8.0 Review / tabulation of groundwater data across the Galilee Basin study area tenements

The surface and subsurface geology varies considerably from the steeply dipping rocks near the faulted basin margin in the north and east, to the relatively flat lying sediments in the west, to the complex stratigraphic relationships at the edge of the Maneroo Platform. The analysis of the subsurface geology, groundwater stratigraphy, groundwater levels and groundwater quality was further complicated by the pattern of tenure ownership. Specifically, the GBOF member tenements are rarely contiguous. Additionally, there was a need to process and present the data in a manner that adequately protects the GBOF members' confidentiality. Furthermore, the tenements are in different stages of development.

The subsurface geology, groundwater stratigraphy, groundwater levels and groundwater quality data are presented and discussed for each of the active tenements in the following sections.

8.7 Summary of available data for ATP 780

ATP 780 is located in the central Galilee Basin study area, south-east of Barcaldine (Figure 1.2). Drainage in the 5,192 km^2 tenement is westward via the larger Alice River in the north and Patrick Creek in the south. Patrick Creek is fed by the north draining tributaries, Evory and Evora Creeks. The tenement is traversed from east to west by the Capricorn Highway. The Landsborough Highway follows the western edge of the tenement.

8.7.1 Surface geology for ATP 780

Quaternary alluvium is widespread across the tenement surface surrounding small and isolated outcrops of Cretaceous to Triassic age strata (Figure 3.1). The Rewan and Moolayember Formations sediments outcrop in the north-east. The Ronlow beds are present at the surface in the centre of ATP 780. The Doncaster Member of the Wallumbilla Formation outcrops in the west. One large contiguous outcropping of the Mackunda Formation has been mapped in the south-west.

The extensive alluvial surface cover conceals the basal Jurassic unconformity and likely sub-cropping aquifer formations such as the Hutton Sandstone. The Permian unconformity is located to the east of ATP 780.

The geological mapping for ATP 780 does not indicate any major faults at the surface.

8.7.2 Exploration well drilling history for ATP 780

Nine exploration wells have been drilled within ATP 780 (Table 8.33). The earliest exploration well was drilled on 30 May 1930 and the most recent well recorded in QPED (2011) was drilled 2 September 1980. The exploration drilling carried out within ATP 780 has been dominated by shallow stratigraphic exploration holes.

Table 8.33 Drilling summary for ATP 780

Attribute		Count
Total number of wells		9
Type of well	Petroleum	2
	Stratigraphic	7
Earliest spud date	30-May-1930	
Latest spud date	2-Sep-1980	
Depth shallowest well (m bKB)	46.9	
Depth deepest well (m bKB)	205.4	
Average well depth (m bKB)	85.4	

8.7.3 Water bore drilling history for ATP 780

DERM records 283 registered water bores within ATP 780 (Table 8.34). There are two registered surface water locations within ATP 780 (Table 8.34). The first bore was drilled in 1883 (RN 2774) and the most recent bore was drilled on 18 September 2010 (RN 146294). The shallowest bore was drilled to 15 m bGL (RN 100330021) and likely penetrated Tertiary sediments or shallow Cretaceous sediments and the deepest bore was drilled to 762 m bGL (RN 2652), which penetrated to the Precipice Sandstone. The average water bore depth is 91 m bGL. However, the water bore depth data contained in the DERM GWDB (2010) is limited.

Table 8.34 Summary of DERM registered water bores within ATP 780

Attribute		Count [1]
Total number of bores		285
Type of bore	Artesian Bore--ceased to flow	15
	Artesian Bore--condition unknown	--
	Artesian Bore--controlled flow	19
	Artesian Bore--uncontrolled flow	13
	Subartesian facility	236
	Surface water	2
Bore Status	Abandoned and destroyed	65
	Abandoned but usable	3
	Existing	215
	Proposed	2
Earliest drill date	RN: 2774	1883
Latest drill date	RN: 146294	18/9/10
Number of water bores in QPED		2
Depth of the shallowest bore (m bGL)	RN 100330021	15
Depth of the deepest bore (m bGL)	RN 2652	762
Average bore depth (m bGL)		163

The bores drilled within ATP 780 tap the full range of water-bearing sediments underlying the shallow Quaternary surface alluvium. Thirty-two water bores are recorded to have controlled or uncontrolled artesian flow. Fifteen bores are recorded to have ceased artesian flow. The majority of the bores are recorded to be used for water supply, however, these data are incomplete.

