APPENDIX F1

Conceptual groundwater model
Olympic Dam expansion project – Supplementary Environmental Impact Statement groundwater studies

- Final
- 9 March 2011
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Terms and abbreviations

ALA or ZAL or €a:
Andamooka Limestone aquifer

AHD:
Australian Height Datum

ANZECC:
Australian and New Zealand Environment Conservation Council

ARMCANZ:
Agriculture and Resource Management Council of Australia and New Zealand

artesian Eromanga Basin:
that part of the Eromanga Basin where groundwater pressures are artesian

artesian Eromanga (GAB) aquifers:
the aquifers of the artesian Eromanga Basin

EIS:
Environmental Impact Statement

GAB:
Great Artesian Basin (in this document the term refers to the “artesian Eromanga Basin”)

GDE:
groundwater dependent ecosystem

GFS:
groundwater flow system

NATA:
National Association of Testing Authorities

non-artesian Eromanga Basin:
that part of the Eromanga Basin where groundwater pressures are non-artesian, aquifers may be confined or unconfined

non-artesian Eromanga aquifers:
the aquifers of the non-artesian Eromanga Basin, i.e. groundwater pressures may be sub-artesian or the aquifers host the water table

OD:
Olympic Dam
RSF: rock storage facility
SA EPA: South Australian Environment Protection Authority
SEIS: Supplementary Environmental Impact Statement
SML: Special Mining Lease
SWL: standing water level
TDS: salinity, expressed as total dissolved solids
THA or ZWC: Tent Hill aquifer (lower Arcoona Quartzite and Corraberra Sandstone)
THZ: Torrens Hinge Zone
TSF: tailings storage facility
TSS: total suspended solids
Victorian EPA: Victorian Environment Protection Authority
1. Introduction

1.1. Background

BHP Billiton Olympic Dam Corporation P/L (BHP Billiton) has engaged Sinclair Knight Merz Pty Ltd (SKM) to undertake additional groundwater-related studies to assist in preparation of the Supplementary Environmental Impact Statement (SEIS) for the proposed Olympic Dam Expansion Project. Figure 1.1 presents a locality plan for Olympic Dam.

Submissions received from the public and regulatory agencies requested further information to that provided in the Draft EIS for the proposed expansion. The submissions related to groundwater typically were in regard to the following issues:

- Conceptualisation of the Stuart Shelf groundwater system, and its potential for interaction with the artesian Eromanga (GAB) groundwater system.
- Risk assessment in regards to conceivable impacts of the proposed expansion on regional groundwater-related values.
- Representativeness of groundwater samples collected during the various groundwater investigation programs undertaken for the proposed expansion.
- Beneficial use status of regional groundwaters.
- The potential response of the Lake Torrens brines to the proposed expansion and the potential effects of the proposed expansion on the water balance of the lake.

This report provides information and interpretations in support of the SEIS, specifically to provide more detailed information to submission responses in Chapter 12 of that document. A list of terms and abbreviations presented after the Table of Contents section is provided for clarification of some terms and abbreviations used in this document.

1.2. EIS related studies

Various hydrogeological investigations and interpretations were carried out in support of the Draft EIS. This work continued in parallel with the EIS preparation and a good deal of information and interpretations were consequently not available for the EIS. However, results of the work programs are now available to assist with responses to comments made about the Draft EIS.
Figure 1.1
Locality plan
Details of the hydrogeological work programs (including composite well logs, airlift yield and salinity profiles, and water quality data) are presented in SKM (2010; Appendix F2 of the SEIS) and the following is a summary:

- Drilling, well construction and aquifer testing for EIS-related hydrogeological investigations in the Andamooka Limestone near Lake Torrens and further west toward the Arckaringa Basin (as Attachment A to SEIS Appendix F2).
- Drilling, well construction and aquifer testing for mine pit dewatering and depressurisation trial (as Attachment B to SEIS Appendix F2).
- A groundwater baseline sampling and analytical program (as Attachment C to SEIS Appendix F2).
- Drilling, well construction and aquifer testing for saline groundwater supply investigations of the Andamooka Limestone aquifer (as Attachment D to SEIS Appendix F2).

Other relevant, groundwater-related consultant reports available for preparation of groundwater responses to the SEIS include:

- refinement of the Stuart Shelf groundwater model originally developed for the Draft EIS (SWS, 2010: see Appendix F4 of the SEIS);
- rock storage facility (RSF) infiltration studies (SRK, 2010a: see Appendix F7 of the SEIS); and
- tailings storage facility (TSF) geochemistry studies (SRK, 2010b: see Appendix F5 of the SEIS).

1.3. Report structure

This report is structured as follows:

Section 1  Introduction

*Presents introductory information concerning the need for the report.*

Section 2  Conceptual hydrogeological model

*Presents the current conceptualisation of the hydrogeology of the Stuart Shelf groundwater flow system in relation to other systems operating within the broader region.*

Section 3  Hydraulic connectedness of regional aquifers

*Presents the results of field testing of the hydraulic properties of Adelaide Geosyncline rocks, an assessment of hydrogeochemical data for regional groundwaters, and interpretation of the extent to which regional aquifers might interact with artesian Eromanga (GAB) aquifers.*
Section 4  Beneficial use categories of regional aquifers
Presents an assessment of the potential uses to which regional groundwaters could be applied.

Section 5  Water sampling protocols
Presents information regarding the way in which groundwater sampling has been conducted at wells installed as part of the groundwater studies for the proposed expansion.

Section 6  Lake Torrens brine
Presents discussion of the interpreted interaction of brine developing from Lake Torrens with regional groundwater flow systems.

Section 7  Groundwater effects assessment
Presents an assessment of the effects the proposed expansion might have on groundwater assets within the region.

Section 8  Conclusions
Presents a summary of the key findings / outcomes of this report.

Section 9  References
A listing of reports, publications and mapping products referenced by this report.

Section 10  Acknowledgments
Acknowledgement of people external to SKM who have assisted in preparation of this report.

Attachments
Supporting data and analyses.
2. **Conceptual hydrogeological model**

2.1. **Background**

Olympic Dam (OD) is located on the Stuart Shelf, which is dominated by Cambrian and Proterozoic rocks. To the northwest of the Stuart Shelf lies the Permian Arckaringa Basin. The Arckaringa Basin groundwater system is in hydraulic continuity with the Stuart Shelf groundwater system, and together they comprise the Arckaringa-Stuart Shelf groundwater flow system (GFS).

A groundwater divide occurs toward the northern end of the Arckaringa-Stuart Shelf GFS, separating the primary aquifers of the Arckaringa-Stuart Shelf GFS (the Andamooka Limestone aquifer; ALA, and the Tent Hill aquifer; THA) from the artesian Eromanga (GAB) GFS, which supports the GAB Springs.

The Arckaringa-Stuart Shelf GFS comprises the THA and ALA as well as the "upstream" Boorthanna aquifer of the Arckaringa Basin. This GFS is recharged by incident rainfall (at rates much less than 1 mm/yr; Golder, 1998) and by throughflow from the western and northern Boorthanna aquifer. Water discharge from this GFS occurs predominantly by evaporation from:

- shallow water tables formed at the margins of the GFS, i.e. along the regional evaporative discharge zone that separates the artesian Eromanga (GAB) and Arckaringa-Stuart Shelf GFSs (to the north and northwest of OD), which is characterised by low lying topography (near sea level) and extensive salinised soils; and
- shallow water tables along the margins of Lake Torrens (some returns to the groundwater system occur as “reflux” brines).

Figure 2.1 presents a schematic showing the locations of the GFSs operating within the region, and Figure 2.2 presents an overview of the groundwater flow processes operating in the broader region. Further description of the GFSs that are active in the broader region is provided as Section 3.2.

2.2. **Conceptual hydrogeological model**

Groundwater flow on the Stuart Shelf is dominated by the ALA to the north of OD and the THA to the south. ALA permeability and yield largely relies on solution-enlarged fissures, while THA permeability is largely associated with brittle fracturing without any solution (karstic) effects.
A significant increase in groundwater salinity occurs in the ALA to the north of OD at depths typically below 200 m, and at greater depths beneath the special mine lease (SML) in the THA. ALA groundwater salinity ranges from less than 50,000 mg/L to more than 200,000 mg/L closer to Lake Torrens. The very high groundwater salinities found near Lake Torrens are associated with brine that is discharging from Tertiary sedimentary aquifers beneath the Lake. Section 6 provides more detail.

Along with the extensive salinised groundwater discharge zone that separates the Arckaringa-Stuart Shelf GFS from the *artesian* Eromanga (GAB) GFS, the margins of Lake Torrens form the main groundwater discharge zone for the Arckaringa-Stuart Shelf GFS (Figure 2.2). The Lake is also a major ephemeral surface water body after sufficient rainfall occurs to generate run-off into the Lake, principally from the Flinders Ranges.
The evaporative discharge of groundwater (mainly) and surface water (occasionally) from Lake Torrens has caused salinity stratification (and brine formation) near and beneath Lake Torrens. Regional groundwater discharging from the Arckaringa-Stuart Shelf GFS toward Lake Torrens is constrained by the presence of this brine, resulting in a density driven upward

Figure 2.2 Interpreted groundwater flow processes within the Study Area
convergence of groundwater discharge from the ALA to the margins of the lake. The brine reduces the effective aquifer transmissivity of the ALA near the lake.

Costelloe et al. (2010) have undertaken studies aimed at estimating leakage rates around the southwestern margin of the artesian Eromanga (GAB) Basin. The results of their studies show that evaporative discharge of groundwater from areas where the water table is less than 1 m (termed the saturated zone by Costelloe et al.) range upwards of 100 mm/yr, and where the water table occurs between around 1 and 4 m (termed the transition zone by Costelloe et al.) evaporation losses could range between 10 and 100 mm/yr. These estimates of evaporative discharge from the saturated and transition zones are not insignificant, and can reasonably be expected to form an effective hydraulic (discharge) boundary between the artesian Eromanga (GAB) and Arckaringa-Stuart Shelf GFSs.

The existence of a groundwater divide between the Arckaringa-Stuart Shelf GFS and the artesian Eromanga (GAB) GFS, combined with intervening low permeability Adelaide Geosyncline rocks within which the divide is generally located (see Sections 3.3 and 3.4), indicates there is no connection between the primary aquifers of the Arckaringa- Stuart Shelf GFS (ALA and THA) and the artesian Eromanga (GAB) GFS. This conclusion is supported by hydrogeochemical data (see Section 3.5).

The schematic hydrogeological cross-section presented as Figure 2.3 describes the essential elements of the regional conceptual hydrogeological model, particularly in relation to the Arckaringa- Stuart Shelf and artesian Eromanga (GAB) GFSs to the north of OD. Importantly, the schematic shows:

1. A groundwater divide formed within low permeability Adelaide Geosyncline rocks (and Tent Hill equivalents) toward the north end of the Arckaringa-Stuart Shelf GFS, separating the ALA and THA from the artesian Eromanga (GAB) GFS.

2. Evaporative loss of shallow groundwater at the margins of Arckaringa- Stuart Shelf and the artesian Eromanga (GAB) GFS is an important groundwater discharge process, causing salinisation of shallow and deep soil profiles and groundwater.

3. Density driven brine discharge from Lake Torrens to the ALA and, possibly, around the entire perimeter of the lake. Brine, extending out from Lake Torrens beneath the groundwater that moves towards Lake Torrens, causes the less saline regional groundwater to move up the brine interface to discharge to the margin of the lake.
Figure 2.3
Schematic of the conceptual hydrogeological model of the Stuart Shelf and GAB groundwater flow systems

See notes page 8
3. Hydraulic connectedness of regional aquifers

3.1. Groundwater monitoring locations

Groundwater monitoring locations used for the assessment of groundwater flow behaviour and hydraulic separateness of Stuart Shelf aquifers are presented in Figure 3.1. As shown, 55 wells have been completed in the Andamooka Limestone aquifer (ALA), 21 wells have been completed in the Tent Hill Aquifer (THA) and 78 shallow wells have been completed within regional water table aquifers in both the Stuart Shelf and Adelaide Geosyncline fractured rock aquifers and non-artesian Eromanga aquifers.

These new wells are in addition to wells existing prior to commencing environmental groundwater investigations for the proposed expansion.

3.2. Groundwater flow systems

There are two dominant GFSs within the broader region of Olympic Dam. They are:

- the regional-scale Arckaringa-Stuart Shelf GFS, which incorporates the aquifers of the Stuart Shelf itself (the THA and ALA) as well as the aquifers of the neighbouring (upstream) Arckaringa Basin (the Boorthanna aquifer) to the west (Figure 2.1); and
- the regional-scale artesian Eromanga (GAB) GFS, comprising the aquifers of the Eromanga Basin where they are artesian north of Olympic Dam (Figure 2.1).

Details concerning each of these flow systems can be gained from references presented as Appendix K1 of the Draft EIS, as well as Douglas and Howe (2009) and Howe et al. (2008).

An overview of recharge-discharge mechanisms for the Arckaringa-Stuart Shelf GFS is provided in Section 2. Important concepts for setting the context of the potential for interaction between the artesian Eromanga (GAB) and Arckaringa-Stuart Shelf GFSs, though, are:

- The existence of a groundwater divide (Figure 3.1) separating the Stuart Shelf and artesian Eromanga (GAB) Basin groundwater systems to the north of Olympic Dam. Evidence for this divide includes water table elevation data collected from a number of monitoring wells located to the north of the SML (see Figure 3.1 for locations). Where there are no groundwater level data, a westerly extension of the divide has been inferred along a topographic divide and outcrop of low permeability Adelaide Geosyncline strata of the THZ.
Figure 3.1 Locations of wells used for regional groundwater flow analysis
Figure 3.2  Interpreted groundwater elevation contours for the upper ALA
The extensive area of salinised soils and groundwater along the broad contact (saturated to transition) zone where the two GFSs converge is evidence of a regional-scale groundwater evaporative discharge zone that separates them. Evaporation groundwater losses along this zone could range upwards of 100 mm (Costelloe, et al., 2010).

A third, less extensive GFS that overlies the Arckaringa-Stuart Shelf GFS, occurs to the west and northwest of OD, the non-artesian Eromanga (GAB) GFS. OZ Minerals (2009) presents a detailed description of the hydrogeology of the Arckaringa Basin and overlying (non-artesian) Eromanga Basin. In summary:

- Groundwater discharges as diffuse seepage and evaporation from the non-artesian Eromanga aquifers along the groundwater discharge zone separating the artesian Eromanga (GAB) aquifers from the non-artesian Eromanga aquifers (Figure 2.2).
- The non-artesian Eromanga GFS does not extend onto the Stuart Shelf. The underlying Arckaringa Basin (Boorthanna) aquifer is connected to the aquifers of the Stuart Shelf.

### 3.3. Groundwater flow

#### 3.3.1. Regional water table aquifer

Standing water levels for all wells, where data exist (depths, elevations and density-corrected heads), are presented as Attachment A (Tables A.1 through A.4). Water level data have been used to generate groundwater elevation contours for each primary aquifer of the Stuart Shelf (ALA and THA) and these are presented as Figure 3.2 and Figure 3.3.

Figure 3.4 presents interpreted groundwater elevation contours for the regional water table aquifer of the Arckaringa-Stuart Shelf groundwater flow system (GFS), which extends across a number of hydrostratigraphic units, including the ALA, the THA and Arckaringa Basin. The non-artesian Eromanga aquifer forms a water table aquifer west of Olympic Dam, but does not extend on to the Stuart Shelf proper.

The data used to construct these regional contours have not been corrected for fresh water heads, as salinity data are not available for all locations used to generate the contours (a comparison of Figures 3.2 and 3.4 indicates the lack of salinity correction does not compromise the interpretation of groundwater flow direction across the Stuart Shelf).
Figure 3.3
Interpreted groundwater elevation contours for the THA (March 2009; after Douglas et al., 2009)
Figure 3.4
Interpreted regional water table contours
Attachment A (Table A.6) presents estimated hydraulic conductivity values for the different hydrostratigraphic units of the Stuart Shelf (aquifers and aquitards), which is drawn from information presented in SKM (2010; Appendix F2 of the SEIS).

As shown on Figure 3.4, groundwater is interpreted to flow onto the Stuart Shelf, west from Arckaringa Basin aquifers, predominantly via the highly transmissive ALA. Consistent with the interpreted contours presented in Figure 3.4, water table aquifer discharge is toward the northern end of Lake Torrens, as well as toward low lying topography that occurs where the *artesian* Eromanga (GAB) GFS and Arckaringa-Stuart Shelf GFS converge along the southwestern extent of the *artesian* Eromanga (GAB) GFS.

A groundwater divide (Figure 3.1) separates the primary aquifers of the Arckaringa-Stuart Shelf GFS (ALA and THA) from the *artesian* Eromanga (GAB) GFS.

### 3.3.2. Andamooka Limestone Aquifer (ALA)

At the time of preparation of the Draft EIS, investigations of the ALA were being undertaken to the west and north of Lake Torrens. This section includes recent interpretations of data that were not available for inclusion in the Draft EIS.

Figure 3.2 displays the interpreted groundwater elevation contours for the upper ALA. These contours are based on water level measurements that have been corrected due to the variable density of regional groundwater within the Andamooka Limestone.

The general direction of groundwater flow in the less saline, upper ALA is from west to east in the study area, converging at the northern end of Lake Torrens. A slightly steeper gradient is evident between OD and Lake Torrens compared to the groundwater flow field that occurs to the north of OD, which is likely reflective of lower transmissivity due to reduced saturated thickness of the aquifer.

The lower ALA in the vicinity of the northern end of Lake Torrens is characterised by hyper-saline groundwater or brine (see Figure 3.5, eg. wells RT5b and LR10). A brine wedge extends westward away from the salt lake (Figure 3.6), which has been defined by Schmid (1985) as a groundwater playa. The regional (west to east) groundwater flow field within the upper ALA passes over the saline groundwater / brine interface. The interaction between the Lake Torrens brines and the ALA flow system is discussed further in Section 6.
Figure 3.5
Nested monitoring sites

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Figure 3.6
Interpreted groundwater elevation contours for the lower ALA
The hydraulic gradient in the upper system lessens significantly through the central and eastern sections of the ALA, ranging from $3 \times 10^{-3}$ to $9 \times 10^{-3}$, corresponding with increased aquifer hydraulic conductivity as documented by pumping tests carried out at three sites in this area (MAR2, MAR3 and MAR4; SKM, 2010) and high airlift yields in other wells (e.g. greater than 20 L/s in PT40, PT42, PT44, PT48, PT51; SKM, 2010).

The lower system is characterised by corrected hydraulic gradients in a similar range to the overlying system (Figure 3.6). In contrast to the upper part of the aquifer, however, within 20 km of the northern end of Lake Torrens groundwater in the base of the ALA flows northwestward away from the playa toward the central portion of the ALA where drilling investigations show the base of the Andamooka Limestone is deeper than elsewhere on the Stuart Shelf.

The conceptual hydrostratigraphic cross-section schematic presented as Figure 3.7 shows brines ‘filling’ the deepest sections of the ALA and extending westward up to 50 km from Lake Torrens.

