5 |
| 1986 | 100.3 | 20.00 | 2.500 | 15.80 | 29.30 | 25.10 | 28.20 | 74.40 | 89.30 | 40.60 | 110.1 | 10.70 | 546.3 |
| 1987 | 203.7 | 3.000 | 120.9 | 30.30 | 45.30 | 30.30 | 16.80 | 138.2 | 14.10 | 101.3 | 81.30 | 133.5 | 918.7 |
| 1988 | 124.7 | 140.5 | 39.20 | 223.0 | 34.80 | 18.30 | 64.90 | 49.50 | 84.20 | 1.100 | 96.70 | 106.8 | 983.7 |
| 1989 | 94.20 | 36.40 | 108.3 | 159.9 | 94.30 | 120.7 | 45.30 | 3.200 | 12.20 | 9.700 | 56.60 | 67.20 | 808.0 |
| 1990 | 84.00 | 271.5 | 55.20 | 128.9 | 72.90 | 24.70 | 65.90 | 66.10 | 91.20 | 26.10 | 11.00 | 30.10 | 927.6 |
| 1991 | 83.40 | 0.200 | 15.40 | 1.300 | 54.30 | 50.60 | 43.20 | 6.700 | 11.80 | 14.90 | 24.00 | 126.4 | 432.2 |
| 1992 | 68.40 | 259.0 | 75.40 | 43.40 | 11.60 | 35.00 | 8.200 | 34.50 | 55.60 | 4.600 | 65.30 | 214.8 | 875.8 |
| 1993 | 52.70 | 56.90 | 68.70 | 11.40 | 27.60 | 91.00 | 69.30 | 50.80 | 61.90 | 59.00 | 52.60 | 23.20 | 625.1 |
| 1994 | 83.00 | 90.40 | 87.00 | 67.60 | 3.000 | 23.20 | 19.20 | 12.60 | 2.100 | 28.40 | 30.50 | 85.90 | 532.9 |
| 1995 | 120.1 | 59.60 | 120.7 | 5.700 | 99.60 | 31.80 | 3.800 | 0.600 | 94.30 | 41.50 | 71.20 | 137.7 | 786.6 |
| 1996 | 76.20 | 27.80 | 35.80 | 11.80 | 69.70 | 27.80 | 20.80 | 65.50 | 57.30 | 38.70 | 102.8 | 103.4 | 637.6 |
| 1997 | 108.2 | 115.8 | 36.90 | 0.600 | 34.10 | 47.60 | 20.60 | 4.400 | 47.80 | 34.10 | 20.90 | 17.10 | 488.1 |
| 1998 | 112.7 | 46.10 | 5.700 | 69.50 | 143.6 | 55.20 | 101.5 | 146.6 | 65.30 | 61.50 | 48.90 | 32.20 | 888.8 |
| 1999 | 70.60 | 45.10 | 55.60 | 106.7 | 3.200 | 51.40 | 112.5 | 22.30 | 37.10 | 159.1 | 107.6 | 48.70 | 819.9 |
| 2000 | 45.70 | 25.70 | 254.8 | 79.20 | 9.500 | 13.10 | 33.30 | 24.60 | 23.00 | 44.60 | 96.90 | 70.80 | 721.2 |
| 2001 | 57.10 | 186.6 | 187.0 | 19.50 | 70.90 | 8.200 | 49.30 | 26.30 | 20.60 | 32.20 | 64.70 | 77.90 | 800.3 |
| 2002 | 25.40 | 178.2 | 124.3 | 10.40 | 56.50 | 29.00 | 8.000 | 8.000 | 14.90 | 0.000 | 22.50 | 116.9 | 594.1 |
| 2003 | 9.200 | 70.10 | 44.20 | -1.00 | -1.00 | -1.00 | -1.00 | -1.00 | -1.00 | -1.00 | -1.00 | -1.00 | -1.00 |
| Mean | 79.8 | 80.4 | 76.1 | 73.0 | 49.0 | 52.3 | 47.5 | 38.6 | 44.7 | 51.9 | 59.8 | 72.4 | 707.3 * |
| Max | 313.8 | 360.4 | 333.7 | 244.2 | 246.5 | 354.6 | 245.6 | 200.6 | 166.6 | 285.8 | 190 | 216.9 | 1266 |
| Yr of Max | 1874 | 1908 | 1893 | 1931 | 1913 | 1950 | 1904 | 1899 | 1903 | 1985 | 1927 | 1909 | 1893 |

*Annual total based on average of full years. Based on monthly totals long term average is 725mm.

Table A2
Regional Mean Monthly Evaporation Data (mm)

| Station | Jan | Feb | Mar | Apr | May | Jun | July | Aug | Sep | Oct | Nov | Dec | TOTAL |
|--------------------------------------|------------|------------|------------|------------|-----------|-----------|-----------|-----------|------------|------------|------------|------------|-------------|
| Class A Pan (Individual Stations) | | | | | | | | | | | | | |
| Jerry's Plains | 115.4 | 93.4 | 78.2 | 64.5 | 51.4 | 37.4 | 41.7 | 50.6 | 70.1 | 107.0 | 105.4 | 106.8 | 922 |
| Cessnock (Nulkaba) | 179.8 | 140 | 120.9 | 87 | 58.9 | 48 | 55.8 | 80.6 | 108 | 136.4 | 156 | 182.9 | 1354 |
| Paterson (Tocal AWS) | 189.1 | 145.6 | 130.2 | 102 | 74.4 | 66 | 77.5 | 105.4 | 132 | 164.3 | 180 | 213.9 | 1580 |
| Bureau of Meteorology Maps | 200 | 175 | 150 | 100 | 90 | 45 | 55 | 80 | 110 | 150 | 190 | 230 | 1575 |
| Bureau of Meteorology Maps | | | | | | | | | | | | | |
| Point PET | 220 | 165 | 165 | 120 | 75 | 70 | 70 | 100 | 130 | 165 | 195 | 225 | 1700 |
| Point Open Water (1) | 264 | 198 | 198 | 144 | 90 | 84 | 84 | 120 | 156 | 198 | 234 | 270 | 2040 |
| Areal PET | 180 | 140 | 135 | 90 | 65 | 50 | 50 | 65 | 95 | 140 | 155 | 170 | 1335 |
| Areal Open Water (1) | 216 | 168 | 162 | 108 | 78 | 60 | 60 | 78 | 114 | 168 | 186 | 204 | 1602 |
| ADOPTED | 216 | 168 | 162 | 108 | 78 | 60 | 60 | 78 | 114 | 168 | 186 | 204 | 1602 |
| (1) Assumed PET/Open Water = 0.83 | | | | | | | | | | | | | |

