Silver Springs
Sub-Surface Gas Storage Project

Report on Hydrological Investigations
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Summary

AGL Energy Limited (AGL) propose to use the now depleted Silver Springs gas field as a sub-surface storage for coal seam gas (CSG) prior to its transport to the coast for liquefaction and export. The target gas field is located approximately 50 km south of Surat and 70 km north east of the town of St George (Figure 1). AGL proposes to introduce the gas into the Showgrounds Formation using existing gas wells and a new well.

The Showgrounds Formation at Silver Springs gas field underlies the regionally contiguous Snake Creek Mudstone Member of the Moolayember Formation, which is a recognised as both an effective capping unit and confining layer (Henning *et al.* 2006). Commercial production started in May 1978, confirming that the Snake Creek Mudstone Member is an effective gas trap. Artesian groundwater was also produced in association with the gas and condensate (Bridge Oil Ltd 1988), also confirming that the Snake Creek Mudstone Member is an effective confining layer.

The Department of Employment, Economic Development and Innovation (DEEDI) have rated the gas sequestration potential for 35 basins in Queensland, including the Surat and Bowen Basins (DEEDI 2009). DEEDI (2009) have concluded that the subsurface conditions of the Showgrounds Formation are viable for gas sequestration.

The Silver Springs field is hosted within the Bowen Basin but is overlain by a thick sequence of Surat Basin rocks that host multiple aquifers of the Great Artesian Basin. Henning *et al.* (2006) concluded that there is little natural connection between the Showgrounds Formation and the overlying aquifers. A search was undertake of the Department of Environment and Resource Management Groundwater Database (DERM) groundwater database (GWDB) for records of registered bores and this located 150 bores within a 20 km radius of the Silver Springs gas field.

The bores located the closest to the Silver Springs gas field are the most probable potential receptor bores. There are 20 bores located near the Silver Springs gas field. None of these bores are documented as being completed as water bores tapping the Showground Sandstone in the DERM bore database. However, six of the registered bores are shut-in petroleum wells and these remain open to the Showgrounds Formation.

Although there are bores in the relative proximity of the Silver Springs gas field, these are unlikely to be receptors of impact from the proposed gas storage operations due to the presence of intervening confining units between the likely tapped aquifers and the very much deeper Showgrounds Formation. This conclusion carries the caveat that the petroleum wells near the Silver Springs gas field have sound casing and cementing integrity to preclude artificial cross connections between formations vertically penetrated by the wells. Wells with poor or compromised integrity could potentially allow communication between aquifers, which, under the proposed project, would permit water and gas and condensate to migrate from the Showgrounds Formation to the shallower Great Artesian Basin aquifers. RPS recommends the following activities be undertaken to assess the cross connection potential:

- Investigation of the integrity of the bores proposed to be used for this project, and ideally the other suspended petroleum wells in the field. This may require running geophysical logs for these wells to confirm casing and cementing condition.
- Survey the local landowners to confirm the nature of water supply use from the 20 potential “receptor” bores that are likely to be used to supply water for any use.

- Map the potentiometric head in the Showgrounds formation using newly collected data.

Collect groundwater samples within the vicinity of the project to provide a baseline suite of constituents to establish current groundwater quality and groundwater type of the water within the Showgrounds Formation at the Silver Springs gas field as well as in the local water bores. The analysis suite should include major ions and minor ions such as fluoride and hydrocarbons (i.e. TPH and BTEX).

By-product water recovered from the operating wells during CSG gas recovery would be expected to be unsuitable for surface discharge to waterways in the absence of treatment to address contaminants such as salts and hydrocarbons. Specific attention will need to be paid to the integrity of water holding and treatment facilities, notwithstanding that the amount of water produced is likely to be similar to the very small volumes historically recovered.

The available evidence suggests that the Showgrounds Formation at Silver Springs has gas storage potential. This assessment is based on the presence of the overlying gas seal, the Snake Creek Mudstone Member; the DEEDI (2009) gas sequestration study; and a lack of significant receptors near the Silver Springs gas field.

Limitations Statement

The sole purpose of this report and the associated services performed by RPS Australia East Pty Ltd (RPS) is to provide a report documenting groundwater and surface water investigations undertaken for the Silver Springs Sub-Surface Gas Storage Project in accordance with the scope of services set out in the contract between RPS and AGL Energy Limited ('the Client'). That scope of services was defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to the data sources for the relevant sites.

RPS derived the data in this report primarily from publicly available details for water bores, information provided by AGL Energy Limited and available topographic data.

The passage of time, manifestation of latent conditions or impacts of future events may require further exploration at the sites and subsequent data analysis, and re-evaluation of the findings, observations and conclusions expressed in this report.

No warranty or guarantee, whether express or implied, is made with respect to the data reported or to the findings, observations and conclusions expressed in this report. Further, such data, findings, observations and conclusions are based solely upon site conditions, information, drawings supplied by the Client and others in existence at the time of the investigation.

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Appendices

1 Introduction

1.1 Background

The Silver Springs gas field is located approximately 50 km south of Surat and 70 km north east of the town of St George (Figure 1). This gas / condensate field was discovered by Bridge Oil in May 1970 (Bridge Oil 1988).

AGL Energy Limited (AGL) propose to use the now depleted gas field as a sub-surface storage for coal seam gas (CSG) prior to its transport to the coast for liquefaction and export.

The Silver Springs gas field is hosted within the Triassic age Showgrounds Formation of the upper section of the Bowen Basin. The field is overlain by a thick sequence of Surat Basin rocks that host multiple aquifers of the Great Artesian Basin.

A review of the potential impact of the proposed use of the Silver Springs field for CSG storage is required for regulatory approval purposes. To this end AGL Energy Limited has retained RPS to undertake investigations into the potential impact of the use of the field on groundwater and a preliminary assessment of potential flooding risk at the site.

1.2 The scope of works conducted by RPS for the requested assessment work included the following:

- Project management;
- Obtain and review Geological Survey of Queensland (GSQ) documentation relevant to gas sequestration in depleted reservoirs;
- Obtain details for stratigraphy of wells constructed in the Silver Springs field from the GSQ Queensland Petroleum Exploration Data (QPED) database;
- Review available QPED data to attempt to establish details for groundwater heads in Showgrounds / Clematis Sandstone at Silver Springs;
- Obtain well completion reports for key existing injection wells from GSQ;
- Identify key aquifers in vicinity of Silver Springs field based on available stratigraphy and hydrogeological reporting;
- Undertake a Department of Environment and Resource Management (DERM) groundwater database (GWDB) search over a 20 km radius circle centred on the Silver Springs gas field;
- Review DERM information to identify aquifers tapped by registered water bores within a 20 km radius of Silver Springs gas field;
- Undertake a DERM database search to identify the closest water bores to the Silver Springs field that actively tap the Showgrounds Formation / Clematis Sandstone;
- Review published geological mapping to identify locations of key mapped faults in the vicinity of the Silver Springs gas field;

  - Obtain historical data for water production from the Silver Springs field from AGL Energy Limited or GSQ (if available);
  - Provide initial documentation of the hydrogeological framework, potential water bore receptors and potential water receptors of existing operation;
  - Obtain from Mosaic Oil details of the quality of water historically produced from reservoirs in the Showgrounds / Clematis Sandstones in the Silver Springs area and collate and document this data;
  - Collate historical groundwater quality for major Great Artesian Basin aquifers in the vicinity of the Silver Springs field;
  - Undertake a DERM groundwater database search for bores tapping the Clematis Sandstone, summarise available groundwater quality data and provide commentary regarding background water quality in Clematis Sandstone;
  - Undertake a GSQ QPED database search for bores tapping the Showgrounds Formation, summarise available groundwater quality data and provide commentary regarding background water quality in Showgrounds Formation;
  - Provide a brief description of the conceptual model (groundwater recharge, discharge and flow for the main aquifers) and any surface water-groundwater connectivity;
  - Review available topographic data and define the surface water catchment for the gas field;
  - Undertake a literature review for potentially relevant flood studies / surface water assessments;
  - Provide commentary regarding flooding risk for the field;
  - Identify data gaps and provide an outline of further investigations and/or monitoring programs required to assess the impact of the proposed development on groundwater resources;
  - Document findings in a summary report;
- Deliver the report with a presentation to AGL Energy Limited.

This report provides documentation of the summary findings of the assessment for the aforementioned scope of works.

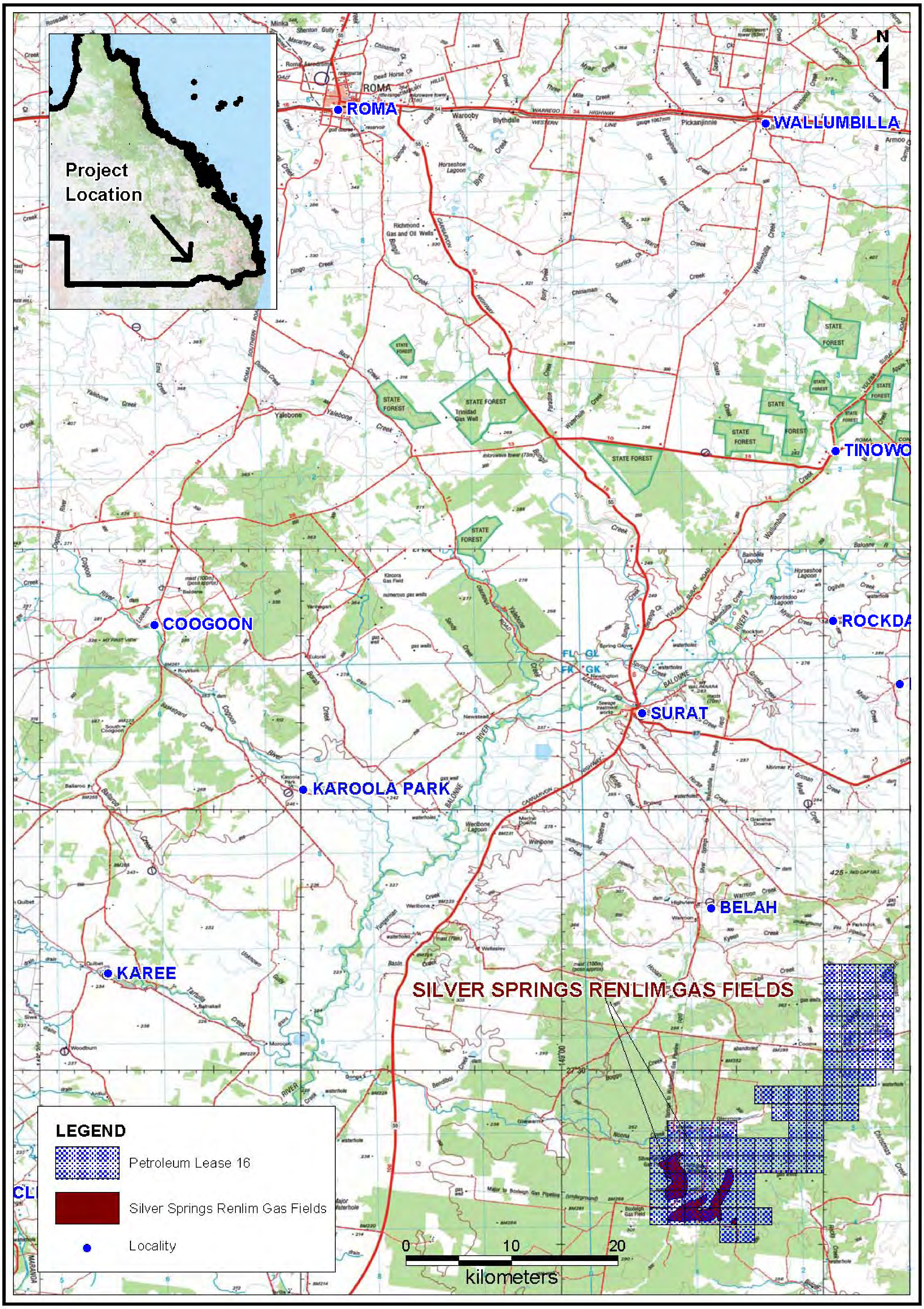

Figure 1: Map Showing the Location of the Silver Springs and Renlim Gas Fields

2 Review of GSQ documentation relevant to gas sequestration in depleted reservoirs

The Queensland Department of Employment, Economic Development and Innovation (DEEDI) has developed an atlas for gas sequestration for Queensland (DEEDI, 2009). The atlas addresses carbon dioxide sequestration, which is appropriate for assessing potential methane storage options, since the geological requirements to sequester carbon dioxide are similar to those necessary to storing methane.

DEEDI (2009) rates the prospectivity [sic] of storing gas using the following criteria:

- A viable reservoir seal;
- A reservoir seal situated in the correct stratigraphic position;
- No fault or joins breeching the seal proximal to the storage unit;
- The base of the seal below 800 m;
- Sufficient formation porosity; and
- Sufficient formation permeability.

DEEDI (2009) has rated the gas sequestration potential for 35 basins in Queensland, including the Surat and Bowen Basins. Although the Silver Springs site is directly underlain by Surat Basin, the gas field, specifically the Showgrounds Formation, is located stratigraphically within the Bowen Basin, which underlies the Surat Basin at depth. Accordingly, the following discussion is based on the storage potential within the Bowen Basin strata and not the Surat Basin strata.

The Queensland portion of the Bowen Basin exceeds 180,000 km^2 and is composed of Permian to Triassic age continental and shallow marine rocks. These clastic sedimentary rocks were deposited in a basin with a complex history of extension, compression and subsidence. The Bowen Basin strata can be up to 10 km in total thickness. The most significant groundwater resources in the Bowen Basin are hosted by the Clematis Group sandstones, which are stratigraphically equivalent to the Showgrounds Formation (Section 8.1).

The Middle Triassic age Showgrounds Formation originally contained over 2,700 Mm^3 of gas and has been the most significant gas producing formation in the Bowen Basin prior to the advent of the current CSG developments. The gas is held in the Showgrounds Formation below a regionally significant seal formed by the Snake Creek Mudstone Member. The Snake Creek Mudstone Member conformably overlies the Showgrounds Formation.

DEEDI (2009) concluded that gas storage in the Showgrounds Formation is viable based on the following criteria:

- A viable seal located at a depth below 800 m;
- A formation located below the regionally contiguous Snake Creek Mudstone Member seal;
- Formation porosity greater than 10%; and
- A median formation permeability of 14 mD (millidarcies);

Henning *et al.* (2006) used a hydrodynamic approach to define flows systems that could be used to sequester carbon dioxide. The hydrodynamic approach included an analysis of pressure data. Henning *et al.* (2006) determined that the hydraulic gradient in the Showgrounds Formation was very low and therefore lateral migration is slow. Henning *et al.* (2006) also used hydrodynamic analysis to suggest that there is very little vertical hydraulic connection between the Showgrounds Formation and the stratigraphically higher Precipice Sandstone, the basal unit of the Surat Basin sequence. It is of some note, however, that Henning *et al.* (2006) did note that there was a potential for the Showgrounds Formation to leak along the zero edge of the formation (i.e. the subcrop margin where the formation pinches out) located approximately 20 km to the west of the Silver Springs gas field.

DEEDI (2009) identified the relatively limited thickness of the overall Showgrounds Formation as the main factor limiting gas storage potential. The Showgrounds Formation was deposited in a braided and meandering fluvial environment and is composed of a series of vertically limited but aerially extensive channel deposits.

The overall temperature gradient in the Bowen Basin has been measured at 37.9 C°/km. The pressure gradient has been measured at 1.4 psia/m. DEEDI (2009) has estimated the potential carbon dioxide storage density at 550 kg/m3. DEEDI (2009) did not estimate the total carbon dioxide storage capacity of the Showgrounds Formation.

3 Silver Springs Gas Field

3.1 History of field

The Silver Springs-Renlim gas field was developed to supply gas to the Brisbane market, 200 km to the east. The Silver Springs-Renlim gas field is located in Petroleum Lease 16 (see Figure 2). Economic gas volumes were confirmed at Silver Springs in May 1970 (Bridge Oil Ltd 1988). The Renlim field was confirmed in 1982. Both the Silver Springs and Renlim fields are gas-condensate fields.

Initially, the Showgrounds Formation was mapped as occurring in different structures at the Silver Springs and Renlim fields. However, 1987 production data indicated that there is physical connection between the fields (Bridge Oil 1988).

The historical well data from the Queensland Petroleum and Exploration database (QPED) records the first well spud data in PL16 at June 1974 and the most recent spud date at July 2009 (Appendix A). The 55 wells, including the 16 existing wells at Silver Springs and Renlim, completed on PL 16 range from 1,900 to 2,300 m in depth.

The status of the PL16 wells is as follows:

- Six wells with gas shows;
- Fifteen wells producing gas;
- Fifteen wells producing gas and condensate;
- Four wells producing oil;
- Four wells producing oil and gas; and
- Thirteen bores that encountered no hydrocarbons.

DEEDI (2009) has rated the Silver Springs gas field as the largest gas field in the Southern Bowen Basin Showgrounds Formation. DEEDI (2009) estimated that the field originally held over 2,700 Mm^3 of gas.

Data presented in Figure 3 illustrates that the gas field pressure declined from just under 2,800 psia in 1977 to nearly 2,300 psia by 1988 (the period covered by the Bridge Oil, 1988 report).

3.2 Stratigraphy of wells constructed in Silver Springs field from GSQ QPED database

The Queensland petroleum exploration database contains references to 11 Silver Springs and 5 Renlim wells (Figure 2). Examples of the stratigraphy at Silver Springs are presented in Table 1 and Table 2 Typical petroleum wells constructed in the Silver Springs area penetrate Cretaceous to Middle Jurassic age Great Artesian Basin aquifer formations before intersecting the Bowen Basin sequence and ultimately the target petroleum reservoir formation the Showgrounds Formation. The Showgrounds Formation is stratigraphically part of the Bowen Basin sequence. The depth to the Showgrounds Formation, deepest formation reached and the aquifer located above the highest plug are summarised in Appendix A.

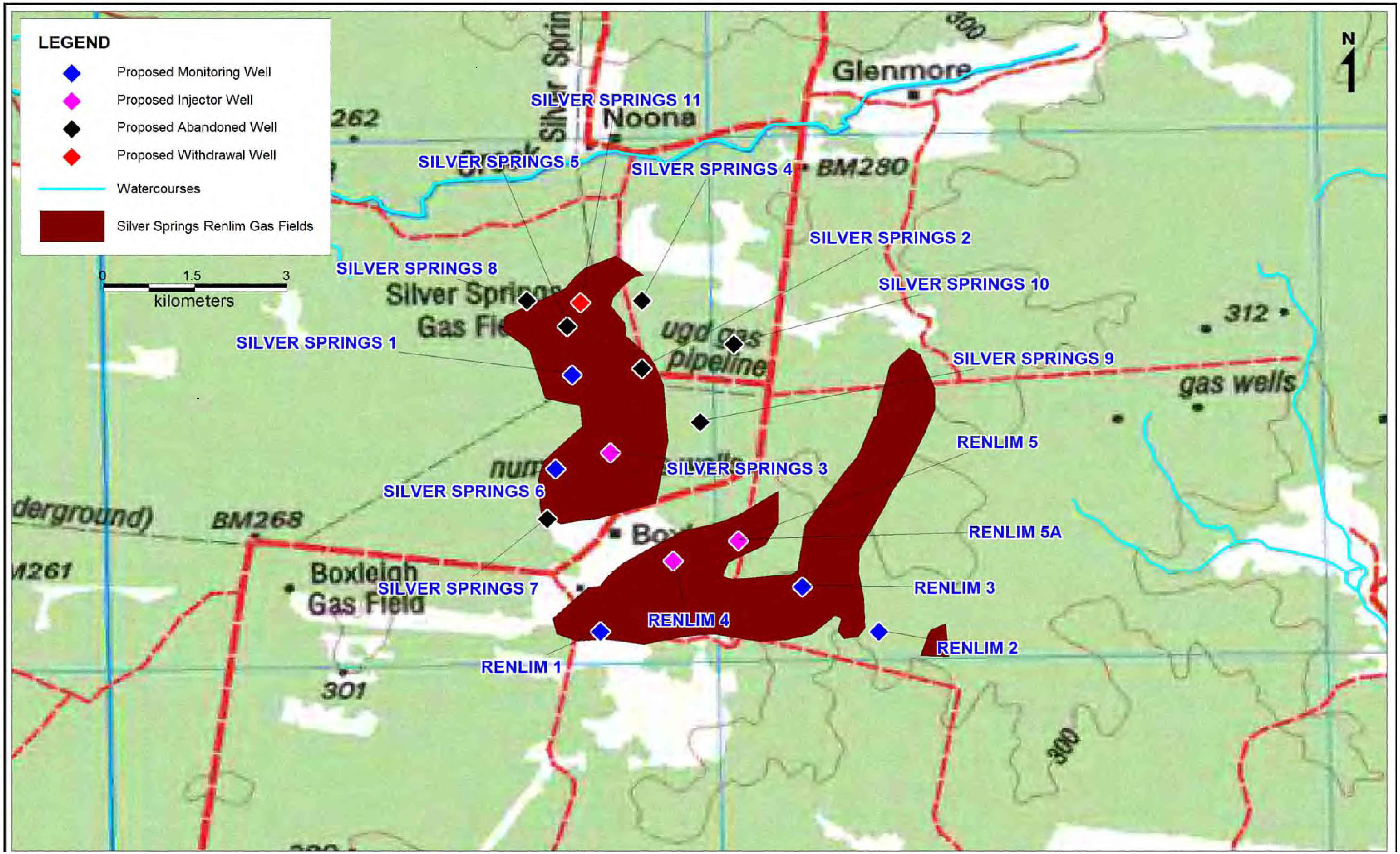

Figure 2: Location of the Silver Springs and Renlim Wells

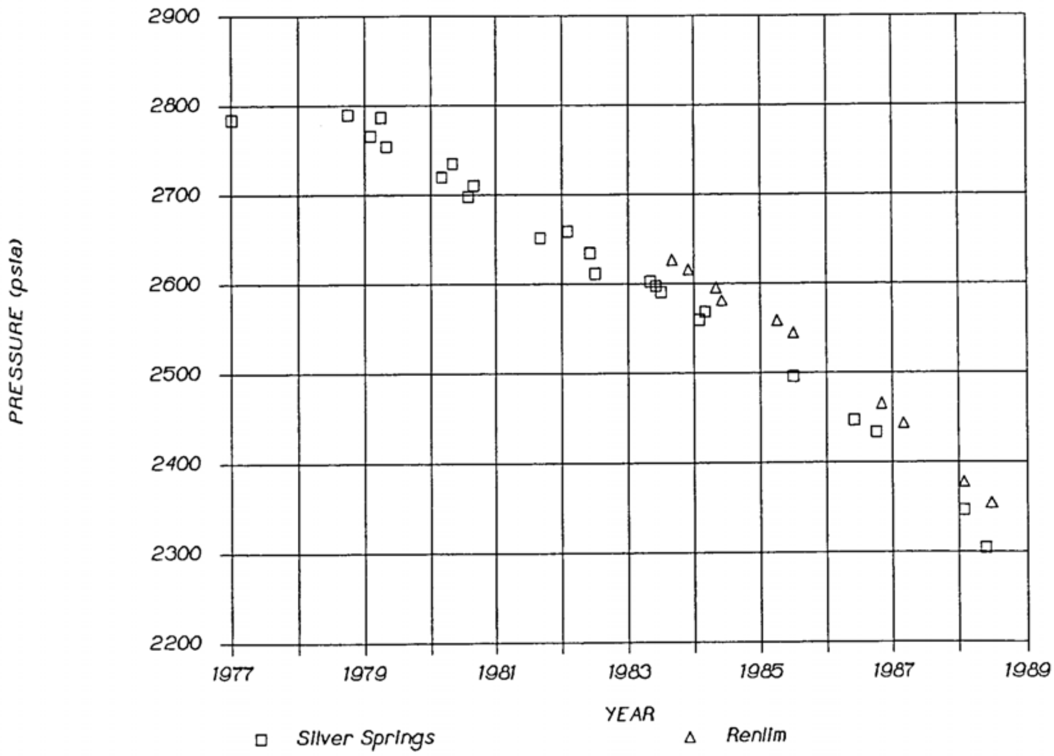

Figure 3: Gas pressure in the Silver Springs and Renlim gas fields (after Bridge Oil, 1988)

Most of the petroleum wells targeting the Showgrounds Formation were not terminated until underlying older basement rocks was encountered. The early Devonian age Timbury Hills Formation has been identified as the basement underlying the Silver Springs gas field.

The well logging for petroleum exploration bore Silver Springs 1 is typical of the petroleum bores that targeted the Showgrounds Formation near the Silver Springs gas field. The Surat Basin aquifer units stratigraphically above the Injune Creek Group which contains the Walloon Sub-Group was frequently grouped into the Blythesdale Group (Section 4) in the available company driller's logs and well completion reports. Table 2 provides the records of stratigraphy for petroleum exploration well Silver Springs 10.

3.3 Review of available QPED data for assessment of groundwater heads in Showgrounds / Clematis Sandstone at Silver Springs

Available data indicates that a series of drill stem tests have been conducted in the Showgrounds Formation in the petroleum exploration bores. A drill stem test (DST) requires isolation of the target production horizons using packers. A packer consists of an inflatable bladder that is placed inside the bore hole and is then inflated to create a seal, thereby isolating a section of the bore hole. The sealed section of the well is in communication with the surface via drill pipe or tubing. The surface connection can be closed off or shut-in and the pressure measured to determine the pressure within the formation isolated by the packer.

DST tests of the Showgrounds Formation were performed in the 16 wells completed in the Silver Springs and Renlim fields.

Table 1 Summary of the stratigraphy at Silver Springs 1
(Stratigraphic Tops Geological Survey Queensland—QPED)

Formation	Depth of formation top (m b GL)	Thickness (m)	Elevation of formation top (m AHD)	Geological age
Sediments	0.0	NA	260.9	Quaternary (?)
Griman Creek Formation	NA	NA	NA	Cretaceous
Surat Siltstone	NA	NA	NA	Cretaceous
Wallumbilla Formation	333.3	201.3	-72.4	Early Cretaceous
Coreena Member	333.3	63.2	-72.4	Cretaceous
Doncaster Member	396.5	138.1	-135.6	Cretaceous
Bungil Formation	534.6	158.5	-273.7	Cretaceous
Mooga Sandstone	693.1	183.2	-432.2	Cretaceous
Orallo Formation	876.3	157.7	-615.4	Jurassic
Gubberamunda Sandstone	1,034.0	155.6	-773.1	Jurassic
Injune Creek Group	1,189.6	319.4	-928.7	Mid to Late Jurassic
Westbourne Formation	1,189.6	83.5	-928.7	Jurassic
Springbok Sandstone	1,273.1	73.2	-1,012.2	Jurassic
Birkhead Formation	1,346.3	162.7	-1,085.4	Jurassic
Hutton Sandstone	1,509.0	164.3	-1,248.1	Mid Jurassic
Evergreen Formation	1,673.3	75.3	-1,412.4	Early Jurassic
Evergreen Formation (Upper Unit)	1,673.3	35.7	-1,412.4	Jurassic
Evergreen Resistivity Marker	1,699.5	NA	-1,438.6	Jurassic
Boxvale Sandstone Member	1,709.0	7.1	-1,448.1	Jurassic
Evergreen Formation (Lower Unit)	1,716.1	32.5	-1,455.2	Jurassic
Precipice Sandstone	1,748.6	8.5	-1,487.7	Early Jurassic
Moolayember Formation	1,757.1	110.4	-1,496.2	Middle Triassic
Moolayember Formation (Upper Unit)	1,757.1	96.0	-1,496.2	Triassic
Snake Creek Mudstone Member	1,853.1	14.4	-1,592.2	Triassic
Showgrounds Formation	1,867.5	10.9	-1,606.6	Triassic
Blackwater Group	1,878.4	5.2	-1,617.5	Late Permian
Timbury Hills Formation	1,883.6	NA	-1,622.7	Devonian
Total depth	1,900.0			

Table 2 Summary of Stratigraphy Silver Springs 10
(Stratigraphic Tops Geological Survey Queensland—QPED)

Formation name	Depth of formation top (m b GL)	Thickness (m)	Elevation of formation top (m AHD)	Geological age
Sediments	0.0	NA	273.3	
Griman Creek Formation	NA	NA	NA	Cretaceous
Surat Siltstone	216.8	132.8	56.5	Cretaceous
Wallumbilla Formation	349.6	200.7	-76.3	Early Cretaceous
Coreena Member	349.6	57.8	-76.3	Cretaceous
Doncaster Member	407.4	142.9	-134.1	Cretaceous
Bungil Formation	550.3	198.3	-277.0	Cretaceous
Mooga Sandstone	748.6	99.7	-475.3	Cretaceous
Orallo Formation	848.3	176.6	-575.0	Jurassic
Gubberamunda Sandstone	1,024.9	177.2	-751.6	Jurassic
Injune Creek Group	1,202.1	344.5	-928.8	Mid to Late Jurassic
Westbourne Formation	1,202.1	94.5	-928.8	Jurassic
Springbok Sandstone	1,296.6	46.3	-1,023.3	Jurassic
Walloon Coal Measures	1,342.9	163.5	-1,069.6	Jurassic
Eurombah Formation	1,506.4	40.2	-1,233.1	Jurassic
Hutton Sandstone	1,546.6	138.7	-1,273.3	Middle Jurassic
Evergreen Formation	1,685.3	79.3	-1,412.0	Early Jurassic
Evergreen Formation (Upper Unit)	1,685.3	37.3	-1,412.0	Jurassic
Evergreen Resistivity Marker	1,710.1	NA	-1,436.8	Jurassic
Boxvale Sandstone Member	1,722.6	10.0	-1,449.3	Jurassic
Evergreen Formation (Lower Unit)	1,732.6	32.0	-1,459.3	Jurassic
Precipice Sandstone	1,764.6	15.4	-1,491.3	Early Jurassic
Moolayember Formation	1,780.0	101.1	-1,506.7	Middle Triassic
Moolayember Formation (Upper Unit)	1,780.0	86.6	-1,506.7	Triassic
Snake Creek Mudstone Member	1,866.6	14.5	-1,593.3	Triassic
Showgrounds Formation	1,881.1	1.1	-1,607.8	Triassic
Timbury Hills Formation	1,882.2	NA	-1,608.9	Devonian
Total depth	1,948.0			

Although relatively complex analyses can be undertaken using the DST pressure data to very accurately assess the pressure head within the DST target formation, final shut-in pressures have been detailed herein to provide a reasonable approximation of heads within the Showground Sandstone. Table 3 provides a summary of this DST data for the Silver Springs and Renlim fields.

All tests were run in the Showgrounds Formation. The dept to the top of the test interval ranged from 1,867 m b GL to 1,923 m b GL (below ground level). The depth to the bottom of the test interval ranged from to 1,889 m b GL to 1,926 m b GL. The final hydrostatic pressure ranged from 2,471 psi to 3,308 psi and averaged 2,961 psi.