8.7.4 Subsurface geology for ATP 780

The summary of the subsurface geology for ATP 780 is based on the geological log from water bore RN 2652. RN 2652 was drilled to a depth of 762 m bGL in 1909 (Table 8.35). This is the deepest bore where the stratigraphic details are known. However, the depth to the formation tops has not been recorded. The summary data presented in (Table 8.35) are presented as they have been recorded in RN 2652 completion details in the DERM GWDB (2010). Note that several formations that are documented elsewhere may not be presented in the stratigraphic details contained in (Table 8.35).

Table 8.35 Type stratigraphy for ATP 780—RN 2652

Depth to formation top (m bKB)	Depth to formation bottom (m bKB)(1)	Basin	Formation name	Age
0		Eromanga Basin sequence	Wallumbilla Formation	Cretaceous
			Cadna-owie Formation	Cretaceous
			Hooray Sandstone	Early Cretaceous
			Westbourne Formation	Late Jurassic
			Adori Sandstone	Jurassic
			Birkhead Formation	Jurassic
			Hutton Sandstone	Jurassic
	762		Precipice Sandstone	Jurassic

(1) DERM Database contained minimal depth to formation tops.

8.7.5 Aquifers within ATP 780

The bores drilled within ATP 780 rarely penetrate the full Eromanga Basin sequence; with the exception of RN 2652 which penetrated the full Eromanga Basin sequence but did not penetrate the underlying Galilee Basin sequence. A single bore taps the shallow alluvium and 22 bores tap the Tertiary sediments present within ATP 780.

Bores within the noted aquifers and water bearing sediments are taken from water quality, pump test 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 summary text. The following Eromanga Basin aquifers and water-bearing sediments are present within ATP 780 (Appendix Table D.1 and Table E.1):

- Winton Formation (2 bores);
- Mackunda Formation (1 bore);
- undifferentiated Wallumbilla Formation (9 bores);
- Coreena Member of the Wallumbilla Formation (1 bore);
- Doncaster Member of the Wallumbilla Formation (1 bore);
- Cadna-owie Formation (no bores identified);
- Hooray Sandstone (3 bores);
- Ronlow beds (28 bores);
- undifferentiated Injune Creek Group (10 bores);
- Westbourne Formation (no bores identified);
- Adori Sandstone (1 bore);
- Hutton Sandstone (17 bores identified); and
- Precipice Sandstone (1 bore identified).

The Moolayember Formation (5 bores) and Clematis Sandstone (7 bores) of the Galilee Basin sequences are present at depth. The Moolayember Formation and Clematis Sandstone have not been logged. However, their presence has been inferred based on deeper holes that have not been geologically logged.

8.7.6 Groundwater level summary for ATP 780

Groundwater level data are available for 14 formations (Table 8.36). The available depth to groundwater level data suggests both subartesian and artesian conditions exist in the aquifers within ATP 780. There are no DST final shut-in pressure values reported for ATP 780. The available groundwater data for the Eromanga aquifers indicate that the prevailing groundwater flow is to the west across the Galilee Basin boundary. This groundwater flow direction is consistent with the flow across the portion of the western Galilee Basin study area (Figure 6.19 to Figure 6.21).

Table 8.36 Summary of groundwater levels from water bores within ATP 780

Basin	Formation name	Measurement period		Count	Depth to groundwater (m bGL)				
		Start	End		Ave	Max	Min	Range	Median
Surficial deposits	Alluvium	20-Jun-1976		1	-1				
	Tertiary sediments	10-Jul-1937	03-Aug-2002	50	-37.4	-93.2	-12	81.2	-36.4
Eromanga Basin Sequence	Winton Formation	04-Dec-1913	17-Apr-1972	7	-9.1	-15.24	0	15.24	-12.2
	Coreena Member of the Wallumbilla Formation	01-Jan-1913	07-Feb-1973	2	-3.7	-7.32	0	7.32	-3.7
	Doncaster Member of the Wallumbilla Formation	11-Jun-1963		1	-15.2				
	Wallumbilla Formation	10-Dec-1938	15-Sep-1993	6	-20.0	-86.9	-0.9	86	-5.79
	Hooray Sandstone	01-Jan-1915	24-Aug-2000	2	-11.8	-14.4	-9.1	5.3	-11.8
	Ronlow beds	17-Oct-1899	27-Aug-2000	24	-17.5	-120.4	-0.9	119.5	-8.2
	Injune Creek Group	01-Jan-1912	09-Mar-1973	8	-21.2	-57	-6.1	50.9	-11.0
	Hutton Sandstone	26-Oct-1899	18-Dec-1998	13	-17.7	-85.3	21.5	106.8	-14.8
	Precipice Sandstone	01-Jan-1909	03-Jun-1937	2	-5.2	-10.36	0	10.36	-5.2
Galilee Basin Sequence	Moolayember Formation	01-Jan-1913	15-Aug-01	13	-14.8	-54.86	-9.12	45.74	-9.2
	Clematis Sandstone	08-Apr-1943	29-Jan-2005	6	-72.2	-109	-36.5	72.5	-77.0