The location of the interface between saline waters and brine has been estimated from EC measurements made during drilling. At a distance of more than around 15 km from Lake Torrens, the interface appears to have a low gradient indicating a stable density stratified system. The interface is higher within the ALA closer to Lake Torrens. Saline groundwater moving towards the discharge zone is effectively forced upward by the density difference, as discussed earlier, and a thicker mixing zone develops. RT5a, located within a few kilometres of Lake Torrens, is screened at the top of the ALA and shows high salinity levels (TDS greater than 50,000 mg/L).

### 3.3.3. Tent Hill Aquifer (THA)

Figure 3.3 presents the interpreted groundwater elevation contours for the THA in the area of Olympic Dam. These contours are based on density corrected water level measurements (see Section 6).

Within the Olympic Dam SML, potentiometric data show the influence of more than 30 years of mine drainage through shafts and vent raises, as well as from the trial dewatering and depressurisation wellfield, which is now being operated as a site saline water supply.

Away from OD, groundwater salinity data for regional monitoring wells RT02b and RT01 (Figure 3.5) suggest hypersaline groundwater occurs at depth within the THA north of the SML, indicating brine from Lake Torrens is also collecting in the deeper hydrostratigraphic units north of Olympic Dam.
Figure 3.7
Schematic of shallow cross-sectional hydrostratigraphy and brine processes of the Stuart Shelf.
3.3.4. **Potential vertical hydraulic gradients**

Figure 3.5 presents (corrected) fresh water heads and vertical gradients for nested groundwater monitoring sites screened across the Stuart Shelf and THZ. Attachment A presents the details of density corrections and vertical hydraulic gradients. Fresh water heads have also been calculated using the density conversion as outlined in Section 6.

At nested SML sites RT16 and RT17 (Figure 3.5) the corrected water levels within the ALA range from around 7 to 11 m higher than that of the underlying THA, indicating the potential for downward leakage from the ALA to the THA in this vicinity, through the Arcoona Quartzite aquitard (AQA). Density corrected hydrographs for RT16 and RT17 (Figure 3.8) support the above observation, indicating minimal connection between the ALA and underlying THA.

At sites RT-1 and RT-2, located north of the SML near to the northern end of Lake Torrens, density corrected water levels indicate the potential for upward leakage from the THA to the ALA (Figure 3.5 and 3.8).

For other regional nested sites, located north of the SML, corrected water levels also indicate the potential for upward leakage of groundwater from the deeper to shallower aquifers.

In considering overall groundwater flow patterns within the Arckaringa-Stuart Shelf GFS, it is likely that the brines beneath Lake Torrens (extending from the ALA down to, at least, the THA) cause ‘fresher’ groundwater moving to the east across the Stuart Shelf from the direction of the Arckaringa Basin groundwater system to move upward and discharge to the outer edges of Lake Torrens where the water table is typically less than a few metres deep.
- Figure 3.8
Hydrographs for nested sites (RT16, RT17, PT24, RT2, RT4, RT5, RT7)
3.4. Geological control on groundwater flow

3.4.1. Overview

The Neoproterozoic sedimentary rock sequences of the Stuart Shelf and Adelaide Geosyncline geological provinces are separated by the Torrens Hinge Zone (THZ). The western limit of the THZ is defined by the Torrens Fault, and the northern margin is defined by the Norwest Fault (Figure 3.9). The regional structures associated with the THZ are aligned along the north-south axis of Lake Torrens and strike to the northwest, running between Olympic Dam (OD) and Lake Eyre, through and beyond the Peake-Denison Inliers (Figure 3.9).

Two geological cross-sections (Figures 3.10 and 3.11) have been prepared, based primarily on available geological drillhole information (including a log of Margaret Creek Bore, which has been prepared based on very old drill cuttings stored by PIRSA; see SKM, 2010), and the Curdimurka (Callen et al., 1992), Billa Kalina (Ambrose and Flint, 1980) and Andamooka (Dalgarno, 1982) 1:250 000 Geological Map Sheets.

3.4.2. Stuart Shelf and artesian Eromanga Basin

General

The following presents information to support the interpretation that the Adelaide Geosyncline THZ forms a ‘barrier’ to interconnectedness between the Stuart Shelf and Great Artesian Basin.

Adelaide Geosyncline strata of the THZ occur in a broad zone extending from east of OD through to the northwest (Figure 3.9). The strata typically comprise of low permeability Neoproterozoic sediments that are folded and faulted. Because of the structure of these rocks the groundwater flow pathways are short and the groundwater flow systems are compartmentalised (Kellet et al, 1999). The low permeability of these strata, the compartmentalisation of the groundwater flow system, the topographic divide and, where available, observed groundwater elevations, provide compelling evidence for the presence of a groundwater divide between the Stuart Shelf GFS and the artesian Eromanga (GAB) GFS.

In Figure 3.10 the interpreted stratigraphic relationship between the various geological units of the region following a line from Olympic Dam in the south through to McEwin Bore in the north is shown. McEwin Bore is an artesian well that intersects the artesian Eromanga (GAB) aquifer. This well is located along the Margaret Creek drainage approximately 10 km northeast of the Welcome, Billa Kalina and Bakewell Springs.
Figure 3.9
Geological locality plan

- Cambrian-Proterozoic
- Palaeozoic-Mesozoic
- Proterozoic
- Cambrian-Ordovician
- Ordovician-Silurian
- Silurian-Devonian
- Devonian-Carboniferous
- Carboniferous-Jurassic
- Jurassic-Cretaceous
- Cretaceous-Neogene
- Neogene-Pleistocene
- Pleistocene-Holocene
- Holocene-Recent
- Recent-Quaternary
- Quaternary-Recent
- Recent-Holocene
- Holocene-Neogene
- Neogene-Pleistocene
- Pleistocene-Recent
- Recent-Quaternary
- Quaternary-Holocene
- Holocene-Recent
- Recent-Neogene
- Neogene-Palaeogene
- Palaeogene-Recent
- Recent-Quaternary
- Quaternary-Holocene
- Holocene-Recent
- Recent-Neogene
- Neogene-Palaeogene
- Palaeogene-Recent
- Recent-Quaternary
- Quaternary-Holocene
- Holocene-Recent
- Recent-Neogene
- Neogene-Palaeogene
- Palaeogene-Recent
- Recent-Quaternary
- Quaternary-Holocene
- Holocene-Recent
- Recent-Neogene
- Neogene-Palaeogene
- Palaeogene-Recent
- Recent-Quaternary
- Quaternary-Holocene
- Holocene-Recent
- Recent-Neogene
- Neogene-Palaeogene
- Palaeogene-Recent
- Recent-Quaternary
- Quaternary-Holocene
- Holocene-Recent
- Recent-Neogene
- Neogene-Palaeogene
- Palaeogene-Recent
- Recent-Quaternary
- Quaternary-Holocene
- Holocene-Recent
- Recent-Neogene
- Neogene-Palaeogene
- Palaeogene-Recent
- Recent-Quaternary
- Quaternary-Holocene
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- Neogene-Palaeogene
- Palaeogene-Recent
- Recent-Quaternary
- Quaternary-Holocene
- Holocene-Recent
- Recent-Neogene
- Neogene-Palaeoge
Figure 3.10
Cross-section A-C showing interpreted hydrostratigraphic and structural relationships north of OD.
Figure 3.11 Cross-section B-C showing interpreted hydrostratigraphic and structural relationships from the Arckaringa Basin through to the Eromanga Basin.
The northern limit of the Stuart Shelf appears to be structurally controlled, where normally deeper Adelaidean sediments have been brought close to the surface, e.g. the Brachina Formation (including equivalents of the Tent Hill Formation). These sediments in turn are overlain unconformably and very close to surface by remnants of the Cretaceous Bulldog Shale of the Mesozoic Eromanga Basin.

Based on limited drillhole and available geological information in the immediate vicinity of McEwin Bore, it is apparent that Adelaidean THZ rocks (possibly the Brachina Formation) are present at depth. These are overlain unconformably by a significantly thicker cover of Eromanga Basin sediments, consisting primarily of Bulldog Shale underlain by the Cadna-owie Formation and Algebuckina Sandstone (the artesian Eromanga (GAB) aquifer). These Eromanga Basin sediments vary in thickness and extent, and are largely controlled by the contours of the erosional surface of the underlying Adelaidean sediments on which they were deposited. They generally thicken out to the north and east.

**Permeability of Adelaide Geosyncline rocks**

Falling head ‘slug tests’ were carried out at ten key groundwater monitoring wells intersecting Adelaide Geosyncline rocks within the THZ, as well as single wells intersecting Stuart Shelf rocks and remnant Eromanga sediments. Figure 3.12 presents a locality plan for the tests.

Table 3.1 summarises the hydraulic conductivity estimates derived for the ‘aquifers’ intersected by the wells. Attachment B presents details of the investigations, including procedures and data analysis.

Figure 3.13 presents a locality plan showing the range in hydraulic conductivity values for the regional aquifers. As shown, the permeability of Adelaide Geosyncline rocks in the area are typically orders of magnitude lower than either the Stuart Shelf aquifers or the artesian Eromanga (GAB) aquifer.

The results of the falling head tests are consistent with the results of other testing conducted in the broader area (in the case of the Cadna-owie Formation), lithologies tested and the literature (Freeze and Cherry, 1979).

Aquifer tests conducted near Olympic Dam mining lease provide estimates of hydraulic conductivity for the Tent Hill aquifer (THA) ranging between $3 \times 10^{-2}$ and 2.2 m/d, and for the ALA of around 7 m/d (SKM, 2010), but to the north of OD the permeability of this aquifer is much less possibly due to compression of the aquifer skeleton arising from deformation (Douglas et al, 2009).
Figure 3.12 Location of falling head tests
Table 3.1 Falling head tests – summary of hydraulic conductivity estimates

<table>
<thead>
<tr>
<th>Hydrogeology</th>
<th>Well ID</th>
<th>Hydraulic Conductivity (m/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bouwer &amp; Rice</td>
</tr>
<tr>
<td><strong>Stuart Shelf</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arcoona Quartzite aquitard</td>
<td>RT02b</td>
<td>2 x 10^{-3}</td>
</tr>
<tr>
<td><strong>Adelaide Geosyncline (THZ)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABC Quartzite / Brachina Formation</td>
<td>RT05c</td>
<td>4 x 10^{-3}</td>
</tr>
<tr>
<td>Brachina Formation</td>
<td>RT09</td>
<td>1 x 10^{-4}</td>
</tr>
<tr>
<td>Amberooona Formation</td>
<td>RT07a</td>
<td>1 x 10^{-3}</td>
</tr>
<tr>
<td>Amberooona Formation</td>
<td>RT07b</td>
<td>2 x 10^{-3}</td>
</tr>
<tr>
<td>Brachina Formation</td>
<td>PT63</td>
<td>4 x 10^{-2}</td>
</tr>
<tr>
<td><strong>Non artesian Eromanga Basin</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulldog Shale</td>
<td>PT41</td>
<td>7 x 10^{-1}</td>
</tr>
<tr>
<td>Bulldog Shale</td>
<td>PT42</td>
<td>1 x 10^{0}</td>
</tr>
<tr>
<td>Cadna-owie Formation</td>
<td>PT62</td>
<td>3.3 x 10^{1}</td>
</tr>
</tbody>
</table>

Further north within the artesian Eromanga (GAB) GFS estimates of hydraulic conductivity are reported to range from around 5 to 40 m/d (REM, 2005; WMC Resources, 1997; AGC, 1982).

3.4.3. Arckaringa Basin and artesian Eromanga Basin

To the northwest of Olympic Dam in the vicinity of the Billa Kalina fault system and the Billa Kalina Spring, Proterozoic basement strata are overlain by Permian sediments of the Arckaringa Basin, which are in turn overlain by Eromanga Basin sediments (Figures 3.9 and 3.11).

Logging of very old samples taken during the construction of Margaret Creek Bore indicate almost 90 m of Boorthanna Formation underlie around 50 m of artesian Eromanga (GAB) Basin sediments and overlie Proterozoic quartzite (the Arcoona Quartzite or its equivalent). Figure 3.11 presents the interpreted geological cross-section between McEwin Bore and Coorie-Appa Bore, showing the interpreted stratigraphy and structural relationship of the Adelaidean (Adelaide Geosyncline), Permian (Arckaringa Basin) and Mesozoic (non-artesian and artesian Eromanga Basin) sediments. Note that the cross-section is aligned along the northern side of the inferred Margaret Creek Fault, to the south of which Proterozoic rocks
sub-crop and outcrop, and occurs within what Costelloe et al. (2010) describe as the *transition* and *saturated* groundwater discharge zone, where evaporative losses for groundwater can be expected to range up to and beyond 100 mm/yr.

**Figure 3.13** Range of hydraulic conductivity estimates for the different regional hydrostratigraphic units
The primary aquifer within the Permian Arckaringa Basin suite of sediments within the area of interest occurs within the Boorthanna Formation, a diamictite. Drilling logs for the area show the formation is extremely heterogeneous in keeping with its depositional environment and aquifers, where they occur, are formed within discrete ‘pods’ of silty and sandy sediments that are separated both vertically and laterally by a low permeability siltstone / mudstone matrix. Drilling in the broader region shows significant structural displacement and block faulting of the Permian sediments.

The area of particular interest to this discussion is the Billa Kalina Spring, and nearby springs and wells. Not only does this location lie at the structurally and lithologically complex juncture of the artesian Eromanga (GAB) Basin and the Arckaringa Basin, it is also intersected by major faults that have dislocated most geological units in the region (Proterozoic through to Mesozoic; see Figure 3.11). The faults include the Torrens Fault zone, the Margaret Creek Fault (along the present alignment of Margaret Creek) and the Billa Kalina Fault system. These faults effectively form a triangle with Billa Kalina springs located at its eastern apex (Figure 3.11).

To the east of the Torrens Fault, toward McEwin Bore, there is a thicker sequence of Mesozoic Eromanga Basin sediments (the artesian Eromanga aquifers). Permian sediments (Ludbrook, 1961) occur immediately east of the Torrens Fault, but it is concluded from the information presented on map sheets, the convergence of two GFSs and hydrochemistry (see Section 3.5) that these sediments are isolated from the Arckaringa Basin proper.

Significant vertical displacement along the Margaret Creek Fault has brought Permian Arckaringa Basin and Mesozoic Eromanga Basin sediments into contact with Proterozoic strata, effectively forming a barrier to groundwater flow to the southeast. However, elsewhere, where the displacement is not so great (eg. along the Billa Kalina Fault system), Permian sediments (that do not necessarily form aquifers) possibly remain in contact.

Evidence from the Arckaringa Basin shows that structural control of aquifer response to groundwater abstractions is significant, and the Billa Kalina Fault in particular isolates the Arckaringa Basin groundwater system west of the fault from the systems occurring on the east side of the fault. OZ Minerals (2009) presents data supporting this observation. Groundwater potentiometric data for regional compliance monitoring wells are presented on Figure 3.14 (a locality plan for these wells is presented in Figure 3.15). RMD-1 screens a thin sequence of aquifer material in the Boorthanna Formation to the east of Billa Kalina Fault, RMD-4 screens the Boorthanna aquifer west of the Billa Kalina Fault and RMD-7 screens the Boorthanna aquifer west of Prominent Hill’s wellfield. RMS wells screen the non-artesian Eromanga
aquifer. The hydrographs show that groundwater levels at RMD-1 have not responded to abstractions from the Prominent Hill wellfield, whilst a downward trend is evident in the RMD-4 data. The hydrographs also show the shallower Eromanga aquifer (RMS wells) is not responding to abstractions.

3.5. Hydrogeochemistry

3.5.1. Overview

Groundwater data selected for analysis of regional hydrogeochemistry are sourced from public sources (e.g. OZ Minerals, 2008) and work conducted for BHP Billiton (SKM, 2010).

Groundwater sample locations for the assessment of aquifer connectedness using hydrogeochemical data are presented in Figure 3.16.

3.5.2. Salinity

Figure 3.17 presents a comparison of reported groundwater salinities (as TDS) for the artesian Eromanga (GAB) aquifers (and stock wells supported by these aquifers), and the Boorthanna aquifer (Arckaringa Basin) from west of the Billa Kalina Fault system. The data, and the fact that an extensive evaporative groundwater discharge zone separates the two GFSs strongly suggests that artesian Eromanga (GAB) groundwaters are very unlikely to be supported by the Boorthanna aquifer to the west of the Billa Kalina Fault system.

3.5.3. Major ions

Major ion chemistry was analysed with the assistance of Piper plots. The data presented in Figure 3.18 (with components of calcium, magnesium, and carbonate multiplied by ten to better distinguish potential groupings) clearly show the hydrogeochemical distinctness of the artesian Eromanga (GAB) aquifers compared to other aquifers within the broader OD region.

The data support the conceptual hydrogeological model of the OD region, which identifies two primary groundwater flow systems (GFSs) with different groundwater origins, i.e. the Arckaringa-Stuart Shelf GFS and the artesian Eromanga (GAB) GFS. The artesian Eromanga (GAB) groundwaters consistently demonstrate a lower magnesium signature in terms of cations and are more bicarbonate enriched in regards to anions.

Detail of the water chemistry is provided in the Piper plot presented as Figure 3.19, which includes locations of water quality data points to illustrate major ion groundwater chemistry for samples taken from the Arckaringa Basin, non-artesian Eromanga Basin and artesian Eromanga (GAB) Basin.
Pumping commences

- **Figure 3.14**
  Regional potentiometric response to operation of the Prominent Hill mine water supply (source: OZ Minerals, 2009)

- **Figure 3.15**
  Locality plan for well hydrographs presented on Figure 3.14
Figure 3.16  Location of wells and GAB springs used for regional hydrogeochemical analysis
Figure 3.17
Comparison of TDS values for groundwater groups in the vicinity of the Billa Kalina springs
Figures 3.18 and 3.19 suggest four hydrogeochemical zones occur in the region:

1) The *artesian* Eromanga (GAB) Basin centred on Beautiful Valley.
2) The *artesian* Eromanga (GAB) Basin centred on Coward Springs.
3) The margins of the *artesian* Eromanga (GAB) and Arckaringa Basins, centred on the Billa Kalina spring group, including Margaret Creek and McEwin Bores, and the RMD1 monitoring well.
4) The Arckaringa Basin, west of Billa Kalina Fault system.
Figure 3.19  Piper plot presenting regional major ion data in detail

note:
The data for Mg, Ca and HCO₃ have been multiplied by a factor of ten to spread the data on the plot. A smaller plot without the factor has been attached for comparison.
RMD1 well was constructed into the Boorthanna near the margin of the artesian Eromanga (GAB) Basin. Scatter plots of major ions (Attachment C) show that RMD1 groundwater has a very different hydrogeochemical signature to many other waters in the region, including the Billa Kalina Spring group and Arckaringa Basin waters (particularly with regard to Na-Ca, Cl-HCO₃, Ca+Mg-Na, Cl-K, Cl-Ca/Cl), although the Piper plot (Figure 3.19) shows RMD1 groundwater plots with data from Billa Kalina Spring and, even, Coward Springs (considered to be derived from artesian Eromanga (GAB) Basin). This disparity is possibly the result of complex hydrogeochemical interactions occurring with the saturated zone, as described by Costelloe et al. (2010), that separates the Arckaringa-Stuart Shelf and artesian Eromanga (GAB) GFSs.

