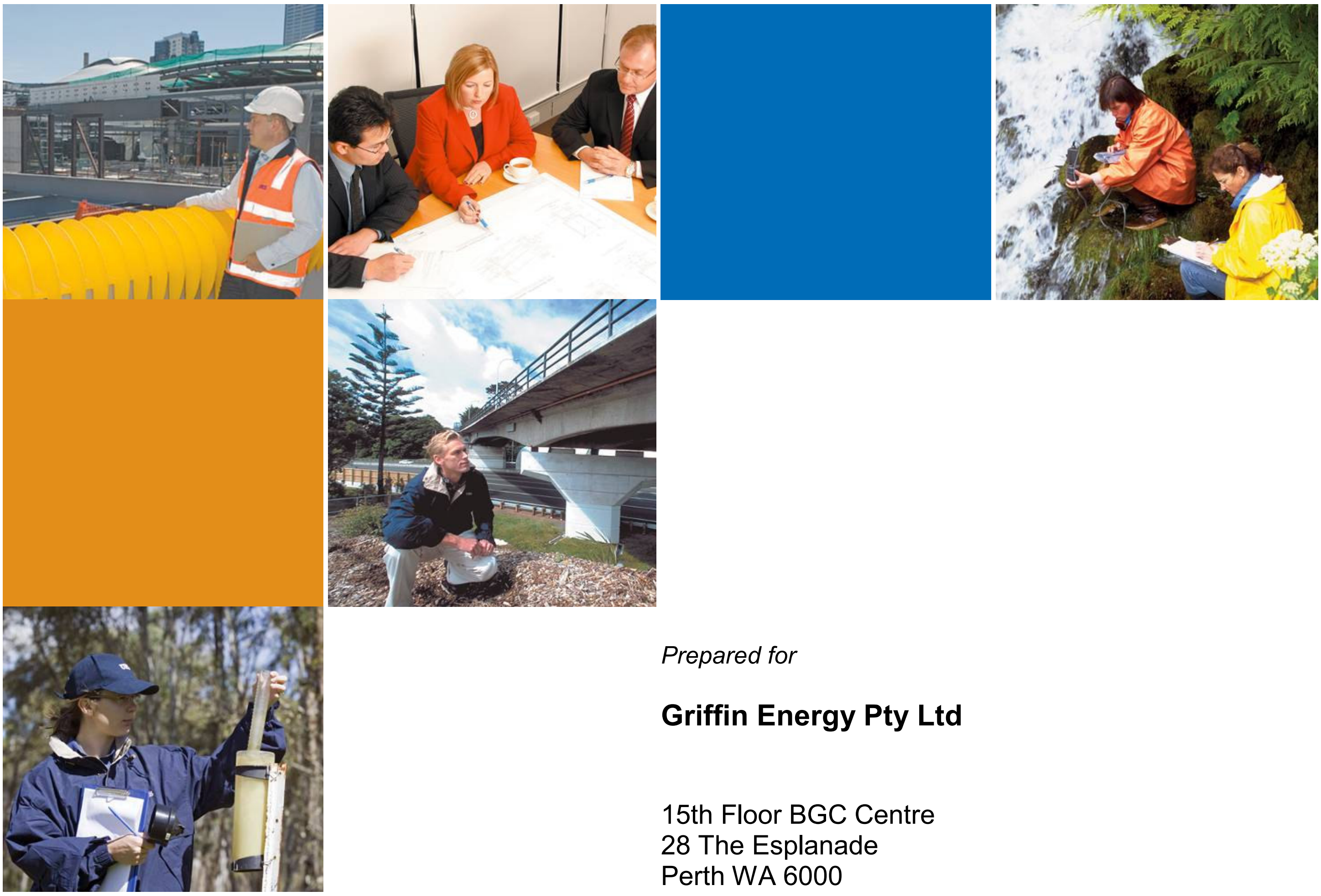
REPORT

Bluewaters Water Supply Strategy



Prepared for

Griffin Energy Pty Ltd

15th Floor BGC Centre
28 The Esplanade
Perth WA 6000

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655-4296749

DRAFT

Project Manager:

....
Emad Sahouryeh
Principal Water Engineer

URS Australia Pty Ltd

Project Director:

....
Ian Brunner
Senior Principal
Hydrogeologist

Level 3, 20 Terrace Road
East Perth
WA 6004
Australia
Tel: 61 8 9326 0100
Fax: 61 8 9326 0296

Date:
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Content

1 Introduction 1-1

1.1 Project Background 1-1

2 Geology of the Collie Basin 2-1

2.1 Stratigraphy 2-1

2.2 Stockton Group and Collie Group 2-2

2.3 Nakina Formation 2-2

3 Hydrogeology of the Collin Basin 3-1

3.1 Aquifer Types/Zones 3-1

3.1.1 Collie Group Aquifer Systems 3-1

3.1.2 Superficial Aquifer System 3-3

3.2 Recharge 3-4

4 Water Management Framework 4-1

4.1 Water Allocation Policies 4-1

4.2 Managing Water Strategies 4-1

5 Assessment of Water Demand 5-1

5.1 Urban Water 5-1

5.2 Power Stations 5-1

5.2.1 Requirements for Blue Waters Power Station 5-1

5.2.2 Muja & Collie Power Stations 5-1

5.2.3 Other Industries 5-2

5.2.4 Irrigation 5-2

5.2.5 Environment 5-2

6 Assessment of Water Sources 6-1

6.1 Groundwater use in Collie Basin 6-1

6.2 Surface Water Resources 6-3

6.3 Potential Water Sources 6-4

6.3.1 Groundwater from Pit Dewatering Abstractions (Premier Sub-Basin) 6-5

6.3.2 Water Supply Borefields 6-11

6.3.3 Diverted stream flow from Collie River Eastern Branch 6-11

6.3.4 Water Supply Dams 6-11

6.3.5 Mine Voids 6-12

7 Bluewaters Water Supply Strategy 7-1

Content

7.1 Priorities for Water Use ... 7-1

7.1.1 From Pit dewatering ... 7-1

7.1.2 From the Collie-Wellington Basin ... 7-1

7.2 From Mine Voids ... 7-1

7.3 Secure Supply Options ... 7-1

7.4 Proposed Supply Strategy ... 7-2

7.5 Priorities of Demand and Supply ... 7-2

7.6 Supply Strategies for Bluewaters Power Station I - IV ... 7-3

7.6.1 Supply Strategy 1 ... 7-3

7.6.2 Supply Strategy 2 ... 7-6

7.6.3 Supply Strategy 3 ... 7-7

7.7 Preferred Strategy ... 7-8

7.8 Monitoring and management of Water Supply ... 7-8

8 Conclusions ... 8-1

9 Limitations ... 9-1

10 References ... 10-2

11 Appendix ... 11-1

List of Tables:

Table 3-1 Stratigraphic Zones of Collie Group Groundwater Abstraction (2003 to 2007) ... 3-2

Table 3-2 Distribution of Recharge Based on Stratigraphic Unit Subcrop Areas ... 3-4

Table 3-3 Simulated Recharge - DoW Groundwater Flow Model (2003) ... 3-5

Table 4-1 Management Units of Collie-Wellington Surface Water Catchment ... 4-4

Table 5-1 Bluewaters Power Station Water Demand ... 5-1

Table 5-2 Verve Energy's proposed future groundwater licence allocations source [6] ... 5-2

Table 5-3 EWR Requirements (source: [6]) ... 5-3

Table 6-1 Surface Water Allocation Limits and Water Availability in Upper Collie ... 6-4

Table 6-2 Actual vs. Predicted Abstractions, Ewington I & II mines, 2005 to 2007 ... 6-9

Table 6-3 Water Abstraction from Griffin Coal Mining Operations ... 6-10

Table 6-4 Assumed Abstractions from Pit 3 and Pit 1 Deeps of the Premier Mine ... 6-10

Content

List of Figures:

Figure 2-1 Hydrogeological Cross-sections of the Collie Coal Basin (source [1]) 2-1
Figure 6-1 Groundwater Allocation Limits and Availability in Premier Sub-basin 6-1
Figure 6-2 Groundwater use in Collie Basin (Source [1])... 6-2
Figure 6-3 Surface water resource and planning boundaries [source: 5] 6-3
Figure 7-1 Power Stations Water Demand versus Supply Availability.. 7-2
Figure 7-2 Bluewaters Supply Scenarios with Triggers 7-3

Appendix

Figure A-1 Ewington I & II Location ......……………………………………………………………..……….11-2
Figure A-2(a-e) Observed vs. Computed borehole drawdown……………………………….…………..11- 3
Figure A3 Historical Abstractions…………………………....…………………………….………….11-8

Section 1 Introduction

Griffin Energy (Griffin) has approval to construct and operate phase I and II of the Bluewaters Power Station (Bluewaters) in the Collie region. Construction of Bluewaters is in progress and commissioning is scheduled for August 2008 (phase I) and August 2009 (phase II).

Griffin is intending to expand on Bluewaters, proposing to add another two phases (phase III and IV). The proposed expansion would occur on the existing Bluewaters site within the Coolangatta Estate. Construction for the expansion of Bluewaters is scheduled for mid-2009. The securing of long-term water supplies for Bluewaters is essential to the project.

To facilitate environmental approvals for the Bluewaters expansion, Griffin is proceeding with the preparation of environmental impact assessments that will culminate in an Environmental Impact Statement. An integral part of the environmental impacts assessments is linked to water supply source development. Water supply derived from dewatering of nearby coal mines represents a preferred source, but other supply options may be preferred at times over an expected 30 to 40 year operating life of Bluewaters.

This report aims to

1. identify and characterise each of the potential sources of water available to meet the anticipated water demands of the proposal over its anticipated life.
2. model water source behaviour to determine yields and impacts of current and other potential anticipated future abstractions or extractions of water from an identified source.
3. evaluate each of the identified potential water supply sources and recommend a proposed strategy that will ensure a reliable supply of water that meets the anticipated demands of the proposal.
4. provide advice on management measures to mitigate any potential environmental impacts associated with the preferred strategy that might be considered for implementation as part of the proposal.

1.1 Project Background

Bluewaters is located in the Collie-Wellington Basin, a domain that involves numerous stakeholders associated with the Salinity Recovery Plan for the Collie River and wider catchment of the Wellington Dam. This stakeholder involvement in the Salinity Recovery Plan are central to the recent findings of the Collie-Wellington Basin Water Source Options Steering Committee's report "Water Source Options in the Collie Wellington Basin, May 2007". Report findings are focussed on delivery of a sustainable fresh water source to the Wellington Dam and the adding of value to this resource through diverting high quality (low salinity) supplies to the Integrated Water Supply System (IWSS). Linked with these findings is the concept of also diverting low-salinity groundwater from pit dewatering abstractions in the Collie Basin to the IWSS.

These aspects support the strategies expressed by the Department of Water (DoW), during past discussions on water supply for Bluewaters, that industrial (including power stations) water supplies be preferentially derived from comparatively poor quality (high salinity) sources and preservation of low-salinity sources for highest value uses. Further, it is our understanding that officers of the DoW have been reluctant to provide groundwater allocation to Bluewaters based on uncertainty regarding the longer-term availability of groundwater resources within the Premier Sub-basin. This uncertainty is understood to stem from perceptions that design pit dewatering abstractions and hence groundwater availability are over-estimated, with support for this perception derived from comparisons of design versus actual pit dewatering abstractions. A firmer understanding of the strategy and policy of the DoW will be provided once the draft Upper Collie Water Management Plan is finalised. This will be a statutory plan.

When the available information is put in context, it is evident that:

Section 1 Introduction

1. There is increasing competition for the local water resources. This competition should be expected to increase in the future, both for low-salinity and industrial water supplies (including from other power stations) as a result of increasing values for water resources and reductions in available supplies linked to lower rainfall.
2. Assessments of long-term groundwater availability carry uncertainty. The evaluation and constraining of this uncertainty in context with power station security of supply is required to deliver robust supply strategies.
3. There may be opportunities in the longer-term to divert low-salinity pit dewatering abstractions for power station use.
4. The DoW and other stakeholders may be supportive of proposed power station water supply options that add benefits and value to the Salinity Recovery Plan and water resources of the Collie-Wellington Basin.

Section 2 Geology of the Collie Basin

The Collie Basin is an elongate, bi lobate sedimentary basin that comprises the Cardiff (western lobe) and Premier (eastern lobe) sub-basins, with the Stockton Ridge forming a crystalline basement divide between the two Sub-basins. Sedimentary deposits in the basin are of Permian, Cretaceous and Tertiary age, forming successions of coal measures, riverine fluvial deposits and lacustrine argillaceous beds [2].

2.1 Stratigraphy

Permian sediments in the Collie Basin unconformably overlie Archaean granitic and gneissic crystalline basement. The Permian sediments do not outcrop, except locally in river bed profiles, and comprise the basal Stockton Group and overlying Collie Group. The Collie Group contains economic coal resources. Throughout the basin area, the Permian sediments are unconformably overlain by fluvial, lacustrine and lateritic Cretaceous to Recent sediments that comprise the Nakina Formation and superficial formations. Broad aspects of the Collie Basin stratigraphy are shown on Figure 2-1.

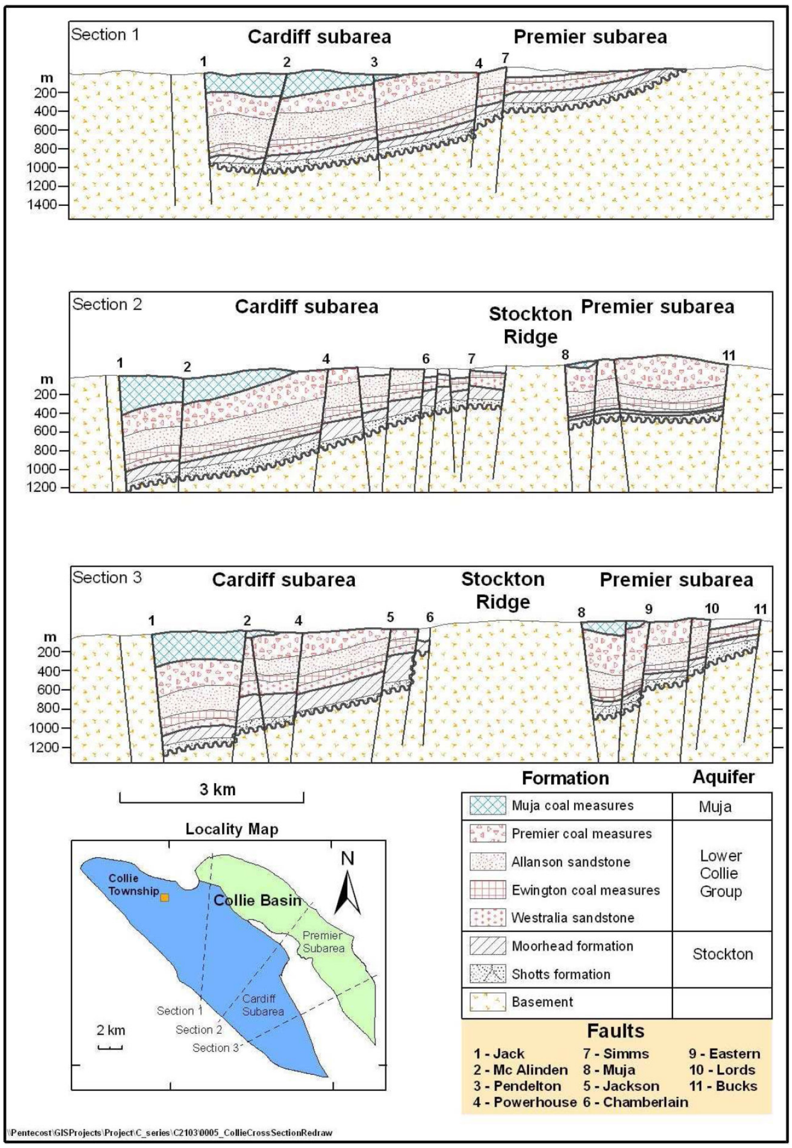


Figure 2-1 Hydrogeological Cross-sections of the Collie Coal Basin (source [1])

2.2 Stockton Group and Collie Group

The basal Stockton Group overlies crystalline basement and is subdivided into the Shotts Formation and Moorehead Formation, both of which include glacial deposits. The Collie Group overlies the Stockton Group and is comprised of interbedded sandstones, siltstones, mudstones, carbonaceous shales, clays and coal seams. The Collie Group comprises numerous stratigraphic sub-sets including (from the bottom up): Westralia Sandstone, Ewington Coal Measures, Allanson Sandstone, Premier Coal Measures and Muja Coal Measures. These stratigraphic successions were deposited in a layer-cake form in both sub-basins, though the distribution of the individual units is not uniform. In broad terms, the Stockton Group and Westralia Sandstone underlie most of the basin area. Above the Westralia Sandstone, the younger stratigraphic units occur in progressively decreasing domains. As such the youngest unit, the Muja Coal Measures, has comparatively limited distribution in both sub-basins, underlying about 43% of the Cardiff Sub-basin and 4% of the Premier Sub-basin

The shallow sub-cropping successions of both the Collie Group and Stockton Group that directly underlie the Nakina Formation are typically weathered and bleached by leaching.

