Report
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Surat Gas Project Updated CSG WMMP Annual Report

Reporting Period: 22 October 2023 to 21 October 2024

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1. Purpose

Arrow Energy's (Arrow) Surat Gas Project (SGP) was approved by the Australian Government under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) decision 2010/5344 on 19 December 2013. The conditions attached to approval EPBC 2010/5344 require a Stage 1 Coal Seam Gas (CSG) Water Monitoring and Management Plan (WMMP) (as required under condition 13 and approved by the Australian Government on 18 December 2018) and an Updated CSG WMMP (as required under condition 17 and approved by the Australian Government on 22 November 2019) be prepared.

Section 8.2.4 of the SGP Updated CSG WMMP requires Arrow to publish an annual report presenting a summary of progress towards Arrow's commitments and document Arrow's compliance against the approval conditions. This annual report is required to be prepared within three months of the anniversary date of the SGP commencement, which was 22 October 2020. This Report has been prepared to fulfil these obligations for the reporting period of 22 October 2023 to 21 October 2024 and provides:

- a summary of relevant monitoring results, and analysis and interpretation of data, including:
    - groundwater levels (Section 3.1)
    - groundwater chemistry results (Section 3.2)
    - subsidence monitoring results (Section 3.3)
- documentation of corrective actions implemented to address exceedances of trigger thresholds, limits, or non-compliance with approval conditions (Sections 3 and 5.4)
- details of any updates to the Field Development Plan (FDP) and implications for water monitoring and management (Section 4)
- reporting of any relevant ongoing studies and research projects, and includes any supporting technical studies as appendices to the annual report (Section 5)
- documentation of Arrow's compliance against the approval conditions over the preceding 12 months, including monitoring obligations and implementation of the early warning monitoring system (EWMS) (Section 5.4)
- reporting against the performance measure criteria detailed in Section 8.3 of the SGP Updated CSG WMMP (Sections 3, 5 and 5.4).

2. Surat Gas Project Status

The SGP commenced on 22 October 2020 and, in the first 12 months, production had not started from any SGP production wells during that reporting period and, as such, no water was produced from these wells during that reporting period.

During this reporting period (22 October 2023 – 21 October 2024), 57 SGP production wells have started production, for a total of 234 SGP producing wells.

2.1 Well Installations

A total of 263 production wells have been installed since commencement of the SGP.

2.2 Well Production

Table 1 presents the location and start date of the SGP production wells, which commenced production during this reporting period. Figure 2-1 shows the location of these wells. The monthly water production volumes for all SGP wells are summarised in Table 2**.**

Table 1: SGP Production well details and start dates

Well Name	Easting (m)	Northing (m)	PL	Production Start date
Longswamp 181	314083	6982701	PL260	4-Nov-23
Longswamp 182	314085	6982716	PL260	4-Nov-23
Longswamp 183	314087	6982730	PL260	4-Nov-23
Tipton 521	319195	6969222	PL198	6-Nov-23
Tipton 522	319211	6969221	PL198	6-Nov-23
Tipton 523	319227	6969221	PL198	6-Nov-23
Tipton 524	319243	6969220	PL198	6-Nov-23
Tipton 525	319259	6969219	PL198	6-Nov-23
Tipton 526	319275	6969218	PL198	6-Nov-23
Tipton 527	319291	6969218	PL198	6-Nov-23
Tipton 528	319307	6969217	PL198	6-Nov-23
Longswamp 185	312503	6982781	PL260	21-Nov-23
Longswamp 186	312505	6982796	PL260	21-Nov-23
Tipton 431	319547	6982155	PL198	22-Nov-23
Tipton 432	319545	6982139	PL198	22-Nov-23
Tipton 433	319543	6982123	PL198	23-Nov-23
Tipton 230	316467	6967287	PL198	7-Jan-24
Tipton 241	316225	6961851	PL198	7-Jan-24
Tipton 246	315911	6962641	PL198	7-Jan-24
Tipton 278	316649	6968752	PL198	7-Jan-24
Tipton 308	314258	6962093	PL198	7-Jan-24
Tipton 253	315614	6971412	PL198	20-Jan-24

Tipton 285	316091	6971700	PL198	20-Jan-24
Tipton 243	316476	6963383	PL198	22-Jan-24
Tipton 267	317279	6969403	PL198	22-Jan-24
Longswamp 284	317820	6981254	PL260	26-Jan-24
Tipton 471	322629	6976789	PL198	11-Apr-24
Tipton 472	322631	6976804	PL198	11-Apr-24
Tipton 473	322633	6976819	PL198	11-Apr-24
Tipton 474	322635	6976834	PL198	11-Apr-24
Stratheden 166	308662	6993102	PL252	23-Jun-24
Stratheden 142	307649	6990973	PL252	24-Jun-24
Stratheden 143	307647	6990957	PL252	24-Jun-24
Stratheden 144	307644	6990942	PL252	24-Jun-24
Tipton 436	320096	6984047	PL198	4-Jul-24
Tipton 437	320098	6984063	PL198	4-Jul-24
Tipton 438	320101	6984078	PL198	4-Jul-24
Longswamp 191	315827	6983183	PL260	5-Jul-24
Longswamp 192	315825	6983167	PL260	5-Jul-24
Longswamp 193	315822	6983151	PL260	5-Jul-24
Longswamp 194	315820	6983135	PL260	5-Jul-24
Longswamp 291	317878	6982855	PL260	9-Jul-24
Longswamp 292	317880	6982871	PL260	9-Jul-24
Longswamp 293	317882	6982887	PL260	9-Jul-24
Longswamp 294	317884	6982903	PL260	9-Jul-24
Tipton 262	317704	6971591	PL198	22-Jul-24
Tipton 275	317531	6970274	PL198	22-Jul-24
Tipton 251	316148	6972171	PL198	29-Jul-24
Tipton 254	316442	6970335	PL198	16-Jun-24
Tipton 256	316693	6971167	PL198	16-Jun-24
Stratheden 201	307201	6985323	PL252	22-Aug-24
Stratheden 202	307216	6985323	PL252	22-Aug-24
Stratheden 203	307231	6985323	PL252	22-Aug-24
Stratheden 204	307246	6985323	PL252	22-Aug-24
Tipton 331	316214	6972754	PL198	21-Sep-24
Tipton 332	316230	6972752	PL198	21-Sep-24
Tipton 333	316246	6972750	PL198	21-Sep-24
Tipton 334	316262	6972748	PL198	21-Sep-24
Stratheden 195	305611	6986004	PL252	10-Oct-24

Table 2: 2023 – 2024 water production volumes by month and annual total

Month	Volume extracted (ML)
November 2023	620.6
December 2023	632.6
January 2024	656.1
February 2024	586.4
March 2024	603.5
April 2024	558.5
May 2024	563.4
June 2024	520.0
July 2024	575.5
August 2024	575.2
September 2024	522.2
October 2024	514.6
Total annual	**6928.5**

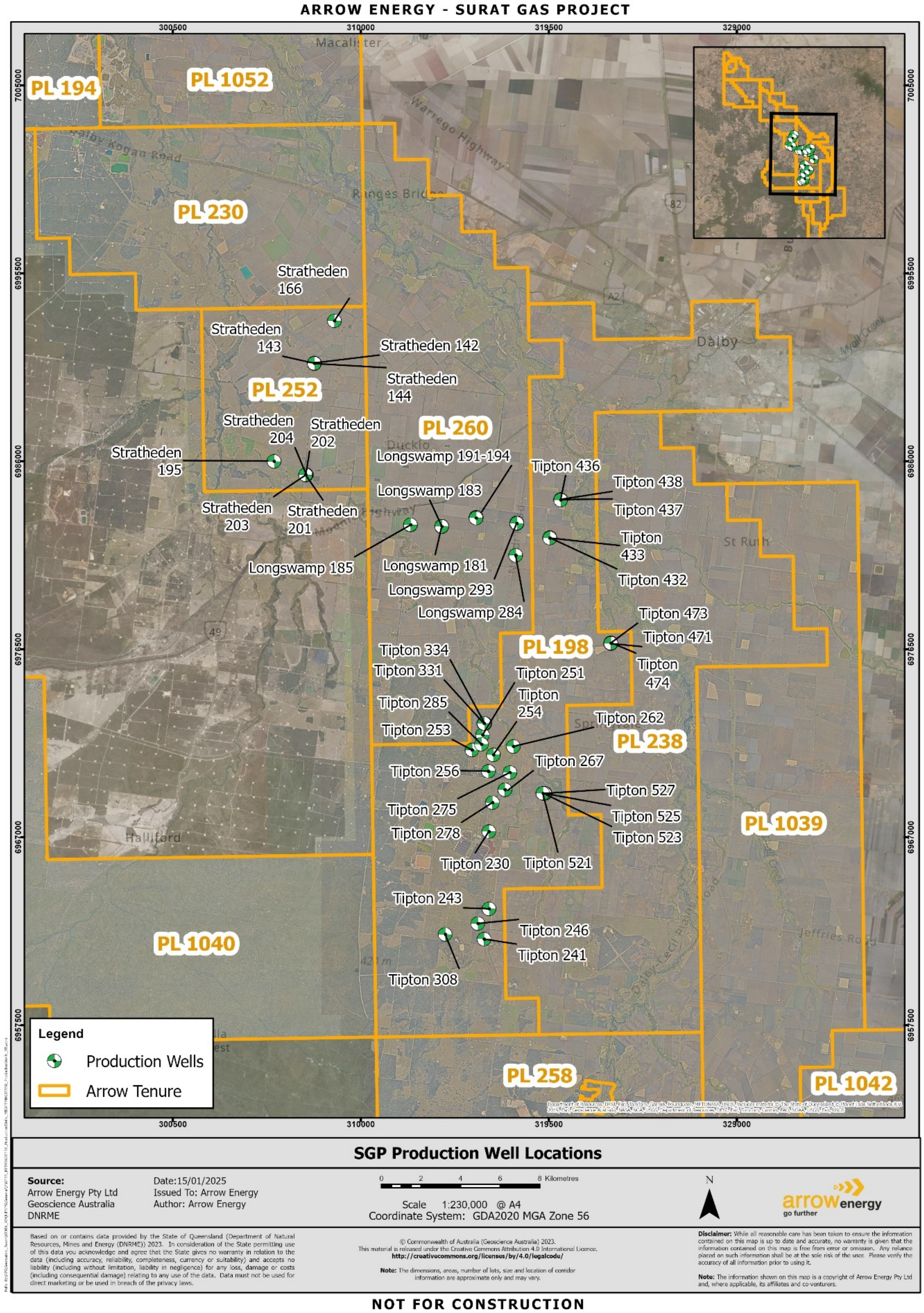


Figure 2-1: SGP production wells' locations that have commenced production during this reporting period (22 October 2023 – 21 October 2024)

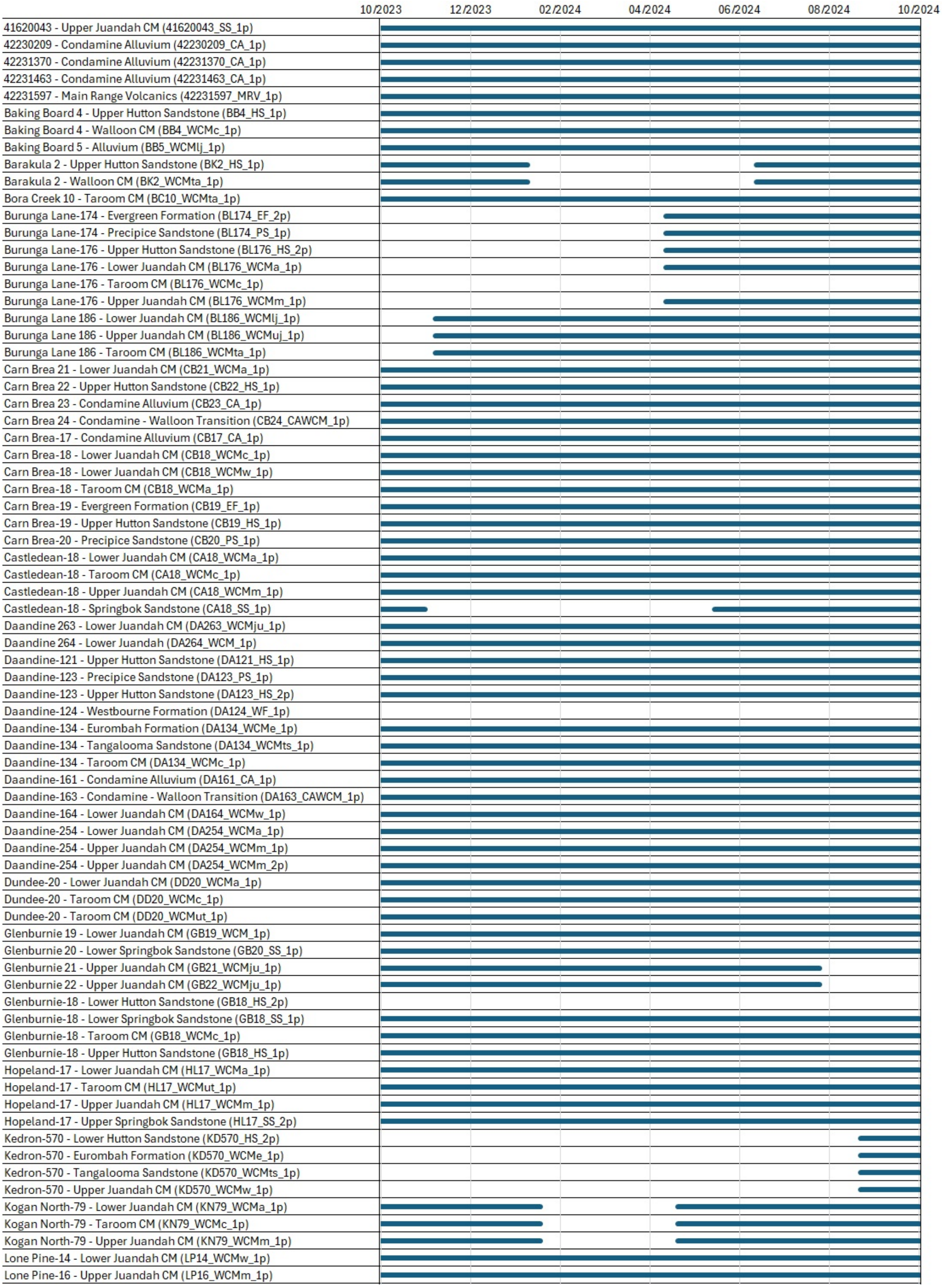
3. Monitoring and Management Programs

3.1 Groundwater pressure/level

Data collection

Groundwater pressure and level data were collected from all operational WMMP monitoring points throughout the reporting period (Refer to Table 6). During this reporting period, Burunga Lane-174 and Burunga Lane-176 land access issue has been resolved and monitoring recommenced on 2/05/2024. In accordance with Section 7.3 of the SGP Updated CSG WMMP, the locations monitored, and the frequency of monitoring were carried out throughout the reporting period in alignment with the most current Underground Water Impact Report (UWIR), which was the 2021 UWIR prepared by the Office of Groundwater Impact Assessment (OGIA, 2021). Burunga Lane 186, a new monitoring point under the 2021 UWIR, commenced monitoring on 28/11/2023. A summary of the groundwater pressure / level monitoring program as required by the 2021 UWIR is provided in Section 3.4.

Throughout the reporting period there were instances where data were unable to be collected due to monitoring equipment failure or access to the monitoring point was not in place. Data availability during the reporting period is presented below in Figure 3-1.


10/2023
12/2023
02/2024
04/2024
06/2024
08/2024
10/2024
41620043 - Upper Juandah CM (41620043_SS_1p)
42230209 - Condamine Alluvium (42230209_CA_1p)
42231370 - Condamine Alluvium (42231370_CA_1p)
42231463 - Condamine Alluvium (42231463_CA_1p)
42231597 - Main Range Volcanics (42231597_MRV_1p)
Baking Board 4 - Upper Hutton Sandstone (BB4_HS_1p)
Baking Board 4 - Walloon CM (BB4_WCMc_1p)
Baking Board 5 - Alluvium (BB5_WCMlj_1p)
Barakula 2 - Upper Hutton Sandstone (BK2_HS_1p)
Barakula 2 - Walloon CM (BK2_WCMta_1p)
Bora Creek 10 - Taroom CM (BC10_WCMta_1p)
Burunga Lane-174 - Evergreen Formation (BL174_EF_2p)
Burunga Lane-174 - Precipice Sandstone (BL174_PS_1p)
Burunga Lane-176 - Upper Hutton Sandstone (BL176_HS_2p)
Burunga Lane-176 - Lower Juandah CM (BL176_WCMa_1p)
Burunga Lane-176 - Taroom CM (BL176_WCMc_1p)
Burunga Lane-176 - Upper Juandah CM (BL176_WCMm_1p)
Burunga Lane 186 - Lower Juandah CM (BL186_WCMlj_1p)
Burunga Lane 186 - Upper Juandah CM (BL186_WCMuj_1p)
Burunga Lane 186 - Taroom CM (BL186_WCMta_1p)
Carn Brea 21 - Lower Juandah CM (CB21_WCMa_1p)
Carn Brea 22 - Upper Hutton Sandstone (CB22_HS_1p)
Carn Brea 23 - Condamine Alluvium (CB23_CA_1p)
Carn Brea 24 - Condamine - Walloon Transition (CB24_CAWCM_1p)
Carn Brea-17 - Condamine Alluvium (CB17_CA_1p)
Carn Brea-18 - Lower Juandah CM (CB18_WCMc_1p)
Carn Brea-18 - Lower Juandah CM (CB18_WCMw_1p)
Carn Brea-18 - Taroom CM (CB18_WCMa_1p)
Carn Brea-19 - Evergreen Formation (CB19_EF_1p)
Carn Brea-19 - Upper Hutton Sandstone (CB19_HS_1p)
Carn Brea-20 - Precipice Sandstone (CB20_PS_1p)
Castledean-18 - Lower Juandah CM (CA18_WCMa_1p)
Castledean-18 - Taroom CM (CA18_WCMc_1p)
Castledean-18 - Upper Juandah CM (CA18_WCMm_1p)
Castledean-18 - Springbok Sandstone (CA18_SS_1p)
Daandine 263 - Lower Juandah CM (DA263_WCMju_1p)
Daandine 264 - Lower Juandah (DA264_WCM_1p)
Daandine-121 - Upper Hutton Sandstone (DA121_HS_1p)
Daandine-123 - Precipice Sandstone (DA123_PS_1p)
Daandine-123 - Upper Hutton Sandstone (DA123_HS_2p)
Daandine-124 - Westbourne Formation (DA124_WF_1p)
Daandine-134 - Eurombah Formation (DA134_WCMe_1p)
Daandine-134 - Tangalooma Sandstone (DA134_WCMts_1p)
Daandine-134 - Taroom CM (DA134_WCMc_1p)
Daandine-161 - Condamine Alluvium (DA161_CA_1p)
Daandine-163 - Condamine - Walloon Transition (DA163_CAWCM_1p)
Daandine-164 - Lower Juandah CM (DA164_WCMw_1p)
Daandine-254 - Lower Juandah CM (DA254_WCMa_1p)
Daandine-254 - Upper Juandah CM (DA254_WCMm_1p)
Daandine-254 - Upper Juandah CM (DA254_WCMm_2p)
Dundee-20 - Lower Juandah CM (DD20_WCMa_1p)
Dundee-20 - Taroom CM (DD20_WCMc_1p)
Dundee-20 - Taroom CM (DD20_WCMut_1p)
Glenburnie 19 - Lower Juandah CM (GB19_WCM_1p)
Glenburnie 20 - Lower Springbok Sandstone (GB20_SS_1p)
Glenburnie 21 - Upper Juandah CM (GB21_WCMju_1p)
Glenburnie 22 - Upper Juandah CM (GB22_WCMju_1p)
Glenburnie-18 - Lower Hutton Sandstone (GB18_HS_2p)
Glenburnie-18 - Lower Springbok Sandstone (GB18_SS_1p)
Glenburnie-18 - Taroom CM (GB18_WCMc_1p)
Glenburnie-18 - Upper Hutton Sandstone (GB18_HS_1p)
Hopeland-17 - Lower Juandah CM (HL17_WCMa_1p)
Hopeland-17 - Taroom CM (HL17_WCMut_1p)
Hopeland-17 - Upper Juandah CM (HL17_WCMm_1p)
Hopeland-17 - Upper Springbok Sandstone (HL17_SS_2p)
Kedron-570 - Lower Hutton Sandstone (KD570_HS_2p)
Kedron-570 - Eurombah Formation (KD570_WCMe_1p)
Kedron-570 - Tangalooma Sandstone (KD570_WCMts_1p)
Kedron-570 - Upper Juandah CM (KD570_WCMw_1p)
Kogan North-79 - Lower Juandah CM (KN79_WCMa_1p)
Kogan North-79 - Taroom CM (KN79_WCMc_1p)
Kogan North-79 - Upper Juandah CM (KN79_WCMm_1p)
Lone Pine-14 - Lower Juandah CM (LP14_WCMw_1p)
Lone Pine-16 - Upper Juandah CM (LP16_WCMm_1p)

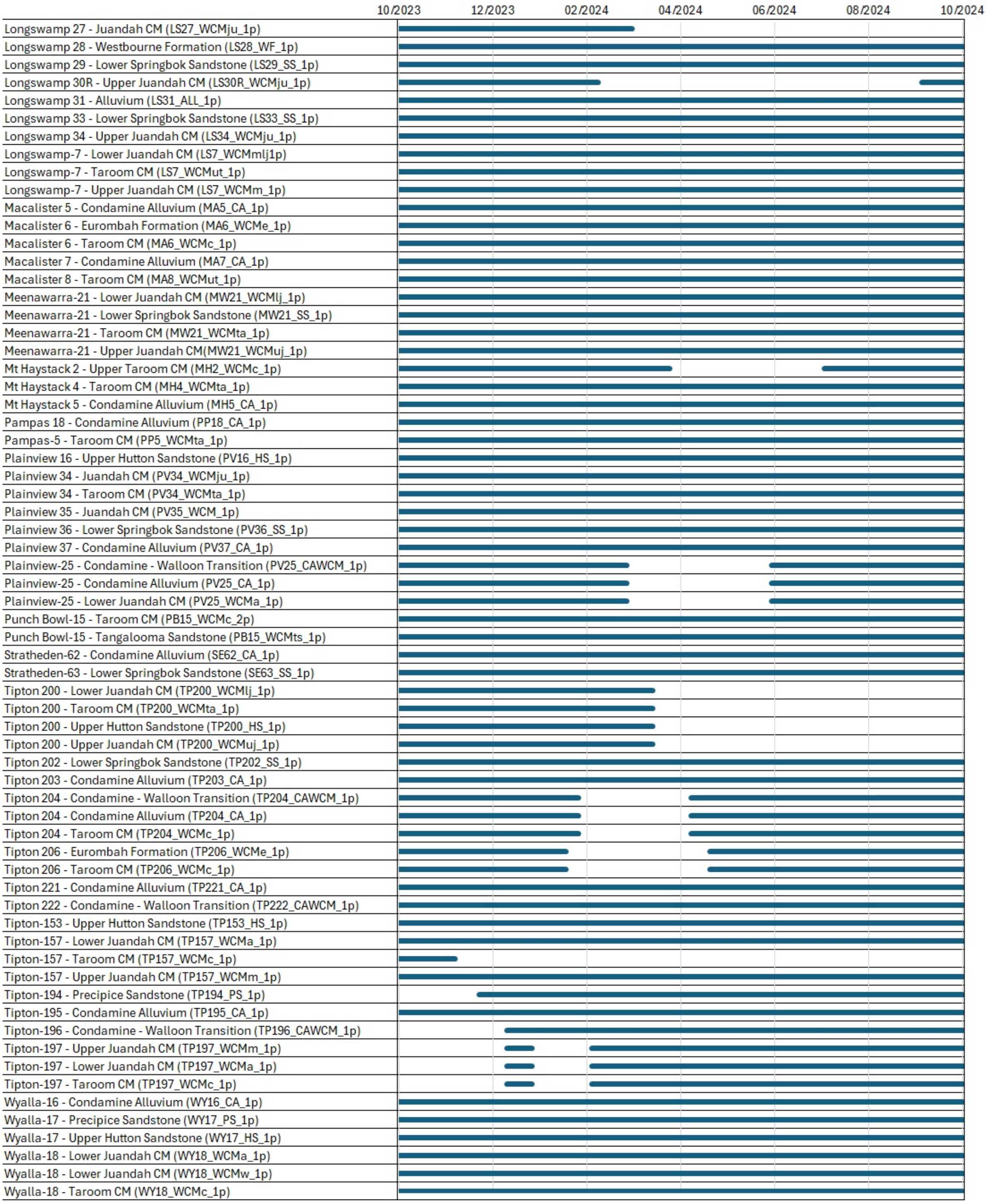


Figure 3-1: Data availability from groundwater level/pressure monitoring points during the reporting period

It should be noted that although not all hourly data were collected from the monitoring points noted here, the majority of hourly data for the reporting period was collected from almost all of these monitoring points. Individual hydrographs for each monitoring point are provided in Appendix A.