Table 3 Final Hydrostatic Pressures at Silver Springs and Renlim

Well Name	Packer top (m b GL)	Packer bottom (m b GL)	Final hydrostatic pressure (psi)	Derived piezometric elevation (m AHD)
Silver Springs 1	1,867	1,899	3,184	375
Silver Springs 2	1,877	1,892	2,779	79
Silver Springs 3	1,873	1,898	2,784	87
Silver Springs 4	1,883	1,925	3,308	446(1)
Silver Springs 5	1,876	1,900	3,138	333
Silver Springs 6	1,883	1,889	3,088	291
Silver Springs 7	1,905	1,910	3,086	268
Silver Springs 8	1,906	1,919	3,076	260
Sliver Springs 10	1,882	1,895	2,750	54(1)
Renlim 1	1,897	1,903	2,908	150(1)
Renlim 2	1,923	1,926	2,471	-183(1)

(1) Results of DST are likely to be unreliable.

3.4 Well completion reports for key wells proposed to be used for injection

The bores currently proposed to be used for the injection and withdrawal of CSG for storage / recovery are:

- Silver Springs 3;
- Silver Springs 11;
- Silver Springs 12 (proposed);
- Renlim 4; and
- Renlim 5A.

Simplified well logs for these proposed injection and withdrawal wells at the Silver Springs and Renlim gas field are presented in Appendix B. The well logs presented in Appendix B were developed using a combination of data from the DERM registered bores database, the QPED wells database and details from company well completion reports obtained via the QDEX system. The QPED database contains company and Geological Survey of Queensland stratigraphic interpretations. Where the data were available, deference was given to the Geological Survey interpretations.

The well logs were simplified as available data were insufficient to identify detailed stratigraphy for all of the wells and to accurately represent the well completion details. For example, the stratigraphic data for the upper 1,400 m of Renlim 4 were not recorded.

It is also noted that there were some conflicts between the data presented in the DERM database and the QPED database. These conflicts were resolved by consulting the original company well completion reports held on file in the QDEX system. Although, the original well completion reports are available, the amount of detail in each report recorded varied considerably.

All of the four key existing wells proposed to be used for the project have the same basic construction with steel casing extending from the surface to the Showgrounds Formation. The casing is perforated at the Showgrounds Formation in all four wells except in Silver Springs 11. Typically a 140 mm diameter production casing was installed in these wells. However, a much narrower production casing string was set in Silver Springs 3. The available documentation indicated that annular spaces outside the casing in each of the four wells were fully grouted to the depth of the blowout preventer. An Otis PL packer was placed at a depth of 1,848 m b GL in Renlim 4. The available documentation suggests that the casing in all of the four wells was grouted to depth. However, that assessment is based on the driller's daily progress notes, which only contain details on the volume of grout placed not the depth of grout placed.

Given a lack of consistent documentation, the proposed use for these wells and the now significant age of these wells, the integrity of the wells with respect to casing, grout and surface seal will need to be tested as part of the project development (see Section 12 herein).

3.5 Historical data for water production from Silver Springs field

Water production data for the Silver Springs / Renlim gas fields were obtained from:

- The Mines and Energy website of DEEDI (http://www.dme.qld.gov.au/mines/production_and_reserves_statistics.cfm); and
- Silver Springs / Renlim Productivity Test (Bridge Oil 1988).

Mines and Energy data are available in six-month intervals commencing in July 2006. This Mines and Energy water production data are presented in Table 4. The highest water production total was recorded in the interval between July 2006 and December 2006. Water production values have declined since 2006. Gas production has remained relatively constant or has declined slightly over this period.

Bridge Oil Ltd published a water production graph for the ratio of water production to gas production in the first three quarters of 1988 (Bridge Oil, 1988). The graph presented in Figure 4 illustrates an initial constant water production relative to gas production for the first two quarters followed by a peak in the third quarter. There was sharp decline in August 1988, which likely corresponds to a testing interval.

Unfortunately, additional water production data are not available; accordingly it is not possible to further assess water production from the Showgrounds Formation at the Silver Springs gas field at this time. Notwithstanding this, from the data presented in Table 4 it is clear that recent groundwater production from the Silver Springs / Renlim gas field has been relatively small.

Table 4 Water Production at the Silver Springs / Renlim gas field.

Water Production Ending	Water (ML)
December 2006	6.40
June 2007	6.24
December 2007	2.61
June 2008	2.12
December 2008	3.39
June 2009	3.37
December 2009	1.13

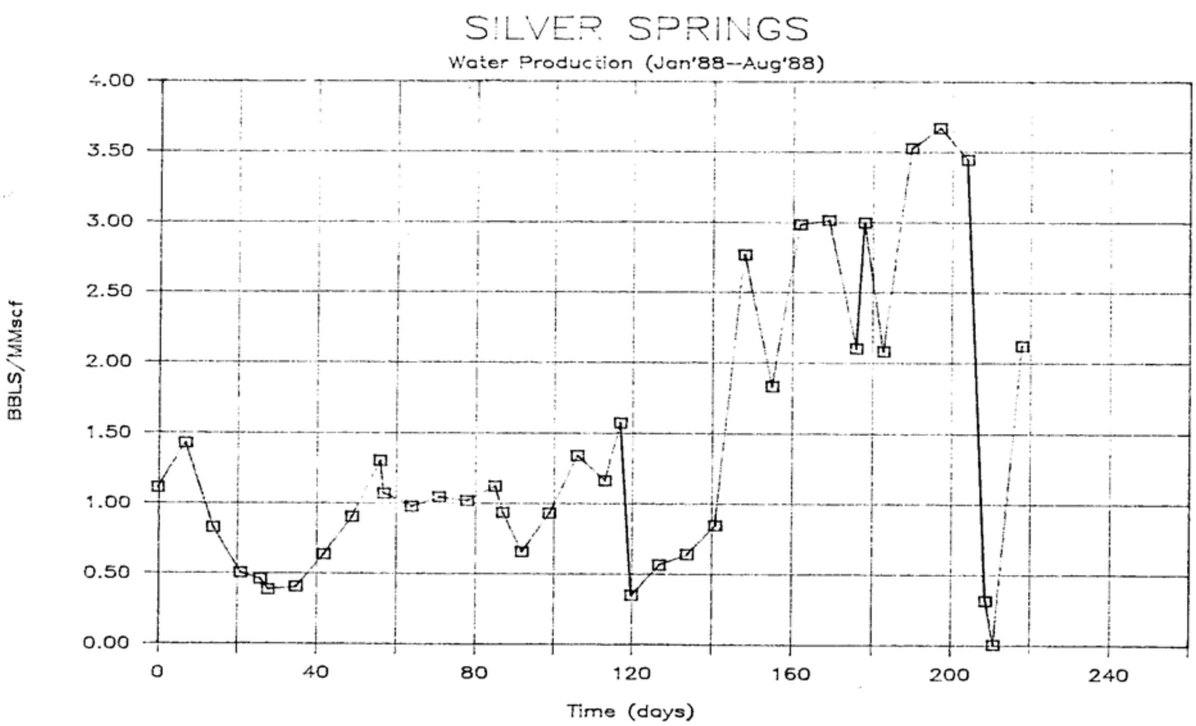

Figure 4 Water Production at Sliver Springs, Q1 to Q3 1988

4 Key aquifers in vicinity of Silver Springs field

The following geological formation, are considered to be aquifer units, based on DERM register bore data, within a 20 km radius of the Silver Springs gas field:

- Griman Creek Formation (relatively poor producer of poor quality water);
- Rolling Downs Group:
  - » Surat Siltstone (minor aquifer only); and
- Wallumbilla Formation (i.e. Coreena and Doncaster members);
- Blythesdale Group:
  - » Bungil Formation;
  - » Mooga Sandstone;
  - » Orallo Formation (minor aquifer only); and
  - Gubberamunda Sandstone;
- Injune Creek Group:
  - » Westbourne Formation (minor aquifer only)
  - » Springbok Sandstone; and
  - Walloon Subgroup (Walloon Coal Measures);
- Hutton Sandstone;
- Evergreen Sandstone (i.e. Boxvale Sandstone Member); and
- Precipice Sandstone.

Of these aforementioned sandstones the relative economic significance of the sandstone in the vicinity of the Silver Springs / Renlim gas fields is strongly impacted by the depths of the formation as it pertains to drilling costs.

For example, some of the upper Cretaceous age formations such as the Griman Creek Formation, Surat Siltstone and Wallumbilla Formation are significantly less productive and host poorer quality water in some locations than, for example, the Mooga Sandstone or Gubberamunda Sandstone. However, the shallower formations are more accessible and may yield potentially useful sub artesian stock supplies.

It is noted that the Walloon Sub-Group is not listed above as a significant aquifer. This is because in the area of interest it is not exploited for groundwater supplies. It is, however, noted that the coals in the Walloon Sub-Group are a major coal seam gas target within the Surat Basin and could at some time in the future become subject to significant pumping stress.

4.1 DERM groundwater database search for 20 km radius around centre of Silver Springs gas field

A DERM GWDB search was undertaken for records of registered bores located within a 20 km radius of the Silver Springs gas field (see Figure 5a and 5b). RPS isolated the registered bores near the Silver Springs gas field using the following coordinates:

- 27.4 degrees south (northern limit);
- 27.8 degrees south (southern limit);
- 148.31 degrees east (western limit); and
- 149.31 degrees east (western limit).

Records for 150 registered bores were located for the aforementioned area. A summary table of records for these bores is presented in Appendix A.

4.2 Identification of aquifers tapped by registered water bores within 20 km radius of Silver Springs gas field

Although there are DERM GWDB records for 150 bores within a 20 km radius of the Silver Springs gas field, the DERM GWDB only recorded attributed aquifers to four of these bores. In an effort to attribute aquifers to the remaining DERM registered water bores, casing and stratigraphic data contained in the DERM database were examined. It was, however, found that although the DERM database does contain stratigraphic details for 104 registered bores in the area of interest, there was very limited casing data available for these bores.

The available stratigraphic data in the DERM database suggests that the majority of the registered bores were originally drilled as petroleum explorations wells. Further to this, the available QPED database and reports available via the QDEX system also indicate that the majority of the bores near the Silver Springs gas fields were drilled to explore for petroleum resources.

Of the 150 bores contained in the DERM database, 115 were also listed in the QPED database. There were 43 wells in the QPED database that do not have corresponding DERM database registration numbers.

Over 48 of the QPED wells have been documented as having been converted to water bores by plugging or sealing off the deeper target petroleum reservoir formations (Appendix A). Seven of the QPED wells were documented to be producing hydrocarbons. Approximately one quarter of the QPED wells in the area of interest were documented as “plugged and abandoned” or “suspended, capped or shut-in”. The “shut-in” wells are interpreted to be open to the Showgrounds Formation. The completion details for the remaining wells were not sufficiently detailed to allow an assessment of whether these wells are currently, or were historically used as water bores.

DERM registered bore 22403 is the closest bore the Silver Spring gas field where the aquifer unit has been identified. DERM registered bore 22403 is located over 10 km from the gas field. The aquifer tapped by the bores close the Silver Springs gas field has not been identified; however, available evidence (i.e. DEEDI logs and exploration reports) suggest these bores, if completed to tap groundwater, are completed in one or more of the Blythesdale Group formations.

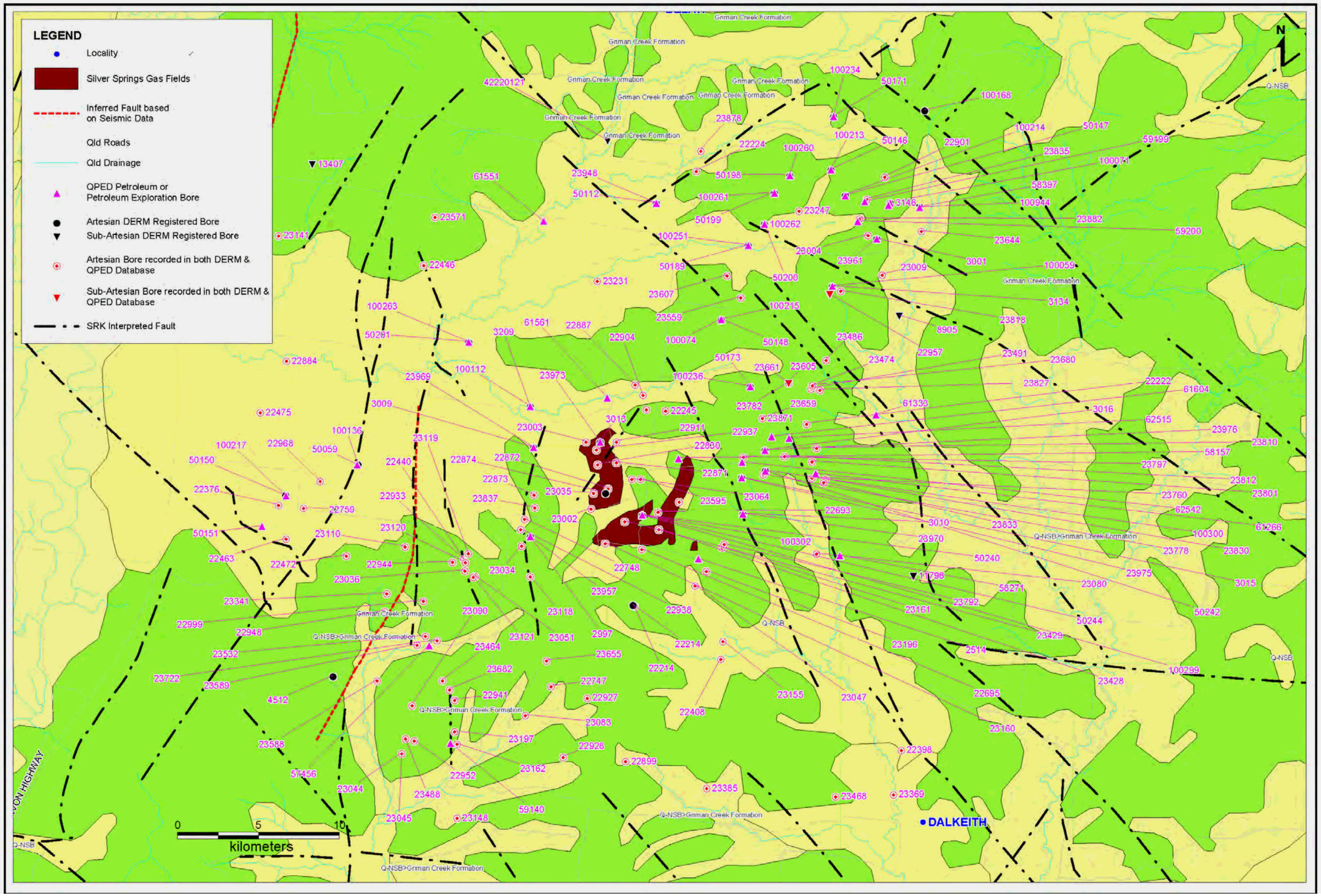

Figure 5(a) QEPD and DERM registered bores within 20 km of the Silver Springs gas field with fault traces indicated in the SRK Study (After SRK 2008)

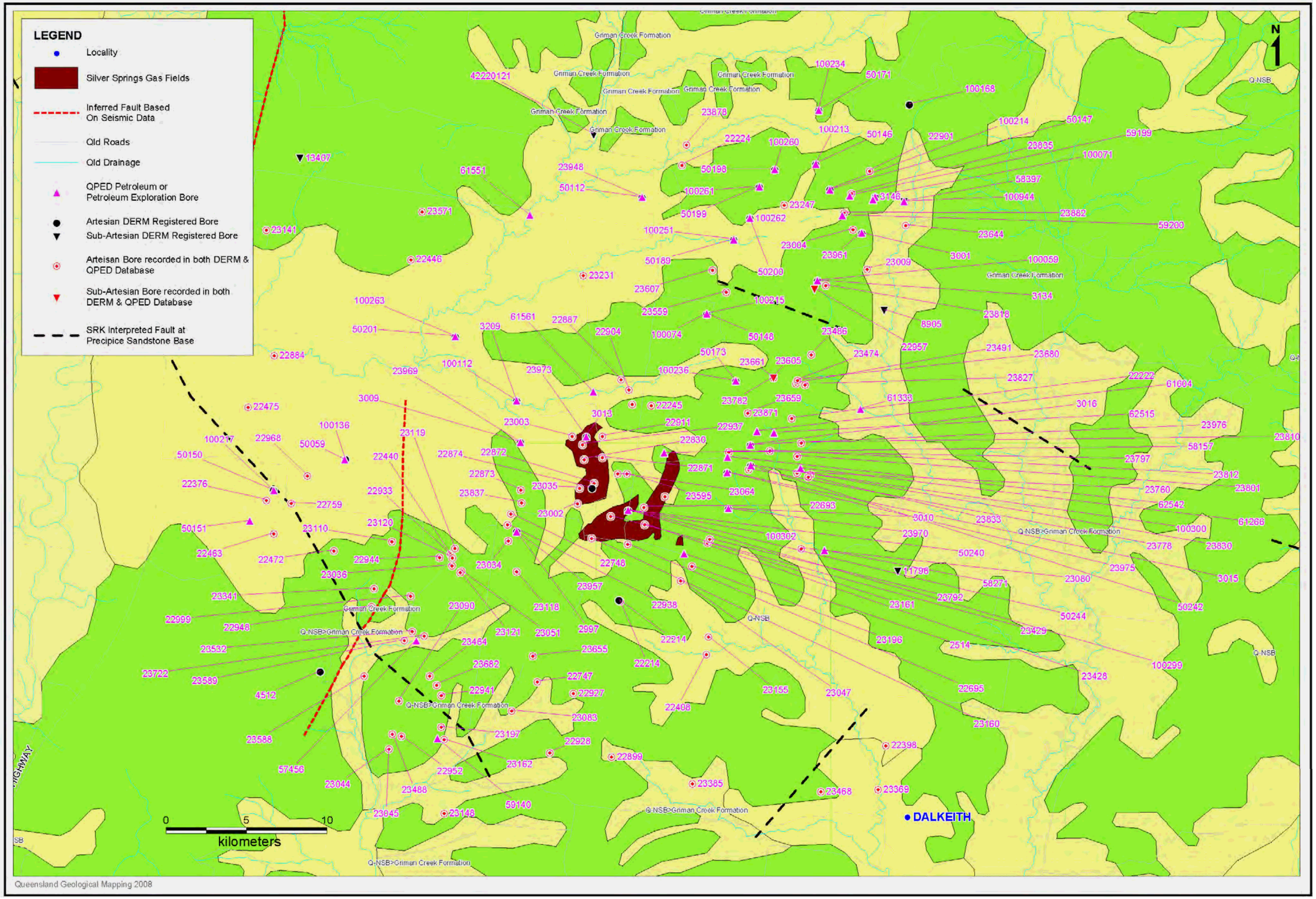

Figure 5 (b) QEPD and DERM registered bores within 20 km of the Silver Springs gas field with only the fault traces indicated at the base of the Precipice Sandstone (After SRK 2008)

4.3 DERM database search to identify closest water bores to Silver Springs field that actively tap Showgrounds Formation / Clematis Sandstone

No bores are documented as being completed as a water bore in the Showground Sandstone in the DERM bore database. Available data, drawn from the QPED database and available well completion reports, also supports a conclusion that few if any water bores are completed in the Showgrounds Formation.

DERM records 319 bores tapping the Clematis Group sandstones (see Figure 6). All of the bores recorded as tapping the Clematis Group sandstone are located no closer than 100 km to the north of the Silver Springs field. There is a marked concentration of Clematis Group sandstone bores within the Arcadia Valley, which lies within the Mimosa Syncline to the north of the Surat Basin outcrop extent. This concentration reflects the fact that the Clematis Group sandstones occur at a shallower depth in the Arcadia Valley as well as the absence of other more productive aquifers in that area. From Figure 6 it can also be seen that there is an actuate belt of bores tapping the Clematis Group sandstones further to the north west. These bores are constructed in the margins of the Galilee Basin.

Available DERM database bore depth data, specifically the depth to the bottom of the casing, suggests that the typical Clematis Group sandstone bores are generally completed between 50 and 200 m deep with a small number completed as deep as or deeper than 700 m.

The Showgrounds Formation at Silver Springs is typically present 1,800 to 1,900 m below ground level. It is, therefore, reasonable to conclude that nearly all of the bores that extract groundwater from the Clematis Group sandstone lie significantly hydraulically up gradient of the project site.

4.4 GSQ QPED database search for bores tapping Showgrounds Formation

DERM and DEEDI data indicate that all of the petroleum wells drilled near the Silver Springs gas field penetrate the Showgrounds Formation and deeper units.

DERM records 55 bores penetrating the Showgrounds Formation near the Silver Springs gas field. The DERM database lacks construction details for these 55 bores, accordingly it is not possible to ascertain what water-bearing formations these bores were completed to tap; however, petroleum company reports available through the QDEX system document that most of the relevant petroleum bores, when converted to a water bore, plug off the formations either at the Westbourne Formations, a regional confining unit, or at the Walloon Coal Measures / Springbok Sandstone interval (Appendix A).

The majority of the relevant petroleum bores converted to water wells now tap the aquifers in the Blythesdale Group. Although no reference to a petroleum bore being completed in Showgrounds Formation was identified, the QPED data indicate that 36 wells may be currently be open to the Showgrounds Formation. The wells open to the Showgrounds Formation are believed to be shut-in gas wells that could potentially be used to extract either gas or groundwater.

Accordingly, the available QPED and DERM GWDB data does not indicate that the Showgrounds Formation or its equivalent, the Clematis Group sandstones, are specifically exploited for groundwater use near the Silver Springs gas field.

Although the available data suggest that the Showgrounds Formation is a frequent drilling target near the Silver Springs gas field, this exploration drilling targets petroleum and not groundwater (Figure 5).

A summary of all the QPED bores within 20 km of the Silver Springs gas field is presented in Appendix A.

4.5 Historical groundwater quality for major Great Artesian Basin aquifers in vicinity of the Silver Springs field

There are no available groundwater quality data available for the 150 DERM registered water bores tapping aquifers within 20 km of the Silver Springs gas field.

In the absence of this bore specific data, a compilation of groundwater quality data has been made drawing on published information (e.g. Quarantotto 1989 and Great Artesian Basin Consultative Committee, 1989) and from water quality data in the DERM GWDB data outside of the 20 km radius of the Silver Springs gas field. RPS compiled water quality data from the DERM registered bore for an area up to 50 km from the Silver Springs gas field. The water quality data search area therefore measures 100 km by 100 km.

Groundwater in the main Cretaceous and Jurassic age aquifers of the Great Artesian Basin is largely fresh. Total dissolved solids are low, generally between 500 and 1,500 mg/L. Groundwater quality in the Surat Basin ranges from good to saline and is generally suitable for stock watering although sodium dominant waters preclude irrigation use except in some areas of NSW. Groundwater in the Great Artesian Basin is dominated by sodium-bicarbonate type waters; however, locally the water can be chloride and sulphate type groundwater (Herzeg 1991).

The differences in water quality in the Great Artesian Basin aquifer are due to:

- Sediment deposition and composition of the aquifers;
- Groundwater residence time;
- Source of the groundwater;
- Inter-aquifer/aquitard mixing of groundwater; and
- Depth and direction of groundwater flow.

4.6 Groundwater Quality in the Blythesdale Group

In the Surat Basin the formations within the Blythesdale Group are the:

- Bungil Formation;
- Mooga Sandstone;
- Orallo Formation; and
- Gubberamunda Sandstone

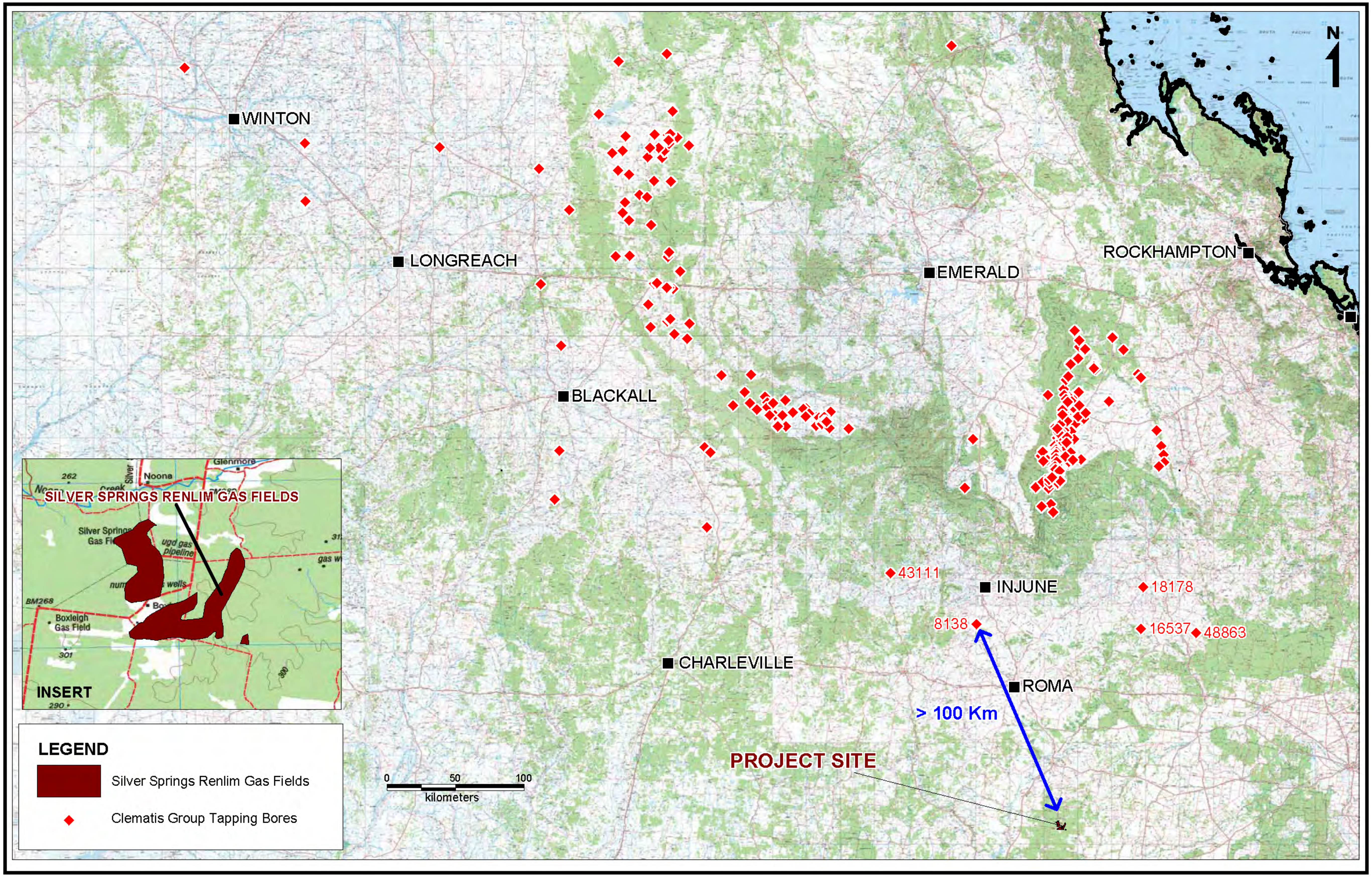

Figure 6: Showing the Locations of Registered Bores Tapping the Clematis Formation (Showgrounds Formation Equivalent)

The Mooga Sandstone and Gubberamunda Sandstone are major regional aquifers with stratigraphic continuity eastwards across the Surat Basin where they merge with the sandy basin margin facies of the Kumbarilla Beds and westwards where they merge into the Hooray Sandstone.

Groundwater in the Blythesdale Group aquifers near the Silver Springs gas field are sodium-bicarbonate-chlorite types (Figure 7). This is a common groundwater type for the shallower Great Artesian Basin aquifer systems (Quarantotto 1989). The pH of groundwater in Blythesdale Group aquifers is generally slightly alkaline with a range from 8 to 9 (see Table 5). Fluoride concentrations in the Blythesdale Group have an overall range from 0.3 mg/L to 4.9 mg/L with an average around 1.9 mg/L. Chloride concentrations in the Blythesdale Group range from 75 mg/L to 2,690 mg/L with an average in the order of 335 mg/L. Bicarbonate concentrations in these aquifers range from below the laboratory reporting limit to 1,313 mg/L with an average in the order of 615 mg/L.

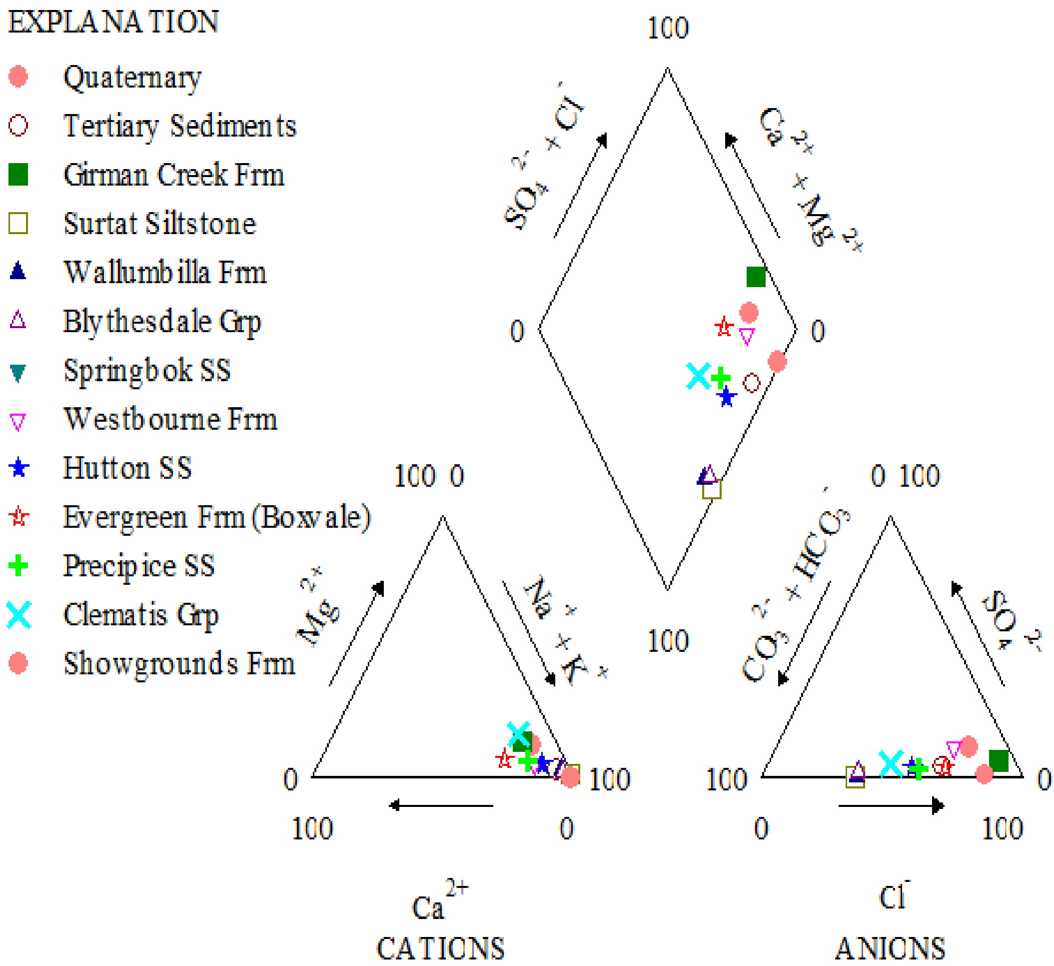

Figure 7 Piper Diagram of groundwater samples obtained within 50 km to the Silver Springs gas field.