Post deposition, numerous normal faults have altered the occurrence of the layer cake sedimentary deposits. Most of these faults have a northwest strike, and are parallel to the elongate basin axes. The faults and resulting deformation cause complex horst, graben and synclinal structures. The basin margins are also fault controlled.

2.3 Nakina Formation

The Nakina Formation is of Cretaceous Age and rests unconformably on the Collie Group sediments (Figure A1). The unconformity represents an erosion surface. The Nakina Formation is comprised of poorly consolidated sands interbedded with clay. Commonly the Nakina Formation deposits display light yellow, brown and orange iron-oxide colouring.

The distribution and thickness of the Nakina Formation and overlying Superficial formation are commonly difficult to differentiate from the underlying arenaceous rocks of the underlying Collie Group, except where exposed by mining. Typically, the Nakina Formation and Superficial formation are characterised by:

- an aggregate thickness from 0 to 20 m, but commonly less than 5m;
- the formation base being gently undulating and tilted at low-gradients sub-parallel to the ground surface; and
- the least thickness occurring beneath valley floors, near low-lands and watercourses.

Section 3 Hydrogeology of the Collin Basin

The Collie Basin contains a large, predominantly fresh groundwater resource. Based on basin area and geometry, the volumes of groundwater in storage are estimated to be in the order of 7.0 x 10^6 ML. Within both Sub-basins, the Cardiff and the Premier, seven distinct aquifers are found which have been grouped into four major groups – the Superficial, Muja Coal Measure, Lower Collie Group and Stockton Group. The Superficial aquifer includes both the Nakina and Superficial Formations. Recharge occurs mainly via direct infiltration of rainfall and some infiltration from the Collie River south and east branches. The natural groundwater flow patterns have been altered by mining so that flow is now towards mine dewatering and Collie River south and east branches. The quality of the groundwater is naturally fresh. However, due to disturbance from mining activity, acidity ranges from pH of 2 to 3 near mines to pH of 6 to 7 in other parts. In the basin, water acidity generally increases with depth. Groundwater in the Collie Coal Basin is abstracted for mine dewatering as well as supply for power stations, local households and gardens, and irrigation of berries, olives, lawns and school ovals. There are currently 18 groundwater licences to abstract a total of 67 gigalitres a year. Over 99 per cent of this total is for mine dewatering and power station supply.

3.1 Aquifer Types/Zones

The Collie Basin hydrogeology and groundwater resources are broadly defined by:

- A Superficial aquifer system, formed by the Nakina and Superficial Formations. This aquifer system is unconfined or semi-confined.
- The Lower Collie Group that forms structurally-complex multiple-layered stratigraphic units in which the occurrence and extent of individual aquifers is broadly limited by synclinal structures, faults and subcrop zones of discrete stratigraphic units. Aquifer systems of the Collie Group host the predominant groundwater resources of the Collie Basin.
- The Stockton Group, which underlies the Collie Group and forms a succession of fine-grained fluvial and glacial deposits of comparatively lower transmissivity. These successions unconformably rest on crystalline basement. Information on the Stockton Group is limited and thus it’s role in the Collie Basin hydrogeology is uncertain.

The hydrogeological characteristics of the superficial and Collie Group aquifer systems are summarised below.

3.1.1 Collie Group Aquifer Systems

Many discrete aquifers are formed by the Collie Group sediments. Most aquifers are multi-layered and delineated by coal seams that form the upper and lower confining beds. The Collie Group aquifer systems are limited in their areal distribution (by coal seam subcrops, synclinal basin-form structures and fault zones) and none underlie the entire Collie Basin.

Aquifer Nomenclature and Hydrostratigraphy

The stratigraphic intervals from which groundwater has been abstracted during the period 2003 to 2007 are summarised in Table 3-1.

Table 3-1 Stratigraphic Zones of Collie Group Groundwater Abstraction (2003 to 2007)

Abstraction Source	Cardiff Sub-basin		Premier Sub-basin	
	Zone of Groundwater Abstraction – Upper and Lower Coal Seams	Coal Measures or Formation	Zone of Groundwater Abstraction - Upper and Lower Coal Seams	Coal Measures or Formation
Shotts Borefield			Premier 4 to Hymen	Premier/Allanson Sandstone
Cardiff Borefield	Phoenix to sub-Wallsend	Allanson Sandstone/Ewington		
Abandoned WD-2 and WD-6 Mines	Ben to Collieburn 2	Muja		
Muja Mine and Premier Mine – Pit 4			Ate to Premier 3 (Uraeus)	Muja/Premier
Chicken Creek Mine			Gryps to Tantalus	Premier
Premier Mine Pit 1			Premier 1 to Premier 5	Premier
Ewington II Mine			PO5 to P40 (Juno to Tantalus)	Premier

In general, the aquifer nomenclature has been based on:

- The local name for the coal seam underlying each aquifer zone; and
- Terminology used by the mining companies in dewatering programmes.

Aquifer Characteristics

Sandstone intervals within the Collie Group form the most important aquifer zones. Coal seams and associated mudstone, clay and shale beds form confining layers of comparatively low transmissivity. Groundwater occurrence and flow are primarily controlled by the sandstone aquifers, and local fold and fault structures. The distribution of individual Collie Group aquifers is controlled by:

- The structural form and setting of overlying and underlying coal seams;
- Fault zones;
- Erosion that occurred before deposition of the nakina formation; and
- The margins of the basin.

Most aquifer systems except those formed by the Muja Coal Measures extend over significant areas of the both Sub-basins. Generally, the aquifer systems are associated with double plunging synclinal basins of egg-cup form. The aquifer subcrop zones occur on the limbs of the syncline structures. As such, the aquifer systems are generally confined, due to the dipping strata. These aquifers systems are unconfined or semi-confined only in subcrop zones.

Recharge to and discharge from the aquifers systems occurs in subcrop areas, through the Superficial aquifer and also in places where the Collie River is incised into the Collie Group successions.

Natural groundwater levels in lowland and wetland areas occur near the ground surface. The subcrop zones of the developed aquifer systems locally show the greatest drawdown effect from water supply and mine dewatering abstractions. Commonly, fault zones influence the extent of the drawdown effects; where fault zones are transmissive and therefore larger areas are influenced by the groundwater abstraction. Similarly, where fault zones aren't transmissive greater drawdown is observed

3.1.2 Superficial Aquifer System

The distribution and bottom elevation of the basal Superficial aquifer, the base of the Nakina Formation has been interpreted from drill-hole intersections and mapping of mine pit walls.

The interpreted elevations for the base of the Superficial aquifer indicates:

- The thickness is greatest in basin margin areas and beneath laterite-capped hills and ridges within the basin;
- The thickness is least beneath valley floors and lowlands;
- Base elevations are lower beneath valley floors and lowlands; and
- The topography of the base of the aquifer is generally sub-parallel to the ground surface topography.

Groundwater flow within the Superficial aquifer appears to be broadly controlled by the surface topography. Recharge occurs beneath the hilltops and ridges and groundwater flow is predominantly toward watercourses and lowland areas.

The interpreted base of the Superficial aquifer has been compared to transient shallow groundwater levels to understand the hydrological and hydrogeological processes. Based on these comparisons, it is interpreted that:

- The formations that form the Superficial aquifer, the Nakina and Superficial Formations, are only saturated in limited areas aligned along watercourses and lowland damplands;
- The base of the aquifer typically occurs above the water table: and ephemeral and perched conditions may occur locally where low-transmissivity beds impede rainfall infiltrating to the water table.

Based on the above assessments, the following conceptual hydrological model has been developed for groundwater occurrence and flow within the superficial aquifer system:

- Aquifer zones are predominantly formed by laterite and sand beds that intercept most rainfall infiltration.
- Local ephemeral perched aquifers may occur above clay beds beneath hilltops or ridges; groundwater flow in the perched aquifer zones is seasonal in response to infiltration from winter rainfall.
- Aquifer zones are permanently saturated beneath valley floors and lowlands where the water table typically occurs at a depth of less than 2 m.
- Groundwater flow directions predominantly reflect the topography and surface drainages.
- Groundwater flow occurs from hilltop and ridge areas to local watercourses and damplands.
- Valley floors and lowlands form discharge areas.

- Discharge from the superficial aquifer into local watercourses, wetlands or lowlands is predominantly seasonal and fresh.
- The physical and hydrogeological characteristics of the superficial aquifer are variable. Typically, the aquifer is of variable lithology and thickness and, is irregular and anisotropic in terms of hydraulic properties so that preferred groundwater flow paths may occur.
- Groundwater abstraction within the Collie Basin has locally and regionally altered the water table profile over time. Abstractions and reducing rainfall trends over the past two to three decades have resulted in lowering of water table elevations.

3.2 Recharge

The Collie Basin occupies an area of about 230 km^2. The majority of recharge to the basin is through the infiltration of rainfall to the Superficial aquifer. Recharge is transmitted vertically and/or laterally into the subcrop zones of the Collie Group aquifer system.

Recharge to the basin area is interpreted to range from about 20,000 to 31,000 ML/annum. This range is based on 8 to 13% of the long-term annual average rainfall (954 mm/annum at Collie) infiltrating to the water table. Seepage from watercourses is also interpreted to contribute 3,000 ML to 5,000 ML to the superficial aquifer each year.

The quoted range of annual recharge approximately quantifies the sustainable yield of the Collie Basin. As the groundwater resources are contained within multiple aquifer systems linked to discrete stratigraphic units, the recharge to and sustainable yield from individual aquifers (or groups of aquifers/stratigraphic units) is broadly interpreted to be approximately proportional to the ratio of individual aquifer subcrop areas to the total basin area. Assessments of recharge to individual stratigraphic units in the Cardiff and Premier Sub-basins based on this interpretation are listed in Table 3-2.

Table 3-2 Distribution of Recharge Based on Stratigraphic Unit Subcrop Areas

Stratigraphic Unit	Subcrop Surface Areas(1) (km^2)		Recharge(2) (ML/annum x 1000)	
	Cardiff Sub-basin	Premier Sub-basin	Cardiff Sub-basin	Premier Sub-basin
Muja Coal Measures	59.24	3.63	5.2 - 8.2	0.3 - 0.5
Premier Coal Measures	36.37	45.89	3.2 - 5.0	4.0 - 6.3
Allanson Sandstone	26.26	13.37	2.3 - 3.6	1.2 - 1.9
Ewington Coal Measures	9.65	14.57	0.8 - 1.2	1.3 - 2.0
Westralia Sandstone	5.55	9.06	0.5 - 0.8	0.8 - 1.2
Moorhead Formation	1.58	1.40	0.1 - 0.2	0.1 - 0.2
Shotts Formation	0.32	1.15	negligible	0.1 - 0.2
Aggregate Total	138.98	89.07	12.1 - 18.9	7.8 - 12.3
Total basin recharge			20.0 - 31.0	

Notes: 1. The Collie Basin has been subdivided in area assuming the Powerhouse and Chamberlain Faults divide the Cardiff and Premier Sub-basins.
2 Based on the infiltration of 8 to 13% of the annual average rainfall.

Recharge assessments are also incorporated in recent work by the DoW associated with the development of a representative groundwater flow model of the Collie Basin. The developed model has been applied to simulate recharge, with 10% of annual rainfall infiltrating to the water table. Findings from the model (WRC, 2002) are summarised in Table 3-3.

The simulated recharge of 17,300 ML/annum is of a similar order, though less than, the lower-bound recharge interpreted based on sub-crop area of the predominant stratigraphic units. Recharge distributions in the model are predominantly linked to the domains of the Premier Coal Measures and Allanson Sandstone. These domains account for 50 to 75% of the simulated recharge in the Cardiff and Premier Sub-basins.

Table 3-3 Simulated Recharge - DoW Groundwater Flow Model (2003)

Stratigraphic Unit	Recharge (ML/annum x 1000)	
	Cardiff Sub-basin	Premier Sub-basin
Muja Coal Measures	2.6	0.3
Premier Coal Measures	3.0	2.0
Allanson Sandstone	4.5	1.3
Ewington Coal Measures	1.3	0.3
Westralia Sandstone	0.9	0.3
Moorhead Formation Shotts Formation	0.6	0.2
Aggregate Total	**12.9**	**4.4**
Total Basin Recharge	**17.3**	

Section 4 Water Management Framework

The allocation of water from Collie Basin is governed by existing policies and strategic documents that address the availability of surface and groundwater resources to meet consumptive use requirements without adversely affecting the ecological sustainable yield of the basin.

4.1 Water Allocation Policies

The Rights in Water and Irrigation Act 1914, provides the basis for allocation policies by the Department of Water. Under the Mining Policy for “Use and release options for dewatering discharge” the Department of Water lists several preferences for the use/ and or release of mine dewatering discharge. These prefernces are ranked accordingly [5] as follows:

1. Efficient on-site use, including mitigation of any impacts of use. Dewatering discharge can be used for fit-for-purpose activities (such as processing and dust suppression). The proponent needs to demonstrate that the water is of suitable quality for the end use.
2. Transferred to meet other demand, including power stations and public water supply, as approved by the department.
3. Injection back into the aquifer at designated sites determined by the proponent and agreed by the department
4. Controlled release to the environment where the dewater discharge is allowed to flow (either through a pipe or overland) into a designated drain, water course or wetland determined by the proponent and agreed by the department.

4.2 Managing Water Strategies

A set of broader strategic principles for water management is defined in several recent reports by the Department of Water, which provide the foundation for decision making on water allocation and licensing in the Upper Collie.

Managing water in the Upper Collie: A status report on surface and groundwater management (DoW Oct 2007)

The Department of Water is currently developing a water management plan for the Upper Collie surface and groundwater areas. The plan will cover the Upper Collie River, the Harris River, the Bingham River and their tributaries, as well as the groundwater resources in the Collie Coal Basin. The water management plan will: provide a management framework defining water management objectives; define the amount of water available on a yearly basis from each water resource (allocation limits); set the rules of access to water; and define water licensing policies.

Water source options in the Collie-Wellington Basin (Final report to the Minister for Water Resources- May 2007)

On 18 October 2006, the Minister for Water Resources announced an investigation into the proposed future uses of water from the Collie Coal Basin and Wellington Dam.

The Collie-Wellington Basin Water Source Options Steering Committee was established to identify, assess and prioritise current and potential water source options for the Collie-Wellington Basin and outline the future direction of assessment and stakeholder engagement.

There were five key findings and nine recommendations from this investigation

Section 4 Water Management Framework

Findings

- The best productive use of water from the Collie-Wellington Basin will be achieved by diverting approximately 14 GL of early winter saline stream flows of the Collie River into mine voids then removing the diverted water from the catchment, either by piping it to the ocean, or by treating it by reverse osmosis to produce approximately12 GL of potable water.
- All productive uses of water require a reduction in salinity levels and, in the case of drinking water, additional water treatment. The most productive uses are urban consumption followed by industrial use (*particularly if this includes the needs of the region's power stations*).
- Demands for water from the Collie-Wellington Basin for 'higher value' uses, at the volumes and qualities needed to render them competitive, will reduce the amount of water available for irrigation and possibly require further restrictions to be placed on the recreational pursuits permitted within the catchment.
- It is likely that a combination of water source options, treatments and delivery methods will best provide water at required volumes and standards; also it is possible that these can be staged. Further studies are needed to establish water source limits and availability, existing infrastructure capacity, sustainable limits to water availability and the most cost effective method of implementation.
- Opportunities exist for private as well as public sector involvement. Opportunities for the private sector include the outright ownership of facilities as well as the provision of planning, design, operational management and contracting services.

Recommendations

- The work carried out should be extended and refined in order to establish a definitive water resource development plan for the Collie-Wellington Basin. This work should include, but not be limited to, establishing future demands by types of use, required standards and forms of treatment needed to achieve these, definitive costs (including those associated with integration into the IWSS), sources and availabilities of water etc. In completing this work, due consideration must be give to social and environmental issues in addition to the economics of the project.
- The volume of water diverted from the Collie River East diversion should be increased to 14 GL.
- The feasibility of using groundwater generated by mine dewatering as a source of drinking water should be subjected to further investigation.
- The future demand for fit for purpose water for industry and agriculture in the Greater Bunbury area needs to be determined. The future statutory water management plan for the Collie-Wellington Basin should consider allocations for these uses.
- Managed recreation within the Wellington Dam catchment should continue; however more stringent control is needed over this. The implications for water quality of activities that involve direct contact with water should be reviewed. Further, any future investigation into the use of Wellington Dam as source of potable water should be required to establish the additional treatment cost which needs to be incurred in order to permit recreational activities to occur within the catchment.
- Given the Water Corporation's role as a purchaser and provider of bulk water it is recommended that high level strategic water source planning be separated from the role of water service provision.
- Government should encourage the private sector to become involved in the future development of the water resources of the Collie- Wellington Basin. Opportunities for this involvement include the rationalisation and delivery of water produced as a result of mine dewatering, the ownership and/or operation of treatment plants, the ownership and operation of pipelines as well as for the

more traditional forms of participation such the provision of design, operational management and construction services.

- Participation by the private sector in certain aspects of water supply within the Collie Wellington Basin needs to be accommodated within the integrated plans prepared for the region and care taken to ensure that such participation conforms with other elements such as those applicable to land and water use, economic development, physical and social infrastructure and the environment.
- Work on the implementation of the Salinity Recovery Plan for the Collie River, including river restoration, reafforestation and diversion of the Collie River East Branch in its current form should continue.