**Table A3
General Climatic Data**

LOSTOCK DAM

| | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | ANN | NO. | % COMP |
|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|--------|
| | YRS | | | | | | | | | | | | | | |
| Mean Daily Max Temp °C | 29.1 | 28.1 | 26.4 | 23.6 | 19.8 | 16.9 | 16.4 | 18.2 | 21.3 | 24.4 | 26.3 | 28.8 | 23.3 | 32.2 | 93 |
| Highest Max Temp °C | 42.4 | 42.5 | 39.8 | 36.7 | 27.5 | 25.0 | 26.0 | 28.3 | 34.9 | 38.5 | 42.0 | 42.0 | 42.5 | 32.8 | 95 |
| Mean Daily Min Temp °C | 17.2 | 17.2 | 15.4 | 12.7 | 10.2 | 7.8 | 6.5 | 6.9 | 9.2 | 11.8 | 13.9 | 16.1 | 12.0 | 32.3 | 93 |
| Lowest Min Temp °C | 9.2 | 10.2 | 5.6 | 3.6 | 0.7 | 1.2 | -1.7 | 0.1 | 1.0 | 3.3 | 6.0 | 7.3 | -1.7 | 32.7 | 93 |
| Mean 9am Relative Humidity (%) | 78 | 84 | 83 | 80 | 82 | 80 | 77 | 73 | 68 | 67 | 73 | 72 | 76 | 32.7 | 94 |
| Mean 9am Wind Speed (km/hr) | 5.7 | 5.1 | 5.3 | 6.7 | 8.1 | 10.0 | 11.3 | 11.6 | 10.7 | 9.4 | 7.6 | 6.9 | 8.2 | 31.7 | 91 |
| Mean 3pm Relative Humidity (%) | 56 | 62 | 61 | 56 | 55 | 61 | 55 | 46 | 46 | 48 | 51 | 46 | 53 | 10.9 | 86 |
| Mean 3pm Wind Speed (km/hr) | 12.7 | 11.0 | 10.2 | 12.0 | 12.8 | 14.4 | 16.1 | 17.0 | 16.2 | 16.4 | 14.7 | 15.8 | 14.2 | 10.9 | 85 |
| Mean Rainfall (mm) | 134.3 | 123.9 | 126.8 | 66.6 | 78.9 | 53.0 | 39.6 | 34.1 | 48.5 | 64.3 | 83.8 | 93.4 | 947.2 | 34.5 | 100 |
| Mean No. Rain days | 12.9 | 12.5 | 12.9 | 10.3 | 11.3 | 10.9 | 9.6 | 8.8 | 9.1 | 11.2 | 12.7 | 11.4 | 133.6 | 34.5 | 100 |
| Highest Monthly Rainfall (mm) | 413.8 | 448.4 | 418.5 | 272.2 | 274.0 | 138.7 | 152.8 | 163.6 | 121.5 | 312.8 | 180.5 | 231.2 | | 34.5 | 100 |
| Lowest Monthly Rainfall (mm) | 13.6 | 15.0 | 4.6 | 0.6 | 3.8 | 3.2 | 0.0 | 3.0 | 0.0 | 3.2 | 11.8 | 7.2 | | 34.5 | 100 |
| Highest Recorded Daily Rain (mm) | 97.8 | 146.0 | 143.6 | 57.6 | 116.8 | 74.4 | 74.8 | 55.0 | 67.6 | 145.0 | 81.0 | 102.4 | 146.0 | 34.5 | 100 |
| Mean No. of Clear Days | 5.2 | 5.1 | 5.6 | 9.6 | 9.5 | 7.8 | 11.8 | 11.7 | 9.0 | 7.9 | 5.8 | 7.3 | 96.2 | 12.4 | 96 |
| Mean No. of Cloudy Days | 13.1 | 12.6 | 10.6 | 7.9 | 9.2 | 10.4 | 6.5 | 6.2 | 7.7 | 9.7 | 10.6 | 10.2 | 114.6 | 12.4 | 96 |

PATERSON (TOCAL AWS)

| | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | ANN | NO. | % COMP |
|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|--------|
| | YRS | | | | | | | | | | | | | | |
| Mean Daily Max Temp °C | 29.4 | 28.6 | 26.8 | 24.2 | 20.6 | 17.6 | 17.3 | 19.2 | 22.1 | 24.8 | 26.5 | 29.0 | 23.8 | 29.6 | 81 |
| Highest Max Temp °C | 43.7 | 44.6 | 41.2 | 37.3 | 29.5 | 26.1 | 27.3 | 30.4 | 36.2 | 40.1 | 42.5 | 44.2 | 44.6 | 30.2 | 82 |
| Mean Daily Min Temp °C | 17.5 | 17.5 | 15.6 | 12.5 | 9.8 | 7.5 | 6.0 | 6.5 | 8.8 | 11.3 | 13.7 | 16.2 | 11.9 | 30.8 | 84 |
| Lowest Min Temp °C | 8.6 | 9.4 | 8.0 | 4.0 | 0.5 | 0.2 | -4.7 | -1.5 | -0.6 | 3.4 | 5.3 | 6.2 | -4.7 | 30.9 | 81 |
| Mean 9am Relative Humidity (%) | 75 | 80 | 80 | 77 | 80 | 78 | 75 | 69 | 64 | 63 | 68 | 68 | 73 | 28.2 | 77 |
| Mean 9am Wind Speed (km/hr) | 6.4 | 5.2 | 5.7 | 6.7 | 8.4 | 11.4 | 11.7 | 13.6 | 13.6 | 11.1 | 9.3 | 8.0 | 9.3 | 30.5 | 83 |
| Mean 3pm Relative Humidity (%) | 53 | 57 | 59 | 57 | 59 | 59 | 55 | 48 | 47 | 49 | 50 | 49 | 54 | 28.0 | 82 |
| Mean 3pm Wind Speed (km/hr) | 13.9 | 11.8 | 11.1 | 10.9 | 11.2 | 13.9 | 15.2 | 18.2 | 18.1 | 16.5 | 16.3 | 15.8 | 14.4 | 30.6 | 89 |
| Mean Rainfall (mm) | 116.6 | 115.5 | 122.3 | 76.7 | 79.2 | 66.7 | 41.7 | 37.5 | 45.7 | 68.8 | 79.4 | 78.1 | 928.3 | 34.3 | 100 |
| Mean No. Rain days | 11.8 | 11.3 | 11.9 | 9.2 | 11.1 | 9.8 | 8.8 | 7.6 | 7.9 | 9.8 | 11.5 | 9.4 | 120.1 | 34.3 | 100 |
| Highest Monthly Rainfall (mm) | 319.9 | 487.0 | 350.2 | 416.0 | 226.4 | 173.0 | 136.2 | 145.8 | 118.2 | 288.2 | 156.2 | 222.8 | | 34.3 | 100 |
| Lowest Monthly Rainfall (mm) | 2.8 | 7.8 | 9.6 | 1.6 | 3.8 | 3.0 | 0.0 | 0.0 | 0.0 | 1.3 | 10.6 | 13.2 | | 34.3 | 100 |
| Highest Recorded Daily Rain (mm) | 96.6 | 194.4 | 140.4 | 97.0 | 81.6 | 68.3 | 60.4 | 49.3 | 52.2 | 96.0 | 92.0 | 80.2 | 194.4 | 34.2 | 100 |
| Mean No. of Clear Days | 7.7 | 5.6 | 8.8 | 10.7 | 9.6 | 10.5 | 12.8 | 16.1 | 12.1 | 9.5 | 7.2 | 8.5 | 119.1 | 31.4 | 92 |
| Mean No. of Cloudy Days | 12.3 | 11.7 | 10.7 | 8.5 | 9.5 | 9.2 | 7.2 | 5.9 | 7.2 | 8.8 | 11.1 | 10.5 | 112.7 | 31.4 | 92 |