Table 5 Summary of Groundwater Quality near the Silver Springs gas field (DERM GWDB data)

Age (Number of Samples)		pH	Turbidity	Silicon Dioxide	Hardness	Alkalinity	Sodium Adsorption Ratio	Residual Alkalinity	Total Ions	TDS	Sodium	Potassium	Calcium	Magnesium	Iron	Manganese	Bicarbonate	Carbonate	Chloride	Fluoride	Nitrate	Sulphate	Zinc	Aluminium	Boron	Copper
			NTU	mg/L	mg/L	mg/L	mg/L	milli-eq/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Quaternary (13)	Mean	8.0	15	46	476	341	17.5	3.1	2773	2604	801	12	82.2	65.9	0.14	0.005	393	13	1176	0.2	7.3	249	0.02	0.05	0.95	0.07
	Maximum	8.0	15	86	3750	650	62.6	12.8	17400	17100	5070	76	554	576	1.1	0.03	793	114	8760	0.9	18	1660	0.02	0.05	0.95	0.07
	Minimum	7.0	15	13	11	140	2.5	--	355	351	60	ND	1	2	--	ND	ND	ND	53	ND	ND	4	0.02	0.05	0.95	0.07
Tertiary Sediments (9)	Mean	8.0	--	15	108	389	33.7	7.6	1649	1103	567	1.3	24.0	11.7	0.11	0.007	226	122	638	0.9	0.3	58	--	--	--	--
	Maximum	9.0	--	18	469	708	68.3	14.0	4407	4407	1524	4	122	43	0.6	0.02	820	299	2188	2.3	1	293	--	--	--	--
	Minimum	7.0	--	12	7	200	10.4	2.5	926	--	372	--	2.4	ND	--	ND	ND	ND	190	ND	ND	ND	--	--	--	--
Griman Creek (75)	Mean	8.0	0.8	19.4	1565	342	33.8	5.1	7089	2558	2069	5.2	299	201	0.13	0.14	283	88	3820	0.8	1.8	360	--	--	2.5	--
	Maximum	9.0	0.8	29	7860	1149	101	22.8	27715	18559	7440	20.2	1480	1011	1.1	2.1	1303	675	14878	3.3	18	2836	--	--	2.5	--
	Minimum	--	0.8	9	5	0	10.2	--	838	--	250	--	0	ND	--	ND	ND	ND	76	ND	ND	ND	--	--	2.5	--
Surat Siltstone (4)	Mean	8.0	--	20	24	953	71	18.5	1781	403	672	3.8	5.4	2.5	0.28	0.01	288	430	377	2.6	1.9	3.5	--	--	--	--
	Maximum	9.0	--	20	58	1127	101	21.3	2178	1613	821	3.8	11.4	7.2	0.28	0.01	1150	675	509	3.1	1.9	8.6	--	--	--	--
	Minimum	7.0	--	20	8	826	46.8	16.2	1428	--	591	3.8	2.9	0.1	0.28	0.01	ND	31	320	2	1.9	ND	--	--	--	--
Wallumbilla Formation (8)	Mean	8.0	0.8	17.3	64	647	53.5	11.6	1503	1133	436	3.45	11.1	8.9	0.26	0.01	759	21	268	1.3	0.5	5.3	--	--	2.5	--
	Maximum	9.0	0.8	20	244	994	101	19.7	2382	2124	752	4.2	58	24	0.6	0.02	1150	30.5	1036	3.1	1.9	12	--	--	2.5	--
	Minimum	8.0	0.8	16	5	215	4.9	2	540	430	120	1.8	1	0.1	0.03	ND	250	6.8	75.7	0.2	ND	ND	--	--	2.5	--
Blythesdale Group (124)	Mean	8	0.9	22.2	62.6	713	55.9	99.7	1634	1012	516	1.9	14.8	6.6	0.1	0.1	614	173	336	1.9	2.1	20	0.005	0.04	2.2	0.01
	Maximum	9	1	30	1463	1149	101	2100	4226	4166	1174	5.9	400	155	0.6	2.3	1313	675	2690	4.9	110	140	0.01	0.1	3.5	0.03
	Minimum	--	0.8	16	5	310	2.6	3.44	838	--	230	--	ND	ND	--	ND	ND	ND	75.7	0.3	ND	ND	ND	ND	0.3	ND
Springbok Sandstone (15)	Mean	8.0	--	--	29.3	939	61	18	1649	--	676	--	6.2	3.3	--	--	--	563	396	2.4		2.9	--	--	--	--
	Maximum	9.0	--	--	58	1127	71.2	21	2027	--	821	--	11.4	7.2	--	--	--	675	509	3		8.6	--	--	--	--
	Minimum	7.0	--	--	13	826	46.8	16.23	1428	--	591	--	2.9	1.4	--	--	--	495	336	2	ND	ND	--	--	--	--
Hutton Sandstone (1906)	Mean	8.1	5.4	24	95	252	18.8	5.9	847	640	247	6.3	23.6	7.7	0.16	0.22	267	24	254	0.8	0.6	23	0.02	0.03	0.4	0.02
	Maximum	11.9	194	99	21676	2361	191	1500	62563	62563	15420	40.5	6009	1617	20	185	2879	583	38144	10	29	1422	0.72	0.7	9.7	0.5
	Minimum	5.7	--	0	0	0	--	--	0.02	--	--	--	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Evergreen Sandstone (Boxvale Member) (381)	Mean	7.6	17.3	15.9	247	224	10.6	3.6	1041	694	259	5.9	71.6	14.4	0.12	0.035	234	23	395	0.38	1.2	30	0.02	0.01	0.15	0.02
	Maximum	11.7	194	87	9892	2814	127	54.6	21270	21060	4443	28.3	3550	491	10	0.31	3411	382	12600	4.19	135	1030	0.1	0.05	2.7	0.05
	Minimum	--	0.1	ND	ND	10	--	--	75.48	--	2	--	0.7	ND	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Precipice Sandstone (617)	Mean	7.5	11.6	17.4	75.9	144	9.3	2.2	501	394	138	4.3	21.9	5.5	0.35	0.05	151	15	163	0.3	0.3	10.7	0.02	0.02	0.4	0.02
	Maximum	12.2	70	64	6007	2628	97.6	44.4	12144	12144	4460	30	2332	250	9	1.9	3103	261	7313	5	9.9	782	0.11	0.15	7	0.05
	Minimum	4.8	0.2	ND	ND	2	--	--	7.9	--	2	--	0	ND	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Clematis Formation (551)	Mean	7.8	115	15.9	125	205	6.7	2.4	598	449	135	12.8	21.3	17.7	0.23	0.07	237	7.8	148	0.4	0.6	22	0.1	0.02	0.08	0.02
	Maximum	12.2	310	52	3268	748	47.3	14.5	19195	19195	6010	76	624.9	447.6	17	0.7	912	410.4	9614	50	7.1	2340	0.3	0.05	0.11	0.05
	Minimum	5.6	0.1	2	2	ND	0.9	--	60.9	--	12	1	0.1	ND	--	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Showgrounds at Silver Springs (4)	Mean	6.9	--	--	342	849	--	--	--	16495	7471	31.2	68	14	168	--	984	748	4493	16245	5	100	--	--	--	--
	Maximum	8.4	--	--	1010	1439	--	--	--	50000	23000	150	340	50	300	--	1755	1970	17000	1.5	10	400	--	--	--	--
	Minimum	4.0	--	--	79.6	51	--	--	--	4220	67.4	0.44	1	0.2	36	--	18	--	49.7	2490	2.5	0.9	--	--	--	--

ND - Not detected above the Laboratory Reporting Limit

-- - No Analysis or No Sample

4.7 Injune Creek Group

In the vicinity of the Silver Springs Field the Injune Creek Group comprises the following units:

- Westbourne Formation;
- Springbok Sandstone; and
- Walloon Sub-Group (Walloon Coal Measures)

The Springbok Sandstone is a significant regional aquifer but of less importance than the Mooga Sandstone and Gubberamunda Sandstone of the Blythesdale Group with the exception of areas of NSW where the units grades into the much more sandy Pilliga Sandstone. In the Surat Basin, the Westbourne Formation is generally considered to form a regional aquiclude; however, it does host some sandy water beds that are sporadic in distribution and form poorly productive aquifers.

The Walloon Sub-Group (Walloon Coal Measures) is generally not considered to be a major aquifer unit. However, where it is present at shallow levels generally remote from Silver Springs and well to the north and east it is frequently exploited as a source of sub-artesian stockwater supplies. The Walloon Coal Measures is a major source of CSG and is subject to significant development effort by a number of key energy companies.

Groundwater samples from the Westbourne Formation can be classified as sodium-chloride to sodium-chloride-bicarbonate types (Quarantotto, 1989).

Groundwater in the Springbok Sandstone aquifer near the Silver Springs gas field is a sodium type (Figure 7). There are no results for bicarbonate, so the anion type cannot be assessed using the available data. The pH of groundwater in Springbok Sandstone aquifer is slightly alkaline ranging from 7 to 9 (Table 5). Fluoride concentrations in the Springbok Sandstone ranged from 2 mg/L to 3 mg/L and averaged 2.4 mg/L. Chloride concentrations in this formation ranged from 396 mg/L to 509 mg/L and averaged 336 mg/L.

Groundwater samples from the Walloon Coal Measures can be classified as sodium-chloride type (Quarantotto 1989). There are no groundwater analyses for samples drawn from near the Silver Springs gas field available for either the Westbourne Formation or the Walloon Coal Measures that could be included on Figure 7 or in Table 5.

4.8 Hutton Sandstone

The major aquifers underlying the Walloon Sub-Group and overlying the Showgrounds Formation include the Hutton Sandstone, Boxvale Member of the Evergreen Sandstone and the Precipice Sandstone. Near the Silver Springs gas field the groundwater in the Hutton Sandstone is a sodium-chloride type (Figure 7).

Groundwater salinity in the Hutton Sandstone generally ranges from fresh to brackish with slightly alkaline pH. Fluoride concentrations in the Hutton Sandstone range from 0.8 mg/L to 10 mg/L while chloride concentrations range from 254 mg/L to 38,144 mg/L. Bicarbonate concentrations in this formation range from 267 mg/L to 2,879 mg/L.

In some areas, notably to the north near its outcrop, the Hutton Sandstone aquifer yields water very good domestic quality water (Quarantotto 1989). Groundwater in the Hutton Sandstone near the outcrops is richer in calcium, magnesium, chloride and sulphate than it is deeper in the formation.

4.9 Evergreen Formation (Boxvale Sandstone Member)

Groundwater in the Boxvale Sandstone Member of the Evergreen Formation is of sodium-chloride type (Figure 7).

Groundwater salinity in the Boxvale Sandstone Member ranges from fresh to saline with generally slightly alkaline pH. In this unit, fluoride concentrations range from 0.0.38 mg/L to 4.19 mg/L. The chloride concentrations in groundwater for this unit range from 395 mg/L to 12,600 mg/L, while bicarbonate concentrations range from 234 mg/L to 3,411 mg/L.

In some locations, the Boxvale Sandstone Member aquifer yields water suitable for human consumption (Quarantotto 1989). Although, these areas would be located closer to the outcrop area of this formation. Groundwater in the Boxvale Sandstone Member near the outcrop area is richer in calcium, magnesium, chloride and sulphate and depleted in sodium and bicarbonate than it is deeper in the formation.

4.10 Precipice Sandstone

The Precipice Sandstone unit is the oldest of the Surat Basin units. Where present in the stratigraphic sequence it forms the lowermost unit of the Surat Basin. It has been extensively explored for hydrocarbons and it hosts the Moonie Oil Field. It is a major aquifer having relatively porous and permeable orthoquartztite sandstones.

Groundwater salinity in the Precipice Sandstone ranges from fresh (closer to the outcrop areas) to brackish (further down dip and flow path towards the central sections of the basin); however, some samples drawn from the Precipice Sandstone are saline. Groundwater pH in this formation range from slightly acidic to slightly alkaline. Groundwater fluoride concentrations in this unit typically range from 0.3 mg/L to 5 mg/L, although some higher values have been reported for this formation near Miles. Chloride concentrations in this unit range from 163 mg/L to 7,313 mg/L while bicarbonate concentrations range from 151 mg/L to 3,103 mg/L.

As previously indicated, closer to the outcrop areas the Precipice Sandstone aquifer yields water of very good domestic quality water (Quarantotto 1989) although elevated dissolved iron can be problematic. Groundwater salinity in this unit are relatively lower near the outcrop / recharge areas, located in the in the northeast, than the groundwater in the southern areas closer to the subcrop margin.

The Showgrounds Formation was deposited in a freshwater fluvial environment, although some authors suggest that there were some minor marine influences during deposition. Four groundwater samples for the Showgrounds Formation have been obtained from two petroleum wells in the area of interest.

The Piper diagram plots of groundwater chemistry presented in Figure 7 indicate that the Showgrounds Formation hosts sodium-chloride type groundwater. Salinity of groundwater samples obtained from the Showgrounds Formation ranges from 4,200 to 50,000 mg/L although the reliability of the higher salinity sample would be questionable. Groundwater in the Showgrounds Formation is generally not suitable for human consumption.

The available data that suggest relatively poor quality groundwater in the Showgrounds Formation are consistent with drilling contractors plugging off the Showgrounds Formation when converting petroleum wells to water wells (see Section 8).

The Clematis Group sandstones are the lateral and stratigraphic equivalent to the Showgrounds Formation. The Clematis Group sandstones are tapped as a groundwater resource generally in areas where this unit is closer to the surface. The closest Clematis Sandstone bore is located over 100 km from the Silver Springs gas field (see Figure 6).

Groundwater in the Clematis Group sandstones is of sodium-bicarbonate to sodium-chloride type (Figure 7). The Clematis Group sandstones have a recorded salinity range of 449 mg/L to 19,195 mg/L total dissolved solids. The highest recorded key chemical parameter groundwater concentrations for the Clematis Group sandstone are:

- 6,010 mg/L for sodium;
- 912 mg/L for bicarbonate;
- 410 mg/L for carbonate;
- 9,614 mg/L for chloride; and
- 50 mg/L for fluoride

By contrast the maximum recorded concentrations for these same constituents in the Showgrounds Formation in Silver Springs / Renlim field are:

- 50,000 mg/L for sodium (possibly from an unreliable sample);
- 1,755 mg/L for bicarbonate;
- 1,750 mg/L for carbonate;
- 30,000 mg/L for chloride (possibly form an unreliable sample); and
- 3 mg/L for fluoride.

Habermehl (undated) has documented increases in chloride and sodium along groundwater flow lines in the Great Artesian Basin. The much greater recorded salinity in the Showgrounds Formation compared to the Clematis Group sandstones is in accordance with Habermehl's observation.

5 Review of published geological mapping to identify the locations of key mapped faults in vicinity of Silver Springs gas field

The following information was reviewed to identify faults and major structures near the Silver Springs gas field:

- Published geological maps—The Surat Queensland 1:250:000 Series Geological Map (Thomas and Reiser 1967)
- DERM stratigraphic and lithological data;
- QPED stratigraphic and lithological data;
- Selected QDEX drilling and exploration reports; and
- Bowen and Surat Basins regional structural framework study (SRK 2008).

Available subsurface mapping included with the Surat 1:250,000 sheet indicates that the Great Artesian Basin sequence underlying the Silver Springs gas field generally dips gently to the southeast towards the Taroom Trough.

North-to-south oriented faulting is indicated in the available published surface geological mapping based on seismic survey data between the Silver Springs gas field and the Balonne River (see Figure 5(a) and 5(b) and Figure 8. In this surface geological mapping two distinct fault traces have been mapped. These fault traces are off-set by 10 km under the Danga Creek and Boggo Creek Alluvium.

The available published geological map indicates near vertical structure for the faults with probable normal displacement.

The data pertaining to the relative displacement of these faults as presented in the published 1:250,000 scale mapping is inconsistent. The surface mapping indicates that the western side of these faults has moved upward relative to the eastern side of the faults. However, the cross sectional information presented on the 1:250,000 scale map is at variance with this and indicates for the northernmost of these fault traces, the western side of the fault is downthrown compared to the eastern side of the fault. It is noted that the fault presented on the section is not indicated to reach the surface and appears to be truncated near the contact between the Mooga Sandstone and Orallo Formation. The fault displaces all of the lower formations from the base of the Mooga Sandstone to the basement (Figure 8).

The direct influence of this faulting on groundwater flow is unknown. It does, however, appear to correlate with the transition between groundwater flow dominated by the Thomby Range to Balonne River flow system as discussed by Hitchon and Hayes (1971).

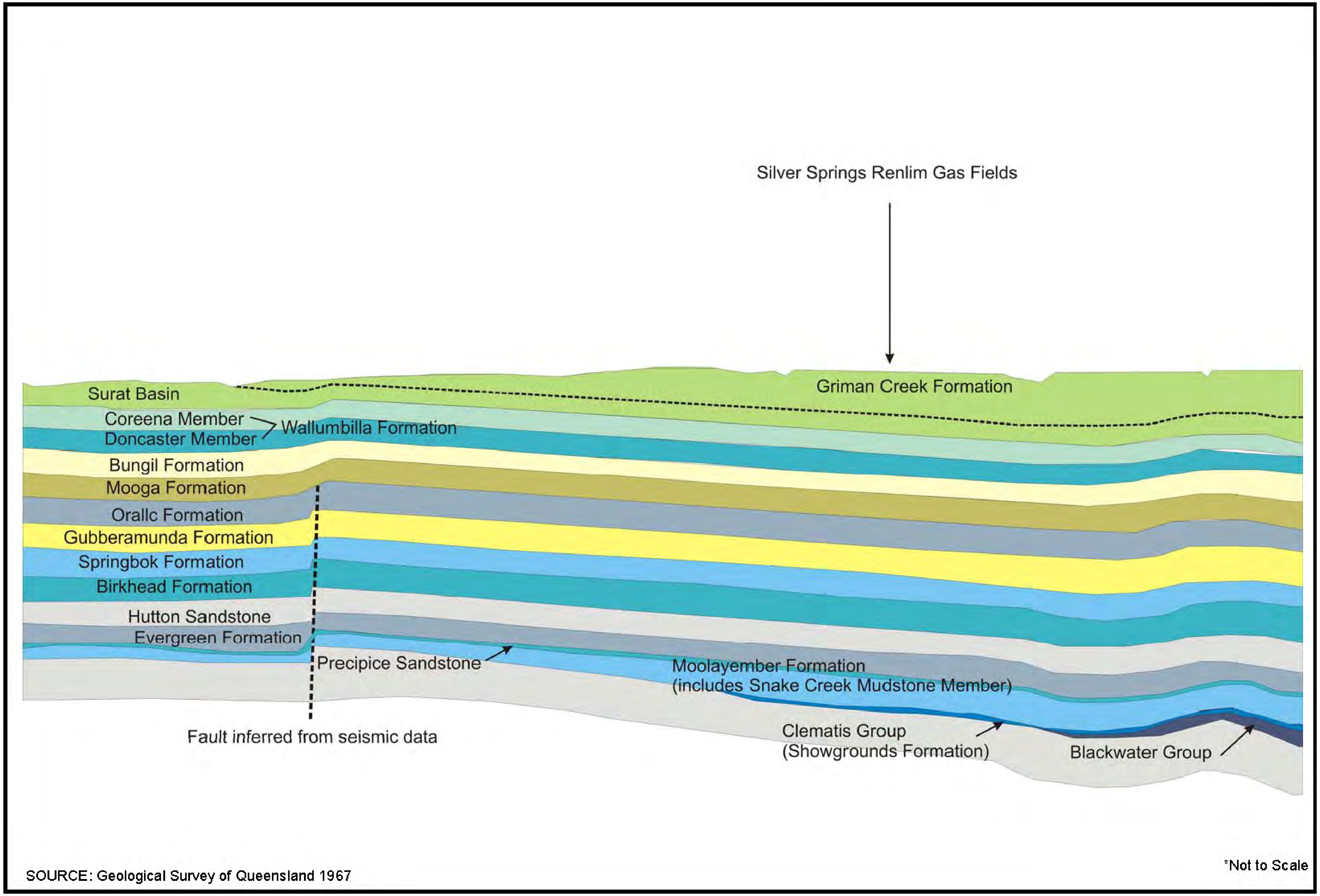

Figure 8 Geological Cross Section showing fault in the Bowen Basin and lower Surat Basin Rocks (not to scale).

The Thomby Range to Balonne River flow system of Hitchon and Hayes (1971) is in the Blythesdale Group and Springbok Sandstone. Groundwater flow below the upper Jurassic aquifers shifts from a westward movement to upward groundwater movement dominated by a larger groundwater flow system that extends downward into the basement rock (Hitchon and Hays 1971). Specifically, groundwater flow in the un-faulted rocks is downward below the Thomby Range, westward under the project site and upward below the Balonne River. Groundwater flow in the faulted rocks appears to be upward from the basement rocks towards the Balonne River in the faulted rocks.

While there is an apparent correlation between the change in groundwater flow direction and the faulted and un-faulted rocks, it is unknown if the faulting as indicated on the 1:250,000 scale mapping is the cause or if this or is simply a natural transition between a locally influenced groundwater flow system and a much larger regionally influenced groundwater flow system.

Given that the geological mapping for the Silver Springs gas field has been completed on a regional scale, available drilling and exploration reports available through the QDEX system were examined for more details on faults and structures. However, no further information regarding the faulting was discussed in these reports.

The 1:250,000 scale mapping of the Surat Geological Sheet is very regional in nature. More detailed structural analysis is provided by SRK (2008) (i.e. Bowen and Surat Basins regional structural framework study). This study combined an analysis of aerial imagery (i.e. air photography and satellite images), geophysical data (i.e. gravity and seismic data) and well control to develop structural mapping of the Bowen Basin and Surat Basin.

The SRK interpreted faults near the project site are illustrated on Figure 5(a) and Figure 5(b). Figure 5(a) shows all of the SRK faults regardless of the formation or depth of the faulting. This map indicates a fault to be present, the trace of which transects the Silver Springs gas field. Given the fact that gas was naturally accumulated in the Showgrounds Formation at Silver Springs, it is unlikely that this feature impacts either the Showgrounds Formation or the Snake Creek Mudstone Member. If this feature did indeed impact on the Snake Creek Mudstone Member seal, then it appears that it would not have provided a permeability path sufficient to allow vertical migration of hydrocarbons. Alternatively, it may be the case that the SRK mapped fault that transects the Silver Springs field only impacts older, underlying units.

RPS examined the inferred faults compiled by SRK for the base of the Precipice Sandstone. These faults are illustrated on Figure 5(b). This figure suggests that there are no faults transecting the Silver Springs gas field that disturb the overlying Surat Basin aquifers within 10 to 15 km of the project site.

6 Potential water bore receptors

The DERM GWDB was searched to identity water bores near the Silver Springs project site. Two separate searches where completed. The first search focused on all water bores near the project site. The second search determined the locations of the bores completed in the Showgrounds Formation or equivalents (i.e. Clematis Group sandstones).

There are 150 registered water bores drilled between the early 1900's and August 2009 within 20 km of the Silver Springs Gas Fields (Figure 5a and 5b). These water bores have been completed in the formations and aquifers of the Surat Basin lying stratigraphically above the Westbourne Formation. A summary of the registered bore data is presented in Appendix A.

It is noted that in the area around the Silver Springs gas field there is a marked paucity of data recorded in the DERM GWDB pertaining to attribution of contributing aquifer and bore casing details

For water bores where DERM did not attribute the source aquifer, stratigraphic and lithological data contained in the DERM database was further investigation. The stratigraphic and lithological data contained in the QDEX reports was also examined to determine the aquifers tapped by the petroleum bores that were converted to water bores. Thirty five petroleum bores have been converted to water bores, all of which were plugged stratigraphically above the Westbourne Formation to target the aquifers in the Blythesdale Group.

Only two bores are registered as Abandoned or Destroyed by DERM; however, DEEDI records 19 wells as plugged and 29 wells abandoned or as suspended, capped or shut-in. The remaining 148 bores are listed as active in the DERM database.

DERM records the artesian status for the registered bores near the Silver Springs gas field as follows:

- 57 bores with artesian flow—control unknown;
- 85 bores with artesian flow—controlled; and
- 7 sub-artesian bores

The bores located the closest to the Silver Springs gas field are the most probable potential receptor bores. There are 20 bores near the Silver Springs gas field (Figure 9). Of these 20 bores five have been converted to water bores. The stratigraphically lower formations, specifically the Showgrounds Formation, have been plugged off in these five water bores. The company well completion reports for these bores obtained from the QDEX system report that in all cases the bores were plugged no deeper than the top of the Walloon Sub-Group. There is, however, a paucity of data pertaining to the subsequent perforation of casings above these plugs to permit groundwater entry to the bores.

Six of the registered bores are shut-in petroleum wells and these bores remain open to the Showgrounds Formation. Four of the bores have been abandoned and there are no data on the fate of the remaining five bores.

The majority of the plugs have been placed to access either the Springbok Sandstone or the Blythesdale Group.

Although there are bores in the relative proximity of the Silver Springs gas field, in fact these are unlikely to be receptors of impact from the proposed gas storage operations due to the presence of intervening confining units between the likely tapped aquifers and the very much deeper Showgrounds Formation.

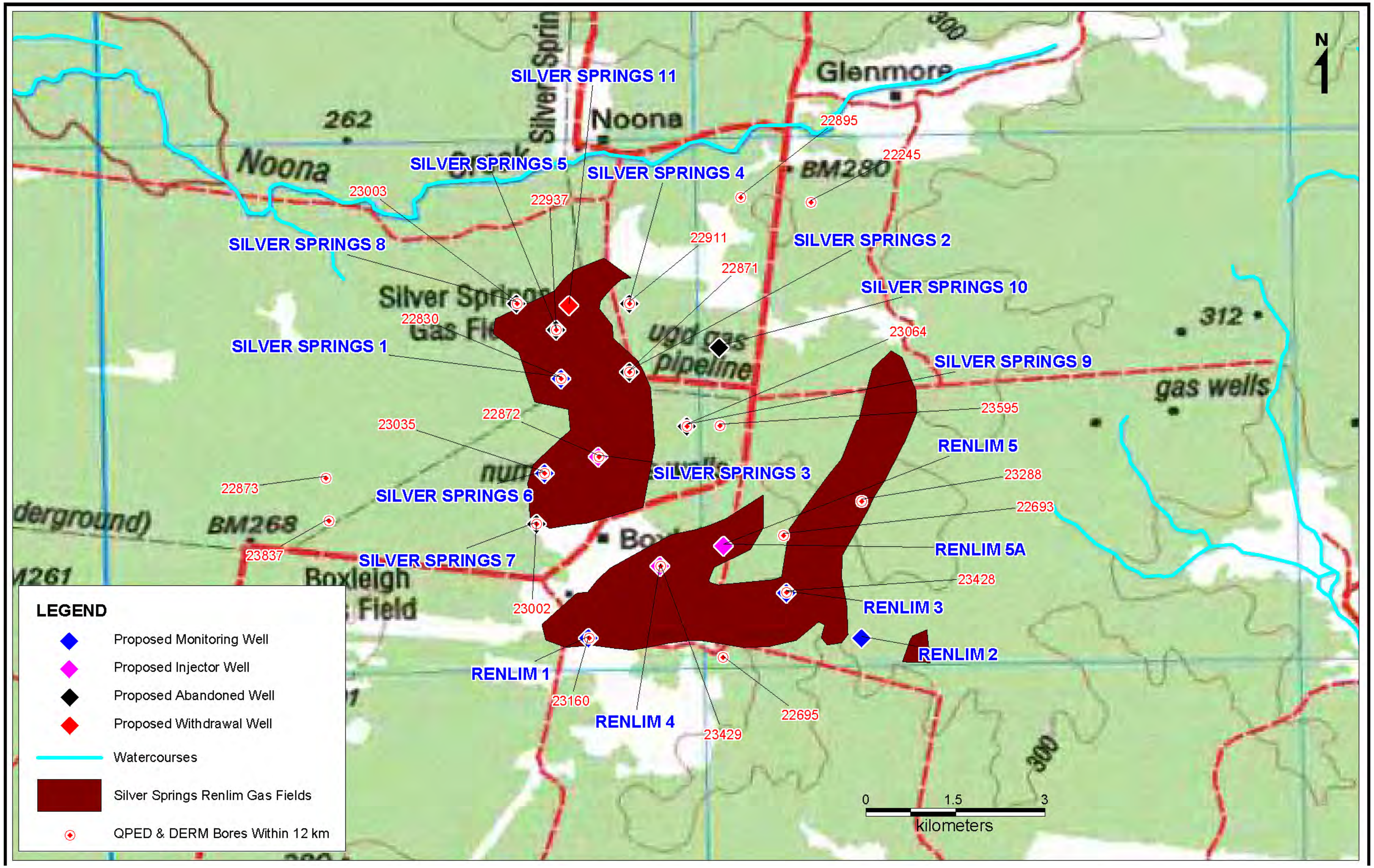

Figure 9 Potential Receptor Bores.

7 Other potential water receptors of existing operation

7.1 Rivers and Creeks

AGE (2005) reported on streams that are likely to receive baseflow from discharge from the Great Artesian Basin. This report did not indicate that the streams in the Balonne River area in the vicinity of the Silver Springs gas field received baseflow from the Great Artesian Basin. Accordingly, the local watercourses could only be receptors insofar as the discharge of groundwater from the gas field via production wells was concerned. Given this, then the major potential surface water receptors proximity to the Silver Springs gas fields are:

- Noona Creek and ultimately, and
- The Balonne River

The location of these waterways and other local waterways relative to the gas field are indicated on Figure 10.

The discussion of other potential water receptors is linked to the discussion of groundwater discharge discussed in Section 8.