Upper Collie Water Management Plan (Draft Dec 2007)

The Upper Collie water management plan sets criteria on how water resources will be managed in the Upper Collie surface water and groundwater areas to meet increasing water demands, while protecting the natural environment.

The plan details:

- the Upper Collie water allocation planning boundaries, by subarea and resource
- the amount of surface and ground water available for allocation
- how available water will be allocated amongst competing users, including mine dewatering
- the water management framework including
    - policies for allocation and use
    - policies for private self-supply and commercial users
    - the principles and objectives (or targets) for water use and management
    - how the plan will be reviewed and evaluated over time.

Salinity Situation Statement for the Collie River Catchment (WRC 2001)

The State Salinity Strategy by the State Government identified Collie River as one of the five Catchments requiring Water Resources recovery to ensure adequate supplies of drinking quality water for the future.

This Catchment, covers almost 3,000 square kilometres including the Wellington Reservoir, has been divided into eight Management Units. Nearly three-quarters of the salt load into the Wellington Reservoir comes from just three of these areas: the Collie River-East, Collie River-South and James Well Management Units (Table 4-1).

Table 4-1 Management Units of Collie-Wellington Surface Water Catchment

Management Unit	Flow (Gigalitres per year)*	Salt load (kilotonnes per year)**	Salinity (mg/L TDS)
Collie River – East	14.5	49.4	3418
Collie River – South	23.3	24.0	1031
James Well	5.5	19.2	3466
Bingham River	7.3	1.6	216
Collie River – Central East	14.3	10.6	741
Collie River – Central	29.3	13.2	450
Harris River	7.0	1.5	209
Wellington Reservoir	43.6	8.7	198
Total Inflow Wellington Reservoir	**144.8**	**128.1**	**885**

The review of the salinity situation in the Collie Recovery Catchment concluded that:

- Since 1990 the salinity of inflow to Wellington Dam has been stable. This is thought to be due in part to the stabilization of the effect of the effects of land clearing and in part due to the effects of plantations established to offset the effects of land clearing.
- Further reduction in salinity is expected once all existing and planned plantations have been fully established. This will not, though, be sufficient to meet the inflow salinity targets.
- There are other technically feasible management options with potential to reduce the inflow salinity to its target, including engineering options and/or further tree planting.
- Full effects of treatments can be expected to be realized within 10 years of commencement. Hence all required treatments should be in place by 2005 to meet the 2015 target.
- Continuing protection of remnant native vegetation is important to maintain its water-use functions, loss of which negates efforts to reduce salinity by other means.

Recommendations

Management options

- The economic and social costs and benefits of the various management options need to be associated with their physical impacts on stream flow, salinity and salt- affected land.
- The long-term sustainability of commercial tree plantations needs to be determined. Issues to be addressed include the incentives for private owners to embark on a new rotation after harvesting, maintenance of soil fertility, and the possibility of salt accumulation in the root zone if trees are planted where deep groundwater is discharging.
- The practicality of groundwater pumping needs to be tested in field trials whose design is based on computer modelling. The design phase should include estimation of the reduction in salt-affected area to be expected as a result of pumping. The trial should provide information to estimate the effectiveness of groundwater pumping in reducing salt load discharged to rivers, and to estimate the costs of larger scale implementation.

Monitoring and evaluation

- Reports should be updated with more recent data at 5 year intervals until the achievement of the salinity target for inflows to Wellington Dam.
- Monitoring of stream flow and salinity should continue at mainstream gauging stations to test whether the peak salinities have passed and when future treatments have a discernible effect on salt loads and stream flow.
- A study should be undertaken to determine appropriate annual cycles of Leaf Area Index (LAI) for lucerne under practical grazing regimes and water availability, to better model the salinity benefits of using lucerne as a management option.

Section 5 Assessment of Water Demand

5.1 Urban Water

Water for Urban use is planned to be taken from Wellington Dam after treatment to supply the Integrated Water Supply System (IWSS) and (GSTWSS). The demand of water supply to GSTWSS is not expected to increase dramatically as population growth is estimated at 1.6% per year (WAPC, 2005).

5.2 Power Stations

5.2.1 Requirements for Blue Waters Power Station

Development of Bluewaters Power Station (stages III & IV) will require a secure water supply. Absence of a secure source will adversely influence the ability of the power station to operate at all times. A total annual supply of 13 GL is required (for all four stages), for a design operating period of 30 years (Table 5-1). This requirement is based on raw water being of salinity less than 500 mg/L.

Table 5-1 Bluewaters Power Station Water Demand

End of	No. of	Annual Demand (GL/a)				
Year	Year	Bluewaters I	Bluewaters II	Bluewaters III	Bluewaters IV	Total
2008	1	3.25				3.25
2009	2	3.25	3.25			6.5
2010	3	3.25	3.25			6.5
2011	4	3.25	3.25	3.25	3.25	13
2012 - 2046	5 - 39	3.25	3.25	3.25	3.25	13
2047	40	3.25	3.25	3.25	3.25	13
2048	41		3.25	3.25	3.25	13
2049	42			3.25	3.25	13
2050	43			3.25	3.25	13

5.2.2 Muja & Collie Power Stations

Around ninety-two per cent of water supplied to the power stations comes from mine dewatering [1]. The remainder is met through production bores (8%) in the Cardiff and Premier Sub-basins and surface water from Harris Reservoir (<1%). The remainder of the mine water is used in mining activities (6%) or released to the environment (33%).

Water supplies for both the Muja and Collie Power Stations are variably sourced from:

- Shotts Borefield, commissioned in 1981;
- Cardiff South Borefield, commissioned in 1985;
- the Western Borefield, in the now abandoned WD2 Mine, since the early 1960s;
- the now abandoned WD6 Mine, from 1983;
- Muja Mine, from the late 1960’s (estimate)
- Premier Mine from 1995 (Pit1) and subsequently include Pit4 also;
- Ewington II Mine from late 1997, including initial abstractions from Ewington I that enter local watercourses;
- Woolnough Borefield (which operates as part of the Ewington II long-term pit dewatering programme), predominantly commissioned in stages in the latter half of 2004; and

- Ewington I Starter Pit Borefield that was commissioned from November 2005. Abstracted groundwater is disposed via local watercourses to Collie River South Branch. Disposed groundwater mixes with that from Ewington II.

Table 5-2 Verve Energy's proposed future groundwater licence allocations source [6]

Borefield	Current licence entitlement (GL/yr)	Proposed licence entitlement (GL/yr)	Aquifer resource
WD6	3.65	2.00	Muja
W2	5.10	1.00	Muja
ACIRL	0.73	0.00	Muja
Cardiff	3.65	2.60	Lower Collie
Stockton	0.00	4.44	Lower Collie
Total	**13.13**	**10.04**	

5.2.3 Other Industries

The long term total industrial demand is estimated by the South West Development Commission to be around 50 GL/A with about half this amount needed in the short to medium term [3].

Some of the Industrial users with great potential include local alumina producers, Worley Alumina and Alcoa. There is also demand for the expansion of industry in Kemerton Industrial Estate and the new Coolangata Industrial Estate.

5.2.4 Irrigation

Currently, 85GL of water from Wellington Dam is allocated, predominantly for irrigated agriculture within the Collie Irrigation District. Despite Wellington Dam's size and relatively high yield, its water is currently non potable and barely suitable for irrigation.

The productive return from agricultural water use is very low compared to urban or industrial use and does not have priority in water allocation [1].

There are currently some other barriers that need to be addressed before allocating water for irrigation, such as the impact of salinity, soil types and the availability of fertile agricultural land with access to irrigation water.

Water marketing options are a consideration given the circumstances of Irrigation from Wellington Dam.

5.2.5 Environment

The groundwater-dependent ecosystems considered in the assessment are the pools of the Collie River south and east branches. The pools are those identified by the Collie Water Advisory Group (CWAG), in 1996 and 1999, and are considered to hold significant social value to the local communities of Cardiff and Muja South Extension. The pools are:

1) Long
2) Walker
3) B. Cox
4) Cardiff
5) Grahams
6) Piavaninis
7) Chinamans
8) Muja South Extension Bridge/town (East Branch)

9) Duderling (East Branch).

The EWR requirements are shown in Table 5-3.

Table 5-3 EWR Requirements (source: [6])

Subarea	GL
Harris River	3.49
Collie River East Branch (Muja South Extension)	16
Collie River Lower East subarea (Coolangatta gauging station)	25.4
Bingham River subarea	0.9
Collie River South Branch subarea	7.522
Collie Central Area incl. requirements below the Wellington Reservoir	27.87

Section 6 Assessment of Water Sources

The significant aspects of option assessment will be understanding the regulatory perspective in relation to supply options and characterising potential environmental impacts of obtaining supply in both a local and regional context. The framing of security of supply over a period of 30 to 40 years within reasonable bounds of uncertainty is also expected to present significant challenges.

It is anticipated that integrated supply options would provide the most value to the project. An integrated supply approach would limit reliance on a single source (say groundwater) or a single supplier and enable flexibility in the meeting of long-term supply demands for all stakeholders. It is likely to be important that the integrated supply helps in the Salinity Recovery Plan of the Collie-Wellington Basin and recognises the value of both local and regional water resources.

This section looks at all the potential groundwater and surface water resources, the water demand of various categories of water users, the allocation policies from the regulatory authorities and putting all these components together to establish a regional water balance for the Collie Coal Basin.

6.1 Groundwater use in Collie Basin

(From: *Upper Collie Water Management Plan, Draft 2007*)

In the Premier subarea the main groundwater abstraction is for coal mining below the watertable and the need to dewater mine pits for safe mining. Groundwater is also abstracted for power station water supply. Beside that, the Department of Water also estimates that 0.03 GL/yr are abstracted from the Premier subareas for general stock and domestic purposes.

No more water is available for allocation from the Premier subarea. The Premier subarea is fully allocated. Water allocated for consumptive use cannot exceed the respective allocation limits. The total allocation limit for the Premier subarea is 2.2 GL/yr. The distribution of this amount across each aquifer resource is shown in Table 6-1 along with the amount of water currently available.

Figure 6-1 Groundwater Allocation Limits and Availability in Premier Sub-basin

Subarea	Aquifer	Allocation limit (GL/yr)	Current licensed entitlements (GL/yr)	Estimated stock and domestic use (GL/yr)	Total allocated (GL/yr)	Water available	Mine dewatering entitlements (GL/yr)
Premier	Nakina	0	0	0	0	No water available	0
	Muja	0	0	0	0	No water available	0
	Lower Collie	2.20	4.40	0.03	4.43	No water available	49
	Stockton	0	0	0	0	No water available	0

All other consumptive uses within the Premier subarea will be allocated within the allocation limit. At the cessation of any dewatering operations, the allocation associated with the dewatering licence will not be available for consumptive use. The previously allocated dewater will then provide recharge to the aquifer.

Section 6 Assessment of Water Sources

The figure below taken from "Water source options in the Collie-Wellington Basin (Final report to the Minister for Water Resources- May 2007)" shows the current and expected groundwater use in Collie Basin. Mine dewatering used in power generation is expected to almost triple to 20 GL by 2010 (Figure 6-2).

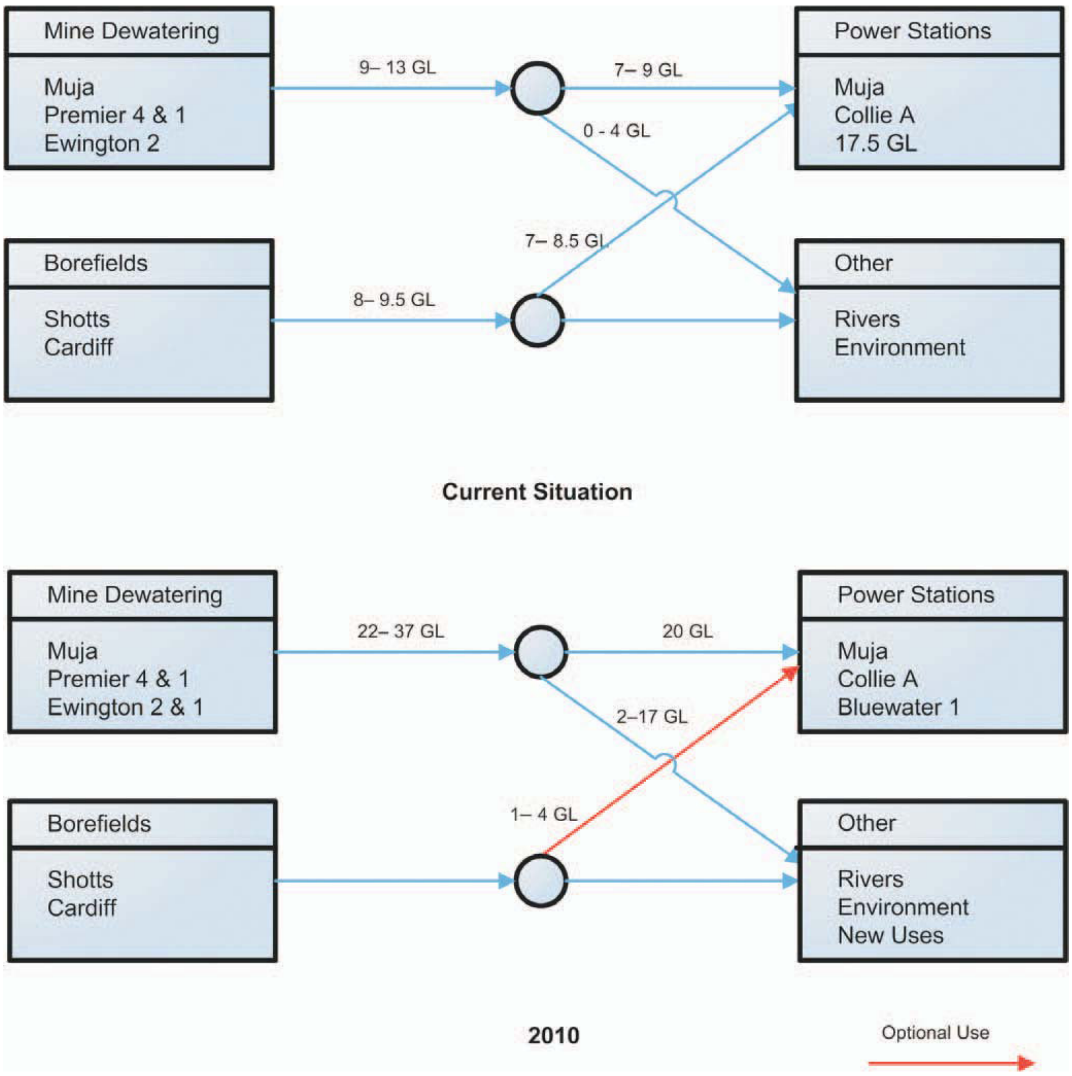


Figure 6-2 Groundwater use in Collie Basin (Source [1])

6.2 Surface Water Resources

(Taken from: [5])

The Upper Collie surface water area includes the main stream of the Collie River, the Collie River South and East branches and the Bingham and Harris rivers. The Collie and Harris rivers have been dammed to create the Wellington and Harris reservoirs. Surface water will be managed according to seven subareas, each with an individual allocation limit. Figure 6-3 displays the surface water resources and their planning boundaries.

The subareas are:

- Collie River Central (containing the Wellington Reservoir)
- Harris River (containing the Harris Reservoir)
- Lower Harris
- Collie River East Branch
- Collie River Lower East Branch
- Bingham River
- Collie River South Branch.

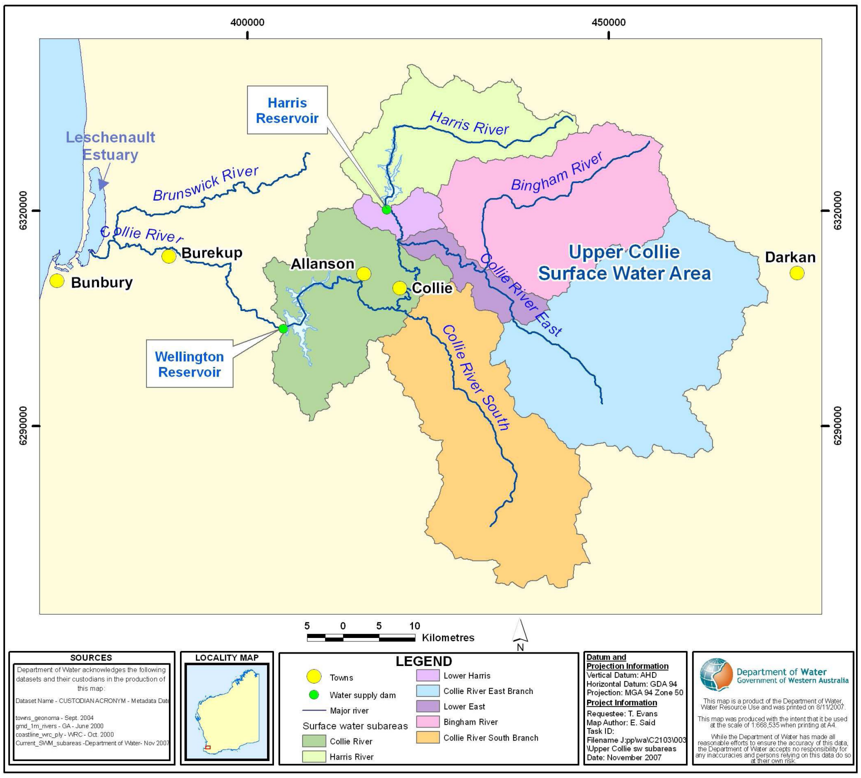


Figure 6-3 Surface water resource and planning boundaries [source: 5]

The water available status for each of the Upper Collie surface water sub-areas at the time this plan was written (November 2007) is summarised in Table 6-1 below.