In accordance with Section 9.12 of the 2021 UWIR (OGIA, 2021), Arrow provided to OGIA a WMS network implementation report and WMS water monitoring report by the required dates of 1 April and 1 October 2024.

Data analysis

An analysis of data collected to the end of the reporting period is provided in the following sections, noting that water production from SGP production wells continued during the reporting period and, as a result, changes in observed groundwater levels/pressure have been analysed with respect to groundwater extraction.

EWMS comparison

Biannual comparison of the collected groundwater level/pressure data against the EWMS values was undertaken within 90 days of the end of each six-monthly monitoring period. No EWMS exceedances were identified during the reporting period and illustrations of these comparisons are provided in Appendix A.

Condamine Alluvium trend analysis

A hydrograph of the groundwater level data collected from the Condamine Alluvium monitoring bores is shown in Figure 3-2. The data show general groundwater flow in the Condamine Alluvium, within the vicinity of Arrow's monitoring network, is from south to north.

Groundwater level trends are variable within the Condamine Alluvium. The majority of the bores located in the central Condamine Alluvium area (groundwater elevation between 305 and 330 m AHD) displaying strong seasonal responses to non-CSG groundwater take (Figure 3-3), particularly for irrigation in the warmer months, and thus the greatest observed drawdown (and generally subsequent recovery).

Long-term groundwater level data (Figure 3-2) depict a seasonal change in groundwater level trend across most monitoring bores. Bores 42230209, Macalister 5, Pampas 18, Plainview 37, Tipton 195, Tipton 203, Tipton 221, and Wyalla-16 have a generally stable trend with no observable seasonal variation. Carn Brea 23, Carn Brea 17, Daandine-161, Macalister 7, Plainview 25, 42231463, and 42231370 also have a relatively stable trend but show seasonal responses.

Groundwater level of the bore Stratheden-62 was previously following seasonal variations, but it has a more stable trend over the last 5 years. The SGP production wells located near Stratheden-62 commenced extraction from the reservoir in April 2022 and the water level in this bore has remained stable throughout the reporting period.

Tipton 204 groundwater levels have previously shown declining trends but have started to show an increasing trend in the last 2 years and became relatively stable during this reporting period. The groundwater level of Mt Haystack 5, located furthest upgradient and away from CSG development in the Condamine Alluvium monitoring background conditions, had been declining prior to 2020 and the commencement of the SGP, subsequently responded to increased recharge events during 2020 to 2023, and has relatively stabilized in the current period.

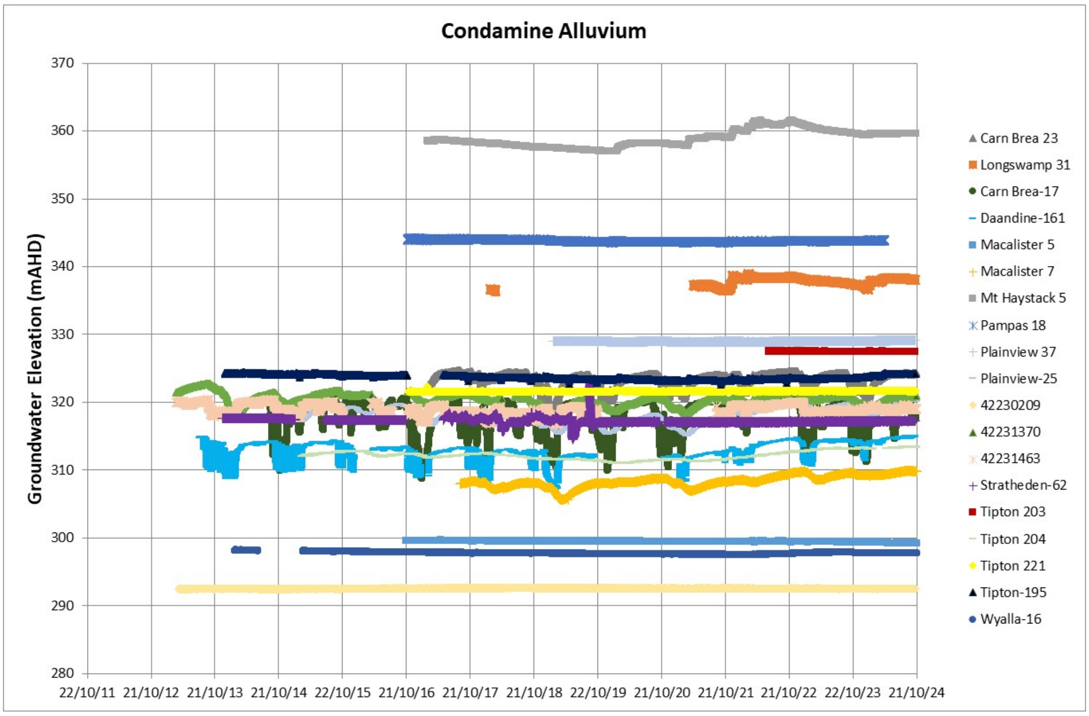


Figure 3-2: Condamine Alluvium monitoring bores hydrograph

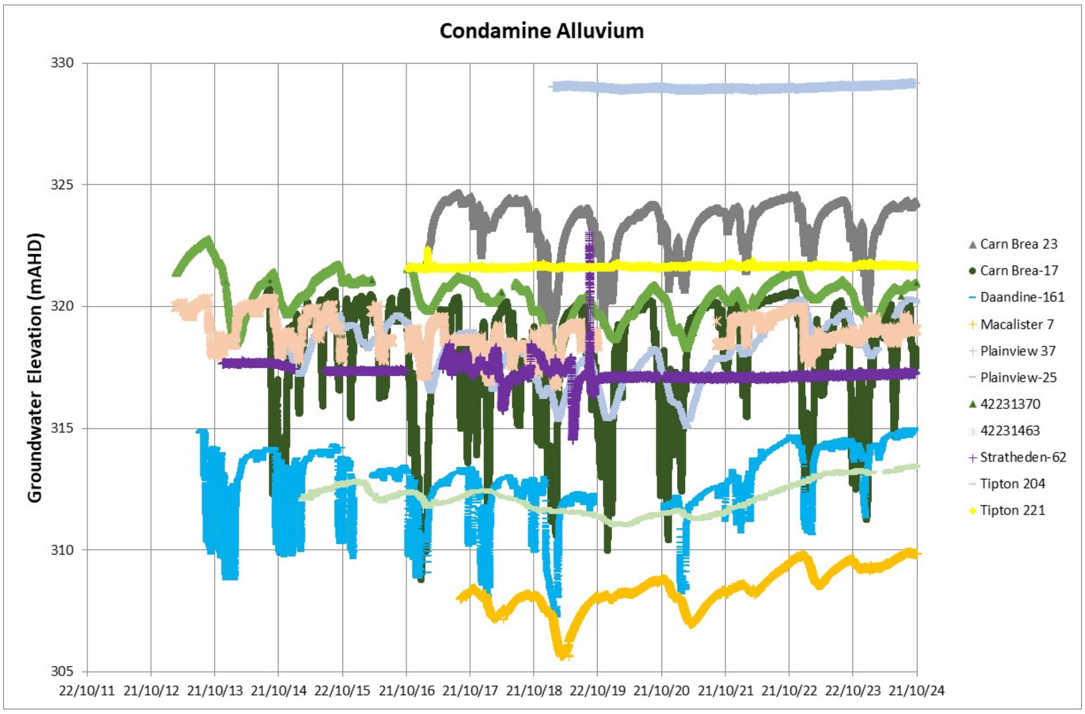


Figure 3-3: Central Condamine Alluvium area monitoring bores hydrograph

Springbok Sandstone trend analysis

Groundwater levels/pressure in the Springbok Sandstone monitoring bores displayed varying trends; however, all monitoring points except for Glenburnie 20 (given its monitoring interval is a perched seepage zone and is not representative of the regional water table) and part of the monitoring record for Hopeland-17 (where the sandstone is a very low permeability and still recovering from groundwater sampling) displayed a groundwater elevation between 290 and 350 m AHD during this reporting period (Figure 3-4).

Bores Stratheden-63, Glenburnie-18 (following a period of pressure equalisation succeeding bore installation), Glenburnie 20, Plainview 36, Longswamp 29, and Longswamp 33 displayed generally stable groundwater pressure trends. The groundwater levels of Meenawarra-21 and Tipton 202 both exhibited an increasing trend, rising from 302.0 to 304.3 mAHD and from 297.2 to 299.7 mAHD, respectively. Hopeland-17 displayed variability in its groundwater pressure, most likely a result of nearby CSG production on neighbouring non-Arrow tenements (as noted in Section 5.6.2.2 of the 2021 UWIR (OGIA, 2021)), a workover in May 2020 to install a new pressure gauge (the gauge failed in November 2018) and swabbing of the bore in December 2020 to collect a groundwater sample (which the bore was still recovering from at the end of the reporting period as a result of very low permeability of the formation). Despite this, the groundwater level of Hopeland-17 has shown a generally increasing trend since January 2021. The SGP production wells located near Stratheden-63 commenced extraction from April 2022, a response to this production is not evident in the water level data during this reporting period. These trends in the Springbok Sandstone monitoring bores continued throughout the reporting year.

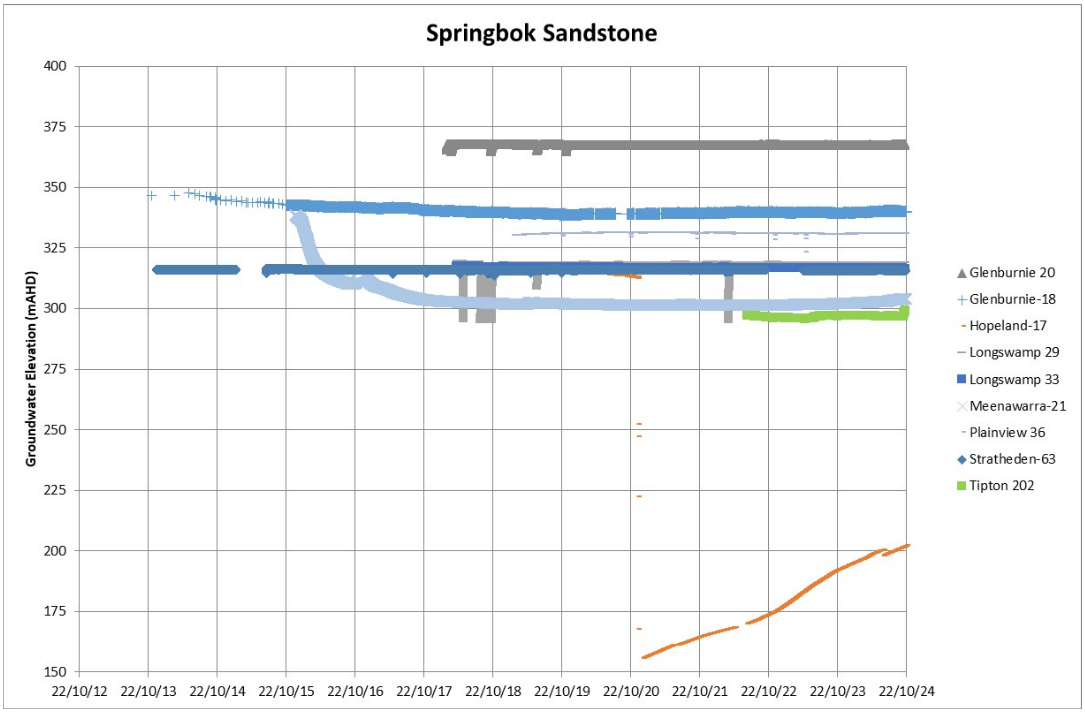


Figure 3-4: Springbok Sandstone monitoring bores hydrograph

Hutton Sandstone trend analysis

All Hutton Sandstone monitoring bores exhibited a long-term declining trend (Figure 3-5), with the majority showing rates consistent with Section 5.6.2.1 of the 2021 UWIR (OGIA, 2021), up to 2 m per year. The largest observed drawdown (22.7 m) has been recorded in bore Wyalla-17 since 2019 (rate of 4.0 m/year), the majority of which occurred within the first six months of installation, with a drawdown rate of 3.2 m during this current reporting period. Daandine-123 recorded a drawdown of 14.9 m since August 2020 (rate of 3.6 m/year). The least drawdown of 0.35 m (rate of 0.06 m/year) has been observed in Tipton-153 since 2019. The small observed drawdown rate in Kedron-570 (0.21 m/year) is also consistent with the 2021 UWIR (OGIA, 2021) which states that there is generally no groundwater level trends in the Hutton Sandstone north of the Great Dividing Range. The initial steeper drawdown curves observed in Wyalla-17 and following the installation of a new pressure gauge in Daandine-123 (July 2020), are likely a result of pressure equalisation between the bore and the formation following the workover of the bores to install the gauges. Plainview 16 was installed relatively recently (in July 2021) and thus has a correspondingly short monitoring period. However, a generally declining groundwater level, with a rate of 0.69 m/year, has been observed at this bore to date. Similar to Plainview 16, Tipton 200 was installed recently; however, its groundwater level has increased at a rate of 6.1 m/year since installation. There was a hardware calibration issue with the monitoring equipment in this bore, and the skid has been offline from April 2024 to the present.

These long-term trends have continued throughout the reporting period, with the land access issue for Burunga Lane-174 and Burunga Lane-176 being resolved, allowing monitoring to recommence on 2/05/2024 (Table 6 and Table 7).

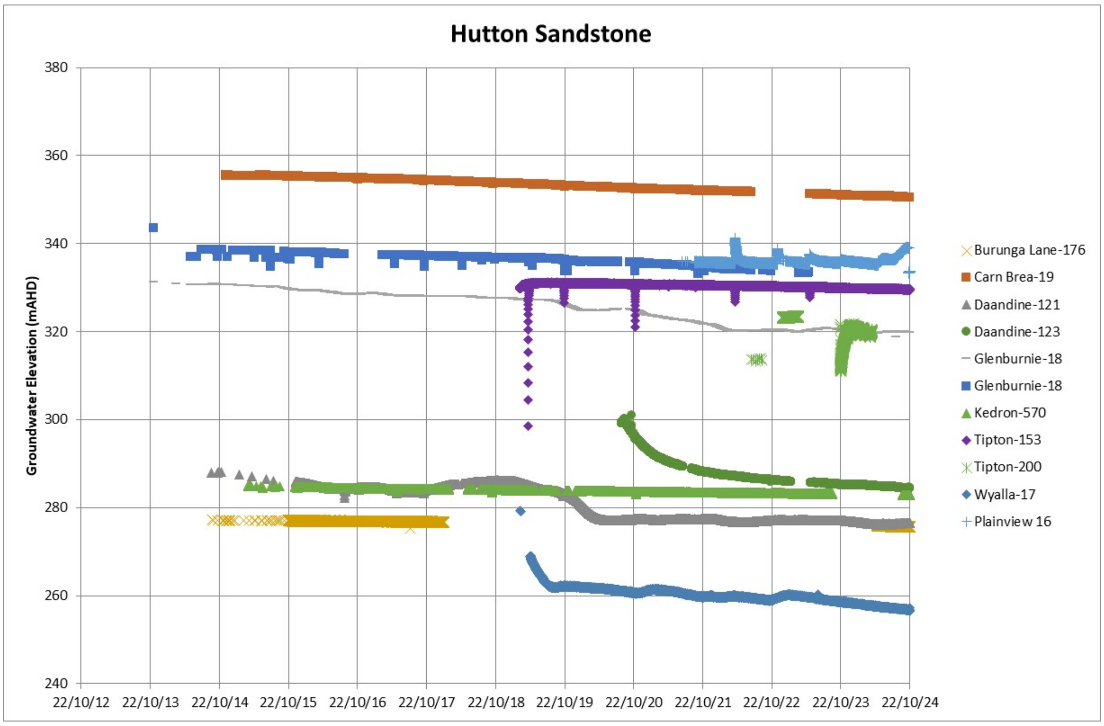


Figure 3-5: Hutton Sandstone monitoring bores hydrograph

Precipice Sandstone trend analysis

Observed groundwater pressure trends in the Precipice Sandstone monitoring bores shows a declining trend in the monitoring bores located further south within Arrow's tenure (Figure 3-6). These trends are consistent with that described in Section 5.6.2.4 of the 2021 UWIR (OGIA, 2021) where there is extensive non-CSG development (in parallel with the Moonie oil field and intensive stock use) which has resulted in regionally observed declines in groundwater pressure in the south. The 2021 UWIR indicates areas where reinjection is occurring correlates to increasing groundwater level trends. This has been confirmed by the groundwater level in Arrow's northern monitoring bore, Burunga Lane-174, which has shown an increasing trend since May 2024. The lowest rate of drawdown (0.42 m/year) and highest rate of drawdown (5.87 m/year) during this reporting period have been recorded in Wyalla-17 and Tipton-194, respectively. It should be noted that the groundwater level at Daandine-123 continued its increasing trend during this reporting period, with a rate of 2.19 m/year.

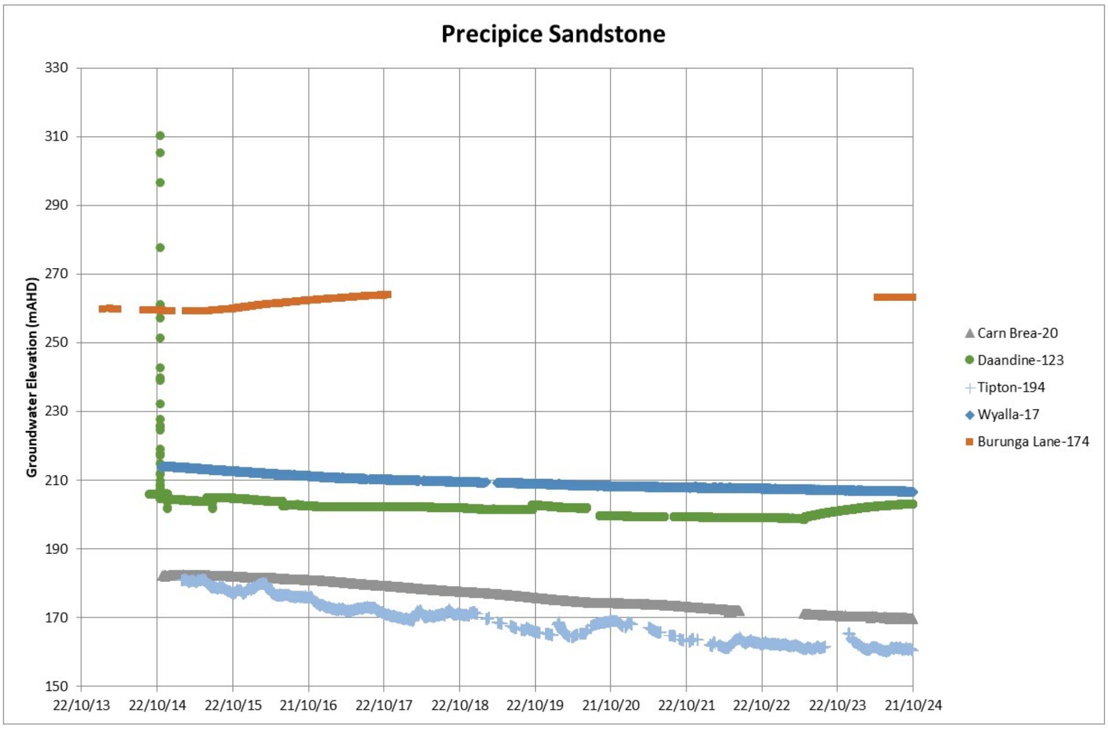


Figure 3-6: Precipice Sandstone monitoring bores hydrograph

Walloon Coal Measures trend analysis

Hydrographs for the Walloon Coal Measures (WCM) observed groundwater pressures are presented in Figure 3-7 to Figure 3-10. The WCM are the reservoir target for production of CSG. The pressure data have been split into four hydrographs since there are a large number of monitoring points and variations in observed pressure value. The hydrographs demonstrate, as predicted, the pressure responses at those locations close to CSG operations such as those monitoring points located at Daandine production field, Tipton production field and Hopeland area, while those monitoring bores further away from CSG operations display a more subdued (or no) pressure response. This relationship between observed drawdown in the WCM and distance from nearest production is consistent with that reported for the WCM across the Surat CMA in the 2019 and 2021 UWIR (OGIA 2019, 2021).

Production from SGP production wells started in April 2022. Further declines in groundwater levels at Longswamp-7 sites were observed after this date as SGP production wells are closer to this bore than other non-SGP productions wells, however these monitoring points were already showing a decline in groundwater levels due to these other non-SGP production wells.

Insignificant changes in the groundwater level of Daandine-254, installed in the lower Juandah CM (DA254_WCMa_1p), were observed during this reporting period. However, the groundwater level at Daandine-254, installed in the Upper Juandah CM (DA254_WCMm_2p), continued its increasing trend, while Daandine-254, installed in the Upper Juandah CM (DA254_WCMm_1p), continued its decreasing trend, consistent with previous years. Similarly, Daandine-134 continued its decreasing trend, also in line with previous years. At these sites (Daandine-254 and Daandine-134), CSG production is approaching maturity.