**Isotope analysis**

Age dating of groundwaters can be used to provide an indication of the residence time of groundwaters within aquifers, distinguish between different groundwater groups, or identify mixing of groundwaters of different ages. The ³⁶Cl isotope is useful in hydrogeological studies due to its radioactive decay properties (half life 3x10⁵ years), such that ³⁶Cl:Cl ratios can be used to compare ages of groundwaters up to two million years old. Older groundwaters have a lower ³⁶Cl:Cl ratio, and lower concentrations of ³⁶Cl (atoms per litre) than comparatively younger groundwaters.

Available ³⁶Cl concentrations in groundwater, presented in Table C.1 (Attachment C, with references) and Figure 3.20, show a marked contrast between groundwaters from the artesian Eromanga (GAB) aquifers and other regional aquifers.

In particular, the results show:

- southwestern artesian Eromanga (GAB) groundwaters have significantly lower ³⁶Cl concentrations compared to groundwaters in the other regional groundwater systems;
- Stuart Shelf and Adelaide Geosyncline groundwaters report notably elevated ³⁶Cl values, which likely indicate more recent recharge; and
- the ³⁶Cl signature of Yarra Wurta Springs discharge and groundwater in the Amberooona Formation (an Adelaide Geosyncline formation) are very similar, suggesting the spring discharge is sourced largely from east of the Torrens Fault and not from the Stuart Shelf aquifers (consistent with the conclusions of Schmid (1985) and Johns (1968) concerning other Lake Torrens Springs). See Section 6 for further discussion.
Figure 3.20

$^{36}$Cl concentrations in groundwater samples from regional groundwater systems
3.6. The potential for interaction between the artesian Eromanga (GAB) GFS and the Arckaringa-Stuart Shelf GFS

3.6.1. Overview

The potential for groundwater interaction between the Arckaringa-Stuart Shelf GFS and the GFS, which hosts the GAB springs, is a key question in the determination of the groundwater impact arising from the proposed OD expansion.

Sections 3.2 through 3.5 provide context for the following discussion concerning the potential for interaction between the artesian Eromanga (GAB) GFS and the Arckaringa–Stuart Shelf GFS.

3.6.2. Stuart Shelf and artesian Eromanga (GAB) Basin

The following presents a summary of the understanding developed from the various groundwater investigations undertaken to assess the hydrogeological setting of the OD region, including those presented in this report and by Kellet et al (1999):

- Low permeability rocks of the Adelaide Geosyncline within the intensely folded THZ separate the artesian Eromanga Basin and the Stuart Shelf.
- A groundwater divide aligned along the northern Stuart Shelf also separates the artesian Eromanga Basin and the Stuart Shelf groundwater systems. This divide is maintained by groundwater recharge.
- A regionally extensive groundwater discharge zone coincident with where the two GFSs converge separates the GFSs.
- Hydrogeochemical data, including $^{36}$Cl isotope data show that two distinctly different water qualities occur within the GFSs.

In addition to the above, numerical modeling (SWS, 2010) demonstrates there is no interaction between the two GFSs.

3.6.3. Arckaringa Basin and artesian Eromanga (GAB) Basin

Much evidence of groundwater potential and chemistry of the Arckaringa Basin was collected as part of extensive hydrogeological investigations that supported the environmental approvals for the Prominent Hill Mine (refer Figure 1.1 for location). The demonstration of a lack of connection between the Arckaringa Basin and the artesian Eromanga (GAB) Basin was crucial to gaining approvals for the Prominent Hill mine.

Well hydrographs in the area of interest show there are no groundwater pressure responses on the east side of the Billa Kalina fault system to operation of the Prominent Hill mine wellfield.
Groundwater chemistry and potentiometric surface data for monitoring well RMD1, in conjunction with other locations where similar types of data exist, provides a valuable insight into groundwater flow dynamics in the Billa Kalina Fault area. RMD1 reports an unusual hydrogeochemical signature that is neither artesian Eromanga (GAB) Basin nor Arckaringa Basin-proper. Significant geological structure and hydraulic boundaries (such as the regional-scale evaporative discharge zone) is the likely cause of this. The available data support the conclusion that there is no groundwater interaction of any significance (between any of the regional groundwater systems) across the Billa Kalina Fault system.

3.6.4. Summary

The conclusions arising from the above analysis of available information and data are:

- there is little interaction of any significance between the artesian Eromanga (GAB) groundwater system and the groundwater systems of the Stuart Shelf and Arckaringa Basin; and
- the proposed open cut mine development at OD is very unlikely to alter this situation.

These conclusions are consistent with those of Kellet et al (1999) and Howe et al (2008), i.e. there is little to no hydraulic connection between the artesian Eromanga (GAB) Basin and the Stuart Shelf/Arckaringa Basin groundwater systems.

Geological structure, principally in the form of the Torrens Hinge Zone (THZ), but also other complex faults systems, groundwater divides between GFSs, and convergence of groundwater flow systems at a regional-scale evaporative discharge zone provide the basis for this lack of hydraulic interaction.
4. Beneficial use categories of regional aquifers

State and federal legislation has set water quality guidelines for the protection of various beneficial uses or values (eg. ANZECC/ARMCANZ, 2000; SA EPA, 2003; Victorian EPA, 1997). Groundwaters can therefore be classified according to beneficial use, based on specific analytes.

In relation to groundwater salinity, as measured by total dissolved solids (TDS), the Stuart Shelf, Adelaide Geosyncline and Arckaringa Basin aquifers are generally not suitable for irrigation, stock or recreational use (Table 4.1).

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Number of wells</th>
<th>Mean TDS (mg/L)</th>
<th>Beneficial use[^1]</th>
<th>TDS (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Min</td>
</tr>
<tr>
<td>Stuart Shelf (ALA)</td>
<td>49</td>
<td>68,817</td>
<td>None</td>
<td>13,550</td>
</tr>
<tr>
<td>Stuart Shelf (THA)</td>
<td>22</td>
<td>61,607</td>
<td>None (R)[^2]</td>
<td>10,741</td>
</tr>
<tr>
<td>Adelaide Geosyncline (THZ)</td>
<td>6</td>
<td>100,433</td>
<td>None</td>
<td>28,500</td>
</tr>
<tr>
<td>Arckaringa Basin (Boorthanna Aquifer)</td>
<td>54</td>
<td>18,715</td>
<td>None (S, R)[^2]</td>
<td>5,800</td>
</tr>
<tr>
<td>Eromanga Basin – non-Artesian shallow aquifer</td>
<td>24</td>
<td>11,372</td>
<td>S, R (I, None)[^2]</td>
<td>1,484</td>
</tr>
<tr>
<td>GAB wells</td>
<td>16</td>
<td>4,709</td>
<td>S, R (I)[^2]</td>
<td>2,262</td>
</tr>
</tbody>
</table>

[^1]: Beneficial uses:
- I. Irrigation for agriculture, parks and gardens (limit = 3,500 mg/L; Vic EPA 1997)
- S. Stock watering (limit = 10,000 mg/L for sheep without loss of production; ANZECC/ARMCANZ, 2000)
- R. Recreation (limit = 13,000 mg/L; Vic EPA, 1997)

[^2]: In localised parts of aquifer system (as indicated by specific wells)

In contrast, the lower salinities of the Eromanga Basin groundwaters, particularly in the GAB, generally permit stock and recreational use. In localised areas, there is even potential to use water from these aquifers for irrigation.
5. Water sampling protocols

5.1. Introduction

Samples of groundwater were collected from wells constructed as part of the OD expansion studies under the supervision of an SKM hydrogeologist. The samples were collected upon completion of drilling, construction and development. The samples were submitted to a NATA-registered laboratory for analysis of a range of analytes including total suspended solids (TSS).

In some cases the reported TSS value was very high, and some in the regulatory community suggested this was an indication that the collected samples would not be representative of in-situ groundwater quality.

The following section details the method of sampling undertaken and concludes that sample analysis is representative of in-situ groundwater chemistry.

5.2. Methodology of sample collection and laboratory analysis for groundwater quality

5.2.1. Standard procedure

Groundwater sampling involved removal of at least three wet bore volumes of water from the sampled well prior to sample collection, consistent with procedures outlined in NEPC (1999).

Groundwater samples were taken at the completion of well development or at the end of pumping tests. Boreholes were pumped by airlift typically for 1 to 2 hours, during which time some 5,000 to 20,000 L of water were removed from the aquifer (and in the case of 24 to 48 hour pumping tests, considerably more). These volumes were typically 20 to 30 times the wet bore volumes. During the development or testing works, EC and pH were measured to determine that these parameters were stable before samples were taken.

5.2.2. OD expansion drilling and testing programs

Each of the ‘new wells’ was drilled using conventional air-hammer techniques, whereby cuttings were lifted from the hole and penetration gained with the use of pressurised air and, in cases of low airlift yield, biodegradable drilling foam. Muds and chemicals were not used at any of the ‘new well’ sites.

Well completions ranged from placement of screens alongside the main aquifer production zone(s) (in observation wells completed as part of the regional EIS, saline water supply and mine pit dewatering/depressurisation trial programs) or open hole (test production wells completed for saline water supply and managed aquifer recharge programs).
After the completion of drilling and well construction, each well was developed using pressurised air with the airline set above the screened interval, typically around 50 m below the standing water level (SWL). Prior to collection of water samples, each well was developed clean of cuttings and foam (where used), following which the quality of water lifted from the well was field tested every five to ten minutes for a minimum of an hour or until three consecutive readings stabilised to within 10% of previous readings. During this time, more than three wet bore volumes were removed from the well. Throughout the drilling programs, additional samples were also collected (SKM, 2010):

- during drilling; from the upper and lower sections of the ALA or other encountered geological units;
- using disposable bailers at least 3 days post-completion of drilling and airlifting; and/or
- during extended pumping tests.

Collected samples were filtered in the field for analysis of dissolved metals, but were not field filtered for analysis of pH, electrical conductivity (EC), total dissolved solids (TDS), TSS, turbidity, alkalinity, major ions and other analytes. The samples were collected into laboratory prepared containers, stored on ice and submitted to ALS Environmental Pty Ltd (ALS) for testing, under standard chain of custody arrangements and within holding times specified for each tested analyte.

5.3. Reported TSS results

Analytical results of TSS measured in groundwater samples collected from wells constructed as part of the works conducted by SKM are presented as Attachment D.

In cases where multiple samples were collected from a well, the last sample collected at the end of development is considered to be most representative of in-situ groundwater and the samples collected during the drilling of a well are considered less representative. On occasions, where production wells were pumped for extended periods of time, samples collected after pumping are considered most representative of in-situ groundwater.

Attachment D displays the TSS results of wells that were sampled multiple times during drilling, development and testing:

- Wells drilled as part of Motherwell Extension (MXT nomenclature) reported TSS value up to two orders of magnitude higher when sampled during drilling than the equivalent airlift and bailed samples.
Samples collected from production wells drilled for saline water supply (TPW nomenclature) and managed aquifer recharge (MAR nomenclature) studies report relatively similar TSS values after airlifting as after pumping.

The airlifted sample collected from RT-2a reports a TSS value relatively similar to that of a sample taken during drilling, whereas the reported value for the PT-6 sample is significantly higher during drilling.

A sample collected from PT-5a at completion of drilling reported a significantly higher TSS value compared to the sample collected after construction.

The observations outlined above and presented in Table 4.2 are consistent with the method of sample collection and well completion, that is:

- airlifted samples would be expected to result in higher reported TSS values than for bailed or pumped samples; and
- samples collected from openhole completions would be expected to result in higher reported TSS values than for those from wells constructed with screens.

![Figure 4.1 Reported TSS values for Stuart Shelf groundwater samples vs. method of collection](image-url)
5.4. Discussion

Significantly higher reported TSS values have been reported for water samples collected on airlift pumping, either during drilling or following well construction, than for those samples collected using pumping or bailing. Similarly, higher reported TSS values have been reported for water samples collected from openhole completions than for constructed wells.

The extended development of all new wells was considered more than adequate to provide a representative groundwater sample. However, the process of airlifting, particularly within open holes, often resulted in sampled water containing suspended solids. Figure 4.1 presents the distribution of TSS values for different methods of sample collection.
6. Lake Torrens brine

6.1. Lake Torrens physical setting

As has been documented in the project baseline groundwater studies (Appendix K1, Draft EIS) the available data strongly suggest that the ALA and THA of the Stuart Shelf discharge to the margins of the major regional salt lake (Lake Torrens), which is identified as a groundwater-dominated playa (Schmid, 1985).

The lake is underlain by more than 200 m of Tertiary to Recent sediments, including sands and clays that have been laid down within a Cainozoic graben (Schmid, 1985; Johns, 1968). The graben is bounded to the west by north-south trending step faults that are likely coincident with the Torrens Fault that bounds the THZ (Risley, 1963; Schmid, 1985). A number of springs aligned along the axis of the lake and the Torrens Fault are driven by artesian pressures hosted by aquifers at the base of the lake sediments. Groundwater is released from these deep aquifers via fractures within the Cainozoic infill (Johns, 1968). Mountford Springs and other springs, located approximately in the mid-point of the lake, have similarities to typical GAB springs, in terms of driving mechanisms. The springs are sustained by groundwater discharge from the east (Johns, 1968).

The description of Mountford Springs by Johns (1968) bears similarity to Yarra Wurta Springs located at the north end of Lake Torrens (Figure 6.1), i.e. cauliflower-form gypsum precipitation, and it is considered possible that the saline Yarra Wurta Springs are sustained in the same way as these other Lake Torrens springs.

The lake sediments gradually shallow to the east from the step faults that are associated with the Torrens Fault, and are saturated with brine (greater than 100,000 mg/L TDS) to depths of around 60 m, below which hypersaline groundwater (30,000 to 70,000 mg/L TDS) resides (Johns, 1968).

Schmid (1985) concluded that the majority of the brine within Lake Torrens sediments is sourced from groundwater moving from the east (i.e. from the western flanks of the Flinders Ranges), and that groundwater contributions from the west are negligible. This conclusion is endorsed by the authors of this report and Golder (2010).

6.2. Conceptualisation of Lake Torrens brine processes

A number of exhaustive studies around Australia and internationally have helped improve the conceptual understanding of variable density flows in aquifers discharging to salinas (see Schmid, 1985; Macumber, 1991; Holzbecher, 2005; Field et al, 2008).
Consistent with the observations further south (Schmid, 1985; Johns, 1968), nineteen groundwater wells installed within several kilometres of the lake’s northerly extent, and others further west of the Lake, have encountered a salinity interface (halocline), above which saline groundwater typical of the regional aquifers occurs and below which brine emanating from Lake Torrens occurs.

Figure 6.2 presents a conceptual diagram of brine formation and circulation beneath a groundwater dominated playa. Brines produced by the evaporative concentration of salts in groundwater (or even surface water when it occurs) will sink as a consequence of higher density (so called “reflux” brines) and progressively extend outwards from salt lakes, displacing and mixing with ambient groundwaters. Over long timescales (i.e. tens of thousands of years, Nield et al. 2008), the interface between the lower salinity regional groundwater and the brines takes on a ‘wedge’ like appearance, similar to haloclines found in coastal regions. Regional flows of lower salinity groundwater towards these lakes are effectively forced upwards above the brine interface to discharge at the surface, and then lost by evaporation in the case of Lake Torrens.

Hydraulic head data and salinity profiles collected in 49 groundwater wells installed in the vicinity of Lake Torrens have been used to characterise groundwater flow patterns and demonstrate the existence of a large body of brine extending into the base of the ALA to the west and north of the northern part of the lake.
The extent of the brine from Lake Torrens is partly controlled by the rate at which brine can be formed, which in turn is related to the discharge rate from contributing groundwater flow systems. It is likely that brines continue to accumulate below the lake and extend away from the lake. By comparison, salt-water wedges at coasts have infinite sources of saline water to intrude coastal aquifers, and are entirely controlled by hydrogeological conditions.

It is crucial that hydraulic head data collected in the field is interpreted in light of the variable groundwater densities. Traditionally, hydraulic heads \( h_i \) are ‘corrected’ by converting them to equivalent freshwater heads \( h_{f,i} \) using equation 1. Figure 6.3 presents the concept.

\[
h_{f,i} = \frac{\rho_i}{\rho_f} h_i - \frac{\rho_i - \rho_f}{\rho_f} z_i
\]

(Eq.1)

In certain analyses of groundwater flow patterns in variable density groundwater flow systems, this approach can nevertheless produce erroneous results. Vertical flows cannot be evaluated solely by freshwater heads as the buoyancy effect produced by the density contrast also needs to be considered. Additionally, in evaluating horizontal flows using data from wells screened at different depths, it should be noted that freshwater heads may vary with depth even for hydrostatic conditions.

Both these considerations apply to the ALA in the vicinity of Lake Torrens, where salinities vary from 20,000 to 260,000 mg/L, and where well screen levels are up to 200 m different in elevation.
Post et al (2007) has outlined more reliable methods for density correction. Where horizontal flow components are evaluated for piezometers screened at different depths, ‘normalised’ freshwater heads \( h_{i,r} \) need to be calculated with respect to a suitable reference depth \( z_i \) using equation 2. (below). The average water density between measurement point \( z_i \) and the reference level \( z_r \) is denoted \( \rho_a \), and is often poorly defined, thereby introducing a degree of uncertainty into the magnitude of the horizontal flow component.

\[
h_{i,r} = z_r + \frac{\rho_i}{\rho_f} (h_i - z_i) - \frac{\rho_a}{\rho_f} (z_r - z_i)
\]

(Eq.2)

As defined by equation 3 (below), the vertical flow component, \( q_z \), needs to consider the vertical equivalent freshwater head gradient \( \Delta h_f / \Delta z \) as well as the buoyancy effect produced by the relative density contrast \( \rho_a / \rho_f \). Without the buoyancy term, nested piezometers in an aquifer under hydrostatic conditions will mistakenly indicate that there are head differences that could cause vertical flows.

\[
q_z = - K_f \left[ \frac{\Delta h_f}{\Delta z} + \left( \frac{\rho_a}{\rho_f} \right) \right]
\]

(Eq.3)
6.3. Analysis of density corrected heads for the ALA

6.3.1. Lateral flow component

In order to assess the horizontal component of groundwater flow patterns in the ALA, measured hydraulic heads have been converted to equivalent freshwater heads for the upper and lower sections of the aquifer and normalised at specific reference levels to account for the different screen elevations in a variable density groundwater flow system.

The upper ALA corresponds with lower salinity groundwater (typically less than 40,000 mg/L TDS) and the lower ALA with brines (up to 250,000 mg/L), a mixing zone and, to the west of the system, with lower salinity groundwater. As shown in Figure 6.4, reference levels \( z_r \) of 30 and -50 mAHDI have been used to adjust levels in the upper and lower monitoring wells, respectively. While the use of reference levels normalises the measurements, it also introduces a level of uncertainty, due to the need to estimate the average groundwater density between the screened level and the reference point.