8.7.7 Summary of DERM GWDB flow and pumping test data for ATP 780

Pumping test data was received for 75 water bores in DERM GWDB (2010) for ATP 780 (Figure 6.23). The aquifer has been identified for 39 of these water bores. The first flow test was conducted on a bore in 1887 and the most recent was conducted on 18 April 2007 (DERM GWDB, 2010).

These bores have been identified as tapping the following aquifers and water bearing zones:

- Tertiary Sediments;
- Winton Formation;
- Wallumbilla Formation;
- Ronlow beds;
- Hooray Sandstone;
- Adori Sandstone;
- undifferentiated Injune Creek Group;
- Hutton Sandstone; and
- Precipice Sandstone.

The changes in aquifer pressure and depth to groundwater over time were assessed by plotting the discharge upon arrival at the bore (Figure 8.18), changes in the static groundwater level (Figure 8.19) and changes in calculated static groundwater level observations (Figure 8.20).

Generally, groundwater discharge declines from 31 L/s in 1903 to 3 L/s per bore in 2003 (Figure 8.18). The decline is non-linear and concentrated in the 1910s. The groundwater discharge observations from bores that could not be attributed to a specific aquifer also experience a similar non-linear decline.

The static groundwater level observations are dominated by bores drilled in subartesian aquifers prior to the 1980s and by bores drilled in artesian aquifers starting in the 1990s (Figure 8.19). Static groundwater levels in the Ronlow beds are relatively stable over the measurement period, with slight high between 2002 and 2003. There is a slight upward trend to the static groundwater level observations recorded in bores drilled in the Wallumbilla Formation and in the Hutton Sandstone (Figure 8.19).

The calculated static groundwater levels for bores with an unknown aquifer attribution and for bores screened in the Ronlow beds increase slightly over time (Figure 8.20). There are too few observations available for the remaining aquifers to complete a more detailed trend assessment.

Figure 8.18 Bore discharge (L/s) at arrival for ATP 780 water bores with data, 1900 to 2010

