8.12 Summary of available data for ATP 984

ATP 984 is located approximately 80 km south-east of Hughenden (Figure 1.2). The 5,273 km^2 tenement is drained to the south by Towerhill, Prairie, Bullock, and Torrens Creeks. The south-western corner of the tenement is drained by Landsborough Creek. All of these watercourses flow southward and eventually converge approximately 110 km north of Longreach to form the Thomson River (Figure 1.2).

8.12.1 Surface geology for ATP 984

There are two distinct geological provinces exposed at the surface within ATP 984. Tertiary age Wondoola beds outcrop along the major creeks in eastern ATP 984 (Figure 3.1). Mixed within the Wondoola beds exposures are a series of outcrops of the Tertiary age Glendower Formation. The Glendower Formation outcrops lie along a north-east to south-west trend. A thin layer of Quaternary alluvium covers the centre of ATP 984 (Figure 3.1).

The Wondoola beds, Glendower Formation and Allaru Mudstone outcrop west of the central area of Quaternary alluvium (Figure 3.1). A small section of the Mackunda Formation outcrops in the south-western corner of the tenement. These outcrops are oriented from north to south with the younger Wondoola beds and Glendower Formation overlying the eastern margin of the Allaru Mudstone outcrop and other older Eromanga Basin sediments.

8.12.2 Exploration well drilling history for ATP 984

Five exploration wells have been drilled within ATP 984 (Table 8.54). The exploration wells have been drilled to explore for CSG resources. The exploration wells were drilled between 1993 and 2009. Lithological details are only available from the wells drilled by Enron in the 1993. The lithological details for the Enron (Enron Exploration Australia Pty LTD) wells have not been recorded in QPED (2011) but were available in the well completion reports filed in QDEX (EEAPL, 1993). Unpublished lithological details have been made available to RPS and were used to supplement this assessment.

Table 8.54 Drilling summary for ATP 984

Attribute		Count
Total number of bores		5
Type of bore	Coal Seam Gas	5
Earliest spud date	19-Oct-93	
Latest spud date	31-Oct-09	
Depth shallowest bore (m bKB)	246	
Depth deepest bore (m bKB)	1,494	
Average bore depth (m bKB)	993	

8.12.3 Water bore drilling history for ATP 984

DERM records 149 registered water bores within ATP 984 (Table 8.55). The first bores were drilled in 1890 (RN 1010 and 4665) and the most recent bore was drilled on 24 August 2010 (RN 146293). The shallowest bore was drilled to 207 m bGL (RN 69095) and the deepest bore was drilled to 1,495 m bGL (RN 100115). The average bore depth is 204 m bGL.

The water bores are dominantly subartesian, and based on surface geology, likely to be drilled in the shallow Quaternary alluvium, Tertiary sediments or shallow Rolling Downs Group sediment aquifers. There are 12 current or former artesian bores within ATP 984. Seven bores have ceased to flow and one bore is reported to have uncontrolled artesian flow.

Table 8.55 Summary of DERM registered water bores within ATP 984

Attribute		Count
Total number of bores		149
Type of bore	Artesian Bore--ceased to flow	7
	Artesian Bore--condition unknown	--
	Artesian Bore--controlled flow	4
	Artesian Bore--uncontrolled flow	1
	Subartesian facility	137
Bore Status	Abandoned and destroyed	45
	Abandoned but usable	1
	Existing	102
	Proposed	1
Earliest drill date	RN 1010 and 4665	1890
Latest drill date	RN 146293	24-Aug-2010
Number of water bores in QPED		--
Depth of the shallowest bore (m bGL)	RN 69095	207
Depth of the deepest bore (m bGL)	RN 100115	1,495
Average bore depth (m bGL)		851

8.12.4 Subsurface geology for ATP 984

The subsurface geology for ATP 984 is derived from exploration wells Aberfoyle 1 and Aberfoyle 1A drilled by Enron in 1993 (Table 8.56). The summary data presented in Table 8.56 are presented as they have been recorded in Aberfoyle 1 well completion report (QPED, 2011). Note that several formations that are documented elsewhere may not be presented in the stratigraphic details contained in Table 8.56.