The reference level \( z_r \) for the upper ALA piezometers has been set near to the average mid-point of all well screens in this network, and it is assumed that \( \rho_a \) is equal to \( \rho_i \). This is a reasonable assumption considering that the groundwater salinities in the upper section of the network are reasonably consistent (as shown by EC measurements taken during drilling; refer SKM, 2010).

The reference level for the lower ALA has been set at the lowest possible point without descending below the base of the aquifer. Based on EC measurements taken during drilling, the density profile between \( z_i \) and \( z_r \) is characterised by a zone of sharp rise in density corresponding to the mixing zone between saline groundwater and underlying brine (Figure 6.5). Where the transition zone \( z_b \) occurs halfway between \( z_i \) and \( z_r \), the average density, \( \rho_a \), is directly related to the location of the centre of the transition zone \( z_b \) and is defined by equation 4 below, where \( \rho_i \) and \( \rho_r \) are assumed to be representative of conditions below and above the interface respectively. This assumption is reasonable considering the measured EC profiles in Figure 6.5. It should be noted that the salinity profile constructed from the EC measurements taken during drilling is likely to be skewed by previous groundwater inflows within the open drill hole. This introduces a level of uncertainty into the location of the transition zone, and therefore into \( \rho_a \). The error margin in the calculation of \( h_{cr} \) is therefore estimated by taking the location of \( z_i \) to be ±20%, which is a reasonable arbitrary value based on the salinity profiles observed during drilling (Figure 6.5 and SKM, 2010).

\[
\rho_a = \rho_i \times \frac{z_b - z_i}{z_r - z_i} + \rho_r \times \frac{z_r - z_b}{z_r - z_i}
\]  

(Eq. 4)
The converted head data are presented in Attachment A.
Figure 6.4  a) Groundwater wells used to evaluate the lateral component of groundwater flow in the upper ALA
Figure 6.4 b) Groundwater wells used to evaluate the lateral component of groundwater flow in the lower ALA
Figure 6.5 Interpreted salinity profile in selected wells near northern end of Lake Torrens
The interpreted contours in the upper system (Figure 3.2) indicate groundwater movement is moving west through the ALA toward the northern end of Lake Torrens. The hydraulic gradient lessens significantly through the central and eastern sections of the ALA and ranges from $3 \times 10^{-3}$ to $9 \times 10^{-3}$, corresponding with increased aquifer hydraulic conductivity as documented by pumping tests carried out at three sites in this area (MAR2, MAR3 and MAR4; SKM, 2010) and high airlift yields in other wells (e.g. greater than 20 L/s in PT40, PT42, PT44, PT48, PT51; SKM, 2010).

The lower system is characterised by corrected hydraulic gradients in a similar range to the overlying system (Figure 3.6). In contrast to the upper part of the aquifer, however, within 20 km of the northern end of Lake Torrens, groundwater in the base of the ALA flows northwestward away from the playa toward the central portion of the ALA where drilling investigations show the base of the Andamooka Limestone is deeper than elsewhere on the Stuart Shelf.

### 6.3.2. Vertical flow component

Attachment A presents corrected hydraulic heads and vertical gradients for the ALA at various nested groundwater monitoring sites. The data show the lower and upper ALA to be close to hydrostatic at most sites, indicating limited vertical movement within the aquifer. The directions of the vertical hydraulic gradients (Figure 3.5) are downward over the western section of the ALA and upward in four of the five sites located near to the northern end of Lake Torrens. The area of upward hydraulic gradients coincide with the ‘trough’ in normalised freshwater heads within the lower ALA (Figure 3.6), suggesting that there is potential for upwelling of brines and mixing with lower salinity groundwater.

### 6.3.3. Summary of flow directions in ALA

The conceptual hydrostratigraphic cross-section schematic presented as Figure 3.7 shows brines ‘filling’ the deepest sections of the ALA and extending westward up to 50 km from Lake Torrens. The location of the interface between saline waters and brine has been estimated from EC measurements made during drilling. At a distance of roughly more than 15 km from Lake Torrens, the interface appears to have a low gradient indicating a stable density stratified system. The interface is higher within the ALA closer to Lake Torrens. Saline groundwater moving towards the discharge zone is effectively forced upward by the density difference, as discussed earlier, and a thicker mixing zone develops. RT5a, located within a few kilometres of Lake Torrens, is screened at the top of the ALA and shows high salinity levels (TDS greater than 50,000 mg/L).
The level of uncertainty in calculating equivalent heads in the lower system indicates the flow system may be sensitive to variations in groundwater density.

The cross-section presented as Figure 3.7 illustrates how the saline ALA flow system reduces significantly in thickness whilst moving eastward towards Lake Torrens (i.e. a reduction in effective transmissivity). The aquifer is 80 to 100 m thick west of MXTB14, but is effectively less than 20 to 40 m thick within about 20 km of Lake Torrens as lateral groundwater flows towards the lake are constrained between the brine interface and the overlying lower permeability shale formations.

### 6.4. Inferred brine response to upper-ALA drawdowns

Water affecting activities associated with the proposed expansion of the Olympic Dam mine have the potential to cause drawdown in the regional ALA. The existence of brine at the base of some (deeper) parts of the ALA means there is the potential to displace brine upwards if water table drawdowns occur in those parts of the ALA that have a profile of upper groundwater of low salinity (and density) overlying deep brine of higher density.

It is possible to estimate the elevation of the brine interface using equation 4, whilst adopting the simplifying assumption that the system is hydrostatic (i.e. there is no vertical transfer of water within the groundwater system). As shown in Table 6.1, the brine interface predicted in this manner is similar to the observed salinity profile at several of the drill-sites (see Figures 6.4 and 6.5), suggesting the corrected freshwater heads are broadly representative of conditions in the upper and lower parts of the ALA at these sites. However, it is possible that the groundwater flow system is still evolving towards a state of equilibrium because predicted interface levels are higher than the observed interface.

#### Table 6.1 Predicted brine interface elevations (m AHD)

<table>
<thead>
<tr>
<th>Location (well)</th>
<th>Observed</th>
<th>Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT66</td>
<td>-129</td>
<td>-60</td>
</tr>
<tr>
<td>MAR3</td>
<td>-94</td>
<td>-85</td>
</tr>
<tr>
<td>MAR2-50</td>
<td>-80</td>
<td>-54</td>
</tr>
<tr>
<td>RT5</td>
<td>-80</td>
<td>-56</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drawdown (m)</th>
<th>1</th>
<th>2</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7</td>
<td>11</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>15</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>15</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>13</td>
<td>33</td>
</tr>
</tbody>
</table>
When the hydraulic heads in the upper part of the aquifer are lowered because of drawdown, in this instance either associated with groundwater pumping or the long term effects of drainage of groundwater (with evaporative discharge) into the pit void, a new brine interface equilibrium can be estimated (assuming an unlimited source of brines). Table 6.1 and Figure 6.6 present estimated increases in brine interface elevations for a range of drawdowns at selected ALA locations (Figure 6.7).

Figure 6.6 illustrates the upward movement of a brine interface that typically occurs when pumping from the groundwater above such an interface. The phenomenon is sometimes referred to as “upconing”.

The final pit void at Olympic Dam will be a long-term regional groundwater sink located some tens of kilometres from the area within which the brine interface has been demonstrated to occur. The groundwater that will drain into the pit and evaporate will almost all come directly from the THA, which underlies the ALA. The final pit void is located in an area where the base of the ALA is close to or above the regional water table.
Figure 6.7
Locality plan for brine interface displacement calculations
It is anticipated, therefore, that even if drainage to the final pit void causes a measurable drawdown in the ALA in the area of brine occurrence, the brine interface will not rise because the effect of the drainage into the final pit void will be to underdrain the ALA. That is, drawdown will develop in the ALA because of leakage downward from the ALA in response to the lowered heads in the THA beneath the brine rather than because of withdrawals from the upper ALA above the brine.
7. Groundwater impact assessment

7.1. Introduction

To understand the level of potential impact posed to groundwater systems as a result of mine development, it is necessary to consider how operations such as dewatering, supply development, and tailings management might change the ‘natural’ groundwater regime and so impact upon groundwater systems and potential users of groundwater.

Direct groundwater effects of mining operations relate to the physical impacts of mine water affecting activities on groundwater systems. Four categories of direct effects have been identified by Brereton et al (2008), they are:

- **Groundwater quantity;**
  includes consideration of changes to groundwater levels / pressures and flux through systems under consideration.

- **Groundwater quality;**
  includes consideration of salinity and concentrations of other important water quality constituents (such as metals, pH, nutrients and radionuclides).

- **Groundwater – surface water interaction;**
  includes consideration of changes to the level of interaction between groundwater and surface water systems (such as stream baseflow and evaporative losses from saline lake systems).

- **Physical disruption of aquifers;**
  includes consideration of whether or not there will be permanent disruption of a groundwater system by mining, and to what extent.

Indirect effects relate to groundwater receptor response to the combined direct effects. The term receptor is used here to include environmental, social and economic users of groundwater resources. Examples of typical groundwater receptors that may be impacted by a mining operation include:

- **Environmental;**
  groundwater dependent ecosystems such as aquatic ecosystems that are maintained to some extent by baseflow, and terrestrial vegetation that utilises groundwater to meet some or all of its water requirements.

- **Economic;**
  agricultural enterprises that rely on groundwater for irrigation or stock watering, and other mining operations that utilise groundwater to meet all or some of their mine water requirements.
- Social
  includes recreational use of water resources, as well as urban and rural water supply.

Groundwater impact (threat) assessments for mining operations need to consider both the direct and receptor effects of a mining operation on local to regional scale groundwater systems within a regional context (Figure 7.1). For a threat to emerge there needs to be an exposure pathway linking direct effects with receptors.

- Figure 7.1 Groundwater impact assessment framework (after Howe et al., 2010)

A brief summary of each of the four key steps of the groundwater impact assessment is provided here:

- Context setting
  Involves placing the mining proposal into a regional context, eg. interactions between groundwater flow systems, climatic factors and preliminary identification of potential groundwater receptors (environment, social, economic) that might be impacted adversely by mine development within a region.

- Groundwater effects assessment
  Comprises identification of ‘direct effects’ to the groundwater system arising from mine water affecting activities.

- Exposure assessment
  Involves developing an understanding of the receiving environment that will potentially be altered by direct effects, and clearly identifying those receptors that are exposed to these effects.

- Threat assessment
  Involves an assessment of the degree to which direct effects will impact on receptors, both spatially and temporally.
7.2. Olympic Dam groundwater affecting activities

7.2.1. Overview

The following provides an overview of the Olympic Dam water affecting activities. Each of these has been discussed in more detail in the Draft EIS and accompanying appendices, but is again presented here for contextual reasons.

The existing Olympic Dam (OD) operation comprises an underground mine and associated infrastructure. The proposed expansion will comprise of both an underground and open cut mine, and associated infrastructure.

Table 7.1 presents a comparison of the current and proposed operation in terms of activities having the potential to impact on groundwater (groundwater affecting activities), with a focus on those activities described in the Draft EIS for the proposed expansion, that is:

- the mine void;
- dewatering requirements;
- rock and tailings storage facilities; and
- saline water supply wellfields.

As noted in Table 7.1, water affecting activities associated with the proposed expansion that do not exist for the existing operation include the mine pit, rock storage facility and off-SML water supply wellfields.

7.2.2. Mine void

As discussed at length in the Draft EIS and associated appendices, post-mining, the underground workings will fill over a period of time and the mine pit void will act as an evaporative sink to the regional groundwater system such that a pit lake post-mining will have a maximum elevation around 650 m below ground level, that is more than 550 m below the pre-mine water table (refer Chapter 11, Chapter 12 and Appendix J2 of the Draft EIS).
Table 7.1 Comparison of existing and proposed future groundwater affecting activities

<table>
<thead>
<tr>
<th>Water affecting activity</th>
<th>Existing</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mine workings</td>
<td>☑ (underground)</td>
<td>☑ (combined underground and open cut)</td>
</tr>
<tr>
<td>Tailings storages</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Rock storages</td>
<td>-</td>
<td>☑</td>
</tr>
<tr>
<td>Water storages</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>SML saline water supply wellfields [2]</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Stuart Shelf saline water supply wellfields [3]</td>
<td>-</td>
<td>☑</td>
</tr>
</tbody>
</table>

Notes:
1. GAB Wellfields are not included in this analysis because (i) they will continue to operate under existing licences and therefore do not form part of the expansion project EIS, and (ii) there is a demonstrated lack of direct hydraulic connection between the Stuart Shelf and artesian Eromanga (GAB) GFSs (see Section 2).
2. Includes dedicated water supply wells as well as proposed future dewatering wells and expanded saline water supply wellfields (SML).
3. Andamooka Limestone aquifer (ALA).

7.2.3. Groundwater abstractions

Depressurisation

In the vicinity of the mine site, the THA has responded to drainage into the underground workings by a number of raise bores constructed to intersect the underground workings, operation of the Saltwater Wellfield, and leakage through the Tregolana Shale under vertical hydraulic gradients established as a result of drainage of the basement rocks. Appendix K of the Draft EIS notes that raise bores, alone, have drained, on average, at rates between 14 and 24 L/s from the THA since 1984. Figure 2.3 presents interpreted March 2009 groundwater elevations, showing a cone of depression within the THA centred on the underground workings as a result of drainage through the vent raises and minor groundwater withdrawals.

The proposed expansion includes open cut mining methods and dewatering requirements to ensure safe and efficient mining. Pumping rates are expected to be around 40 L/sec in the long-term (Douglas et al, 2009).

The low permeability rocks underlying the THA will also be depressurised through the use of in-pit sumps and horizontal drain holes.
Saline water supplies - SML

Wellfields will be operated on the SML to supplement the supplies drawn from mine dewatering, to meet mine and process water requirements. One of these wellfields will be located to the southwest of the mine pit, near the Mining and Metallurgical Infrastructure Area (MMIA), and the other to the east of the mine pit near the proposed new location of the Roxby Downs airport. Abstractions from these wellfields could total up to 5 ML/day.

The effect of the SML sourced saline water supply will assist in dewatering of the Tent Hill aquifer (THA) and so assist in mine pit depressurisation. The existing cone of depression within the THA arising from underground mining operations is expected to expand as a result of these new (expanded) abstractions. The extent of influence of these wellfields on the groundwater system will be constrained by geological structure, as well as the hydraulic conductivity and storativity of the different hydrostratigraphic units, but locally large drawdowns relative to the zone of influence of the mine itself can be expected due to typically low to moderate hydraulic conductivities.

On decommissioning of the wellfields, it could be expected that some recovery of groundwater levels/pressures will occur. The extent to which this recovery occurs will, however, be dependent on the influence imposed on the local to regional-scale groundwater system by the drainage of groundwater into the decommissioned mine pit.

Saline water supplies - ALA

The primary saline water supply to be developed for the OD construction period is proposed to be sourced from the ALA to the north of the SML. The ‘Motherwell’ wellfield, which is proposed to be located to the north of the SML, is anticipated to provide supplies ranging between 15 and 25 ML/day, peaking at 28 ML/d. At this stage, it is proposed to operate the Motherwell Wellfield for the construction and pre-mine phase only.

The ALA is a highly transmissive aquifer. Groundwater supply development will likely result in limited drawdown relative to the zone of influence. Groundwater level recovery following decommissioning of the wellfield will likely be slow given the large abstraction rates in comparison to low recharge rates (rainfall and throughflow from the Arckaringa Basin groundwater system to the west). It is likely, though, that the mine will impose a greater influence than the Motherwell Wellfield on the ALA in the long-term (post-closure).

Summary

At the end of mining (50 years), drawdowns of around 1 m are predicted for the ALA 5 km north of the SML (SWS, 2010). Operation of the Motherwell wellfield is predicted to result in around 2 to 4 m of drawdown outside the footprint of the wellfield, but water level recovery will occur following decommissioning of this supply in 2017 (SWS, 2010).
7.2.4. **Rock storages**

Background recharge rates in the OD region are very low, much less than 0.1% (less than 0.5 mm/yr).

However, the quarrying of the mine pit and subsequent placement of overburden and other rock materials within the RSF (Rock Storage Facility) will provide a surface with different hydraulic properties from the natural ground. The RSF materials will have greater porosity (effective as well as total) and permeability than those of the undisturbed material. It is possible that there will be an increase in rainfall recharge rates over the RSF footprint via preferential flow paths, the rate perhaps ranging between 1 and 5% of average rainfall (i.e. 2 to 10 mm/yr; SRK, 2010a). These higher recharge rates near to the mine pit will serve to offset the impact of mine pit evaporative losses (post-mining) on regional groundwater levels, in particular those of the ALA.

However, RSF design, water management, trafficking and closure design will help to militate against these higher levels of recharge that may be experienced in the post-closure period.

Recharge over the RSF footprint is unlikely to be significant at the regional-scale, other than reducing the zone of mine pit influence on the groundwater system during and post-mining (SWS, 2010).

7.2.5. **Tailings storages**

Whilst tailings thickening and engineered design will serve to minimise seepage from the TSF, successive tailings lifts will effectively increase the driving head on seepage outside the lined decant area. Seepage rates could range up to those levels observed for the latter cells of the existing TSF (i.e. around 30 mm/yr; SRK, 2010b).

At cessation of mining, it is proposed to cap the TSF to effectively reduce seepage rates back to around background rainfall recharge rates that occur in the OD region (around 0.1 mm/yr; SRK, 2010b).

Tailings seepage will result in the mounding of groundwater within the ALA, as is already observed to be occurring. Geochemical assessments presented as Appendix F5 of the SEIS and in the Draft EIS (Appendix K4) demonstrate the effectiveness of the materials underlying the TSF and RSF to neutralise seepage and aid in the sorption and co-precipitation of seepage constituents. However, some residual groundwater quality change is expected due to tailings percolate reaching the water table aquifer (ALA).
7.3. **Receptor identification**

7.3.1. **Study area definition**

The Study Area for the impact assessment is consistent with the geological Stuart Shelf and encompasses the likely hydrogeological interactions with other groundwater systems (e.g. the Torrens Basin, the Arckaringa Basin, and the *artesian* (GAB) and *non-artesian* Eromanga Basin).

7.3.2. **Potential receptors**

*Environmental*

**GAB Springs**

*Artesian* Eromanga (GAB) aquifers support the ecologically significant GAB Springs. On the basis of the information presented in this document as well as the Draft EIS and supporting appendices, in particular the observation that a groundwater divide separates the Arckaringa-Stuart Shelf GFS from the Hinge Zone GFS and, ultimately the *artesian* Eromanga (GAB) GFS, it is concluded that the Springs will not be impacted by groundwater affecting activities associated with the proposed expansion of OD.

**Lake Torrens Springs**

A number of hypersaline springs / seeps are located around Lake Torrens, many of them hypersaline.