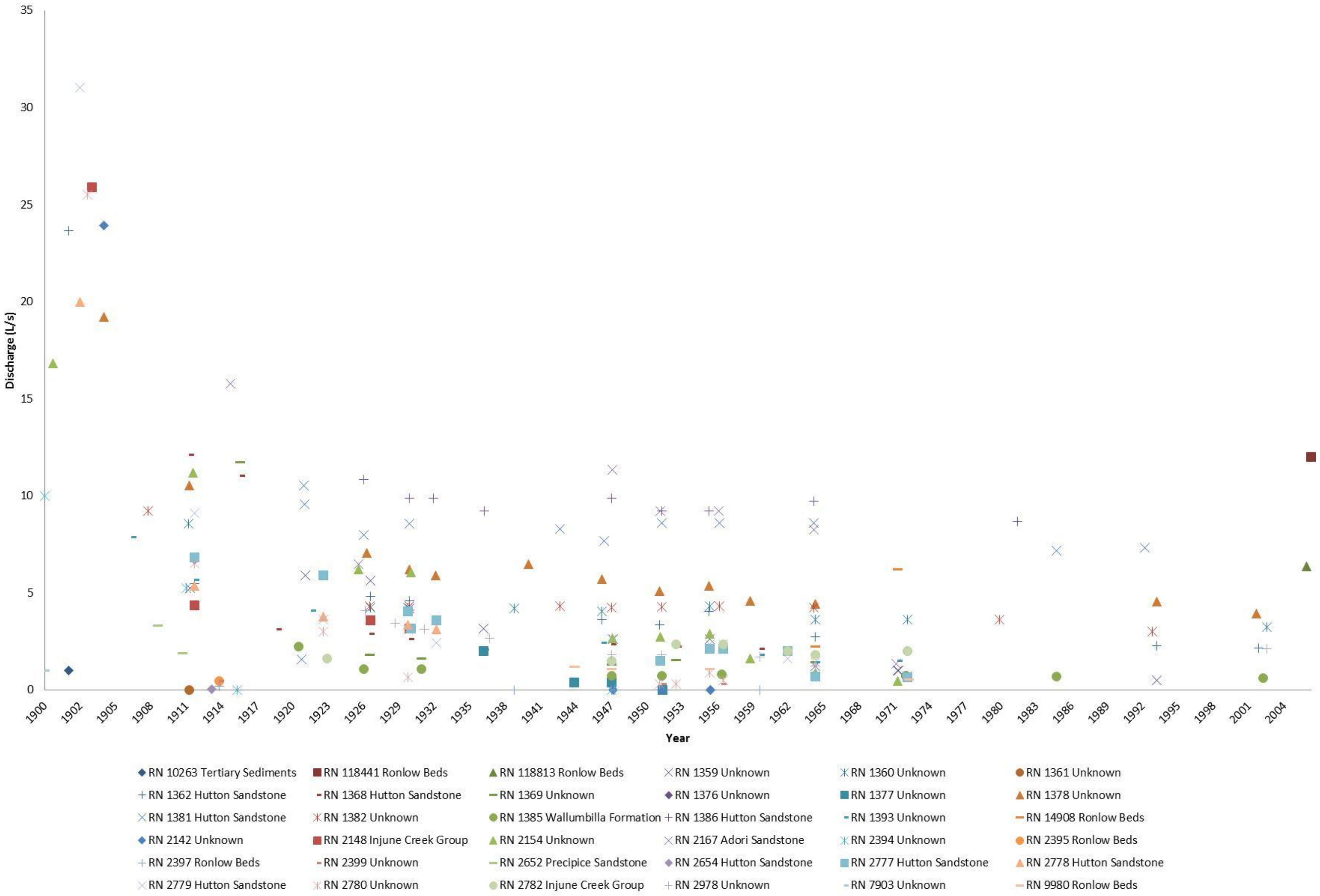


Figure 8.19 Static groundwater levels for ATP 780 water bores with data, 1900 to 2010