Notwithstanding the work by AGE (2005), regionally, the Balonne River and its alluvium would be a regional sink for the discharge from the uppermost units of the Surat Basin as well as local Tertiary age sediments and Quaternary age alluvium. It is also possible that there is some periodic discharge of shallow groundwater during periods of high aquifer storage (after sustained periods of above average rainfall) from the near surface aquifers to the alluvium of the local creek systems (e.g. Danga Creek and Noona Creek).

The potential receiving area is restricted by the limited size of the above aquifers, the limited vertical and lateral extent of the creek alluvium and the relatively small creek size. The potential receiving area is also restricted by the surface water and groundwater divide defined by the Thomby Range located 20 km south-east of the Silver Springs gas fields.

7.2 Springs

The Great Artesian Basin hosts a large number of springs and these springs are the subject of considerable regulatory concern. Broadly DERM classifies these springs as either recharge springs or discharge springs.

The discharge springs are located near areas were the Great Artesian Basin aquifer units are exposed at the surface; typically in the recharge areas northeast the project site. The nearby Thomby Range was considered by Hitchon and Hays (1971) to be one of the recharge areas in the Great Artesian Basin; however, there are no springs documented in the Thomby Range area (Ransley and Habermehl 2004).

The discharge springs of the basin are generally located in areas well down gradient from the recharge areas and manifest as groundwater discharge related to either structural (fault related) or stratigraphic (e.g. unconformities against basement inliers) features.

Although some faulting has been mapped near the Silver Springs gas field, DERM does not record the presence of springs within 20 km of the Silver Springs gas field.

The closest documented springs are the “Barton” and “Sridge” springs located 150 km north, and up-gradient of the study site (Ransley and Habermehl 2004). The source aquifer for those springs has not been documented. However, the Gubberamunda Sandstone is mapped as the surface geological unit at the “Barton” and “Sridge” springs.

The closest down gradient springs (in terms of regional scale groundwater flow), are the “Towie” and “Tego” springs located approximately 250 km to the south-east of the project site. The source aquifer for these springs has not been documented; however, they discharge through surface material mapped as Quaternary age alluvium. The Coreena Member of the Wallumbilla Formation is the closest Great Artesian Basin unit mapped near the “Towie” and “Tego” Springs.

The “Town Spring” is located 250 km north west of the project site. The source aquifer has not been documented and the surface material is mapped as Quaternary Alluvium.

Available stratigraphic information suggests that the Showgrounds Formation does extend northward towards “Barton” and “Sridge” springs. Available stratigraphic information indicates that the Showgrounds Formation subcrop is truncated by a fault west of the Silver Springs Gas fields.

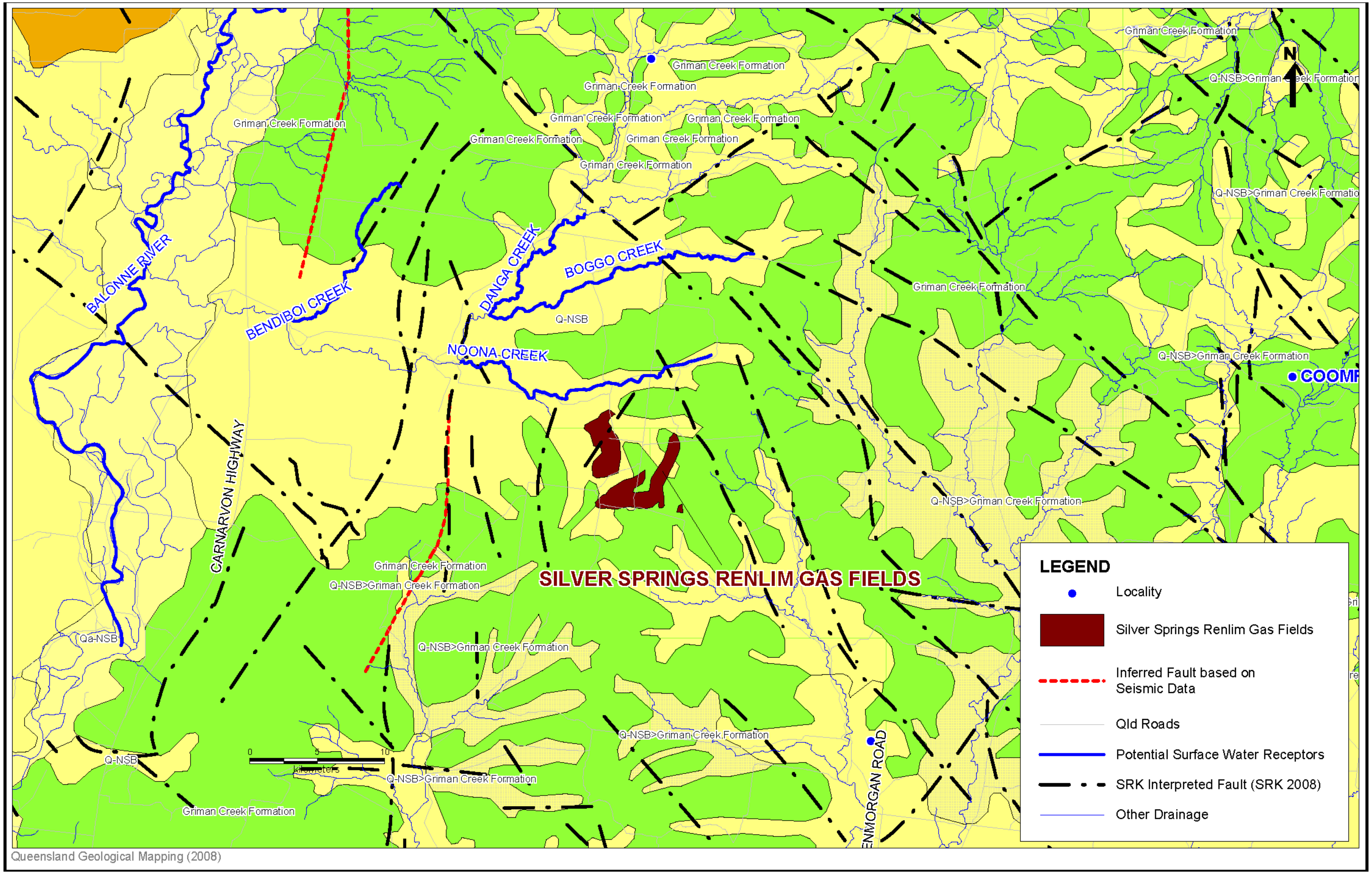

Figure 10 Potential Surface Water Receptors

8 Hydrogeological framework & conceptual model for main aquifers

8.1 Stratigraphic framework

The Silver Springs gas field is hosted by the Bowen Basin; however, the surface site of the gas field is located in the Great Artesian Basin. The Great Artesian Basin, at over 1.7 Mkm^2, is the largest groundwater basin in Australia. It covers approximately one fifth of Australia and extends from far north Queensland to into New South Wales, South Australia and the Northern Territory. The eastern limit of the Great Artesian Basin is defined by the Great Dividing Range (although some sediments of contemporaneous age extend east cross the Kumbarilla Arch into the Clarence Moreton Basin). Some sections of the Great Artesian Basin exceed 3,000 m in depth. . A typical cross section of the Great Artesian Basin is presented in Figure 11.

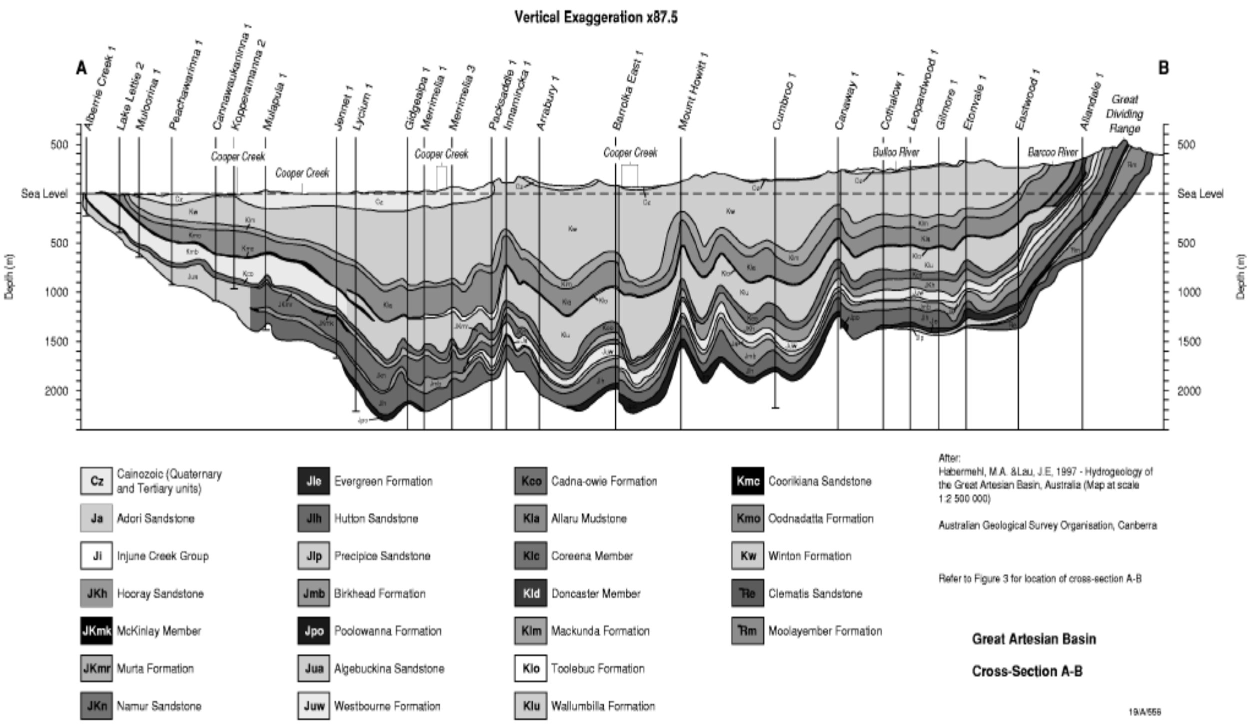

Figure 11 Typical Cross Section of the Great Artesian Basin.

The Great Artesian Basin is a multi-layered sedimentary system that was deposited during the Mesozoic era (225 to 60 million years ago) (Habermehl, 1980). The depositional environments with the basin shifted from fluvial to lacustrine and swamps a number of times. Within the Surat Basin these changes have resulted in deposition of the fluviatile aquifer sandstones such as the Mooga Sandstone. Gubberamunda Sandstone, Springbok Sandstone, Hutton Sandstone and Precipice Sandstone and fine grained confining layers such as the Evergreen Formation and Westbourne Formation. The shift from fluvial depositional environments to lakes and swamps allowed the organic matter that would become the coal seams in the Walloon Sub-Group to develop.

The Great Artesian Basin can be been divided into five major sedimentary basins based on ridges in the basement (Habermehl 1980). These basins are:

- Eromanga Basin;
- Surat Basin;
- Carpentaria Basin'
- Bowen Basin; and
- Galilee Basin

While the Silver Springs gas field site is located in the Surat Basin, the reservoir for this field is hosted by the Bowen Basin, which underlies the Surat Basin in this location.

All of the major recognised Great Artesian Basin aquifer and confining units for the Surat Basin have been identified in the drilling logs near the Silver Springs gas field. The typical stratigraphic sequence in this area is illustrated in Table 6.

Table 6 Great Artesian Basin Formation underlying the Silver Springs gas field—Typical Section

Formation		Age	Dominant lithology	Aquifer
Unconsolidated sediments		Tertiary	Unconsolidated	
Griman Creek Formation		Early Cretaceous	Sandstone and Siltstone	Aquifer
Surat Siltstone			Siltstone and Mudstone	Infrequently used
Wallumbilla Formation	Coreena Member		Siltstone and Sandstone	Aquifer
	Doncaster Member		Mudstone	
Blythesdale Group	Bungil Formation		Sandstone	Aquifer
	Mooga Sandstone		Sandstone	Aquifer
	Orallo Formation		Sandstone	Aquifer
	Gubberamunda Sandstone		Sandstone	Aquifer
Westbourne Formation		Late Jurassic	Shale and Siltstone	Confining
Injune Creek Group	Springbok Sandstone			
	Walloon Coal Measures	Middle Jurassic	Mudstone, siltstone, coal and sandstone	Aquifer (rarely used for potable water)
Hutton Sandstone			Sandstone	Aquifer
Evergreen Formation			Mudstone, Siltstone and Sandstone	Confining
Evergreen Formation (Boxvale Sandstone Member)		Early Jurassic	Sandstone	Aquifer
Moolayember Formation		Late Triassic	Mudstone and sandstone	Aquifer
Snake Creek Mudstone Member		Middle Triassic	Mudstone	Confining/Cap
Showgrounds Formation			Sandstone	Aquifer and petroleum producer
Timbury Hills Formation		Early Devonian	Basement Metasediments	Basement

8.2 Conceptual model for Quaternary and Tertiary age sediments

The Silver Springs gas field is underlain by unconsolidated Quaternary age alluvium and possibly Tertiary age sediments. These materials are associated with the Dango Creek and Boggo Creek, which have deposited materials from the Thomby Range and surrounding landscape.

The lack of records for shallow bores tapping this alluvium in the DERM database suggests that it is not an important local source of water. Tertiary age sediments are locally tapped for groundwater in some areas of the Surat Basin, but not in the vicinity of the Silver Springs gas field.

The Quaternary age and Tertiary age sediments include unconsolidated sand, gravel and silt (i.e. alluvium). The most significant area of alluvium is that associated with the Balonne River. Groundwater use from the Balonne River alluvium is of a far smaller scale than that from the Condamine River alluvium 45 km to the north east.

One available groundwater sample for the Balonne River Alluvium recorded a slightly brackish salinity of 1,880 mg/L total dissolved solids.

Groundwater recharge to the surface sediments is from infiltration of precipitation, and exchange between the aquifer and the rivers and creeks.

Groundwater discharge from the surface sediments would occur via evapotranspiration, discharge to rivers and creeks during periods of peak storage and groundwater abstraction.

8.3 Conceptual model for Griman Creek Formation

The Cretaceous age Griman Creek Formation is composed of lithic glauconitic sandstone, siltstone and mudstone. The Griman Creek Formation is up to 480 m thick and was deposited in a shallow marine fluvial environment.

Groundwater in this formation occurs at depths between 6 and 55 m b GL below ground level. Griman Creek Formation groundwater is sodium-chloride type (Quarantotto 1989). Groundwater salinity in this formation over the Surat Basin ranges from 600 mg/L to 25,000 mg/L total dissolved solids and averages 3,500 mg/L total dissolved solids. In this formation lower salinity values appear to correlate with higher bicarbonate values. Water hosted by this formation is generally unsuitable for human consumption.

Groundwater recharge to this unit is via direct precipitation where the Griman Creek Formation is exposed at the surface, north, south and east of the Silver Springs gas field. Groundwater recharge to this unit would also occurs in the Thomby Range, which forms a forms major surface water and groundwater divide south and east of the project site (Hitchon and Hays 1971).

Groundwater discharge from this unit would occur to the alluvium of the Balonne River during periods of very high storage, otherwise discharge would occur via evapotranspiration or via groundwater abstraction. As noted above, although DERM does not document any water bores tapping the Griman Creek Formation within 20 km of the project site, the available data suggests that up to five bores may be completed to tap groundwater in the Griman Creek Formation within this radius. DERM records approximately 350 bores completed to tap the groundwater of the Griman Creek Formation in the Surat Basin.

8.4 Conceptual model for Surat Siltstone Member Formation

The Cretaceous age Surat Siltstone is composed of siltstone, mudstone, and some fine glauconitic sandstone. The Surat Siltstone is up to 150 m thick and was deposited in a shallow marine environment. Groundwater in this formation occurs at very approximately 40 m b GL.

Regionally, groundwater salinity in the Surat Siltstone ranges from 580 to 1,630 mg/L total dissolved solids and average 870 mg/L total dissolved solids. Groundwater pH in this formation is generally above 7. Groundwater in this unit is a sodium—bicarbonate type. Groundwater drawn from this unit is generally suitable for human consumption, except for some areas of brackish groundwater.

Recharge to the Surat Siltstone would be via direct infiltration of precipitation where it outcrops a long way to the north and north west of the Silver Springs area and potentially where it may subcrop beneath alluvium well to the north west of the Silver Springs area.

Groundwater discharge from this formation would be dominated by groundwater abstraction or by discharge to the Balonne River at high aquifer storage levels. As noted above, DERM does not document any Surat Siltstone bores within 20 km of the project site. Regionally across the Siltstone, DERM have only indicated that 23 bores specifically have been completed to tap the groundwater of the Surat Siltstone. Clearly this is an underestimate of the number of water bores that in fact tap this formation.

8.5 Conceptual model for Wallumbilla Formation (Coreena & Doncaster Members)

The Cretaceous age Wallumbilla Formation is composed of siltstone, mudstone, and commonly glauconitic and calcareous sandstone. The Coreena Member of the Wallumbilla Formation is up to 210 m thick, whilst the Doncaster Member is up to 290 m thick. The Wallumbilla Formation was deposited in a shallow marine environment. Within the Wallumbilla Formation groundwater occurs at depths between 2 and 90 m b GL.

Salinity in the Wallumbilla Formation groundwater across the Surat Basin ranges from 880 mg/L to 12,000 mg/L and averages 3,000 mg/L total dissolved solids. The groundwater in this formation is generally of sodium—bicarbonate type. Quarantotto (1989) has documented that groundwater in this formation are enriched in boron ad strontium. Groundwater drawn from the Wallumbilla Formation is generally not suitable for human consumption.

Groundwater recharge to the Wallumbilla Formation would be dominated by direct infiltration of incident rainfall in areas of formation outcrop; such as adjacent to the valley of the Cogoon River located well to the north west of the Silver Springs site.

Groundwater discharge from the Wallumbilla Formation in the regional around Silver Spring would primarily be via groundwater abstraction.

As noted above, DERM does not document any bores specifically tapping the Wallumbilla Formation bores within 20 km of the project site. Regionally, DERM records over 1,000 bores completed to tap the groundwater of the Coreena Member and nearly 900 bores completed to tap the groundwater of the Doncaster Member of the Wallumbilla Formation.

8.6 Conceptual model for Blythesdale Group

There are four significant groundwater-bearing formations in the Blythesdale Group. These are:

- Bungil Formation
- Mooga Sandstone
- Orallo Sandstone
- Gubberamunda Sandstone

There is generally sufficient data available to discuss these individual formations in the Blythesdale Group separately. Unfortunately, the majority of the bores advanced in the 20 km radius of the Silver Springs gas field were drilled to access the petroleum-bearing formations near the base of the sequence. Accordingly the upper strata of the Surat Basin sequence were rarely logged in detail if they were logged at all.

The QPED database records 154 petroleum bores wirhin the 20 km radius of the Silver Springs gas field. The company well completion reports drawn from the QDEX system document that the 48 bores converted to water wells were plugged at the base of the Blythesdale Group, or typically just above the contact with the Westbourne Formation (Appendix A).

Where data allow, formations are be discussed separately in the following sections. However, where data are limited, the formations comprising the Blythesdale Group are discussed as a single unit.

8.6.1 Bungil Formation

The Cretaceous age Bungil Formation is composed of glauconitic, labile to quartzose, siltstone, mudstone and siltstone. The Bungil Formation is up to 200 m thick was deposited in a shallow marine and deltaic environment. Groundwater occurs between 1 and 90 m b GL.

Groundwater salinity in the Bungil Formation across the Surat Basin ranges from 180 mg/L to 6,000 mg/L and averages 1,350 mg/L total dissolved solids. Groundwater in areas near the recharge areas of the Bungil Formation contain more calcium magnesium, chloride and sulphate than is found at depth in the Bungil Formation (Quarantotto 1989).

Groundwater recharge to the Bungil formation would occur through the infiltration of rainfall and ephemeral stream flow in its belt of outcrop to the north of Roma. Groundwater in the Bungil Formation would flow regionally with a similar pattern to that of the Mooga Sandstone – Gubberamunda Sandstone – Hooray Sandstone ultimately across the Surat Basin and Eromanga Basin towards South Australia where discharge from it occurs via springs and via diffuse upward flow to evaporation.

As noted above, DERM does not document any bores that specifically are attributed to the Bungil Formation within 20 km of the project site. Regionally, DERM records over 900 bores completed to tap the groundwater of the Bungil Formation across the Surat Basin.

8.6.2 Mooga Sandstone

The Cretaceous aged Mooga Sandstone is composed of sandstone, siltstone and mudstone. The Mooga Sandstone is up to 300 m thick was deposited in fluvial and lacustrine environments. Groundwater occurs between 2 and 6 m b GL.

Salinity in the Mooga Sandstone groundwater ranges from 370 mg/L to 2,200 mg/L and averages 1,000 mg/L total dissolved solids. Groundwater from the near the outcrop areas of the Mooga Sandstone is dominated by the sodium-bicarbonate type water. Bores tapping the Mooga Sandstone at depth typically have encounter groundwater with higher bicarbonate and lower calcium, magnesium, chloride and sulphate than found at shallower depths (Quarantotto 1989).

The Mooga Sandstone is recharged by the infiltration of incident rainfall in its outcrop areas located to the north of Roma and also probably by infiltration of ephemeral stream flow in creeks and gullies in this area.

Groundwater in the Mooga Sandstone flows regionally through the lateral equivalent Hooray Sandstone towards South Australia where discharge from it occurs via springs and via diffuse upward flow to evaporation.

As noted above, DERM does not document any Mooga Sandstone bores within 20 km of the project site. Regionally, DERM records 223 bores completed to tap the groundwater of the Mooga Sandstone.

8.6.3 Orallo Formation

The Cretaceous aged Orallo Formation is composed of sandstone, siltstone, mudstone, conglomerate and coal. The Orallo Formation is up to 250 m thick and was deposited in fluvial, lacustrine and swampy environments. Regionally, groundwater in this formation occurs at depths between 0 and 100 m b GL.

Regionally, groundwater salinity in the Orallo Formation ranges from 800 mg/L to 11,500 mg/L and averages 2,400 mg/L total dissolved solids. Groundwater from the near the outcrop areas of the Orallo Formation is dominated by the sodium-chloride type water. Groundwater drawn from the Orallo is generally not suitable for human consumption.

Groundwater flow systems within the Orallo Formation are not well documented. However, this finer textured unit lies between the Mooga Sandstone and Gubberamunda Sandstones. These and these three groups ultimately grade laterally into the Hooray Sandstone. The Hooray Sandstone flow system has significant hydraulic continuity across the Great Artesian Basin. Accordingly the recharge and discharge processes for this formation would be similar to the overlying Mooga Sandstone and underlying Gubberamunda Sandstone.

As noted above, DERM does not document any bores specifically tapping the Orallo Formation bores within 20 km of the project site. However, regionally across the Surat Basin, DERM records at least 141 bores completed to tap the groundwater of the Orallo Formation.

8.6.4 Gubberamunda Sandstone

The Cretaceous age Gubberamunda Sandstone is composed of sandstone, siltstone and mudstone. The Gubberamunda Sandstone is up to 250 m thick was deposited in fluvial, lacustrine and swampy environments. Regionally, groundwater occurs in this formation from depths ranging from 4 to145 m b GL.

Groundwater salinity in the Gubberamunda Sandstone ranges from 160 mg/L to 1,700 mg/L and averages 750 mg/L total dissolved solids. Groundwater from the near the Gubberamunda Sandstone outcrop areas is dominated by the sodium-chloride type water. The shallower

Gubberamunda Sandstone groundwater is dominantly sodium-chloride type while the deeper groundwater is sodium-bicarbonate type (Quarantotto 1989).

As noted above, DERM does not document any bores specifically tapping the Gubberamunda Sandstone within 20 km of the project site. Regionally, DERM records at least 337 bores completed to tap the groundwater of the Gubberamunda Sandstone in the Surat Basin.

The Gubberamunda Sandstone ultimately grades into the Hooray Sandstone. As mentioned above, the flow system has significant hydraulic continuity across the Great Artesian Basin. Accordingly the recharge and discharge processes for this formation would be similar to the overlying Mooga Sandstone and the laterally equivalent Hooray Sandstone, which discharges in the form of localised springs, vertical leakage to overlying aquifers and groundwater abstraction..

The Gubberamunda Sandstone is not exposed at the surface rear the Sliver Springs gas field. The geological mapping for the Surat 1:250,000 geological also does not show the Gubberamunda Sandstone rocks outcropping near or under the Balonne River. Therefore, it reasonable to conclude that the aquifers of the Gubberamunda Sandstone is not directly connected to the surface water systems and that any groundwater to surface water connections the do exist are via the overlying Wallumbilla Formation, Surat Siltstone and Griman Creek Formation.

8.7 Conceptual model for the Westbourne Formation

The Jurassic aged Westbourne Formation is composed of interbedded shales, siltstones, very fine-grained quartzose sandstone and rare coal. The Westbourne Formation is up to 220 m thick was deposited in a lacustrine environment. Regionally, groundwater occurs in this formation from depths ranging from 24 and 155 m b GL.

Salinity in the Westbourne Formation groundwater ranges from 160 mg/L to 2,800 mg/L and averages 790 mg/L total dissolved solids. Groundwater in the Westbourne Formation is dominantly sodium-chloride type (Quarantotto 1989).

As noted above, DERM does not document any Westbourne Formation bores within 20 km of the project site. Regionally, DERM records 126 bores completed to tap the groundwater of the Westbourne Formation.

There is a paucity of information to assess the groundwater flow patterns in the Westbourne Formation. It would, however, be expected that as the Westbourne Formation has stratigraphic continuity across the Nebine Ridge into the Eromanga Basin. It would therefore be expected that this unit would have a similar flow system to the Mooga Sandstone / Gubberamunda Sandstone / Hooray Sandstone system with regional flow from its outcrop areas cross the Surat Basin and Eromanga Basin ultimately towards the basin margin in South Australia.

The Westbourne Formation is considered a major regional confining unit in the Surat Basin due to a lithological composition dominated by fine grained sediments

8.8 Conceptual model for Springbok Sandstone

The Jurassic aged Springbok Sandstone is composed of labile sandstone, siltstone, mudstone, with some coal. The Springbok Sandstone is up to 250 m thick was deposited in a fluvial environment. Regionally, groundwater occurs in this formation from depths ranging from 12 and 85 m b GL.

The Springbok Sandstone is separated from the Walloon Coal measures by a well documented unconformity. The Springbok Sandstone is known to occur in small channels eroded into the top of the Walloon Coal Measures; therefore, there is an inferred direct hydraulic connection between Springbok Sandstone and the Walloon Coal Measures. Local geochemical evidence does confirm a possible hydraulic connection between the Springbok aquifer and water-bearing sandstones and coal measure near the top of the Walloon Coal Measures.

Salinity in the Springbok Sandstone groundwater ranges from 250 mg/L to 2,800 mg/L and averages 1,150 mg/L. Groundwater in the Springbok Sandstone is dominantly a sodium-bicarbonate type (Quarantotto 1989).

As noted above, DERM does not document any Springbok Sandstone bores within 20 km of the project site. Regionally, DERM records 53 bores completed to tap the groundwater of the Springbok Sandstone.

Recharge to the Springbok occurs in the north and eastern sections of the Surat Basin; however, there evidence of groundwater exchange between the lower Springbok, where occurs in channels eroded into the Walloon Coal Measures, and the upper most water-bearing strata in the Walloon Coal Measures.

Locally, the Springbok aquifer appears to discharge to the overlying aquifer west of the Silver Springs gas field. Regionally, the groundwater flow in the Springbok Sandstone is likely down-gradient to the southeast away from its recharge areas well to the north of the Silver Springs site. The Springbok Sandstone is confined by the overlying Westbourne Formation. The Springbok Sandstone is not exposed at the surface rear the Sliver Springs gas field.

The geological mapping for the Surat 1:250,000 geological does not show the Springbok Sandstone outcropping near or under the Balonne River. Therefore, it reasonable to conclude that the Springbok Sandstone aquifer is not directly connected to the surface water systems and that any groundwater to surface water connections that do exist would be via much shallower formations (e.g. Wallumbilla Formation, Surat Siltstone and Griman Creek Formation).

8.9 Conceptual model for Walloon Sub-Group

The Jurassic age Walloon Sub-Group consists of shale, siltstone, sandstone, coal, mudstone and limestone. This unit is up to 500 m in thickness and was deposited in fluvial, lacustrine and swampy environments. The Walloon Sub-Group contain in the order of 10 to 15% coal, which occurs in 40 to 45 coal seams of variable thickness. Regionally, groundwater occurs in this formation from depths ranging from 2 and 130 m b GL.

The fine-grained lithologies of mudstones, shales and rare limestones dominate the Walloon Sub-Group, hence it is considered to form a regional aquitard. However, where this formation occurs at relatively shallow depths its coal seams and sandstones are frequently tapped for stock bores and therefore in some areas it is a significant groundwater supply source.

Groundwater salinity in the Walloon Sub-Group ranges from 950 mg/L to 13,000 mg/L and averages 4,500 mg/L total dissolved solids. This groundwater is dominantly a sodium-chloride type (Quarantotto 1989). The groundwater in the shallower Walloon Sub-Group rocks is rich in calcium, magnesium, chloride and sulphate. Groundwater deeper in this unit is richer in sodium and bicarbonate than the shallower groundwater.

As noted above, DERM does not document any bores specifically tapping the Walloon Sub-Group within 20 km of the project site. Regionally, DERM has recorded over 3,000 bores completed to tap the groundwater of the Walloon Sub-Group. The Walloon Sub-Group outcrops over wide area of productive farm lands northeast of Chinchilla.

Most recharge for the Walloon Sub-Group would take place along its eastern and north-eastern margins on the western slope of the Great Dividing Range were the unit outcrops.

Much further to the east north east of the Silver Springs site the Walloon Sub-Group subcrop under the Condamine River alluvium. Linkages between the groundwater in the Condamine River Alluvium and the Walloon Sub-Group have been investigated since at least 1966 (Lumsden 1966).

The recharge beds of this unit are located where the sandstone aquifers outcrop or are buried by permeable sediments (i.e. alluvium). The recharge beds are dominantly composed of sandstone aquifers and interbedded mudstone aquitard.

Locally, the Walloon Sub-Group appears to discharge to the overlying aquifers west of the Silver Springs gas field. Groundwater discharge from the Walloon Sub-Group, at a regional scale, is likely occurring to the south of the project site. It is likely, however, that at Great Artesian Basin scale, groundwater in this unit would flow southward and ultimately discharge via upward leakage into the overlying formations.

Groundwater abstraction from bores would be a major source of groundwater discharge from the Walloon Sub-Group. DERM documents over 3,000 abstraction bores completed within this unit. This is likely to represent only a small fraction of the water abstraction bores that will be constructed if the proposals to develop the Surat Basin's considerable CSG resources proceed to completion.

While some areas of the Walloon Sub-Group form a regional aquitard and groundwater confining unit, it is noted that some areas of this unit host productive aquifers, some of which are in direct contact with the overlying Springbok Sandstone.