The Yarra Wurta Springs are located at the northern end of Lake Torrens (Figure 8.2) and occur within the THZ, where the ALA is underlain by Adelaide Geosyncline rocks. The pools at these springs support bacterial mats, filamentous green algae and the Lake Eyre Hardyhead fish, which does not have a conservation significance listing. However, Yarra Wurta Springs is one of few known refuge populations that exist within the Lake Torrens surface water catchment.

Studies of the flora and fauna of the Yarra Wurta Springs conducted as part of the Draft EIS established there are no species afforded additional protection under Commonwealth or State legislation inhabiting the area that have a dependence on the hypersaline springs.

Located at the northern end of Lake Torrens, Yarra Wurta Spring occurs where regional groundwater flow lines converge from west, north and east (Figure 3.4). However, there is evidence to suggest the springs are primarily supported by groundwater originating from northeast and/or east of Lake Torrens, discharging along regional geological structures controlled by the Torrens Fault (refer Section 6 and Golder, 2010).
Work undertaken by Johns (1968) and Schmid (1985) suggest that the Lake Torrens springs are supported by groundwater moving into the lake sediments from the east (i.e. from the western flanks of the Flinders Ranges). This conclusion is supported by $^{36}\text{Cl}$ isotope data (Section 2.4.4). The hydrological and structural geological setting of Lake Torrens appears to control the presence of Yarra Wurta Springs, thereby mitigating against any adverse effects associated with any drawdown impacts imposed on the ALA as a result of the proposed expansion of OD.

![Figure 7.2 Locality plan for potential receptors](image-url)
Freshwater swamps

A number of ‘freshwater’ swamps, including Bamboo Swamp, are located between 50 and 100 km west-northwest of the northern extent of Lake Torrens (Figure 8.2). The ‘swamps’ are terminal drainage features of Millers Creek and become inundated following rainfall events that are large enough to result in large runoff volumes.

The depth to water table beneath these ‘swamps’ exceeds 30 m and, as a result, any (riparian) vegetation fringing them is expected to utilise soil water and are unlikely to demonstrate any form of groundwater dependence.

Terminal drainage features of the Arcoona Plateau

A number of terminal drainage features occur on the Stuart Shelf, for example Coorlay Lagoon and Canegrass Swamp (Figure 8.2). Coorlay Lagoon is located approximately 30 km south of OD and is a terminal lake for a number of watercourses that drain the Arcoona Plateau to the south. The water table at this location occurs within the Arcoona aquitard and lies very close to the ground surface (probably less than 5 m in some areas depending on topography). Fringing riparian vegetation to the lagoon reportedly includes *Melaleuca* sp.

Coorlay Lagoon fills after major storms and runoff, and then slowly empties. The lack of salt on its bed suggests the lagoon is disconnected from the groundwater system except as an intermittent source of infiltration.

Judging from groundwater salinity within the Arcoona aquitard, typically being greater than 50,000 mg/L, it is considered very unlikely that riparian vegetation surrounding Coorlay Lagoon relies on regional groundwater at all. The fact that most occurrences of *Melaleuca* are saplings of fairly uniform age with a few occurrences of mature trees, supports the conclusion that the fringing vegetation to Coorlay Lagoon is dependent on occasional surface water inundation of the lagoon following significant rainfall runoff events to provide for environmental water requirements.

Canegrass Swamp is an ephemeral freshwater swamp located approximately 35 km north of OD (Figure 8.2) where the depth to groundwater is probably tens of metres. It is considered very unlikely that any ecosystems associated with this drainage feature demonstrate any form of groundwater dependence because of the depth to the water table and high groundwater salinity.

Terrestrial vegetation

The dominant terrestrial vegetation communities around OD are:

- chenopod shrubland; and
- acacia woodlands with an understory of chenopod shrubs.

The observed depth to, and salinity of, groundwater around OD (typically greater than 50 m and 50,000 mg/L, respectively) strongly suggest that these vegetation communities and associated ecosystems are not reliant on groundwater. There is no evidence that the lowered groundwater in the area around the existing mine has had any effects on vegetation.

**Economic**

**Pastoralists**

Stockwater supplies on pastoral stations on the Stuart Shelf are typically reliant on rainfall runoff into dams. Groundwater is rarely relied upon for these types of water supplies primarily because salinity concentrations exceed what can safely be used by humans and stock without some form of treatment.

Figure 8.3 presents a plan showing the locations of wells that are known to provide stockwater supplies. Seven of these are located on pastoral leases held by BHP Billiton (Andamooka, Purple Downs and Roxby Downs), four are located on Parakylia and three are located on Parakylia South. Comparison of water quality data (salinity) and well completion depths for these wells (refer Draft EIS, Appendix K2) against the results of various groundwater investigations undertaken by BHP Billiton (SKM, 2010) indicates the pastoral wells do not draw on the regional aquifers (THA or ALA). For example, Comet Well to the west of the SML (Figure 2.1) reports groundwater salinity of around 2,200 mg/L and a completion depth of around 29 m (Draft EIS, Appendix K2), whereas ALA investigation well MXTB09 (Figure 2.1) reports groundwater salinity in excess of 50,000 mg/L and a standing water level of 48 m (SKM, 2010, Attachment D.2).

It is reasonably concluded, then, that these wells draw water from lenses of groundwater perched above the regional aquifers, most likely from sandy lenses within the Bulldog Shale.

**Other miners**

The Stuart Shelf and broader Gawler Craton geological provinces are subject to growing mineral exploration activities. However, apart from OD the only other mining operation in production or under development within 200 km and within the Stuart Shelf groundwater catchment is the Prominent Hill mine. The mine water supply for the Prominent Hill mine is sourced from the southeastern portion of the Arckaringa Basin’s Boorthanna aquifer.
Figure 7.3  Pastoral lease locality plan
Oil & gas

Oil and gas exploration and production activities take place some 300 km to the northeast of OD in the Cooper Basin, a part of the artesian Eromanga (GAB) GFS. No impact on these receptors will occur.

On the basis of information presented above, Table 7.2 presents a summary of the groundwater dependence status of the possible receptors identified within the OD Study Area.

- **Table 7.2 Likely groundwater receptors for OD expansion impact assessment**

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Groundwater dependent</th>
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<tr>
<td>Bamboo Swamp</td>
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<tr>
<td>Canegrass Swamp</td>
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<tr>
<td>Terrestrial vegetation</td>
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</tr>
<tr>
<td>Coorlay Lagoon</td>
<td>□</td>
</tr>
<tr>
<td>Yarra Wurta Springs</td>
<td>✔</td>
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<tr>
<td>Pastoral water supply wells</td>
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</tr>
<tr>
<td>Prominent Hill Mine water supply</td>
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</table>

Notes: ✘ - no  ✔ - yes  □ - unlikely

**7.4. Groundwater impact assessment**

Section 7.1 identifies the mine water affecting activities associated with the proposed OD expansion. Table 7.3 lists these activities and their potential to affect groundwater systems with respect to the direct effects of quantity, quality, aquifer disruption of aquifers and groundwater surface water interaction.

Table 7.3 shows that there is potential for a number of mine water affecting activities to have direct effects on the regional groundwater system. Section 7.2 discusses these effects on the groundwater system in relation to the groundwater receptors identified in Table 7.2.
Table 7.3 Direct groundwater effects associated with proposed OD expansion water affecting activities

<table>
<thead>
<tr>
<th>Water affecting activity</th>
<th>Quantity</th>
<th>Potential direct effects</th>
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<tr>
<td></td>
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<td></td>
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<td>Mine workings (dewatering during mining)</td>
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<td>☒</td>
<td>☒</td>
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<tr>
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<td>☒</td>
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</tr>
<tr>
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<tr>
<td>Water storages</td>
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</tr>
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<td>☒</td>
<td></td>
<td></td>
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</tr>
<tr>
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<td>☒</td>
<td>☒</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following provides brief details of the potential effects:

- **Mine workings during mining**
  - Quantity: Dewatering operations during mining and development of the mine pit (resulting in the intersection of a number of Stuart Shelf aquifers) will result in dewatering and depressurisation of the regional groundwater system, in both water table and confined aquifers.
  - Aquifer disruption: The development of a mine pit will disrupt the groundwater system within the SML.
  - Groundwater – surface water interaction: Mine workings will not directly impact on interaction between groundwater and surface water systems.

- **Mine workings after mining**
  - Quantity: The mine pit will result in permanent dewatering and depressurisation of the regional groundwater system, in both water table and confined aquifers. This is likely to significantly reduce the flux through the ALA toward Lake Torrens. 500 years after mining at OD is completed, drawdowns of around 1 m are conservatively predicted to extend as far as Yarra Wurta Springs (SWS, 2010).
Quality: The permanent mine pit may result in brine formation within the host rocks of the OD orebody (i.e. below the THA), which are already very saline, as a result of evaporative concentration of salts.

Aquifer disruption: The development of a mine pit will permanently disrupt the groundwater system within the SML.

Groundwater – surface water interaction: Evaporation from the post-mining pit lake will not directly impact on interaction between existing groundwater and surface water systems. However, drawdown within the ALA as a result of mine pit evaporative losses will occur, which has the potential to impact upon Yarra Wurta Springs (see ‘quantity’ discussion above).

- **Tailings storages**
  Quantity: Tailings seepage recharges the underlying groundwater system at rates until post-closure capping takes place.
  Quality: Tailings seepage is likely to alter ambient groundwater quality of the underlying groundwater system.

- **Rock storages**
  Quantity: Seepage from the rock storage facility will recharge the underlying groundwater system at rates higher than background recharge until natural sealing takes place through weathering processes.
  Quality: Seepage from the rock storages will alter ambient groundwater quality of the underlying groundwater system.

- **SML saline water supply wellfields**
  Quantity: Operation of the water supply wellfields on the SML will result in a depressurisation of, primarily, the THA during operation. This is likely to be insignificant compared to dewatering operations.

- **Stuart Shelf saline water supply wellfield**
  Quantity: Operation of the ALA water supply wellfields will result in a depressurisation of the ALA during operation, and for some time after whilst recovery occurs. This is likely to significantly reduce the flux through the ALA toward Lake Torrens. In addition, drawdown at the western extent of the Stuart Shelf is expected, but not to the extent that operation of the Prominent Hill Mine water
supply is compromised.

Quality:
Depressurisation of the shallow ALA may result in the brine interface rising from the deep ALA.

Groundwater – surface water interaction:
Wellfield operation has the potential to reduce the potentiometric head that generates Yarra Wurta Springs discharges in the order of one metre by 500 years post-closure.

**Threat assessment**

Based on the above discussion concerning potential direct groundwater effects, the following presents an assessment of those groundwater receptors potentially threatened by these effects:

- The threat posed to the Coorlay Lagoon environmental receptor by groundwater drawdown in response to mine dewatering and post-mine evaporation from the pit lake is unlikely to be significant as, on the basis of groundwater salinity alone, it is considered that ecosystems associated with the lagoon are not dependent on groundwater.

- The Yarra Wurta Springs environmental receptor, an obligate GDE, is possibly threatened by the proposed expansion of OD in the long-term (i.e. after mine closure) because the Springs are located at the discharge end of the Arckaringa-Stuart Shelf GFS. Note, however, that hydrogeochemical evidence (see Section 2.3) supported by findings of Johns (1968) and Schmid (1985) strongly suggests that spring discharges are sourced from Adelaide Geosyncline groundwater systems to the east of the Torrens Fault or from deep groundwater beneath Lake Torrens discharging via structural conduits in the lake sediments.

- Pastoral wells located within 50 km of OD, and on BHP Billiton held leases, may be exposed to small groundwater drawdowns that could impact on the pumping efficiency of windmill or small electro-submersible pumps, if the wells are operational in the long-term (i.e. greater than 50 years). However, the perched stockwater aquifers are likely to be in poor hydraulic connection with the regional groundwater system and so the threat of interrupted supply is considered small.

- The Prominent Hill Mine water supply wellfield draws water from the Boorthanna aquifer, a deeply confined aquifer of the Arckaringa Basin. Available drawdowns in the Boorthanna aquifer are such that any drawdown caused by operation of the Stuart Shelf saline water supply wellfield is likely to be mitigated such that the Prominent Hill water supply will not be compromised.
8. **Conclusions**

8.1. **Stuart Shelf groundwater dynamics**

On the Stuart Shelf, the ALA forms the dominant water table aquifer. Regional flow, both shallow and deep, in the aquifer is towards the northern end of Lake Torrens where groundwater likely discharges via evaporation near to the margins of the lake. There is deep movement of brine derived from Lake Torrens. This brine is moving slowly outwards from the lake through the deeper ALA and THA.

In the vicinity of the mine lease, groundwater within the THA is already influenced by mining activities with a cone of depression centred on the underground workings and a small number of abstraction wells.

Vertical hydraulic gradients for nested sites across the Stuart Shelf and THZ all appear to be close to hydrostatic, indicating limited to no vertical flow between the ALA and THA, and between the deep brines and shallower saline groundwaters of the ALA.

8.2. **Conceptual hydrogeological model**

The proposed expansion of OD will operate within the Arckaringa-Stuart Shelf GFS, the primary aquifers of which are separated from the *artesian* Eromanga (GAB) GFS by a groundwater divide. North and south of this divide the Arckaringa-Stuart Shelf GFS is characterised by low permeability rocks of the Adelaide Geosyncline. An extensive regional groundwater discharge/evaporation zone also separates the *artesian* Eromanga (GAB) GFS from the Arckaringa-Stuart Shelf GFS, effectively forming an hydraulic (discharge) boundary that mitigates against any significant interaction between the two flow systems.

The Arckaringa-Stuart Shelf GSF receives very low rates of rainfall recharge, and extends from the Arckaringa Basin in the west (with throughflow moving onto the Stuart Shelf) and Lake Torrens in the east where evaporative discharge occurs at the lake edge. A component of groundwater discharge from this GFS also occurs along the southwest margin of the *artesian* Eromanga (GAB) Basin.

The evaporative discharge of groundwater from Lake Torrens has caused salinity stratification (and brine formation) near and beneath the lake. Very high groundwater salinity observed at depth in the ALA and in the THA north of Lake Torrens is evidence of density driven brine discharge from the sedimentary aquifers beneath Lake Torrens.

The available hydrogeochemical data strongly suggest that Yarra Wurta Springs is supported by groundwater discharging from Adelaide Geosyncline rocks to the northeast of Lake Torrens. Work
undertaken by Johns (1968) suggests that these Springs may even be supported by artesian aquifers hosted by deep sediments within the Lake Torrens graben that are recharged from the east, consistent with the hydrogeochemical data.

### 8.3. The potential for interaction between the artesian Eromanga (GAB) aquifers and aquifers of the Stuart Shelf and Arckaringa Basin

In addition to intervening low permeability rocks of the THZ, more than 50 km north of Olympic Dam a groundwater divide separates the primary aquifers of the Arckaringa-Stuart Shelf GFS from the artesian Eromanga (GAB) GFS. It is concluded that the proposed expansion of OD will not impact at all on GAB Springs that are located at the discharge end of the artesian Eromanga (GAB) GFS.

Further to the northwest, the contact between the Arckaringa Basin and artesian Eromanga (GAB) Basin occurs within a structurally and lithologically complex environment. The displacement of different formations against each other and hydraulic boundaries (such as possible fault gouge and a regional scale groundwater discharge/evaporation zone) all serve to limit interaction between the two flow systems. Hydrogeochemical data support this conclusion.

The overriding conclusions arising from the above analysis of available information presented in this report are:

- there is little interaction of any significance between the artesian Eromanga (GAB) groundwater system and the groundwater systems of the Stuart Shelf and Arckaringa Basin; and
- the proposed open cut mine development at OD is very unlikely to alter this situation.

### 8.4. Beneficial use categories for regional aquifers

Available groundwater salinity data show that the main aquifers of the Arckaringa-Stuart Shelf GFS (i.e. the ALA and THA) in general do not have any beneficial use other than for industrial water supplies.

### 8.5. Water sampling protocols and TSS

Water sampling protocols adopted for the groundwater studies undertaken for the proposed OD expansion environmental studies are consistent with industry practice (e.g. methods of sample collection, preservation and shipment, holding times, analysis by NATA-registered laboratories). Reported laboratory data (salinity, pH, metals and other analytes) are considered to representative of in-situ groundwater quality.
8.6. Lake Torrens

8.6.1. Hydrology

Work completed by Schmid (1985) shows that the brines beneath Lake Torrens are largely sourced from the evaporative concentration of groundwaters moving from east of the lake. Schmid further concluded that groundwater discharge to Lake Torrens from west of the Torrens Fault is negligible.

Johns (1968) studied the Springs occurring in the central portion of Lake Torrens and, consistent with the findings of Schmid (1985), found that Springs discharges are sourced from deep sediments at the base of the Lake Torrens graben that are recharged from creek lines, and fractured rock and sedimentary aquifers east of the lake. Based on this, and $^{36}$Cl isotope data, it is reasonable to assume that Yarra Wurta Springs function similarly to other Lake Torrens Springs, possibly mitigating the risk of potential drawdown impacts associated with post-closure drainage of groundwater into the final pit void, from which it evaporates.

8.6.2. Brine

Groundwater wells installed across much of the eastern portion of the Stuart Shelf have encountered a halocline within the ALA, which represents a contrast with lower ALA brine. Closer to Lake Torrens, the THA also shows evidence of density driven brine discharge. The brine arises largely as a result of the evaporative concentration of salts in groundwater.

The brine causes the saline (fresher) groundwater moving towards Lake Torrens to be effectively forced upward by the density difference, reducing the effective transmissivity of the ALA (the aquifer is 80 to 100 m thick in the western portion of the Stuart Shelf, but is effectively less than 20 to 40 m thick within about 20 km of the Lake), as flow is constrained between the halocline and the overlying lower permeability shale formations.

Fresh water corrected hydraulic heads and vertical gradients for the ALA at various nested groundwater monitoring sites show the lower (hypersaline) and upper (saline) ALA to be hydrostatic or close to hydrostatic at most sites, indicating limited vertical movement takes place between the upper and lower parts of the aquifer.

Numerical modeling has shown that operation of the proposed Motherwell saline water supply wellfield (which will draw water from the Andamooka Limestone aquifer) is likely to have the greatest influence on regional groundwater drawdowns during operation of the proposed expanded mine (up until 2017 when the wellfield is planned to be decommissioned). The impact of the mine pit on groundwater in this area in the long-term will not be as great as that associated with operation of this proposed water supply (SWS, 2010).
In terms of the potential change in vertical hydraulic gradients and brine mobilisation, analytical modeling suggests the impact of the proposed Motherwell wellfield will not be extensive. Further, if some mobilisation of brine does occur it will not impact adversely on any sensitive receptors.

8.7. Groundwater impact assessment

A number of receptors have been identified as being possibly threatened by groundwater effecting activities associated with the proposed OD expansion, many of which have been shown to not have any significant exposure pathway between them and groundwater affecting activities associated with the proposed expansion, e.g. Coorlay Lagoon, the freshwater swamps and pastoral water supply wells.