The groundwater levels at Longswamp 34 during this reporting period were consistent with previous years decreasing trend.

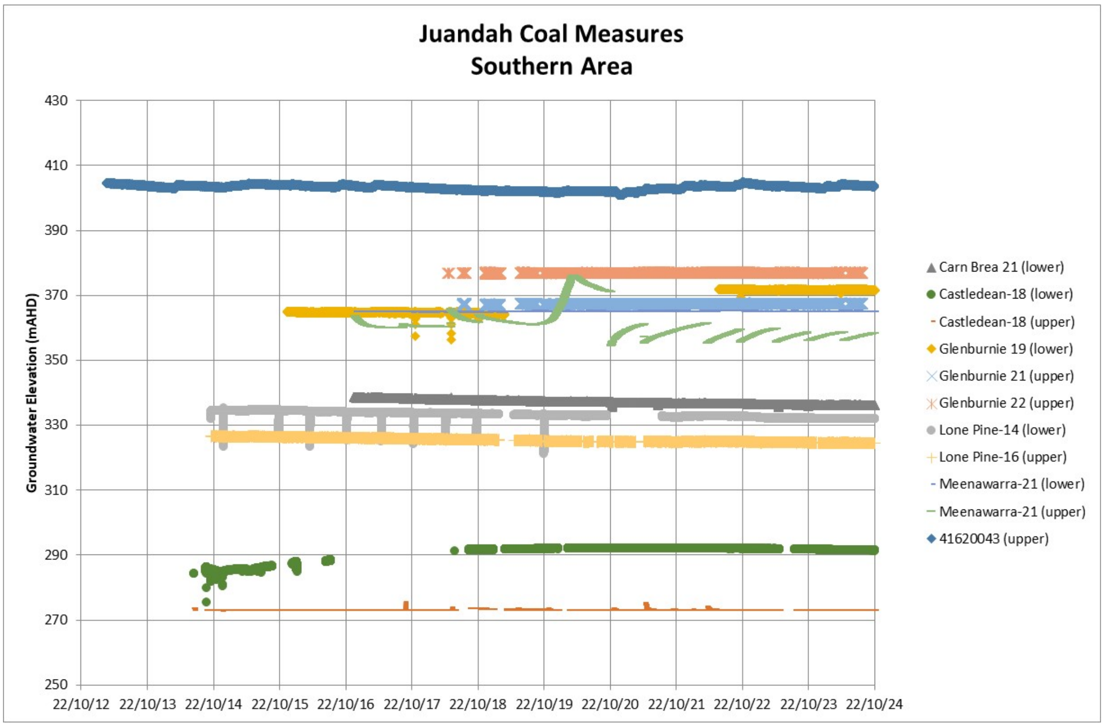


Figure 3-7: Juandah Coal Measures monitoring bores hydrograph – southern area

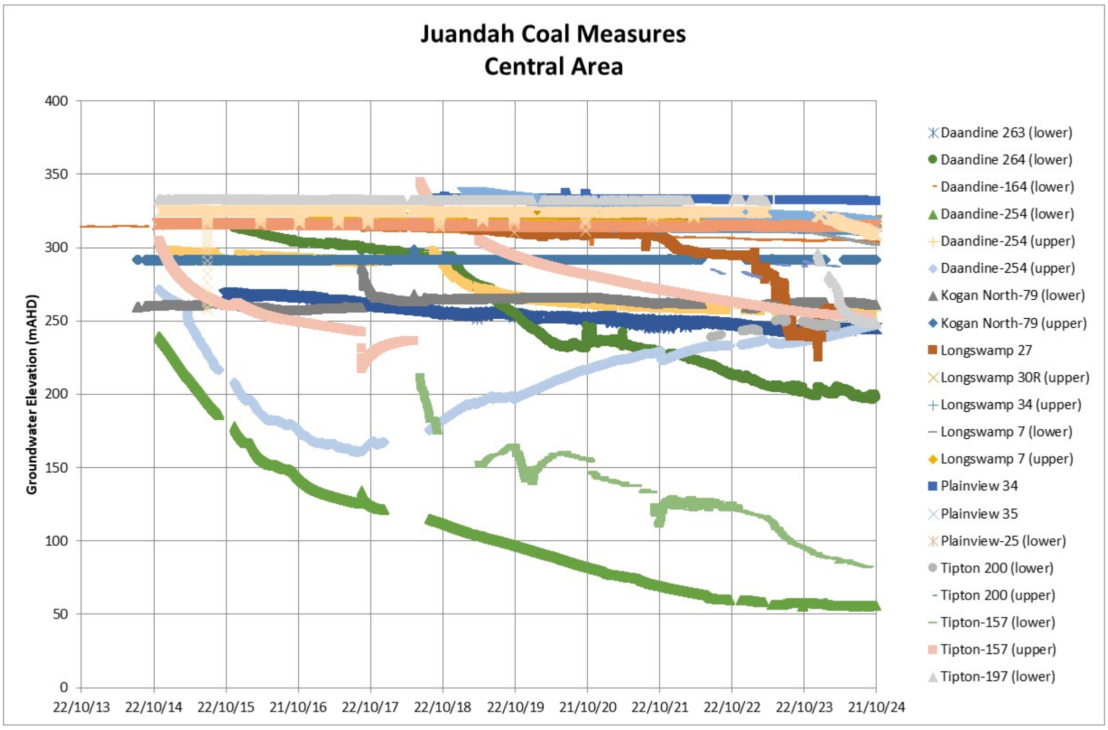


Figure 3-8: Juandah Coal Measures monitoring bores hydrograph – central area

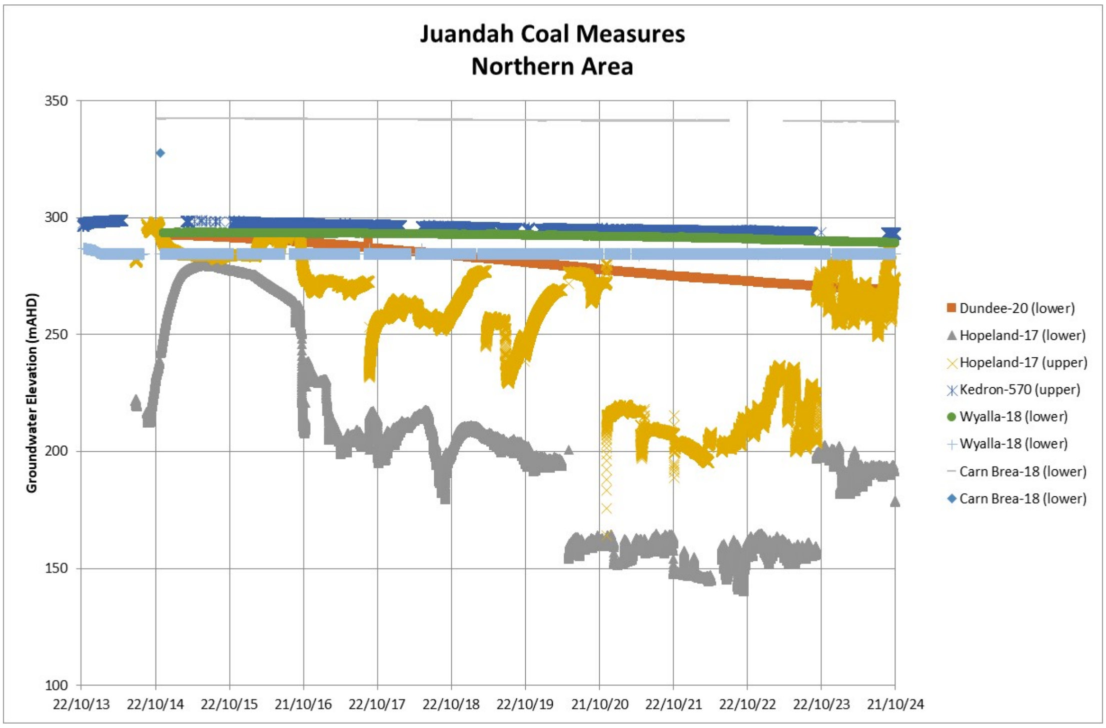


Figure 3-9: Juandah Coal Measures monitoring bores hydrograph – northern area

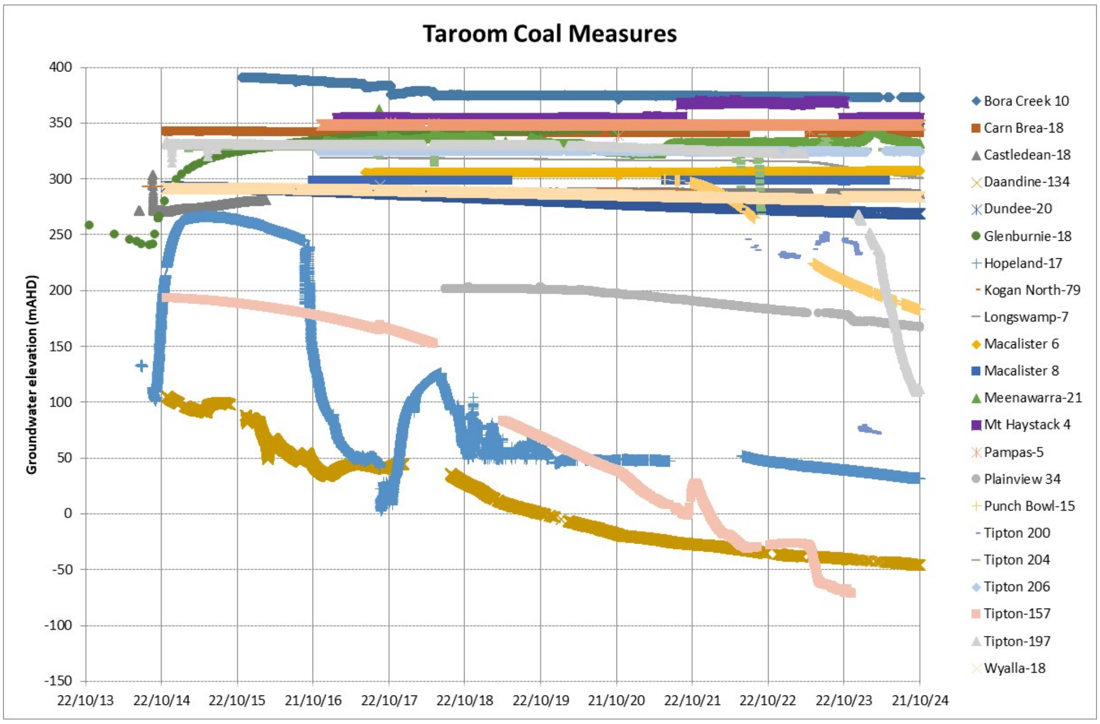


Figure 3-10: Taroom Coal Measures monitoring bores hydrograph

3.2 Groundwater quality

Data collection

Groundwater samples were collected from all operational WMMP monitoring points throughout the reporting period where land access arrangements were in place. In accordance with Section 7.3 of the SGP Updated CSG WMMP, the locations monitored and frequency of monitoring throughout the reporting period were in alignment with the current UWIR, which was the 2021 version. A summary of changes to the groundwater quality monitoring program is provided in Section 3.4 and a list of monitoring bores sampled during the reporting period is provided in Table 3. It should be noted that the 2021 UWIR specifies (Table 9-4) that sampling is no longer required from monitoring points where five samples have been collected (including one sample of dissolved strontium and strontium isotopes ($^{87}Sr/^{86}Sr$) in Springbok Sandstone, Hutton Sandstone and Precipice Sandstone monitoring points).

A summary of groundwater sampling conducted during the reporting period is provided in Table 3. The groundwater samples were analysed for the 2021 UWIR suite which is provided in Table 8 and the results are provided in Appendix B.

Table 3: 2021 UWIR groundwater chemistry monitoring points

Bore Name	OGIA MP ID	Formation	Sampling Completed During Reporting Period*
Burunga Lane-176	477	Hutton Sandstone	Not required
Carn Brea-17	39	Condamine Alluvium	Not required

Carn Brea-18	41	WCM	Not required
Carn Brea-19	45	Hutton Sandstone	Not required
Daandine-121	183	Hutton Sandstone	Not required
RN 42230209	282	Condamine Alluvium	Not required
Glenburnie-18	739	Hutton Sandstone	Not required
Plainview 36	790	Springbok Sandstone	Not required
Stratheden-63	623	Springbok Sandstone	Not required
Tipton-195	85	Condamine Alluvium	Not required
Tipton-197	89	WCM	Not required
Tipton 202	830	Springbok Sandstone	Sampled on 8/05/2024 and scheduled for sampling in April/May 2025
Wyalla-16	248	Condamine Alluvium	Not required
RN 42231370	52	Condamine Alluvium	Not required

* Refer to Table 6 and Table 7 for sampling requirements (2021 UWIR monitoring requirement).

Data analysis

The 2021 UWIR discusses the water quality parameters for each groundwater monitoring zone in terms of the 20th, 50th, and 80th percentiles. The section below discusses in detail the water quality results for the sole formation where water quality data was obtained during this annual reporting period (Springbok Sandstone) as well as a brief comparison of the hydrogeochemistry of the other formations in the form of piper diagrams to demonstrate the differences in proportions of major ions in groundwater samples.

Field parameters

Springbok Sandstone

A statistical summary of the historical field water quality parameters is provided in Table 4 for Springbok Sandstone considering 20th, 50th and 80th percentiles. These statistics were compared to those in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP), specifically the Lower GAB, Eastern Springbok Outcrop values. The purpose of the EPP is to achieve the objective of the Environmental Protection Act 1994 in relation to Queensland waters - that is, to protect Queensland's water environment whilst allowing for development that is ecologically sustainable. This is achieved through adopting or deriving local Water Quality Objectives (WQO). In deciding local water quality objectives for Queensland waters, Section 8 of the EPP (Water and Wetland Biodiversity) gives precedence to site specific studies for a water (i.e., local studies) (DES 2023).

The 3 bores monitoring this unit have 80th percentiles for EC below the 80th percentile EPP WQ objective. However, Stratheden-63 and Tipton 202 have higher 20th and 50th percentiles than the EPP objectives. The pH measured at the 3 bores is higher than the EPP objectives for the 20th, 50th and 80th percentile. It should be noted that the pH measured at Tipton 202 has likely been affected by cement grout ingress to the gravel pack within the wellbore. Therefore, the pH values measured at Tipton 202 were not included in the calculation of pH percentiles for all bores.

Table 4: Summary field water quality percentiles for Springbok Sandstone

Parameter		Plainview 36	Stratheden -63	Tipton 202	All bores	EPP WQ objective
EC (µS/cm)	Count	6	9	4	19	
	20 per*	1299.00	3865.80	4559.20	1366.40	1420.0
	50 per	1326.00	4121.00	5257.00	3986.50	3175.00
	80 per	1406.00	4461.00	6848.80	4581.00	9480.00
pH	Count	6	9	4	19	
	20 per	8.16	8.92	11.68	8.29	7.50
	50 per	8.20	9.30	12.01	9.27	8.00
	80 per	8.32	9.79	12.42	11.03	8.40
REDOX (mV)	Count	6	9	4	19	
	20 per	-118.50	-237.54	-180.02	-219.94	NA
	50 per	-64.75	-212.40	-135.75	-142.60	NA
	80 per	43.30	-181.64	-67.28	-15.98	NA
TEMP (°C)	Count	6	9	4	19	
	20 per	22.20	22.18	22.16	22.16	NA
	50 per	24.25	26.20	22.60	24.20	NA
	80 per	28.00	30.50	23.48	28.68	NA

* per = percentile

Tipton 202 elevated pH values

Tipton 202 was drilled to monitor groundwater level and quality in the Springbok Sandstone. The lithological log records the bore intersected Condamine Alluvium to 22.9 mbgl, before continuing to TD of 137m in the underlying Springbok Sandstone.

Elevated pH, ranging from 11.37 to 12.85, has been recorded only in four samples collected to date from Tipton 202. Additionally, Hydroxide Alkalinity as $CaCO_3$, has also been reported in Tipton 202, ranging from 27 to 1570 mg/L. High pH values and the presence of Hydroxide Alkalinity are both indicators of cement grout influencing the groundwater hydrochemistry within the borehole. It is likely that cement grout has breached the bentonite seal and percolated into the gravel pack within the annulus. Bore construction details indicate there is approximately 95 m of grout vertically separating the base of the alluvium from the top of the bentonite seal. Groundwater electrical conductivity, as EC in samples from this bore, ranges from 2,093 to 7,910 µS/cm.

The Queensland Department of Regional Development, Manufacturing and Water (RDMW) has a monitoring bore RN 42231280 drilled and completed in the Condamine alluvium, located approximately 2,600 m to the east of Tipton 202. A total of 12 groundwater samples have been collected and analysed from this bore, with the reported electrical conductivity as EC ranging from 655 to 976 µS/cm. As the groundwater electrical conductivity measured in Springbok Sandstone at Tipton 202 is much higher (EC 2,093 to 7,910 µS/cm) than the electrical conductivity in the Condamine Alluvium, it is likely the Springbok Sandstone has been effectively isolated from the overlying Condamine Alluvium in Tipton 202. Therefore, other data collected from Tipton 202 are considered representative and fit for purpose.

EC data (laboratory data and field measurements where no laboratory data is available) collected to date is shown in Figure 3-11. The data show EC levels in the monitoring bores are generally stable with a decreasing trend in Tipton 202.

The collected pH data are presented in Figure 3-12, showing that pH levels in the monitoring bores are generally stable with a declining trend in Tipton 202.

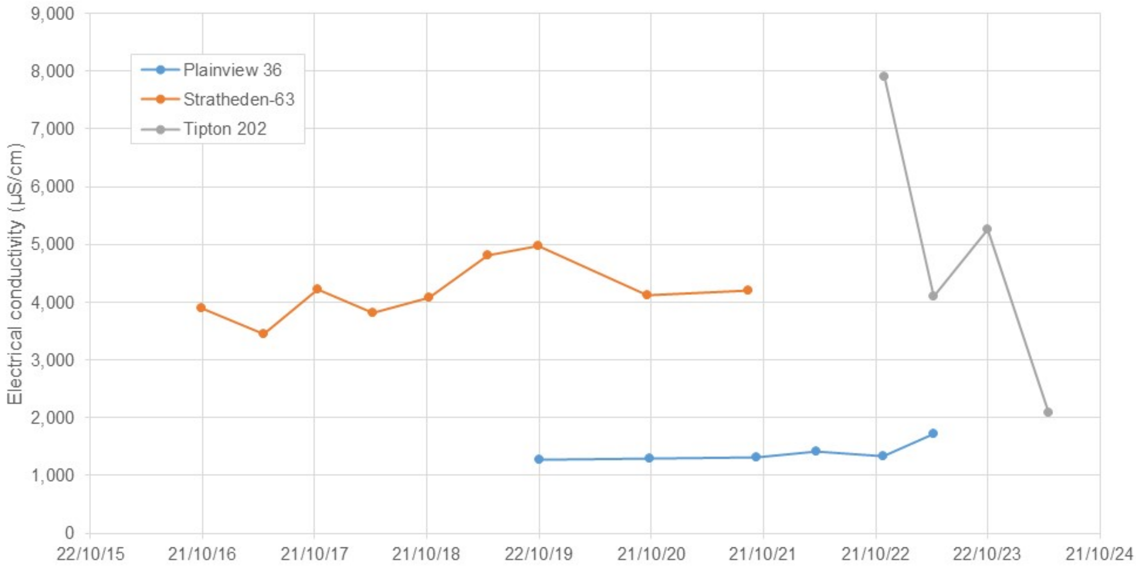


Figure 3-11: Springbok Sandstone electrical conductivity

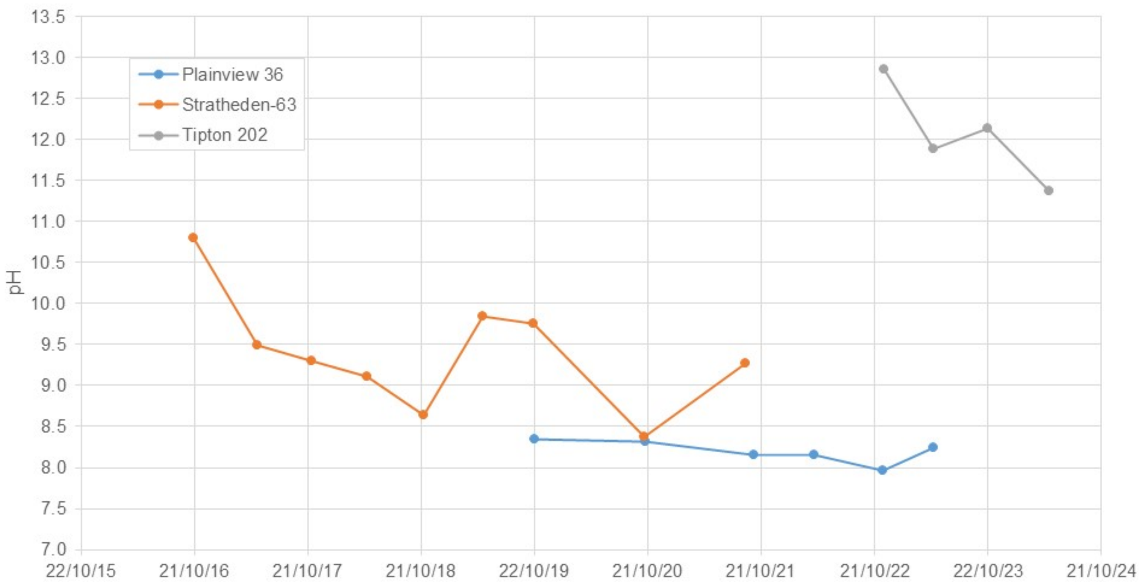


Figure 3-12: Springbok Sandstone pH

Metals, major ions and other key analytes

In the analysis of the water quality results, the Queensland Department of Environment, Science, and Innovation (DESI, 2021) recommends a minimum of eight samples at each site be used in the comparison of water quality. In this report, historical samples from bores have also been combined to statistically analyse the results into 20th, 50th and 80th percentiles. A comparison of the water quality results for the Springbok Sandstone (the sole formation sampled this reporting period) for analytes listed in the 2021 UWIR along with the relevant water quality guideline values are shown in Appendix B.

Springbok Sandstone

Water quality data was collected from three bores—Plainview 36, Strathedan-63, and Tipton 202—screened in Springbok Sandstone. The water quality results and statistical summary for Springbok Sandstone are presented in Appendix B. Results indicate that concentrations of calcium at 20th, 50th, and 80th percentiles, zinc at the 80th percentile, and chloride, magnesium, and sodium at the 20th percentile exceeded the 95% aquatic ecosystem protection values (ANZG, 2018) outlined in Appendix B. Additionally, chloride concentrations at the 20th percentile, sodium concentrations at the 20th percentile, and Total Dissolved Solids (TDS) at 20th, 50th, and 80th percentiles exceeded the drinking water guidelines.