Table 6-1 shows that there is no available water for allocation from Harris River, Collie River East Branch, Bingham River and Mungalup reservoir on Collie River central.

Wellington Dam has the only tangeable amount of water available for allocation (17 GL/yr). As indicated by DoW, 5 Gl of this available water will be available for power generation, while the remainder will be made available for public supply.

Table 6-1 Surface Water Allocation Limits and Water Availability in Upper Collie

Subarea	Resource	Allocation limit (GL/yr)	Current licensed entitlement (GL/yr)	Estimated unlicensed use (GL/yr)	Total allocated (GL/yr)	Water available
Collie River Central	Wellington Reservoir	85.10	68.00	0	68.00	Water available *
	Mungalup Reservoir	0.50	0.50	0	0.50	No water available
	Collie River mainstream	1.00	0.44	0.06	0.50	Water available
Harris River	Harris Reservoir	15.00	15.00	0	15.00	No water available
Lower Harris	Lower Harris	1.22	0.05	> 0.01	0.05	Water available
Collie River East Branch	Collie River East Branch	14.00	3.00	0.25	3.25	No water available +
Collie River Lower East Branch	Collie River Lower East Branch	1.00	0	0.04	0.04	Water available
Bingham River	Bingham River	0	0	0.01	0.01	No water available
Collie River South Branch	Collie River South Branch	5.02	3.20	0.02	3.22	Water available

*-subject to reallocation,

+-based on DoW plans.

6.3 Potential Water Sources

The identification of potential water sources would be strongly governed by water quality and cost boundaries and subject to the regulatory framework by the Government.

Understanding the regulatory perspective in relation to supply options and characterising potential environmental impacts of supply in both a local and regional context is crucial for assessing suitable options.

The considered options in this assessment include:

- Groundwater from pit dewatering abstractions, Premier Sub-basin.
- Wellington Dam.
- Harris River Dam.
- Diverted stream flow, Collie River.
- Surface water and groundwater in mined voids.

The groundwater from pit dewatering abstraction in the Premier Sub-basin is the preferred immediate option and that will be the focus of this study, while the integrated supply options will still be considered for medium to long-term security of water supply for Bluewaters. It is understood that supply of mine dewatering abstraction for power stations use would form part of the conditions of Groundwater Well Licences abstraction for the mine developments at Ewington. The licences might also include appropriate aspects of longer term plans based on integrated supply optionsl

The potential water sources are discussed in more details in the following sections.

6.3.1 Groundwater from Pit Dewatering Abstractions (Premier Sub-Basin)

Abstraction of groundwater in the Collie Basin occurs under licence, as authorised by the Department of Environment and more recently the Department of Water (DEC and DoW, formerly the Waters and Rivers Commission) with respect to Section 26D of the Rights in the Water and Irrigation Act 1914, and the terms, limitations and conditions of the current Groundwater Well Licences (GWLs). The Griffin Coal Company has a licence for annual abstraction of 30 GL of groundwater for pit dewatering, however historical abstraction data has been well below this limit (Figure A-3).

Abstraction Allocation

There are currently four licences to abstract 53.4 GL/ yr water from the Lower Collie Group within the Premier subarea [6]. The licence holders include Griffin Coal, Wesfarmers Premier Coal and Verve Energy. In addition, there are private users and some and domestic use (0.03 GL / yr).

Historical Abstraction

Figure A-3 summarises historical annual abstractions from all sources between 1984 and June 2007.

Annual groundwater abstraction since 1984 has generally been within the range of 15,000 ML to 30,000 ML, averaging about 21,000 ML. These rates of abstraction are within the quoted range of recharge to the total basin area but may exceed the sustainable yield for the particular stratigraphic intervals from which groundwater is being withdrawn by individual borefields or mines. Estimates of sustainable yield for the Bluewaters Energy water supply can be discerned from historical annual abstraction rates (from Ewington I and II) shown in **Error! Reference source not found.**. In general details of the sustainable yield for the operating mines are not included because dewatering abstraction by design should exceed recharge to the individual mine areas.

Prior to May 1994, when the mines were operating, water supply abstraction was tailored to mine dewatering requirements and based on groundwater level data, historical abstraction exceeded the sustainable yield of the local aquifers. After 1996, a decrease in the total annual abstraction has occurred, in response to improved water management and overall operational efficiencies. Total annual abstraction since 1996 has averaged around 16,000 ML/annum.

The six year (2000-2006) average abstraction from mine dewatering was 9.16 GL/ yr, and for Power use was 1.49 GL / yr.

Modelling Future Abstractions

Forecasts of the cumulative transient abstractions for dewatering of the Ewington I, Ewington II and Muja South Extension deposits are summarised in Table 6-3. These forecasts are based on predictictive groundwater flow modelling. Predictive groundwater flow modelling has been used extensively to evaluate the dewatering designs for the Ewington I and Ewington II deposits (URS, 2006 and Appendix) for Wesfarmers Pits 3 and 1 Deeps (URS 2004, 2005 and 2007 and elsewhere in the Cardiff and Premier Sub-Basins. The models have all been developed in FEFLOW and have the same form, but vary in respect to starting head conditions. In order to determine that previous predictions of available dewatering supply are valid, the model for Ewington II has been modified to include current abstraction history (2004 to verified by comparing drawdown measured in observation bores with that predicted by the model for the time frame since the original model for Ewington I & II was developed (2004 to now).

Model Form

The model active domain comprises all of the Premier Sub-basin and the northeastern portions of the adjoining Cardiff Sub-basin (URS, 2004, 2005, 2006 and 2007). The basin boundaries form the boundaries of the model; these are all no-flow boundaries. The model domain comprises all of the stratigraphy in the Premier Sub-basin and the data used in model construction included:

- topography;
- geological model floor elevations for the coal seams of the Premier Coal Measures and Ewington Coal Measures as provided by the mining companies;
- structure contours of other stratigraphic units compatible with those developed by the Water and Rivers Commission for the development of a Collie Basin model;
- use of geophysical logs to determine the typical aggregate thickness of coal seams, shale, mudstone and siltstone units that form confining layers;
- groundwater levels observed throughout the Premier Sub-basin; and
- existing production bores and groundwater abstraction histories for mining and water supply projects

The model comprises 35 layers. In the top and basal few layers, the structure and stratigraphy is broadly represented. Throughout the lower Premier Coal Measures (below the P4 Seam), Allanson Sandstone and Ewington Coal Measures successions, the model closely represents the mapped coal seam distributions..

Within the model domain, various starting head conditions have been employed based on the location and prevailing area of model interest. For example modelling of the Wesfarmers (URS, 2007) focused on Pit 3 and 1 Deeps and thus a starting head of 210m above the Australian Height Datum (AHD) was used; while for Griffin (URS 2006) the focus was the Ewington I & II deposits and starting heads of 213 mAHD 215 m AHD were used, respectively. There are no boundary conditions that sustain this starting head condition. As such, the model incorporates a finite and fixed storage volume that is not recharged or supplemented in any way.

Model Parameters and Material Types

Individual aquifers and aquitards are represented in the model as different material types, each with discrete hydraulic parameters. The interpreted findings of aquifer tests within the Premier Sub-basin have been applied to characterise the hydraulic behaviours of the individual aquifer systems. Derived transmissivity and hydraulic conductivity values from these tests have been applied in the developed groundwater flow models. The applied values are not lower-bound or upper-bound but broadly represent the middle of the interpreted range. In all cases, the assigned values represented the entire domain of each individual aquifer, irrespective of lateral variations in depth of cover. The aquifer test data are representative of investigations to depths up to about 250m. These data provide a consistent range of interpreted hydraulic conductivities, typically between 1 and 10 m/day, and show no trends linked to depths of cover. There are no data that suggest the transmissivity and hydraulic conductivity of the aquifer systems decreases due to increases in depth of cover (URS 2004, 2005, 2006 and 2007).

Most of the aquifer systems were simulated as being isotropic, with equivalent lateral (x and y) and vertical (z) hydraulic conductivities. This aspect of the model is unusual as typically, simulated vertical hydraulic conductivities are up to an order of magnitude less than the horizontal values in order to represent the influence of thin clay and mudstone/shale interbeds on groundwater flow.

The applied approach enhances the vertical groundwater flow components and the simulation of leaky aquifer characteristics. Within the predominant aquifer systems, the simulated vertical hydraulic conductivities range from 2 to 10 m/day. The simulated vertical hydraulic conductivity of the individual coal seam aquitards is typically 5×10^{-5} m/day; several thin mudstone/shale beds within the Allanson Sandstone differ from this, having a value of 5×10^{-3} m/day. Lesser vertical hydraulic conductivities have been applied to these beds because they do not incorporate coal seams, are thin and are of uncertain continuity and extent.

In the developed models each significant aquitard is represented as a discrete layer and characterised with a vertical hydraulic conductivity (5×10^{-5} m/day) half an order of magnitude lower than in previous studies. Consequently, the simulated aquifers have been framed to represent an isotropic flow system to compensate for this approach and to enable the effective replication of known leakage effects when the aquifers are stressed.

The effective vertical hydraulic conductivity of individual layers is understood to be based on the harmonic mean of hydraulic conductivities for the adjoining layers. As such, the effective vertical hydraulic conductivities for the simulated aquitards are about 1×10^{-4} m/day.

Simulation of Faults

The developed groundwater flow models (URS 2004, 2005, 2006 and 2007) do not discretise any fault zones. The developed groundwater flow models are based on the interpreted and mapped stratigraphy, essentially the structure contours (roof and floor) of the coal seams, represented as continuous layers. Within the vicinity of fault zones, each layer thins and changes elevation to accommodate the throw on the fault zones. As such the simulated fault zones:

- Juxtapose aquifers and aquitards based on the mapped stratigraphy;
- Typically reduce the local aquifer transmissivity as layers thin, forming partial barriers to lateral and vertical groundwater flow;
- Form multiple-layer successions of interbedded aquifers and aquitards that form partial barriers to lateral and vertical groundwater flow; and
- Retain the layer-cake structure of the aquitards, maintaining their integrity and limiting the vertical linking of aquifer systems by faulting.

This approach enables the simplification of the model structure. It also intentionally promotes vertical flow through aquitards due to leakage effects rather than the *ad hoc* and arbitrary vertical linking of aquifers by faults. This approach is based on the premise that leakage is the predominant vertical flow mechanism over the sub-basin as a whole, transmitting more groundwater than the fault zones. The developed approach also provides a reasonable and practical representation of the faults whilst avoiding the incorporation within the model of numerous variables and assumptions regarding the fault zones given there are no actual hydraulic data that characterise individual or grouped fault zones, either on a local or regional scale

Model Calibrations

Results of the Ewington I and II model calibrations are documented in URS 2006.

In order to understand, in broad terms, the drawdown impacts of long-term historical and future abstractions, the calibrated models incorporated all sources of abstraction at the time of calibration, namely 7,544 kL/day from the Muja Syncline (Muja and Pit 4), 5,454 kL/day from the aquifers above the P5 Seam in Pit 1 and 7,890 kL/day from the Shotts Borefield. Concurrent abstractions simulated from the proposed mining operations at both Ewington I and Ewington II are based on dewatering designs at the time of simulation. Also, concurrent abstractions simulated from the proposed Pit 3 and Pit 1 Deeps mining operations at the Premier Mine were based on then current dewatering designs (1995 to 2003 abstractions totalled 18,111 GL). The cumulative impacts of these historical and current abstractions predominantly control the observed groundwater levels and groundwater level trends in the relevant aquifer systems and formed the basis of the calibration (URS 2006).

The calibrated models do not incorporate recharge fluxes for rainfall infiltration. As such, the models have uniform starting heads as controlled by boundary conditions. The starting heads employed for previous models of the Ewington I and II areas (URS, 2006) were 213 m AHD and 215 m Australian Height Datum (AHD), starting in 1981 and 2003 respectively.

It is believed that with the history of usage of the models that they continue to demonstrate that they have appropriate functionality, and provide a robust and verifiable platform for long-term dewatering designs. The calibrated models have a regional context and were developed based on available knowledge and evidence of the geology and hydrogeology. The long-term abstraction history that was incorporated into the original models provided a strong reflection of cumulative recharge and storage characteristics of the regional aquifer systems. Also, the models provided a benchmark for the understanding of available groundwater resources that remain in storage and of future cumulative drawdown impacts, on both a local and regional scale, due to proposed future abstractions The calibrated groundwater flow models were used to predict the dewatering requirements for the Ewington I and Ewington II mines. The dewatering abstractions were then planned for use as the secure water supply for the Bluewaters I and II power plants (Table 6-3). Fundamental aspects of the modelling approach include:.

- Commencement of dewatering at Ewington I during July 2005.
- Continued pumping from two water supply wells at Ewington II.
- Commencement of dewatering of the deeper Premier Coal Measures aquifer systems at Ewington II during November 2004.
- The incorporation of concurrent abstractions from existing pit dewatering and water supply operations.
- The incorporation of concurrent abstractions from other proposed pit dewatering operations at both the Ewington I and Ewington II deposits.
- Operation of the dewatering system until 2030.

Model Verification

To test the validity of the original dewatering predictions, drawdowns predicted by the Ewington II calibrated model were compared against observed drawdown in the period 2004 to 2007. The starting head boundary condition employed here for the verification of available supply is 214 m Australian Height Datum (AHD) starting in mid 2004. This verification period picks up at the end of the period modeled by the calibrated model documented in (URS 2006). Drawdown was used for the verification, instead of heads, because of the problems noted with heads in Ewington I and II calibrated models.

A comparison of the actual abstractions during the verification period compared to those originally predicted, are shown in Table 6-2.

Table 6-2 Actual vs. Predicted Abstractions, Ewington I & II mines, 2005 to 2007

YEAR	Actual Abstraction GL/Yr			Predicted Abstraction GL/Yr			Difference GL/Yr
	Ewington I	Ewington II	Total	Ewington I	Ewington II	Total	
2005	0	8,173	8,173	2,503	20,479	22,982	14,809
2006	829	18,101	18,930	12,643	30,916	43,559	24,629
2007	1,964	13,355	15,319	10,504	22,886	33,390	18,071

Comparison of the observed versus predicted drawdown at observation piezometers in the vicinity of the Ewington 1 & II mines are shown in Figures A-2a-e. For most of the observation bores the observed drawdown matches fairly closely with the predicted drawdown both in magnitude and in the trend. The exception being ME 01 B, and ME 31-P50, P60 and P80. With ME 1 A the observed drawdown is almost 15 m while the predicted drawdown is almost nil. The fact that the predicted drawdown in the companion ME 01 A piezometer matches that observed leads one to suspicion representation of the ME 1 B piezometer. The predicted drawdown in the ME31-P50, P60, and 80 Piezometers does roughly match the magnitude and trend of the observed drawdown. Again, the character of the observed drawdown, stepwise changes, leads one to also suspicion this data. It is believed that the original predictions are verifiable based on the close match between observed and predicted drawdowns in 16 of the 20 piezometers.

In the original dewatering simulations mining at Ewington 1 would have started in It needs to be recognised that the predicted long-term forecasts of abstraction carry some uncertainty. The uncertainty is linked to the limited available evidence, particularly within the Allanson Sandstone and Ewington Coal Measures, of the potential long-term yields from and storage within the aquifer systems proposed to be locally dewatering to facilitate mining. Nevertheless, the predictive results are interpreted to indicate that the mine dewatering abstractions at Ewington I and Ewington II provide a robust platform for long-term water supply to the proposed power station(s). Such interpretations are based on the understanding that the developed groundwater flow models provide conservatively low estimates of the available groundwater resources. For instance, the developed groundwater flow models:

- Have no boundary conditions that sustain starting head within the model domain. As such, the models incorporate a finite and fixed storage volume that is not recharged or supplemented in any way. There is no throughflow or recharge in the model water balance.
- Do not discretise fault zones as potentially transmissive structures that may laterally or vertically link the Premier Coal Measures, Allanson Sandstone, Ewington Coal Measures and Westralia Sandstone.
- Simulate specific yields of the aquifer systems are 5% by volume, interpreted to be conservatively low for sandstones in shallow aquifer settings. The simulated specific yields are half those used by the Water and Rivers Commission in their regional groundwater flow model of the Collie Basin (Varma, s: Report HG5, Hydrogeology and Groundwater Resources of the Collie Basin, Western Australia, December 2002).
- Are calibrated based on Premier Basin abstraction records, except those from the Chicken Creek Mine, from 1981. Given the models have no discrete recharge, the calibration specific yields would actually incorporate an effective recharge component.

- Show a robust calibration, with observed and simulated groundwater levels in numerous piezometers within the Premier Sub-Basin being correlated a trend-line R^2 of 0.9004.
- Show the calibration head conditions are typically 0.5 to 3.0m lower than the measured groundwater levels within the Premier Coal Measures and Allanson Sandstone.
- Incorporate, within the predictive simulations, concurrent abstractions from existing operations: being 7,544 kL/day from Muja Syncline, 5,454 kL/day from the aquifer above the P5 Seam in Pit 1 and 7,890 kL/day from the Shotts Borefield.
- Incorporate, within the predictive simulations, concurrent abstractions from all currently proposed mining operations at Ewington I, Ewington II, and Muja South Extension (Table 6-3) and Pit 3 and Pit 1 Deeps of the Premier Mine (Table 6-4) .