Table A3 (Cont'd)
General Climatic Data

| SCONE (PHILIP STREET) | | | | | | | | | | | | | | | |
|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------|--------|
| | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | ANN | NO. YRS | % COMP |
| Mean Daily Max Temp °C | 32.0 | 30.9 | 29.0 | 24.9 | 20.7 | 17.2 | 16.7 | 18.7 | 22.3 | 25.9 | 28.9 | 31.5 | 24.9 | 75.9 | 89 |
| Highest Max Temp °C | 42.0 | 43.1 | 38.9 | 36.8 | 28.3 | 25.2 | 26.6 | 28.9 | 34.5 | 40.0 | 43.3 | 42.2 | 43.3 | 26.9 | 100 |
| Mean Daily Min Temp °C | 16.4 | 16.1 | 14.0 | 10.0 | 6.5 | 4.5 | 3.1 | 4.0 | 6.2 | 9.7 | 12.4 | 14.9 | 9.8 | 74.5 | 88 |
| Lowest Min Temp °C | 8.9 | 9.6 | 4.3 | 0.7 | -3.3 | -3.0 | -4.9 | -4.2 | -0.8 | 1.8 | 5.5 | 6.8 | -4.9 | 26.9 | 99 |
| Mean 9am Relative Humidity (%) | 66 | 72 | 72 | 71 | 77 | 80 | 77 | 70 | 65 | 62 | 60 | 59 | 69 | 33.3 | 74 |
| Mean 9am Wind Speed (km/hr) | 7.4 | 6.8 | 6.7 | 6.8 | 6.2 | 6.6 | 7.4 | 8.1 | 8.7 | 9.2 | 8.5 | 8.1 | 7.5 | 26.8 | 99 |
| Mean 3pm Relative Humidity (%) | 41 | 44 | 43 | 43 | 51 | 55 | 50 | 44 | 42 | 42 | 38 | 36 | 44 | 22.9 | 85 |
| Mean 3pm Wind Speed (km/hr) | 11.6 | 11.0 | 10.9 | 11.0 | 9.9 | 10.2 | 11.4 | 12.5 | 12.6 | 12.3 | 12.5 | 12.6 | 11.5 | 26.5 | 98 |
| Mean Rainfall (mm) | 83.4 | 69.2 | 56.5 | 43.9 | 44.8 | 46.7 | 41.8 | 40.6 | 43.8 | 52.6 | 55.2 | 68.6 | 641.1 | 116.7 | 98 |
| Mean No. Rain days | 7.4 | 6.3 | 6.1 | 6.1 | 6.7 | 8.0 | 7.3 | 7.3 | 6.5 | 7.2 | 6.9 | 7.3 | 83.0 | 115.3 | 97 |
| Highest Monthly Rainfall (mm) | 281.7 | 349.0 | 244.6 | 165.1 | 199.9 | 195.0 | 169.2 | 154.0 | 161.0 | 174.8 | 177.4 | 218.8 | | 116.7 | 98 |
| Lowest Monthly Rainfall (mm) | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.5 | 0.0 | 3.0 | 1.0 | 0.0 | | 116.7 | 98 |
| Highest Recorded Daily Rain (mm) | 177.8 | 127.8 | 99.1 | 63.8 | 99.1 | 73.0 | 64.0 | 52.8 | 77.5 | 91.0 | 121.9 | 85.9 | 177.8 | 116.1 | 97 |
| Mean No. of Clear Days | 9.2 | 7.4 | 8.6 | 10.2 | 8.4 | 8.2 | 10.9 | 12.2 | 11.7 | 9.4 | 8.8 | 9.7 | 114.6 | 26.9 | 100 |
| Mean No. of Cloudy Days | 10.8 | 10.6 | 10.9 | 10.1 | 12.0 | 12.9 | 10.0 | 8.9 | 9.1 | 11.1 | 9.9 | 9.4 | 125.7 | 26.9 | 100 |
| SINGLETON ARMY | | | | | | | | | | | | | | | |
| | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | ANN | NO. YRS | % COMP |
| Mean Daily Max Temp °C | 30.6 | 29.5 | 28.2 | 24.9 | 21.0 | 17.8 | 17.0 | 19.2 | 22.2 | 25.5 | 27.5 | 30.4 | 24.3 | 18.5 | 87 |
| Highest Max Temp °C | 42.2 | 43.0 | 40.0 | 37.5 | 28.5 | 24.3 | 26.0 | 28.5 | 36.1 | 41.0 | 42.5 | 44.0 | 44.0 | 20.3 | 96 |
| Mean Daily Min Temp °C | 17.7 | 17.9 | 16.1 | 12.6 | 9.5 | 6.8 | 5.2 | 6.3 | 8.8 | 11.8 | 14.1 | 16.7 | 11.6 | 18.0 | 85 |
| Lowest Min Temp °C | 7.1 | 8.5 | 8.0 | 3.0 | 1.0 | 0.0 | -3.4 | -0.5 | 0.5 | 4.0 | 5.5 | 8.5 | -3.4 | 20.2 | 94 |
| Mean 9am Relative Humidity (%) | 72 | 77 | 74 | 75 | 80 | 81 | 77 | 71 | 64 | 61 | 65 | 63 | 72 | 14.3 | 69 |
| Mean 9am Wind Speed (km/hr) | 5.5 | 5.5 | 6.4 | 6.3 | 6.3 | 6.7 | 7.9 | 7.0 | 7.6 | 7.7 | 6.8 | 6.5 | 6.7 | 14.0 | 66 |
| Mean 3pm Relative Humidity (%) | 49 | 52 | 51 | 49 | 56 | 56 | 52 | 42 | 42 | 42 | 43 | 40 | 48 | 14.1 | 68 |
| Mean 3pm Wind Speed (km/hr) | 10.8 | 11.3 | 10.2 | 9.1 | 8.3 | 8.1 | 9.7 | 9.7 | 9.7 | 11.1 | 11.9 | 11.7 | 10.1 | 14.0 | 66 |
| Mean Rainfall (mm) | 94.3 | 88.9 | 72.7 | 58.4 | 59.7 | 37.9 | 29.4 | 37.1 | 45.3 | 69.1 | 67.9 | 63.0 | 723.7 | 20.8 | 98 |
| Mean No. Rain days | 10.8 | 10.3 | 10.5 | 9.4 | 9.7 | 9.5 | 8.0 | 7.8 | 8.4 | 10.0 | 10.3 | 7.9 | 112.6 | 19.3 | 91 |
| Highest Monthly Rainfall (mm) | 238.7 | 248.1 | 199.9 | 184.8 | 169.9 | 107.8 | 83.2 | 161.4 | 101.9 | 199.3 | 144.3 | 151.3 | | 20.8 | 98 |
| Lowest Monthly Rainfall (mm) | 15.6 | 6.6 | 2.3 | 0.0 | 7.0 | 6.0 | 0.0 | 2.6 | 0.4 | 3.8 | 6.5 | 6.8 | | 20.8 | 98 |
| Highest Recorded Daily Rain (mm) | 65.0 | 67.6 | 89.9 | 61.4 | 89.2 | 51.5 | 29.8 | 57.6 | 34.6 | 58.4 | 61.5 | 58.5 | 89.9 | 20.4 | 96 |
| Mean No. of Clear Days | 4.9 | 4.1 | 4.6 | 5.8 | 6.1 | 5.2 | 7.9 | 10.0 | 7.1 | 5.8 | 4.3 | 5.0 | 70.8 | 15.9 | 75 |
| Mean No. of Cloudy Days | 11.1 | 11.7 | 10.2 | 7.3 | 10.0 | 9.3 | 5.9 | 6.1 | 7.1 | 9.2 | 9.1 | 9.2 | 106.3 | 15.9 | 75 |

Table A3 (Cont'd)
General Climatic Data

| CESSNOCK (NULKABA) | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | ANN | NO. YRS | % COMP |
|----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------------|-----------|
| Mean Daily Max Temp °C | 30.3 | 29.4 | 27.4 | 24.5 | 20.9 | 18.1 | 17.6 | 19.6 | 22.5 | 25.2 | 27.2 | 29.4 | 24.3 | 26.8 | 87 |
| Highest Max Temp °C | 44.0 | 44.4 | 40.6 | 34.6 | 29.4 | 25.5 | 25.3 | 30.6 | 35.4 | 40.1 | 42.9 | 41.7 | 44.4 | 27.1 | 87 |
| Mean Daily Min Temp °C | 17.6 | 17.6 | 15.4 | 11.7 | 8.7 | 5.9 | 4.5 | 4.8 | 7.7 | 10.8 | 13.6 | 16.0 | 11.2 | 27.3 | 88 |
| Lowest Min Temp °C | 8.1 | 8.4 | 6.6 | 1.0 | -1.4 | -2.9 | -4.2 | -3.3 | -0.6 | 0.6 | 4.0 | 5.6 | -4.2 | 27.3 | 87 |
| Mean 9am Relative Humidity (%) | 70 | 75 | 75 | 75 | 80 | 81 | 79 | 71 | 63 | 60 | 65 | 64 | 71 | 28.8 | 93 |
| Mean 9am Wind Speed (km/hr) | 10.3 | 9.6 | 9.8 | 9.4 | 9.8 | 10.6 | 11.1 | 12.6 | 14.0 | 13.3 | 12.0 | 11.5 | 11.2 | 27.2 | 87 |
| Mean 3pm Relative Humidity (%) | 49 | 53 | 55 | 52 | 56 | 56 | 51 | 45 | 43 | 45 | 47 | 46 | 50 | 28.3 | 91 |
| Mean 3pm Wind Speed (km/hr) | 16.7 | 15.6 | 15.1 | 12.9 | 12.4 | 13.8 | 14.3 | 16.0 | 17.8 | 17.0 | 17.3 | 17.1 | 15.5 | 25.2 | 81 |
| Mean Rainfall (mm) | 91.2 | 100.9 | 88.5 | 56.8 | 56.4 | 48.6 | 33.4 | 38.4 | 39.6 | 58.7 | 69.2 | 69.1 | 750.8 | 38.3 | 100 |
| Mean No. Rain days | 10.5 | 10.2 | 10.6 | 8.6 | 9.1 | 8.5 | 7.3 | 7.7 | 7.5 | 9.4 | 10.7 | 9.3 | 109.4 | 38.3 | 100 |
| Highest Monthly Rainfall (mm) | 251.3 | 370.0 | 289.3 | 246.6 | 170.9 | 196.6 | 126.7 | 159.8 | 109.3 | 187.6 | 176.4 | 187.7 | | 38.3 | 100 |
| Lowest Monthly Rainfall (mm) | 2.5 | 4.8 | 4.0 | 1.9 | 3.6 | 4.2 | 0.5 | 0.0 | 0.4 | 1.3 | 13.9 | 7.8 | | 38.3 | 100 |
| Highest Recorded Daily Rain (mm) | 99.2 | 148.8 | 137.8 | 65.4 | 130.0 | 86.2 | 60.0 | 75.2 | 49.6 | 81.8 | 65.0 | 69.6 | 148.8 | 38.3 | 100 |
| Mean No. of Clear Days | 4.8 | 3.8 | 4.8 | 5.8 | 5.9 | 6.6 | 8.1 | 10.1 | 7.5 | 5.9 | 4.4 | 4.4 | 72.2 | 29.0 | 94 |
| Mean No. of Cloudy Days | 12.4 | 12.4 | 11.9 | 9.8 | 11.1 | 9.4 | 8.1 | 7.1 | 8.0 | 10.7 | 12.5 | 11.3 | 124.7 | 29.0 | 94 |