Key time series plots were developed for analytes that exceeded the guideline criteria in samples collected from Stratheden-63, Plainview 36, and Tipton 202. It is important to note that no samples have been required from Stratheden-63 since 2021, and from Plainview 36 since 2023. A single sample was collected from Tipton 202 during this reporting period, with the next round of sampling scheduled for April/May 2025. Figure 3-13 presents calcium concentration in samples collected from Plainview 36, Stratheden-63, and Tipton 202. The concentration of calcium at Stratheden-63 fluctuated between 36 and 171 mg/L. Notably, the last two samples from this bore indicate that its concentration has relatively stabilised. The concentration of calcium in a single sample collected from Tipton 202 during this reporting period is lower than that of the samples taken in the previous period. Tipton 202’s calcium concentrations display a generally decreasing trend over time, consistent with its pH and electrical conductivity (refer to Figure 3-11 and Figure 3-12). The concentration of calcium at Plainview-36 remained relatively constant, with minimal fluctuations over time. Figure 3-14 displays chloride concentrations in samples collected from Plainview 36, Stratheden-63, and Tipton 202. The concentration of chloride at Stratheden-63 (>1,000 mg/L) were significantly higher than that at Plainview-36 (around 200 mg/L) and Tipton 202 (<500 mg/L). It should be noted that the concentration of chloride at Plainview-36 exhibited minimal fluctuations, remaining around 200 mg/L. The chloride concentration in a single sample collected from Tipton 202 during this reporting period (500 mg/L) is consistent with the value observed in the previous reporting period (480 mg/L). Figure 3-15 illustrates magnesium concentrations in samples collected from Plainview 36, Stratheden-63, and Tipton 202. At Stratheden-63, magnesium concentrations fluctuated between 1 and 15 mg/L from 22/10/2016 to 1/09/2021. Specifically, the concentration increased from 1 to 15 mg/L between 22/10/2016 and 9/05/2019, and then decreased from 15 mg/L to 8 mg/L between 9/05/2019 and 1/09/2021. In contrast, magnesium concentrations at Plainview-36 remained constant at 4 mg/L across all samples. The concentration of magnesium in a single sample collected from Tipton 202 during this reporting period was below the laboratory's limit of reporting (LOR = 1 mg/L), consistent with historical records.

The concentration of sodium in samples collected from Plainview 36, Stratheden-63, and Tipton 202 is presented in Figure 3-16. Similar to chloride, sodium concentrations are significantly higher at Stratheden-63 (>600 mg/L) compared to Plainview-36 (around 300 mg/L) and Tipton 202 (average 340 mg/L). Notably, sodium concentrations at Plainview-36 (ranging from 253 to 336 mg/L) fluctuated within a narrow range, similar to the fluctuations observed at Tipton 202 (ranging from 318 to 357 mg/L).

Figure 3-17 displays TDS in samples collected from Plainview 36, Stratheden-63, and Tipton 202. At Stratheden-63, TDS followed a pattern similar to that of calcium, chloride, and sodium. TDS values at Plainview 36 fluctuated minimally, ranging from 725 to 807 mg/L. Similarly, TDS values at Tipton 202 show a declining trend over time, consistent with the observed decrease in its calcium concentrations.

It can be observed from water quality time series plots that all peak concentrations at Stratheden-63 occurred in 2019.

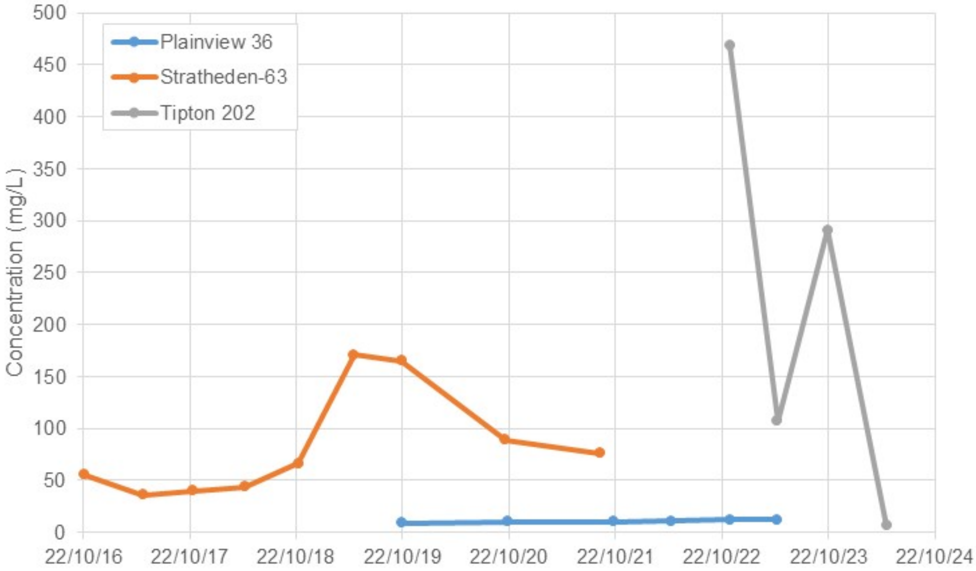


Figure 3-13: Springbok Sandstone: Calcium

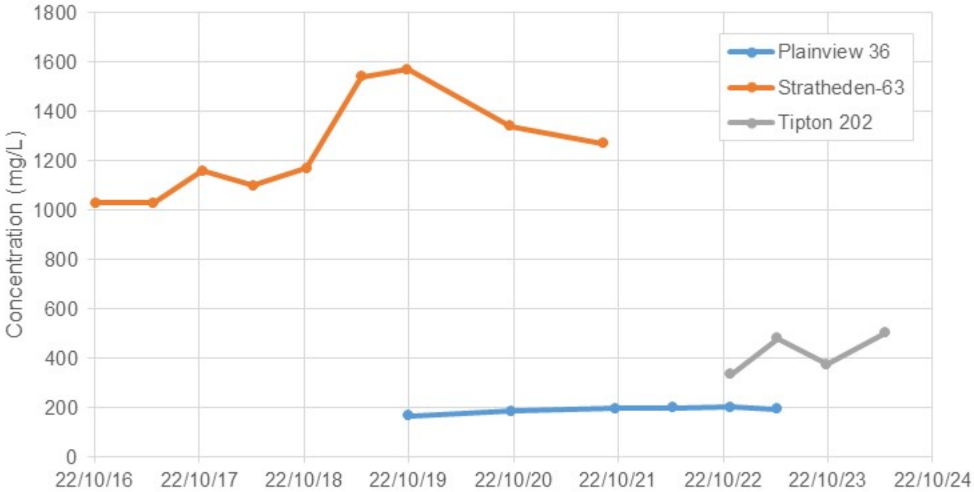


Figure 3-14: Springbok Sandstone: Chloride

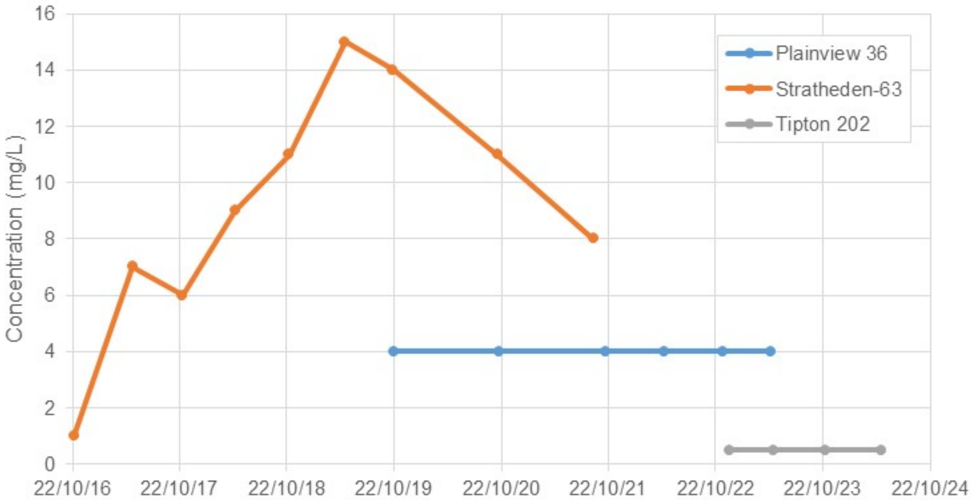


Figure 3-15: Springbok Sandstone: Magnesium

arrow energy go further

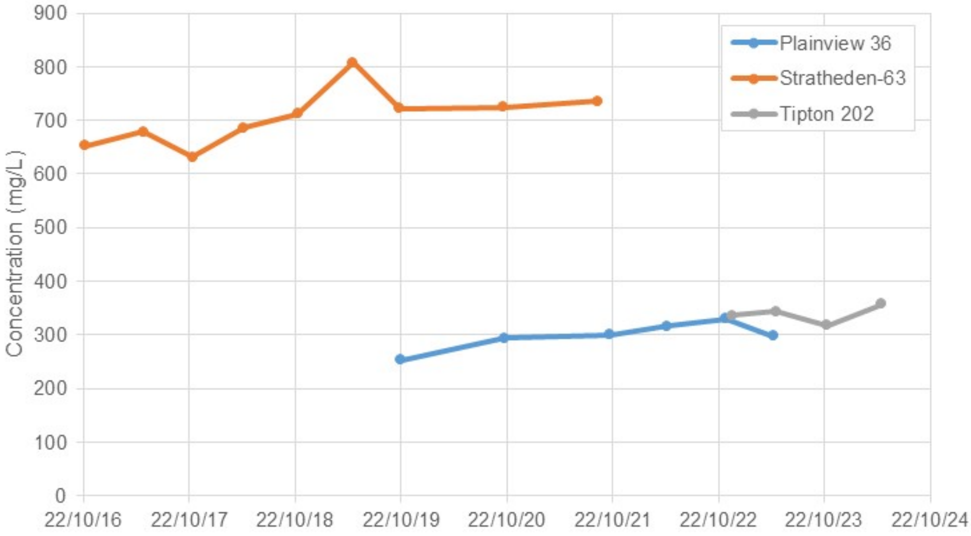


Figure 3-16: Springbok Sandstone: Sodium

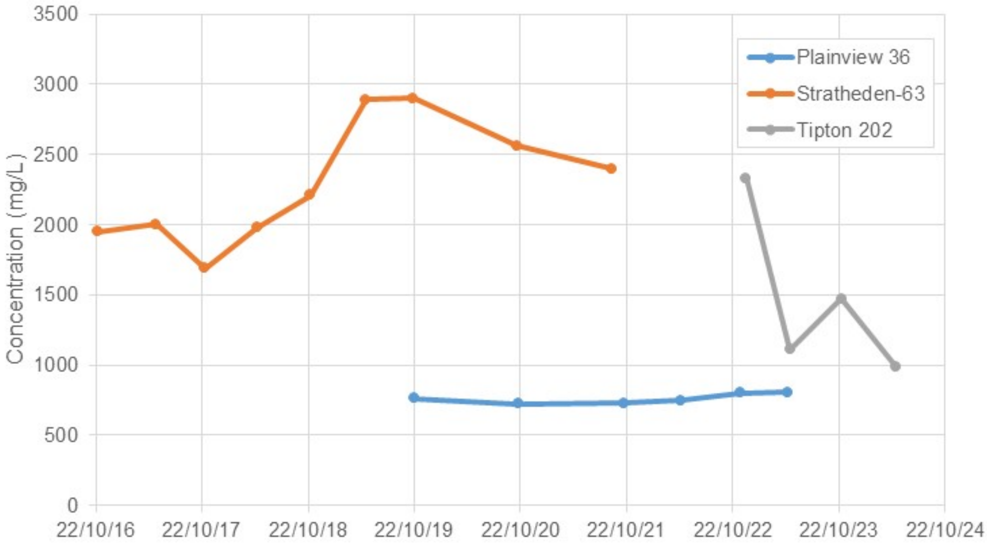


Figure 3-17: Springbok Sandstone: TDS

Chemical composition

The chemical composition of samples collected since 2017 from each of the geological formations is presented in Figure 3-18 to Figure 3-23 as piper diagrams to highlight the similarities and differences in the proportions of major ions in groundwater from the various formations.

No major ion data was required to be collected for Condamine Alluvium during this annual reporting period. The Condamine Alluvium piper diagram (Figure 3-18) shows all bores except for Carn Brea-17 are predominantly sodium-chloride type water with carbonate-bicarbonate contributions and a magnesium and calcium contribution in Tipton-195. The chemical composition of samples collected from Carn Brea-17 indicates it is a magnesium-bicarbonate type water.

There is either no trend or a clustered recurring trend in chemical composition evident in all bores except for Wyalla-16 which shows a steady increasing carbonate-bicarbonate contribution.

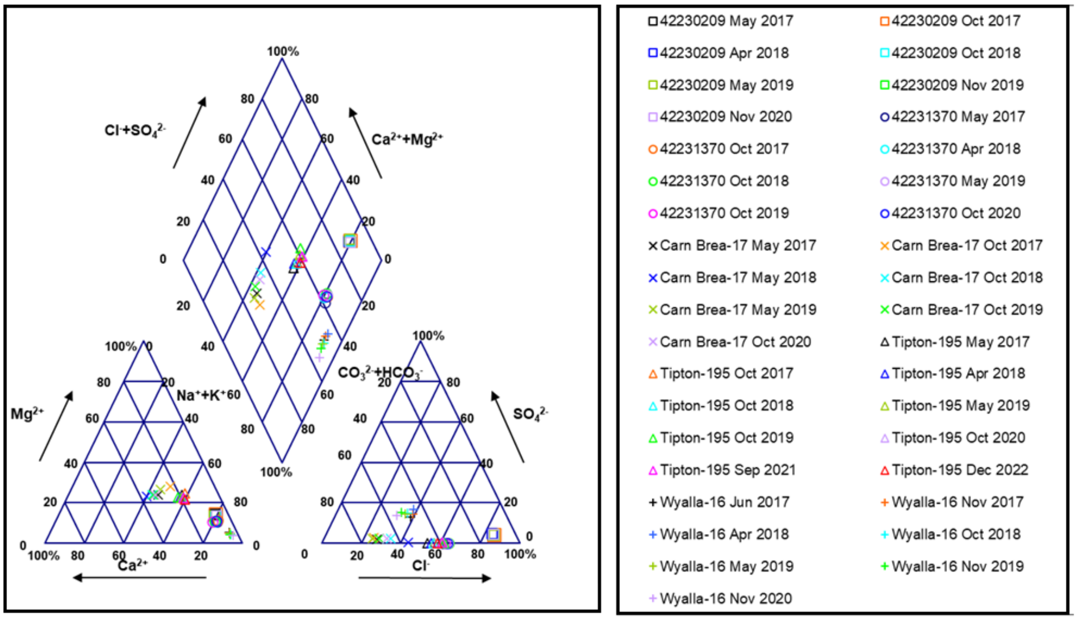


Figure 3-18: Condamine Alluvium Piper Diagram

No major ion data was required to be collected for the Westbourne Formation monitoring point (Daandine-124) (Figure 3-19) during this annual reporting period. Data previously collected shows it is sodium-chloride type water with no trend in chemical composition evident over time.

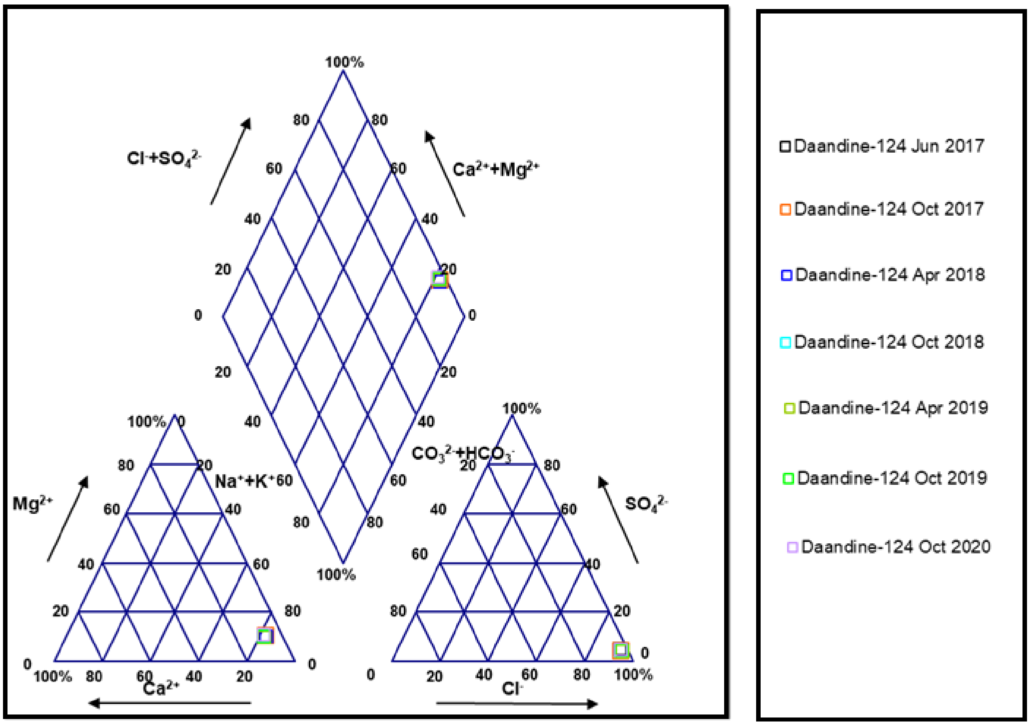


Figure 3-19: Westbourne Formation Piper Diagram

The major ion data for the Springbok Sandstone monitoring point Stratheden-63 (Figure 3-20) show it is sodium-chloride type water and there is a recurring trend in the calcium to sodium ratio evident over time. The chemical composition of Plainview 36 shows it is sodium-bicarbonate type water and there is no trend in the data. Samples from this monitored formation at Plainview 36 during different sampling events had a similar chemical composition. Three samples were collected from Tipton 202 during the previous reporting period and one sample during this reporting period. These samples show that the groundwater was initially calcium, magnesium-chloride type water then plots as sodium-chloride type water. As discussed earlier in this report, groundwater at Tipton 202 is likely influenced by cement grout ingress to the gravel pack, which may explain the differences in major ion composition observed in samples collected from this bore relative to other samples from the Springbok Sandstone.

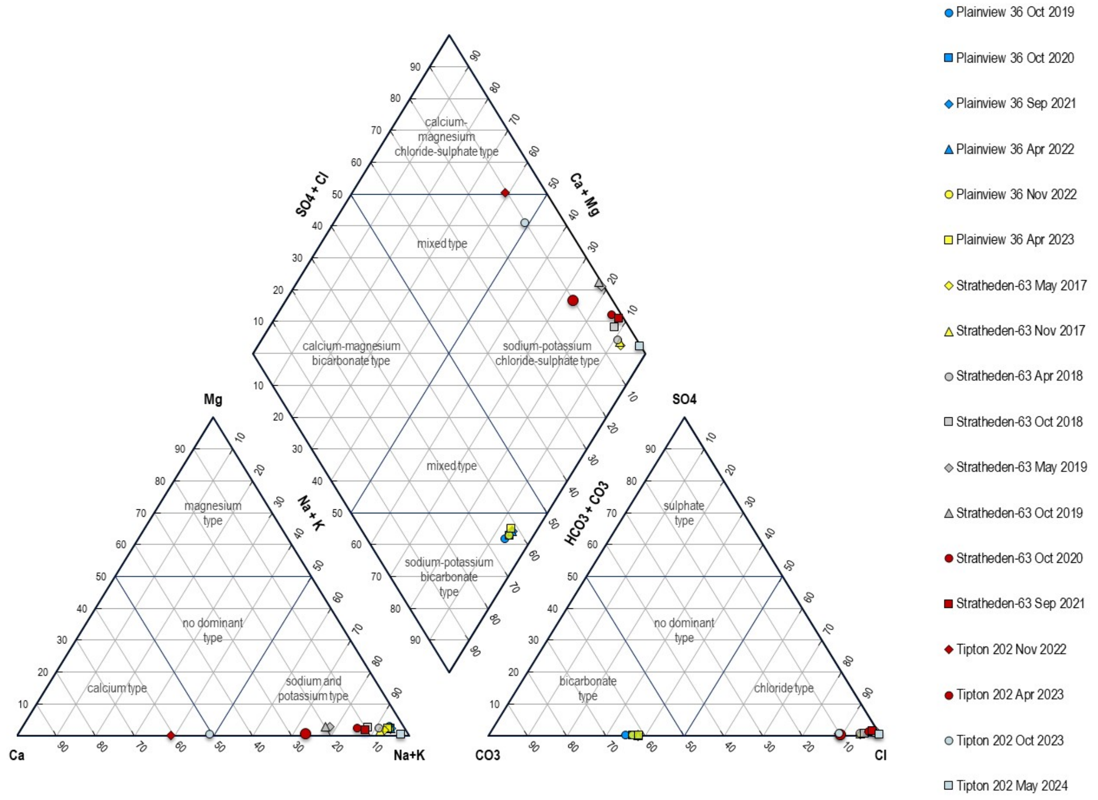


Figure 3-20: Springbok Sandstone Piper Diagram

No major ion data was required to be collected for the WCM monitoring points (Figure 3-21) during this annual reporting period. Data previously collected shows Tipton-197 is sodium-chloride type water with a carbonate-bicarbonate contribution, and Carn Brea-18 is a sodium-bicarbonate type water. There is no trend evident in chemical composition in Tipton-197 while Carn Brea-18 is displaying a steady increasing carbonate-bicarbonate and decreasing chloride contributions over time.

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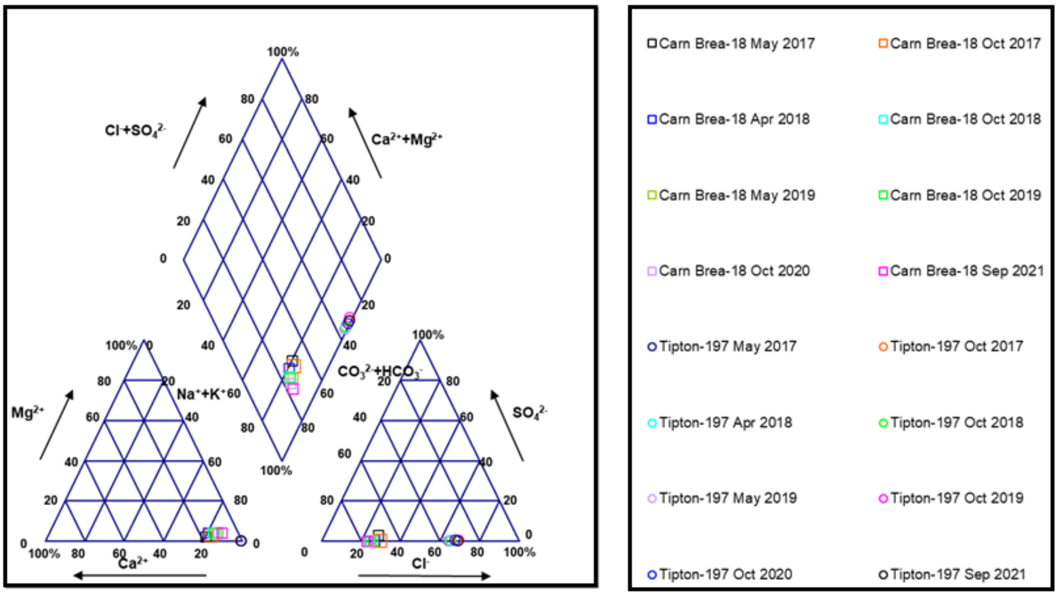


Figure 3-21: WCM Piper Diagram

No major ion data was required to be collected for the Hutton Sandstone monitoring points (Figure 3-22) during this annual reporting period. Data previously collected show the Hutton comprises sodium-bicarbonate type water. There is a recurring trend in the calcium to sodium ratio evident over time in Carn Brea-19, and a recurring trend in the bicarbonate to chloride ratio evident over time in Daandine-121.