The basal Jurassic unconformity was not logged in wells Aberfoyle 1 and Aberfoyle 1A but likely occurs within the upper 247 m of the bore that have been logged as undefined. Additional available data suggest that the basal Jurassic unconformity lies to a depth of approximately 400 m bGL elsewhere in the tenement. The basal Jurassic unconformity outcrops to the east of ATP 984 (Figure

3.5). The depth difference for the basal Jurassic unconformity at the two drill sites and the location of the unconformity outcrop is consistent with the general dip of the Eromanga Basin and Galilee Basin sequences present within ATP 984.

Table 8.56 Type stratigraphy ATP 984—EAA Aberfoyle 1

Depth to formation top (m bKB)	Depth to formation bottom (m bKB)	Basin	Formation name	Age
0	247	Eromanga Basin sequence	undifferentiated	
247	849	Galilee Basin Sequence	Moolayember Formation	Middle Triassic
849	934		Clematis Sandstone	Early to Middle Triassic
934	1,324		Rewan Formation	Late Permian to Early Triassic
1,324	1,463		Betts Creek beds	Late Permian
1,463	1,476		Colinlea Sandstone	Late Permian
1,476	1,495		Jochmus Formation	Late Carboniferous to Early Permian

The Permian unconformity was encountered at over 1,450 m bGL at wells Aberfoyle 1 and Aberfoyle 1A. This unconformity outcrops to the east of the basal Jurassic unconformity (Figure 3.5). The Permian unconformity was encountered at shallower depths under the western portion of the tenement suggesting a thinning of the overlying sediments towards the western side of the Koburra Trough.

The near surface Quaternary alluvium, Tertiary age and shallow Eromanga Basin aquifers are separated from the underlying coal measures by 600 m of the Moolayember Formation interburden, which overlies the Clematis Sandstone and Rewan Formation. The Galilee Basin aquifer and the Clematis Sandstone, is separated from the underlying coal measures by 390 m of the Rewan Formation. The Galilee Basin aquifer and the Colinlea Sandstone, directly underlies the Betts Creek beds.

The Moolayember and Rewan Formations are present between the Eromanga Basin and the underlying Permian coal measures.

The Colinlea Sandstone is apparently absent between the Betts Creek beds and the Jochmus Formation in the west.

8.12.5 Aquifers within ATP 984

Bores within the noted aquifers and water-bearing sediments are taken from water quality, pump test and and water level tables found in the DERM GWDB (2010). These data are not tabulated in this report, thus, bore quantities presented in this report will not necessarily be reflected in the aquifer summary text. The following Eromanga Basin aquifers and water-bearing sediments are present within ATP 984 (Appendix D, Table D.11 and Appendix E, Table E.1):

- Winton Formation (no bores identified);
- Mackunda Formation (no bores identified);

- Allaru Mudstone (no bores identified);
- Wallumbilla Formation (3 bores);
- Ronlow beds (12 bores);
- Hooray Sandstone (5 bores);
- Westbourne Formation (1 bore);
- Adori Sandstone (no bores identified); and
- Hutton Sandstone (1 bore).

No bores are recorded tapping the following Galilee Basin aquifers and water-bearing sediments that have been identified in ATP 984 (Appendix D, Table D.11 and Appendix E, Table E.1):

- Moolayember Formation;
- Clematis Sandstone;
- Betts Creek beds;
- Colinlea Sandstone; and
- Jochmus Formation.

The above list of aquifers and potentially water-bearing strata has been compiled based on data in the DERM GWDB (2010) and the stratigraphic data detailed in the well completion reports for ATP 984.

8.12.6 Groundwater water level summary for ATP 984

Depth to groundwater observations have been made 17 times within ATP 984 (Table 8.57). Groundwater level data are available for four formations that include the major Eromanga Basin aquifers the Hooray and Hutton Sandstones (Appendix Table D-1).

The groundwater level measurements range from a groundwater level collected on 1 January 1912 to the last recorded date of 14 October 1988. The overall groundwater levels are relatively shallow, generally averaging less than 50 m bGL.

The analysis of the groundwater level data is limited by a lack of data on the depth to the well screen or the depth to the casing perforations. Therefore, it is not currently possible to relate the static groundwater level measures to aquifer pressure.