**Table A4
Catchment and Gauging Station Statistics Middle Hunter and Glennies Creek**

| GS# | 210001 | 210122 | 210098 | 210023 | 210117 | 210109 | 210050 | 210049 | 210121 | 210042 | 210115 | 210116 |
|-------------------------|----------------------|----------------------------|--|------------------------|------------------------------|-------------------------------|------------------------|-----------------------|-----------------------------|------------------------|-----------------------------------|-----------------------------------|
| | Hunter R @ Singleton | G/Ck @ U/S Hunter Junction | Glennies Creek Fall Brook @ Camberwell | G/Creek @ The Rocks #1 | G/Creek @ G/Ck Dam – Storage | Carron Brook @ U/S Fall Brook | Swamp Ck @ Ravensworth | York Ck @ Ravensworth | Foybrook @ Newdell Junction | Foybrook @ Ravensworth | Foybrook @ investigation site u/s | Foybrook @ investigation site d/s |
| Coordinates | | | | | | | | | | | | |
| East (m) | 328217 | 318717 | 320100 | 334300 | 335200 | 339000 | 318300 | 317600 | 316300 | 316350 | 316400 | 316500 |
| North (m) | 6395770 | 6401994 | 6405100 | 6416900 | 6417950 | 6420200 | 6408400 | 6411800 | 6411900 | 6413800 | 6415300 | 6414700 |
| Area (km ²) | 16400 | 550 | 534 | 236 | 225 | 96 | 19 | 12 | 173 | 170 | 165 | 167 |
| Rating Curve | 1035 | 24 | -- | 96 | | 25 | 86 | 75 | 14 | 188 | 40 | 35 |
| # Gaugings | | | | | | | | | | | | |
| # Curves | 76 | -- | -- | -- | | 5 | -- | -- | 1 | 67 | -- | -- |
| H'st Gauged (ml/d) | 457509 | 236 | -- | 8318 | | 2167 | 34.25 | 345 | 862 | 2050 | 609 | 549 |
| Estimated Max (ml/d) | | | | | | | | | | | | |
| Ratio | | | | | | | | | | | | |
| Flow Record | | | | | | | | | | | | |
| Start | 22.01.72 | -- | -- | 01.02.44 | | 24.01.79 | 01.03.58 | 01.03.58 | 31.03.88 | 22.03.56 | 01.12.81 | 01.12.81 |
| End | 02.03.04 | | | 01.04.63 | | 04.08.82 | 01.07.68 | 01.01.69 | 03.01.92 | 23.11.99 | 01.01.86 | 01.01.86 |
| Temporal Eff. | 81% | | | 86% | | 93% | 97% | 98% | 100% | 93% | 99% | 99% |
| Rating Eff. | | | | | | | | | | | | |
| Overall | | | | | | | | | | | | |
| Annual Runoff | | | | | | | | | | | | |
| (mm) | 32.45 | | | 257 | | 90.6 | 48.0 | 55.4 | 143.6 | 90.5 | 77.0 | 73.5 |
| Runoff % | | | | | | | | | | | | |
| Flow Statistics | | | | | | | | | | | | |
| No. of Days | 11728 | | | 6999 | | 1287 | 3775 | 3959 | 1372 | 15951 | 1492 | 1492 |
| Mean ml/d | 1457 | | | 166 | | 23.8 | 2.5 | 1.82 | 68 | 42.1 | 34.8 | 33.6 |
| Median ml/d | | | | | | | | | | | | |
| Std. Dev. ml/d | 1521 | | | 1011 | | Record too short | 1 | 14.1 | -- | 41.5 | 222 | 217 |
| Skew | 1.42 | | | 15.7 | | -- | 11.7 | 20.8 | | 1.07 | 15.9 | 16.3 |
| Max flow ml/d | 366014 | | | 33273 | | 8159 | 353 | 563 | 18720 | 25288 | 5150 | 5150 |
| Date of max flow | 04.03.77 | | | 20.02.56 | | 06.05.79 | 23.04.64 | 15.05.62 | 03.02.90 | 03.02.90 | 14.10.85 | 14.10.85 |

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Table A4 (Cont'd)
Catchment and Gauging Station Statistics Middle Hunter and Glennies Creek

| GS# | 210113 | 210074 | 210078 | 210075 | 210077 | 210008 | 210035 | 210071 | 210080 |
|----------------------------|-------------------------------|--------------------------------------|-------------------------------------|---|--|--------------------------------------|---|---------------------------------|------------------------------------|
| | Foybrook @ Upper Hebden | McMahons Ck @ Liddell (site 5) | Tinkers Ck @ Liddell (site 1) | Bayswater Ck @ u/s Liddell (site 2) | Maidswater Ck @ Liddell (site 4) | Hunter R u/s Muswellbrook weir | Glendon Brk @ Mitchell's Flat (dam site) | Glendon Brk @ Glendon Brk | West Brook @ u/s Glendon Brk |
| Coordinates | | | | | | | | | |
| East (m) | 315000 | 313000 | 307900 | 307900 | 308900 | 300500 | 339749 | 343800 | 338500 |
| North (m) | 6418500 | 6418200 | 6416000 | 6416800 | 6419500 | 6428750 | 6396069 | 6401000 | 6405800 |
| Area (km ²) | 123 | 1 | 7 | 11 | 6 | 4220 | 476 | 275 | 80 |
| Rating Curve # Gaugings | 55 | 71 | 77 | 26 | -- | 202 | -- | 90 | 113 |
| # Curves | -- | 4 | 22 | -- | 2 | -- | -- | 10 | 1 |
| H'st Gauged (ml/d) | 195 | 925 | 111 | 3 | -- | 61360 | -- | 1850 | 5120 |
| Estimated Max (ml/d) | | | | | | | | | |
| Ratio | | | | | | | | | |
| Flow Record | | | | | | | | | |
| Start | 01.07.80 | 25.09.72 | 26.09.72 | 01.01.68 | 31.12.72 | 01.07.18 | -- | 12.11.70 | 10.08.78 |
| End | 01.01.86 | 01.01.83 | 03.01.92 | 01.08.71 | 01.01.83 | 01.01.63 | -- | 06.07.78 | 11.12.03 |
| Temporal Eff. | 100% | 93% | 98% | 96% | 98% | 95% | | 94% | 95% |
| Rating Eff. | | | | | | | | | |
| Overall | | | | | | | | | |
| Annual Runoff | | | | | | | | | |
| (mm) | 80.4 | 73.4 | | 14.8 | 73.1 | 87.2 | | | 121.9 |
| Runoff % | | | | | | | | | |
| Flow Statistics | | | | | | | | | |
| No. of Days | 2010 | 3749 | 7037 | 973 | 3652 | 16255 | | 2792 | 9254 |
| Mean ml/d | 27.06 | 0.201 | 22.8 | 0.447 | 1.2 | 1008 | | 389 | 26.7 |
| Median ml/d | | | | | | | | | |
| Std. Dev. ml/d | 194 | 0.189 | 22.1 | 2.97 | 0.850 | 4080 | | 469 | 23.8 |
| Skew | 17.6 | 1.49 | 0.703 | 14.0 | 1.26 | 19.6 | | 1.56 | 0.838 |
| Max flow ml/d | 3827.5 | 535 | 17946 | 41.59 | 1511 | 161382 | | 91909 | 72892 |
| Date of max flow | 14.10.85 | 24.01.76 | 29.01.84 | 20.01.69 | 20.03.78 | 27.02.55 | | 19.01.71 | 31.01.88 |