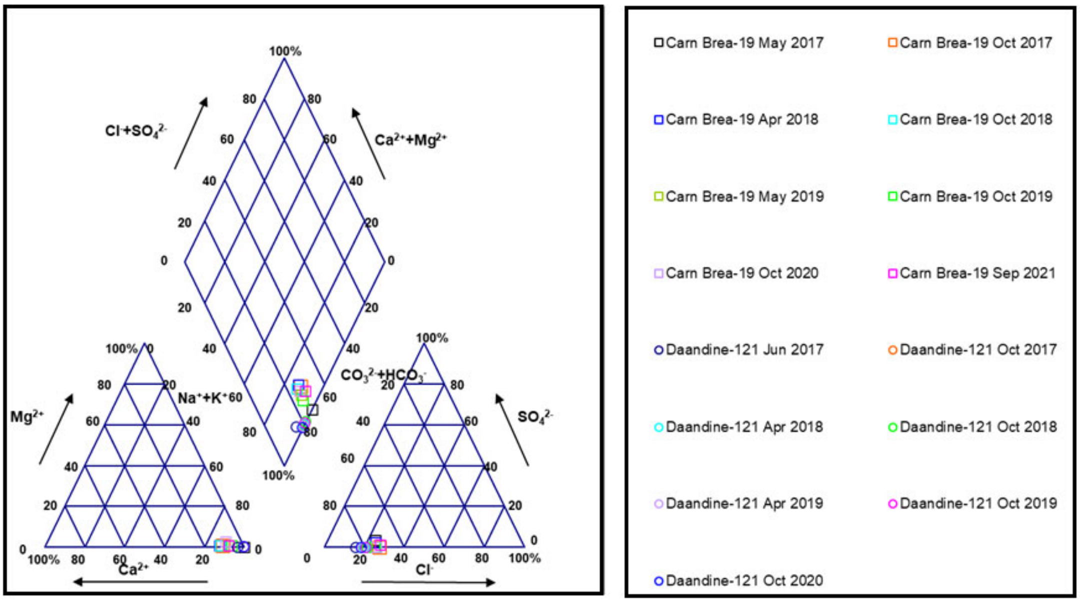


Figure 3-22: Hutton Sandstone Piper Diagram

arrow energy go further

No major ion data was required to be collected for the Precipice Sandstone monitoring points (Figure 3-23) during this annual reporting period. Data previously collected show Wyalla-17 is sodium-chloride type water with a carbonate-bicarbonate contribution, and Carn Brea-20 is a sodium-bicarbonate type water. There is no trend evident in chemical composition in Wyalla-17 while Carn Brea-20 is displaying a slight but steady increasing chloride contribution over time.

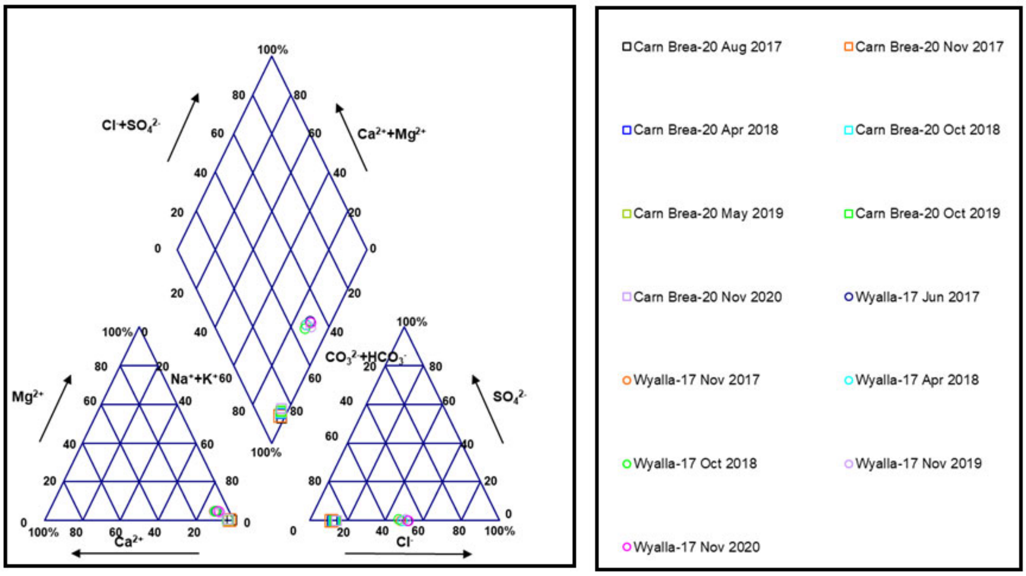


Figure 3-23: Precipice Sandstone Piper Diagram

Trend analysis

The Mann-Kendall trend analysis is a method used to assess whether concentrations of monitored water quality parameters are increasing or decreasing, provided there are at least four data points. The trend analysis for the Springbok Sandstone, Westbourne Formation, Hutton Sandstone, Precipice Sandstone, and Condamine Alluvium is detailed in the previous annual report.

Water quality samples were only collected within the Springbok Sandstone (Tipton 202) during the current annual reporting period (see Table 3). Therefore, trend analysis is conducted solely for this bore. A total of four samples were collected for Tipton 202, including the sample from the current reporting period, which meets the minimum requirement of samples needed to perform a Mann-Kendall trend analysis.

The Mann-Kendall statistic and trend for Tipton 202 are summarized in Table 5. It is observed that for field parameters such as dissolved oxygen (FIELD DISS OX), electrical conductivity (FIELD EC), and pH, the Mann-Kendall trend remains stable. However, for field REDOX, the trend is decreasing. It is important to note that additional data is required to determine a Mann-Kendall trend for field temperature (FIELD TEMP). Similarly, the trend for dissolved major cations (Magnesium, Sodium, and Potassium) remains stable, while for Chloride, the major anion, the trend is increasing. Additional data is needed to establish a

Mann-Kendall trend for Calcium. A stable Mann-Kendall trend was calculated for Carbonate Alkalinity. However, additional data is needed to determine trends for Bicarbonate Alkalinity and Total Alkalinity. Similarly, a stable trend was calculated for Fluoride, while additional data is needed to determine the trend for Sulfate. Mann-Kendall trend analysis shows an increasing trend for dissolved Strontium, while additional data is needed to calculate the trend for dissolved Barium.

Table 5: The Mann-Kendall statistic and trend calculated for Tipton 202

Analyte	Mann-Kendall Trend	No. of data points	Mann-Kendall Statistic (S)
FIELD DISS OX	Stable	4	-2
FIELD EC	Stable	4	-4
FIELD PH	Stable	4	-4
FIELD REDOX	Decreasing Trend	4	-6
FIELD TEMP	More Data Needed	4	2
Calcium	More Data Needed	4	2
Magnesium	Stable	4	0
Sodium	Stable	4	0
Potassium	Stable	4	1
Chloride	Increasing Trend	4	-1
Carbonate Alkalinity	Stable	4	-1
Bicarbonate Alkalinity	More Data Needed	4	0
Total Alkalinity	More Data Needed	4	1
Sulfate	More Data Needed	4	1
Fluoride	Stable	4	1
Dissolved Barium	More Data Needed	4	1
Dissolved Strontium	Increasing Trend	4	1

3.3 Ground movement monitoring

Coal seam gas occurs within coal formations through adsorption to the surface of the coal under hydrostatic pressure. Depressurisation of the coal seams below a threshold by groundwater extraction reduces hydrostatic pressure and liberates the gas from the formation. As the pressure falls, the gas migrates to the extraction wells. This process requires substantial lowering of groundwater pressure.

At any point below the ground surface, the weight of overlying strata is supported partly by water pressure and partly by the fabric of the rock mass. Any reduction in water pressure therefore results in an increased proportion of the load being carried by the rock mass, leading to compression of the rock. This is known as an increase in effective stress. The combined compression over the thickness of rock strata affected by reduced water pressure will result in some compaction of the coal seams and may cause overlying formations to subside, resulting in some subsidence at the ground surface.

The development of a CSG field, where the effect of depressurisation of individual wells interact with each other over time, results in relatively uniform depressurisation within a field and a depressurisation surface which gradually decreases away from the CSG field. Any CSG induced ground surface movement is normally expected to be regionally consistent and, with the magnitudes predicted, unobtrusive in terms of environmental and land use impacts. However, monitoring systems have been established to distinguish any significant ground surface movement as a result of CSG operations from natural ground surface changes, such as attrition and climatic induced soil swelling and depletion.

OGIA has previously developed a 3D numerical model coupling geomechanics to groundwater depressurisation, predicting magnitude of subsidence and change in slope as a result of CSG operations in the area of the Condamine Alluvium, and developed an analytical model predicting magnitude of subsidence in the greater Surat Basin, as reported in the 2021 UWIR (OGIA, 2021).

The 3D numerical geomechanical model was built incorporating all available data on local geomechanical properties and lithological distribution, with predicted depressurisation from the OGIA groundwater model used as an input to make predictions of subsidence. A model grid ranging from 250 by 250m to 750 by 750m with 88 vertical layers was used to account for variations in lithology, and OGIA generated a set of 1,000 models from stochastic realisations of geomechanical properties to explore the range of uncertainty in predictions. History matching these models to the available Interferometric Synthetic Aperture Radar (InSAR) data in the vicinity of the Condamine Alluvium allowed the 50 best fitting models to be selected to generate predictions of subsidence. Predicted subsidence and change in slope are therefore reported statistically in the 2021 UWIR as a median (P50) prediction derived from those 50 model runs. Predicted subsidence from the 2021 UWIR, including predicted temporal development of subsidence at specific locations, is presented in Figure 3-24:, with predicted maximum changes in slope within the cropping areas of the Condamine River floodplain at any time during CSG field development presented in Figure 3-25.

OGIA processed outputs from the uncertainty analysis to derive probability of magnitudes of subsidence and slope occurring at each model cell. This is presented as maps of the probability of 0.001% (0.01m in 1km) and 0.005% (0.05m in 1km) slope change, together with probability of 100mm and 150mm magnitude subsidence occurring within the cropping areas of the Condamine River floodplain, in Figure 3-26. The Horrane Fault is a large north-south trending fault zone east of Cecil Plains, with displacement of up to approximately 100m. Displacement of the fault and the low permeability of the fault core can result in differential depressurisation patterns either side of the fault, resulting in the greatest predicted change in slope across the Horrane Fault.

During the previous reporting period, OGIA published a report on coal shrinkage (Aghighi, H, et. al. 2023). Coal shrinkage is the reduction in coal volume due to the extraction of gas. Coal shrinkage contributes to the total subsidence observed at the surface and is implicitly represented in OGIAs prediction model (Aghighi, H, et. al. 2023, p21).

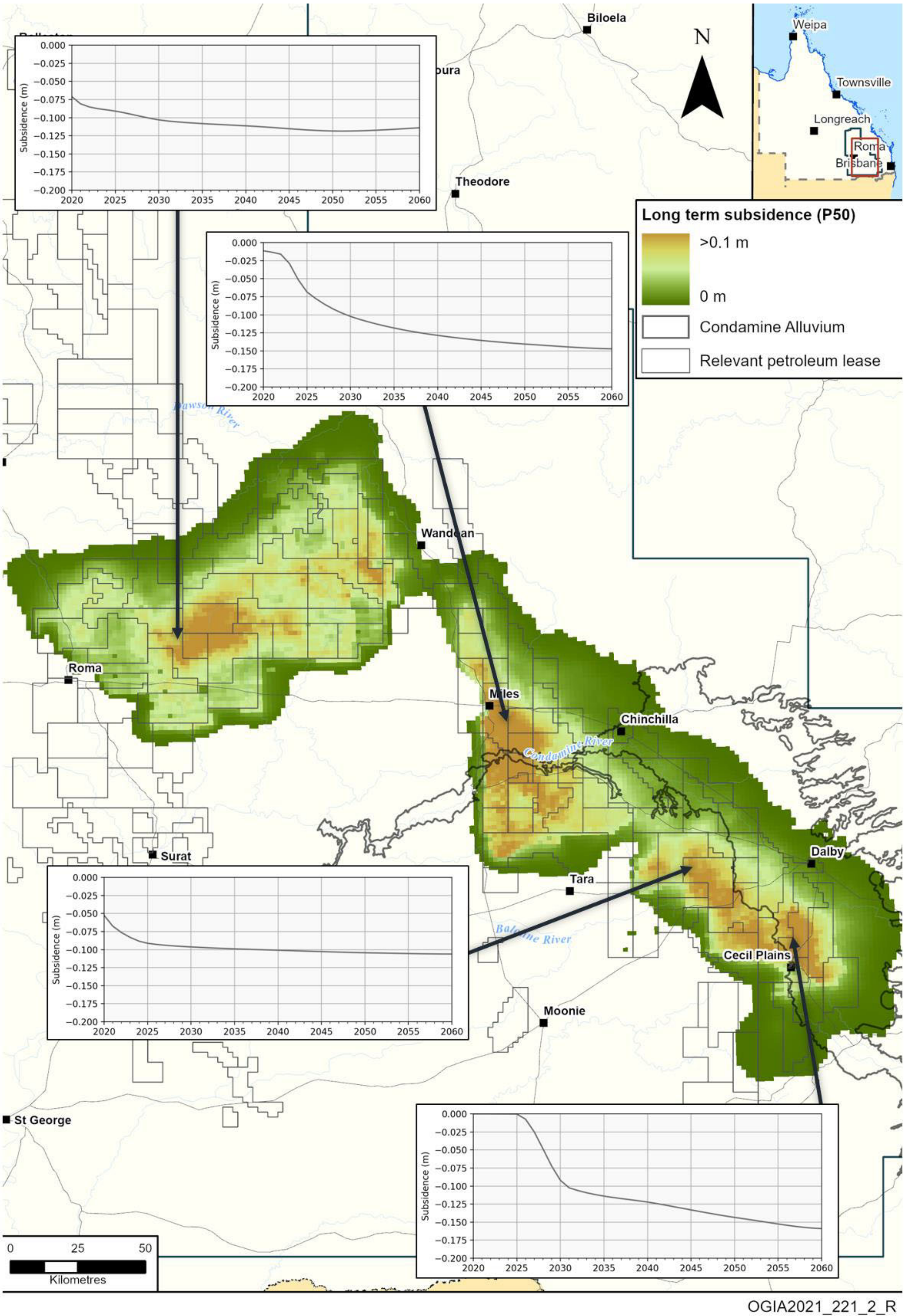


Figure 3-24: 2021 UWIR predicted long-term CSG-induced subsidence across the Surat Basin (after OGIA, 2021)

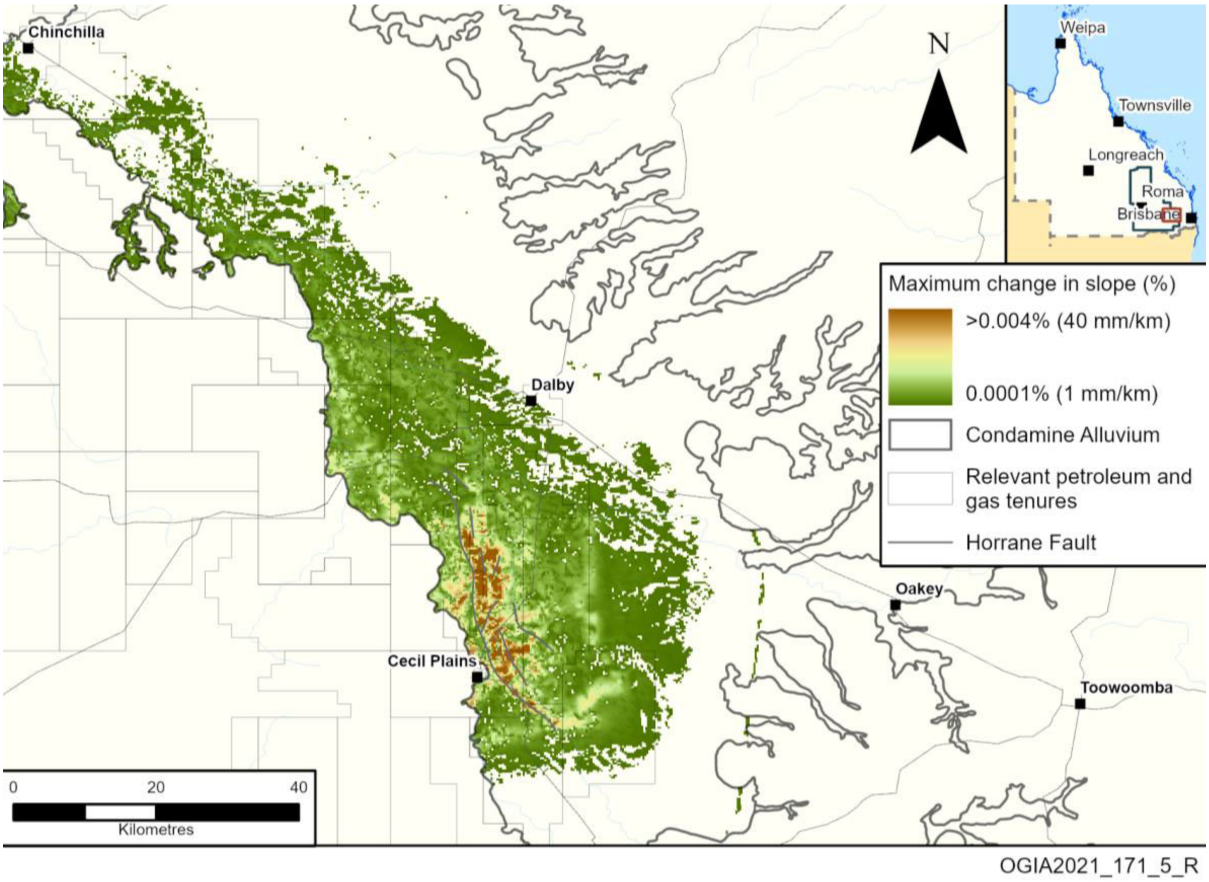


Figure 3-25: Predicted maximum change in ground slope from CSG-induced subsidence within the Condamine Alluvium area (after OGIA, 2021)

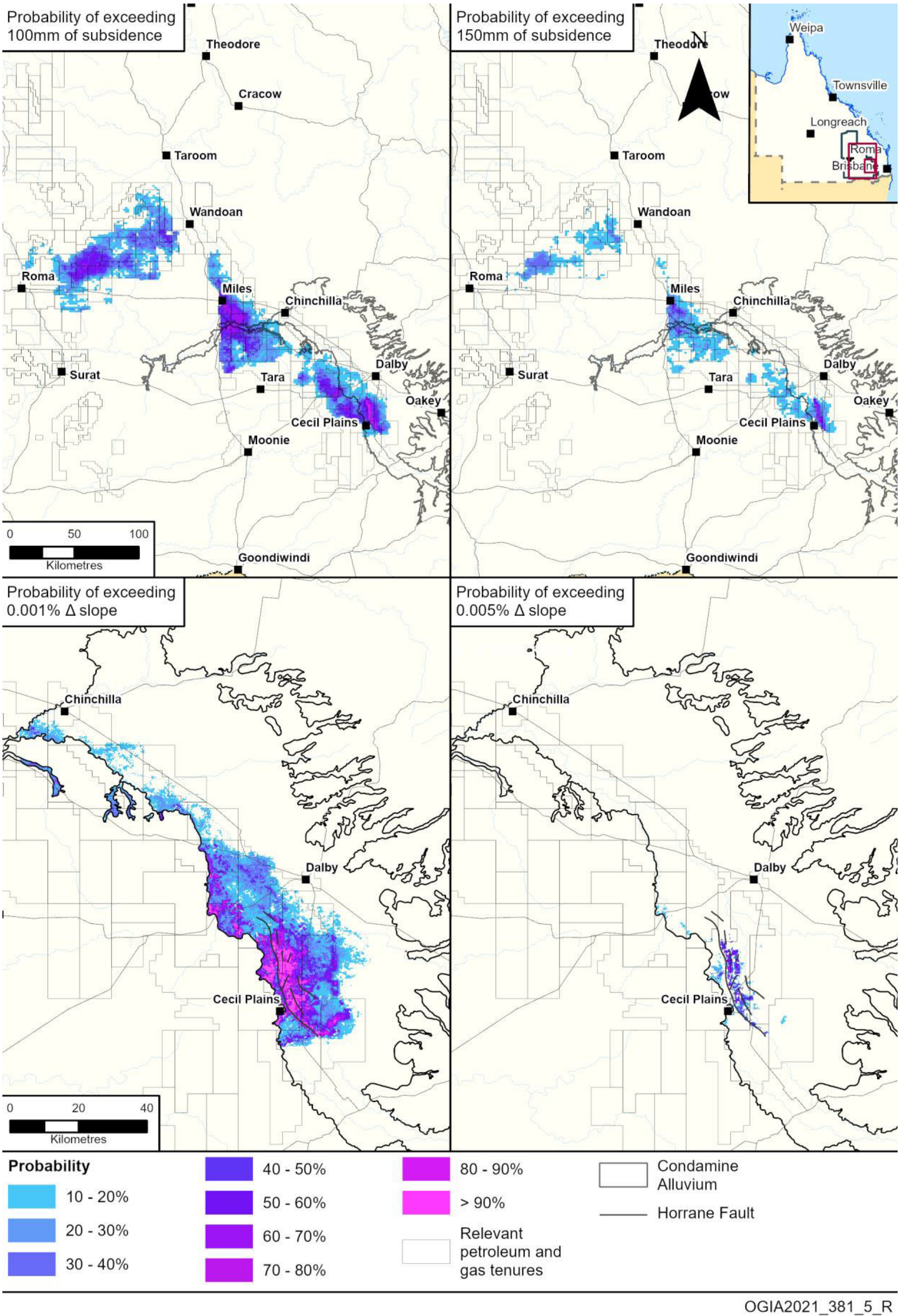


Figure 3-26: Probabilities of predicted subsidence and resulting change in slope within the Condamine Alluvium area (after OGIA, 2021)

Data collection

Monitoring of subsidence was carried out by Altamira using satellite borne InSAR, a radar technique used in geodesy and remote sensing (Altamira, 2016), which provides change in ground elevation over time.

Arrow has acquired InSAR data since 2006, with the most recent satellite system (Sentinel) providing data since 2015. The Sentinel satellite system passes every 12 days (every 6 days since 2017) providing high frequency ground motion monitoring, with a vertical resolution to approximately 1mm.

The InSAR data provides a baseline from which future data can be assessed to determine changes in vertical ground elevation, and also provides a snapshot of current vertical ground movement.