Each of these aspects clearly provides a minimalist approach to the simulation of available groundwater resources and hence pit dewatering abstractions. This approach adds robustness to the longer-term forecasts of the pit dewatering abstractions. If local fault zones actually laterally or vertically transmit significant flows, the specific yields (and recharge) actually exceed 5%, and all of the simulated abstractions are not concurrent, then the forecast dewatering abstractions form both Ewington I, Ewington II and Muja South Extension would increase.

The average salinity of dewatering from Ewington I and II varies between 209 – 397 mg/L TDS, and for Muja South Extension between 990-2270 mg/L TDS

Table 6-3 Water Abstraction from Griffin Coal Mining Operations

Year	Ewington I (ML/year)	Ewington II (ML/year)	Muja South Extension (ML/year)	Aggregate Abstractions (ML/year)
1	2,500	20,500	23,000	46,000
5	8,800	14,200	23,000	46,000
10	5,900	14,200	20,100	40,200
15	6,300	13,700	20,000	40,000
20	5,500	11,100	16,600	33,200
25	4,800	8,000	12,800	25,600
30	2,000	4,000	12,800	18,800

Table 6-4 Assumed Abstractions from Pit 3 and Pit 1 Deeps of the Premier Mine

Year	Aggregate Pit Dewatering	
	Abstraction (ML/year)	Salinity (mg/L)
1	22000	418
3	32,000	425
5	32,000	400
10	31,000	340
20	22,000	309
25	20,000	309

6.3.2 Water Supply Borefields

Shott Borefield

Groundwater from the Woolnongh Borefield at the Ewington II Mine is diverted to the Shotts Transfer Station, where it is usually transferred for power station use. At times, the volumes of groundwater delivered to the Shotts Transfer Station exceed power station demands. Consequently there is an overflow.

Overflow volumes have ranged from 6 to 500 ML/month. The overflow is fresh (Electrical Conductivity <600 µS/cm and slightly acidic (pH ~ 5).

Overflows from the Shotts Transfer Station enter the local watercourses. Initially the overflows are channelled (avoiding interactions with local infrastructure) to a series of sand pits on the Shotts site. The sand pits have about a 10 ML storage capacity and promote infiltration and evaporation. From the sand pits, the overflow follows existing drains within lowland areas near the WO5H Void. These drains discharge surface water to the Collie River South Branch.

Verve Energy is licensed to abstract from the Shotts production bores (4.4 GL/yr) for power generation purposes. This licence is currently being renewed and it is likely that it will be reduced to 2 GL/yr, due to a reduction in use (Figure A-3). The six year average use for the period 2000 - 2006 is 1.49 GL.

6.3.3 Diverted stream flow from Collie River Eastern Branch

Current studies propose the diversion of 14 GL of Collie River to Wellington Dam for use in the IWSS. By current plans, 5GL/yr of the water in Wellington Dam will be directly available for power generation at 100% security.

6.3.4 Water Supply Dams

Wellington Dam

The document *"Water source options in the Collie-Wellington Basin (Final report to the Minister for Water Resources- May 2007)"* considered two options in which 20 GL of groundwater used for power stations is substituted with Wellington Dam water.

Using this water for power generation has an impact on the cost of electricity. The cost of treating water is estimated to be between 155 – 173 c/kL, whereas dewatering water from mining costs about 5% of this estimate. In addition the capital and operating cost of diverting water from Wellington Dam to the Bluewaters power station would be substantial.

Other factors that need to be considered are:

1) The timing of the IWSS and Wellington Dam project
2) The time needed to fully evaluate the sustainability of a preferred secured water supply option.
3) Other social, environmental and technical feasibility issues.

Harris Dam

Harris Dam is located in the north of the Collie River catchment and has a capacity of 71 GL. The dam was built in 1989 to supply water to the Great Southern Towns Water Supply Scheme (GSTWSS) when supply to this scheme was under threat due to rising salinity levels in the previous source, Wellington Dam. Harris Dam has also experienced declining inflows.

In contrast to Wellington Dam, Harris Dam water contains low levels of salt and bromide and is not exposed to the same level of recreational activity in the catchment. It is generally believed that the Dam's capability would be improved if higher water levels could be maintained, thereby reducing the risk of turbidity. Furthermore, Harris Dam can play an important role in receiving additional water redirected from the Collie- Wellington Basin, (potentially 12GL/A). Currently, 17.5 GL of water is allocated from Harris Dam to IWSS and GSTWSS for urban use.

6.3.5 Mine Voids

Surface water from the Collie River south branch is diverted to fill the 'Lake Kepwari' coal mine void (Western 5H). One of the key issues raised [5] is the use of Western 5H mine void as an emergency water source for power generation.

Use of mine voids for storage or transfer of water will be managed through the licensing program. Currently, there is a surface water allocation licence of 3.2 GL/a [4].

Section 7 Bluewaters Water Supply Strategy

In the short term, it is anticipated that groundwater from pit dewatering could, subject to approval, provide the bulk of water needed for the Bluewaters power station. In the medium to long term, as details of integrated supply options are defined, these options could provide the water needed for the Bluewaters power station. An integrated supply approach would limit reliance on a single source (say groundwater) and enable flexibility in the meeting of long-term supply demands. In both the short term, and the medium to long term Griffin needs to be an active participant in negotiations with the other stakeholders to ensure a secure supply, especially in the finalization of the details integrated supply options. It is likely to be important that the integrated supply adds value to the Salinity Recovery Plan of the Collie-Wellington Basin and recognises the value of local and regional water resources.

Outlined below is the Water supply strategy for the Bluewaters Power Station. The approach outlined is reasonable and practical in context with the mining operations linked to the proposed new power station(s).

7.1 Priorities for Water Use

7.1.1 From Pit dewatering

Clearly there is more than an adequate available supply from current and proposed mine dewatering to meet the water supply needs of the Bluewaters power station in the short term.

7.1.2 From the Collie-Wellington Basin

Currently, most of the Wellington Dam water (about 68 GL) is allocated to irrigated agriculture and 17 GL for Water Corporation / Verve Energy. The Government is planning to reallocate the Wellington Dam water to the highest value use, i.e., drinking quality water. The next highest priority use is water for Mining and other industries [1]. It is estimated that 30 GL/A will be needed for industry. It is proposed [5] to allocate 5 Gl/a for Power Stations.

7.2 From Mine Voids

Within the Cardiff subarea in areas of abandoned mine voids, groundwater has become acidic and may continue to acidify as groundwater levels recover.

Surface water from the Collie River south branch is diverted to fill the ‘Lake Kepwari’ coal mine void (Western 5H). One of the key issues raised [5] is the use of Western 5H mine void as an emergency water source for power generation.

Use of mine voids for storage or transfer of water will be managed through the licensing program. Currently, there is a surface water allocation licence of 3.2 GL/a [4].

7.3 Secure Supply Options

There are only three secure individual local water supply sources in the vicinity of the proposed power stations. These are:

- Groundwater (fresh and brackish) abstracted from the Collie Basin for the dewatering of current, planned and proposed coal-mining operations.
- Brackish to fresh water from Wellington Dam.
- Saline water from mine voids

Section 7 Bluewaters Water Supply Strategy

7.4 Proposed Supply Strategy

The proposed strategy is both practical and reasonable. It is based on forecasts of mine dewatering abstractions and known water resources issues in the Wellington Catchment and Collie Basin. It is also framed understanding there is competition for the available resources, particularly abstractions from mine dewatering, as these are usually of high quality and comparatively easily diverted for power station use.

In fundamental terms, the developed supply options should be demonstrably secure, sustainable for the life of the power stations and environmentally responsible. Given the comparatively large supply volumes and competition for the available water resources, where practicable, an independence from other water supply activities may be prudent.

7.5 Priorities of Demand and Supply

This study deals with demand and supply with respect to Bluewaters III and IV over the 30 year design life of the project. However, in order to assess available supply, it is important to understand the requirements of Verve Energy and Bluewater I & II, as they will be accessing the same supply sources.

Figure 7-1 shows total power station demand versus available supply sources. Even after allowing for Verve Energy's needs, there is sufficient supply from mine dewatering to cover the needs of Bluewaters power station.

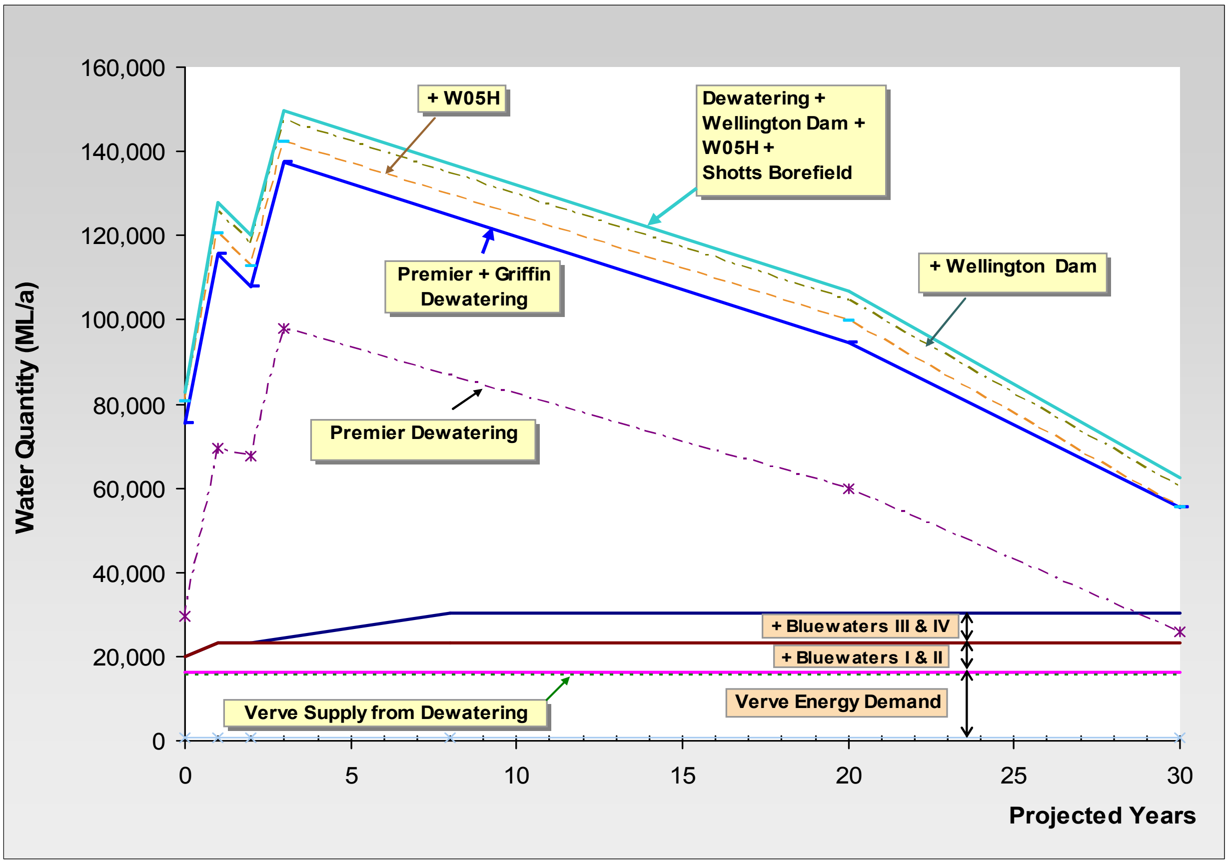


Figure 7-1 Power Stations Water Demand versus Supply Availability

In this assessment only water that is assumed to be available for Bluewaters is considered. The demand is also constrained to Bluewaters Power Station only.

Section 7 Bluewaters Water Supply Strategy

The following supply options are considered to be secure sources for Bluewaters:

1) Ewington 1 dewatering.
2) Ewingtin 2 (incl. Woolnough): dewatering.
3) Muja South Extension mine dewatering
4) Premier Mine (Pit3 and Pit 1 Deep (this source is assumed to go ahead)
5) Wellington Dam: 5 GL/a at 100% security.
6) Void W05H: diverted and treated stream flow (5 GL/a).

Source 4 above is a potentially substantial sources. It can substantially enhance the security of supply, however, part of this water will be required by Verve Energy. At this stage it is not clear how much excess water from Premier Mine can be used for Bluewaters Power Station. Therefore, as a conservative measure, this source will not be considered at this stage. The supply scenarios for Bluewaters Power Station are shown graphically in Figure 7-2.

7.6 Supply Strategies for Bluewaters Power Station I - IV

7.6.1 Supply Strategy 1

In this strategy the first three sources (in section 7.5) are considered to be sufficient to meet the demand of Bluewaters power station. Therefore, the following section focuses on various scenarios from these sources (Figure 7-2):

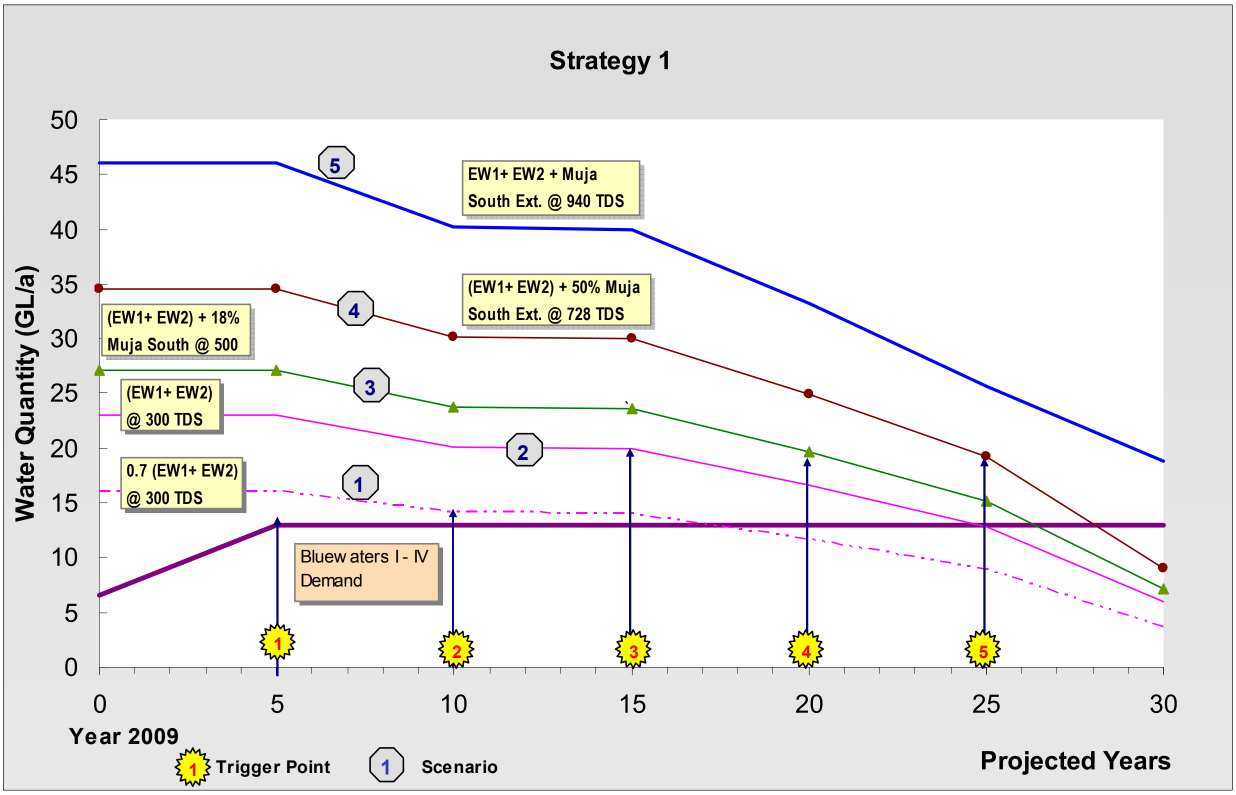


Figure 7-2 Bluewaters Supply Scenarios with Triggers for Strategy 1

Section 7 Bluewaters Water Supply Strategy

Scenario 1

This scenario applies if abstraction does not exceed 70% of forecast from Ewington I and II mine dewatering. Water quality has an average TDS of 300 mg/L and pH value ranging from 5.2 - 5.8

Trigger 1

At the start of Bluewaters III & IV abstraction volumes and water quality would need to be monitored.

Trigger 2

After 10 years, abstractions may be sufficient; however, for security of supply, a secondary source would need to be considered.

Scenario 2

This scenario applies if future abstractions from Ewington I and II mine dewatering are as predicted by the model. Water quality is the same as above.

Triggers 3

This scenario provides sufficient water for Bluewaters up to 20 years of operation, however, at 15 years, monitoring of abstraction volumes will decide the timing of a new source. After 20 years, a secondary source would need to be considered.

Scenario 3

This scenario assumes that abstractions from Ewington I and II are as modelled, but considers also mine dewatering from Muja South Extension at 18% of design capacity (@ TDS 1580 mg/L). This will produce water quality with TDS of 500 mg/L for the shandied mix and helps manage 18% of Muja South Extension dewatering discharge.