However, groundwater impact assessment for the project shows that Yarra Wurta Springs, an obligate GDE, may be exposed to reduced discharge effects due to ALA drawdowns that may arise because of evaporative discharges from the mine pit water body (post-closure). Conservative numerical groundwater flow modeling (that does not consider a possible east-of-Lake Torrens source of Springs discharge) predicts that drawdowns of around 1 m may be encountered at the location of the Springs 500 years from mine closure. As such, the threat posed to Yarra Wurta Springs by the proposed OD expansion cannot be ruled out, although an adverse effect is unlikely.

The Prominent Hill Mine water supply wellfield draws water from the Boorthanna aquifer, a deeply confined aquifer of the Arckaringa Basin. Available drawdowns in the Boorthanna aquifer are such that any drawdown caused by operation of the proposed Motherwell wellfield through to 2017 will not compromise the mines water supply.
9. References


Dalgarno, C.R. 1982 Andamooka, South Australia, 1:250 000 Map Sheet SH 53-12 - Second edition Geological Survey of South Australia 1v Map


SKM. 2010. Olympic Dam expansion project – collation of hydrogeological-related data and information post Draft EIS. Prepared for BHP Billiton Olympic Dam Corporation P/L by Sinclair Knight Merz Pty Limited. Appendix F2 of the Supplementary EIS.

SRK. 2010a. Olympic Dam rock storage facility: assessment of infiltration and percolation. Prepared for BHP Billiton by SRK Consulting (Australasia) Pty Ltd. Appendix F7 of the Supplementary EIS.

SRK. 2010b. Supplemental geochemical investigations. Prepared for BHP Billiton by SRK Consulting (Australasia) Pty Ltd. Appendix F5 of the Supplementary EIS.

SWS. 2010. Updates to Stuart Shelf Regional Groundwater Flow Model. Prepared for BHP Billiton by Schlumberger Water Services Australia Pty Ltd. Appendix F4 of the Supplementary EIS.


10. Acknowledgements

A number of people external to SKM have assisted in the preparation of this report by providing additional technical review (John Waterhouse of Golder Associates and Blair Douglas of BHP Billiton). Their assistance is gratefully acknowledged.
Attachment A
Regional groundwater data & density corrections
Table A.1 Density corrected hydraulic heads for the upper ALA

<table>
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<th>Well ID</th>
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<th>Measured salinity TDS i (mg/L)</th>
<th>Estimated salinity at zr TDS r (mg/L)</th>
<th>Density in well ρi (kg/m³)</th>
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<th>Average density (kg/m³)</th>
<th>Measured hydraulic head (m)</th>
<th>Freshwater head at zr (m)</th>
<th>Freshwater head at screen (m)</th>
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## Table A.1  Density corrected hydraulic heads for the upper ALA (cont.)

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<th>Measured salinity</th>
<th>Estimated salinity at $z_i$</th>
<th>Density in well $\rho_i$</th>
<th>Estimated gw density at $z_i$ $\rho_r$</th>
<th>Average density $\rho_a$</th>
<th>Measured hydraulic head $h_i$</th>
<th>Freshwater head at $z_i$ $h_{f,r}$</th>
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Notes:  
1. Estimated from EC measurements taken during drilling with a conversion factor of $EC = 0.6 \times TDS$  
2. Open hole & fully penetrating wells used, with hydrostatic conditions assumed and water table = $h_i$ at top of ‘screen’ (i.e. open section drillhole with potential inflows)  
   $z_i = (h_i - 5m)$ when $h_i$ is below base of collar or top of Andamooka Limestone; $z_i =$ top of screen when $h_i$ is above base of collar or top of Andamooka Limestone  
3. Estimated values at top of aquifer; published TDS data measured using low flow sampling technique at deeper levels within open hole well
## Table A.2 Density corrected hydraulic heads for the lower ALA

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<tr>
<th>Well ID</th>
<th>Midpoint of screen (z_s) (m)</th>
<th>TDS in well (TDS_i) (mg/L)</th>
<th>Depth of brine interface (z_b) (m)</th>
<th>Estimated salinity at z_s (TDS_r) (mg/L)</th>
<th>Density in well (ρ) (kg/m³)</th>
<th>Ambient gw density at z_s (ρ_a) (kg/m³)</th>
<th>Average density (ρ_a) (kg/m³)</th>
<th>Measured hydraulic head (h_i) (m)</th>
<th>Freshwater head at z_s (h_f,i) (m)</th>
<th>Error margin (h_f,i – h_f,r) (m)</th>
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Notes:
1. Estimated from EC measurements taken during drilling
2. Calculated by raising or lowering level of brine interface (z_b) by 20%: upper z_b = z_b x 1.2; lower z_b = z_b x 0.8
### Table A.3  Compiled data

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<th>R1 (mg/l)</th>
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**Indicated limestone Aquifer (Upper) using reference level: 5mAHD**

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**Indicated limestone Aquifer (Lower) using reference level: Z53) (mAHD)**

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<tbody>
<tr>
<td>MT6b2</td>
<td>680,360</td>
<td>6,654,627</td>
<td>42.26</td>
<td>33.00</td>
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</tr>
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<td>MT6a2</td>
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<td>42.68</td>
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<td>MT6c2</td>
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<td>6,654,627</td>
<td>42.26</td>
<td>33.00</td>
<td>42.68</td>
</tr>
</tbody>
</table>

**Equivalent freshwater head with well screens normalised to reference level, a (from Post et al., 2007)**

\[ h_{cr} = z_{cr} + \rho_{1}\left(z_{1} - z_{cr}\right) - \rho_{2}\left(z_{cr} - z_{1}\right) \quad (12) \]
### Table A.4 Predicted direction of vertical groundwater movement at nested sites

<table>
<thead>
<tr>
<th>Well</th>
<th>Hydrostratigraphic unit</th>
<th>Thickness of aquitard (m)</th>
<th>Mean screen level (m AGD)</th>
<th>Measured head (m AGD)</th>
<th>Salinity in well (g/L)</th>
<th>Density of gw (g/L)</th>
<th>Freshwater head at z_1 (m AGD)</th>
<th>Bucancy term (m AGD)</th>
<th>Effective gradient</th>
<th>Potential direction of gw (m AGD)</th>
<th>Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT16a</td>
<td>ALA</td>
<td>100</td>
<td>36.8</td>
<td>43.27</td>
<td>22000</td>
<td>1017</td>
<td>43.35</td>
<td>0.075</td>
<td>0.023</td>
<td>-0.104</td>
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</tr>
<tr>
<td>RT16b</td>
<td>THA</td>
<td>-68.5</td>
<td>50.59</td>
<td>55000</td>
<td>1041</td>
<td>35.80</td>
<td>37.54</td>
<td>25000</td>
<td>1017</td>
<td>45.01</td>
<td>0.080</td>
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<tr>
<td>RT17a</td>
<td>ALA</td>
<td>134</td>
<td>36.9</td>
<td>48.70</td>
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<td>0.031</td>
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<tr>
<td>RT17b</td>
<td>THA</td>
<td>-142.1</td>
<td>30.54</td>
<td>60000</td>
<td>1045</td>
<td>38.31</td>
<td>37.54</td>
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<td>1017</td>
<td>45.01</td>
<td>0.080</td>
</tr>
<tr>
<td>LR-10</td>
<td>ALA</td>
<td>258</td>
<td>17.5</td>
<td>37.41</td>
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<td>-0.260</td>
<td>0.089</td>
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</tr>
<tr>
<td>RT-1</td>
<td>THA</td>
<td>-98.9</td>
<td>38.99</td>
<td>200000</td>
<td>1150</td>
<td>103.07</td>
<td>37.54</td>
<td>37000</td>
<td>1028</td>
<td>37.56</td>
<td>-0.260</td>
</tr>
<tr>
<td>RT-2a</td>
<td>ALA</td>
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<td>49.5</td>
<td>43400</td>
<td>1033</td>
<td>42.32</td>
<td>-0.279</td>
<td>0.092</td>
<td>0.186</td>
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</tr>
<tr>
<td>RT-2b</td>
<td>THA</td>
<td>-234.4</td>
<td>25.50</td>
<td>203000</td>
<td>1152</td>
<td>68.53</td>
<td>37.54</td>
<td>37000</td>
<td>1028</td>
<td>37.56</td>
<td>-0.260</td>
</tr>
<tr>
<td>RT6a</td>
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<td>1023</td>
<td>40.31</td>
<td>-0.186</td>
<td>0.075</td>
<td>0.110</td>
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<tr>
<td>RT4b</td>
<td>Yarloo Shale</td>
<td>-424.5</td>
<td>35.79</td>
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<td>1128</td>
<td>97.89</td>
<td>37.54</td>
<td>37000</td>
<td>1028</td>
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<td>-0.260</td>
</tr>
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<td>RT5a</td>
<td>ALA (upper)</td>
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<td>40.93</td>
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<td>0.117</td>
<td>0.003</td>
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<td></td>
</tr>
<tr>
<td>RT5b</td>
<td>ALA (lower)</td>
<td>-113.5</td>
<td>38.84</td>
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<td>1395</td>
<td>54.33</td>
<td>-0.303</td>
<td>0.338</td>
<td>0.117</td>
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<td></td>
</tr>
<tr>
<td>RT5c</td>
<td>ABC Q12 / Brahma</td>
<td>-478.5</td>
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<td>200000</td>
<td>1180</td>
<td>121.38</td>
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<td>37000</td>
<td>1028</td>
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</tr>
<tr>
<td>RT7a</td>
<td>ALA</td>
<td>136</td>
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<td>50000</td>
<td>1041</td>
<td>54.68</td>
<td>-0.075</td>
<td>0.077</td>
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</tr>
<tr>
<td>RT7b</td>
<td>Ambersona</td>
<td>-116.0</td>
<td>46.60</td>
<td>150000</td>
<td>1113</td>
<td>64.78</td>
<td>37.54</td>
<td>37000</td>
<td>1028</td>
<td>37.56</td>
<td>-0.260</td>
</tr>
</tbody>
</table>

**Note:**
1. K_l = Vertical hydraulic conductivity
2. gw = Groundwater
3. Head gradient assumes thickness of aquitard (m) with the exception of RT5a & RT5b where head gradient assumes mean screen level in the absence of aquitard

$$q_v = -K_l \left[ \frac{\Delta h_f}{\Delta z} + \left( \frac{\rho_a - \rho_f}{\rho_f} \right) \right]$$

- **q_v**: Vertical flow component
- **h_f**: Freshwater head gradient
- **z**: Bucancy term

---

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Table A.5  Predicted direction of vertical groundwater movement at nested sites

<table>
<thead>
<tr>
<th>Well</th>
<th>Mean screen level $z_i$ (mAHD)</th>
<th>Measured head $h_i$ (mAHD)</th>
<th>Measured TDS i (mg/L)</th>
<th>Density in well $\rho_i$ (kg/m$^3$)</th>
<th>Freshwater head at $z_i$ $h_f,i$ (mAHD)</th>
<th>Buoyancy term $(\rho_a - \rho_f)/\rho_f$</th>
<th>Effective gradient $\Delta h_f/\Delta z$</th>
<th>Predicted direction of gw movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAR2-10a</td>
<td>-19.98</td>
<td>41.25</td>
<td>31700</td>
<td>1024</td>
<td>42.71</td>
<td>-0.08</td>
<td>0.10</td>
<td>-0.020 DOWN</td>
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<tr>
<td>MAR2-10b</td>
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<td>28.76</td>
<td>230000</td>
<td>1173</td>
<td>47.35</td>
<td>-0.10</td>
<td>0.10</td>
<td>0.000</td>
</tr>
<tr>
<td>MAR2-50a</td>
<td>-21</td>
<td>39.86</td>
<td>32100</td>
<td>1024</td>
<td>41.33</td>
<td>-0.10</td>
<td>0.10</td>
<td>0.004 UP</td>
</tr>
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<td>237000</td>
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<td>47.78</td>
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<td>0.004</td>
<td>0.009</td>
</tr>
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<td>28000</td>
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<td>0.009</td>
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<td>28000</td>
<td>1021</td>
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<td>0.04</td>
<td>0.004 UP</td>
</tr>
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<td>0.007</td>
<td>0.004</td>
<td>0.009</td>
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<td>43.41</td>
<td>14200</td>
<td>1011</td>
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<td>-0.01</td>
<td>0.02</td>
<td>-0.002 DOWN</td>
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<td>0.009</td>
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<td>33200</td>
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<td>50300</td>
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<tr>
<td>MXTB10b</td>
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<td>41.72</td>
<td>28800</td>
<td>1022</td>
<td>45.27</td>
<td>0.007</td>
<td>0.004</td>
<td>0.009</td>
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Table A.5  Predicted direction of vertical groundwater movement at nested sites (cont.)

<table>
<thead>
<tr>
<th>Well</th>
<th>Mean screen level $z_i$ (mAHD)</th>
<th>Measured head $h_i$ (mAHD)</th>
<th>Salinity in well TDS i (mg/L)</th>
<th>Density in well $\rho_i$ (kg/m$^3$)</th>
<th>Freshwater head at $z_i$ $h_{f,i}$ (mAHD)</th>
<th>Freshwater head gradient $\Delta h_f/\Delta z$</th>
<th>Buoyancy term $(\rho_a-\rho_f)/\rho_f$</th>
<th>Effective gradient</th>
<th>Predicted direction of gw movement</th>
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</thead>
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<td>42.04</td>
<td>30600</td>
<td>1023</td>
<td>42.54</td>
<td>-0.02</td>
<td>0.02</td>
<td>-0.002</td>
<td>DOWN</td>
</tr>
<tr>
<td>MXTB12b</td>
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<td>41.91</td>
<td>30800</td>
<td>1023</td>
<td>43.61</td>
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<td>43.63</td>
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<td>42.85</td>
<td>30800</td>
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<td>45.10</td>
<td>-0.002</td>
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</tr>
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<td>1033</td>
<td>42.32</td>
<td>-0.21</td>
<td>0.11</td>
<td>0.098</td>
<td>UP</td>
</tr>
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<td>221000</td>
<td>1195</td>
<td>65.23</td>
<td>-0.21</td>
<td>0.11</td>
<td>0.098</td>
<td>UP</td>
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Table A.6 Estimated hydraulic conductivities for nested groundwater monitoring wells

<table>
<thead>
<tr>
<th>Hydrogeology</th>
<th>Well Location</th>
<th>Hydraulic Conductivity (m/d)</th>
<th>Data Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andamooka Limestone Aquifer</td>
<td>RT5a and RT5b</td>
<td>6.5 x 10^{-1} to 1.7 x 10^2</td>
<td>SKM (2010)</td>
</tr>
<tr>
<td>Arcoona Quartzite Aquitard</td>
<td>RT16a, RT16b, RT17a, RT17b, RT02a, RT02b</td>
<td>9 x 10^{-4} to 2 x 10^{-3}</td>
<td>SKM (2010)</td>
</tr>
<tr>
<td>Yarloo Shale</td>
<td>LR10, RT01, RT04a, RT04b</td>
<td>2 x 10^{-5} to 9 x 10^{-3}</td>
<td>Estimated (BHP-B 2008 ) and Section 2.3</td>
</tr>
<tr>
<td>Adelaide Geosyncline Rocks</td>
<td>RT07a and RT07b, RT05c</td>
<td>1 X 10^{-4} to 1 x 10^{-2}</td>
<td>Section 3.4</td>
</tr>
</tbody>
</table>
Attachment B
Falling & rising head hydraulic testing results
B.1 Procedure and data analysis

Procedure

Falling head tests were used to obtain estimates of hydraulic conductivity for hydrostratigraphic units predominately within the THZ (Figure 3.12). The procedure involved introducing a solid PVC ‘slug’ to the water column of each well and then recording water level recovery using downhole pressure transducers.

The pressure transducer was lowered to approximately 5 m below the static water level and set to record water pressure at intervals ranging from 0.5 to 30 seconds.

Data analysis

Time series groundwater level data were downloaded from the logger and imported into a spreadsheet template for the Hvorslev solution (Fetter, 1988), which is suitable for providing ‘near well’ estimates of hydraulic conductivity values for confined aquifers. Analysis of the falling head data was also evaluated using the Bouwer-Rice method (Bouwer, 1989), again with the use of a spreadsheet template. The data are presented as Attachment B.2 and B.3.

Stuart Shelf

Falling head slug tests were conducted at two groundwater monitoring wells (RT02b and RT04b) screened within the Arcoona Quartzite Aquitard and the Yarloo Shale respectively. Estimated hydraulic conductivity values for RT02b range between $2 \times 10^{-3}$ and $5 \times 10^{-3}$ m/d.

Estimated hydraulic conductivity values for RT04b range between $2 \times 10^{-5}$ and $2 \times 10^{-2}$ m/d. During the falling head test a blockage was encountered within the well at a depth of approximately 35 m below ground level (bgl) and, as such, the results may not be representative (and have been excluded from the summary presented in Table 3.1).

Adelaide Geosyncline

Falling head tests were conducted on five groundwater monitoring wells (RT05c, RT07a, RT07b, RT09 and PT63) screened within Adelaide Geosyncline rocks of the THZ (ABC Range Quartzite, Brachina Formation and Amberoona Formation). Estimated hydraulic conductivity values range between $1 \times 10^{-4}$ and $1 \times 10^{-2}$ m/d.
Non-artesian Eromanga Basin

Falling head tests were conducted on four groundwater monitoring wells (RT41, RT42 and PT62) screened within the Bulldog Shale and the remnant Cadna-owie Formation of the non-artesian Eromanga Basin (i.e. south of the artesian springs zone).