The Walloon Sub-Group rocks are not exposed at the surface rear the Silver Springs gas field. The geological mapping for the Surat 1:250,000 geological sheet does not indicate the Walloon Sub-Group to outcrop near or directly under the Balonne River (although it would be present at significant depth). It reasonable to conclude that the Walloon Sub-Group is not directly connected to the surface water system in the vicinity of the Silver Springs site.

8.10 Conceptual model for Hutton Sandstone

The middle Jurassic age Hutton Sandstone is a pale brown to pale grey, poorly sorted, medium-grained, feldspathic sub-labile sandstone (at base) and fine-grained, well-sorted quartzose sandstone (at top). It also consists of minor dark grey carbonaceous siltstone, mudstone and rare pebble conglomerate. The Hutton Sandstone is a major regional Jurassic age artesian aquifer unit in the Great Artesian Basin in both the Eromanga Basin and Surat Basin.

The Hutton Sandstone is up to180 m thick and was deposited in a fluvial environment. Regionally, groundwater occurs in this formation from depths ranging from 0 and 150 m b GL.

Groundwater salinity in the Hutton Sandstone ranges from 70 mg/L to 4,500 mg/L and averages 900 mg/L total dissolved solids. Sodium, chloride, bicarbonate and sulphate contribute the high salinity values in this formation (Quarantotto 1989). Nearly half of the groundwater water samples of this formation in the Surat Basin are of sodium chloride type. In this unit groundwater is higher in calcium, magnesium, chloride and sulphate near outcrops than it is at depth.

Groundwater flow models developed by the Bureau of Rural Sciences indicate that less than 1% of precipitation falling on the exposed Great Artesian Basin aquifer formations (e.g. Hutton Sandstone) infiltrates to recharge the groundwater systems (Great Artesian Basin Strategic Management Plan, September 2000).

Most recharge for the Hutton Sandstone takes place along eastern and north-eastern margins on the western slope of the Great Dividing Range. The recharge beds are located where the sandstone aquifers outcrop or are directly covered by permeable sediments (i.e. alluvium) over 200 km northeast of the site. The recharge beds for this unit are dominantly composed of sandstone aquifers although the unit hosts interbedded mudstone aquitards. Some additional regional recharge to this unit occurs along the arid western margin of the Great Artesian Basin.

Groundwater discharge from the Hutton Sandstone would occur down gradient of the Silver Springs gas field. Natural discharge areas for Hutton Sandstone are provided by springs and adjoining sedimentary formations south of the Silver Springs site (Radke *et al.* 2000).

Groundwater abstraction in the form of uncontrolled and controlled artesian bores and pumped bores in sub-artesian areas represents a major discharge from the Hutton Sandstone. DERM does not document any bores specifically tapping the Hutton Sandstone within 20 km of the project site. DERM documents over 1,800 bores tapping the Hutton Sandstone aquifer over its full extent in the Surat Basin.

Quarantotto (1989) mapped the piezometric surface for Hutton Sandstone and suggested that groundwater in this unit flows to the north and east. It is, however, noted that Quarantotto's groundwater flow directions were concluded from a series of control points located well to the north east of the site. This spatial bias of control points does not paint a complete picture of groundwater flow in the Hutton Sandston.

The Hutton Sandstone is confined by the overlying Walloon Sub-Group. The Hutton Sandstone is not exposed at the surface near the Silver Springs gas field. It reasonable to conclude that the Hutton Sandstone aquifer is not directly connected to the surface water systems and that any groundwater to surface water connections that do exist are via the overlying formations.

It is, however, noted that elsewhere in the Surat Basin that the Hutton Sandstone is connected to surface water systems via discharge springs. However, there are no discharge springs linked to the Hutton Sandstone aquifer near the Silver Springs gas field.

8.11 Conceptual model for Evergreen Formation

8.11.1 Evergreen Formation

The early Jurassic age Evergreen Formation is a calcareous mudstone and siltstone with minor sandstone and coal beds.

The Evergreen Formation is up to 300 m thick and predominantly of shales and mudstones with argillaceous silty sandstones, particularly near its base. Regionally, groundwater occurs in this formation from depths ranging from 46 and 135 m b GL.

Groundwater salinity in the Evergreen Formation ranges from 1,100 mg/L to 12,500 mg/L and averages 3,500 mg/L total dissolved solids. Groundwater from the Evergreen Formation is nearly always sodium-chloride type and is generally unsuitable for human consumption. Sodium, chloride, bicarbonate and sulphate in the groundwater of this formation contribute the high salinity values (Quarantotto 1989). Groundwater in this unit is higher in calcium, magnesium, chloride and sulphate near outcrops than it is at depth.

As noted above, DERM does not document any bores that specifically tap the Evergreen Formation within 20 km of the project site. Regionally, DERM records 209 bores completed to tap groundwater from this formation over the extent of the Evergreen Formation.

8.11.2 Evergreen Formation—Boxvale Sandstone Member

The early Jurassic aged Boxvale Sandstone Member of the Evergreen Formation consists of labile and sub-labile, fine to medium-grained sandstone, carbonaceous mudstone, siltstone and minor coal; and locally and oolitic ironstone. The Boxvale Sandstone Member is up to 60 m thick and was deposited in a fluvial lacustrine deltaic environment. Regionally, groundwater occurs in this formation from depths ranging from 2 and 100 m b GL.

Groundwater salinity in the Boxvale Sandstone Member groundwater ranges from 100 mg/L to 12,500 mg/L and averages 3,500 mg/L total dissolved solids. Groundwater from the Boxvale Sandstone Member is nearly always sodium-chloride type and where it is exploited it is generally suitable for human consumption; however, there is a relative paucity of data for its quality in deeper sections of the Surat Basin such as at Silver Springs. Groundwater dominated by bicarbonate is the most common water type for this unit; however, there are significant potions of this aquifer that host chloride or bicarbonate-chloride types (Quarantotto 1989). In this formation groundwater is higher in magnesium, chloride and sulphate and lower in sodium and bicarbonate near outcrops than it is at depth.

8.11.3 Evergreen Formation—Boxvale Sandstone Member flow systems

Groundwater flow models developed by the Bureau of Rural Sciences indicate that less than 1% of precipitation falling on the exposed Great Artesian Basin aquifer formations infiltrates to recharge the groundwater systems (Great Artesian Basin Strategic Management Plan, September 2000).

Most recharge for the Evergreen Formation and Boxvale Sandstone Member takes place along eastern and north-eastern margins on the western slope of the Great Dividing Range. The recharge beds are located where the sandstone aquifers outcrop or are buried by permeable sediments (i.e., alluvium).

Groundwater discharge from the Evergreen Formation and Boxvale Sandstone Member would occur from spring discharge and ultimately from the upward migration of groundwater into shallow formations. There is potential for this upward migration to occur well to the east of the site in the via major regional fault systems such as the Leichhardt – Burunga / Goondiwindi- Moonie Fault system. There is also potential for this to occur via unconformable surfaces where this unit pinches out against basement highs such as against the Nebine Ridge, which lies to the far west of the Silver Springs site.

Groundwater abstraction represents a major discharge from the Evergreen Formation and Boxvale Sandstone Member. DERM documents nearly 350 bores tapping the Evergreen Formation and Boxvale Sandstone Member over its full extent. However, no bores are recorded to specifically tap the Evergreen Formation and Boxvale Sandstone Member near the project site.

The Evergreen Formation is considered to form a regional confining unit that confines both the Boxvale Sandstone Member as well as the underlying Precipice Sandstone. The Evergreen Formation and Boxvale Sandstone Member are not exposed at the surface rear the Silver Springs gas field. The geological mapping for the Surat 1:250,000 geological sheet does not indicate Evergreen Formation or Boxvale Sandstone Member outcrop near or under the Balonne River.

It is reasonable to conclude that the Evergreen Formation and Boxvale Sandstone Member aquifer are not directly connected to the surface water systems and that any groundwater to surface water connections that do exist would be via faulted connections via overlying formations.

8.12 Conceptual model for Precipice Sandstone

The early Jurassic age Precipice Sandstone consists of a white to brown, poorly sorted, thick-bedded, cross-bedded, fine to very coarse-grained, pebbly quartzose sandstone with minor white to yellowish brown, laminated siltstones, carbonaceous shale, lithic sub labile sandstone and a granule conglomerate. The Precipice Sandstone is up to 150 m thick was deposited in a fluvial environment. Regionally, groundwater occurs in this formation from depths ranging from 1 and 185 m b GL.

Groundwater salinity in the Precipice Sandstone ranges from 60 mg/L to 550 mg/L and averages 175 mg/L total dissolved solids in areas closer to its outcrop. In these areas groundwater from the Precipice Sandstone is dominantly the sodium-bicarbonate type and is generally suitable for human consumption (Quarantotto 1989). At further depth in the Surat Basin down dip from the recharge areas the salinity of groundwater in the Precipice Sandstone increases significantly. The higher salinities may potentially reflect much longer residence times in the central sections of the basin in comparison to the near outcrop areas where there is considerable rejection of recharge and local discharge of groundwater to springs and streams.

Most recharge for the Precipice Sandstone takes place along eastern and north-eastern margins on the western slope of the Great Dividing Range. The recharge beds are located where the sandstone aquifers outcrop or are buried by permeable sediments (i.e., alluvium). The recharge beds dominantly composed of sandstone aquifers.

Piezometric data for the Precipice Sandstone are very limited. Quarantotto (1989) mapped a general eastward groundwater gradient in this unit in north of the Silver Springs gas field. Henning *et al.* (2006) compiled a piezometric surface map for the Silver Springs area using petroleum well data. They found the groundwater gradient at Silver Springs to be to the southwest and identified a piezometric surface high underlying the Thomby Range to the southeast of Silver Springs. Groundwater flow on the southeast side of the Thomby Range has been mapped by Henning el al. (2006) as flowing to the southeast. Henning et al (2006) noted that the groundwater flow directions in the Showgrounds Formation were similar to that in the Precipice Sandstone, reflecting regional influences. However, Henning *et al.* noted that the piezometric high in the Precipice Sandstone corresponded to a piezometric low in the Showgrounds Formation, indicating no linkage between these aquifers.

Significant groundwater discharge from the Precipice Sandstone occurs close to its outcrop areas located well to the north of the Silver Springs site. This discharge occurs through discharge to streams such as the Dawson River and via numerous artesian springs. Much less is known about the discharge from this formation in the deeper section of the Surat Basin. This formation pinches out to the south and any groundwater discharge from it in the areas to the south and east of the Silver Springs site would occur ultimately from the upward groundwater migration into shallow formations. As with the Evergreen Formation, there is potential for this upward migration to occur well to the east of the site via major regional fault systems such as the Leichhardt – Burunga / Goondiwindi- Moonie Fault system (Evans, 1996). There is also potential for this to occur via unconformable surfaces where this unit pinches out against basement highs such as against the Nebine Ridge that lies to the far west of the Silver Springs site.

The Precipice Sandstone is considered to be confined beneath the Evergreen Formation. The Precipice Sandstone is not exposed at the surface rear the Silver Springs gas field. It is reasonable to conclude that the Precipice Sandstone aquifer is not directly connected to the surface water systems at the Silver Springs site and that any groundwater to surface water connections that do exist are via the overlying formations.

Groundwater abstraction also represents an appreciable discharge from the Precipice Sandstone. However, available data suggests that there are no water bores specifically tapping the Precipice Sandstone near the project site.

8.13 Conceptual model for Showgrounds Formation & equivalents

Groundwater resources are typically not produced from the Showgrounds Formation near the Silver Springs gas field except as minor extraction as a by-product of hydrocarbon production. Groundwater is, however, produced the from the Showgrounds Formation equivalent, the Clematis Group sandstones significantly to the north of the project site.

The middle Triassic age Showgrounds Formation is a pale grey to white medium to very coarse-grained quartzose sandstone. The Showgrounds Formation underlies the Moolayember Formation and the Snake Creek Mudstone Member. The top of the Moolayember Formation marks the base of the Surat Basin strata and represents the upper surface of the Bowen Basin strata. Near the Silver Springs gas field, the Showgrounds Formation can be up to 100 m thick, but it is much thinner often no more than 5 m thick. It was deposited in a fluvial environment.

Piezometric water levels for the Showgrounds Formation as calculated from final hydrostatic pressures in the Silver Springs area have ranged from 54 to 375 m AHD, discounting the obvious data outliers (Table 3).

Groundwater salinity in samples (8 x samples from 3 x wells) collected from the Showgrounds Formation groundwater ranges from 4,200 mg/L to 50,000 mg/L total dissolved solids. The upper salinity values were associated with elevated potassium values suggesting that drilling fluid had appreciably contaminated the samples.

Groundwater from the Showgrounds Formation a sodium-chloride type and is generally unsuitable for human consumption. Sodium, chloride, bicarbonate and sulphate contribute to the high salinity values.

As previously noted, DERM does not document any bores that specifically tap the Showgrounds Formation or Clematis Group Sandstones bores within 20 km of the project site. However, regional DERM records show 319 bores completed to tap the groundwater of the Clematis Formation (Figure 6).

Groundwater recharge in the Showgrounds Formation would occur well to the north-east of the Silver Springs gas field. Groundwater recharge would be dominated by downward groundwater flow from exposed sandstone aquifers of the Clematis Group sandstones in the Arcadia Valley (Figure 6). The Showgrounds Formation is stratigraphically situated beneath a regionally significant capping formation, the Snake Creek Mudstone Member (see Section 2). Accordingly, local leakage from overlying formations if present at all, contributes little to the Showgrounds Formation.

The Snake Creek Mudstone Member of the Moolayember Formation confines groundwater and methane in the underlying Showgrounds Formation so there is very little local natural groundwater discharge from this unit. The major groundwater discharge from the Showgrounds Formation comes from the gas productions wells completed in the Showgrounds Formation at Silver Springs and Renlim (Figure 2).

Henning et al (2006) mapped pre-production groundwater flow in the Showgrounds Formation. Henning *et al.* indicate a general south easterly flow direction in this formation; however, they noted that the hydraulic gradient to the north of Silver Springs was low and accordingly the rate of groundwater flow would also be low as well. It is possible that south easterly groundwater flow through this unit ultimately encounters major regional fault systems that allow some limited upward interconnection with younger formations in areas remote from the Silver Springs site in much the same manner as postulated by Evans (1996).

The Showgrounds Formation is considered to be confined below the Snake Creek Mudstone Member of the Moolayember Formation. The Showgrounds Formation is not exposed at the surface rear the Sliver Springs gas field. It is reasonable to conclude that the Showgrounds Formation aquifer is not directly naturally connected to the surface water systems and that any groundwater to surface water connections that do exist are via the overlying formations. Any effective connection between this formation and the overlying, younger aquifer units of the Surat Basin section of the Great Artesian Basin could only occur via existing deep boreholes if the integrity of the annular cementing and casing has been compromised.

9 Overview of surface water at Silver Springs gas field

9.1 Surface catchment of Silver Springs gas field

The area of lease PL16 is shown on Figure 1.

The lease area extends in a generally south-west to north-east direction along the Thomby Range. The Thomby Range separates the Moonie River Basin from the Balonne-Condamine River Basin.

Some of the PL16 area drains south and east into Christmas Creek and Rocky Creek, which flow into the Moonie River or its tributaries.

Part of the PL16 area drains generally westward into the Merroombil Creek, Boggo Creek and Noona Creek. These creeks drain into the Balonne River upstream of Beardmore Dam.

The general extent of the gas fields within the PL16 lease area is shown in Figure 12. There are a number of drainage lines passing through the gas fields area, and these are shown as “Trib 1”, Trib 2” and “Trib 3” in the figure.

The approximate boundaries of the catchment areas of these drainage lines are also shown in Figure 12. “Trib 1”, which flows northwards past Boxleigh Station, has a catchment area of approximately 68 km^2 at its confluence with “Trib 2”. “Trib 2” has a catchment area of 48 km^2 at its confluence with “Trib 1”.

These drainage lines have longitudinal slopes of 2 to 3 m/km and are considerably steeper than the longitudinal slope of around 0.2 m/km of the Balonne River between Weribone and St George. There appear to be a number of small dams or tanks along or adjacent to these drainage lines, which would be used mainly for stock-watering.

9.2 Literature review for potentially relevant flood studies / surface water assessments

A search has been made of recorded flood information for this PL16 area. There are no stream gauging stations within the PL16 area, or on the streams emanating from the lease area.

The nearest stream gauging stations or flood warning gauges are:

- Teelba Creek at Teelba (BOM number 43097) with Teelba Creek being a tributary of Moonie River;
- Balonne River at Weribone (DERM stream gauge number 422213A); and
- Balonne River at Warroo (BOM number 43107).

Information from these gauges will give some indication of periods of flooding at the site, but will not be directly useful in determining flooding extent or depth of flooding across the site.

No information could be found on any flood studies, flood reports, or records of flood events in the PL16 area.

9.3 Flooding risk at Silver Springs field

In order to determine the flooding risk at specific locations within the lease area, it would be necessary to have better topographic information (e.g. higher resolution DEM than the existing SRTM DEM), and some survey cross section information for the drainage lines in this area.

In the absence of the aforementioned information, and in the absence of specific anecdotal information or recorded flood data, it is only possible to generalise on the flooding risk in this area.

It is noted that the area is remote from major streams such as the Balonne River or Moonie River and no part of the site is located on the floodplains of these streams. Accordingly there will be little risk of flooding from major flood events in these rivers.

Given that a substantial part of the lease area is located along the Thomby Range, which is a watershed between two river basins, it is unlikely that widespread or extended duration flooding would occur across the area.

It is most likely that:

- the streams in the vicinity of the field are very ephemeral;
- flooding would be confined to narrow corridors along the drainage lines; and
- that the duration of flooding would be of the order of the storm duration plus one day.

This has been confirmed by personal communication with Tim Petersen (now production manager) who has been involved with the site for 20 years. He has indicated that flooding has not been a significant issue on the site, and that during storm events, water levels in the drainage lines typically rise at most by approximately 1 metre and may block access tracks through the site for short periods. Under such conditions the stream water levels remain high only for a day or so as the water quickly recedes. Mr Petersen indicated that the most significant stream is Boxleigh Creek (mot probably identified as "Trib 1" in Figure 9).

Further advice was also received from Stuart Galway (Land and Approvals Manager – Upstream Gas, AGL) as follows:

> *"There is no site specific data for flooding on site. The Silver Springs operations plant site has never flooded. During the flood times Boxleigh Creek floods which is the nearest watercourse but does not cause an issue to the Silver Springs Plant or access to some wells. There are also a couple of the watercourses between the plant and Roma that flood restricting access to the site."*

If more detailed information regarding flooding risk is required, it would be necessary to identify the features of interest, and to obtain ground level information at and around these features. Survey cross section information for the nearest drainage line would be needed as well. With such information, it would be possible to carry out some hydrologic and hydraulic analyses to predict design flood levels in the relevant drainage lines, and to determine the flood immunity of the particular feature.

If flooding were considered to be a critical issue, it may be warranted to set up a river height monitoring station (e.g. an ALERT gauge) or a peak height recorder at the location. In this way, over time, some flood level information will become available from which flooding risk could be determined. However, in view of the information obtained to date, the above action does not appear to be warranted.

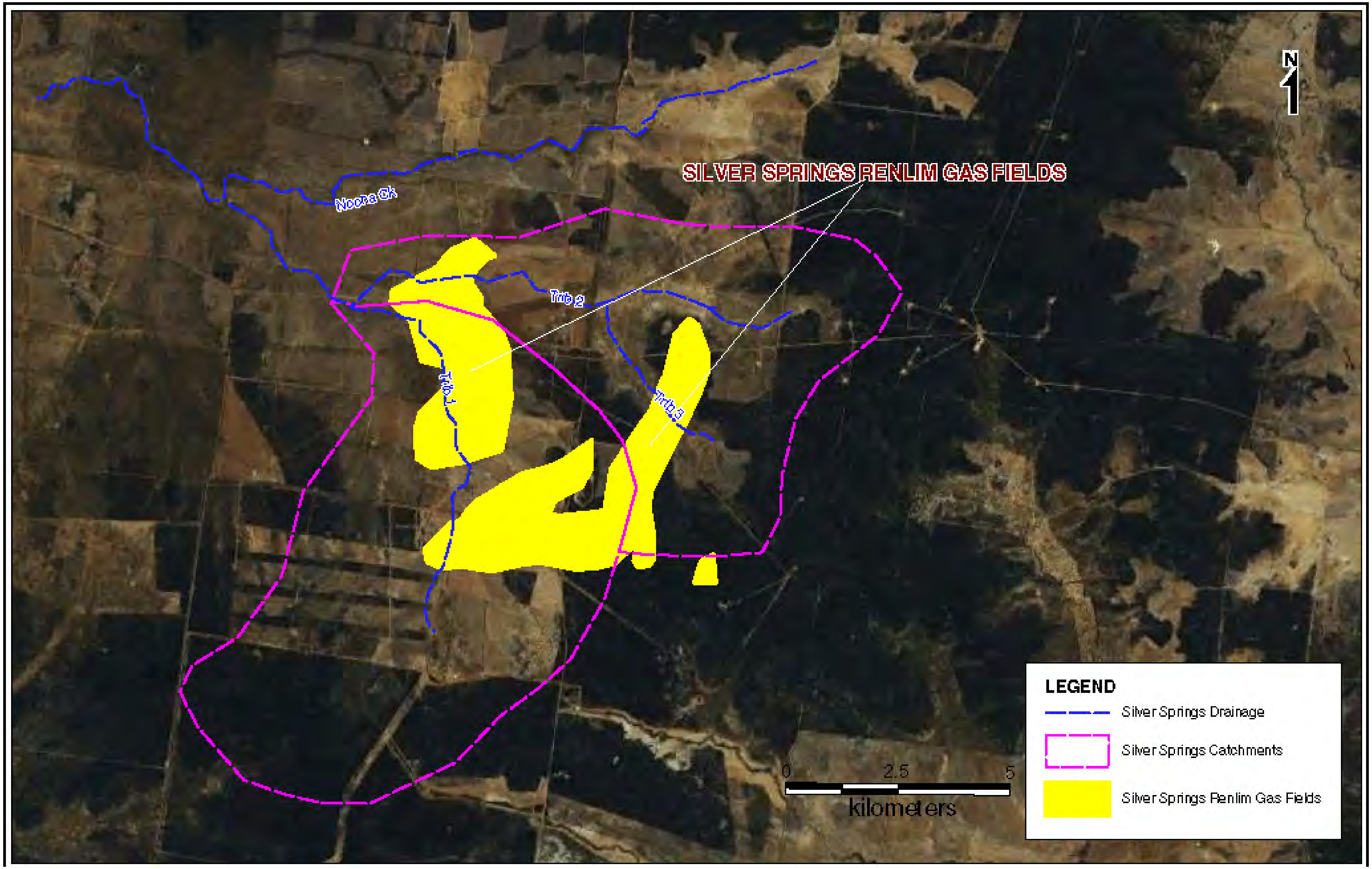

Figure 12 Surface Water Drainage of the Silver Springs gas field

10 Identified data gaps and outline of further investigations and/or monitoring programs required to assess impact of the proposed development on groundwater resources

10.1 Stratigraphy

Although there is relatively high quality well data available with regard to the deeper stratigraphic intervals at the Silver Springs site, there is a relative lack of detail available for the shallower Surat Basin aquifer sequences. This is a historical artifact of the practice of not logging petroleum wells in the sequences above which commercial hydrocarbons were anticipated.

This is an important consideration since many of these petroleum wells have subsequently been converted to water bores and the specific aquifers that these bores now tap is not known.

Wireline and mud logging of the full depths of any bores constructed to support the future development of this project should be undertaken.

10.2 Well and Bore Completion

As previously mentioned, although there are high quality data for well completion for the petroleum wells near the Silver Springs gas field, unfortunately, the data are not consistent or available for all petroleum wells and are generally lacking for the water bores. Additional information on the well and bore completions would be desirable to allow a better understanding of the hydrology of the system and the potential risk to existing users.

10.3 Regional Geology

There is a fault indicated to lie approximately 10 km to the west of the Silver Springs gas field that is on the 1:250,000 scale Surat geological sheet. This fault was apparently identified based on seismic data. SRK (2006) also indicate the presence of this fault. The significance of this fault to regional groundwater flow remains uncertain.

Henning et al (2006) suggested that there is a zero edge to the Showgrounds Formation west of the Silver Springs gas field. This zero edge and associated disconformity / unconformity could potentially offer a hydraulic connection between the Showgrounds Formation and the Precipice Sandstone if the Moolayember Formation thins markedly in this area. The location and nature of this zero edge relative to the current proposal should be determined.

10.4 Piezometric Surfaces and Groundwater Flow

There is limited available head data for the bores surrounding the Silver Springs area and available DST data are by nature “spot” observations. Accordingly, it is not possible currently to assess the actual hydraulic heads in the Showgrounds Formation at the site. Opportunities to gather a more coherent water level dataset should be considered for both the Showgrounds Formation and more shallow formations tapped by water bores. This may require reviewing the well completion reports in detail or retrieving the bore cards on file with DERM to determine the aquifer formation the plugged petroleum wells were perforated to tap.

10.5 Groundwater quality data

There is a marked lack of groundwater quality data available for the water bores surrounding the Silver Springs site. It would be desirable that a program be undertaken to collect groundwater samples from these bores to establish baseline physico-chemical parameters, major ion chemistry and trace contaminant chemistry (e.g. total petroleum hydrocarbons and BTEX compounds prior to commencing the CSG injection program) values.

These data would be useful to support attribution of source aquifers to water bores as well as to providing baseline data for long-term monitoring of potential impact..

11 Conclusions

The following key conclusions are made:

- DEEDI (2009) concluded that gas storage in the Showgrounds Formation is viable based on the following criteria:
  - A viable seal located at a depth below 800 m;
  - A formation located below the regionally contiguous Snake Creek Mudstone Member seal;
  - Formation porosity greater than 10%; and
  - A median formation permeability of 14 mD (milli darcies).
- A series of significant Great Artesian Basin aquifers are present at the Silver Springs gas field in strata stratigraphically above the Showgrounds Formation reservoir. These aquifers include (from the stratigraphically lowest):
  - Precipice Sandstone (basal Surat Basin);
  - Boxvale Sandstone Member of the Evergreen Formation;
  - Hutton Sandstone;
  - Springbok Sandstone;
  - Gubberamunda Sandstone;;
  - Mooga Sandstone; and
  - Bungil Formation
- Henning *et al.* (2006) concluded that there is little natural connection between the Showgrounds Formation Sandstone and the overlying aquifers.
- There are no registered or reported Great Artesian Basin springs in close proximity or in connection with the aquifer underlying the Silver Springs gas field. The closest documented springs are the "Barton" and "Sridge" springs located 150 km north, and up gradient of the study site (Ransley and Habermehl, 2004).
- Although the Showgrounds Formation is a lateral equivalent of the Clematis Group sandstones and may be in lateral hydraulic connection, the nearest water bore identified that has a recorded contributing Clematis Group sandstone water bed is registered number 8138 located 150 km to the north north west of the Silver Springs gas field.
- There are no potential water bore receptors in close proximity to the Silver Springs gas field. This conclusion carries the caveat that the petroleum wells near the Silver Springs gas field have sound casing and cementing integrity to preclude artificial cross connections between formations vertically penetrated by the wells.

- There are no specific surface water receptors in close proximity to the Silver Springs gas field that could be impacted by groundwater.
- With respect to flooding risk, the streams in the vicinity of the field are very ephemeral, flooding would be confined to narrow corridors along the drainage lines and the duration of flooding would be of the order of the duration of incident storms plus one day.
- The key potential hydrologically related impacts of the gas storage proposal are seen as:
  - If the integrity of the petroleum wells (including wells converted to water bore) that extend to the Showgrounds Formation reservoir is compromised, then there could be potential for gas to migrate into overlying formations or wells converted to water bores. Given that the Silver Springs field historically produced both natural gas and condensate, there could be contamination impacts from dissolved hydrocarbons; and
  - By-product water recovered from the operating wells during CSG gas recovery would be expected to be unsuitable for surface discharge to waterways in the absence of treatment to address contaminants such as salts and hydrocarbons. Specific attention will need to be paid to the integrity of water holding and treatment facilities, notwithstanding that the amount of water produced is likely to be similar to the very small volumes historically recovered.

12 Recommendations

The following key recommendations are made:

- An investigation should be undertaken of the integrity of the bores proposed to be used for this project, and ideally the other suspended petroleum wells in the field. This may require running geophysical logs for these wells to confirm casing and cementing condition.
- Conduct a survey of the local landowners to determine if any of the 20 potential “receptor” bores are likely to be used to supply water for any use. Any bore that is likely to be used should be investigated to determine the depth of the plug and the aquifer the bore taps. If necessary, the bore cards on file with DERM should be consulted to determine the perforation depths, which can then be used to identify the aquifer tapped above the plug.
- Additional data pertaining to the zero edge of the Showgrounds Formation should be sought to allow it to be mapped and its relevance to the current project determined.
- The location and nature of the fault west of the site should be confirmed using available data. In addition to this, the SRK fault dataset (SRK 2008) should be further queried to determine the nature of the faults inferred to be present at and near the Silver Springs gas field. Specifically, the fault dip direction and angle should be determined if possible. The offset across these faults should be determined.
- The groundwater head within the Showgrounds Formation should be mapped using newly acquired data. These data can be collected as the wells and bores are accessed during project development.
- Groundwater samples should be collected at bores within the vicinity of the project to provide a baseline suite of constituents to establish current groundwater quality and groundwater type of the water within the Showgrounds Formation at the Silver Springs gas field. The analysis suite should include major ions and minor ions such as fluoride. Sampling should also include analysis for hydrocarbons (i.e. TPH and BTEX) since is an active petroleum field.