Geotechnical ground movement monitoring points have also been installed to provide a ground-truthing check of the InSAR data. These points are instrumented with Global Navigation Satellite System (GNSS) Continually Operating Reference Stations (CORS), and provide millimetric accuracy of changes in vertical elevation.

Periodic surveys using Light Detection And Ranging (LiDAR), a remote-sensing technique using airborne laser scanning systems, have been undertaken to provide snapshots of relative elevation of the land and derived slopes at moment of capture. These surveys, which provide for accurate assessment of slopes at property and regional scale, have been acquired for Arrow in 2012, 2014, 2020, 2021, 2022, 2023 and 2024. The LiDAR data provides a temporal baseline from which future data can be assessed to determine changes in slope.

These monitoring methods detect changes in the ground surface from all potential causes, not just CSG induced subsidence.

Data analysis

Following the baseline InSAR survey for the period 2006 to 2015, and reported in the Stage 1 WMMP, Tre-Altamira was commissioned for ongoing surface deformation monitoring across the Arrow tenements, with the latest data available up to the end of June 2024.

Figure 3-27 shows a down-sampled data set, where the point cloud InSAR data was reduced to the median vertical velocity within a 1,000 m x 1,000 m grid. Stable has been classified as ground motion of less than 8 mm per year (subsidence or uplift) as related to the screening level identified in the Stage 1 WMMP.

These data show stability across most of Arrow’s tenure, together with areas of downward ground movement, majority of which being away from areas of gas production. Areas of ground movement are particularly observed over the reactive vertosol soils of the Condamine Alluvium.

Areas of poor satellite data coherence, with only a small number of InSAR points per square km, occur within the area of the Condamine Alluvium. Coherence is a measure of the local spatial correlation between radar images, where changes to the reflection of the radar signal (such as due to rapid vegetation growth or changes in soil moisture) result in irregular variation in phase and higher noise in the data. Overall, there was 147 of the (1km x 1km) grid cells within 4.5km of CSG wells, where 2D vertical movement was unable to be resolved due to lack of coherent persistent scatterers. For these cells, ascending and descending distributed scatterers were used to indicate ground movement instead, along with LiDAR for changes in slope. One cell was found to have no InSAR or LiDAR data within 4.5km of CSG production. On inspection it was determined that this grid cell was located wholly within the Lake Broadwater footprint and so was not analysed further.

As shown below, 344 of the (1km x 1km) cells had recorded downward ground movement in excess of the screening level of 8 mm per year for more than 50% of the coherent InSAR points within those cells. Of these, 109 grid cells were located within 4.5km of Arrow producing wells (the reasonable distance within which CSG induced subsidence might be detectable). As these 109 grid cells exceeded the screening level, further assessment of changes to the ground surface and slopes within and around the grid cell areas was undertaken, using the InSAR point clouds and LiDAR surveys, to assess if there was any CSG induced subsidence impacts and exceedance of investigation levels.

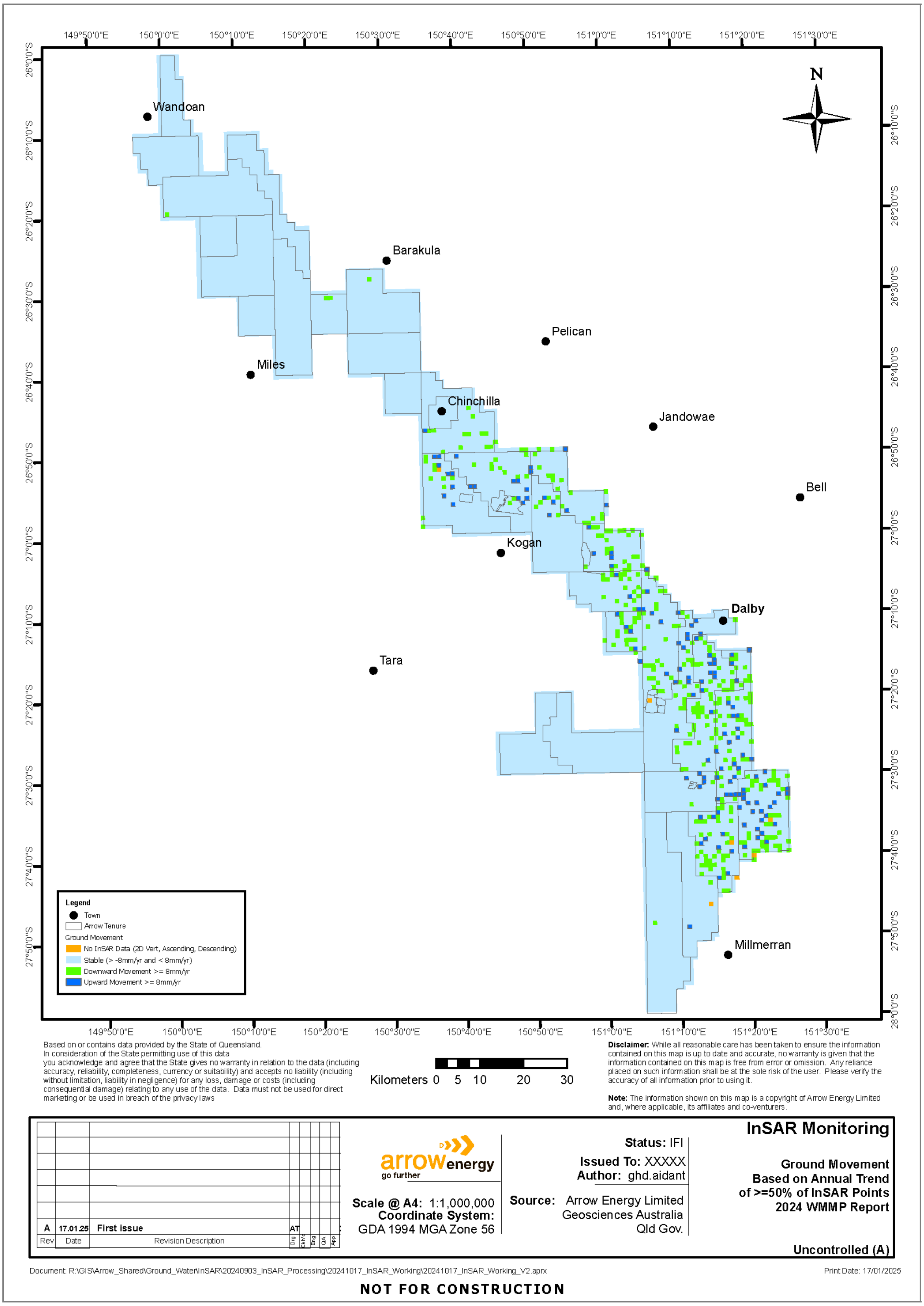


Figure 3-27: Ground Movement based on annual trend of majority (>=50%) of InSAR points within 1kmx1km cell

A process was undertaken considering areal slope change on a 10m resolution grid. It was determined that 20 of the 109 grid cells had areal slope change (LiDAR derived) in excess of 0.001m/m. These 20 cells were investigated further to validate if investigation levels had been exceeded due to CSG activity.

Transects were taken along structural and natural features within the grid cells, the location and results of these are summarised in Appendix D. Slope was calculated from LiDAR using least squares regression. 10m Average Digital Elevation Models (DEMs) were used within paddocks to reduce noise from furrows, 1m DEMs were used elsewhere. Of the transects taken across the 20 grid cells, there was no apparent slope changes to structural or natural features beyond trigger levels. Therefore, no further site-specific investigations or trigger threshold exceedance action plans were required or initiated during the reporting period.

3.4 Update to monitoring network

Groundwater monitoring locations and frequency of monitoring were revised upon the release of the 2021 UWIR in line with Section 7.3 of the SGP Updated CSG WMMP. The monitoring network presented in Table 7-1 of the SGP Updated CSG WMMP has been aligned with the 2021 UWIR water monitoring strategy (WMS) to ensure monitoring is undertaken proportionally to the predicted impacts presented in the 2021 UWIR. A summary of the changes to the monitoring network is provided in Table 6 and the updated list of monitoring points (and their purpose) is provided in Table 7 and illustrated in Figure 3-28 and Figure 3-29. In addition to the changes noted in Table 6, the groundwater chemistry suite and sampling frequency have been revised to align with 2021 UWIR and is presented in Table 8.

Key changes to the monitoring programs are:

- the number of monitoring points has increased from 120 in the SGP Updated CSG WMMP to 150 to align with the 2021 UWIR,
- the groundwater analysis suite has been expanded to include strontium isotopes (87Sr/86Sr) (this was changed under the 2019 UWIR),
- Table 4-2 of the 2021 UWIR supporting document "*Details of the Water Monitoring Strategy for the Underground Water Impact Report 2021*" (OGIA 2021b) (and also Table H-4 of the 2019 UWIR) stipulates a groundwater sampling frequency of every six months until five samples have been obtained, with one of these samples analysed for dissolved strontium and strontium isotopes ($^{87}Sr/^{86}Sr$) in Springbok Sandstone, Hutton Sandstone and Precipice Sandstone monitoring points.

Table 6: Summary of changes to the Updated CSG WMMP monitoring points to align with the 2021 UWIR monitoring requirements

Location ID	Target Aquifer	Original monitoring requirement as per Updated CSG WMMP			2021 UWIR Monitoring Requirement	Monitoring point status and current monitoring requirement based on 2021 UWIR
		Level / pressure	Water Quality	CA-WCM flux		
Bora Creek-10	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Burunga Lane-174	Evergreen	✓			No change. Still required to be monitored for the 2021 UWIR.	Access issue to the site was resolved. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring in Burunga Lane-174 (removed from UWIR). No samples collected due to access issues.
Burunga Lane-174	Precipice	✓	✓		No change to the pressure monitoring requirement. Water quality monitoring requirement has been removed from the 2021 UWIR.	
Burunga Lane-176	Hutton	✓	✓		No change. Still required to be monitored for the 2021 UWIR.	
Burunga Lane-176	WCM	✓				
Carn Brea-17	Condamine Alluvium	✓	✓	✓	No change to the level monitoring requirement. Water quality monitoring is no longer required as sufficient number of samples have been collected as per Table 9-4 of the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring (completion of collection of five samples in Q4 2020).
Carn Brea-18	WCM	✓	✓ (at UWIR MP 41 only)	✓	No change to the pressure monitoring requirement. Water quality monitoring is no longer required as sufficient number of samples have been collected as per Table 9-4 of the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring (completion of collection of five samples in Q4 2020).
Carn Brea-19	Evergreen	✓			No change to the pressure monitoring requirement.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Carn Brea-19	Hutton	✓	✓		No change to the pressure monitoring requirement. Water quality monitoring is no longer required as sufficient number of samples have been collected as per Table 9-4 of the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring (completion of collection of five samples in Q4 2020).
Carn Brea-20	Precipice	✓	✓		No change to the level monitoring requirement. Water quality monitoring requirement has been removed from the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring (removed from UWIR).
Carn Brea-21	WCM	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Carn Brea-23	Condamine Alluvium	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Carn Brea-24	CA / WCM transition layer	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Castledean-18	Springbok	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point is operational but dry. Monitoring as per Updated CSG WMMP.
Castledean-18	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Daandine-121	Hutton	✓	✓		No change to the pressure monitoring requirement. Water quality monitoring is no longer required as sufficient number of samples have been collected as per Table 9-4 of the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring (completion of collection of five samples in Q4 2020).
Daandine-123	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring is no longer required under the 2021 UWIR.
Daandine-124	Westbourne	✓	✓		No change to the level monitoring requirement. Water quality monitoring requirement has been removed from the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring (removed from UWIR).
Daandine-134	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Daandine-134	Eurombah	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Daandine-161	Condamine Alluvium	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Daandine-163	CA / WCM transition layer	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.

Location ID	Target Aquifer	Original monitoring requirement as per Updated CSG WMMP			2021 UWIR Monitoring Requirement	Monitoring point status and current monitoring requirement based on 2021 UWIR
		Level / pressure	Water Quality	CA-WCM flux		
Daandine-164	WCM	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Daandine-254	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Daandine-263	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Daandine-264	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Dundee-20	WCM	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Glenburnie-19	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Pressure gauge had failed. Pressure gauge became operational again in June 2022. Monitoring as per Updated CSG WMMP.
Hopeland-17	Springbok	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Hopeland-17	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Kedron-570	Eurombah	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Kedron-570	Hutton	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Kedron-570	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Kedron-570	Springbok	✓			Monitoring point removed from the previous UWIR (2019).	Monitoring point no longer monitored as per the 2019 and 2021 UWIRs.
Kogan North-56	WCM	✓		✓	Monitoring point removed from the 2021 UWIR (previously removed in 2019 UWIR).	Monitoring point no longer monitored as per the 2021 UWIR (previously removed in 2019 UWIR) Monitoring point plugged and abandoned.
Kogan North-79	CA / WCM transition layer	✓		✓	Monitoring point removed from the 2021 UWIR (previously removed in 2019 UWIR).	Monitoring point no longer monitored as per the 2021 UWIR.
Kogan North-79	Condamine Alluvium	✓		✓	Monitoring point removed from the 2021 UWIR (previously removed in 2019 UWIR).	Monitoring point no longer monitored as per the 2021 UWIR.
Tipton-153	Hutton	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Long Swamp-1 (replaced by Longswamp 27)	WCM	✓			Monitoring point replaced by Longswamp 27 installed adjacent to Long Swamp-1.	Monitoring point (Longswamp 27) operational. Monitoring as per Updated CSG WMMP.
Longswamp-7	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Macalister-5	Condamine Alluvium	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Macalister-8	WCM	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Meenawarra-21	Springbok	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Meenawarra-21	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Meenawarra-5	WCM	✓			Monitoring point removed from the 2021 UWIR.	Monitoring point no longer monitored as per the 2021 UWIR.
Pampas-18	Condamine Alluvium	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational.

Location ID	Target Aquifer	Original monitoring requirement as per Updated CSG WMMP			2021 UWIR Monitoring Requirement	Monitoring point status and current monitoring requirement based on 2021 UWIR
		Level / pressure	Water Quality	CA-WCM flux		
						Monitoring as per Updated CSG WMMP.
Pampas-5	WCM	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Plainview-35	WCM	✓			No change. Monitoring point replaced previous UWIR monitoring point Plainview-1.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Plainview-25	CA / WCM transition layer	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring points operational. Monitoring as per Updated CSG WMMP.
Plainview-25	Condamine Alluvium	✓		✓		
Plainview-25	WCM	✓		✓		
RN 41620043	WCM (previously assessed by OGIA as Springbok Sandstone)	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
RN 42230088	Condamine Alluvium	✓		✓	Monitoring point removed from the 2021 UWIR.	Monitoring point no longer monitored as per the 2021 UWIR.
RN 42230209	Condamine Alluvium	✓		✓	No change to the level monitoring requirement. Water quality monitoring is no longer required as sufficient number of samples have been collected as per Table 9-4 of the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring (completion of collection of five samples in Q4 2020).
RN 42231294	Condamine Alluvium	✓		✓	Monitoring point removed from the 2021 UWIR.	Monitoring point no longer required to be monitored as per the 2021 UWIR.
RN 42231295	WCM	✓		✓	Monitoring point removed from the 2021 UWIR.	Monitoring point no longer required to be monitored as per the 2021 UWIR.
RN 42231339	Condamine Alluvium	✓			Monitoring point removed from the 2021 UWIR.	Monitoring point no longer required to be monitored as per the 2021 UWIR.
RN 42231370	Condamine Alluvium	✓	✓		No change to the level monitoring requirement. Water quality monitoring is no longer required as sufficient number of samples have been collected as per Table 9-4 of the 2021 UWIR	Monitoring point operational. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring (completion of collection of five samples in Q4 2020).
RN 42231463	Condamine Alluvium	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Stratheden-63	Springbok	✓	✓		No change to the level monitoring requirement. Water quality monitoring is no longer required as sufficient number of samples have been collected as per Table 9-4 of the 2021 UWIR	Monitoring point operational. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring (completion of collection of five samples in Q4 2020, and collection of samples for analysis of strontium isotopes completed in Q4 2021).
Tipton-157	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Tipton-195	Condamine Alluvium	✓	✓	✓	No change to the level monitoring requirement. Water quality monitoring is no longer required as sufficient number of samples have been collected as per Table 9-4 of the 2021 UWIR	Monitoring point operational. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring (completion of collection of five samples in Q4 2020).
Tipton-196A	CA / WCM transition layer	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Tipton-197	WCM	✓	✓ (at UWIR MP 89 only)	✓	No change to the level monitoring requirement. Water quality monitoring is no longer required as sufficient number of samples have been collected as per Table 9-4 of the 2021 UWIR	Monitoring point operational. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring (completion of collection of five samples in Q4 2020).
Tipton-204	CA / WCM transition layer	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Tipton-204	Condamine Alluvium	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Tipton-204	WCM	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Tipton-206	Eurombah	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational.

Location ID	Target Aquifer	Original monitoring requirement as per Updated CSG WMMP			2021 UWIR Monitoring Requirement	Monitoring point status and current monitoring requirement based on 2021 UWIR
		Level / pressure	Water Quality	CA-WCM flux		
						Monitoring as per Updated CSG WMMP.
Tipton-206	WCM	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Tipton-221	Condamine Alluvium	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Tipton-222	CA / WCM transition layer	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Macalister 7	Condamine Alluvium	✓		✓	No change. Still required to be monitored for the 2021 UWIR	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Macalister 6	WCM	✓		✓	No change. Still required to be monitored for the 2021 UWIR	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Macalister 6	Eurombah	✓			No change. Still required to be monitored for the 2021 UWIR	Monitoring point operational. Monitoring as per Updated CSG WMMP.
Wyalla-17	Hutton	✓			No change. Still required to be monitored for the 2021 UWIR	Monitoring point operational. Monitoring as per Updated CSG WMMP.
UWIR Site 94	Hutton	✓			This monitoring point is no longer required under the 2021 UWIR (previously not required in 2019 UWIR).	Monitoring point no longer required.
UWIR Site 94 (Burunga Lane 186)	WCM	✓			No change. Still required to be monitored for the 2021 UWIR.	Monitoring point became operational in 2023.
Wyalla-16	Condamine Alluvium	✓	✓	✓	No change to the level monitoring requirement. Water quality monitoring is no longer required as sufficient number of samples have been collected as per Table 9-4 of the 2021 UWIR	Monitoring point operational. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring (completion of collection of five samples in Q4 2020).
Wyalla-17	Precipice	✓	✓		No change to the level monitoring requirement. Water quality monitoring requirement has been removed from the 2021 UWIR	Monitoring point operational. Monitoring as per Updated CSG WMMP except for the cessation of water quality monitoring (completion of collection of five samples in Q4 2020).
Wyalla-18	WCM	✓		✓	No change. Still required to be monitored for the 2021 UWIR.	Monitoring point operational. Monitoring as per Updated CSG WMMP.

Table 7: Revised Updated CSG WMMP Monitoring Network as per the 2021 UWIR WMS

Location ID	OGIA MP ID	Latitude	Longitude	Target Aquifer	Status	Monitoring point purpose			
						Level / pressure	Quality	CA-WCM flux	Early warning
41620043	578	-27.922222	151.121389	WCM	Complete	✓			✓
42230209	281	-26.7422	150.6799	Condamine Alluvium	Complete	✓	✓	✓	✓
42231370	51	-27.491498	151.393194	Condamine Alluvium	Complete	✓	✓		✓
42231463	37	-27.548794	151.313017	Condamine Alluvium	Complete	✓		✓	✓
42231597	597	-27.73082	151.76343	Main Range Volcanics	Complete	✓			
Baking Board 4	877	-26.567	150.653	WCM	Complete	✓			
Baking Board 5	891	-26.48009491	150.5512695	Alluvium	Complete	✓			
Barakula 2	878 and 869	-26.480094	150.551269	WCM, Hutton Sandstone	Complete	✓			
Bora Creek 10	579	-27.924504	151.12492	WCM	Complete	✓			
Burunga Lane 186	494, 495, 496	-26.2301	149.9534	WCM	Complete	✓			
Burunga Lane-174	478, 625	-26.242667	150.050176	Precipice, Evergreen	Monitoring points installed. Land access issue was resolved and monitoring recommenced on 2/05/2024.	✓			✓ (478)
Burunga Lane-176	473, 474, 475, 476, 477	-26.242897	150.049993	WCM, Hutton	Monitoring points installed. Land access issue was resolved and monitoring recommenced on 2/05/2024.	✓	✓ (477)		✓ (476)
Carn Brea 21	94	-27.437622	151.357504	WCM	Complete	✓		✓	
Carn Brea 22	882	-27.43779	151.357466	Hutton	Complete	✓			
Carn Brea 23	92	-27.43762778	151.3576733	Condamine Alluvium	Complete	✓		✓	✓
Carn Brea 24	93	-27.437628	151.357707	Condamine Alluvium - Walloon Transition Layer	Complete	✓		✓	
Carn Brea-17	38	-27.533016	151.36648	Condamine Alluvium	Complete	✓	✓		✓
Carn Brea-18	40, 41, 42, 43	-27.532995	151.36633	WCM	Complete	✓	✓ (41)	✓	
Carn Brea-19	44, 45, 46	-27.532975	151.36618	Hutton, Evergreen	Complete	✓	✓ (45)	✓	✓ (44)
Carn Brea-20	47	-27.532954	151.36603	Precipice	Complete	✓	✓		✓
Castledean-18	375, 376, 377, 378	-26.552914	150.221984	WCM, Springbok	Complete	✓			✓ (375)
Daandine 263	181	-27.102426	150.961255	WCM	Complete	✓			
Daandine 264	148	-27.15307149	151.0442114	WCM	Complete	✓			
Daandine-121	182	-27.100415	150.955656	Hutton	Complete	✓	✓		✓
Daandine-123	719, 720	-27.144075	150.948059	WCM, Precipice	Complete	✓			
Daandine-124	157	-27.144119	150.948001	Westbourne Formation	Complete	✓			
Daandine-134	162, 163, 164	-27.14401378	150.9485653	Tangalooma Sandstone, Eurombah, WCM	Complete	✓			
Daandine-161	166	-27.118534	151.075606	Condamine Alluvium	Complete	✓		✓	✓
Daandine-163	167	-27.119974	151.075875	Condamine Alluvium - Walloon Transition Layer	Complete	✓		✓	
Daandine-164	168	-27.120008	151.075969	WCM	Complete	✓		✓	
Daandine-254	160, 161, 159	-27.144104	150.948239	WCM	Complete	✓			
Dundee-20	283, 284, 285	-26.743476	150.678351	WCM	Complete	✓		✓	
Glenburnie 19	23	-27.639218	151.167664	WCM	Complete	✓			
Glenburnie 20	732	-27.83304667	151.0972642	Springbok	Complete	✓			
Glenburnie 21	733	-27.83242474	151.0980474	WCM	Complete	✓			
Glenburnie 22	734	-27.83252476	151.0981482	WCM	Complete	✓			
Glenburnie-18	735, 736, 737, 738, 739	-27.72017464	151.1565154	Hutton, WCM, Springbok	Complete	✓	✓ (739)		
Hopeland-17	615, 616, 617, 618	-26.973208	150.611817	Springbok, WCM	Complete	✓			✓ (615)
Kedron-570	626, 627, 628, 629	-26.413424	150.153717	WCM, Tangalooma Sandstone, Hutton	Complete	✓			✓ (629)