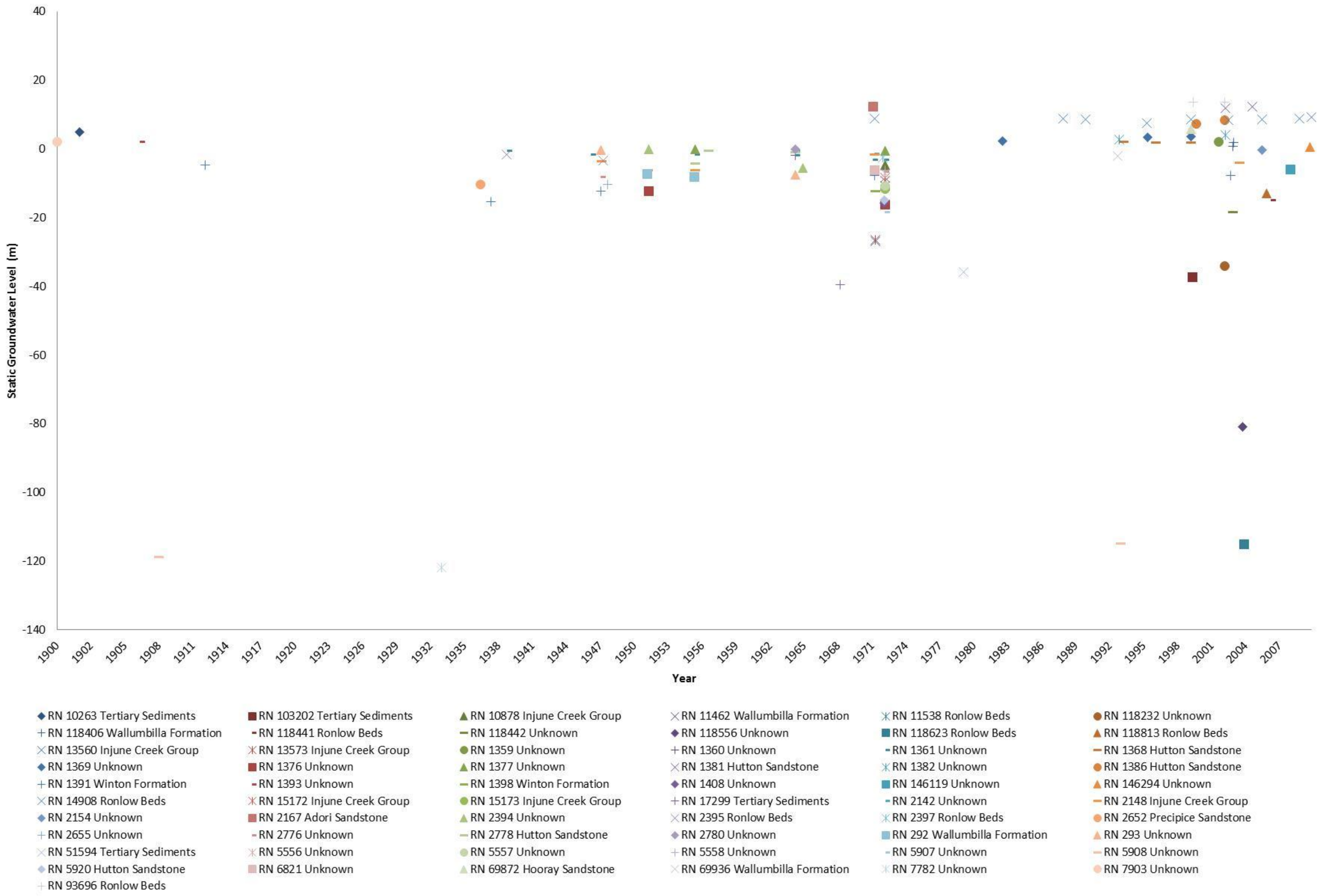
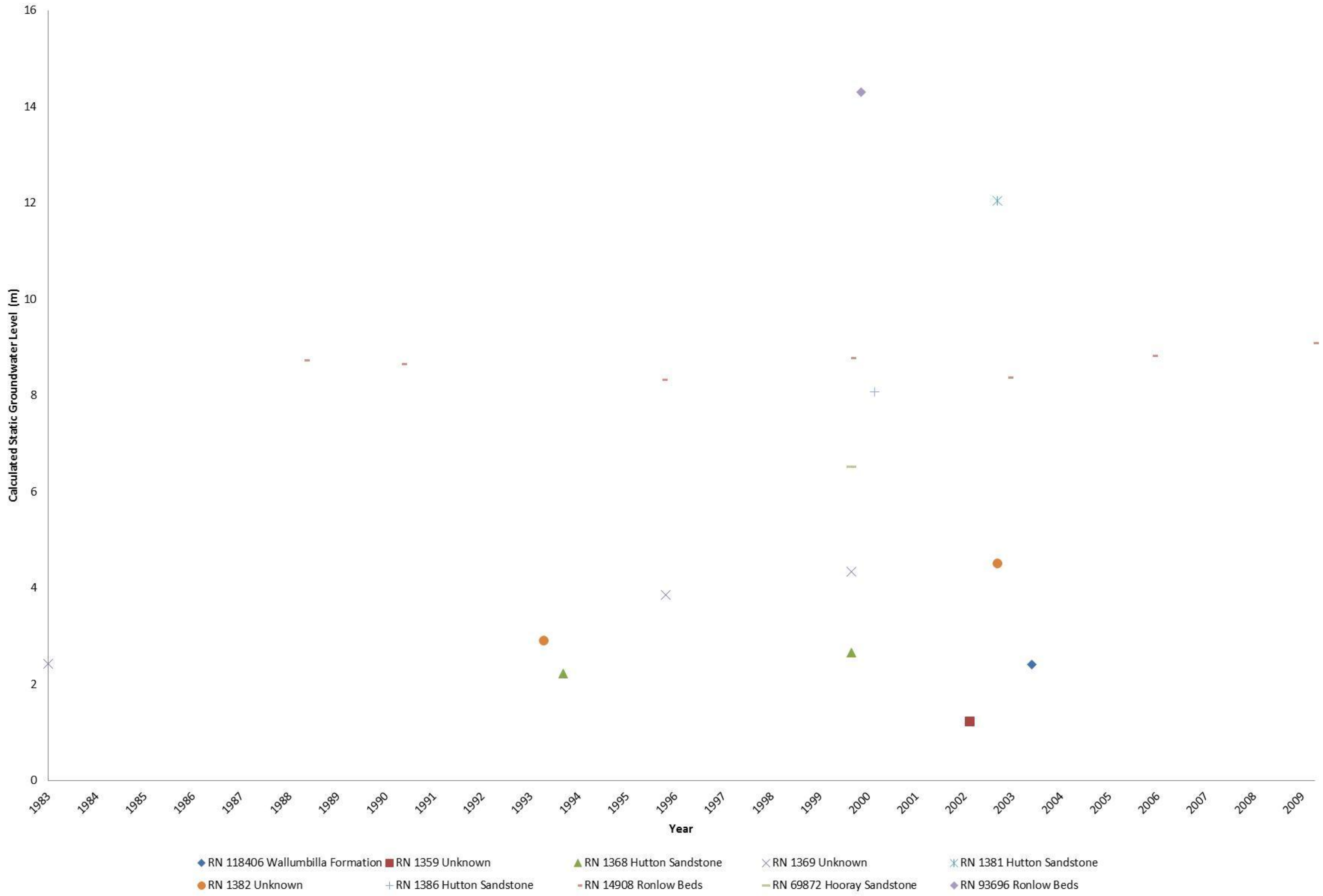