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Appendix A

DERM Registered Bores and QPED Well Summary Tables

Table A- 1 Summary of DERM Registered Bores

Bore registered number	Existing (Y/N)	Facility Type	Original bore name	Latitude	Longitude	Natural surface elevation (m AHD)	Date Drilled	Aquifer Above Plug, Perforation Depth Unknown	Well Yield L/S	Total cased depth (m bGL)	Water Level (m bGL)	Measurement Date
4512	N	Artesian (Ceased Flow)	THOMBY PRIVATE BORE	-27.71725416	148.9381178	264.7	4/10/1919	Mooga Sandstone	No data	1132	41.4	04-Oct-19
8905	Y	Sub-artesian	BEECHWOOD	-27.51500842	149.2938124	320	29/11/1941	Griman Creek Formation	No data	157.3	-21.3	29-Nov-41
11796	N	Sub-artesian	LEIRAVALE BORE	-27.66092747	149.3025167	350	1/01/1951	Unknown	No data			
13407	Y	Sub-artesian	BASIN DOWNS NO 2	-27.43009644	148.9252982	275	7/09/1957	Griman Creek Formation	No data	128.9	-48.8	07-Sep-57
22214	Y	Artesian (Controlled Flow)	UOD WUNGER 1	-27.6770689	149.1265611	302.2	3/11/1963	Griman Creek Formation	No data			
22222	Y	Artesian (Controlled Flow)	UOD BIDGEL 1	-27.57565011	149.2355725	338.2	29/12/1963	Abandoned	No data			
22224	Y	Artesian (Controlled Flow)	UOD LYNROCK 1	-27.4339838	149.1664057	286.7	7/12/1963	Abandoned	No data			
22245	Y	Artesian (Controlled Flow)	UOD BOGGO CREEK 1	-27.56842845	149.1469626	291.2	12/02/1964	Abandoned	No data			
22376	Y	Artesian (Controlled Flow)	UOD MAJOR 1	-27.62484073	148.9023685	265	21/04/1965	Open to Showgrounds	No data			
22398	Y	Artesian (Controlled Flow)	UOD DALKEITH 1	-27.75752975	149.2948656	242.7	18/01/1965	Abandoned	No data			
22408	Y	Artesian (Controlled Flow)	UOD YOOROOGA 1	-27.7062574	149.1746542	264.4	8/02/1965	Griman Creek Formation	No data			
22440	Y	Artesian (Controlled Flow)	UOD THOMBY 1	-27.65147436	149.0201728	294.6	5/05/1965	Abandoned	No data			
22446	Y	Artesian (Controlled Flow)	UOD GLENEARN 1	-27.48676269	148.9952977	269.9	17/05/1965	Griman Creek Formation	No data			
22463	Y	Artesian (Controlled Flow)	UOD MAJOR 2	-27.63905969	148.908148	250	24/06/1965	Gubberamunda Sandstone	No data	1159	24.2	01-Jan-65
22472	Y	Artesian (Controlled Flow)	UOD WANGANUI 1	-27.64936173	148.946454	263.2	14/07/1965	Abandoned	No data			
22475	Y	Artesian (Controlled Flow)	UOD MOULLIT 1	-27.56270106	148.8924482	262.9	24/07/1965	Abandoned	No data			
22693	Y	Artesian (Controlled Flow)	UOD NOONA 1	-27.62509515	149.142241	298.9	5/09/1969	Unknown	No data			
22695	Y	Artesian (Controlled Flow)	UOD GLENMORE 1	-27.65036026	149.115029	285.1	10/11/1969	Abandoned	No data			
22747	Y	Artesian (Controlled Flow)	UOD MOURACHAN 1	-27.72273905	149.0749137	287.6	25/04/1970	Unknown	No data			
22748	Y	Artesian (Controlled Flow)	UOD BOXLEIGH 1	-27.62898441	149.0850198	267.4	15/06/1970	Open to Showgrounds	No data			
22759	Y	Artesian (Controlled Flow)	UOD MAJOR 3	-27.62211981	148.9196959	271.4	11/09/1970	Abandoned	No data			
22830	Y	Artesian (Controlled Flow)	BON SILVER SPRINGS	-27.59842871	149.1044636	260.9	30/06/1974	Open to Showgrounds	No data			
22871	Y	Artesian (Controlled Flow)	BON SILVER SPRINGS	-27.59731753	149.1161301	269.4	19/04/1976	Open to Showgrounds	No data			
22872	Y	Artesian (Controlled Flow)	BON SILVER SPRINGS	-27.61176201	149.1108525	266.4	14/12/1976	Unknown	No data			
22873	Y	Artesian (Controlled Flow)	BON BOXLEIGH 2	-27.61537341	149.0644643	282.5	11/05/1976	Abandoned	No data			
22874	Y	Artesian (Controlled Flow)	SILVER SPRINGS	-27.61453979	149.1094636	Not Surveyed	1/01/1978	Unknown	No data	716.7		
22884	Y	Artesian (Controlled Flow)	HPP BENDIBOI 1	-27.52918219	148.9010038	Not Surveyed	9/01/1979	Unknown	No data			
22887	Y	Artesian (Controlled Flow)	BON BOGGO CREEK 3	-27.55370635	149.1277962	Not Surveyed	16/05/1979	Unknown	No data			
22895	Y	Artesian (Condition Unknown)	BON BOGGO CREEK 4	-27.56759519	149.1350184	Not Surveyed	22/10/1979	Gubberamunda Sandstone	No data			
22899	Y	Artesian (Controlled Flow)	HEP DUNMARA 1	-27.76431559	149.1178845	Not Surveyed	31/12/1979	Gubberamunda Sandstone	No data			
22901	Y	Artesian (Condition Unknown)	BON COOMA 1	-27.43731628	149.2847372	382.5	25/12/1979	Orallo Formation	No data	231.1		
22904	Y	Artesian (Controlled Flow)	BON BOGGO CREEK 2	-27.55953965	149.1327962	Not Surveyed	6/09/1978	Open to Showgrounds	No data			
22911	Y	Artesian (Controlled Flow)	BON SILVER SPRINGS	-27.58565086	149.11613	Not Surveyed	29/10/1978	Abandoned	No data			
22927	Y	Artesian (Controlled Flow)	HEP MOURACHAN 2	-27.7291983	149.0977891	Not Surveyed	9/10/1980	Gubberamunda Sandstone	No data			
22928	Y	Artesian (Controlled Flow)	HEP GOLDEN SPRINGS 1	-27.76212641	149.0826824	Not Surveyed	4/11/1980	Gubberamunda Sandstone	No data			
22933	Y	Artesian (Condition Unknown)	BON THOMBY CREEK 1	-27.65148482	149.0202988	Not Surveyed	22/11/1979	Open to Showgrounds	No data			
22937	Y	Artesian (Controlled Flow)	BON SILVER SPRINGS	-27.59009539	149.1036302	Not Surveyed	14/04/1979	Unknown	No data			
22938	Y	Artesian (Controlled Flow)	BON BOXLEIGH 3	-27.63476513	149.0558702	Not Surveyed	10/06/1979	Unknown	No data			
22941	Y	Artesian (Controlled Flow)	BON YELLOWBANK CREEK	-27.73032923	149.014777	Not Surveyed	15/01/1981	Mooga Sandstone	No data			
22944	Y	Artesian (Controlled Flow)	BON THOMBY CREEK 3	-27.65289051	149.0131527	Not Surveyed	6/02/1981	Gubberamunda Sandstone	No data			
22948	Y	Artesian (Controlled Flow)	CON WONOLGA 1	-27.68032811	148.9703512	Not Surveyed	22/01/1981	Springbok Sandstone	No data			
22952	Y	Artesian (Controlled Flow)	CON BEARDMORE 1	-27.75583785	148.9848131	Not Surveyed	12/02/1981	Gubberamunda Sandstone	No data			
22957	Y	Sub-artesian	BON BEECHWOOD 1	-27.50315001	149.2500161	Not Surveyed	6/05/1981	Orallo Formation	No data			
22968	Y	Artesian (Controlled Flow)	HPP BYANBUNNOO 1	-27.61021804	148.9466122	Not Surveyed	6/08/1981	Springbok Sandstone	No data	1742		
22999	Y	Artesian (Controlled Flow)	CON WONOLGA EAST 1	-27.67426164	148.9946941	Not Surveyed	8/01/1982	Springbok Sandstone	No data	1915.7		
23002	Y	Artesian (Controlled Flow)	BON SILVER SPRINGS	-27.62315097	149.1002973	Not Surveyed	1/10/1981	Gubberamunda Sandstone	No data	1918.1		
23003	Y	Artesian (Controlled Flow)	BON SILVER SPRINGS	-27.58565098	149.0969636	Not Surveyed	28/12/1981	Gubberamunda Sandstone	No data	1909.9		
23004	Y	Artesian (Controlled Flow)	BON GLEN FOSSLYN 2	-27.46981641	149.2741821	350	22/01/1982	Gubberamunda Sandstone	No data			
23009	Y	Artesian (Controlled Flow)	BON GLEN FOSSLYN 1	-27.49203866	149.283071	350	13/07/1980	Open to Showgrounds	No data			
23034	Y	Artesian (Controlled Flow)	BON BOXLEIGH 4	-27.64359814	149.0558251	Not Surveyed	7/05/1980	Unknown	No data			
23035	Y	Artesian (Controlled Flow)	BON SILVER SPRINGS	-27.61453984	149.1016861	Not Surveyed	6/06/1980	Unknown	No data			
23036	Y	Artesian (Controlled Flow)	BON THOMBY CREEK 2	-27.6578737	149.0211321	Not Surveyed	6/08/1980	Open to Showgrounds	No data			
23044	Y	Artesian (Controlled Flow)	CON BEARDMORE SOUTHW	-27.75976468	148.9810078	Not Surveyed	18/03/1982	Springbok Sandstone	No data	1857.8		
23045	Y	Artesian (Controlled Flow)	CON BEARDMORE SOUTHW	-27.76052158	148.9809503	Not Surveyed	28/02/1982	Griman Creek Formation	No data	210.6		
23047	Y	Artesian (Controlled Flow)	BON SIRRAH 1	-27.66613735	149.165419	Not Surveyed	25/03/1982	Gubberamunda Sandstone	No data	1959.9		
23051	Y	Artesian (Controlled Flow)	BON THOMBY CREEK 6A	-27.66059882	149.0281652	Not Surveyed	12/05/1982	Gubberamunda Sandstone	No data	1915.1		
23064	Y	Artesian (Controlled Flow)	BON SILVER SPRINGS	-27.60648414	149.1258522	Not Surveyed	3/09/1982	Gubberamunda Sandstone	No data	1944.9		
23080	Y	Artesian (Controlled Flow)	BON ROCKY GLEN 1	-27.64842786	149.2416842	Not Surveyed	10/12/1982	Springbok Sandstone	No data	2040		
23083	Y	Artesian (Controlled Flow)	HEP WEST MOURACHAN 1	-27.73854595	149.0590607	Not Surveyed	17/12/1982	Gubberamunda Sandstone	No data	1889		
23090	Y	Artesian (Controlled Flow)	HPP JOHNSTON 1	-27.73014275	148.9824944	Not Surveyed	29/03/1983	Springbok Sandstone	No data	1874.5		
23110	Y	Artesian (Controlled Flow)	HPP BENDEE 1	-27.64374522	148.9794651	Not Surveyed	9/07/1981	Open to Showgrounds	No data			
23118	Y	Artesian (Controlled Flow)	BON BOXLEIGH 5	-27.6612004	149.0618656	Not Surveyed	11/12/1981	Unknown	No data			
23119	Y	Artesian (Controlled Flow)	BON THOMBY CREEK 4	-27.64779235	149.0225276	Not Surveyed	2/03/1981	Abandoned	No data			
23120	Y	Artesian (Controlled Flow)	BON THOMBY CREEK 5	-27.65328146	149.0213374	Not Surveyed	31/03/1981	Open to Showgrounds	No data			
23121	Y	Artesian (Controlled Flow)	BON THOMBY CREEK 6	-27.66148479	149.0264099	Not Surveyed	9/11/1981		No data			
23141	Y	Artesian (Condition Unknown)	HPP BRIGALOW 1	-27.4700966	148.90391	Not Surveyed	27/09/1983	Springbok Sandstone	No data			
23148	Y	Artesian (Controlled Flow)	BON LINCOLN 1	-27.79618957	149.0165745	Not Surveyed	26/12/1983		No data	1900		
23155	Y	Artesian (Controlled Flow)	HEP NARDOO 1	-27.69710185	149.1828906	Not Surveyed	7/06/1984	Gubberamunda Sandstone	No data	1996		
23160	Y	Artesian (Controlled Flow)	BON RENLIM 1	-27.6422274	149.1092629	Not Surveyed	24/02/1982	Open to Showgrounds	No data			
23161	Y	Artesian (Controlled Flow)	BON SIRRAH 2	-27.64669326	149.1782323	Not Surveyed	10/06/1982	Open to Showgrounds	No data			
23162	Y	Artesian (Controlled Flow)	BON YELLOWBANK CREEK	-27.75511384	149.0159014	Not Surveyed	19/04/1982	Open to Showgrounds	No data			
23196	Y	Artesian (Controlled Flow)	BON SIRRAH 3	-27.6582942	149.1721739	Not Surveyed	28/07/1982	Open to Showgrounds	No data			
23197	Y	Artesian (Controlled Flow)	BON YELLOWBANK CREEK	-27.74737294	149.0146837	Not Surveyed	18/08/1982	Unknown	No data			
23231	Y	Artesian (Controlled Flow)	BON ONERRY 1	-27.49565092	149.1041849	Not Surveyed	29/01/1985	Springbok Sandstone	No data	2172		
23247	Y	Artesian (Controlled Flow)	BON ROSWIN 1	-27.45620556	149.2308493	309.2	11/02/1984	Open to Showgrounds	No data			
23288	Y	Artesian (Controlled Flow)	BON RENLIM 2	-27.61926173	149.1555741	Not Surveyed	14/01/1984	Open to Showgrounds	No data			

Bore registered number	Existing (Y/N)	Facility Type	Original bore name	Latitude	Longitude	Natural surface elevation (m AHD)	Date Drilled	Aquifer Above Plug, Perforation Depth Unknown	Well Yield L/S	Total cased depth (m bGL)	Water Level (m bGL)	Measurement Date
23341	Y	Artesian (Controlled Flow)	BHP WONOLGA 2	-27.67010309	148.9719376	286.2	21/08/1985	Springbok Sandstone	No data	1833		
23369	Y	Artesian (Controlled Flow)	BON CAPTAIN COOK 1	-27.78290648	149.2900156	Not Surveyed	7/11/1985	Gubberamunda Sandstone	No data	2142.7		
23385	Y	Artesian (Controlled Flow)	HEP COOLAMON 1	-27.77937244	149.173093	Not Surveyed	16/01/1985	Orallo Formation	No data	1935.5		
23428	Y	Artesian (Controlled Flow)	BON RENLIM 3	-27.63481737	149.1427967	Not Surveyed	16/12/1984	Open to Showgrounds	No data			
23429	Y	Artesian (Controlled Flow)	BON RENLIM 4	-27.63037306	149.1214081	Not Surveyed	18/02/1985	Open to Showgrounds	No data			
23464	Y	Artesian (Controlled Flow)	BON MCGREGOR 1	-27.71929538	149.006943	Not Surveyed	29/11/1986	Springbok Sandstone	No data	7054		
23468	Y	Artesian (Controlled Flow)	BON CAUSEWAY 1	-27.78414422	149.2539048	Not Surveyed	19/12/1986	Springbok Sandstone	No data			
23474	Y	Artesian (Controlled Flow)	BON TAYLOR 2	-27.5542612	149.2391834	Not Surveyed	16/05/1987	Gubberamunda Sandstone	No data	6801		
23486	Y	Artesian (Controlled Flow)	BON TAYLOR 3	-27.5398167	149.2477942	Not Surveyed	26/07/1987	Gubberamunda Sandstone	No data	1675		
23488	Y	Artesian (Controlled Flow)	LPP BEARDMORE 2	-27.75200206	148.9836008	Not Surveyed	7/07/1987	Unknown	No data	1835		
23491	Y	Artesian (Condition Unknown)	BON TAYLOR 1	-27.55426109	149.2558497	340	30/04/1986	Open to Showgrounds	No data			
23532	Y	Artesian (Condition Unknown)	SPC MCWHIRTER 1	-27.69411134	148.9961056	Not Surveyed	2/12/1985	Open to Showgrounds	No data			
23559	Y	Artesian (Condition Unknown)	BON MERROOMBIL 2	-27.50481703	149.1941836	Not Surveyed	26/08/1987	Gubberamunda Sandstone	No data	2160		
23562	Y	Artesian (Condition Unknown)	BON KIPPERS 1	-27.74565767	149.244655	Not Surveyed	21/09/1987	Gubberamunda Sandstone	No data	1978		
23571	Y	Artesian (Controlled Flow)	CON GLENEARN NORTH 1	-27.45981815	149.0022418	Not Surveyed	14/12/1987	Springbok Sandstone	No data	1860		
23588	Y	Artesian (Controlled Flow)	SOC HOLLOW TREE 1	-27.71928537	148.9657508	Not Surveyed	16/09/1987	Gubberamunda Sandstone	No data	6117		
23589	Y	Artesian (Controlled Flow)	SOC MCWHIRTER 2	-27.68415386	148.9930238	Not Surveyed	28/10/1987	Walloon Coal Measures	No data	6578		
23595	Y	Artesian (Condition Unknown)	BON SILVER SPRINGS 1	-27.59315076	149.1314076	Not Surveyed	6/06/1988	Springbok Sandstone	No data			
23605	Y	Sub-artesian	BON TAYLOR GA	-27.5528724	149.2241836	Not Surveyed	1/08/1988	Gubberamunda Sandstone	No data			
23607	Y	Artesian (Condition Unknown)	BON MERROOMBIL 1	-27.49259486	149.1855725	Not Surveyed	13/06/1987	Open to Showgrounds	No data			
23644	Y	Artesian (Condition Unknown)	BON TINKER 1	-27.46759398	149.3075149	350	1/01/1989	Gubberamunda Sandstone	No data			
23655	Y	Artesian (Controlled Flow)	HEP LOCHNAGAR 1	-27.70768717	149.0706303	Not Surveyed	4/10/1987	Gubberamunda Sandstone	No data			
23659	Y	Artesian (Controlled Flow)	BON TAYLOR 13A	-27.57259473	149.2077952	Not Surveyed	1/11/1989	Springbok Sandstone	No data			
23661	Y	Artesian (Controlled Flow)	BON TAYLOR 14	-27.53648352	149.2250168	Not Surveyed	18/11/1989	Springbok Sandstone	No data			
23680	Y	Artesian (Condition Unknown)	BON TAYLOR 2A	-27.5542612	149.2391834	Not Surveyed	7/08/1987	Gubberamunda Sandstone	No data			
23682	Y	Artesian (Condition Unknown)	SOC YELLOWBANK CREEK	-27.72454046	149.0114107	Not Surveyed	8/08/1987	Open to Showgrounds	No data			
23722	Y	Artesian (Condition Unknown)	SOC MCWHIRTER EAST 1	-27.6970405	149.0036327	Not Surveyed	1/12/1987	Open to Showgrounds	No data			
23760	Y	Artesian (Condition Unknown)	BON TAYLOR 4	-27.60592786	149.2389061	Not Surveyed	31/03/1988	Open to Showgrounds	No data			
23778	Y	Artesian (Condition Unknown)	BON TAYLOR 5	-27.60398362	149.2083509	Not Surveyed	26/06/1988	Gubberamunda Sandstone	No data			
23782	Y	Artesian (Condition Unknown)	BON TAYLOR 6	-27.5528724	149.2241836	Not Surveyed	12/07/1988	Gubberamunda Sandstone	No data			
23792	Y	Artesian (Condition Unknown)	BON SIRRAH 5	-27.6425949	149.1830739	Not Surveyed	26/08/1988	Open to Showgrounds	No data			
23797	Y	Artesian (Condition Unknown)	BON TAYLOR 7	-27.59426147	149.195851	Not Surveyed	13/09/1988	Open to Showgrounds	No data			
23801	Y	Artesian (Condition Unknown)	BON TAYLOR 8	-27.59676119	149.2386282	Not Surveyed	6/10/1988	Open to Showgrounds	No data			
23810	Y	Artesian (Condition Unknown)	BON TAYLOR 9	-27.58926118	149.2416837	Not Surveyed	8/11/1988	Open to Showgrounds	No data			
23812	Y	Artesian (Condition Unknown)	BON TAYLOR 10	-27.59370575	149.221684	Not Surveyed	25/11/1988	Open to Showgrounds	No data			
23818	Y	Artesian (Condition Unknown)	BON BEECHWOOD 2	-27.50120552	149.2569603	Not Surveyed	14/12/1988	Open to Showgrounds	No data			
23827	Y	Artesian (Condition Unknown)	BON TAYLOR 11	-27.5564834	149.2439056	Not Surveyed	20/01/1989	Open to Showgrounds	No data			
23830	Y	Artesian (Condition Unknown)	BON TAYLOR 12	-27.60648337	149.2472393	Not Surveyed	4/02/1989	Abandoned	No data			
23833	Y	Artesian (Condition Unknown)	BON TAYLOR 12A	-27.60648337	149.2472393	Not Surveyed	20/02/1989	Open to Showgrounds	No data			
23835	Y	Artesian (Condition Unknown)	BON TINKER 2	-27.44953856	149.2733486	350	14/03/1989	Open to Showgrounds	No data			
23837	Y	Artesian (Condition Unknown)	BON BOXLEIGH 6	-27.62092897	149.06502	Not Surveyed	28/03/1989	Open to Showgrounds	No data			
23871	Y	Artesian (Condition Unknown)	BON TAYLOR 13	-27.57259473	149.2077952	Not Surveyed	20/10/1989	Open to Showgrounds	No data			
23878	Y	Artesian (Controlled Flow)	BON LYNROCK 2	-27.42259488	149.1691833	300	5/12/1989	Springbok Sandstone	No data			
23882	Y	Artesian (Condition Unknown)	BON TINKER 3	-27.46064974	149.2683487	350	25/12/1989	Open to Showgrounds	No data			
23948	Y	Artesian (Controlled Flow)	FALCON NO 1 OIL WELL	-27.45203953	149.1411284	Not Surveyed	31/08/1993	Unknown	No data	1190		
23957	Y	Artesian (Condition Unknown)	BON BOXLEIGH 7	-27.63898455	149.0619646	Not Surveyed	7/04/1991	Unknown	No data			
23961	Y	Artesian (Condition Unknown)	BON EAST GLEN 1	-27.47203861	149.2797376	Not Surveyed	27/05/1991	Unknown	No data			
23969	Y	Artesian (Condition Unknown)	BON NORTH BOXLEIGH 1	-27.58898453	149.0641864	Not Surveyed	23/04/1991	Unknown	No data			
23970	Y	Artesian (Condition Unknown)	BON NORTH SIRRAH 1	-27.62620593	149.1955735	Not Surveyed	26/03/1991	Unknown	No data			
23973	Y	Artesian (Condition Unknown)	BON SILVER SPRINGS 1	-27.5859287	149.1058523	Not Surveyed	7/05/1991	Unknown	No data			
23975	Y	Artesian (Condition Unknown)	BON TAYLOR 15	-27.60592814	149.1947401	Not Surveyed	9/03/1991	Unknown	No data			
23976	Y	Artesian (Condition Unknown)	BON TAYLOR 16	-27.59065027	149.2094619	Not Surveyed	22/02/1991	Unknown	No data			
100059	Y	Artesian (Condition Unknown)	BON BEECHWOOD 3	-27.49870556	149.2516827	Not Surveyed	16/06/1992	Unknown	No data			
100071	Y	Artesian (Condition Unknown)	BON TINKER 4	-27.4517607	149.2880706	Not Surveyed	4/07/1992	Unknown	No data			
100074	Y	Artesian (Condition Unknown)	ANU MILES 1	-27.51731711	149.1819616	Not Surveyed	14/08/1993	Unknown	No data			
100112	Y	Artesian (Condition Unknown)	BON WHITE 1	-27.56592898	149.0619639	Not Surveyed	22/08/1992	Unknown	No data			
100136	Y	Artesian (Condition Unknown)	OCA BRAVO 1	-27.59842969	148.9539104	Not Surveyed	23/01/1994	Unknown	No data			
100168	Y	Artesian (Condition Unknown)	BON EAST BOUNDARY 1	-27.40009398	149.3097364	Not Surveyed	17/05/1994	Unknown	No data			
100213	Y	Artesian (Condition Unknown)	BON LARK 1	-27.43342759	149.2508488	Not Surveyed	22/06/1993	Unknown	No data			
100214	Y	Artesian (Condition Unknown)	BON LINK 1	-27.44759419	149.2597377	Not Surveyed	20/03/1994	Unknown	No data			
100215	Y	Artesian (Condition Unknown)	BON MAGPIE 1	-27.51731711	149.1819616	Not Surveyed	14/08/1993	Unknown	No data			
100217	Y	Artesian (Condition Unknown)	OCA MAJOR 4	-27.61565221	148.9083556	Not Surveyed	7/08/1993	Unknown	No data			
100234	Y	Artesian (Condition Unknown)	BON NORTH BOUNDARY 1	-27.40342761	149.2525152	Not Surveyed	26/04/1994	Unknown	No data			
100236	Y	Artesian (Condition Unknown)	BON NORTHWEST TAYLOR	-27.554817	149.2002951	Not Surveyed	30/03/1995	Unknown	No data			
100251	Y	Artesian (Condition Unknown)	BON RAVEN 1	-27.4756503	149.1989055	Not Surveyed	8/07/1993	Unknown	No data			
100260	Y	Artesian (Condition Unknown)	BON ROSWIN NORTH 1	-27.43648336	149.2250159	Not Surveyed	22/07/1992	Unknown	No data			
100261	Y	Artesian (Condition Unknown)	BON ROSWIN NORTH 2	-27.44620568	149.2152939	Not Surveyed	30/05/1993	Unknown	No data			
100262	Y	Artesian (Condition Unknown)	BON ROSWIN WEST 1	-27.46370577	149.2091831	Not Surveyed	8/08/1992	Unknown	No data			
100263	Y	Artesian (Condition Unknown)	BON SAMBEN 1	-27.52981811	149.0233531	Not Surveyed	13/03/1995	Unknown	No data			
100299	Y	Artesian (Condition Unknown)	PAR RENLIM 5	-27.62703966	149.1322412	Not Surveyed	8/05/1995	Unknown	No data			
100300	Y	Artesian (Condition Unknown)	PAR TAYLOR 17	-27.60203916	149.2097398	Not Surveyed	6/06/1995	Unknown	No data			
100302	Y	Artesian (Condition Unknown)	PAR RENLIM 5A	-27.62703966	149.1322412	Not Surveyed	21/05/1995	Unknown	No data			
100944	Y	Sub-artesian	MNL TINKER 5	-27.454444	149.306389	Not Surveyed		Unknown	No data			
42220121	Y	Sub-artesian		-27.416944	149.110556	Not Surveyed	14/09/2001	Unknown	No data	15	-3.05	07-Apr-06