The groundwater flow direction assessment for the aquifers present within ATP 984 is based on groundwater contours presented on Figure 6.19, Figure 6.20 and Figure 6.21. ATP 984 is located in the north central Galilee Basin study area. The groundwater flow in the Rolling Downs Group aquifers, Cadna-owie Formation / Hooray Sandstone aquifer and Hutton Sandstone aquifer is to the west towards the Lovelle Depression. The groundwater flow direction for ATP 984 is driven by the groundwater high associated with the intake beds located to the north and the deep basin associated with the Lovelle Depression to the south and west.

Table 8.57 Summary of groundwater levels from water bores within ATP 984

Basin	Formation name	Measurement period		Count	Depth to groundwater (m bGL)				
		Start	End		Ave	Max	Min	Range	Median
Eromanga Basin Sequence	Wallumbilla Formation	28-Jun-1948		1	-25.0				
	Ronlow beds	13-Dec-1890	04-Feb-1981	10	-50.6	-12.8	-76.2	63.4	-67.1
	Hooray Sandstone	21-Sep-1953	14-Oct-1988	3	-35.5	-28.0	-45.7	17.72	-32.9
	Westbourne Formation	24-Sep-1950	04-Feb-1981	3	-50.7	-33.5	-72.9	39.32	-45.7

8.12.7 Summary of DERM GWDB flow and pumping test data for ATP 984

Pumping test data was received for 52 water bores in DERM GWDB (2010) for ATP 984 (Figure 6.23). The aquifer has been identified for 12 water bores in this tenement. The first flow test was conducted on a bore in 1890 and the most recent was conducted on 24 August 2010 (DERN GWDB 2010).

These bores have been identified as tapping the following aquifers:

- Wallumbilla Formation;
- Hooray Sandstone;
- Ronlow beds; and
- Westbourne Formation.

The changes in aquifer pressure and depth to groundwater over time were assessed by plotting the discharge upon arrival at the bore (Figure 8.38) and changes in the static groundwater level (Figure 8.39).

Only one calculated static groundwater level has been recorded. The static groundwater level was calculated to be 38.15 m aGL at RN 4673 on 24 March 1988.

The aquifer has not been identified for any of the bores within ATP 984 with groundwater discharge data. The data that are available show a non-linear decline in the peak groundwater discharge from 33 L/s per bore in 1906 to 6 L/s per bore in 1965 (Figure 8.38). No groundwater discharge observations were recorded after 1965.

Relatively few multiple static groundwater level observations were recorded for bores drilled within ATP 984. Therefore, it is difficult to determine any trends to the available data (Figure 8.39). Although no major trends could be determined, the data suggests a slight decline to the groundwater levels in the bores drilled in the Hooray Sandstone.

Figure 8.38 Bore discharge (L/s) at arrival for ATP 984 water bores with data, 1900 to 2010