Hydraulic conductivity estimates for RT41 and RT42 range between $7 \times 10^{-1}$ and 1.5 m/d. The hydraulic conductivity estimates for PT62, screened within the Cadna-owie Formation, are the highest of any of the tests conducted during this program of work, ranging between 23 and 33 m/d. (note: PT62 is the only location drilled on the Stuart Shelf as part of the BHP Billiton work programs that encountered significant intersections of saturated / partially saturated Cadna-owie Formation.
B.2 Bouwer-Rice method
Aquifer Test Solutions: Slug Tests

Project Name: BHP-B SEIS Field Investigations
Client: BHP-B

Date: 02-May-10
Time: 13:38

Well No. / Name: RT02b

Depth to equilibrium water level (m RL): 51.78 mPVC

Type of test: Falling head

Type of test: Lw = H

Depth to Water at Time '0': 51.65 (m)

Y0 = 0.13 (m)

<table>
<thead>
<tr>
<th>Data point</th>
<th>Elapsed time (mins)</th>
<th>Depth to water (m)</th>
<th>Drawdown * (Yt)</th>
</tr>
</thead>
<tbody>
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<td>0.0050</td>
<td>51.65</td>
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<td>2.5000</td>
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<td>0.091</td>
</tr>
<tr>
<td>1000</td>
<td>5.0000</td>
<td>51.697</td>
<td>0.083</td>
</tr>
<tr>
<td>1500</td>
<td>7.5000</td>
<td>51.704</td>
<td>0.076</td>
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* Includes residual drawdown for falling head test

Prepared by Alistair Walsh, 10 May 2010
Revision A 17/03/2011 \ RT02b Bouwer&Rice Analysis(compressed).xls \ B&R Page (Test Data)
Aquifer Test Solutions: Slug Tests Bouwer Rice

Project Name: BHP-B SEIS Field Investigations
Client: BHP-B
Date: 02-May-10
Time: 13:38

Well No. / Name: RT02b
Depth to equilibrium water level (m RL): 51.78 mTOC

Type of test: Rising head
Well Completion: Fully Penetrating

\[
\begin{align*}
rc &= \text{casing radius} & 0.025 \\
r_w &= \text{radial distance between undisturbed aquifer and well centre} & 0.1015 \\
L_w &= \text{length of intake} & 24 \\
H &= \text{saturated thickness of aquifer} & 24 \\
L_w &= \text{distance b/n water table and bottom of intake} & 290 \\
R_e &= \text{effective well radius} & 36.46 \\
t &= \text{time} & 40 \\
Y_o &= \text{initial drawdown} & 0.13 \\
Y_t &= \text{vertical distance between the water level in well at time t and equilibrium level} & 0.06 \\
L_w/r_w &= \text{dimensionless co-efficient that is a function of } L_w/r_w \text{ and } L_w < H & 236.453202 \\
A &= \text{dimensionless co-efficient that is a function of } L_w/r_w \text{ and } L_w < H & 6.45 \\
B &= \text{dimensionless co-efficient that is a function of } L_w/r_w \text{ and } L_w < H & 1.25 \\
C &= \text{dimensionless co-efficient that is a function of } L_w/r_w \text{ and } L_w = H & 7.5 \\
\end{align*}
\]

\[
\begin{align*}
\text{If } L_w < H: \\
\ln \left( \frac{R_e}{r_w} \right) &= \left\{1.1 \times \ln \left( \frac{L_w}{r_w} \right) \right\}^{-1} + A + B \times \ln \left( \frac{H - L_w}{r_w} \right) \times \left( \frac{L_w}{r_w} \right)^{-1} \\
Y_t &= - \frac{L_w}{H - L_w} \\
\text{If } L_w = H: \\
\ln \left( \frac{R_e}{r_w} \right) &= \left\{1.1 \times \ln \left( \frac{L_w}{r_w} \right) \right\}^{-1} + C \times \left( \frac{L_w}{r_w} \right)^{-1} \\
Y_t &= 5.88 \\
K &= \left( r_w^{-2} \times \ln \left( \frac{R_e}{r_w} \right) \right) \cdot 2 \times t^{-1} \times \ln \left( \frac{Y_o}{Y_t} \right) \\
&= 1.48E-06 \quad \text{m/min} \\
&= 0.002 \quad \text{m/d}
\end{align*}
\]

**Aquifer Test Solutions:** Slug Tests

**Bouwer Rice**

**Project Name:** BHP-B SEIS Field Investigations  
**Client:** BHP-B  
**Date:** 30-Apr-10  
**Time:** 09:11

**Well No. / Name:** RT05c  
**Depth to equilibrium water level (m RL):** 18.667 m PVC

**Type of test:**  
- Rising head
- Falling head

**Type of test:**  
- $L_w = H$
- $L_w < H$

**Depth to Water at Time '0':**  
- $Y_0 = 0.857$ (m)

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* Includes residual drawdown for falling head test

Prepared by Alistair Walsh, 10 May 2010

Revision A  
17/03/2011 \ RT05c Bouwer& Rice Analysis(compressed).xls \ B&R Page (Test Data)
Project Name: BHP-B SEIS Field Investigations  
Client: BHP-B  
Well No. / Name: RT05c  
Depth to equilibrium water level (m RL): 18.667 m TOC

Type of test: Rising head  
Well Completion: Fully Penetrating

\[ \text{if } L_w < H \]
\[ \ln\left(\frac{R_w}{r_c}\right) = \left\{1.1 \cdot \left[\ln\left(\frac{L_w}{r_w}\right)\right]^{-1} + A \cdot \ln\left[H - L_w, 2\pi \cdot \left(\frac{L_w}{r_w}\right)^{0.5}\right]^{-1}\right\}^{-1} \]

\[ = \frac{L_w}{H} = \frac{214}{214} = 1 \]

\[ = \frac{7.55}{m} \]

\[ Y_t = 0.857 \]

\[ \text{Vertical distance between the water level in well at time } t \text{ and equilibrium level} \]

\[ L_w = 615.333 \]

\[ \text{Distance between water table and bottom of intake} \]

\[ r_c = 0.025 \]

\[ r_w = 0.1015 \]

\[ L_w = 214 \]

\[ H = 214 \]

\[ L_w = 615.333 \]

\[ \text{If } L_w = H \]
\[ \ln\left(\frac{R_w}{r_c}\right) = \left\{1.1 \cdot \left[\ln\left(\frac{L_w}{r_w}\right)\right]^{-1} + C \cdot \left(\frac{L_w}{r_w}\right)^{-1}\right\}^{-1} \]

\[ = 7.55 \text{ m} \]

\[ K = \frac{1}{2} \cdot \ln\left(\frac{R_w}{r_c}\right) \cdot 2L^{-1} \cdot t^{-1} \cdot \ln \left(\frac{Y_t}{Y_i}\right) \]

\[ = 2.47E-06 \text{ m/min} \]

\[ = 0.004 \text{ m/d} \]
Aquifer Test Solutions: Slug Tests

**Project Name:** SHF-B GES Field Investigations

**Company:** Bouwer Rice

**Depth to equilibrium water level (m RL):** 16.633 m

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### Type of Test
- **slug test**
- **falloing head**
- **rising head**

### Data

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*Includes residual drawdown for falling head test

**Type of Test:**
- **slug test**
- **falloing head**
- **rising head**

**Revision A 17/03/2011**

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Prepared by: Alistair Walsh, 10 May 2010
Revision A

17/03/2011 | RT09 Bouwer Rice Analysis (compressed).xls | B&R Page (Test Data)
Aquifer Test Solutions: Slug Tests Bouwer Rice

Project Name: BHP-B SEIS Field Investigations
Client: BHP-B
Date: 02-May-10
Time: 13:38

Well No. / Name: RT09
Depth to equilibrium water level (m RL): 16.603 mTOC
Type of test: Rising head
Well Completion: Fully Penetrating

rc = casing radius
rw = radial distance between undisturbed aquifer and well centre
Lw = length of intake
H = saturated thickness of aquifer
Le = distance b/n water table and bottom of intake
Rw = effective well radius
t = time
Yo = initial drawdown
Yt = vertical distance between the water level in well at time t and equilibrium level
Lw/rw = dimensionless co-efficient that is a function of Lw/rw, and Lw < H
A = dimensionless co-efficient that is a function of Lw/rw, and Lw < H
B = dimensionless co-efficient that is a function of Lw/rw, and Lw < H
C = dimensionless co-efficient that is a function of Lw/rw, and Lw < H

\[ \ln\left(\frac{R_w}{r_c}\right) = \begin{cases} 
1.1 \cdot \left[\ln\left(\frac{L_w}{r_w}\right)\right]^{-1} + A + B \cdot \ln\left(\frac{H-L_w}{r_w}\right) \cdot \left(\frac{L_e}{r_w}\right)^{-1} & \text{if } L_w < H \\
1.1 \cdot \left[\ln\left(\frac{L_w}{r_w}\right)\right]^{-1} + C \cdot \left(\frac{L_e}{r_w}\right)^{-1} & \text{if } L_w = H 
\end{cases} \]

K = \left[\frac{r_c^2 \cdot \ln(R_w/r_c)}{2L_w} \right] \cdot t^{-1} \cdot \ln\left(\frac{Y_t}{Y_o}\right)

K = \frac{5.91 \times 10^{-8}}{0.0001} \text{ m/min m/d}

Produced by: Alistair Walsh
Date: 7/05/2010

Checked by: Kate Furness
Date: 10/05/2010

Aquifer Test Solutions: Slug Tests

**Project Name:** BHP-B SEIS Field Investigations

**Client:** BHP-B

**Date:** 30-Apr-10

**Time:** 03:00

**Well No. / Name:** RT07a

**Depth to equilibrium water level (m RL):** 13.136 mPVC

**Type of test:** Rising head

**Type of test:** Lw = H

**Depth to Water at Time '0':**

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* Includes residual drawdown for falling head test

Prepared by Alistair Walsh, 10 May 2010

Revision A

17/03/2011 \ RT07a Bouwer&Rice Analysis(compressed).xlsx \ B&R Page (Test Data)
Aquifer Test Solutions: Slug Tests

Project Name: BHP-B SEIS Field Investigations
Client: BHP-B
Date: 30-Apr-10
Time: 03:00

Well No. / Name: RT07a
Depth to equilibrium water level (m RL): 13.136 mTOC

Type of test: Rising head
Well Completion: Fully Penetrating

If \( L_w < H \)

\[
\ln\left(\frac{R_e}{r_w}\right) = \left\{1.1 \cdot \left[\ln\left(\frac{L_w}{r_w}\right)\right]^{-1} + A + B \cdot \ln\left[\frac{H - L_w}{r_w}\right] \cdot \left(\frac{L_e}{r_w}\right)^{-1}\right\}^{-1} = \frac{5.95}{m}
\]

If \( L_w = H \)

\[
\ln\left(\frac{R_e}{r_w}\right) = \left\{1.1 \cdot \left[\ln\left(\frac{L_w}{r_w}\right)\right]^{-1} + C \cdot \left(\frac{L_e}{r_w}\right)^{-1}\right\}^{-1} = \frac{L_w}{m}
\]

\( r_c \) = casing radius
\( r_w \) = radial distance between undisturbed aquifer and well centre
\( L_e \) = length of intake
\( H \) = saturated thickness of aquifer
\( L_w \) = distance b/n water table and bottom of intake
\( R_e \) = effective well radius
\( t \) = time
\( Y_o \) = initial drawdown
\( Y_t \) = vertical distance between the water level in well at time \( t \) and equilibrium level
\( L_e/r_w \) = dimensionless co-efficient that is a function of \( L_e/r_w \) and \( L_w < H \)
\( A \) = 9.5
\( B \) = 3
\( C \) = 12.75

\( K = \left[ \frac{r_e^2 \cdot \ln\left(\frac{R_e}{r_w}\right)}{2L - 1} \right] t^{-1} \cdot \ln\left(\frac{Y_o}{Y_t}\right) \)

Produced by: Alistair Walsh Date: 7/05/2010
Checked by: Kate Furness Date: 10/05/2010

**Aquifer Test Solutions: Slug Tests**

**Bouwer Rice**

**Project Name:** BHP-B SEIS Field Investigations  
**Date:** 01-May-10  
**Client:** BHP-B  
**Time:** 10:00

**Well No. / Name:** RT07b  
**Depth to equilibrium water level (m RL):** 18.597 mPVC

**Type of test:** Rising head  
**(enter “3” against appropriate test type)**

**Type of test:** Lw = H  
**(enter “3” against solution constraint)**

**Depth to Water at Time ‘0’:** 17.83 (m)  
**Y₀ = 0.767 (m)**

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Prepared by Alistair Walsh, 10 May 2010  
Revision A  17/03/2011 \ RT07b Bouwer&Rice Analysis(compressed).xls \ B&R Page (Test Data)
**Aquifer Test Solutions: Slug Tests**

**Bouwer Rice**

**Project Name:** BHP-B SEIS Field Investigations  
**Date:** 01-May-10

**Client:** BHP-B  
**Time:** 10:00

**Well No. / Name:** RT07b  
**Depth to equilibrium water level (m RL):** 18.597 m TOC

**Type of test:** Rising head  
**Well Completion:** Fully Penetrating

---

**rc**  
casing radius  
0.025

**rw**  
radial distance between undisturbed aquifer and well centre  
0.076

**Lw**  
length of intake  
32

**H**  
saturated thickness of aquifer  
182

**Lw**  
distance b/n water table and bottom of intake  
179.403

**Re**  
effective well radius  
32.12

**t**  
initial drawdown  
69

**Yw**  
vertical distance between the water level in well at time t and equilibrium level  
0.767

**Le/rw**  
dimensionless co-efficient that is a function of **Le/rw**, and **Lw** < **H**  
421.0526316

**A**  
dimensionless co-efficient that is a function of **Lw**, and **Lw** < **H**  
8

**B**  
dimensionless co-efficient that is a function of **Lw**, and **Lw** < **H**  
2

**C**  
dimensionless co-efficient that is a function of **Lw**, and **Lw** = **H**  
10

---

If **Lw** < **H**

\[
\ln\left(\frac{R_e}{R_w}\right) = \left\{1.1 \cdot \left[\ln\left(\frac{L_w}{r_w}\right)\right]^{-1} + A + B \cdot \ln\left(\frac{H - L_w}{r_w}\right) \cdot \left(\frac{L_w}{r_w}\right)^{-1}\right\}^{-1}
\]

\[
= \frac{L_w}{r_w} = H \ m
\]

If **Lw** = **H**

\[
\ln\left(\frac{R_e}{R_w}\right) = \left\{1.1 \cdot \left[\ln\left(\frac{L_w}{r_w}\right)\right]^{-1} + C \cdot \left(\frac{L_w}{r_w}\right)^{-1}\right\}^{-1}
\]

\[
= 6.05 \ m
\]

---

**K**  
[rc^{-2} \cdot \ln(R_e/R_w)] \cdot 2L \cdot t \cdot \ln(Y_w/Y_f)

\[
= 1.14E-06 \ \text{m/min}
\]

**Produced by:** Alistair Walsh  
**Date:** 7/05/2010

**Checked by:** Kate Furness  
**Date:** 10/05/2010

---

Ref.  
Aquifer Test Solutions: Slug Tests

Bouwer Rice

Project Name: BHP-B SEIS Field Investigations
Client: BHP-B

Date: 02-May-10
Time: 12:25

Well No. / Name: PT63
Depth to equilibrium water level (m RL): 8.1 mPVC

Type of test: Rising head
Type of test: Falling head

Depth to Water at Time '0':
Y0 = 0.19 (m)

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* Includes residual drawdown for falling head test.

Prepared by Alistair Walsh, 10 May 2010
Revision A
Aquifer Test Solutions: Slug Tests

Project Name: BHP-B SEIS Field Investigations
Client: BHP-B
Date: 02-May-10
Time: 12:25

Well No. / Name: PT63
Depth to equilibrium water level (m RL): 8.1 mTOC
Type of test: Rising head
Well Completion: Fully Penetrating
Falling head
Partially Penetrating

\[ r_c = \text{casing radius} \]
\[ r_w = \text{radial distance between undisturbed aquifer and well centre} \]
\[ L_w = \text{length of intake} \]
\[ H = \text{saturated thickness of aquifer} \]
\[ L_w = \text{distance b/n water table and bottom of intake} \]
\[ R_e = \text{effective well radius} \]
\[ t = \text{time} \]
\[ Y_o = \text{initial drawdown} \]
\[ Y_t = \text{vertical distance between the water level in well at time } t \text{ and equilibrium level} \]
\[ L_w / R_e = \text{dimensionless co-efficient that is a function of } L_w / R_e \text{ and } L_w < H \]
\[ A = 6.5 \]
\[ B = 1.25 \]
\[ C = 7.5 \]

\[ K = \left[ r_c^{-2} \ln \left( R_e / r_w \right) \right] 2L^{-1} \cdot t^{-1} \cdot \ln \left( Y_o / Y_t \right) \]

\[ = 2.62 \times 10^{-5} \text{ m/min} \]
\[ = 0.038 \text{ m/d} \]

## Slug Tests

**Aquifer Test Solutions: Slug Tests**

**Project Name:** BHP-B SEIS Field Investigations  
**Client:** BHP-B  
**Well No. / Name:** RT41  
**Type of test:** Rising head  
**Depth to equilibrium water level (m RL):** 19.675 m PVC  
**Time:** 09:58

### Data

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*Includes residual drawdown for falling head test*
**Aquifer Test Solutions:**

**Slug Tests**

**Bouwer Rice**

**Project Name:** BHP-B SEIS Field Investigations  
**Date:** 29-Apr-10

**Client:** BHP-B  
**Time:** 09:58

**Well No. / Name:** RT41  
**Depth to equilibrium water level (m RL):** 19.675 mTOC

**Type of test:** Rising head  
**Well Completion:** Fully Penetrating

---

**Diagram and Calculations:**

\[ r_c \] = casing radius  
\[ r_w \] = radial distance between undisturbed aquifer and well centre  
\[ L_w \] = length of intake  
\[ H \] = saturated thickness of aquifer  
\[ L_{w_b} \] = distance b/n water table and bottom of intake  
\[ R_e \] = effective well radius  
\[ t \] = time  
\[ Y_{0} \] = initial drawdown  
\[ Y_t \] = vertical distance between the water level in well at time \( t \) and equilibrium level  
\[ L_{w_b}/r_w \] = dimensionless co-efficient that is a function of \( L_{w_b}/r_w \) and \( L_w < H \)

- 0.05  
- 0.1015  
- 22  
- 22  
- 82.325  
- 16.07  
- 1.2  
- 0.275  
- 0.04  
- 216.7487685

**A =** dimensionless co-efficient that is a function of \( L_{w_b}/r_w \) and \( L_w < H \)  
- 6.3

**B =** dimensionless co-efficient that is a function of \( L_{w_b}/r_w \) and \( L_w < H \)  
- 1.2

**C =** dimensionless co-efficient that is a function of \( L_{w_b}/r_w \) and \( L_w = H \)  
- 7.2

\[ \ln[(R_e/r_w)] = \{1.1 \cdot [\ln(L_{w_b}/r_w)]^{-1} + A \cdot [\ln(H-L_{w_b})/r_w] \cdot (L_{w_b}/r_w)^{-1}\}^{1} = L_{w_b} = H \]

- \[ Y_t = Y_{0} - 0.04 \]

**Produced by:** Alistair Walsh  
**Date:** 6/05/2010

**Checked by:** Kate Furness  
**Date:** 10/05/2010

**K =** dimensionless co-efficient that is a function of \( L_{w_b}/r_w \) and \( L_w = H \)  
- 4.62E-04 m/min

**Produced by:** Alistair Walsh  
**Date:** 6/05/2010

**Checked by:** Kate Furness  
**Date:** 10/05/2010

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Ref.  