Figure 8.20 Calculated static groundwater levels for ATP 780 water bores with data, 1900 to 2010



8.7.8 Groundwater quality within ATP 780

Laboratory chemical analysis data are available for groundwater samples drawn from 45 bores recorded as tapping 11 different aquifer systems or water-bearing sediments (Table 8.37 and Appendix Table E-1). At least one groundwater quality sample is available from each of water-bearing sediments within ATP 780. The bores that are present within ATP 780 frequently target the shallow aquifers but the deeper bores are also well represented.

Groundwater quality samples were obtained from between 54 and 649 m bGL:

- Groundwater pH varied between 5.6 and 8.6;
- Total dissolved solids ranged from 143 to 42,096 mg/L, indicating dominantly fresh to brackish groundwater systems;
- Electrical conductivity ranged from 260 to 12,400 µS/cm;
- Sodium ranged from 21.5 to 12,475 mg/L;
- Calcium ranged from 0.1 to 2,328 mg/L;
- Chloride ranged from 1.6 to 23,780 mg/L;
- Fluoride ranged from 0.04 to 3.3 mg/L;
- Bicarbonate ranged from 12.2 to 571 mg/L;

All of the samples plot as sodium type water on the Piper diagram presented on Figure 8.21. The groundwater samples obtained from the Tertiary sediments plot as sodium / chloride type water. The groundwater samples obtained from the Eromanga Basin plot from chloride to bicarbonate type waters. The groundwater samples from the Galilee Basin sequence also plot from chloride to bicarbonate type waters. There is no clear relationship between anion type and the stratigraphic depth of the aquifer formation.

Figure 8.21 Piper diagram of the summary groundwater quality results from aquifers present within ATP 780