Trigger 4

Water supply will be secured for 25 years of the life of the project. A new source will need to be considered at this stage.

Scenario 4

This scenario assumes that abstractions from Ewington I and II are as modelled. This water is shandied with dewatering from Muja South Extension at 50% % of design capacity (@ TDS 1580 mg/L). This will produce water quality with TDS of 728 mg/L for the shandied mix and helps manage 50% of Muja South Extension dewatering discharge.

Trigger 5

Water supply will be secured for 28 years of the life of the project. An additional source may need to be considered at this stage.

Section 7 Bluewaters Water Supply Strategy

Scenario 5

In this scenario, total dewatering from Muja South Extension mine (av. salinity 1580 mg/L TDS) is shandied with all dewatering abstractions from Ewington I & II (av. salinity 300 mg/L TDS) to produce water with salinity at 940 mg/L. This will provide sufficient water for power generation, while allowing for discharge of the Muja South Extension excess dewatering to be discharged into mine voids in accordance to the current Mining Policy, or to other suitable environment according to limits set by DEC.

Mining Policy – Mine Sites and Mine voids states the following:

"Any use of mine voids for storage or transfer of water will be managed through the licensing program. In cases where mine voids are used for storage of poor quality water (including water of < pH 4 acidity and 1,000 total dissolved salts) proponents are expected to complete impact management plans including provisions for monitoring and mitigating impacts. The duration of storage and options analysis for removing the water must also to be included in the storage plan. Licences will only be issued once there is certainty that the stored water will not impact the quality or availability of existing water within the locality of the void."

Trigger

This scenario is sufficient to provide sufficient water for the 30 year duration of the Bluewaters power station.

Management and Trigger Points for Change in Water Supply Strategy

The draft water supply strategy is strongly focussed on use of the mine dewatering abstractions. The predictive assessments indicate that there is unlikely to be a shortfall in supply to the power stations from the mine dewatering programmes. However, these predictive assessments incorporate some uncertainty. In the long-term, the current uncertainty potentially influences the security of supply. As such, the ranked supply options are intended to be regularly reviewed and modified as appropriate to ensure security of supply. The reviews would incorporate comparative assessments of actual and predicted effects of the mine dewatering abstractions, with subsequent revisions of dewatering abstraction forecasts. This approach would also link future adjustments in planning of existing and future mines to revised dewatering requirements.

Trigger points for change in ranking of supply options and water supply strategy are intended to be linked to circumstances where the review process identifies future shortfalls in supply from mine dewatering abstractions. Trigger points would occur if:

- The reviews identify a potential supply shortfall in mine dewatering abstractions. At this time the future supply options would be re-assessed and prioritised according to security of supply, cost and future risk.
- Supply shortfalls are forecast to occur within a five-year time-frame. Under this scenario, the power stations(s) would have about five years to secure and develop alternative make-up water supplies.

It is anticipated that the predictions of future mine dewatering abstractions will be more accurate after the effects of up to five years abstraction, from Ewington I and the deeper aquifer systems at Ewington II and Muja South Extension have been assessed. These assessments will enable improved interpretation of effective local and regional aquifer hydraulics and storage characteristics and, improvements in calibration of the developed groundwater flow models.

It is understood that supply of mine dewatering abstraction for power stations use would form part of the conditions of Groundwater Well Licences abstraction for the mine developments at Ewington and Muja South. The licences might also include appropriate aspects that address the future reviews of water supply options and trigger points as outlined below.

7.6.2 Supply Strategy 2

Existing water supply is assumed to be maintained for Bluewaters I & II. Sources considered for Bluewaters III & IV are diverted stream flow into W05H mine void and mine dewatering. 1 GL of Water is taken from Collie River stream flow diverted to mine voids and treated by a proposed RO plant that reduces the TDS from about 4000 mg/L down to 500 mg/L. In addition, 2 GL of brackish discharge from Muja South Extension (TDS 1580 mg/L) with good quality water from Ewington 1 and 2 dewatering (TDS 300 mg/L) to produce 6.5 GL of shandied water with a TDS 740 mg/L.

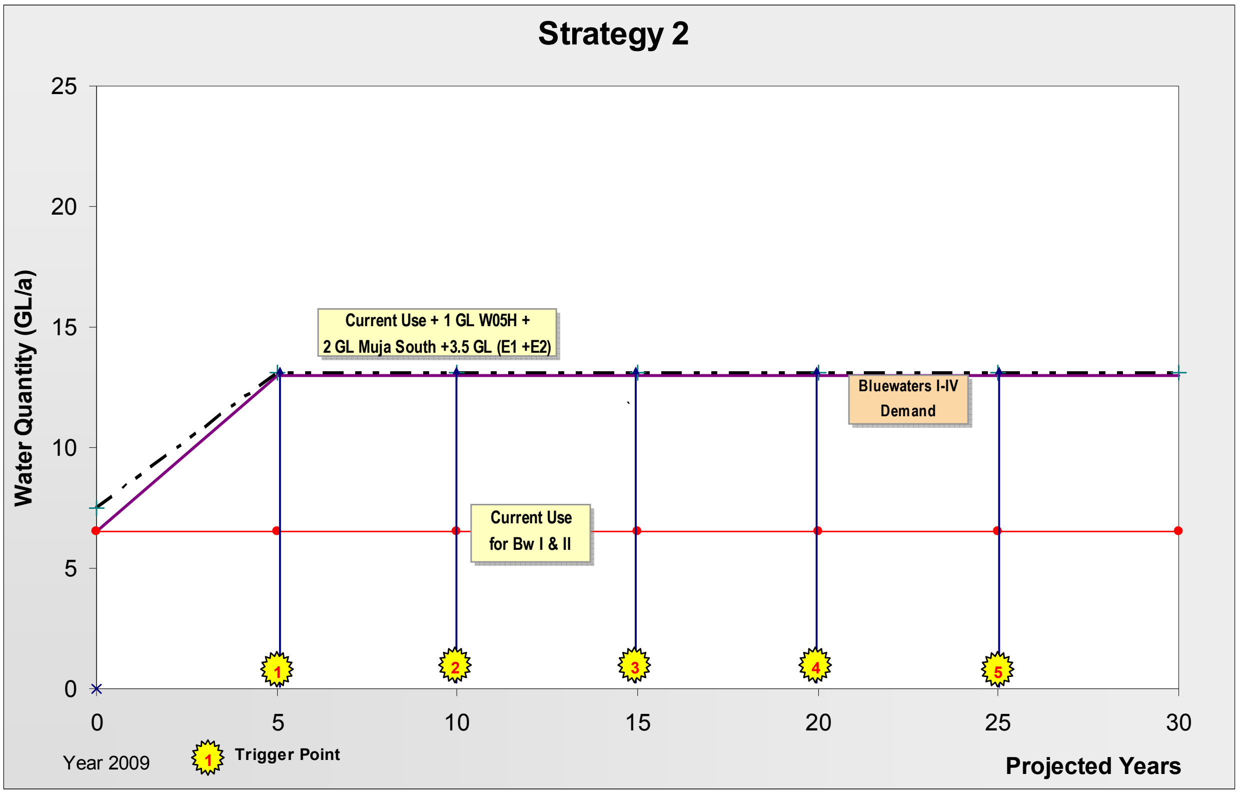


Figure 7-3 Bluewaters Supply Scenarios with Triggers for Strategy 2

Trigger 1

At the start of Bluewaters III & IV abstraction volumes and water quality would need to be monitored.

Triggers 2-4

Five yearly assessments of available water supply and alternative sources.

Trigger 5

At 25 years of project life, abstraction water is expected to drop. This necessitates an additional 7-8 GL of water from an alternative source. This water would be available from Wellington Dam, either through direct allocation or through water trading with agricultural users.

Section 7 Bluewaters Water Supply Strategy

Management and Trigger Points for Change in Water Supply Strategy

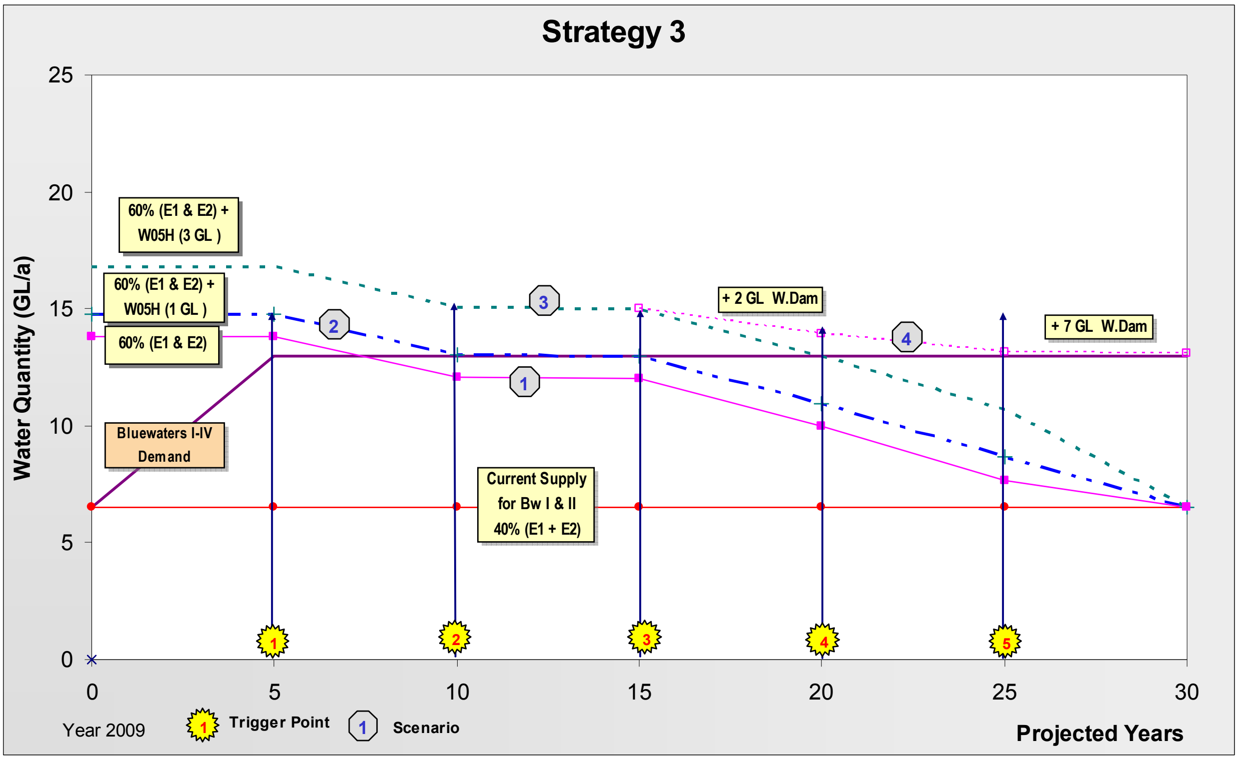
Continuous monitoring of abstraction volumes and water quality is required according to the monitoring and management strategy (section 7.8).

Annual evaluation and reporting of water sources and five yearly assessments of existing and alternative water supply will be done to ensure security of supply for the following five years.

7.6.3 Supply Strategy 3

In this strategy dewatering from Muja South Extension mine is not used. Existing water sources for Bluewaters I & II are assumed to be continued.

Supply for Bluewaters III and IV (6.5 GL/a) is from mine dewatering, diverted stream and Wellington Dam, in accordance to the triggers below.



Trigger 1

At the start of Bluewaters III & IV abstraction volumes and water quality from Ewington 1 and 2 would need to be monitored for a secure supply of at least 60% of the modelled capacity. In addition, 1 GL/a of diverted stream water will be needed for years 5 – 10 of the project life.

Trigger 2

Additional water may be needed. This water would be sourced either from additional dewatering or from diverted stream in mine void (W05H).

Trigger 3

Year 15: additional water (up to 2 GL/a) may be needed. This water would be sourced either from additional dewatering or from Wellington Dam.

Trigger 4-5

Year 20 onwards: additional water (up to 7 GL/a) may be needed. This water would be sourced either from mine voids or Wellington Dam.

Management and Trigger Points for Change in Water Supply Strategy

Continuous monitoring of abstraction volumes and water quality is required according to the monitoring and management strategy (section 7.8).

7.7 Preferred Strategy

Out of the three strategies outlined in the previous section, Strategies 1 and 2 have merits. Supply strategy 2 would be more expensive than Strategy 1, however, it addresses some of DoW's concerns regarding salinity problems in Collie Basin, and would also allow the use of 5.5 GL of dewatering from Griffin mine dewatering.

7.8 Monitoring and management of Water Supply

A monitoring programme appropriate for the assessments of the water supply strategy is outlined in Table 7-1. This programme should be reviewed on an annual basis as part of the annual reporting requirements.

Table 7-1 Monitoring Programme

Monitoring	Parameters	Monitoring Frequency
Local Multipiezometers Regional Multipiezometers	Groundwater Levels	Monthly
	Groundwater Quality: pH, EC and temperature.	Annual (April or October)
Stream Flow Stations	Stream Flow and Rate.	Continuous
	Stream Flow Quality: pH, EC, TDS and Temperature.	Continuous
	Stream Flow Quality: pH, EC, temperature, TDS, TSS, Dissolved Oxygen, Oil and Grease.	Monthly
	Stream Flow Quality: pH, EC, temperature, TDS, TSS, Dissolved Oxygen, Oil and Grease, Al, Cd, Cr, Cu, Fe, Pb, Mn, Ni and Zn.	Quarterly

Monitoring	Parameters	Monitoring Frequency
	Stream Flow Quality: pH, EC, temperature, TDS, TSS, Turbidity, Dissolved Oxygen, HCO3, CO3, Total Alkalinity, Total N, NO3-N, P, Na, K, Mg, Ca, Cl, SO_4, SiO_2, Oil & Grease, Al, As, Be, Cd, Co, Cr, Cu, Fe, Pb, Mn, Mo, Ni, V and Zn.	Annual
Production Bore and Sump Abstractions	Abstraction Volumes	Monthly
	Pump Operating Hours	Monthly
	Groundwater Levels	Monthly
	Groundwater Quality: pH, EC and temperature.	Monthly
	Groundwater Quality: pH, EC, temperature, TDS, TSS, Turbidity, Dissolved Oxygen, HCO3, CO3, Total Alkalinity, Total N, NO3-N, P, Na, K, Mg, Ca, Cl, SO_4, SiO_2, Oil & Grease, Al, As, Be, Cd, Co, Cr, Cu, Fe, Pb, Mn, Mo, Ni, V and Zn.	Quarterly
Abstraction Totals	Cumulative dewatering volumes reported to the local office of the DoE.	Monthly
Mine Voids	Abstraction Volumes	Monthly
	Pump Operating Hours	Monthly
	Groundwater Levels	Monthly
	Groundwater Quality: pH, EC and temperature.	Monthly
	Groundwater Quality: pH, EC, temperature, TDS, TSS, Turbidity, Dissolved Oxygen, HCO3, CO3, Total Alkalinity, Total N, NO3-N, P, Na, K, Mg, Ca, Cl, SO_4, SiO_2, Oil & Grease, Al, As, Be, Cd, Co, Cr, Cu, Fe, Pb, Mn, Mo, Ni, V and Zn.	Quarterly

Section 7 Bluewaters Water Supply Strategy

Monitoring	Parameters	Monitoring Frequency
Water Supply Review Reporting	Preparation of Water Supply Reviews that detail the operational and technical aspects of the project including: • All monitoring data • Water resources management protocols to ensure they remain effective. • Actual abstractions and dewatering achieved compared to the design criteria. • Forecasts of future abstractions. • Trigger points linked to power station water supplies. • Impacts on other groundwater users and stream flows.	Annual.
Water Supply Review Reporting	Preparation of Water Supply Reviews that detail the operational and technical aspects of the project including: • All monitoring data • Water resources management protocols to ensure they remain effective. • Actual abstractions and dewatering achieved compared to the design criteria. • Forecasts of future abstractions. • Trigger points linked to power station water supplies. • Impacts on other groundwater users and stream flows. • Revisions to water supply startegy.	Five Yearly

Section 8 Conclusions

The water supply strategy presented in this report indicates that mine dewatering is sufficient to cover the demand requirements of Bluewaters power Station for the lifetime of the project.

In the short to medium term (first fifteen years of operation), abstracted water from Ewington I & II mine dewatering would be able to supply 13 GL/a and hence provide a secure water source to Bluewaters Power Station (Stages I – IV). For increased reliability, the assessment considered only 70% of the design assumptions for dewatering Ewington I & II for at least the first ten years of Bluewaters life cycle.

The assessment also considered the use of brackish to saline water from Muja South Extension with TDS ranging from 350 mg/L and 2,300 mg/L TDS and a pH of 4.14 to 5.58. This water, when shandied with groundwater from Ewington I & II, provides water quality with TDS ranging from 500 mg/L to 940 mg/L depending on the mix.

The assessment of groundwater quality indicates general compliance with quality criteria for power station use and allows the water to be recycled several times through the power generation processes. This has advantages in that it reduces the amount of total water demand and the quality of effluent discharge to the environment.

There are several potential water abstractions from mine dewatering in the Premier sub-basin, including Premier Pit 1 deeps and Pit 3 mine dewatering. This report assumed only the availability of sources from Griffin mine dewatering for Bluewaters Power Station, as secure sources.