Location ID	OGIA MP ID	Latitude	Longitude	Target Aquifer	Status	Monitoring point purpose			
Kogan North-79	747, 748, 749	-26.99886636	150.9018044	WCM	Complete	✓			
Lone Pine-14	750	-27.55472483	151.3591434	WCM	Complete	✓			
Lone Pine-16	751	-27.55468423	151.3587845	WCM	Complete	✓			
Long Swamp 27	83	-27.343091	151.124186	WCM	Complete	✓			
Longswamp 28	752	-27.3415143	151.0917476	Westbourne Formation	Complete	✓			
Longswamp 29	753	-27.34150399	151.0915948	Springbok	Complete	✓			
Longswamp 30R	754	-27.34148851	151.0914061	WCM	Complete	✓			
Longswamp 31	755	-27.34347302	151.0957158	Condamine Alluvium	Complete	✓			
Longswamp 33	756	-27.26852415	151.0953309	Springbok	Complete	✓			
Longswamp 34	757	-27.26851019	151.0952109	WCM	Complete	✓			
Longswamp-7	145, 146, 147	-27.184333	151.127397	WCM	Complete	✓			
Macalister 5	244	-26.895087	150.954269	Condamine Alluvium	Complete	✓		✓	✓
Macalister 6	205, 206	-27.025681	151.133187	Eurombah Formation, WCM	Complete	✓		✓	
Macalister 7	203	-27.025639	151.133279	Condamine Alluvium	Complete	✓		✓	✓
Macalister 8	245	-26.895103	150.954439	WCM	Complete	✓		✓	
Meenawarra-21	34, 35, 36, 619	-27.57994613	151.1333987	WCM, Springbok	Complete	✓			✓ (619)
Mt Haystack 2	598	-27.727166	151.763337	WCM	Complete	✓			
Mt Haystack 4	600	-27.724061	151.276431	WCM	Complete	✓			
Mt Haystack 5	599	-27.723972	151.276483	Condamine Alluvium	Complete	✓			
Pampas 18	24	-27.61473529	151.2266555	Condamine Alluvium	Complete	✓		✓	✓
Pampas-5	25	-27.614646	151.226669	WCM	Complete	✓		✓	
Plainview 34	1053,1054	-27.3828	151.1869	WCM	Complete	✓			
Plainview 35	77	-27.3842	151.2044	WCM	Complete	✓			
Plainview 36	789, 790	-27.3868	151.216	Springbok	Complete	✓	✓ (790)		
Plainview 37	791	-27.3868	151.216	Condamine Alluvium	Complete	✓			
Plainview-25	119, 120, 121	-27.25210762	151.2922186	Condamine Alluvium, Condamine Alluvium - Walloon Transition Layer, WCM	Complete	✓		✓	✓ (119)
Punch Bowl-15	796, 797	-26.55156345	150.3782458	WCM	Complete	✓			
Stratheden-62	822	-27.19895544	151.0267434	Condamine Alluvium	Complete	✓			
Stratheden-63	622, 623	-27.198933	151.026801	Springbok	Complete	✓	✓ (623)		✓ (622)
Tipton 153	620	-27.358607	151.153091	Hutton	Complete	✓			✓
Tipton 200	832, 834, 835, 836	-27.383	151.173	Hutton, WCM	Complete	✓			
Tipton 202	830, 833	-27.383	151.173	Springbok	Complete	✓	✓ (830)		
Tipton 203	831	-27.383	151.173	Condamine Alluvium	Complete	✓			
Tipton 204	149, 150, 151	-27.149552	151.20938	Condamine Alluvium, Condamine Alluvium - Walloon Transition Layer, WCM	Complete	✓		✓	✓ (149)
Tipton 206	141, 142	-27.215683	151.348949	Eurombah, WCM	Complete	✓		✓	
Tipton 221	138	-27.215626	151.348869	Condamine Alluvium	Complete	✓		✓	✓
Tipton 222	139	-27.215589	151.348817	Condamine Alluvium - Walloon Transition Layer	Complete	✓		✓	
Tipton-157	72, 73, 74	-27.398089	151.088923	WCM	Complete	✓			
Tipton-194	861	-27.38748328	151.1181328	Precipice	Complete	✓			
Tipton-195	84, 85	-27.32054	151.20535	Condamine Alluvium	Complete	✓	✓ (85)	✓	✓ (84)
Tipton-196A	86	-27.320232	151.205042	Condamine Alluvium - Walloon Transition Layer	Complete	✓		✓	
Tipton-197	88, 89, 90, 91	-27.320228	151.205316	WCM	Complete	✓	✓ (89)	✓	

Location ID	OGIA MP ID	Latitude	Longitude	Target Aquifer	Status	Monitoring point purpose			
Plainview 16	792	-27.3858	151.2165	Hutton	Complete	✓			
UWIR MP ID 868	868	-26.312681	150.377656	Hutton	2025	✓			
UWIR MP ID 1047	1047	-27.4429	151.2887	Springbok	Timing to be determined by OGIA	✓			
UWIR MP ID 1048	1048	-27.4429	151.2887	WCM	Timing to be determined by OGIA	✓			
UWIR MP ID 1049	1049	-27.4429	151.2887	Condamine Alluvium	Timing to be determined by OGIA	✓			
UWIR MP ID 1050	1050	-27.4822	151.1834	Springbok	Timing to be determined by OGIA	✓			
UWIR MP ID 1051	1051	-27.4822	151.1834	WCM	Timing to be determined by OGIA	✓			
UWIR MP ID 1052	1052	-27.4822	151.1834	Springbok	Timing to be determined by OGIA	✓			
UWIR MP ID 1060	1060	-27.4340	151.2272	Condamine Alluvium	Timing to be determined by OGIA	✓			
UWIR MP ID 1061	1061	-27.4340	151.2272	Springbok	Timing to be determined by OGIA	✓			
UWIR MP ID 1062	1062	-27.4340	151.2272	WCM	Timing to be determined by OGIA	✓			
Wyalla-16	246, 248	-26.86619798	150.7550201	Condamine Alluvium	Complete	✓	✓ (248)	✓	✓
Wyalla-17	252, 624	-26.86632619	150.7549919	Precipice, Hutton	Complete	✓			✓ (252)
Wyalla-18	249, 250, 251	-26.8660577	150.7550667	WCM	Complete	✓		✓	

Notes:

(1) As noted in Revision 0 of the SGP Updated CSG WMMP, the baseline monitoring assessment indicated Condamine Alluvium bores 42231370, Daandine-161 and Carn Brea-17 exhibited regular drawdown and recovery cycles of several metres because of nearby groundwater extraction for agricultural or other non-CSG uses. The magnitude of these groundwater fluctuations is such that these bores have limited use for early warning monitoring, and as such, have been excluded as early warning monitoring bores in the SGP Updated CSG WMMP.

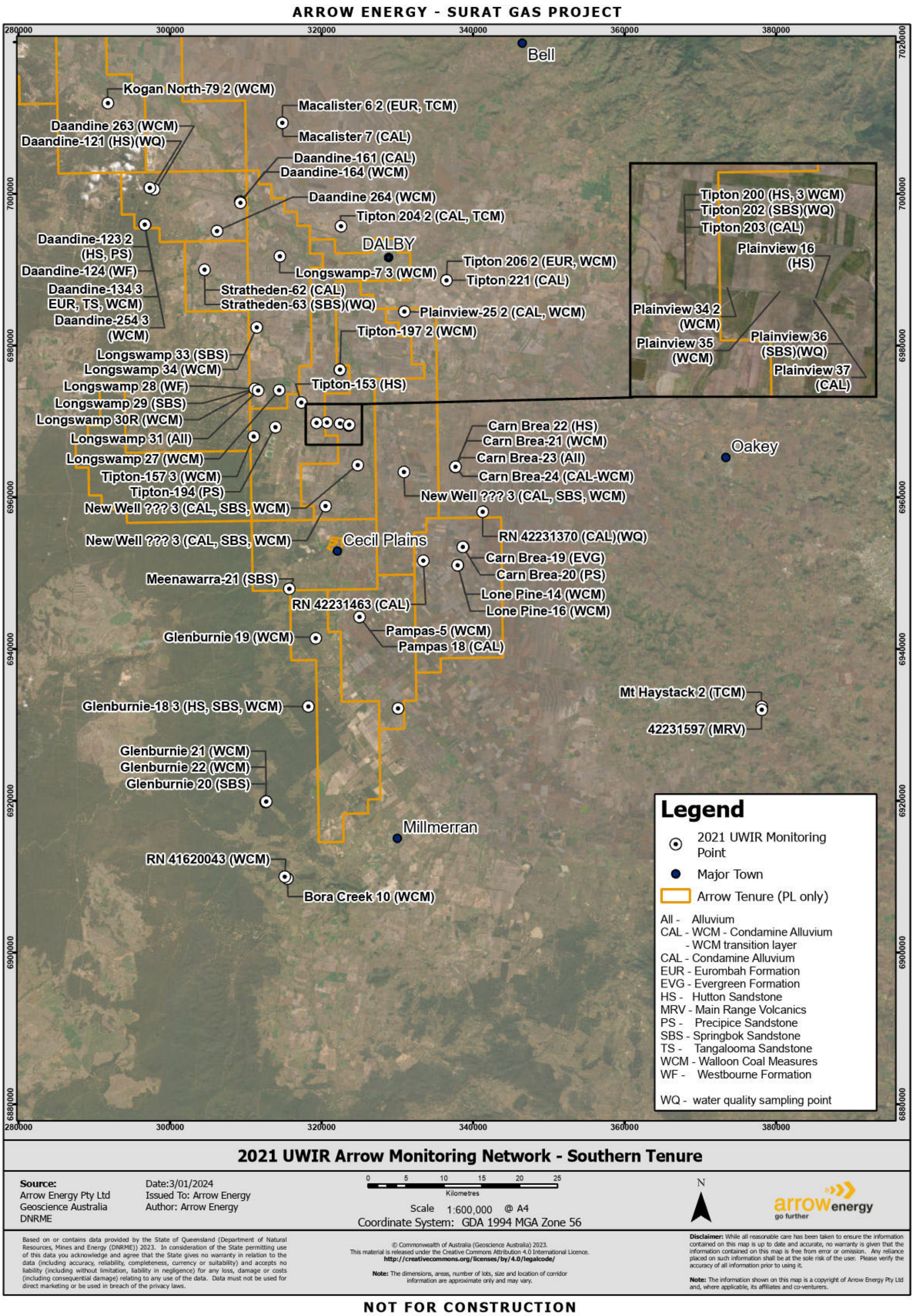


Figure 3-28: 2021 UWIR Arrow Monitoring Network – southern tenure

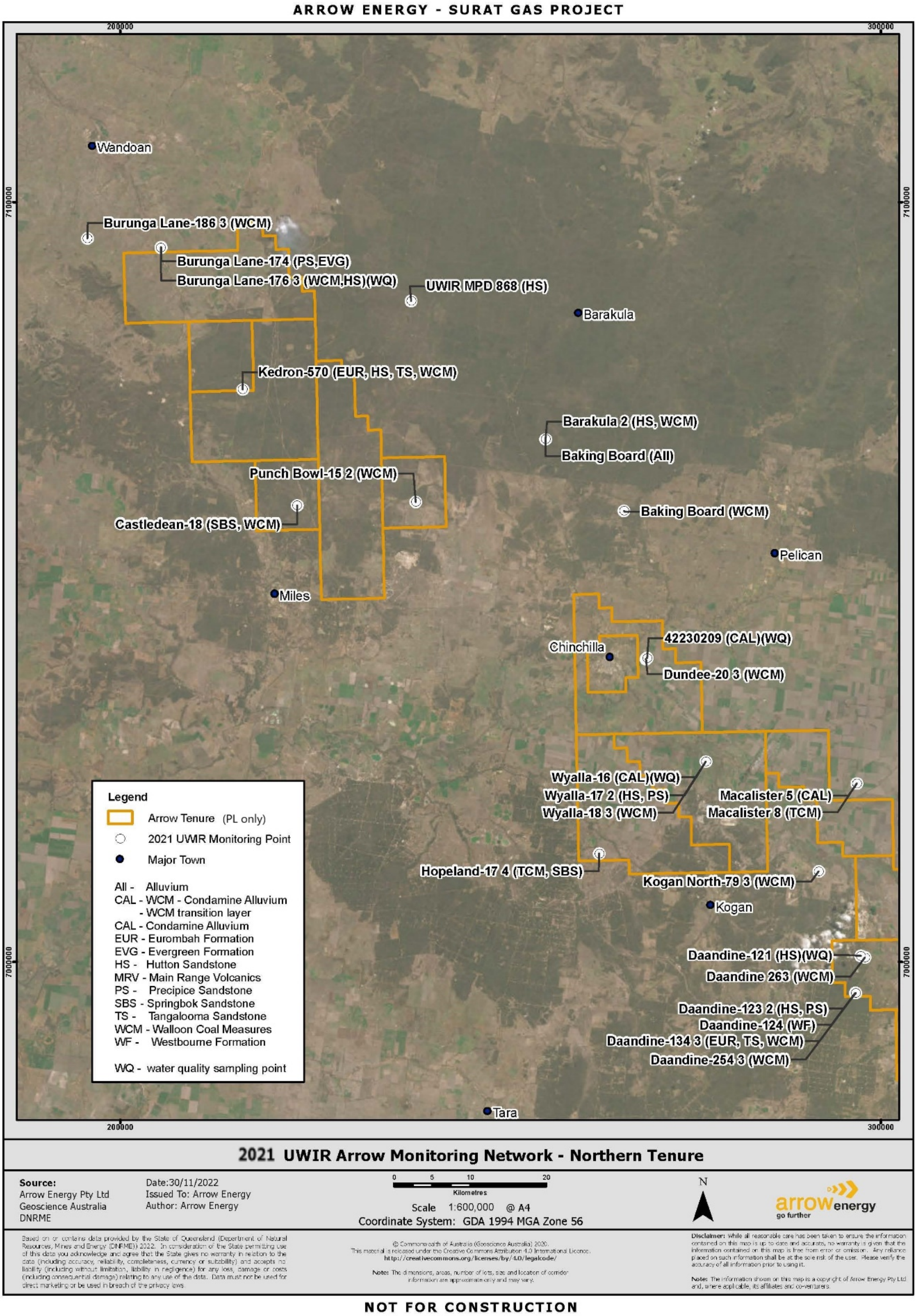


Figure 3-29: 2021 UWIR Arrow Monitoring Network – northern tenure

Table 8: 2021 UWIR groundwater sampling parameters and frequency for groundwater monitoring points

Suite	Type	Parameters to be measured as part of the suite	Frequency
Suite A	Field Parameters	Electrical Conductivity (µS/cm @ 25°C), pH, Redox Potential (Eh), Temperature (°C), Free gas at wellhead (CH_4)	Every six months until five samples obtained
	Laboratory analytes	Major cations and anions: Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Potassium (K^+), Sodium (Na^+), Bicarbonate (HCO_3^-), Carbonate (CO_3^-), Chloride (Cl^-), Sulphate (SO_4 2-), Total Alkalinity	
		Metals (dissolved): Arsenic (As), Barium (Ba), Boron (B), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Nickel (Ni), Selenium (Se), Strontium (Sr^{2+}), Zinc (Zn)	
		Fluoride (F^-), Total Dissolved Solids	
		Gas (dissolved): Methane (CH_4)	
Suite B	Laboratory analytes	Isotopes: Strontium (87Sr/86Sr)	Once only in: SBK, HUT, PCP
		Metals (dissolved): Strontium (Sr^{2+})	

4. Updated Impact Predictions

Following the approval of the Updated CSG WMMP on 22 November 2019, the 2019 UWIR for the Surat CMA was approved by the DES on 16 December 2019. On 17 March 2022, the 2021 UWIR for the Surat CMA was approved for release by the DES (this UWIR came into effect on 1 May 2022) and is the current UWIR at the time of writing this Report. The 2021 UWIR simulated an updated Arrow field development plan (FDP) compared to the Updated CSG WMMP and the 2019 UWIR.

Queensland's regulatory framework requires revision of the UWIR every three years unless the chief executive of DES requires an earlier amendment. The revision incorporates new data and knowledge generated from research work in the preceding years. Understanding of the groundwater flow system since the Updated CSG WMMP has continued to improve with data collected, knowledge built through targeted research, and exploration and development of new modelling techniques to maximise the use of available data.

Improvements in hydrogeological conceptualisation between the Updated CSG WMMP and 2021 UWIR models have included:

- more accurate representation of the extent and thickness of surficial sediments, including the Condamine Alluvium and the Main Range Volcanics
- interpretation of additional primary well log data, seismic interpretation, and surface mapping, resulting in revised modelled geological surfaces and the inclusion of a number of the major geologic faults.
- Understanding of groundwater flow and aquifer connectivity, including by groundwater level and chemistry trend analysis of data from the regional monitoring network, and targeted investigations such as the Condamine Interconnectivity Research Project.

4.1 Groundwater model changes

In addition to further data collection and improvements in hydrogeological conceptualisation, model structure and parameter changes between the SGP Updated WMMP and 2021 UWIR groundwater models also contribute to improvement in impact predictions. The major differences between the models that are likely to have affected the model outputs include:

- model code
- model structure
- model parameterisation.

The influence of these factors is discussed in further detail below.

Model code

The Updated CSG WMMP groundwater model used the MODFLOW 2005 code. This is a single phase or water flow model and does not account for effects of gas on relative permeability. The local, small-scale effects of gas on water flow are important in the rate of flow of water to CSG wells. In a dual phase system, there is an exponential decline in water yield as coal seams are depressurised and gas is desorbed from the coal. This was understood and discussed by OGIA (then Queensland Water Commission) in the 2012 UWIR (QWC, 2012). The 2021 UWIR groundwater model addressed this issue by using the MODFLOW-USG code and modifying how layers desaturate. This is discussed in detail in the 2019 UWIR Groundwater Modelling Report (OGIA, 2019b) and summarised below.

Desaturation in the dual phase context is different from single phase in that more water is derived from pore spaces than elastic storage and the amount of formation permeability (relative permeability) available to water is reduced as more gas is freed to occupy the pore spaces.

In single phase models, air saturation in the vadose zone can be simulated using the van Genuchten equation where desaturation occurs at the air-water interface. In the 2021 UWIR groundwater model this is modified such that it allows desaturation to start at the saturation pressure of the Langmuir isotherm that governs gas desorption or the groundwater pressure, whichever is the lower pressure. This results in a solution for dual phase pressures that has less uncertainty than the upscaling in the large regional model.

Model structure

The Updated CSG WMMP groundwater model simulated the WCM with three layers comprising upscaled interburden layers above and below a nominal coal layer. For the 2021 UWIR groundwater model, six layers are used to represent the WCM. In addition, the Springbok and Hutton sandstones are represented with two layers each in the latter model. This change in structure results in different parameterisation and different boundary conditions for these layers.

In addition to the model's layer structure, the 2021 UWIR groundwater model included dual porosity in the WCM. The necessary upscaling for the large regional model could have distorted the relative water permeability curve. This problem was overcome to a large extent through adoption of a dual porosity formulation whereby a permeable, porous medium is assumed to possess mobile and immobile domains which are separate in function but not in space (OGIA, 2019b).

Model parameterisation

The changes in model code and model structure together with more calibration data available in the 2021 UWIR groundwater model led to changes in model parameterisation that affected the model predictions. The parameterisation approach for each model are presented in both the Updated CSG WMMP and 2021 UWIR (OGIA, 2021c).

4.2 Groundwater drawdown extent

Changes have occurred in the predicted groundwater drawdown extent across the different iterations of the UWIR regional groundwater model, resulting from the simulation of cumulative production from all operators FDP which have been revised over time. Comparisons of the predicted Arrow-only groundwater drawdown between the Updated CSG WMMP and 2019 UWIR are presented in Figure 4-1 to Figure 4-3 as the long-term affected area (5m) drawdown extents for the Springbok Sandstone, Walloon Coal Measures, and Hutton Sandstone. There is no long term affected area for the overlying Condamine Alluvium or underlying Precipice Sandstone from Arrow's operation.

An assessment has been undertaken of the suitability of the 2021 UWIR monitoring network to monitor the predicted changes in groundwater pressure/level, noting that the 2021 UWIR monitoring network supersedes the Updated CSG WMMP monitoring network in line with Section 7.3.1 of the Updated CSG WMMP.

The Springbok Sandstone 5m predicted drawdown extent has increased in the area south of Dalby (primarily due to the modelling approach of the Horrane Fault) whilst it has contracted to the west of Dalby (Figure 4-1). Further north where SGP development has not yet commenced, the Hopeland area has seen an increased predicted drawdown extent, and north of Miles the predicted drawdown extent is of a similar sized but is located further westward. The distribution of the 2021 UWIR Springbok Sandstone monitoring points across the 2021 UWIR predicted drawdown extent is considered sufficient for the purposes of monitoring pressure/levels in the formation for the MNES identified in the Updated CSG WMMP. In addition, Arrow is to undertake monitoring bore installation in the area north of Miles during 2025 to refine the extent and hydrogeological understanding of the Springbok Sandstone.

Previously, in the Updated CSG WMMP, the WCM 5m predicted drawdown extent was shown as two polygons surrounding the area of Chinchilla to Dalby to Cecil Plains, and around the Miles area (Figure 4-2). The 2021 UWIR WCM 5m predicted drawdown extent has increased to one larger polygon which largely covers Arrow's tenure and also extends east towards Toowoomba but is reduced to the west. While there are several reasons for this difference in predicted drawdown (Section 4.1), the 2021 UWIR regional groundwater model has incorporated increased lateral connectivity of the coal seams. As shown in Figure

4-2, the 2021 UWIR WCM monitoring network provides adequate spatial coverage across the predicted WCM drawdown extent and is therefore considered adequate.

The Hutton Sandstone 5m predicted drawdown extent has increased significantly from the Updated CSG WMMP to the 2021 UWIR (Figure 4-3). The location of both predicted 5m drawdown contours are associated with the Horrane Fault; however, it should be noted that Arrow's investigation of the fault indicates that clay smearing in the fault zone limited hydraulic connectivity between the WCM and the Hutton Sandstone (as per Section 4.4.5 of the 2021 UWIR). Nonetheless, the distribution of the 2021 UWIR Hutton Sandstone monitoring points is sufficiently spread across the predicted drawdown extent to detect any hydraulic connection.

In regard to the Condamine Alluvium, section 6.5.2.5 of the 2021 UWIR notes the magnitude of impact is less than 0.3m for most of the area and the footprint of predicted impact is similar to that in the previous 2019 UWIR. The average net loss of water from the Condamine Alluvium to the WCM is predicted to be about 1,270 ML/year over the next 100 years. This is higher than predictions in the 2019 UWIR but comparable to predictions in the 2012 UWIR and 2016 UWIR.