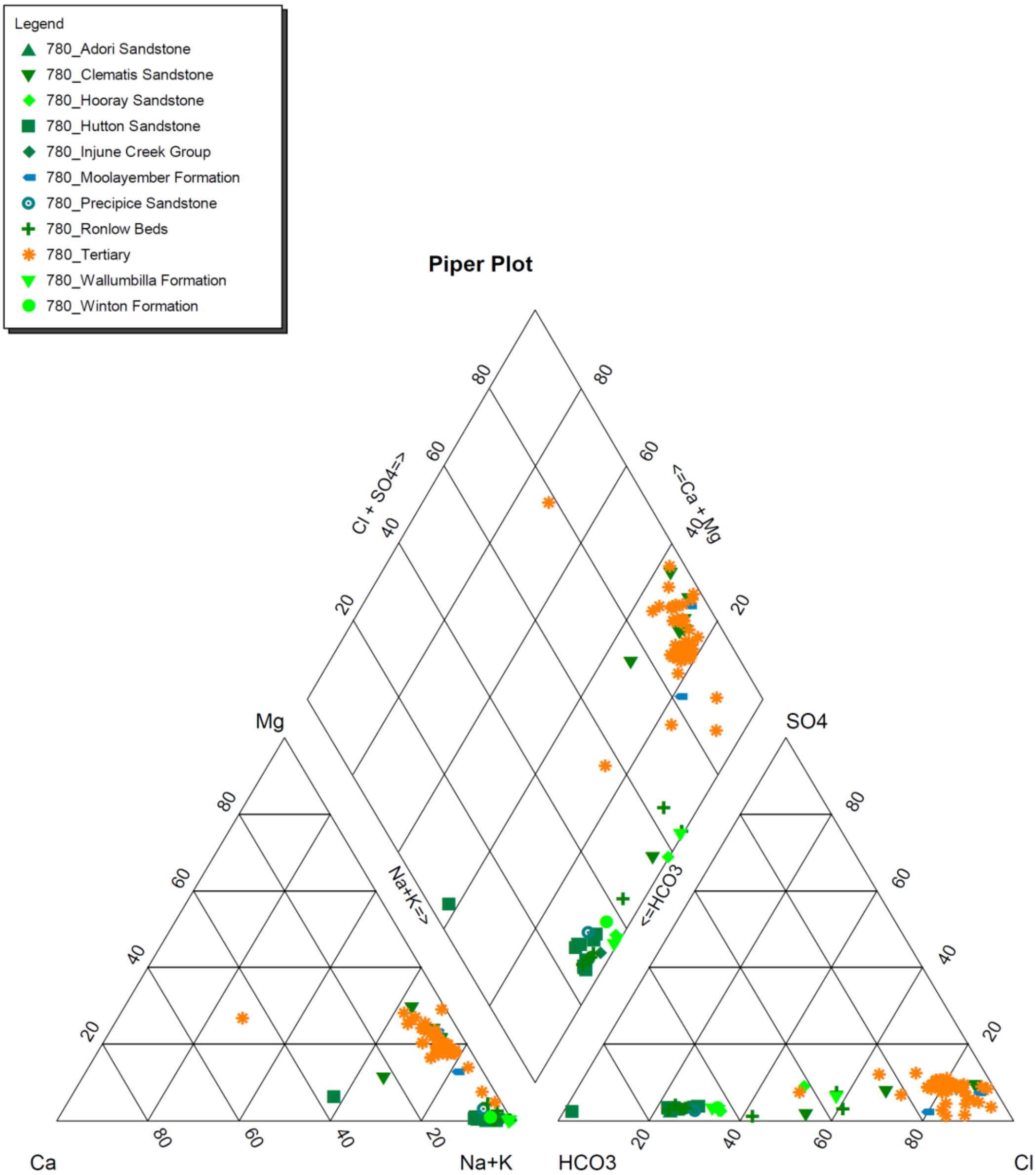


Table 8.37 Groundwater quality data summary for ATP 780

Basin	Identified aquifer or water bearing sediment	Statistic	Depth of Sample m bGL)	Conductivity (uS/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)
Suficial deposits	Tertiary sediments	Total Number	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74	74
		Number of Tests	21	72	74	74	69	73	74	70	74	74	39	63	68	6	74	65.0	11	74	57
		Average	100	1,124	6.9	139	62.5	606	157	10	15	25	2.4	0.17	69	22	286	0.21	2	38	0.3
		Maximum	119	4,200	8	725	485	2,780	584	29	200	124	15	1.6	366.3	59	1,140	1.24	7	121	4
		Minimum	75	387	6	11	13	143	21.5	1	1.1	1.9	0.01	0.01	12.2	1	20	0.07	1	4.2	0.01
Eromanga Basin sequence	Coreena Member of the 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	1	1	1	1	1	1	1	0	1	1	0	0	1	0	1	1.0	0	0	0
		Value	61	910	8	17	200	520	207	--	2	3	--	--	244	--	188	0.4	--	--	--
	Doncaster Member of the 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	1	0	1	1	1	0	1	0	1	1	0	0	0	1	1	1	0	1	0
		Value	317	--	8	45	282	--	400	--	8.6	5.7	--	--	--	169	392	1.5	--	80	--
	Wallumbilla Formation	Total Number	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
		Number of Tests	8	5	5	5	8	7	8	4	8	7	0	2	5	7	8	7.0	2	6	1
		Average	210	1,956	8	1,901	295.9	6,950	2,081	2.75	302	121	--	0.06	334	85	3,589	1.15	4.5	469	0.02
		Maximum	66	470	7	20	57	258	82	2	1.4	0.1	--	0.02	107	1	86	0.38	3	19.5	0.02
		Minimum	387	5,100	9	9,214	740	42,096	12,475	5	2,328	825	--	0.09	571	443	23,780	2.7	6	2,654	0.02
	Adori Sandstone	Total Number	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Number of Tests	3	4	4	1	4	4	4	2	4	2	1	1	4	0	4	4	0	2	0
		Average	185	347	8	48	136.5	214	77	3.5	7	0.55	0.01	0.01	166.1	--	35.8	0.15	--	4.5	--
		Maximum	201	400	8	48	168	230	90	5	19	1	0.01	0.01	205	--	50	0.21	--	5.1	--
		Minimum	153	320	8	48	120	200	71	2	2	0.1	0.01	0.01	145	--	27.2	0.1	--	3.9	--
	Ronlow beds	Total Number	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
		Number of Tests	12	13	13	8	15	11	15	8	15	14	7	4	13	7	15	14	3	15	0
		Average	193	1,566	8	130	192	1,002	377	2	21	5	ND	ND	199.2	65	415	0.37	3	114	--
		Maximum	594	12,400	8	634	621	7,502	2,620	6	196	35	ND	ND	366	372	3,860	0.8	4	801	--
		Minimum	79	300	6	11	49	160	59	0	1.6	0.1	ND	ND	60	1	26	0.1	2	1	--
	Injune Creek Group	Total Number	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		Number of Tests	5	5	5	2	5	5	5	2	5	4	2	0	5	2	5	5	0	5	1
		Average	204	451	8	13	146	266	102	1.5	3	0.8	ND	--	176.2	1.5	56	0.8	--	7	0.01