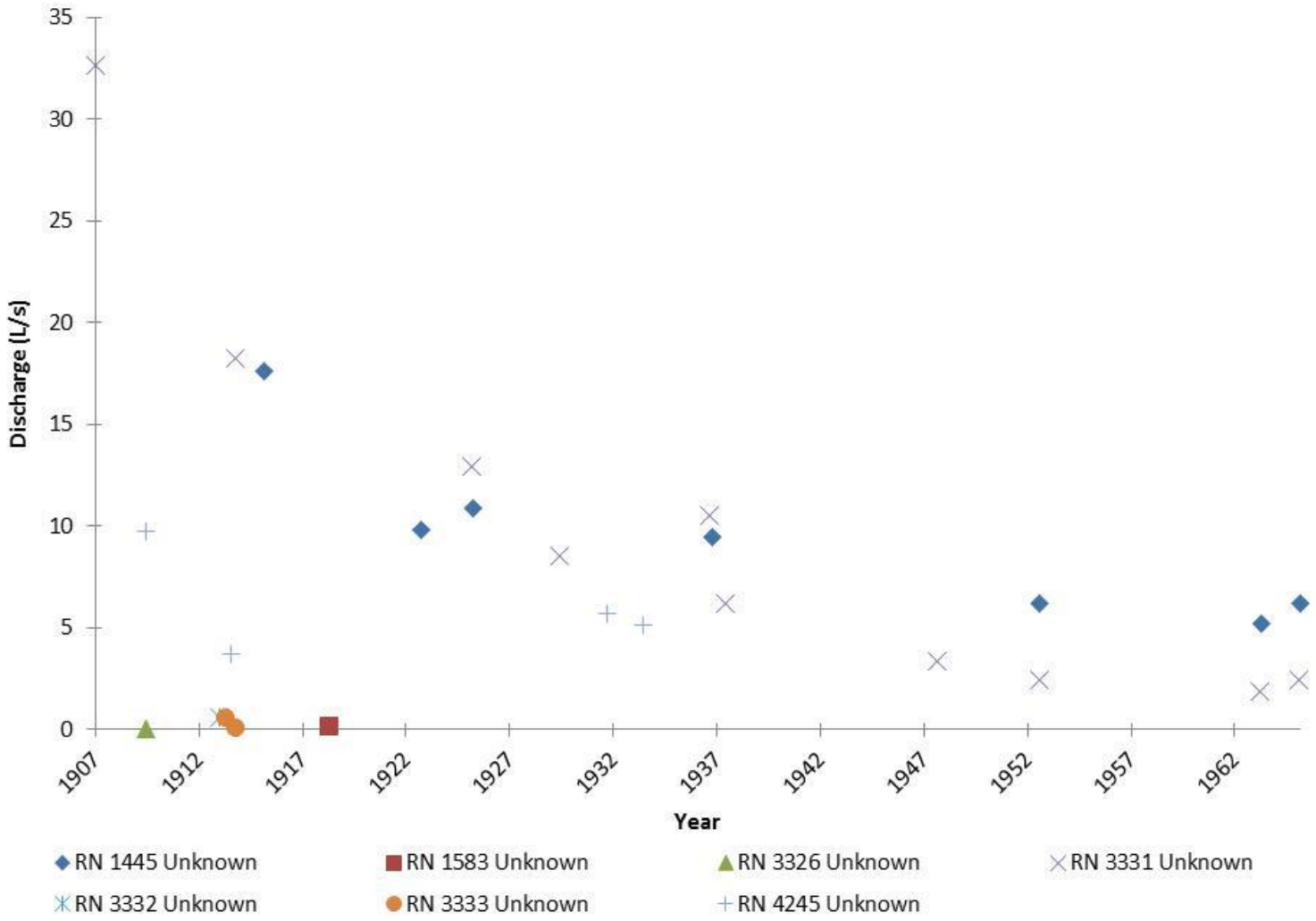
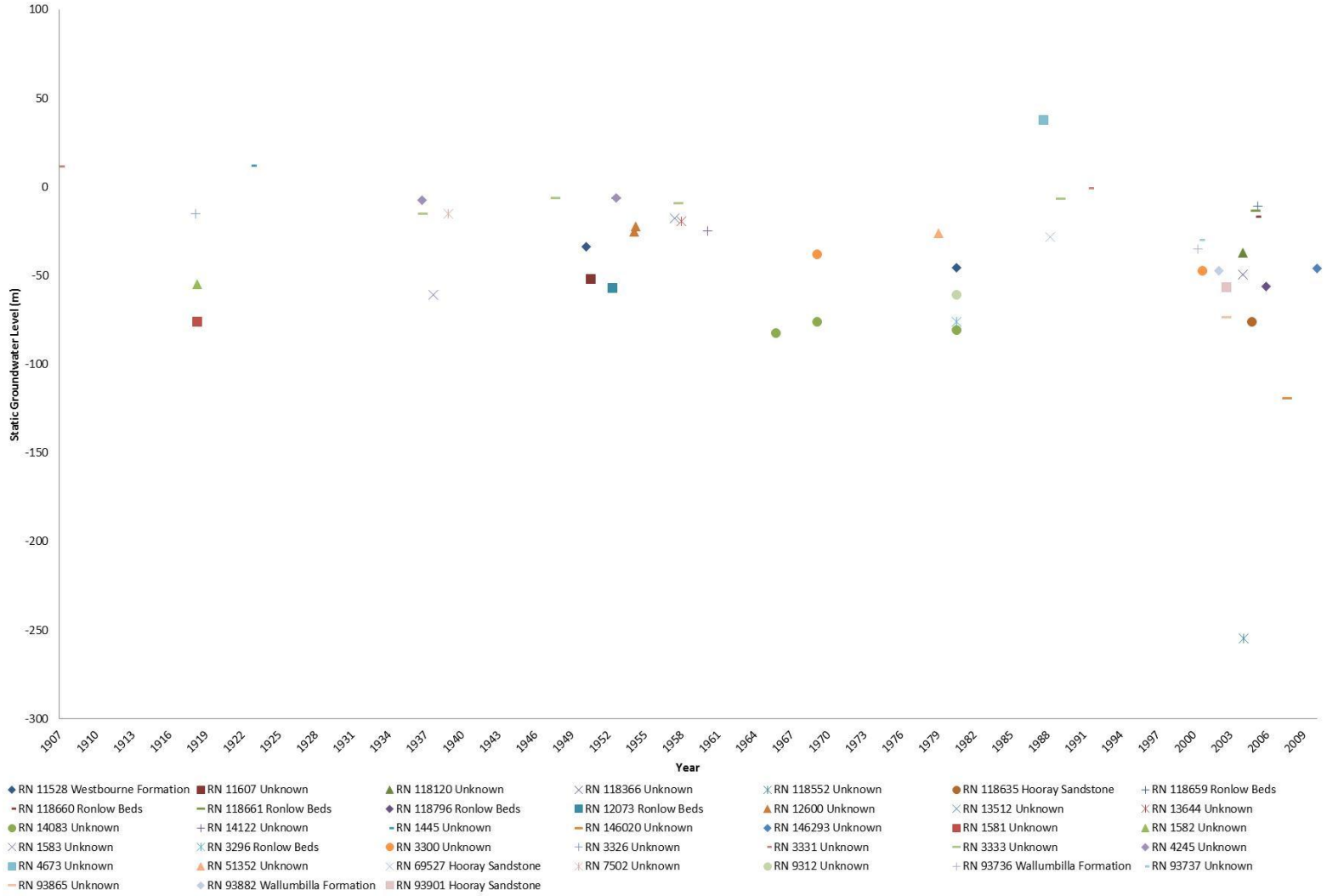