Table A- 2 Summary of QPED Bores

QPED Bore No	DERM Registered Boe Number	Well Name	Latitude (Decimal)	Longitude (Decimal)	Ground Level RL(m)	Total Depth (m gGL)	Rig Release Date	Depth to Bottom of Casing (m)	Depth to top of highest plug (m)	QPED Status	Cemented Flag Y/N	Depth to Top of Deepest Formation (m KB)	Deepest Formation Reached	Depth to top of Showgrounds formation (m)	Aquifer above Plug, Perforation Depth Unknown
57456		ABBOTT 1	-27.7001	148.9986222	260.2	1908	24-Jun-98	210.6	185	Unknown	N	Not Reported	Unknown	Not Reported	Unknown
61333		ARMSTRONG 1	-27.57063611	149.2790472	335	2157	07-Jun-08			Unknown		Not Reported	Unknown	Not Reported	Unknown
58271		BARKER 1	-27.64954167	149.2563972	282.2	2231.7	27-Apr-02	256.61	0	Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
292	22952	BEARDMORE 1	-27.75315556	148.9891806	259.1	1874.5	12-Feb-81	207.6	1341.1	Water Bore		1858.7	Volcanics	1853.2	Gubberamunda Sandstone
1066	23488	BEARDMORE 2	-27.75204444	148.983625	248.8	1865	07-Jul-87	207	1235	Unknown		1833	Sediments and Metamorphics	Not Reported	Unknown
288	23045	BEARDMORE SOUTHWEST 1	-27.76037778	148.9814028	244.66	839.1	28-Feb-82	210.6		Unknown		802.2	Mooga Sandstone	Not Reported	Griman Creek Formation
289	23044	BEARDMORE SOUTHWEST 1A	-27.76037778	148.9814028	244.8	1895.9	18-Mar-82	207.8	1367.9	Water Bore		1828.8	Volcanics	Not Listed	Springbok Sandstone
349	22957	BEECHWOOD 1	-27.50315278	149.2500056	347.2	2187.9	06-May-81	232	1036.3	Water Bore		2176.3	Timbury Hills Formation	2103.7	Orallo Formation
1068	23818	BEECHWOOD 2	-27.50120833	149.25695	360.8	2185	14-Dec-88	230.2		Suspended Capped Shut In		2122	Timbury Hills Formation	2070	Open to Showgrounds
3134		BEECHWOOD 3	-27.49870833	149.2516722	349.3	2128.8	16-Jun-92	231.5		Unknown		2073.1	Kuttung Formation	2050	Unknown
290	23110	BENDEE 1	-27.64454444	148.9833444	280	1832	09-Jul-81	831.8	1225.3	Suspended Capped Shut In		1805	Roma Granites	Not Reported	Open to Showgrounds
291	22884	BENDIBOI 1	-27.54037778	148.9089028	230.4	1668.5	09-Jan-79	185.6	1235.4	Plugged and Abandoned		1655.7	Timbury Hills Formation	Not Reported	Abandoned
350	22222	BIDGEL 1	-27.57565278	149.2355639	338	1988.8	29-Dec-63	183.8	0	Plugged and Abandoned		1986.7	Timbury Hills Formation	Not Reported	Abandoned
352	22245	BOGGO CREEK 1	-27.56843056	149.1469528	291.1	1907.1	12-Feb-64	180.7	0	Plugged and Abandoned		1902	Timbury Hills Formation	Not Reported	Abandoned
353	22904	BOGGO CREEK 2	-27.55954167	149.1327861	269.4	1929.4	06-Sep-78	1866.3		Suspended Capped Shut In		1896.8	Combarngo Volcanics	1893.7	Open to Showgrounds
2268	22887	BOGGO CREEK 3	-27.55370833	149.1277861	274.3	1974.8	16-May-79	205.4	868.7	Water Bore		Not Reported	Blackwater Group	Not Reported	Unknown
354	22748	BOXLEIGH 1	-27.62898889	149.0583444	267.3	1926.3	15-Jun-70	204.2		Suspended Capped Shut In		1923.3	Basement	1886.7	Open to Showgrounds
1079	22873	BOXLEIGH 2	-27.615375	149.0644556	282.5	1968.4	11-May-76	196.9	0	Plugged and Abandoned		1967.8	Timbury Hills Formation	Not Reported	Abandoned
1080	22938	BOXLEIGH 3	-27.63482222	149.0561222	272.2	1926.3	10-Jun-79	204.2		Unknown		1907.4	Timbury Hills Formation	1897.7	Unknown
1081	23034	BOXLEIGH 4	-27.64398889	149.0566778	276.1	1908	07-May-80	207.3		Unknown		1878.5	Timbury Hills Formation	1872.7	Unknown
1082	23118	BOXLEIGH 5	-27.66121111	149.0619556	290.2	1983	11-Dec-81	207		Unknown		1955	Timbury Hills Formation	1912	Unknown
1083	23837	BOXLEIGH 6	-27.62259722	149.0650111	277.4	1958.9	28-Mar-89	1958.2		Suspended Capped Shut In		1908	Basement	1884.7	Open to Showgrounds
2997		BOXLEIGH 7	-27.63898889	149.0619556	281.3	1919.6	07-Apr-91	214.3		Unknown		1881.3	Basement	1873.8	Unknown
50059		BRAVO 1	-27.59871111	148.9533444	254.67	1807.7	23-Jan-94	192.95	168	Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
1199	23141	BRIGALOW 1	-27.4701	148.9039	249.9	1638.3	27-Sep-83	171.5	1158.2	Water Bore		1621.5	Roma Granites	Not Reported	Gubberamunda Sandstone
294	22968	BYANBUNNOO 1	-27.6076	148.9300139	270	1795	06-Aug-81	192.9	1265.8	Water Bore		1775	Basement	1772	Springbok Sandstone
1377	23369	CAPTAIN COOK 1	-27.78315278	149.2900083	233.9	2140.6	07-Nov-85	237.4	1415	Water Bore		2111.5	Volcanics	2037.5	Gubberamunda Sandstone
1484	23468	CAUSEWAY 1	-27.78426389	149.2538972	254.5	2105	19-Dec-86	242.8	1405	Water Bore		2050	Basement	2002.8	Springbok Sandstone
1401	23385	COOLAMON 1	-27.77981944	149.1727889	262.1	1935.5	16-Jan-85	194.5	371.6	Water Bore	Y	2285.4	Timbury Hills Formation	2155.6	Orallo Formation
364	22398	DALKEITH 1	-27.75843056	149.2950083	242.6	2035.5	18-Jan-65	128.9	0	Plugged and Abandoned		1993.7	Showgrounds Sandstone	1993.7	Abandoned
335	22899	DUNMARA 1	-27.76481944	149.1219556	275.8	1937.9	31-Dec-79	208	1274.1	Water Bore		1915.4	Basement	1909	Gubberamunda Sandstone
3001		EAST GLEN 1	-27.47204167	149.2797278	361.8	2258.8	27-May-91	244.5		Unknown		2210.5	Timbury Hills Formation	2112.1	Unknown
382	23009	GLEN FOSSLYN 1	-27.49204167	149.2830611	320	2188.5	13-Jul-80	234.7		Suspended Capped Shut In		2172.6	Timbury Hills Formation	2078.7	Open to Showgrounds
312	22446	GLENEARN 1	-27.48676667	148.9952889	269.8	1814.8	17-May-65	119.8	103.6	Water Bore		1808.7	Timbury Hills Formation	1804.4	Griman Creek Formation
1582	23571	GLENEARN NORTH 1	-27.45982222	149.0022333	312.2	1860	14-Dec-87	199.5	1350	Water Bore		1842.5	Timbury Hills Formation	1839.8	Springbok Sandstone
356	22695	GLENMORE 1	-27.64593056	149.1319556	285	1978.2	10-Nov-69	132	0	Plugged and Abandoned		1954.4	Timbury Hills Formation	1930	Abandoned
336	22928	GOLDEN SPRINGS 1	-27.76232222	149.0827889	274.9	1941.6	04-Nov-80	192	1270	Water Bore		1904.1	Basement	1884.3	Gubberamunda Sandstone
1551	23588	HOLLOW TREE 1	-27.71954444	148.9658472	252.7	1864.5	16-Sep-87	193.3	1197	Water Bore		1806	Timbury Hills Formation	1804.4	Gubberamunda Sandstone
61551		JAWSONE 1	-27.46206389	149.070425	258.6	1962	21-Jul-08			Unknown		Not Reported	Unknown	Not Reported	Unknown
1028	23090	JOHNSTON 1	-27.73343333	148.9877917	275.2	1930.6	29-Mar-83	205.4	1465.2	Unknown		1866.9	Combarngo Volcanics	1863.9	Springbok Sandstone
1518	23562	KIPPERS 1	-27.78426389	149.2538972	253.7	2038.1	21-Sep-87	227	1345	Water Bore		1970.3	Volcanics	1958.8	Gubberamunda Sandstone
58157		LACOMBE 1	-27.59509722	149.1550083	289.6	1958.5	17-Aug-01	209.72	187	Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
50146		LARK 1	-27.43343056	149.2508389	335.15	2290.5	22-Jun-93	2282		Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
1187	23148	LINCOLN 1	-27.79621111	149.016125	253.4	1900.6	26-Dec-83	191	1349	Water Bore		1882.5	Timbury Hills Formation	1868.5	Unknown
50147		LINK 1	-27.447875	149.2597278	338.08	2247.6	20-Mar-94	2247		Unknown		Not Reported	Unknown	Not Reported	Unknown
1520	23655	LOCHNAGAR 1	-27.70843056	149.0722333	281.3	1999.2	04-Oct-87	195.4	1280.2	Water Bore		1969	Basement	1914.8	Gubberamunda Sandstone
385	22224	LYNROCK 1	-27.43398611	149.1663972	279.8	2093.7	07-Dec-63	226.5	0	Plugged and Abandoned		2077.2	Combarngo Volcanics	2011.7	Abandoned
1345	23878	LYNROCK 2	-27.42259722	149.169175	288.8	2165	05-Dec-89	230.8	1365	Water Bore		2110	Volcanics	2030	Springbok Sandstone
50148		MAGPIE 1	-27.51723611	149.1819139	333.75	2194	14-Aug-93	246.6		Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
299	22376	MAJOR 1	-27.62121111	148.9039028	264.9	1699.6	21-Apr-65	1699.6		Suspended Capped Shut In		1684	Showgrounds Sandstone	1684	Open to Showgrounds
2349	22463	MAJOR 2	-27.6401	148.908625	250.5	1702.3	24-Jun-65	125.3	1160.7	Unknown		Not Reported	Unknown	Not Reported	Gubberamunda Sandstone
2350	22759	MAJOR 3	-27.62287778	148.9197361	271.3	1699.9	11-Sep-70	175	175	Water Bore		Not Reported	Unknown	Not Reported	Abandoned
50150		MAJOR 4	-27.61593333	148.908625	265.02	1703	10-Aug-93	1703		Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
50151		MAJOR SOUTH 1	-27.63315556	148.893625	245.83	1701.4	23-Aug-93	1192	1192	Unknown		Not Reported	Unknown	Not Reported	Unknown
1479	23464	MCGREGOR 1	-27.71954444	149.0069556	278.9	2150	29-Nov-86	219.4	1390	Water Bore		2104.4	Granite	1854.5	Springbok Sandstone
1381	23532	MCWHIRTER 1	-27.69454444	148.9961222	266.4	1903.2	02-Dec-85	1876.3		Hydrocarbon		1847.1	Combarngo Volcanics	Not Reported	Open to Showgrounds
1574	23589	MCWHIRTER 2	-27.69954444	148.9911222	256.8	2005	28-Oct-87	195.8	1500	Water Bore		1855	Volcanics	Not Reported	Walloon Coal Measures
1521	23722	MCWHIRTER EAST 1	-27.69704444	149.0036222	262	1896	01-Dec-87	196		Hydrocarbon		1847	Volcanics	1843.7	Open to Showgrounds
1523	23607	MERROOMBIL 1	-27.49259722	149.1855639	313.1	2207	13-Jun-87	246.4		Suspended Capped Shut In		2080.4	Timbury Hills Formation	Not Reported	Open to Showgrounds
2356	23559	MERROOMBIL 2	-27.50481944	149.194175	310.8	2160	26-Aug-87	256.8	1407	Water Bore		Not Reported	Unknown	Not Reported	Gubberamunda Sandstone
301	22475	MOULLIT 1	-27.56926667	148.8925139	262.7	1718.5	24-Jul-65	121.6	0	Plugged and Abandoned		1695	Timbury Hills Formation	Not Reported	Abandoned
339	22747	MOURACHAN 1	-27.722875	149.0750111	287.4	1919.3	25-Apr-70	200.6	624.8			1837.9	Timbury Hills Formation	Not Reported	Unknown
340	22927	MOURACHAN 2	-27.72926389	149.0977889	292	1938.5	09-Oct-80	190	1280	Water Bore		1912.9	Basement	1907.7	Gubberamunda Sandstone
1285	23155	NARDOO 1	-27.69759722	149.1830639	268.2	1995.5	07-Jun-84	199.7	1295.4	Water Bore		1973.9	Timbury Hills Formation	1946.5	Gubberamunda Sandstone
363	22693	NOONA 1	-27.62509722	149.1422306	298.7	1919	05-Sep-69	138.1		Plugged and Abandoned		1909.9	Timbury Hills Formation	Not Reported	Abandoned
50171		NORTH BOUNDARY 1	-27.40343056	149.2525056	323.41	2274	26-Apr-94	2274		Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
3009		NORTH BOXLEIGH 1	-27.58898611	149.0641778	263.3	2067	23-Apr-91	2064		Unknown		1995.7	Kuttung Formation	1904.3	Unknown
3010		NORTH SIRRAH 1	-27.62620833	149.1955639	315.2	2081.5	26-Mar-91	223	0	Abandoned		2026.5	Timbury Hills Formation	1992.7	Abandoned
50173		NORTHWEST TAYLOR 1	-27.55481944	149.2002861	316.78	2117	30-Mar-95	253.3	1995	Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
1300	23231	ONERRY 1	-27.49565278	149.104175	263.9	2172.6	29-Jan-85	215.8	1405	Water Bore		2153	Timbury Hills Formation	2025.5	Springbok Sandstone
50189		RAVEN 1	-27.47565278	149.1988972	288.52	2143	08-Jul-93	236		Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
365	23160	RENLIM 1	-27.64259722	149.1091778	271.9	1948	24-Feb-82	207		Suspended Capped Shut In		1926	Timbury Hills Formation	1906	Open to Showgrounds
2462	23288	RENLIM 2	-27.61926389	149.1555639	287.9	2000	14-Jan-84	202.8		Suspended Capped Shut In		Not Reported	Showgrounds Sandstone	1917	Open to Showgrounds
2463	23428	RENLIM 3	-27.63481944	149.1427861	306.2	2000	16-Dec-84	216.7		Suspended Capped Shut In		Not Reported	Showgrounds Sandstone	1932	Open to Showgrounds
2464	23429	RENLIM 4	-27.630375	149.1214	272.1	1965	18-Feb-85	204		Suspended Capped Shut In		Not Reported	Showgrounds Sandstone	1887	Open to Showgrounds
50240		RENLIM 5	-27.62704167	149.1322333	282.18	1940	08-May-95	260		Unknown	Y	1914.5	Timbury Hills Formation	1905	Unknown
50244		RENLIM 5A	-27.62704167	149.1322333	282.18	1954	21-May-95	1252.12		Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
1026	23080	ROCKY GLEN 1	-27.64843056	149.241675	276.6	2229.8	10-Dec-82	217.8	1400	Water Bore		2084.5	Combarngo Volcanics	2018.5	Springbok Sandstone
1188	23247	ROSWIN 1	-27.45620833	149.2308417	309.2	2173.5	11-Feb-84	169.8		Suspended Capped Shut In		2155	Timbury Hills Formation	2059	Open to Showgrounds
50198		ROSWIN NORTH 1	-27.43648611	149.2250083	360.8	2285	22-Jul-92	250.3	5.18	Unknown	Y	Not Reported	Unknown	Not Reported	Unknown

QPED Bore No	DERM Registered Boe Number	Well Name	Latitude (Decimal)	Longitude (Decimal)	Ground Level RL(m)	Total Depth (m gGL)	Rig Release Date	Depth to Bottom of Casing (m)	Depth to top of highest plug (m)	QPED Status	Cemented Flag Y/N	Depth to Top of Deepest Formation (m KB)	Deepest Formation Reached	Depth to top of Showgrounds formation (m)	Aquifer above Plug, Perforation Depth Unknown
50199		ROSWIN NORTH 2	-27.44620833	149.2152861	344.13	2325	30-May-93	252	4.4	Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
50200		ROSWIN WEST 1	-27.46370833	149.209175	302.03	2230	08-Aug-92	2230	5.18	Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
50201		SAMBEN 1	-27.52982222	149.0233444	246.69	1902	13-Mar-95	256.3	220	Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
367	22830	SILVER SPRINGS 1	-27.59843056	149.1044556	260.9	1900.4	30-Jun-74	203		Suspended Capped Shut In		1887.6	Timbury Hills Formation	1871.5	Open to Showgrounds
1627	23595	SILVER SPRINGS 10	-27.60648611	149.1313972	273.3	1948	06-Jun-88	220	1333	Water Bore		1886.6	Timbury Hills Formation	1885.5	Springbok Sandstone
3013		SILVER SPRINGS 11	-27.58593056	149.1058444	262.7	1928.7	07-May-91	217.2		Unknown		1885	Timbury Hills Formation	1870.2	Unknown
2505	22871	SILVER SPRINGS 2	-27.59731944	149.1161194	269.4	1911.1	19-Apr-76	193.6		Suspended Capped Shut In		Not Reported	Showgrounds Sandstone	1877	Open to Showgrounds
2506	22872	SILVER SPRINGS 3	-27.61176389	149.1108444	266.4	1908	14-Dec-76	1912.2		Unknown		Not Reported	Showgrounds Sandstone	1873	Unknown
2507	22911	SILVER SPRINGS 4	-27.58565278	149.1161194	263.7	1926.3	29-Oct-78	207.3	186.2	Water Bore		Not Reported	Showgrounds Sandstone	1883	Abandoned
2508	22937	SILVER SPRINGS 5	-27.59009722	149.1036222	264.3	1930.3	14-Apr-79	205.4		Unknown		Not Reported	Showgrounds Sandstone	1876	Unknown
2509	23035	SILVER SPRINGS 6	-27.61454167	149.1016778	265.2	1929.4	06-Jun-80	206		Unknown		Not Reported	Showgrounds Sandstone	1883	Unknown
2510	23002	SILVER SPRINGS 7	-27.62315278	149.1002889	272.5	1973	01-Oct-81	211	1257	Water Bore		Not Reported	Showgrounds Sandstone	1905	Unknown
2511	23003	SILVER SPRINGS 8	-27.58565278	149.0969556	259.7	1987	28-Dec-81	196	1187	Water Bore		Not Reported	Showgrounds Sandstone	1906	Gubberamunda Sandstone
2512	23064	SILVER SPRINGS 9	-27.60648611	149.1258417	284.1	1945	03-Sep-82	202	1347	Water Bore		Not Reported	Showgrounds Sandstone	Not Reported	Gubberamunda Sandstone
368	23047	SIRRAH 1	-27.66620833	149.1655639	285.8	2055	25-Mar-82	209.7	1265	Water Bore		2014.5	Timbury Hills Formation	1963	Gubberamunda Sandstone
1025	23161	SIRRAH 2	-27.64509722	149.1825083	307	2026	10-Jun-82	25		Suspended Capped Shut In		2000	Timbury Hills Formation	1967.5	Open to Showgrounds
2513	23196	SIRRAH 3	-27.65815278	149.1725083	293.3	2010	28-Jul-82	203.6		Hydrocarbon		Not Reported	Unknown	Not Reported	Open to Showgrounds
2514		SIRRAH 4	-27.65148611	149.1675083	313.4	2032.6	13-Nov-84	216.2		Unknown		Not Reported	Unknown	Not Reported	Unknown
1218	23792	SIRRAH 5	-27.64315278	149.1838972	301.4	2024	26-Aug-88	220.3		Suspended Capped Shut In		1957.3	Timbury Hills Formation	1940	Open to Showgrounds
1437	23491	TAYLOR 1	-27.55610278	149.2383194	340	2168.4	30-Apr-86	49		Suspended Capped Shut In		2007	Volcanics	2001	Open to Showgrounds
1223	23812	TAYLOR 10	-27.59370833	149.221675	315.8	2064.4	25-Nov-88	227.4		Suspended Capped Shut In		2029.5	Volcanics	1998.5	Open to Showgrounds
1224	23827	TAYLOR 11	-27.55676389	149.2438972	342.5	2095	20-Jan-89	226.5		Suspended Capped Shut In		2048.4	Volcanics	2023.7	Open to Showgrounds
1225	23830	TAYLOR 12	-27.60676389	149.2472306	306.1	2090	04-Feb-89	238.4	0	Plugged and Abandoned		2039	Volcanics	2010.3	Abandoned
1226	23833	TAYLOR 12A	-27.60830833	149.2461278	306.1	2065	20-Feb-89	2063.8		Suspended Capped Shut In	Y	Not Reported	Unknown	Not Reported	Open to Showgrounds
1227	23871	TAYLOR 13	-27.57259722	149.2077861	310.9	2089	20-Oct-89	222	0	Suspended Capped Shut In		2039.9	Volcanics	2010	Open to Showgrounds
1228	23659	TAYLOR 13A	-27.57259722	149.2077861	310	2089	01-Nov-89	222	1393	Water Bore		Not Reported	Unknown	Not Reported	Springbok Sandstone
1341	23661	TAYLOR 14	-27.552875	149.224175	326	2106.2	18-Nov-89	223	1391	Water Bore		2056.8	Combarngo Volcanics	2025.4	Springbok Sandstone
3015		TAYLOR 15	-27.60593056	149.1947306	320.97	2080	09-Mar-91	223.7		Unknown		2030	Timbury Hills Formation	2005.1	Unknown
3016		TAYLOR 16	-27.59065278	149.2094528	324.9	2026	22-Feb-91	225		Unknown		2030.5	Basement	2012.7	Unknown
3016		TAYLOR 16	-27.59065278	149.2094528	324.9	2026	22-Feb-91	225		Unknown		Not Reported	Not Reported	Not Reported	Unknown
50242		TAYLOR 17	-27.60204167	149.2097306	331.95	2056	06-Jun-95	2056		Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
61266		TAYLOR 18	-27.60362222	149.2411861	319.6	2040	18-May-08			Unknown		Not Reported	Unknown	Not Reported	Unknown
61604		TAYLOR 19	-27.58303889	149.2136417	329	2055	02-Sep-08			Unknown		Not Reported	Unknown	Not Reported	Unknown
2530	23474	TAYLOR 2	-27.55426389	149.239175	326	2073	16-May-87	232.6	1365	Water Bore		Not Reported	Unknown	Not Reported	Gubberamunda Sandstone
62542		TAYLOR 20	-27.59733333	149.1951278	311.6	2050	20-Jul-09			Unknown		Not Reported	Unknown	Not Reported	Unknown
62515		TAYLOR 22	-27.58385833	149.2244833	311.2	2038	08-Jul-09			Unknown		Not Reported	Unknown	Not Reported	Unknown
2531	23680	TAYLOR 2A	-27.55426389	149.239175	326	2012.5	07-Aug-87	233.9	1391	Water Bore		Not Reported	Unknown	Not Reported	Gubberamunda Sandstone
2532	23486	TAYLOR 3	-27.53981944	149.2477861	345.5	2074.5	26-Jul-87		1381	Water Bore		Not Reported	Unknown	Not Reported	Gubberamunda Sandstone
1620	23760	TAYLOR 4	-27.60593056	149.2388972	315.2	2060	31-Mar-88	231		Hydrocarbon		2001.2	Volcanics	2000	Open to Showgrounds
1664	23778	TAYLOR 5	-27.60398611	149.2083417	323.8	2088	26-Jun-88	230.4		Hydrocarbon		2034.2	Timbury Hills Formation	1977.6	Gubberamunda Sandstone
2005	23782	TAYLOR 6	-27.552875	149.224175	320.4	2066	12-Jul-88	231	1170	Water Bore		1980	Volcanics	Not Reported	Gubberamunda Sandstone
2006	23605	TAYLOR 6A	-27.552875	149.224175	320.4	2119	01-Aug-88	231	1372	Water Bore		Not Reported	Rewan Formation	Not Reported	Gubberamunda Sandstone
1220	23797	TAYLOR 7	-27.59426389	149.1958417	312.5	2066.3	13-Sep-88	231		Suspended Capped Shut In		2011	Timbury Hills Formation	1985.5	Open to Showgrounds
1221	23801	TAYLOR 8	-27.59676389	149.2388972	318.4	2082	06-Oct-88	231		Suspended Capped Shut In		2017	Volcanics	2002	Open to Showgrounds
1222	23810	TAYLOR 9	-27.58926389	149.241675	329.6	2091	08-Nov-88	228.5		Suspended Capped Shut In		2022.5	Volcanics	2013.5	Open to Showgrounds
370	22440	THOMBY 1	-27.65148889	149.0202889	294.4	1911.4	05-May-65	122.5		Plugged and Abandoned		1903.5	Timbury Hills Formation	1893.7	Abandoned
371	22933	THOMBY CREEK 1	-27.65148889	149.0202889	270.1	1912.3	22-Nov-79	202.4		Unknown		1891	Timbury Hills Formation	1853.2	Open to Showgrounds
2533	23036	THOMBY CREEK 2	-27.65787778	149.0211222	277.1	1916.6	06-Aug-80	1902.9		Suspended Capped Shut In		Not Reported	Unknown	Not Reported	Open to Showgrounds
2535	23119	THOMBY CREEK 4	-27.64815556	149.0230667	267.3	1902	02-Mar-81	195.4		Plugged and Abandoned		Not Reported	Unknown	Not Reported	Abandoned
2536	23120	THOMBY CREEK 5	-27.65343333	149.0214	271	1895.9	31-Mar-81	195.7		Hydrocarbon		Not Reported	Unknown	Not Reported	Open to Showgrounds
2537	23121	THOMBY CREEK 6	-27.66148889	149.0264	277.1	1558.1	09-Nov-81	189	0	Plugged and Abandoned		Not Reported	Unknown	Not Reported	Abandoned
2538	23051	THOMBY CREEK 6A	-27.66093333	149.0272333	277.1	1915	12-May-82	192	1107	Water Bore		Not Reported	Unknown	Not Reported	Gubberamunda Sandstone
1229	23644	TINKER 1	-27.46759722	149.3075056	313.9	2125.7	01-Jan-89	229.2		Water Bore		2067.2	Basement	2023.4	Gubberamunda Sandstone
1230	23835	TINKER 2	-27.44981944	149.2733389	346.8	2236	14-Mar-89	238		Suspended Capped Shut In		2202.7	Timbury Hills Formation	2100.4	Open to Showgrounds
59199		TINKER 2H	-27.45126667	149.2720944	346.8	2303.15	03-Dec-03	2011.77		Unknown		Not Reported	Unknown	2080.7	Unknown
1344	23882	TINKER 3	-27.46065278	149.2686167	319.5	2227.6	25-Dec-89	236		Suspended Capped Shut In		2178.8	Timbury Hills Formation	2080.7	Open to Showgrounds
59200		TINKER 3H	-27.46218611	149.2676028	352.2	2145	27-Nov-03	1977.5		Unknown	Y	Not Reported	Unknown	2105.4	Unknown
3146		TINKER 4	-27.45176389	149.2880611	352.2	2259	04-Jul-92	2258.3		Unknown		2210.8	Timbury Hills Formation	Not Reported	Unknown
59233		TINKER 4H	-27.45335	149.2868917	352.2	2199.6	09-Dec-03	2016.2		Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
58397		TINKER 5	-27.45440278	149.3065194	332.19	2232	03-Sep-02	2167	950	Unknown	Y	Not Reported	Unknown	Not Reported	Unknown
304	22472	WANGANUI 1	-27.64954444	148.9466806	263	1716.3	14-Jul-65	128.6	0	Plugged and Abandoned		1695	Basement	Not Reported	Abandoned
61561		WEST BOGGO CREEK 1	-27.56105556	149.1103333	265.2	1987	18-Aug-08			Unknown		Not Reported	Unknown	Not Reported	Unknown
1186	23083	WEST MOURACHAN 1	-27.73898889	149.0589	276.1	1894	17-Dec-82	194.8	1219.2	Water Bore		1865.1	Basement	1862.3	Gubberamunda Sandstone
3209		WHITE 1	-27.56593056	149.0619556	252	2001	22-Aug-92	231.2	10	Unknown		1950.7	Combarngo Volcanics	Not Reported	Unknown
306	22948	WONOLGA 1	-27.68065556	148.9705694	274.6	1821.2	22-Jan-81	206.7	1346	Water Bore		1808.4	Basement	Not Reported	Springbok Sandstone
1372	23341	WONOLGA 2	-27.67065556	148.9719556	286.2	1827	21-Aug-85	196	1341	Water Bore		Not Reported	Granite	Not Reported	Springbok Sandstone
1189	22999	WONOLGA EAST 1	-27.67482222	148.9950111	273.1	1916	08-Jan-82	194.2	1365.8	Water Bore		1897.1	Granite	Not Reported	Springbok Sandstone
375	22214	WUNGER 1	-27.67759722	149.1272333	302.1	1932.1	03-Nov-63	178.9	170.7	Water Bore		1922.7	Timbury Hills Formation	1913.8	Griman Creek Formation
342	22941	YELLOWBANK CREEK 1	-27.73037778	149.0144556	279.5	1883.7	15-Jan-81	196	944.9	Water Bore		1868.1	Timbury Hills Formation	1861.1	Mooga Sandstone
343	23162	YELLOWBANK CREEK 2	-27.7551	149.016125	250.7	1900	19-Apr-82	191		Hydrocarbon		1876	Timbury Hills Formation	1831	Open to Showgrounds
2573	23197	YELLOWBANK CREEK 3	-27.74815556	149.0144583	262.4	1928	18-Aug-82	1729		Unknown		Not Reported	Not Reported	Not Reported	Unknown
59140		YELLOWBANK CREEK 4	-27.75482222	149.0119583	260	1888	05-Nov-04	1888		Unknown	Y		Unknown	Not Reported	Unknown
1642	23682	YELLOWBANK CREEK NORTH 1	-27.72454444	149.0114	285.7	1909.5	08-Aug-87	10		Suspended Capped Shut In		1891.5	Timbury Hills Formation	Not Reported	Open to Showgrounds
376	22408	YOOROOGA 1	-27.70759722	149.1816778	264.3	1973.6	08-Feb-65	123.1	109.7	Water Bore		1957.1	Timbury Hills Formation	1937	Griman Creek Formation

Appendix B

Well Logs for Silver Springs and Renlim Injection and Withdrawal Bores

RPS Australia	SILVER SPRING SUB-SURFACE GAS STORAGE PROJECT

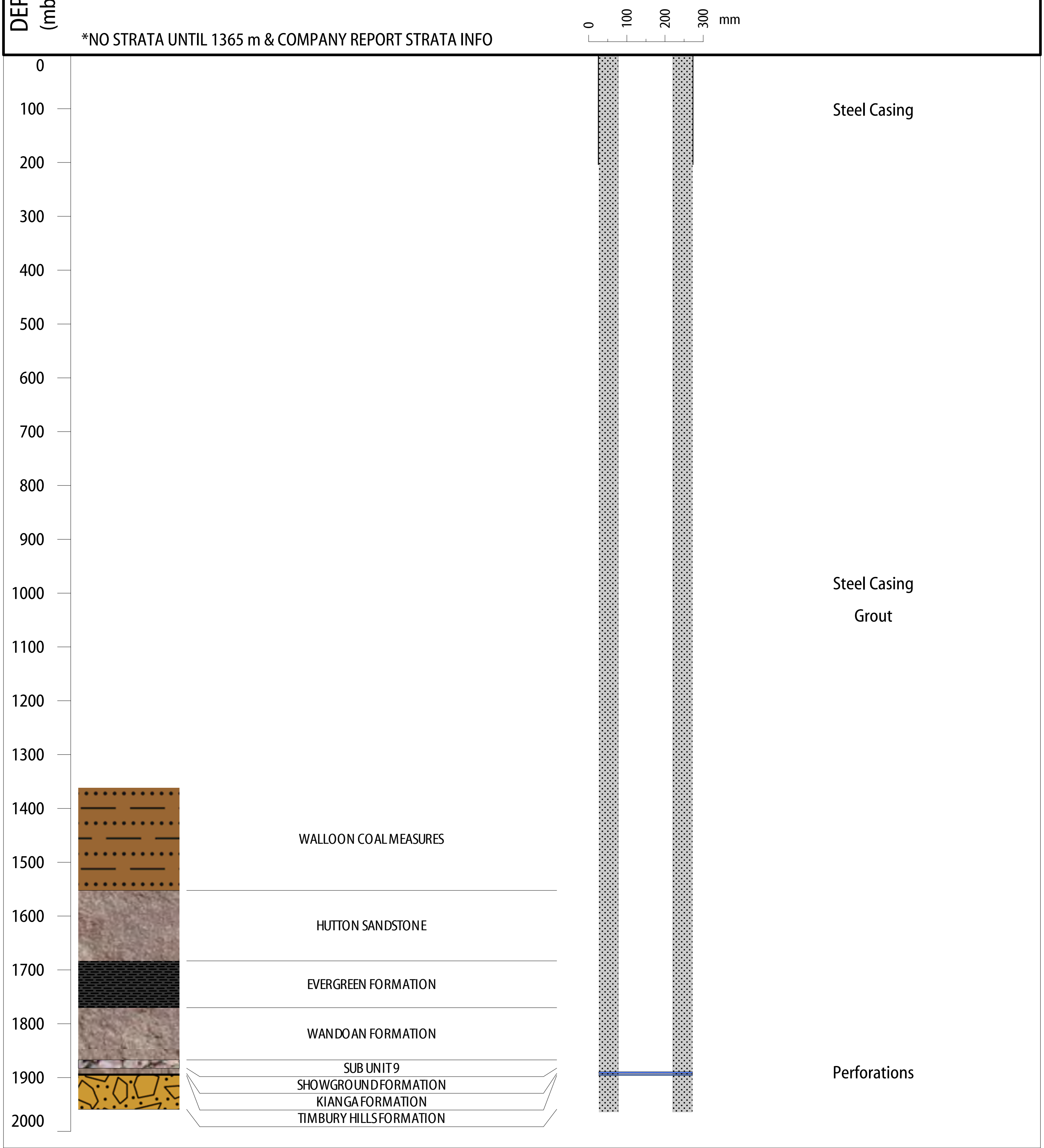
LOG OF BORE NO.:	Renlim 4	CHIP LOGGED BY:	NA	CHECKED BY:	NA
REGISTERED NO:	2464 / 24329	DATE STARTED:	31/01/1985	DATE COMPLETED:	18/02/1985
DRILLING CONTRACTOR:	NA	TOTAL DEPTH:	1965	REFERENCE POINT :	GL
DRILLING METHOD:	NA	NATURAL SURFACE ELEVATION (mAHD):	272.1		
DRILLING EQUIPMENT:	NA	SWL (mbGL) :	NA	Measurement Date:	NA
SAMPLING METHOD:	Disturbed	EASTING: 709317	NORTHING: 6941933	Coord Sys:	GDA94 z56

DEPTH (mbGL)