**Table A5
Catchment and Gauging Station Statistics for Selected Stations in the Goulburn – Hunter Valley**

| | Goulburn @ Goggan | Goulburn @ Kerrabee | Goulburn @ Sandy Hollow | Wybong Ck @ Wybong | Baerami Ck @ Baerami | Merriwa R @ u/s vallances | Wollar Ck @ Wollar | Merriwa R @ Merriwa | Kruri Collaroy @ | Apple Tree Crk @ Dural Gap | Goulburn R @ Ulan | Hunter R @ Maison Dieu | Muggyrang Creek | Lower Pokolbin | First Creek | Middle Creek | Wollombi Brook |
|-------------------------|-------------------|---------------------|-------------------------|--------------------|----------------------|---------------------------|--------------------|---------------------|------------------|----------------------------|-------------------|------------------------|-----------------|----------------|-------------|--------------|----------------|
| GS# | 210006 | 210016 | 210031 | 210040 | 210060 | 210066 | 210082 | 210091 | 210092 | 210120 | 210046 | 210128 | 210069 | 210068 | 210063 | 210067 | 210004 |
| Coordinates | | | | | | | | | | | | | | | | | |
| East (m) | 274800 | 247800 | 271600 | 277300 | 260379.9 | 248894.9 | 777793.9 | 250301.2 | 225891.9 | 297755.4 | 758300.0 | 316651.0 | 338200 | 343600 | 344300 | 344400 | 315250 |
| North (m) | 6414900 | 6410100 | 6418500 | 6427100 | 6407333.8 | 6423482.7 | 6418004.2 | 6440778.9 | 6441382.3 | 6395307.3 | 6424800.0 | 6398841.0 | 6368700 | 6369800 | 6373200 | 6371800 | 6394660 |
| Area (km ²) | 3445 | 5043 | 6895 | 689 | 395 | 693 | 274 | 465 | 515 | 29 | 159 | 14500 | 5 | 25 | 14 | 8 | 1848 |
| Rating Curve # Gaugings | 391 | 402 | 453 | 233 | 178 | 196 | 39 | 131 | 98 | 19 | 160 | 20 | 102 | 118 | 125 | 91 | 458 |
| #Curves | 58 | 101 | 79 | 15 | 44 | 23 | 16 | 53 | 31 | 1 | | 6 | 10 | 4 | 2 | 1 | 88 |
| H'st Gauged (ml/d) | 6210 | 29600 | 29900 | 24100 | 1070 | 1270 | 109 | 16400 | 297 | 93.4 | 44.7 | 2910 | 105 | 130 | 1275 | 890 | 13415 |
| Estimated Max (ml/d) | 60837 | 128928 | 106227 | 22316 | 5012 | 12076 | 1438 | 7350 | 24818 | 257 | 4910 | 92680 | 371 | 2348 | 1129 | 457 | 262700 |
| Ratio | 9.8 | 4.4 | 3.6 | 0.9 | 4.7 | 9.5 | 13.1 | 0.45 | 83.6 | 2.8 | 109.8 | 31.8 | 3.5 | 18.1 | 0.9 | 0.5 | 19.6 |
| Flow Record | | | | | | | | | | | | | | | | | |
| Start | 26.09.73 | 16.07.69 | 09.11.72 | 19.03.79 | 13.10.80 | 01.01.71 | 29.04.80 | 15.09.80 | 21.05.75 | 13.06.84 | 01.03.56 | 26.07.93 | 11.11.63 | 11.11.63 | 25.10.63 | 11.12.63 | 01.02.08 |
| End | Current | Current | Current | Current | 02.01.92 | 02.01.92 | 10.09.97 | 02.01.92 | 31.12.88 | 19.02.98 | 01.09.82 | 02.02.04 | 25.06.93 | 09.12.03 | 27.09.78 | 31.07.78 | 01.01.05 |
| Temporal Eff. | 81% | 80% | 75% | 77% | 79% | 92% | 92% | 84% | 80% | 90% | 97% | 55% | 97% | 93% | 99% | 95% | 65% |
| Rating Eff | 0.4486 | 0.3799 | 0.4527 | 0.3992 | 0.3115 | 0.4642 | 0.4953 | 0.2492 | 0.0253 | 0.9548 | 0.4852 | 0.4579 | 0.4969 | 0.5513 | 0.4980 | 1 | 0.1506 |
| Overall | 0.36 | 0.30 | 0.34 | 0.31 | 0.24 | 0.42 | 0.46 | 0.21 | 0.02 | 0.86 | 0.47 | 0.25 | 0.48 | 0.51 | 0.49 | 0.95 | 0.10 |
| Annual Runoff (mm) | 19.4 | 24.5 | 26.1 | 35 | 33.2 | 23 | 13.8 | 33.1 | 34 | 56.9 | 24.4 | 21.8 | 86 | 54.8 | 9.1 | 9.9 | 81.7 |
| Runoff % | 3 | 3.7 | 4 | 5.4 | 5 | 3.7 | 2.3 | 5.2 | 5.1 | 8.8 | 3.8 | 4.6 | 13 | 8.4 | 1.4 | 1.5 | 12.6 |
| Flow Statistics | | | | | | | | | | | | | | | | | |
| No. of Days | 8983 | 10079 | 8581 | 6675 | 3937 | 7778 | 6200 | 4116 | 4490 | 4928 | 9601 | 7739 | 10518 | 13595 | 5398 | 5087 | 23171 |
| Mean ML/day | 215 | 310 | 409 | 61.7 | 37.1 | 51.5 | 9.01 | 35.6 | 61.7 | 6.43 | 13.2 | 292 | 0.98 | 4.427 | 4.35 | 2.54 | 511 |
| Median ML/day | 42.8 | 69 | 111 | 7.34 | 1.2 | 10.8 | 1.7 | 5.65 | 12.7 | 0.368 | 2.05 | 6.65 | 0 | 0 | 0 | 0 | 39.1 |
| Std.Dev. ML/day | 1620 | 3120 | 2510 | 1015 | 201 | 390 | 42 | 253 | 480 | 16 | 94 | 911 | 12 | 105 | 60 | 29 | 4610 |
| Skew | 31.5 | 61.2 | 29.4 | 67.2 | 13.1 | 20.5 | 18.1 | 19.6 | 35.4 | 5.05 | 27.3 | 8.69 | 40.5 | 68.45 | 484 | 26.3 | 28.1 |
| Max Flow ML/day | 152379 | 128928 | 267951 | 117081 | 7926 | 48242 | 5048 | 50483 | 64908 | 346 | 4905 | 121985 | 2371 | 15557 | 4320 | 1882 | 262681 |
| Date of Max Flow | 4/3/77 | 2/2/71 | 26/2/55 | 9/2/92 | 2/2/71 | 30/1/84 | 2/4/89 | 30/1/84 | 3/3/77 | 21/6/89 | 26/6/56 | 1/8/98 | 1/3/77 | 1/3/77 | 1/3/77 | 1/3/77 | 1/2/55 |

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Appendix B

Estimation of the Drainable Porosity of the Camberwell North Pit Waste Emplacement

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B1 Porosity

In this section estimates of porosity for three separate periods are presented and discussed.

B2 Background

A reduction in sump level is a result of outflows, (pumping to Possum Skin Dam, Camberwell, Rixs Creek, etc.), exceeding inflows, (percolation below the tailing dam(s), D2, percolation from rainfall on the overburden emplacement, and pumping from the underground operation).

The ratio of net water volume extracted to bulk sump volume change is an estimate of the drainable porosity of the waste between the initial and final sump levels selected.