Figure 8.39 Static groundwater levels for ATP 984 water bores with data, 1900 to 2010



8.12.8 Groundwater quality within ATP 984

Laboratory chemical analysis data are available for groundwater samples drawn from four aquifers or water-bearing sediments present within ATP 984 (Table 8.58a and Appendix Table E-1): however, the depth at which the groundwater sample was obtained was recorded at only one water bore. Groundwater quality samples from the Permian coal measures were available for analysis from petroleum exploration drilling, shown in Table 8.58b, but excluded from the discussion below.

Only one sample depth is recorded for the groundwater quality samples collected from aquifers in ATP 978 (at 60m within the Hooray Sandstone in RN 69471).

- Groundwater pH varied between 7 and 9;
- Total dissolved solids ranged from fresh water at 195 to slightly brackish at 2,036 mg/L;
- Electrical conductivity ranged from 400 to 3,450 µS/cm;
- Sodium ranged from 48 to 739 mg/L;
- Calcium ranged from 3.2 to 50.1 mg/L;
- Chloride ranged from 69 to 1,135 mg/L;
- Fluoride ranges from 0.1 to 0.95 mg/L;
- Bicarbonate ranged from below 57 to 281 mg/L.

The constituent loads in the groundwater samples obtained from the bores drilled in the Ronlow beds are slightly higher than in the overlying or underlying aquifers. This could be due to the small number of available samples or due to water bores being drilled in more than a single formation.

Insufficient data are available to develop a Piper diagram for ATP 984 using the DERM GWDB (2010) groundwater quality data. However, groundwater quality data from drill stem testing by a CSG operator were made available to RPS. The groundwater quality results from the drill stem tests in the Permian age coal measure samples were plotted on a Piper diagram presented in Figure 8.40. The high concentrations of potassium suggest that the formation water was mixed with drilling fluid during the sampling process: therefore, it is not possible to assign a cation type. The Permian age coal measure groundwater samples also contained significant sulphate and magnesium concentrations. These constituent concentrations skew the Piper diagram analysis.