MATERIAL DESCRIPTION

*NO STRATA UNTIL 1365 m & COMPANY REPORT STRATA INFO

BORE CONSTRUCTION DIAGRAM



Appendix B - 1
GEOLOGICAL STRATA & BORE COMPLETION LOG FOR RENLIM 4

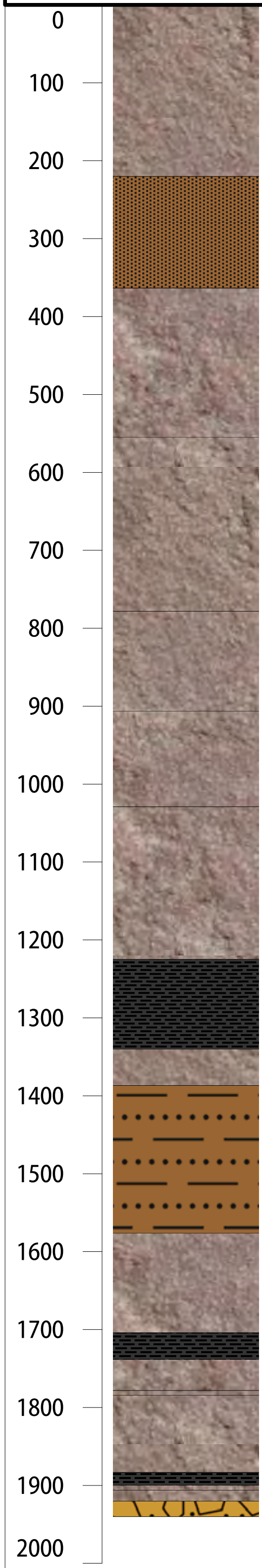
RPS	RPS Australia	SILVER SPRING SUB-SURFACE GAS STORAGE PROJECT		
LOG OF BORE NO.:	Renlim 5A	CHIP LOGGED BY: NA	CHECKED BY: NA	
REGISTERED NO:	50244	DATE STARTED: 8/05/1995	DATE COMPLETED: 21/05/1995	
DRILLING CONTRACTOR:	NA	TOTAL DEPTH: 1954	REFERENCE POINT : GL	
DRILLING METHOD:	NA	NATURAL SURFACE ELEVATION (mAHD): 282.18		
DRILLING EQUIPMENT:	NA	SWL (mbGL) : NA	Measurement Date: NA	
SAMPLING METHOD:	Disturbed	EASTING: 710392	NORTHING: 6942284	Coord Sys: GDA94 z56

DEPTH (mbGL)

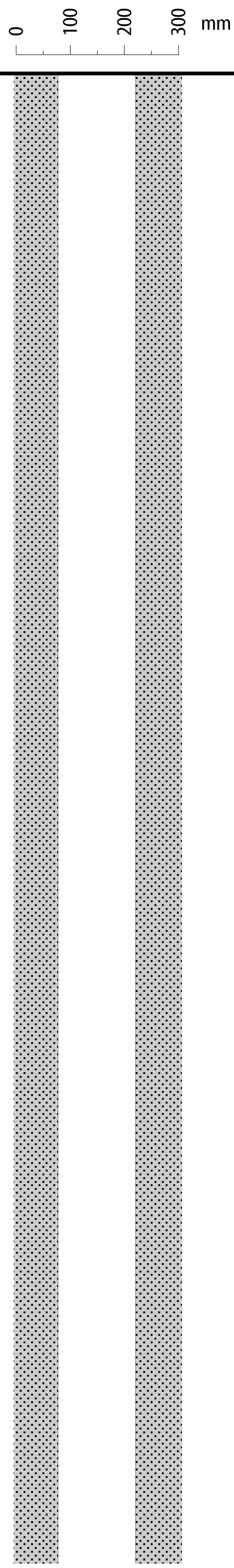
MATERIAL DESCRIPTION

*COMPANY REPORT STRATA INFORMATION

BORE CONSTRUCTION DIAGRAM



- GRIMAN CREEK FORMATION
- SURAT SILTSTONE
- WALLUMBILLA FORMATION (INCLUDING COREENA AND DONCASTER MEMBERS)
- BUNGIL FORMATION
- MOOGA SANDSTONE
- ORALLO FORMATION
- GUBBERAMUNDA FORMATION
- INJUNE CREEK GROUP (WESTBOURNE FORMATION)
- INJUNE CREEK GROUP (SPRINGBOK SANDSTONE)
- INJUNE CREEK GROUP (WALLOON COAL MEASURES)
- HUTTON SANDSTONE
- EVERGREEN FORMATION
- EVERGREEN FORMATION (BOXVALE MARKER)
- PRECIPICE SANDSTONE
- MOOLAYEMBER FORMATION
- SNAKE CREEK MUDSTONE
- SHOWGROUND FORMATION
- BLACKWATER GROUP
- TIMBURY HILLS FORMATION



Steel Casing

Steel Casing

Surface Grout

Appendix B - 2
GEOLOGICAL STRATA & BORE COMPLETION LOG FOR RENLIM 5A

RPS Australia	SILVER SPRING SUB-SURFACE GAS STORAGE PROJECT

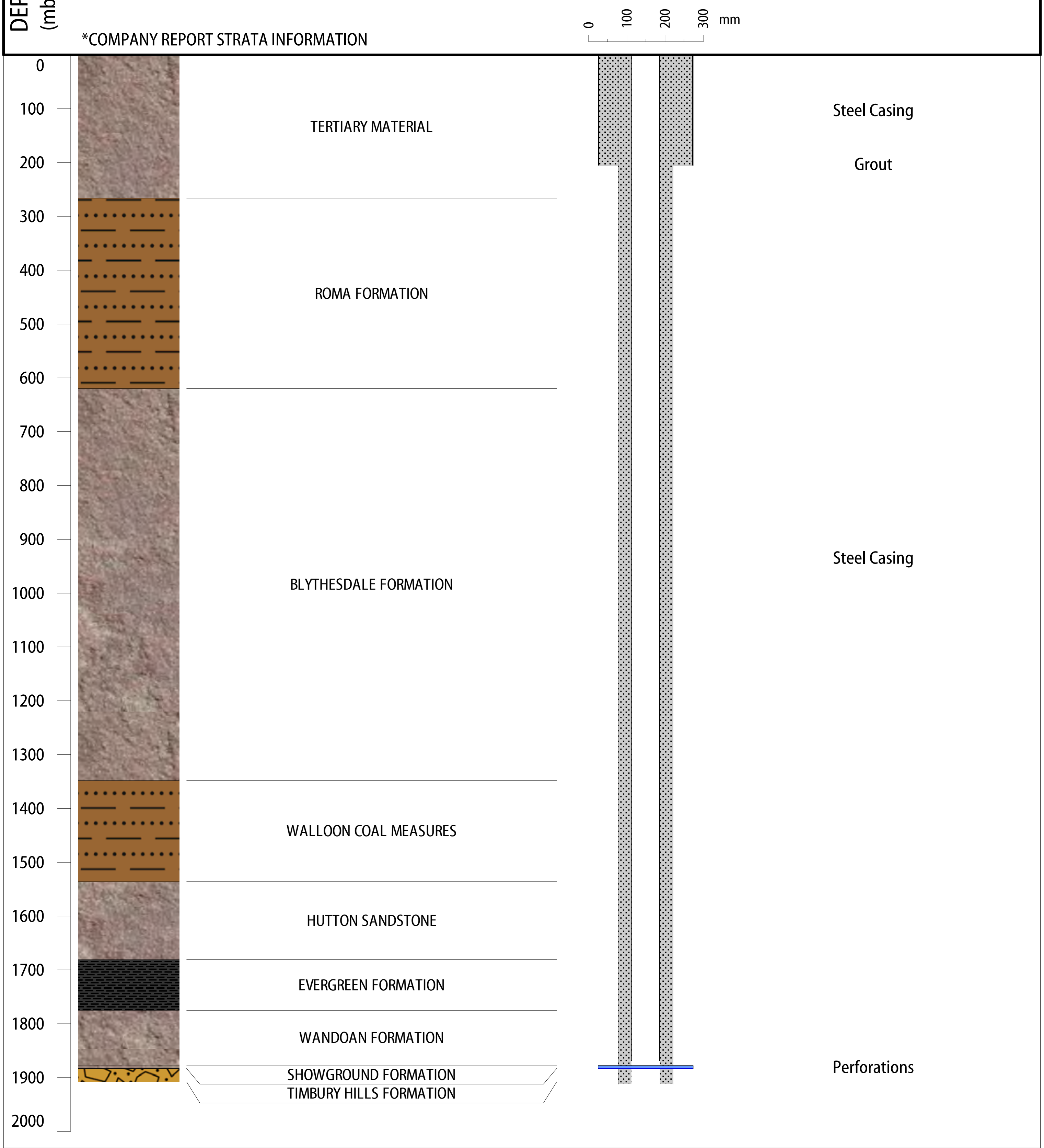
LOG OF BORE NO.:	Silver Springs 3	CHIP LOGGED BY: NA	CHECKED BY: NA
REGISTERED NO:	2506 / 22872	DATE STARTED: 26/11/1976	DATE COMPLETED: 14/12/1976
DRILLING CONTRACTOR:	IBC	TOTAL DEPTH: 6260	REFERENCE POINT : GL
DRILLING METHOD:	NA	NATURAL SURFACE ELEVATION (mAHD): 266.4	
DRILLING EQUIPMENT:	NA	SWL (mbGL) : NA	Measurement Date: NA
SAMPLING METHOD:	Disturbed	EASTING: 708310 NORTHING: 6944014	Coord Sys: GDA94 z56

DEPTH (mbGL)

MATERIAL DESCRIPTION

*COMPANY REPORT STRATA INFORMATION

BORE CONSTRUCTION DIAGRAM



RPS Australia

SILVER SPRING SUB-SURFACE GAS STORAGE PROJECT

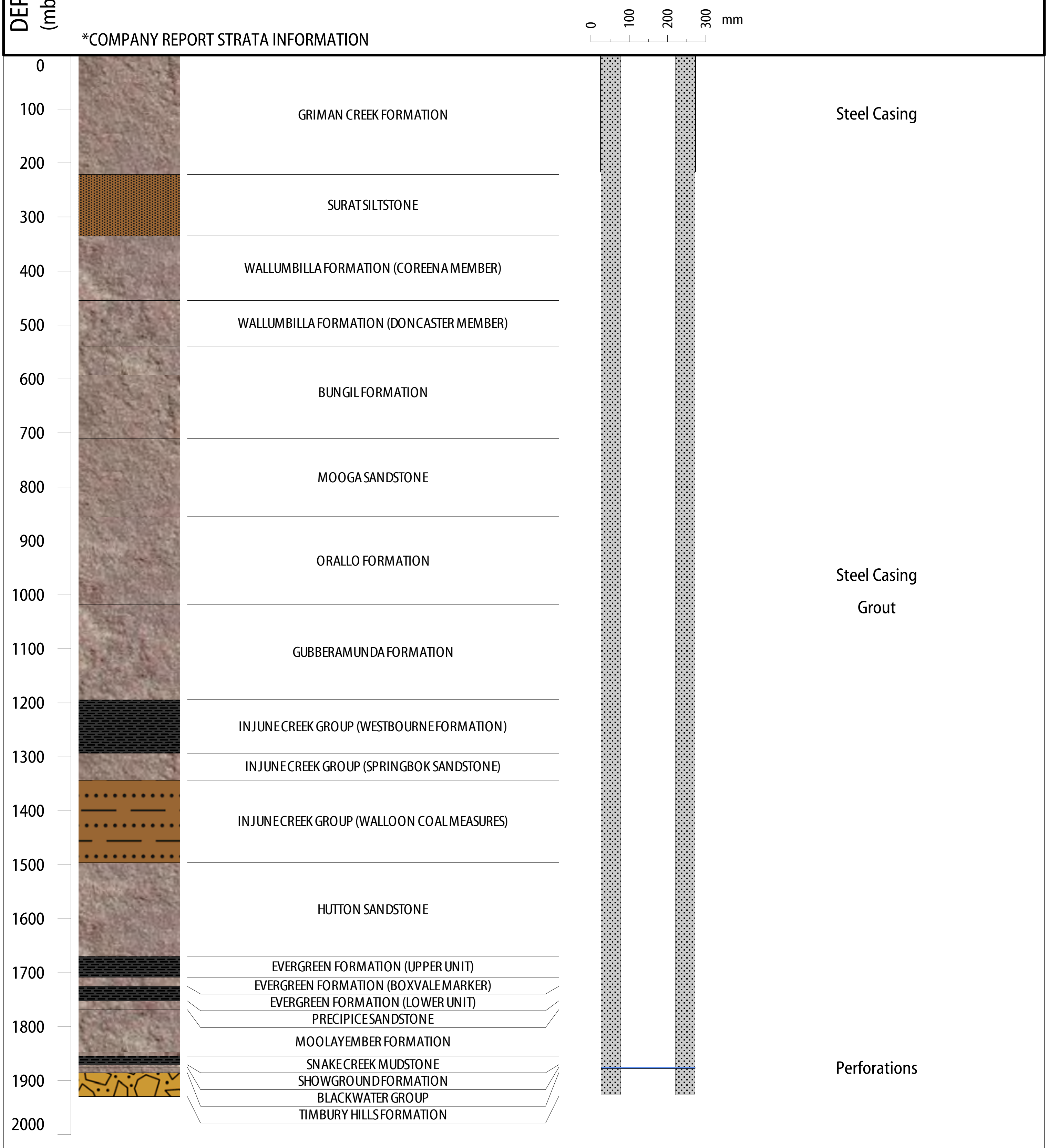
LOG OF BORE NO.:	Silver Springs 11	CHIP LOGGED BY: NA	CHECKED BY: NA
REGISTERED NO:	3013	DATE STARTED: 25/04/1991	DATE COMPLETED: 7/05/1991
DRILLING CONTRACTOR:	Bridge Oil	TOTAL DEPTH: 1928.7	REFERENCE POINT : GL
DRILLING METHOD:	NA	NATURAL SURFACE ELEVATION (mAHD): 262.7	
DRILLING EQUIPMENT:	NA	SWL (mbGL) : NA	Measurement Date: NA
SAMPLING METHOD:	Disturbed	EASTING: 707866 NORTHING: 6946885	Coord Sys: GDA94 z56

DEPTH (mbGL)

MATERIAL DESCRIPTION

*COMPANY REPORT STRATA INFORMATION

BORE CONSTRUCTION DIAGRAM



Appendix C

Glossary of Terms

Word	Definition
Acidity	Having a pH less than 7
AHD	Australian Height Datum
Alkaline	Having a pH greater than 7
Alluvial	Material transported by water.
Alluvium	Sediments deposited by water in rivers, streams or sheetwash.
Anticline	A fold, generally convex upward, whose core contains the stratigraphically older rocks.
Aquiclude	A geologic formation that may contain water (sometimes in appreciable quantities), but is incapable of transmitting significant quantities under ordinary field conditions.
Aquifer	A layer of geologic material that contains water. (ii) A zone, stratum, or group of strata that can store and transmit water in sufficient quantities for a specific use.
Aquifer system	Intercalated permeable and poorly permeable materials that comprise two or more permeable units separated by aquitards, which impede vertical groundwater movement but do not affect the regional hydraulic continuity of the system.
Aquitard	A semi-pervious geologic formation that can store water but transmits water at a low rate compared to the aquifer.
Artesian aquifer	A confined aquifer where the piezometric head rises above the ground surface such that the pressure causes water to flow freely from bores drilled into the aquifer.
Average annual recharge	Is the volume of water added to the groundwater source naturally, usually by infiltration from rainfall and river flows, and assessed on a long-term average basis. This recognises that the amount of recharge to a groundwater source can vary from year to year depending on climatic conditions.
Barrel (bbl)	The unit of volume measurement used for petroleum and its products (1 bbl = 42 US gallons or 159 L.
Base flow	Part of the discharge which enters a stream channel mainly from groundwater (but also from lakes and glaciers) during long periods when no precipitation (or snowmelt) occurs.
Basement	Basement is used in this report to mean the geological materials that underlie both the Surat Basin and Bowen Basin strata
Basin	A depression of large size where sediments have accumulated.
Bedrock	A general term for the solid rock that lies underneath the soil and other unconsolidated material.
b Gl	Below Ground Level.
Bore	In the context of this report, bore refers to a hole drilled into the ground and completed to access groundwater.
BTEX	The petrochemical compounds: Benzene, Toluene, Ethylbenzene and Xylenes
Catchment	The total area of land potentially contributing to water flowing through a particular point.
Coal seam	A layer, vein, or deposit of coal.
Coal seam gas (CSG)	Natural gas (mostly methane) contained within coal.
Completion or completed	Defines the aquifer the well screened or casing perforation is positioned opposite
Contour	An imaginary line on the surface of the earth connecting points of the equal elevation
Darcy's law	The mathematical relationship that governs the rate of flow of groundwater or other fluids, through a porous media: a) Generalised for three dimensions, the rate of viscous flow of water in isotropic porous media is proportional to, and in the direction of, the hydraulic gradient. b) Generalised for other fluids, the rate of viscous flow of homogeneous fluids through isotropic porous media is proportional to, and in the direction of, the driving force.
DERM	Department of Environment and Resource Management
DERM GWDB	DERM Groundwater Database
DEEDI	Department of Employment, Economic Development and Innovation

Word	Definition
Discharge	Water that moves from a groundwater body to the ground surface (or into a surface water body such as a lake or the ocean). Discharge typically leaves aquifers directly through seepage (active discharge) or indirectly through capillary rise (passive discharge). The term is also used to describe the process of water movement from a body of groundwater.
Discharge area	Where significant amounts of groundwater come to the surface, either as liquid water or as vapour by evaporation.
Drawdown	The lowering of a watertable resulting from the removal of water from an aquifer or reduction in hydraulic pressure.
Drill stem test (DST)	The controlled flowing of the fluids from a reservoir to estimates of the flow rate and fluid pressure.
EC	An abbreviation for electrical conductivity, a measure of the ability of a medium to conduct electricity. EC is used often as a surrogate measure of salinity levels in water or soil as the conductivity of a solution generally increases in proportion with its salt content.
Exploration well	A well drilled to determine whether hydrocarbons are present in a particular area or structure.
Fault	(a) A fracture in the Earth's crust along which the rocks on one side are displaced relative to those on the other. (b) A fracture that has experienced translation or movement of the fracture walls parallel to the plane of the fracture
Fault trap	A hydrocarbon trap that relies on the termination of a reservoir against a seal due to fault displacement.
Field	A geographical area under which an oil or gas reservoir lies.
Flow rate	The amount of surface water or groundwater flowing past a given point or line over a defined period of time. Measured as volume, depth or area of water per unit time.
Flow system	Local a flow system transporting groundwater where discharge and recharge occur within a few kilometres of each other. Flows may be permanent or temporary and the water is typically transported down a hill-slope through an unconfined aquifer that is relatively thin (<20 m) and close to the surface.
Flow velocity	The speed at which surface water or groundwater flows. Measured as a distance per unit time (e.g. mm/hr, or m/day).
Fluvial, fluviatile	Having originated by deposition within riverine environments (see Alluvial). Referring to processes occurring in a river.
Formation	(a) A unit in stratigraphy defining a succession of rocks of the same type. (b) A body of rock strata that consists of a certain lithology or combination of lithologies.
Fracture	A sub-planar discontinuity in a rock or soil formed by mechanical stresses.
Fractured rock aquifers	Rocks that are capable of receiving, storing and transmitting significant quantities of water due to the presence of numerous cracks, fissures or fractures in what would otherwise be an impermeable material.
Fresh water	Water with a salinity < 1500 mg/l TDS; drinkable or potable water is implied.
GDE	Groundwater Dependent Ecosystem.
Gravel pack, filter pack	Graded sand or gravel placed in the annular space of a groundwater installation to protect the screens or slotted casing adjacent to selected aquifer horizons.
Groundwater	Water stored below the ground surface that saturates (in available openings) the soil or rock and is at greater than atmospheric pressure and will therefore flow freely into a bore or well. This term is most commonly applied to permanent bodies of water found under the ground.
Groundwater flow	The movement of water through openings in sediment and rock that occurs in the zone of saturation. Lateral groundwater flow - movement of groundwater in a non-vertical direction. Lateral groundwater flows are usually, although not always, more or less parallel to the ground surface.
Group	The lithostratigraphic unit next in rank above formation, consisting partly or entirely of named geological formations.
GSQ	Geological Survey of Queensland

Word	Definition
Head (hydraulic head, static head)	The energy contained within a column of water resulting from elevation or pressure. The static head is the height at which the surface of a column of water could be supported against the action of atmospheric pressure.
Hydraulic conductivity	(a) A measure of the potential rate of flow of a fluid through soil or rock. Hydraulic conductivity is expressed in units of length per unit time, typically millimetres per hour (mm/hour) or metres per day (m/day). (b) A coefficient of proportionality describing the rate at which a fluid can move through the interconnected pore spaces in a porous medium. The density and viscosity of the fluid must be considered in determining conductivity. (c) The volume of fluid that flows through a unit area of porous medium for a unit hydraulic gradient normal to that area;
Hydraulic gradient	(a) The slope of the water table or potentiometric surface. The hydraulic gradient is determined from the decline in groundwater level at two measuring points divided by the distance between them. (b) The change in hydraulic head with direction.
Hydraulic head (h)	The elevation in a well in reference to a specific datum; the mechanical energy per unit weight of water [L].
Hydrocarbons	Naturally-occurring organic compounds containing only the elements hydrogen and carbon that may exist as solids, liquids or gases.
Hydrogeology	The study of groundwater movement through soil, sediment or rock under natural or induced conditions.
Impermeable	Describes the nature of solid material that will not allow fluids to pass freely.
Infiltration	The process where water enters the soil through its surface. The downward movement of water into the soil profile.
Leakage	A flux of fluid from or into an aquifer or reservoir. This commonly refers to cross-formational flow.
Lithology	The physical and mineralogical characteristics of a rock.
Lacustrine	Pertaining to, formed in, growing in, or inhabiting lakes
Member	A division of a formation, generally of distinct lithologic character and of only local extent.
Mesozoic	An era of geologic time between approximately 230 and 65 million years ago and including the Triassic, Jurassic and Cretaceous Periods (see Era).
Metamorphic rock	Rock of any origin altered in mineralogical composition, chemical composition or structure by heat, pressure, or movement at depth in the Earth's crust.
mg/L	Milligrams per litre or parts per million
Migration	The movement of a fluid (water, gas or oil) from regions of higher to lower pressure.
milli darcies (mD)	A unit of measure of permeability. A porous medium has a permeability of 1 darcy when differential pressure of 1 atmosphere across a sample 1 centimetre long and 1 square centimetre in cross section will force a liquid of 1 centipoise of viscosity through the sample at the rate of 1 cubic centimeter per second.
milli-eq/L	The equivalent (symbol: eq or Eq), sometimes termed the molar equivalent, is a unit of amount of substance used in chemistry and the biological sciences
ML	Mega Litre or one million litres
Mudstone	Mudstone is the result of grains of clay having been deposited layer upon layer, compacted by the weight of overlying material and cemented together over millions of years to form a hard rock. They are similar to shales but lack the feature of a layered structure.
Outcrop	(a) The part of a rock formation that appears at the surface of the ground. (b) The part of a geologic formation or structure that appears at the surface of the earth; also, bedrock that is covered only by surficial deposits such as alluvium. (d) To appear exposed and visible at the earth's surface; to crop out.
Palaeozoic	An era of geologic time extending between around 600 and 230 million years ago and including the Cambrian, Ordovician, Silurian, Devonian, Carboniferous and Permian Periods (see Era).

Word	Definition
Perched aquifer (perched water table)	An aquifer in that infiltrating water remains separated from an underlying main body of groundwater, with an unsaturated zone existing between the two. Usually perching occurs due intermediate impermeable or low permeability layer. Where the perched aquifer is unconfined, a perched water table exists.
Perforation	A series of holes in a casing to provide access to a resource (i.e. groundwater, petroleum or methane).
Permeability	A measure of the capacity of rock or stratum to allow water or other fluids such as oil to pass through it (i.e. the relative ease with which a porous medium can transmit a fluid). Typically measured in darcies or millidarcies.
Permian	A geological time period approximately 298 to 251 million years ago.
pH	A measure of the acidity or alkalinity of water. It is related to the free hydrogen ion concentration in solution pH = 7 is neutral; pH < 7 acidic; pH > 7 alkaline.
Piezometric head	The elevation to which water will rise in a piezometer connected to a point in an aquifer. Differences in piezometric head determine the hydraulic gradient and therefore the direction of groundwater flow.
Piezometric surface	A surface of equal hydraulic heads or potentials, typically depicted by a map of equipotentials such as a map of water-table elevations. See potentiometric surface.
Piper diagram	A graphical means of displaying the ratios of the principal ionic constituents in water. (modified from Davis and DeWiest, 1966, and Freeze and Cherry, 1979).
PL	Petroleum Lease.
Pore water pressure	Pressure exerted by fluid in the void space of soil or rock. It is usually expressed with respect to atmospheric pressure so that positive pressures indicate that the porous medium is saturated and negative pressures indicate that it is unsaturated.
Porosity (s or n)	The volume of the voids divided by the total volume of porous medium (the percentage of a rock or soil that is represented by open voids or spaces)
Porous	Having porosity.
Potable	Drinkable. Potable waters can be consumed safely.
Potentiometric surface	A surface of equal hydraulic heads or potentials, typically depicted by a map of equipotentials such as a map of water-table elevations.
Production bore	A bore from which abstraction of groundwater may take place, either through pumping or artesian flow.
Prospectivity	A term used by DEEDI to refer to a geological formation with positive carbon dioxide sequestration characteristics
psia	Pounds per square inch absolute (including atmospheric pressure)
psi	A unit of pressure or pounds per square inch or 6.89 kilopascals
QDEX	Queensland Digital Exploration Reports
QPED	Queensland Petroleum Exploration Data
Radius of influence	Radial distance to points where hydraulic head is noticeably affected by a pumping well.
Recharge	The water that moves into a groundwater body to replenish or increase sub-surface storage. Recharge typically enters an aquifer by rainfall infiltrating the soil surface and then percolating through the zone of aeration (unsaturated soil). Recharge can also come via irrigation, the leakage of surface water storage or leakage from other aquifers. Recharge rate is expressed in units of depth per unit time (e.g. mm/year).
Recharge area	A defined area of land where a significant amount of groundwater recharge occurs.
Recovery	The rate at which the water level in a pumped bore rises once abstraction has ceased.
Relative permeability	The ability of a porous medium to allow flow of a fluid when other fluid phases are present, relative to its ability to allow flow of that fluid when no other fluid phases are present.
Saline (water)	A term used to describe water that has high salinity levels (in excess of 5,000 mg/L) that limit its suitability for many uses.

Word	Definition
Salinity	An accumulation of soluble salts in the soil root zone, at levels where plant growth or land use is adversely affected. Also used to indicate the amounts of various types of salt present in soil or water. (see Total Dissolved Solids).
Sand	Sedimentary mineral grains deposited by wind or water action having a particle size of between 1/16 and 2 mm diameter.
Sandstone	A sedimentary rock composed predominantly of consolidated sand-sized grains (typically between 1/16 and 2 mm), usually quartz, with some cement.
Saturated zone	The part of a body of soil or rock where the voids and spaces are filled with water.
Screen, slotted section	See perforation
Seal	A largely impermeable rock (usually claystone or shale) that retards the passage of fluids (including water, gas or oil).
Sediment	a) Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the Earth's surface either above or below sea level. b) Solid material, whether mineral or organic, which has been moved from its position of origin and redeposited.
Sedimentary rock	Any rock that has formed from the consolidation of sediment.
Seep	Point at where seepage occurs.
Seepage	Occurs where the watertable intersects the ground surface and water flows out. This is active discharge and is driven by the hydraulic gradient.
Shale	A fine-grained sedimentary rock comprised of clays and other finely sized mineral particles.
Shut-In	
Silt	Silts are sedimentary grains having a particle size of between 0.002 to 0.05 mm in diameter.
Siltstone	A sedimentary rock comprised of silt-size particles cemented together. They are the result of grains of silt particles having been deposited layer upon layer, compacted by the weight of overlying material and cemented together over millions of years to form a hard rock.
Shut-in	An oil or gas well that is closed off; the well is shut so that it does not produce a fluid product of any kind.
Spring	A place where groundwater discharges to the ground surface
Standing water level (static water level, SWL)	The depth to groundwater measured at any given time when pumping or recovery is not occurring.
Strata	beds or layers of rock
Structure	Deformed rocks, where the resultant bed configuration is such as to form a trap for migrating water gas and/or hydrocarbons.
Spring	An occurrence of strata beneath the subsurface of an inclusive stratigraphic unit that succeeds an unconformity
Surface flow	A term used to describe the movement of water across the ground surface as run-off or stream flow.
Tertiary	A period of geologic time between approximately 65 and 2 million years ago (see Period).
Throw	Distance of movement along a fault plane.
Total dissolved solids (TDS)	An expression of the total soluble mineral content of water determined by either measuring the residue on evaporation or the sum of analysed chemical constituents. Usually quoted in milligrams per litre (mg/L) or the equivalent parts per million (ppm), TDS may also be approximated from electrical conductivity (EC) measurements using the conversion EC (µS/cm) x 0.68 = TDS (mg/L) (see Electrical Conductivity). Salinity of Water based on Total Dissolved solids: <1500 mg/L TDS — Fresh Water 1500 to 5000 mg/L TDS — Brackish Water > 5000 mg/L TDS — Saline Water

Word	Definition
TPH	Total Petroleum Hydrocarbons is a term used to denote a large family of several hundred chemical compounds that originally come from crude oil.
Transmissivity (T)	The rate of horizontal groundwater flow through the full saturated thickness of an aquifer across a unit width. Transmissivity may be quoted as m^3/day/m [L^3/T/L], but is more commonly expressed as m^2/day [L^2/T]. Transmissivity is related to the hydraulic conductivity of the aquifer by the equation T=Kb.
Triassic	A period of geologic time extending from 230 to 180 million years ago (see Period).
Unconfined aquifer (water table aquifer)	An aquifer where the surface of the saturated zone is at atmospheric pressure. See aquifer.
Unconformity	A surface between successive strata representing a missing interval in the geologic record of time, produced either by an interruption in deposition or by the erosion of depositionally continuous strata followed by renewed deposition.
Watertable	(a) The upper surface of a body of groundwater occurring in an unconfined aquifer. At the watertable, pore water pressure equals the atmospheric pressure. (b) The surface of a body of groundwater within an unconfined aquifer at which the pressure is atmospheric.
Well	In the context of this report, well, refers to a bore that has been drilled and completed to access petroleum resources.
Well screen	A portion of a well casing that is perforated or slotted to allow water to flow through it. The screen and associated filter packing (sand) act as a filtering device to permit the flow of liquid or air but prevents the passage of sediments or backfill particles.
Well yield	The discharge of well at (nearly) steady flow [L^3t-1].
Zero Edge	The edge or end of a formation or rock unit at depth. Often the point where a formation subcrops under younger rocks.