Nett Pit Sump outflow, which drives sump drawdown, is the small difference between two large numbers and therefore poorly defined. Of the two large numbers, inflow is more poorly defined since neither of the largest inputs, i.e. percolation below the tailing dam and overburden emplacement rainfall deep seepage, can be measured directly. Not only must the volumes be estimated but the lag associated with transmission of these flows through the overburden emplacement to the sump is also unknown.

Additionally, porosities may well vary with depth due to overburden pressure and waste material type.

B3 Porosity From Initial Filling of Possum Skin Dam

It has been stated that when Possum Skin Dam was first filled, the draw down of the sump was less than expected – by implication the porosity larger than expected.

This 'apparent' anomaly results from the fact that it was not possible to pump to Possum Skin Dam and supply Camberwell at the same time (other than the electric pump) so while pumping to Possum Skin Dam was continuing, seepage below the tailing dam and D2 was not being fully compensated by pumping back to Camberwell.

Further, the three sump pumps at the time were poorly matched such that the capacity to Possum Skin Dam was only about 160l/s and not 300+ as thought (verified by storage change in Possum Skin Dam), making the filling process slow and the seepage flow below the tailings dam significant.

Finally, Possum Skin Dam was about half full before changing levels were recorded, reducing the volume change on which porosity estimates could be made [Ever present problem of the small differences between large numbers].

Each of these factors were considered and incorporated in the PSM porosity estimates made from this data. **Table B.1** summarises these estimates as detailed in the PSM Report No. 237.01 "Flooded Coal Recovery" April 2004.

Table B.1

Estimated Pit-Sump-Overburden emplacement Drainable/Fillable Porosity for three short periods

| Period | Sump Levels ⁽¹⁾ and Storage | | | | Storage Increment (m ³) | Rate (m ³ /d) | Net Outflow | | Estimated Porosity ⁽²⁾ (-) |
|---|--|------------------------------|--------------------------|------------------------------|---|-----------------------------|-----------------|-----------------------------|---|
| | Initial Level (mAHD) | Storage (m ³) | Final Level (mAHD) | Storage (m ³) | | | Duration (d) | Volume (m ³) | |
| 12/2 – 25/3 | 51.07 | 29,959,201 | 49.83 | 28,432,835 | 1,526,366 | 1,945 | 42 | 81,690 | 0.054 |
| 26/3 – 8/4 | 49.83 | 28,432,835 | 49.26 | 27,748,196 | 684,640 | 3,194 | 14 | 44,716 | 0.065 |
| 9/4 – 18/4 | 49.12 | 27,581,662 | 48.97 | 27,403,944 | 177,719 | 2,582 | 8 | 20,656 | 0.116 |
| | | | | | | | | Mean | 0.078 |
| (1) Correction applied to early levels 05.04.04 | | | | | | | | Std | 0.033 |
| (2) Any delayed yield would result in higher porosities | | | | | | | | Dev | |

B4 Porosity From May – October 2005 Data

Combined flow and sump level data from late May to mid October 2005 are available. Although there were some problems with the meters, for the first time it was about possible to measure all outflows from the sump.

Estimated pumping rates for the period (Ken Barry pers. comm.) were:

- Underground to portal sump 0.9M/d
- Portal to underground 0.85M/d
- 400mm line to D1, (or TD2 or D2) 4.72M/d
- 225mm line to Coal Handling and Processing Plant 2.20M/d
- 225mm line to Rixs Creek 2.00M/d

These indicate a sump dewatering capacity of around 6 920m³/d. Only a small quantity of water had been pumped to Aston and no water had been pumped to Possum Skin Dam since May 2005.

Porosity estimates are directly related to pump rates. If pump rates are 20% higher than indicated, true porosity will also be about 20% higher, and vice versa.

Figure B.1 plots sump levels for the period 27/05/05 to 14/10/05. During this period rainfall was generally less than average, **Table B.2**.

Table B.2
Regional Rainfall, Recent and Long Term Average

| Location | June | July | August | Sept | Oct |
|------------------|------|------|--------|------|-------|
| Singleton | | | | | |
| Average | 34.8 | 40.8 | 31.8 | 50.4 | 34.5 |
| 2005 | 49.6 | 13.4 | 4.9 | 51.1 | 37.5* |
| Scone | | | | | |
| Average | 41.0 | 36.2 | 39.9 | 39.4 | 61.3 |
| 2005 | 76.6 | 35.0 | 17.6 | 50.0 | 37.6* |

*Part month only to 14/10/05

This includes a 25 day Coal Handling and Processing Plant shutdown period with a more or less coincident period without pumping to Rixs Creek.

For about the first 50 days (from 27/05/05) there is a more or less gradual slow decline in water levels. Virtually all of this decline occurs in the first 28 days. At this time Geoff MacKenzie made the general observation that the decline only seemed to occur when there was pumping to Rixs Creek. Taken at face value, with 2ML/d pumped to Rixs Creek, the implied porosity is about 24%.

If capacity to Rixs was half, i.e. 1ML/d, the porosity would also be about half ~12%.

After the period of very gradual decline there are two weeks of rapid decline prior to the Coal Handling and Processing Plant shut down. About the same time as the Coal Handling and Processing Plant shut, pumping to Rixs Creek was postponed for independent reasons. Since pumping was unchanged during this period there must have been significant change in inflow (or a sudden dramatic change in porosity – very unlikely). This change in inflow must have to do with a change in seepage below D2 and TD2. It is most important that the basis of this dramatic change in sump drawdown rate be understood.

In phone discussions with Colin Davies (Camberwell's Contract Environmental Officer) he indicated that tailings discharge had been split between the old TD1 and TD2 about 50-50 and water was being pumped back to D1 from TD2. He did not know if TD1 drained to TD2 or was isolated. Operators have noted that TD2 now appears to be holding water compared with earlier situations where it was observed to drain rapidly in the absence of inflows.