The assessment also considered other sources in accordance with the State Government's Salinity Strategy (2000) and water management objectives in Collie, including the use of Wellington Dam as a supply source; however, these sources may not be needed in the short to medium terms.

The water supply management strategy incorporates periodic monitoring and reviewing of dewatering impacts and will provide at least 5 years lead time on the need to develop alternative sources to secure water supply to Bluewaters Power Station.

Section 9 Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Griffin Coal Mining Pty. Ltd. and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated October 2007.

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

This report was prepared between March 2008 and June 2008 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

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

Section 10 References

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Section 11 Appendix

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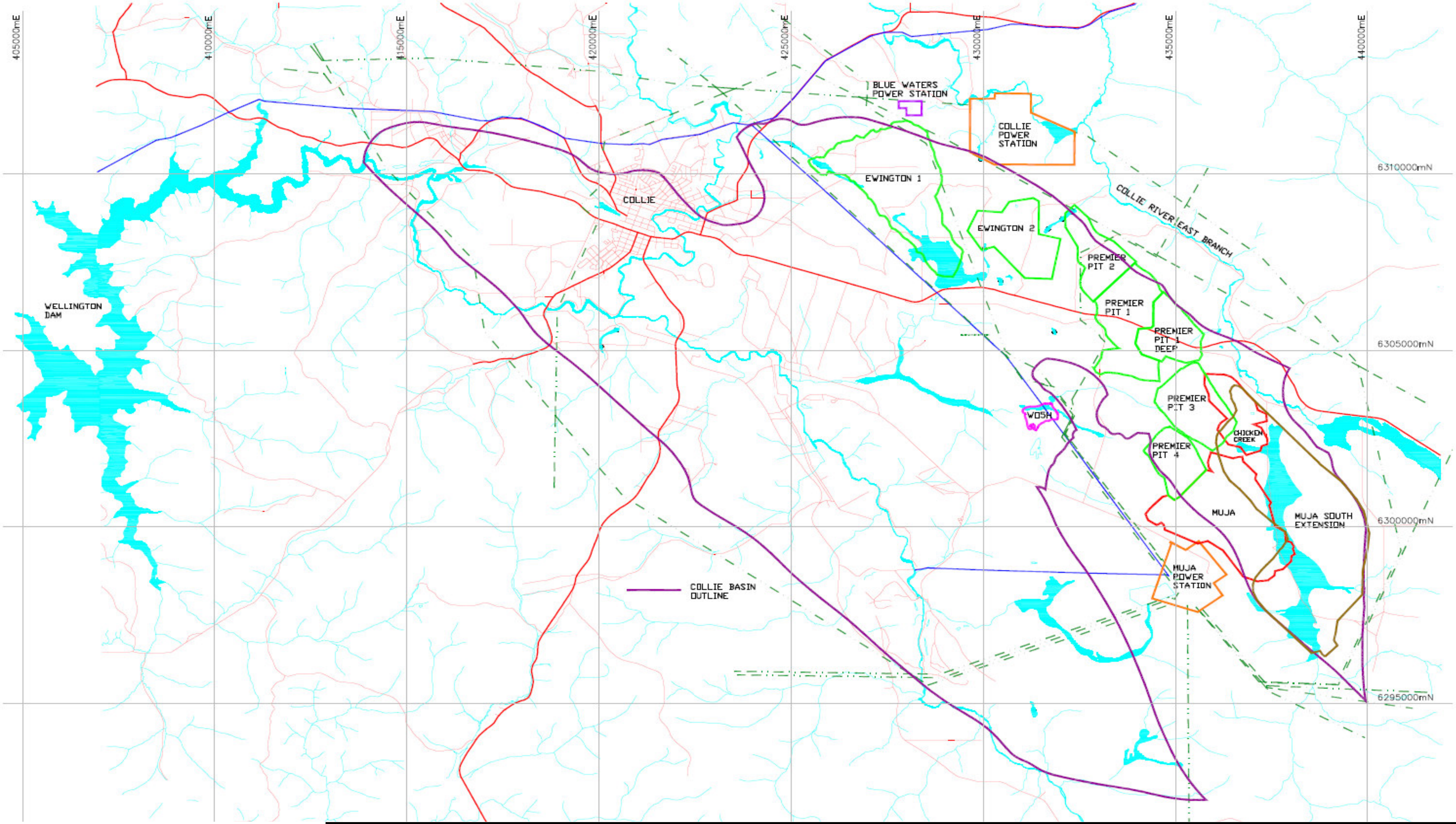
FIGURES



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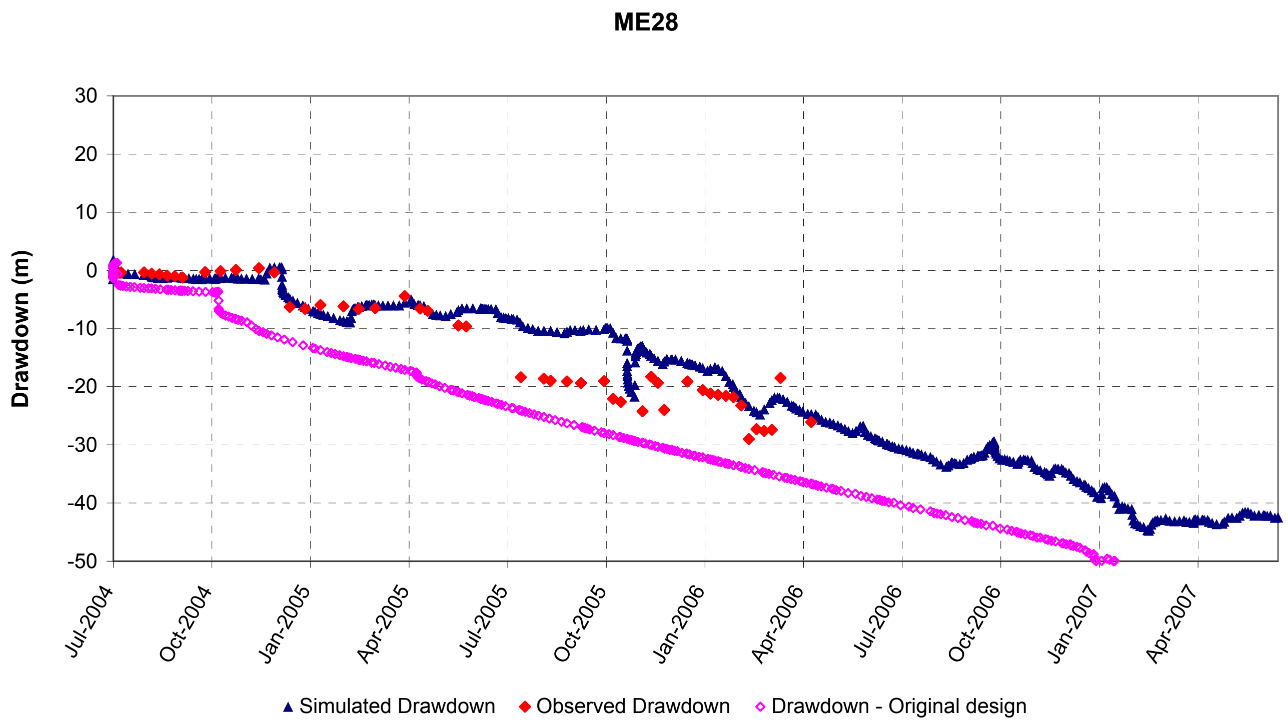
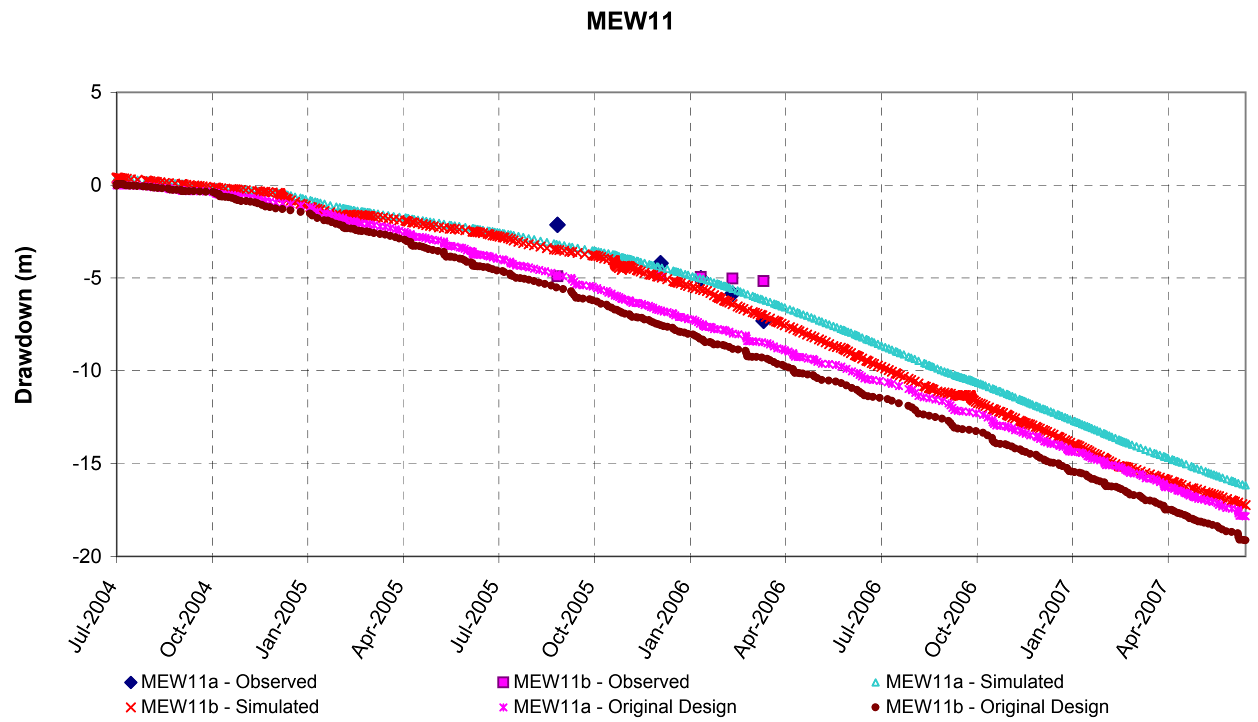
	Drawn:	Approved: IB	Date: 15/04/08	
	Job No: 4296749	File No:		Figure A-1





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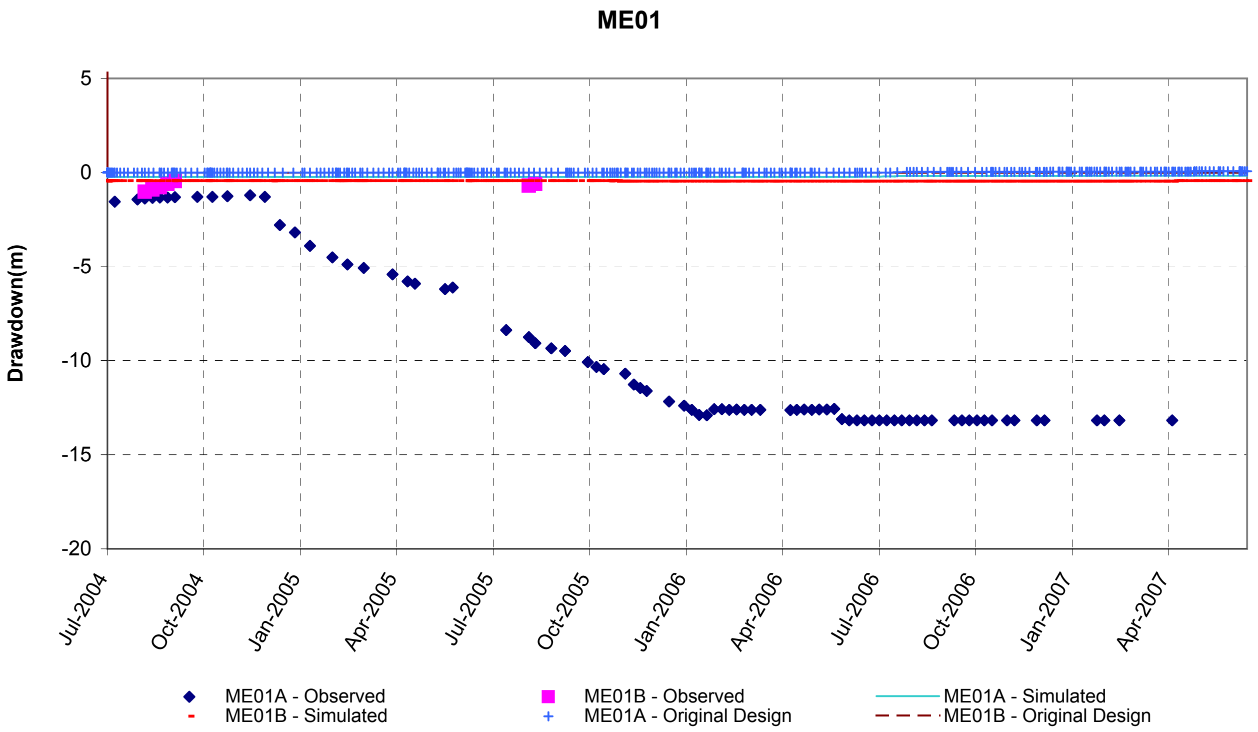

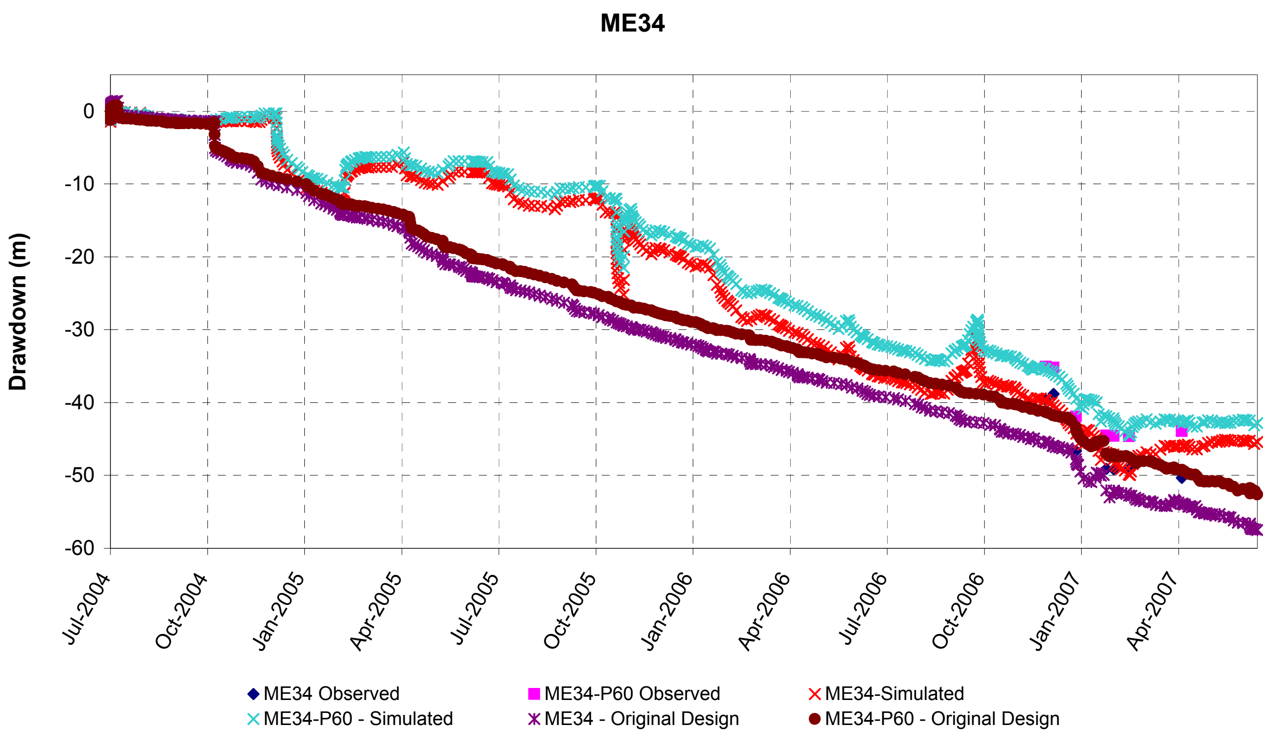

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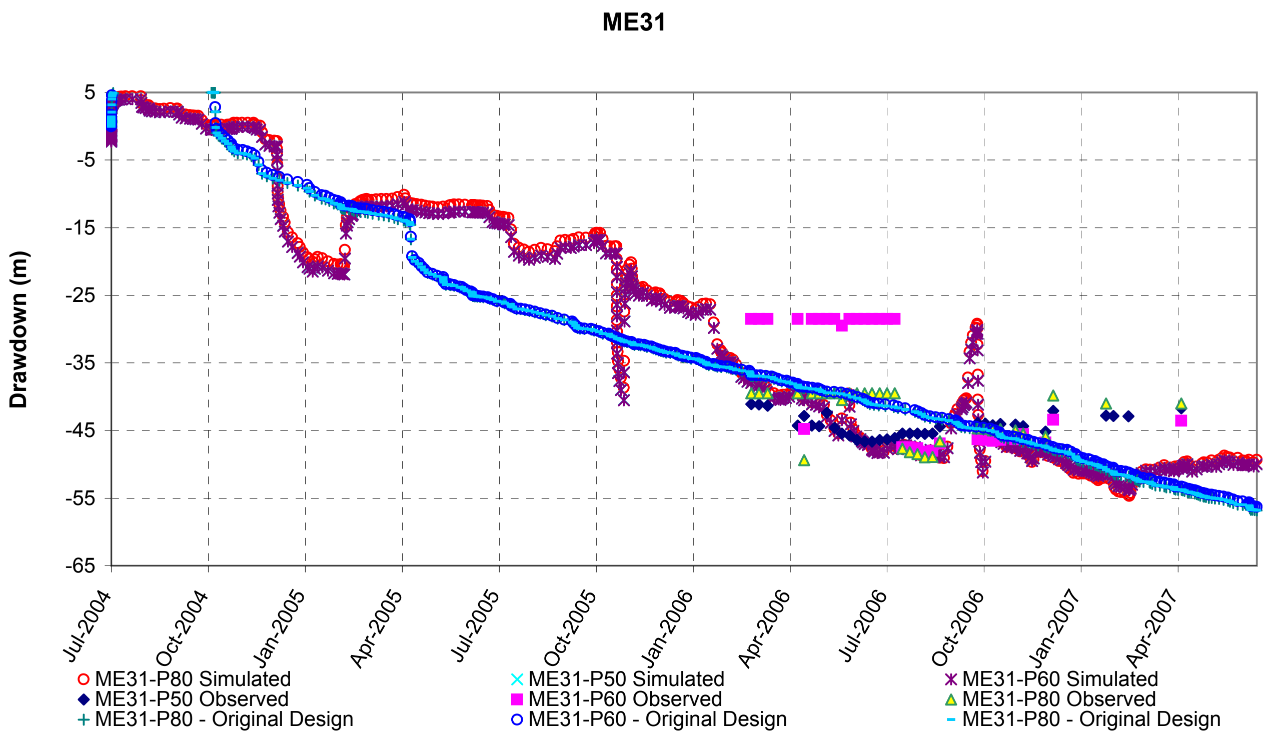