		Maximum	183	330	8	12	121	206	72	1	1.5	0.2	ND	--	145.4	1	29	0.15	--	4.8	0.01
		Minimum	231	840	8	14	212	478	192	2	4	1	ND	--	258	2	142	3.3	--	10	0.01
	Hutton Sandstone	Total Number	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
		Number of Tests	13	16	18	12	19	17	19	12	18	15	4	3	16	15	19	16	1	16	2
		Average	388	339	8	95	132	210.5	142	2.5	13	10	ND	ND	152.4	20	162	0.19	2	16.8	0.02
		Maximum	649	380	9	913	282	238.4	1,450	5	156	127	ND	ND	163	169	2,540	0.25	2	196	0.03
		Minimum	67	260	7	11	33	170	24	1	0.1	0.1	ND	ND	140	1	1.6	0.04	2	0.9	0.01
	Precipice 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	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1

Basin	Identified aquifer or water bearing sediment	Statistic	Depth of Sample m bGL)	Conductivity (uS/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)
		Value	--	434	8	17	151	266.5	77	18	4.1	1.5	0.47	--	182	1	44	0.6	1	5.2	0.03
Galilee Basin sequence	Moolayember 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	1	1	1	0	1	1	0	1	1	0	1	1
		Value	--	1,240	7	102	98	634	198	14	13	17	--	0.05	119.3	--	308.7	0.24	--	11.5	0.03
	Clematis Sandstone	Total Number	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
		Number of Tests	9	10	10	10	10	10	10	10	10	10	2	8	10	1	10	9	4	10	8
		Average	118	1,104	8	137	58	581	160	11	14	25	0.02	0.13	70	1	286	0.37	1.25	39	0.09
		Maximum	348	1,770	8	297	221	903	225	16	33	58	0.02	0.22	270	1	481	0.95	2	70	0.3
		Minimum	54	820	8	18	16	440	105	8	5.7	0.9	0.02	0.07	19	1	180	0.05	1	8.5	0.03

8.7.9 Summary for ATP 780

There are comparatively few exploration wells on this tenement. However, there are over 280 registered water bores within ATP 780. Therefore, the hydrogeological summary for ATP 780 is dominated by information derived from the DERM GWDB (2010).

The registered bores tap the shallow groundwater resources hosted in the Tertiary sediments and the shallow Eromanga Basin sediments most frequently. However, water bores, screened in the water-bearing portions of the Moolayember Formation and the Clematis Sandstone aquifer, are tapped in the east where these formations occur near the surface ATP 780.

The Tertiary sediments that overlie the Eromanga and Galilee Basin sequences are frequently tapped for groundwater. The location of the basal Jurassic unconformity lies near the eastern tenement boundary. The depth to Permian unconformity and the interburden thickness between the Eromanga basin aquifers and the underlying coal measures could not be determined based on the currently available data.