Figure 8.40 Piper diagram of the summary groundwater quality results from Permian age coal measures present within ATP 984

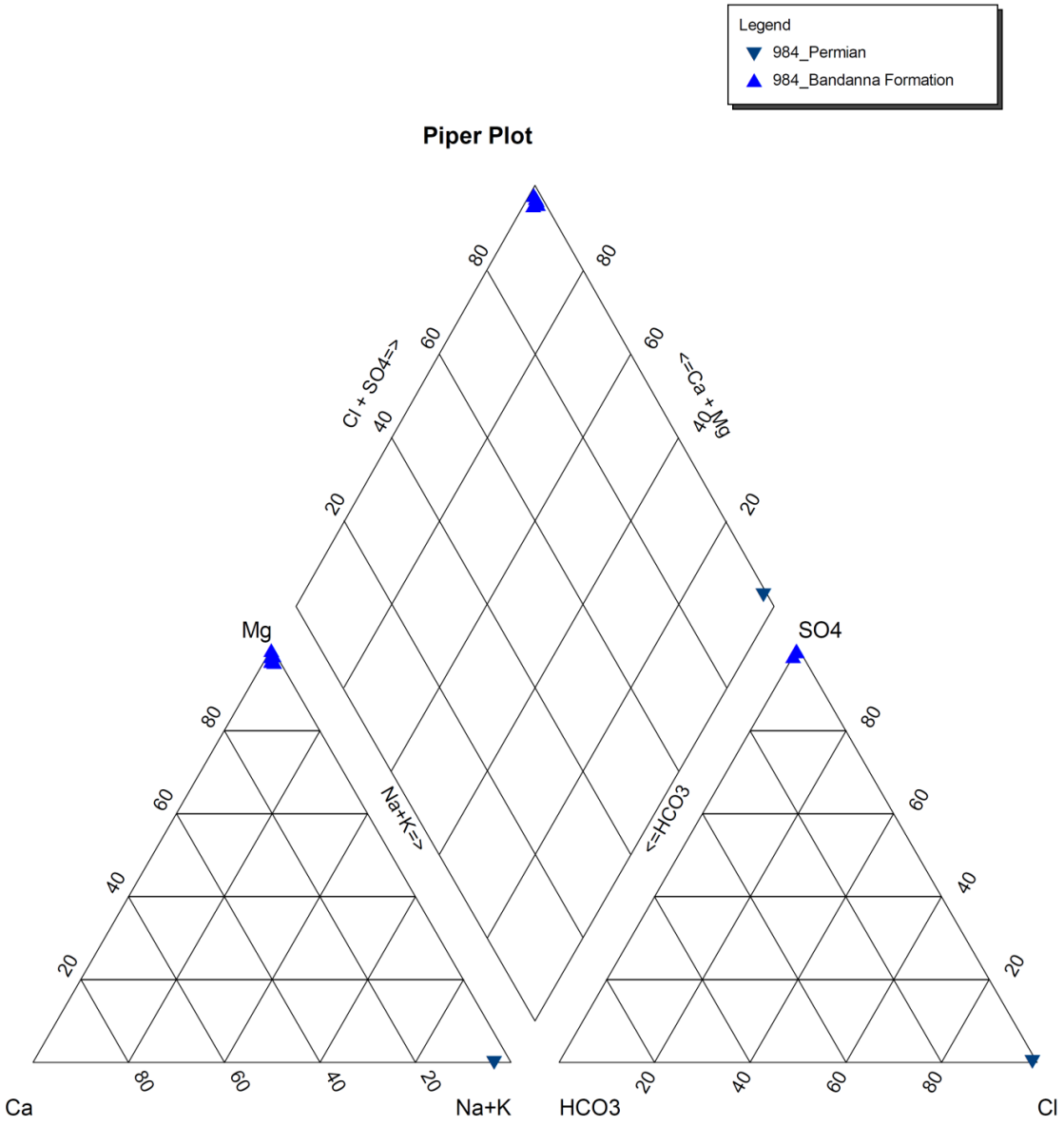


Table 8.58a Groundwater quality data summary for ATP 984

Basin	Identified aquifer or water bearing sediment	Statistic	Depth of Sample (m bGL)	Conductivity (µS/cm)	pH	Hardness (mg/L Ca)	Alkalinity (mg/L)	Total Dissolved Solids ((mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Iron (mg/L)	Manganese (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)	Zinc (mg/L)
Eromanga Basin Sequence	Wallumbilla Formation	Total number	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Number of tests	0	1	1	1	1	1	1	0	1	1	0	0	1	0	1	1	0	1	0
		Value	--	660	8	41	140	342	124	--	8	5	--	--	171	--	120	0.3	--	ND	--
	Ronlow beds	Total number	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
		Number of tests	0	7	6	6	8	7	8	0	8	4	0	0	7	1	8	8	0	7	0
		Average	--	1,412	80	68	138	918	345	--	15.9	13.9	--	--	163	102	459	0.5	--	33.4	--
		Maximum	--	3,450	8	169	200	2,036	739	--	50.1	26	--	--	244	102	1,135	0.95	--	84	--
		Minimum	--	540	7	8	55	295	105	--	3.2	ND	--	--	67	102	84	0.15	--	ND	--
	Hooray Sandstone	Total number	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Number of tests	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
		Value	60	400	9	32	47	195	48	14	6	4.1	ND	ND	57	ND	69	0.1	0.5	12	--
	Westbourne Formation	Total number	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Number of tests	0	1	1	1	1	1	1	0	1	1	0	0	1	0	1	1	0	1	0
		Value	--	1,500	8	45	230	812	306	--	8	6	--	--	281	--	295	0.65	--	58	--

Table 8.58b Drill stem test groundwater quality data summary for ATP 984

Basin	Identified aquifer or water bearing sediment	Statistic	Depth of Sample (m bGL)	Conductivity (µS/cm)	pH	Hardness (mg/L Ca)	Alkalinity (mg/L)	Total Dissolved Solids ((mg/L)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Iron (mg/L)	Manganese (mg/L)	Bicarbonate (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)	Zinc (mg/L)