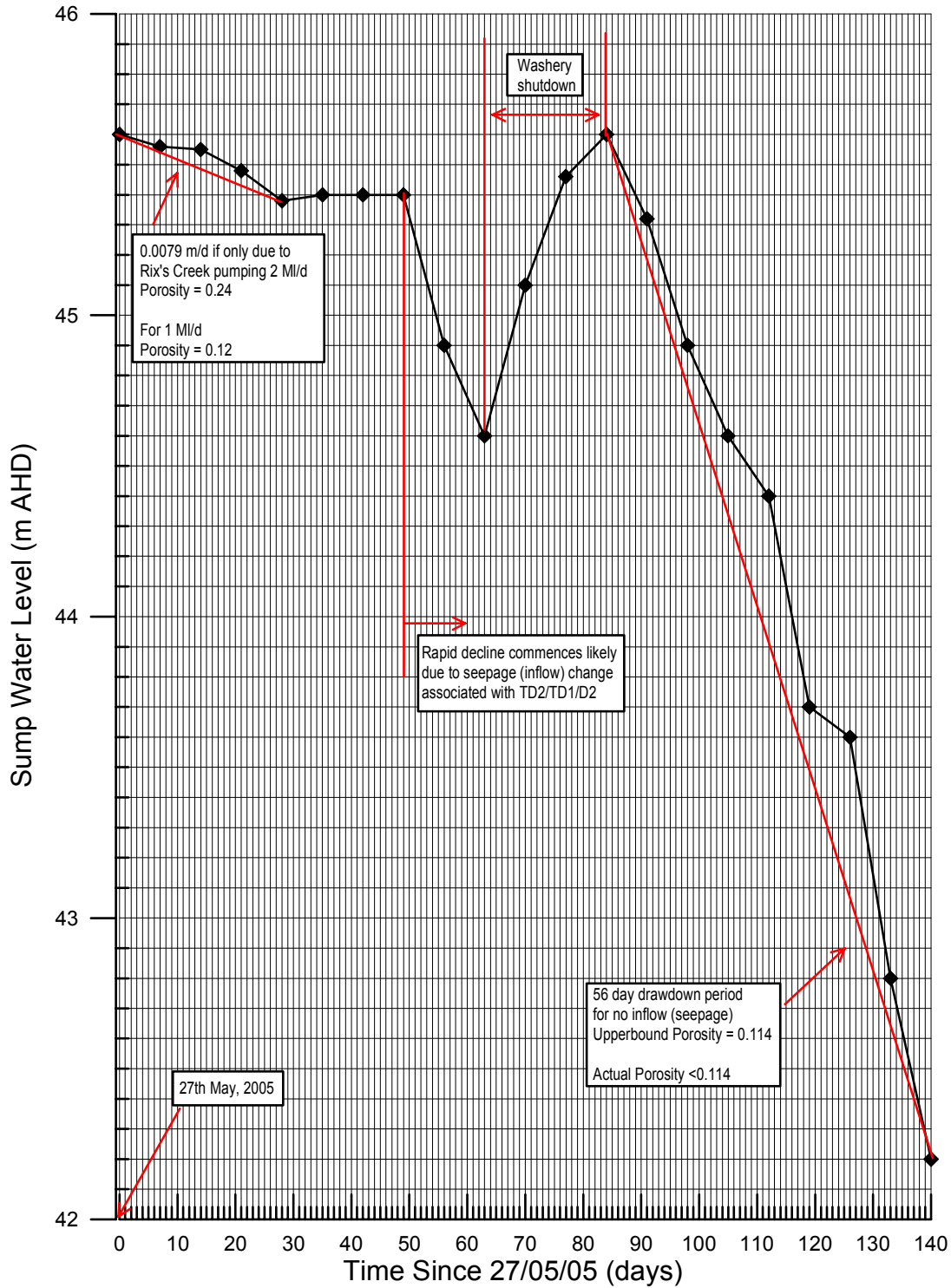


Figure B.1 Portal Sump Levels 27/05/05 to 14/10/05

During the Coal Handling and Processing Plant shutdown there was a recovery in the sump level. On restart of the Coal Handling and Processing Plant the rapid more or less steady decline in sump levels recommenced.

This 50+ day period of steady decline allows an upperbound to be placed on porosity. If it is assumed there is no seepage below TD1, TD2 and D2 for the period and low rainfall, then all water has been drawn from interstitial storage. This provides an upper bound estimate on porosity, which computes to 0.112. [11.2%] This assessment is based on a 56 day period and a 3.4m change in sump level and represents a reliable upperbound porosity estimate, provided pump flows are accurate and a 24/7 pump rate of 6 970m³/d is assumed.

Making a range of plausible assumptions, it is possible to estimate the corresponding porosities. Before TD1 was brought back into use and sump levels were only declining slowly, requiring seepage below TD2 and D2 to about balanced sump pumping. That is seepage was likely in the range 5 500 to 6 500m³/d. Assuming TD1 is impermeable and isolated and receiving 50% of tailings this is immediately reduced to about 3 000m³/d. If it is further assumed that of the water entering TD2 50% is returned (pumped) to D1 then seepage becomes 1 500m³/d.

Table B.3
Porosity Estimates 56 Day Drawdown Period Sept-Oct 2005

| Sump Pump Rate (m ³ /d) | Assumed Tailin g Seepage Rate (m ³ /d) | Implied Porosity (m) | Comment/Assumptions |
|------------------------------------|---|----------------------|---|
| 6 970 | 0 | 0.112 | Theoretical Upperbound |
| 6 970 | 1 500 | 0.087 | 50% to isolated, impermeable, TD1 50% of 50% return water TD2 to D1 |
| 6 970 | 3 000 | 0.064 | TD1 drains to TD2 50% return water |

B5 POROSITY FROM SONDE DATA DECEMBER 2005 – MARCH 2006

Early December 2005 a water level sonde was installed in the Sump. Pumping data for the period 22 December 2005 to 3rd March 2006 is presented in **Figure B.2** for the three discharge lines. **Figure B.3** is a summation of these discharges for the period. Data on discharge from the underground is not available but based on recent experience is assumed to be balanced by dust suppression flows to the underground.

Figure B.4 provides the sump water level trace from 6th December 2005. The recovery mid period corresponds to a Coal Handling and Processing Plant shut down period. The recovery in level is taken to be largely associated with local drawdown around the sump under pumping rather than inflow.

For the period 22nd December to 3rd March 2006, the mean pumping rate is 3 020m³/d and the mean drawdown rate 31mm/d. At the intermediate sump level of 42m/AHD this corresponds to a porosity of 10.1%.

Table B.4
Regional Rainfall, Recent and Long Term Average

| Location | | | | |
|------------------------------|------|------|------|------|
| Singleton | | | | |
| Average | 83.4 | 69.6 | 94.7 | 68.5 |
| 2005-2006 | 11.6 | 27.2 | 20.8 | 22.8 |
| Scone | | | | |
| Average | 67.8 | 87.2 | 78.0 | 52.1 |
| 2005-2006 | 25.4 | 43.6 | 40.6 | 1.2 |
| *Part month only to 09/03/06 | | | | |