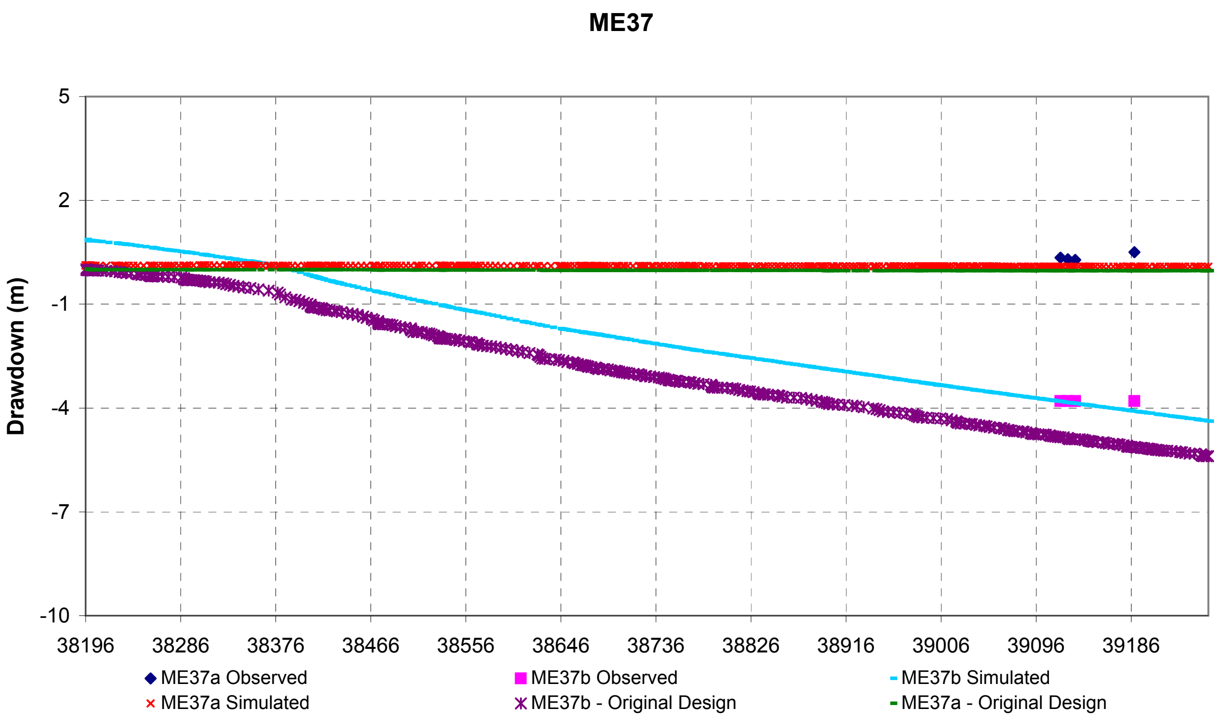

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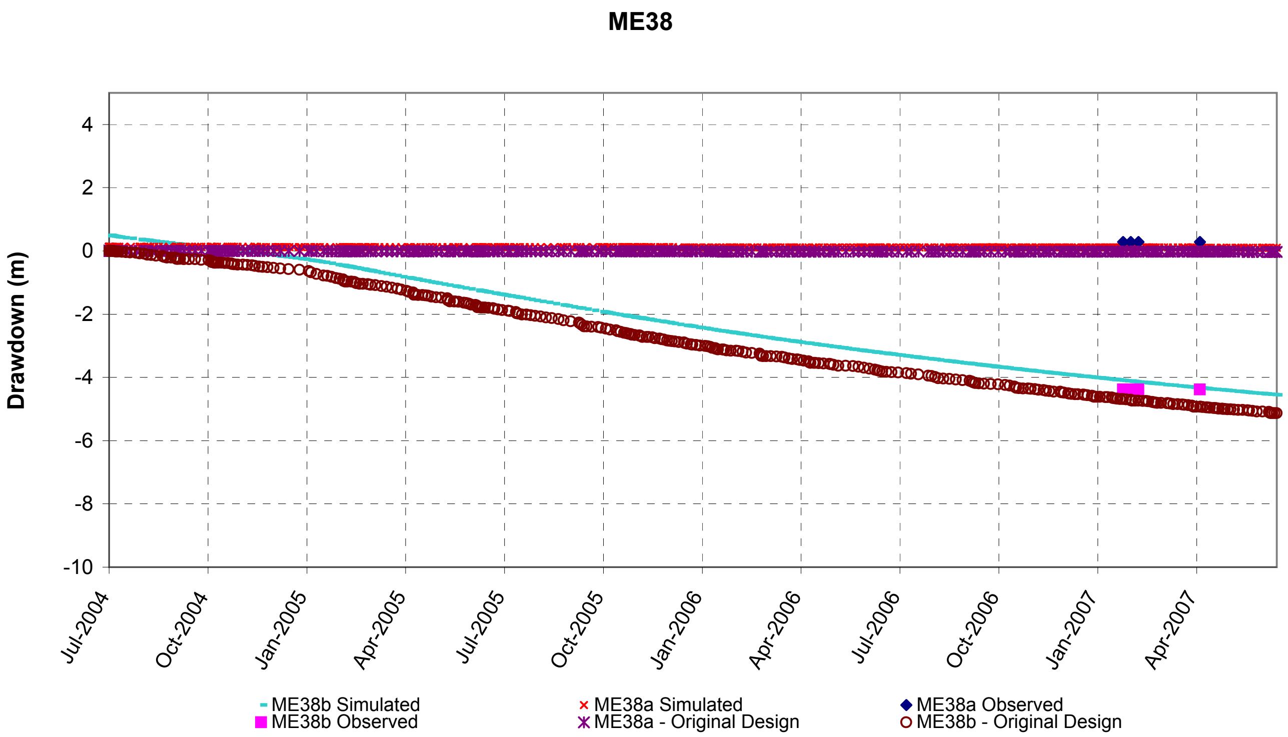

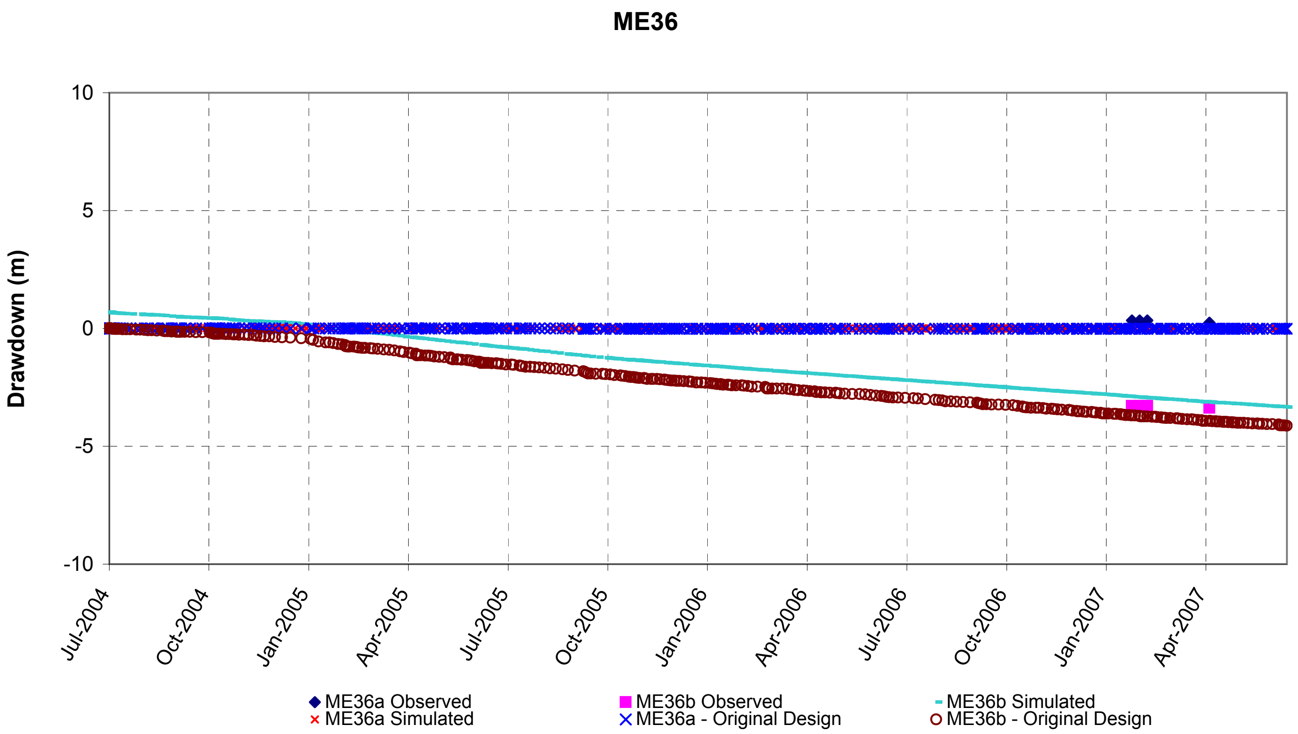

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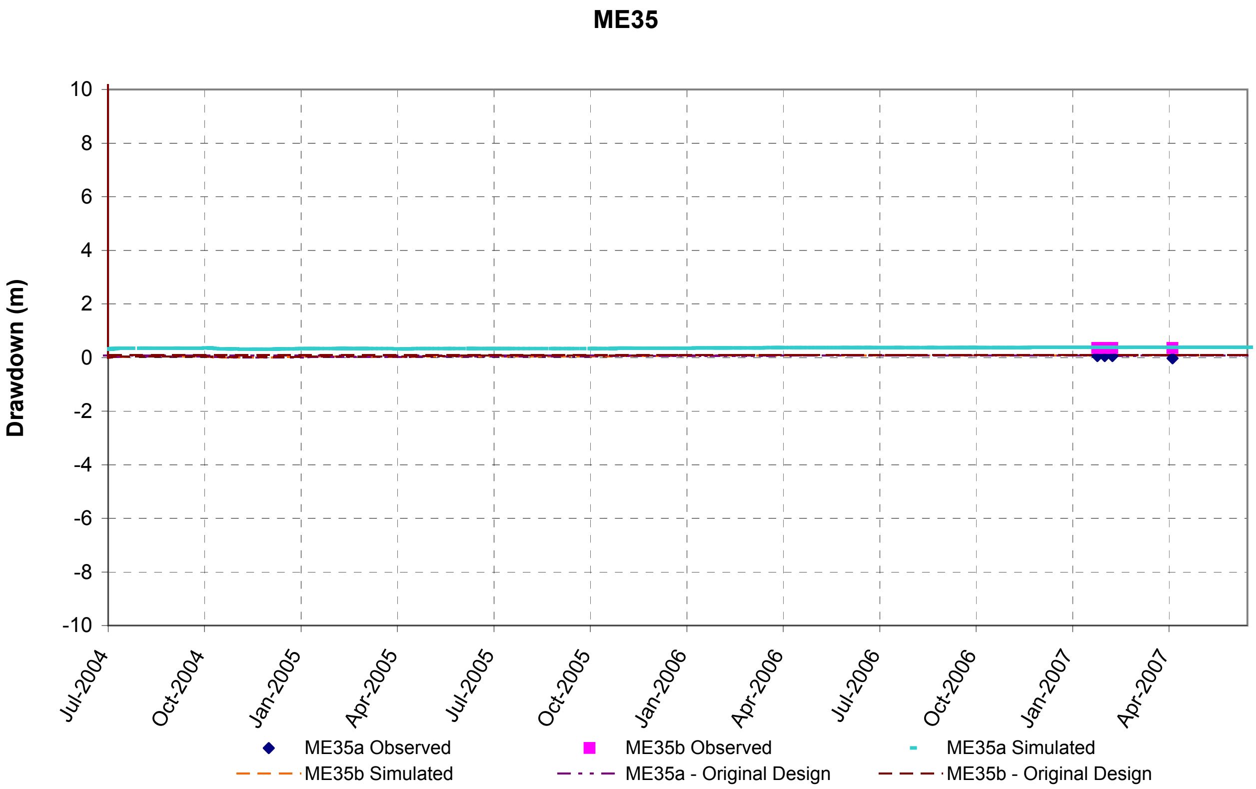

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	Job No: 4296749 / File No:	

Summary of Groundwater Abstraction, ML/yr (1984 - 2007)

Year	WO-5 Mine	WO-5H Mine	Shotts Borefield	Cardiff South Borefield	WD2 Mine	WD6 Mine	WD7 Mine	Muja Mine	Chicken Creek Mine	Premier Mine	Ewington II Mine	Ewington I	Woolnough Borefield	Total
1984	2,196	-	3,370	0	8,950	1,989	630	4,790	490	-	-			22,415
1985	2,108	-	3,320	3,850	7,830	3,157	1,530	4,500	330	-	-			26,625
1986	2,009	-	2,890	2,680	5,270	3,278	2,530	4,050	1,240	-	-			23,947
1987	2,420	34	2,760	630	6,390	3,306	3,150	4,090	2,000	-	-			24,780
1988	2,122	114	1,960	1,830	5,700	3,468	3,770	3,990	2,220	-	-			25,174
1989	2,074	114	2,720	3,720	5,100	3,635	3,680	4,130	2,260	-	-			27,433
1990	2,124	236	2,300	3,380	5,990	4,437	3,440	4,610	2,130	-	-			28,647
1991	2,161	693	2,690	2,550	5,880	4,766	3,810	3,850	1,160	-	-			27,560
1992	2,290	1,285	2,980	2,360	7,170	5,176	2,880	3,490	1,690	-	-			29,321
1993	2,156	1,639	2,180	2,930	5,130	5,241	2,360	5,420	3,590	-	-			30,646
1994	1,709	1,874	3,880	3,250	3,760	1,983	1,010	3,330	3,060	-	-			23,856
1995	1,474	1,767	3,540	3,350	3,240	826		2,480	2,250	2,094	40			21,061
1996	1,426	235	2,854	3,090	4,320	1,720		2,510	2,290	2,131	3,760			24,336
1997	247	-	2,618	3,223	2,315	1,821		3,307	931	1,880	1,927			18,269
1998			1,848	3,868	2,743	1,754		2,858	241	2,000	1,451			16,763
1999			1,945	2,579	2,279	1,460		3,381	365	1,850	3,458			17,317
2000			3,112	3,262	1,835	1,217		2,370	220	1,669	2,645			16,330
2001			2,486	2,479	563	1,553		2,192	361	3,217	3,476			16,327
2002			2,795	2,996	941	867		1,788	163	2,297	4,122			15,969
2003			2376	2768	1044	1213		1577	156	2,006	4,733			15,873
2004			454	3340	1082	1319		2163	179	1,527	6,362			16,426
2005			326	1216	215	646		1248	138	1,055	3,625	192	9,980	8,661
2006			286	233	0	754		263	149	372	2,853	2,453	9,897	7,363
2007(1)								3058	198		3,217	1,711	10,031	8,184
TOTAL(2)	26,516	7,991	55,690	59,584	87,747	55,586	28,790	75,445	27,811	22,098	41,669	4,356	29,908	

Notes: 1 To July 2007 2 23.5 years

Client: Griffin Energy Pty Ltd

URS

Project: Bluewaters Water Supply Strategy

Title: Historical Abstractions

Drawn: | Approved: IB | Date: 15/04/08

Job No: 4296749 | File No:

Figure A-3