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* Includes residual drawdown for falling head test.
Aquifer Test Solutions: Slug Tests Bouwer Rice

Project Name: BHP-B SEIS Field Investigations
Client: BHP-B
Date: 29-Apr-10
Time: 12:25

Well No. / Name: RT42
Depth to equilibrium water level (m RL): 6.355 m TOC

Type of test: Rising head
Well Completion: Fully Penetrating

---

\[
K = \left[ r_c^2 \cdot \ln \left( \frac{R_w}{r_w} \right) \right] 2L^{-1} \cdot t^{-1} \cdot \ln \left( \frac{Y_t}{Y_0} \right)
\]

Prepared by Alistair Walsh, 10 May 2010
Revision A 17/03/2011 \ RT42 Bouwer&Rice Analysis(compressed).xlsx \ B&R (Solution)

**Aquifer Test Solutions:** Slug Tests

**Bouwer Rice**

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* Includes residual drawdown for falling head test.
Aquifer Test Solutions: Slug Tests Bouwer Rice

Project Name: BHP-B Supplementary EIS Field Investigations
Client: BHP-B
Date: 02-May-10
Time: 13:41

Well No. / Name: PT62
Depth to equilibrium water level (m RL): 39.384 mTOC

Type of test: Rising head
Well Completion: Fully Penetrating

\[ r_c = \text{casing radius} = 0.05 \]
\[ r_w = \text{radial distance between undisturbed aquifer and well centre} = 0.1015 \]
\[ L_w = \text{length of intake} = 19 \]
\[ H = \text{saturated thickness of aquifer} = 12 \]
\[ L_w = \text{distance b/n water table and bottom of intake} = 26.62 \]
\[ R_e = \text{effective well radius} = 7.91 \]
\[ t = \text{time} = 0.05 \]
\[ Y_o = \text{initial drawdown} = 0.336269895 \]
\[ Y_t = \text{vertical distance between the water level in well at time t and equilibrium level} = 0.006 \]
\[ L_w/r_w = 187.1921182 \]

\[ A = 5.7 \] (dimensionless co-efficient that is a function of \( L_w/r_w \), and \( L_w < H \))
\[ B = 1 \] (dimensionless co-efficient that is a function of \( L_w/r_w \), and \( L_w < H \))
\[ C = 6 \] (dimensionless co-efficient that is a function of \( L_w/r_w \), and \( L_w = H \))

\[ Y_t(t) = \{1.1 \cdot \ln[L_w/r_w]\}^{-1} + A \cdot \ln[(H-L_w)/r_w] \cdot (L_w/r_w)^{-1} \]
\[ Y_t(t) = \{1.1 \cdot \ln[L_w/r_w]\}^{-1} + C \cdot (L_w/r_w)^{-1} \]
\[ Y_t(t) = \{1.1 \cdot \ln[L_w/r_w]\}^{-1} + A \cdot \ln[(H-L_w)/r_w] \cdot (L_w/r_w)^{-1} \]

\[ Y_t(t) = \{1.1 \cdot \ln[L_w/r_w]\}^{-1} + C \cdot (L_w/r_w)^{-1} \]

\[ K = \left[ r_c^{-1} \cdot \ln(1.1) \right] 2L^{-1} \cdot t^{-1} \cdot \ln \left( \frac{Y_t}{Y_o} \right) \]
\[ K = 2.31E-02 \text{ m/min} \]
\[ K = 33.230 \text{ m/d} \]

Prepared by Alistair Walsh, 10 May 2010
Revision A 17/03/2011 \ PT62 Bouwer&Rice Analysis.xls \ B&R (Solution)

B.3 Hvorslev method
Hvorslev analysis of test conducted at well: RT02b

Data collected by: A. Walsh / T. McCarthy
Client: BHP Billiton
Test location: Borefield Rd
Date: 2/05/2010

Hydrostratigraphic Unit: Arcoona Qtz
Aquifer type: Fractured Rock (confined)

Well depth from RP: 342 m
Length of well screen (L): 24 m
Casing radius (r): 0.025 m
Well radius (R): 0.1015 m

Tₙₗ (interpolated from graph): 1200 seconds

Indicate model that best represents tested well

1. Constructed well
2. Open hole completion

Notes:
- Solution is unsuitable for cases where
  - screen becomes dewatered (rising head test)
  - water table straddles screen (rising or falling head test)

Solution:
\[ K = \frac{r^2 \ln(L/R)}{2LT_0} \]

\( K = 5.93E-08 \text{ m/sec} \) OR \( 0.0051 \text{ m/day} \)
Hvorslev analysis of test conducted at well: RT02b

Date of test: 2/05/2010

SWL: 51.78 m
Slugged head (ho) 0.13 m

Data collected by: A. Walsh / T. McCarthy
Client: BHP Billiton
Test location: Borefield Rd
Aquifer type: Fractured Rock(confined)

\[ T_{37} \text{ (interpolated from graph)} \] 1200 seconds

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Reduced by: Alistair Walsh
Date: 10/05/2010

Checked by: Kate Furness
Date: 10/05/2010

Resource & Environmental Management Pty Ltd
Hvorslev analysis of test conducted at well: RT05c

Data collected by: A. Walsh / T. McCarthy
Client: BHP Billiton
Test location: Mulgaria Station
Date: 30/04/2010

Well depth from RP: 634 m
Length of well screen (L): 214 m
Casing radius (r): 0.025 m
Well radius (R): 0.1015 m
T₃₇ (interpolated from graph): 2610 seconds

Indicate model that best represents tested well

1. Constructed well
2. Open hole completion

Solution:

\[ K = \frac{r^2 \ln(L / R)}{2LT_0} \]

\[ (L / R) > 8 \text{ solution valid} \]

K = 4.28E-09 m/sec OR 0.0004 m/day

notes: 1. solution is unsuitable for cases where
   - screen becomes dewatered (rising head test)
   - water table straddles screen (rising or falling head test)
**Hvorslev analysis of test conducted at well:** RT05c

**Date of test:** 30/04/2010

**Data collected by:** A Walsh

**Client:** BHP Billiton

**Test location:** Mulgaria Station

**Aquifer type:** fractured rock (confined)

**$T_{37}$ (interpolated from graph):** 2610 seconds

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**Client:** Resource & Environmental Management Pty Ltd

**Date:** 10/5/2010

**Checked by:** Alistair Walsh

**Date:** 11/05/2010

**Reduced by:** Kate Furness

**Date:** 10/5/2010

**SLW:** 18.67 m

**Slugged head (ho):** 0.85 m
Aquifer Test Solutions: Slug Tests

Hvorslev analysis of test conducted at well: RT09

Data collected by: A. Walsh / T. McCarthy
Client: BHP Billiton
Test location: Stuart Creek Station
Date: 2/05/2010

Hydrostratigraphic Unit: Brachina Formation
Aquifer type: Fractured Rock (confined)

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$T_{37}$ (interpolated from graph): 21000 seconds

Indicate model that best represents tested well

1. Constructed well

2. Open hole completion

Solution:

$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

$$(L/R) > 8$$ solution valid

$K = 1.53E-09 \text{ m/sec} \quad OR \quad 0.0001 \text{ m/day}$
Hvorslev analysis of test conducted at well: RT09

Date of test: 2/05/2007

Data collected by: A. Walsh / T. McCarthy
Client: BHP Billiton
Test location: Stuart Creek Station
Aquifer type: Fractured Rock (confined)

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Reduced by: Alistair Walsh
Date: 10/05/2010

Checked by: Kate Furness
Date: 10/05/2010

Prepared by Alistair Walsh, 10 May 2010
Revision A
17/03/2011 | RT09 Hvorslev2.xlsx | Test data
Hvorslev analysis of test conducted at well: RT07a

Data collected by: A. Walsh / T. McCarthy
Client: BHP Billiton
Test location: Mulgaria Station
Date: 30/04/2010

Hydrostratigraphic Unit: Amberonna Formation
Aquifer type: fractured rock (confined)

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<td>Casing radius (r)</td>
<td>0.025 m</td>
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<td>Well radius (R)</td>
<td>0.076 m</td>
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$T_{37}$ (interpolated from graph) 200 seconds

Indicate model that best represents tested well

1. Constructed well

2. Open hole completion

notes: 1. solution is unsuitable for cases where
   - screen becomes dewatered (rising head test)
   - water table straddles screen (rising or falling head test)

Solution:

$$K = \frac{r^2 \ln(L/R)}{2LT_0} \quad (L/R) > 8$$

$K = 9.07E-08 \text{ m/sec}$ OR $0.01 \text{ m/day}$
Hvorslev analysis of test conducted at well: RT07a

Date of test: 30/04/2010

Data collected by: A Walsh
Client: BHP Billiton
Test location: Mulgaria Station
Aquifer type: fractured rock (confined)

T37 (interpolated from graph) 200 seconds

SWL: 13.11 m
Slugged head (ho): 0.04 m

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Reduced by: Kate Furness
Date: 10/5/2010

Checked by: Alistair Walsh
Date: 11/05/2010
Hvorslev analysis of test conducted at well: RT07b

Data collected by: A. Walsh / T. McCarthy
Client: BHP Billiton
Test location: Mulgaria Station
Date: 1/05/2010

Hydrostratigraphic Unit: Amberooana Formation
Aquifer type: Fractured Rock (confined)

SWL: 18.51 m
Slugged head (ho): 0.68 m

Well depth from RP: 198 m
Length of well screen (L): 32 m
Casing radius (r): 0.025 m
Well radius (R): 0.076 m

T_{37} (interpolated from graph): 20000 seconds

Indicate model that best represents tested well

1. Constructed well
2. Open hole completion

notes:
1. solution is unsuitable for cases where
   - screen becomes dewatered (rising head test)
   - water table straddles screen (rising or falling head test)

Solution:

\[
K = \frac{r^2 \ln(L/R)}{2LT_0} \quad \text{if} \quad \frac{L}{R} > 8
\]

\[
K = 2.95E-09 \text{ m/sec} \quad \text{OR} \quad 0.0003 \text{ m/day}
\]
Hvorslev analysis of test conducted at well: RT07b

Date of test: 1/05/2010

SWL: 18.51 m
Slugged head (ho) 0.68 m

Data collected by: A. Walsh / T. McCarthy
Client: BHP Billiton
Test location: Mulgaria Station
Aquifer type: Fractured Rock (confined)

T<sub>37</sub> (interpolated from graph) 20000 seconds

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Reduced by: Alistair Walsh
Date: 10/05/2010

Checked by: Kate Furness
Date: 10/05/2010
Hvorslev analysis of test conducted at well: RT41

Data collected by: A. Walsh / T. McCarthy
Client: BHP Billiton
Test location: Borefield Rd
Date: 29/04/2010

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<td>Aquifer type:</td>
<td>Fractured Rock</td>
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Well depth from RP: 102 m
Length of well screen (L): 22 m
Casing radius (r): 0.05 m
Well radius (R): 0.1015 m

$T_{37}$ (interpolated from graph): 20 seconds

Indicate model that best represents tested well

1. Constructed well
2. Open hole completion

notes: 1. solution is unsuitable for cases where
       - screen becomes dewatered (rising head test)
       - water table straddles screen (rising or falling head test)

Solution:

\[
K = \frac{r^2 \ln(L / R)}{2LT_0}
\]

\[
K = 1.53E-05 \text{ m/sec} \quad \text{OR} \quad 1.3202 \text{ m/day}
\]
Hvorslev analysis of test conducted at well: RT41

Date of test: 29/04/2010

SWL: 19.68 m
Slugged head (ho): 0.27 m

Data collected by: A. Walsh / T. McCarthy
Client: BHP Billiton
Test location: Borefield Rd
Aquifer type: Fractured Rock
T₃₇ (interpolated from graph): 20 seconds

<table>
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Reduced by: Alistair Walsh
Date: 10/05/2010

Checked by: Kate Furness
Date: 10/05/2010

Prepared by Alistair Walsh, 10 May 2010
Revision A
Hvorslev analysis of test conducted at well: PT63

Data collected by: A. Walsh / T. McCarthy  
Client: BHP Billiton  
Test location: Stuart Creek Station  
Date: 2/05/2010  

Hydrostratigraphic Unit: Bulldog Shale  
Aquifer type: fractured rock (confined)  

Well depth from RP: 48 m  
Length of well screen (L): 24 m  
Casing radius (r): 0.05 m  
Well radius (R): 0.1015 m  

T<sub>37</sub> (interpolated from graph): 570 seconds

Indicate model that best represents tested well

1. Constructed well

2. Open hole completion

notes: 1. solution is unsuitable for cases where
- screen becomes dewatered (rising head test)
- water table straddles screen (rising or falling head test)

Solution:

\[ K = \frac{r^2 \ln(L/R)}{2LT_0} \]

\[ (L/R) > 8 \text{ solution valid} \]

\[ K = 4.99E-07 \text{ m/sec} \]

OR

\[ 0.043 \text{ m/day} \]
Hvorslev analysis of test conducted at well: **PT63**

**Date of test:** 2/05/2010

**SWL:** 8.10 m  
**Slagged head (ho):** 0.19 m

**Data collected by:** A Walsh / T McCarthy

**Client:** BHP Billiton

**Test location:** Stuart Creek Station

**Aquifer type:** fractured rock (confined)

**$T_{37}$ (interpolated from graph):** 570 seconds

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Hvorslev analysis of test conducted at well: RT42

Data collected by: A. Walsh / T. McCarthy
Client: BHP Billiton
Test location: Borefield Rd
Date: 29/04/2010

SWL: 6.36 m
Slugged head (ho): 0.46 m

Hydrostratigraphic Unit: Bulldog Shale
Aquifer type: fractured rock (confined)

Well depth from RP (L): 72 m
Length of well screen (L): 65 m
Casing radius (r): 0.05 m
Well radius (R): 0.1015 m
T<sub>37</sub> (interpolated from graph): 90 seconds

Indicate model that best represents tested well:

1. Constructed well
2. Open hole completion

Solution:

\[ K = \frac{r^2 \ln(L/R)}{2LT_0} \]

\( (L/R) > 8 \)

solution valid

\[ K = 1.38E-06 \text{ m/sec} \]

OR

\[ 0.119 \text{ m/day} \]

notes: 1. solution is unsuitable for cases where
   - screen becomes dewatered (rising head test)
   - water table straddles screen (rising or falling head test)
Hvorslev analysis of test conducted at well: RT42

Date of test: 2/05/2010

SWL: 6.36 m
Slugged head (ho): 0.46 m

Data collected by: A Walsh, T McCarthy
Client: BHP Billiton
Test location: Borefield Rd

Aquifer type: fractured rock (confined)

\( T_{37} \) (interpolated from graph) 90 seconds

<table>
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<tr>
<th>Time (seconds)</th>
<th>Depth to water ( d ) (m)</th>
<th>d in level ( h/h_0 )</th>
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<tr>
<td>1000</td>
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<td>0.01</td>
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Reduced by: Alistair Walsh
Date: 10/05/2010

Checked by: Kate Furness
Date: 10/05/2010
Hvorslev analysis of test conducted at well: PT62

Data collected by: A. Walsh / T. McCarthy
Client: BHP Billiton
Test location: Stuart Creek Station
Date: 2/05/2010

Hydrostratigraphic Unit: Cadna-Owie
Aquifer type: Sedimentary (confined)

Well depth from RP: 66 m
Length of well screen (L): 19 m
Casing radius (r): 0.05 m
Well radius (R): 0.1015 m

$T_{37}$ (interpolated from graph): 1.25 seconds

Indicate model that best represents tested well

1. Constructed well
2. Open hole completion

Solution:

$$K = \frac{r^2 \ln(L/R)}{2LT_0} \quad (L/R) > 8$$

Solution valid

$$K = 2.75E-04 \text{ m/sec} \quad \text{OR} \quad 23.792 \text{ m/day}$$
Hvorslev analysis of test conducted at well: PT62

Date of test: 2/05/2010

SWL: 39.38 m
Slugged head (ho): 0.33 m

Data collected by: A. Walsh / T. McCarthy
Client: BHP Billiton
Test location: Stuart Creek Station
Aquifer type: Sedimentary (confined)

Tₚₗ (interpolated from graph): 1.25 seconds

Time Depth to water d in level h/h₀
(seconds) (m) (m)

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Depth to water (m)</th>
<th>d in level (m)</th>
<th>h/h₀</th>
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<td>0.0573</td>
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Prepared by Alistair Walsh, 10 May 2010
Revision A

Reduced by: Alistair Walsh
Date: 10/05/2010

Checked by: Kate Furness
Date: 10/05/2010
Attachment C
Major ion & isotope water chemistry
Table C.1  $^{36}$Cl groundwater concentrations for regional aquifers

<table>
<thead>
<tr>
<th>Aquifer system</th>
<th>Sample location</th>
<th>Cl (mg/L)</th>
<th>$^{36}$Cl:Cl (x10$^{-15}$)</th>
<th>$^{36}$Cl atoms/L (x10$^6$)</th>
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<tbody>
<tr>
<td>artesian Eromanga (GAB)</td>
<td>Various [1]</td>
<td>6,300</td>
<td>7.5</td>
<td>0.55</td>
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<td>non-artesian Eromanga</td>
<td>Stock well (Millers Creek) [2]</td>
<td>2,000</td>
<td>94</td>
<td>3.19</td>
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<td>Arckaringa Basin</td>
<td>Shallow Boorithanna (Virgo 9) [2]</td>
<td>23,000</td>
<td>7</td>
<td>2.74</td>
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<td>Stuart Shelf</td>
<td>Tent Hill Aquifer (TPW4) [3]</td>
<td>32,000</td>
<td>28</td>
<td>15.22</td>
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<td>Stuart Shelf</td>
<td>Andamooka Limestone Aquifer (MAR4) [3]</td>
<td>22,500</td>
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<td>Adelaide Geosyncline (RT9a) [3]</td>
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<td>Adelaide Geosyncline (RT7a) [3]</td>
<td>31,900</td>
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Notes:
2. OZ Minerals 2009
3. SKM/REM 2008
Attachment D
Total suspended solids analytical data
Table D.1 Reported TSS values for wells sampled multiple times

<table>
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<tr>
<th>Sample ID</th>
<th>Drilled TSS (mg/L)</th>
<th>Depth</th>
<th>Airlifted TSS (mg/L)</th>
<th>Depth</th>
<th>Bailed TSS (mg/L)</th>
<th>Depth</th>
<th>Pumped TSS (mg/L)</th>
<th>Depth</th>
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<td>MXTB-07a</td>
<td>810</td>
<td>106m</td>
<td>13</td>
<td>98-104m</td>
<td>10</td>
<td>98-104m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MXTB-07b</td>
<td>11</td>
<td>186m</td>
<td>4</td>
<td>166-172m</td>
<td>12</td>
<td>166-172m</td>
<td></td>
<td></td>
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<td>MXTB-10a</td>
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<td>136-142m</td>
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<td>136-142m</td>
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<td></td>
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<td>MAR3</td>
<td></td>
<td></td>
<td>445</td>
<td>228m</td>
<td></td>
<td>318</td>
<td>88-228m</td>
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<td>MAR4</td>
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<td>4740</td>
<td>Open Hole Airlift 70-268.3m (Pws/Pwc)</td>
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<td>PT-5a</td>
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<td>Constructed Airlift 250-262m (Pwc)</td>
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Notes: €a; Andamooka Limestone  Pws; Arcoona Quartzite  Pwc; Corraberra Sandstone
### Table D.2  TSS concentrations and sampled aquifers

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Date Sampled</th>
<th>Sampling Method</th>
<th>Depth/Construction</th>
<th>TSS (mg/L)</th>
<th>Geology</th>
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<td>LR - 10</td>
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<td>Screened interval 98</td>
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<td>Screened interval</td>
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<td>€a</td>
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<td>Screened interval</td>
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Table D.2  TSS concentrations and sampled aquifers (cont.)

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