Galilee Basin Sequence	Bandanna Formation	Total number	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
		Number of Tests	6	6	6	6	6	6	6	6	6	6	0	0	6	1	6	0	5	6	0
		Average	1,428	7,022	8	192	907	4,277	1,443	21	35	25	--	--	1,103	23	1,788	--	1	18	--
		Maximum	1,449	16,200	8	579	1,026	10,381	3,200	42	100	80	--	--	1,252	23	5,158	--	3	47	--
		Minimum	1,398	3,200	7	20	823	1,834	761	2	7	1	--	--	1,006	23	443	--	ND	5	--
	Colinlea Sandstone	Total number	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Number of Tests	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	0	1	1	0
		Value	1,463	565	7	39	176	312	120	8	11	3	--	--	215	--	60	--	ND	21	--
	undifferentiated Betts Creek beds	Total number	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Number of Tests	0	1	0	0	0	0	1	1	1	1	1	0	0	1	1	1	0	0	1
		Value	--	1,141	--	--	--	--	28,049	503	14,900	284	18	--	--	191	10	15,000	--	--	110

8.12.9 Summary for ATP 984

Both Eromanga Basin and Galilee basin aquifer systems have been identified as present within ATP 984. The available data suggest that shallow subartesian aquifers are preferentially tapped. Artesian conditions have been documented but these aquifers are not currently tapped by large numbers of bores. Groundwater level and quality data are lacking, which limits the groundwater flow and aquifer interaction assessment.

The subsurface stratigraphy indicates considerable confining layer thickness for both the Moolayember and Rewan Formations. That is, the interburden thickness between the lower Eromanga basin aquifers and the underlying Permian coal measures can exceed 500 m in places. The confining layer thickness is the greatest in the east and decreases to approximately 250 m or less near the western tenement boundary. The reason for the thinning is not known but is likely due to the shallowing of the Koburra Trough along the Drummond Basin sequence subcrop (Figure 1.3).