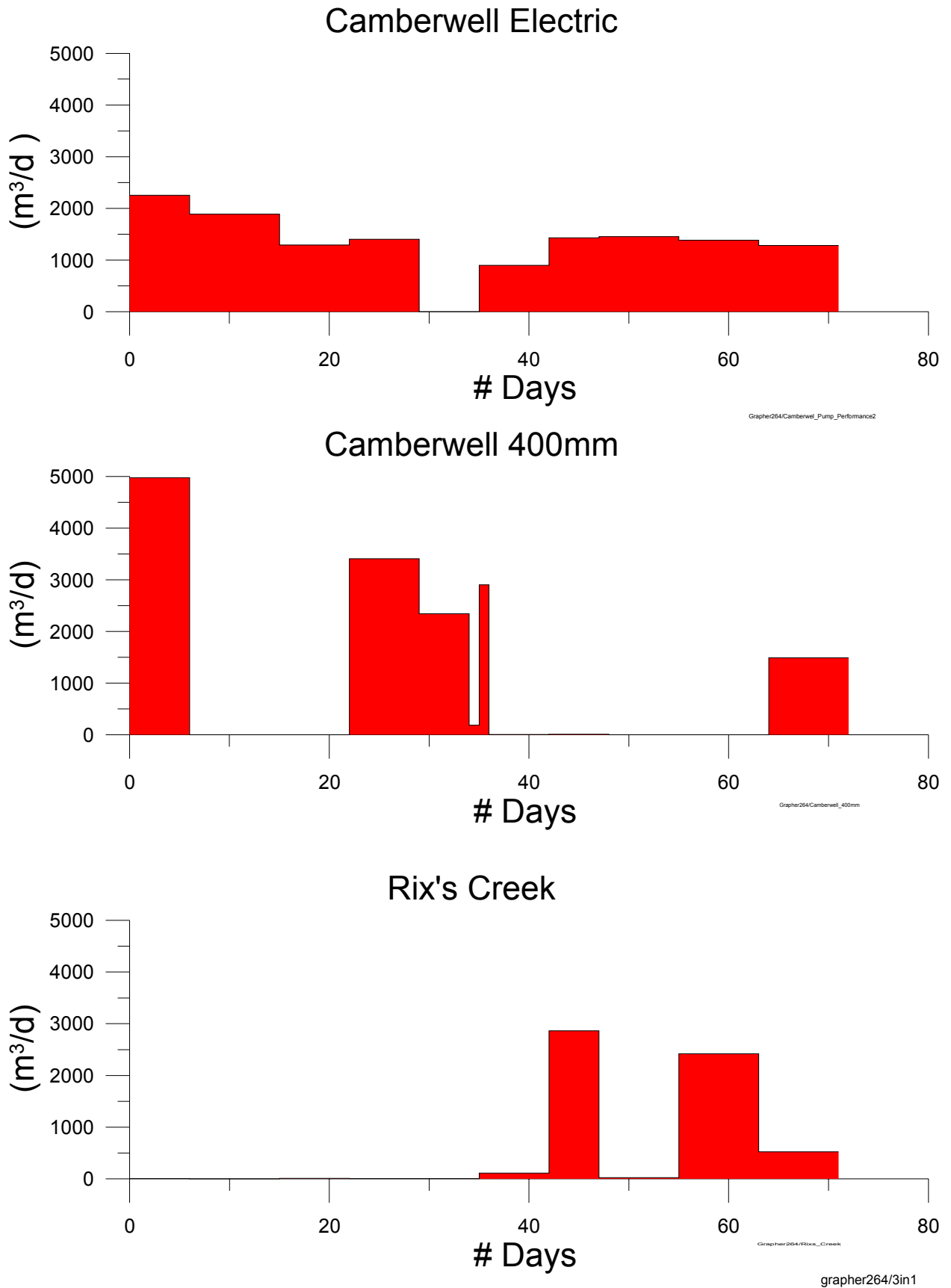


Figure B.2 Component Sump Pumping Rates 22/12/05 to 03/03/06

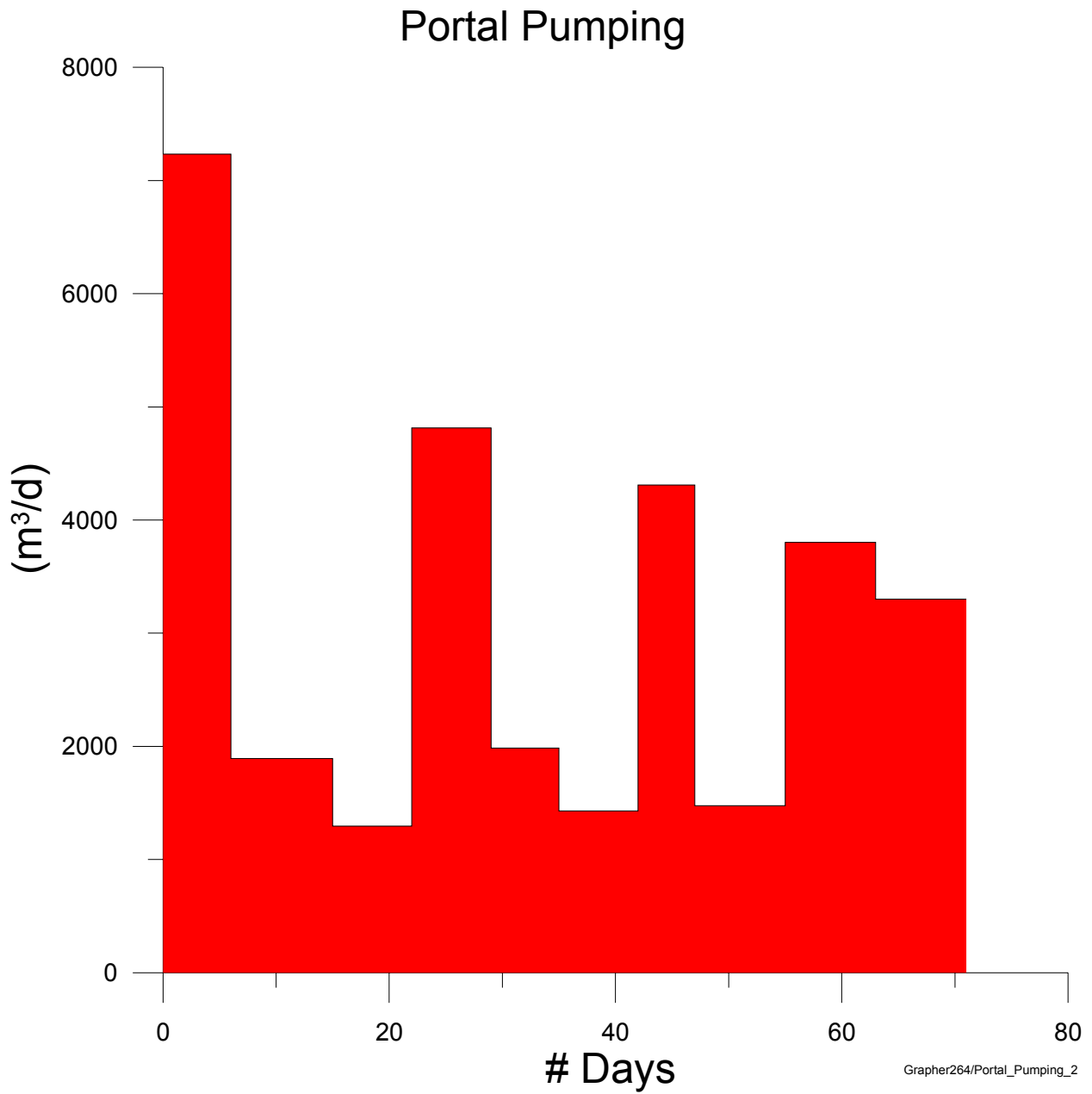
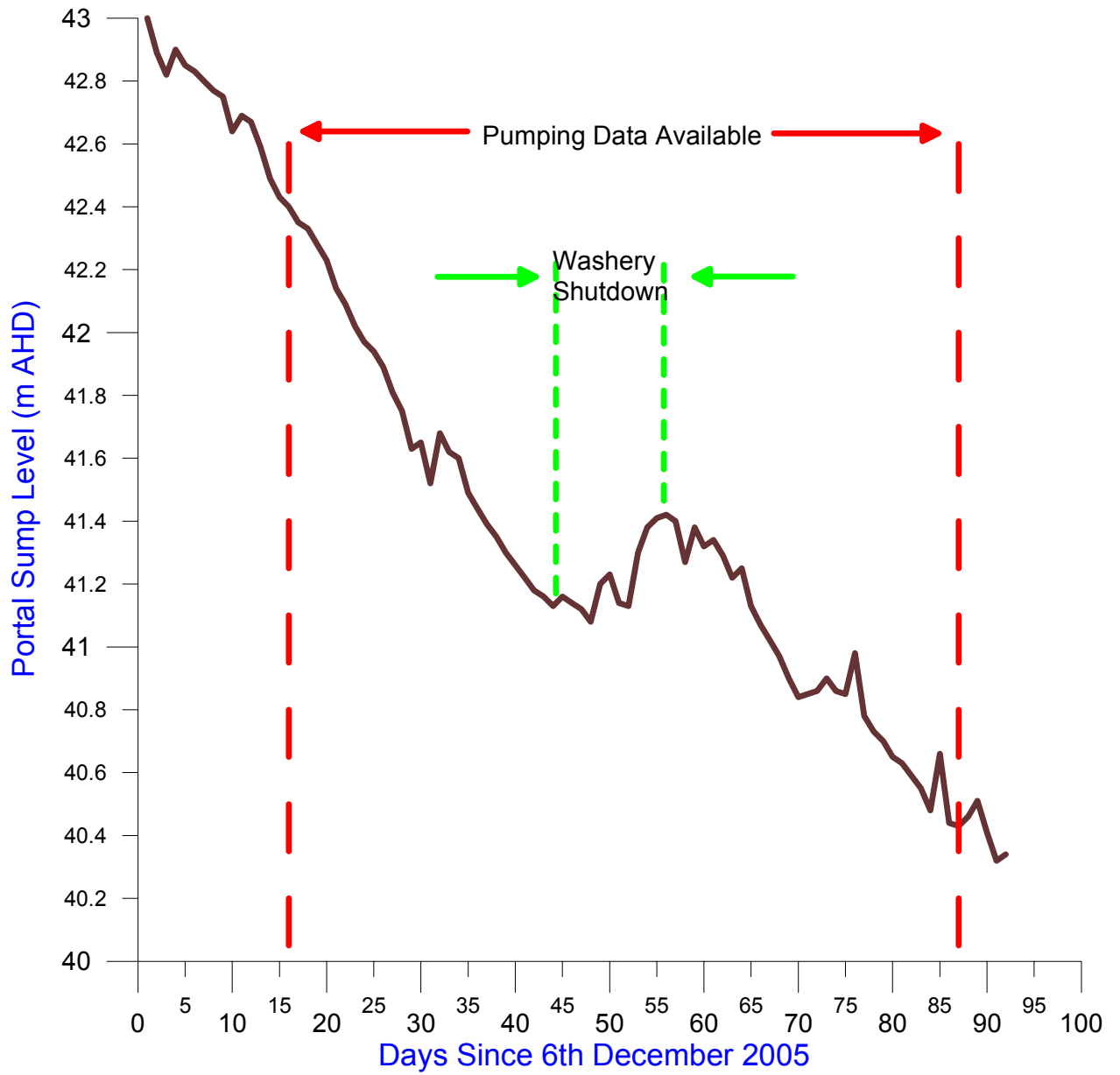


Figure B.3 Combined Sump Pumping Rates 22/12/05 to 03/03/06



grapher264/gck_plot

Figure B.4 Portal Sump Levels 06/12/05 to 09/03/06

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