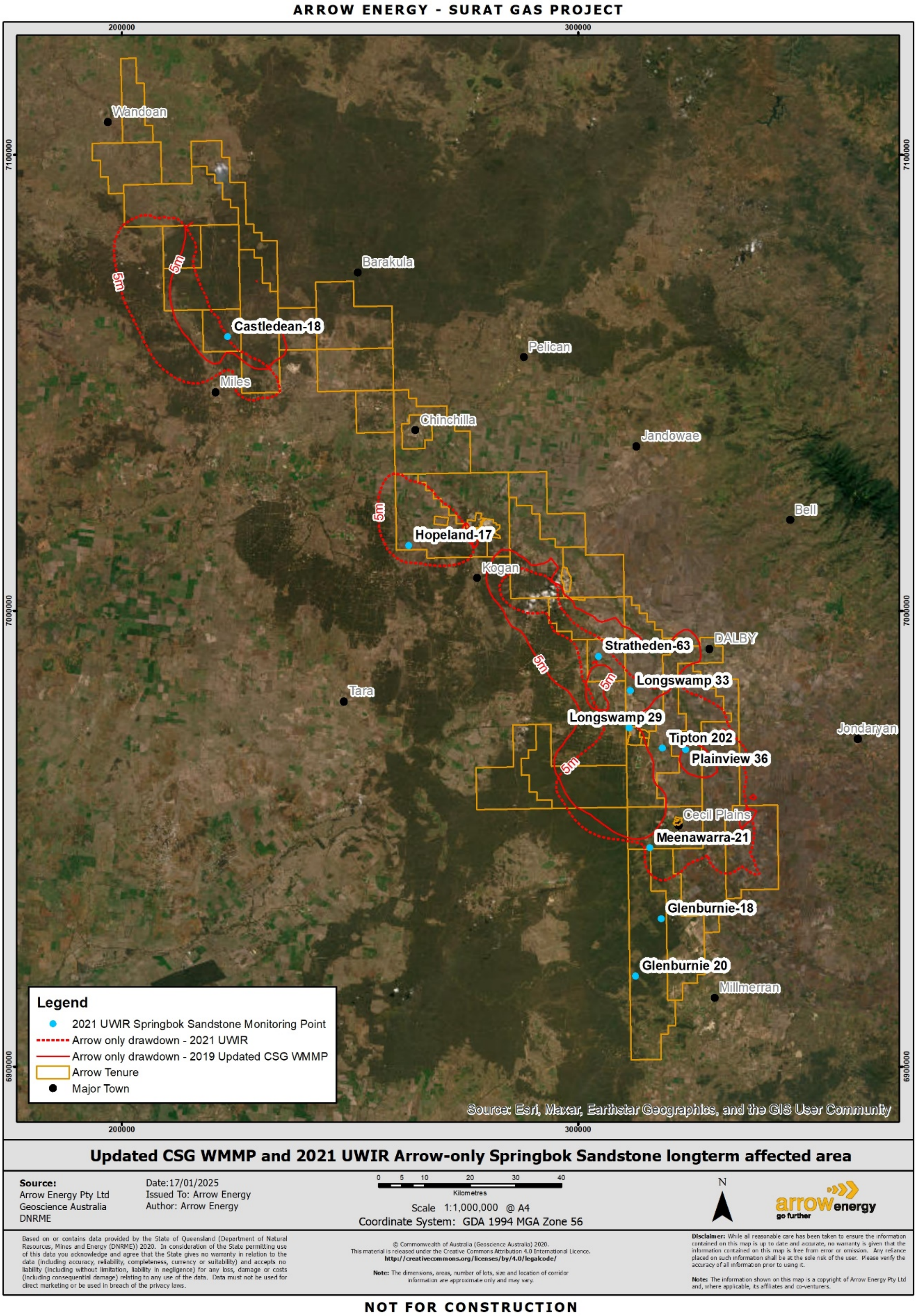
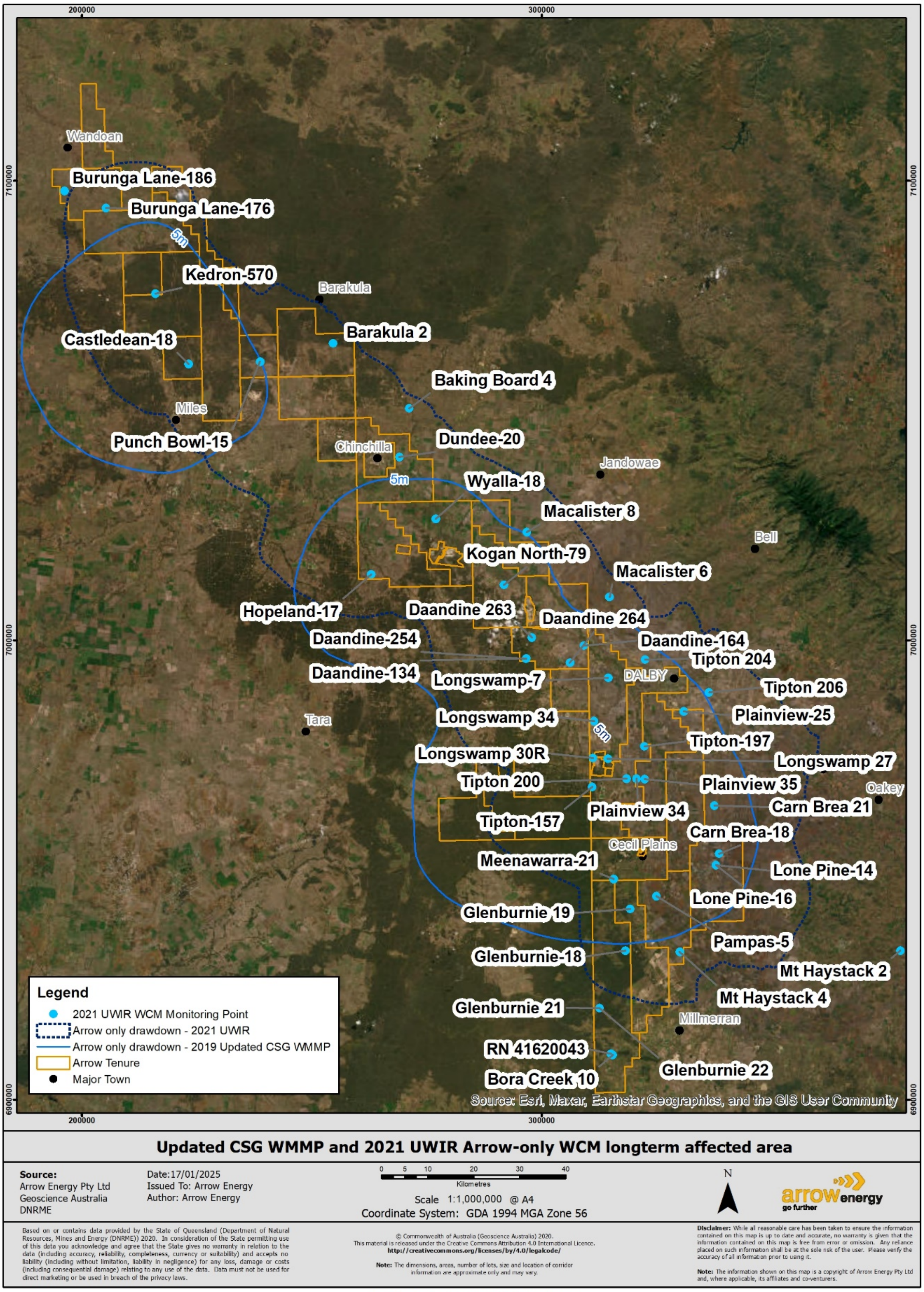


Figure 4-1: Updated CSG WMMP and 2021 UWIR Arrow-only Springbok Sandstone long-term affected area

ARROW ENERGY - SURAT GAS PROJECT



NOT FOR CONSTRUCTION

Figure 4-2: Updated CSG WMMP and 2021 UWIR Arrow-only WCM long-term affected area

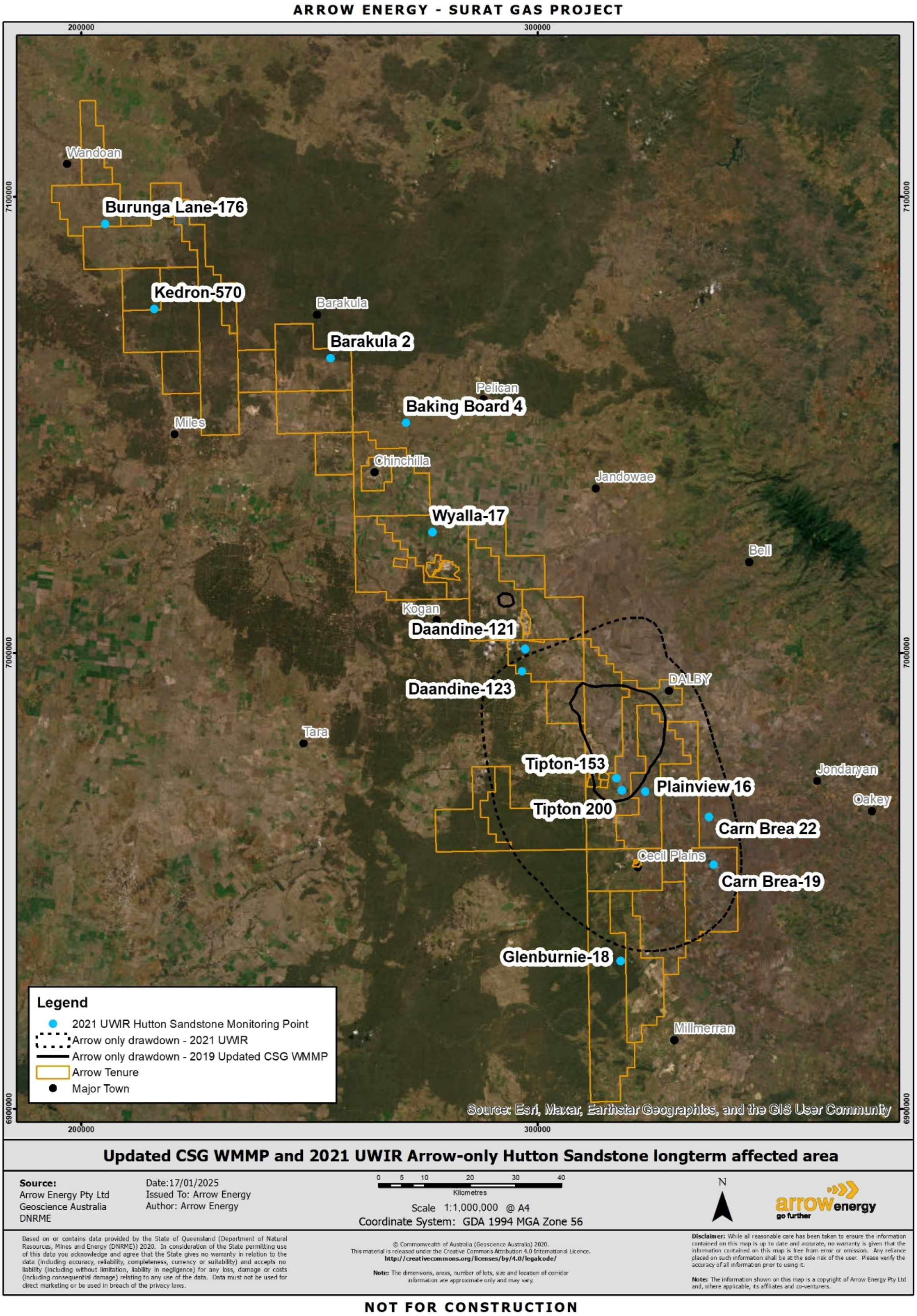


Figure 4-3: Updated CSG WMMP and 2021 UWIR Arrow-only Hutton Sandstone long-term affected area

5. WMMP Revision

In accordance with Section 8.6 of the SGP Updated CSG WMMP, assessments are required to be undertaken upon the release of a new UWIR and after receiving technical files for that UWIR. These assessments are:

- revision of the Early Warning Monitoring System (EWMS);
- risk assessment of potential terrestrial groundwater dependent ecosystems (TGDEs); and
- potential changes to stream connectivity.

An update on these assessments is provided in the following sections.

5.1 Early Warning Monitoring System (EWMS)

Updated EWMS values based on the 2021 UWIR were presented in the 2022-2023 WMMP Annual Report and were derived using data files provided by OGIA. Arrow has since identified that the files provided did not include non-CSG predicted groundwater drawdown which is required to undertake this assessment inline with section 7.5 of the SGP Updated CSG WMMP (i.e. cumulative drawdown comprising CSG and non-CSG groundwater predicted drawdown). Arrow has requested the correct data files from OGIA and, once received, will undertake the EWMS revision process, and report the results accordingly.

5.2 Risk assessment of potential TGDEs

The 2019 UWIR included an assessment of terrestrial groundwater dependent ecosystems (GDE) which was further revised in OGIA's 2019 UWIR Approval Condition 3 Response (OGIA, 2020) released on 16 December 2020. This document was submitted to the DES by OGIA as part of the conditions of approval of the 2019 UWIR[1]. The document is available from OGIA upon request. The 2021 UWIR also included an assessment of terrestrial GDEs which required a follow up desktop assessment to be conducted by Arrow. The associated technical data were provided to Arrow on 6 October 2022 in response to Arrow's request in June 2022 following the SGP commencement on 22 October 2020 and the 2021 UWIR taking effect on 1 May 2022.

Arrow was obliged to revise the TGDEs risk assessment in accordance with Section 8.6 of the SGP Updated CSG WMMP. Arrow completed the revised desktop risk assessment on 21 December 2022 (within 90 days from 6 October 2022) i.e. within 90 days of a new approved UWIR being issued (and upon receiving technical files from OGIA). Arrow's revised risk assessment is provided in Appendix C.

5.3 Field assessment of potential TGDEs

As outlined in the 2022-2023 WMMP Annual Report, Arrow completed a desktop assessment of potential TGDEs potentially at risk of impact from cumulative CSG operations as predicted in the 2021 UWIR. This assessment identified eight

[1] The Chief Executive of the Department of Environment and Science approved the 2019 Surat CMA UWIR on 16 December 2019 with conditions including Condition 3 which required submission of an environmental values assessment with the first annual review that updates the assessment of impacts presented in the approved UWIR on the following environment values: a. terrestrial groundwater dependent ecosystems; b. changes in water quality of each aquifer; and c. irrigation land.

sites requiring further field assessment to be undertaken during dry periods to gather supporting data to confirm the ecosystems' reliance on groundwater and validate the findings of the desktop assessment (refer to the 2022-2023 WMMP Annual Report for further details).

During this reporting period, Arrow attempted to undertake field surveys of the eight sites however mobilisations were delayed due to above average rainfall in the first half of 2024 and subsequent contractor availability. Nonetheless, Arrow undertook field surveys from 30 September to 4 October 2024 covering three of the sites. The report for these field surveys is pending. A further field survey was scheduled for the start of December 2024 however above average rainfall occurred again in the lead up to the field survey, which would have impacted the quality of the data collection, and so it was postponed.

5.4 Potential changes to stream connectivity

Section 5.2 of the SGP Updated CSG WMMP requires Arrow to reassess potential changes to stream connectivity upon each new UWIR being issued and upon receiving technical files from OGIA for that UWIR. If triggered, Arrow will submit a revised WMMP within 90 days (following the initial 90 days for the reassessment) for Ministerial approval.

The SGP Updated CSG WMMP assessment of impacts to stream connectivity used the flux through the base of the Condamine Alluvium applied to the base of the Central Condamine Alluvium Model (CCAM). Analysis of the CCAM modelled results found that potential impacts to downstream users and environmental flow objectives was assessed as negligible, with almost no discernible impact from CSG production. The modelling demonstrated that the maximum flux changes to the Condamine River are small and the predicted impacts to the river and water resource are negligible under the FDP cases current at the time of writing the SGP Updated CSG WMMP.

Potential changes to stream connectivity are reassessed by comparison of the predicted magnitude of the groundwater flux changes provided in the SGP Updated CSG WMMP and that determined using the latest UWIR.

Assessment of CSG induced flux between the Condamine Alluvium and the underlying Great Artesian Basin (GAB) formations is undertaken by OGIA as part of numerical modelling for the UWIR. As documented in the 2021 UWIR, predicted impacts on the Condamine Alluvium are minor despite the proximity of CSG fields, reflecting the relatively high storage, transmissivity, and incidental recharge to this aquifer. The magnitude of CSG induced drawdown is less than 0.3 m for most of the Condamine Alluvium, and the average net loss or flux of water from the Condamine Alluvium to the Walloon Coal Measures is predicted in the 2021 UWIR to be about 1,270 ML/year over the next 100 years. This flux is higher than predictions in the 2019 UWIR (735 ML/year) but comparable to predictions in the 2012 UWIR (1,100 ML/year) and 2016 UWIR (1,160 ML/year) and therefore the SGP Updated CSG WMMP's predicted negligible impact. A revised WMMP is not required as a result of this assessment.

6. Compliance with the WMMP

The approved SGP Updated CSG WMMP was developed based on an adaptive management framework which meets the water-related approval conditions.

Compliance, therefore, with the SGP Updated CSG WMMP demonstrates compliance with the approval conditions.

Throughout the reporting period, Arrow maintained compliance with the WMMP with the exception of eighteen bores which had periods with no groundwater level/pressure monitoring (Section 3.1). Compliance with the WMMP is demonstrated through:

- publication of the approved Updated CSG WMMP on Arrow's website
- publication of this annual report on Arrow's website within three months of the anniversary of the start of the SGP
- providing raw data to OGIA as required in Section 9.13 of the 2021 UWIR for potential inclusion (at the discretion of Department of Regional Development, Manufacturing and Water [DRDMW]) on the Queensland Globe database
- met performance measure criteria for assessment of the protection of matters of national environmental significance (MNES), namely:
    - adequacy of the groundwater monitoring network was reviewed according to the predicted drawdown from a new OGIA model (2021 UWIR) (Section 4.1 and 4.2)
    - Completion of field assessment of potential TGDEs (three sites) based on desktop TGDEs risk assessment conducted by Arrow following the release of 2021 UWIR (Section 5.2)
- monitoring obligations (groundwater and subsidence) were carried out in accordance with the 2021 UWIR with the exception of Tipton-197, Tipton 196A, Tipton 200, Tipton 204, Tipton 206, Tipton-194, Kedron-570, Glenburnie 21, Glenburnie 22, Daandine-123, Glenburnie-18, Kogan North-79, Longswamp 27, Longswamp 30R, Mt Haystack 2, Pampas 18, Plainview-25, and Bora Creek 10 which had periods with no groundwater level/pressure monitoring (Section 3.1)
- the EWMS was implemented noting that there were no exceedances of early warning indicators, trigger thresholds or limits during the reporting period.

In addition to the above, Arrow's compliance with all EPBC Approval 2010/5344 conditions is documented in the report Surat – EPBC Approval 2010/5344 Annual Compliance Report 2023/2024 (S00-ARW-ENV-REP-00067) available on Arrow's website.

7. Document Administration

This document has been created using ORG-ARW-IMT-TEM-00005 v4.0

Revision history

Revision	Revision Date	Revision Summary	Author
1	19/01/2025	Issued for Use	Yousef Beiraghdar

Related documents

Document Number	Document title

Acceptance and release

Author

Position	Incumbent	Release Date
Team Lead Hydrogeology	Yousef Beiraghdar	19/01/2025

Stakeholders and reviewers

Position	Incumbent	Review Date
Team Lead Subsidence	Kane Eskola	19/01/2025
Groundwater Manager	Stephen Denner	19/01/2025

Approver(s)

Position	Incumbent	Approval Date
Groundwater Manager	Stephen Denner	20/01/2025

8. References

Aghighi, H, Schöning, G, Cui, T, Pandey, S, (2023). *Exploring the contribution of coal shrinkage to coal seam gas induced subsidence: a research update paper by the Office of Groundwater Impact Assessment (OGIA)*, Department of Regional Development, Manufacturing and Water, Queensland Government, April 2023.

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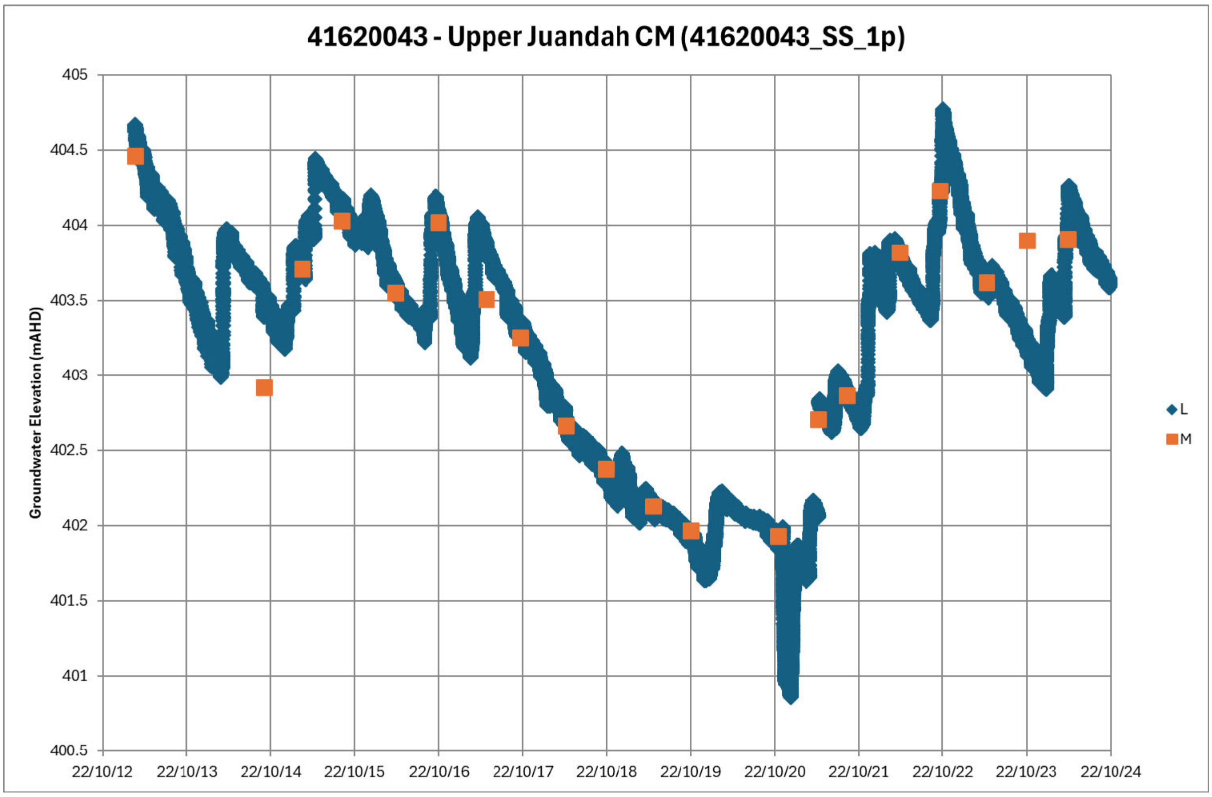
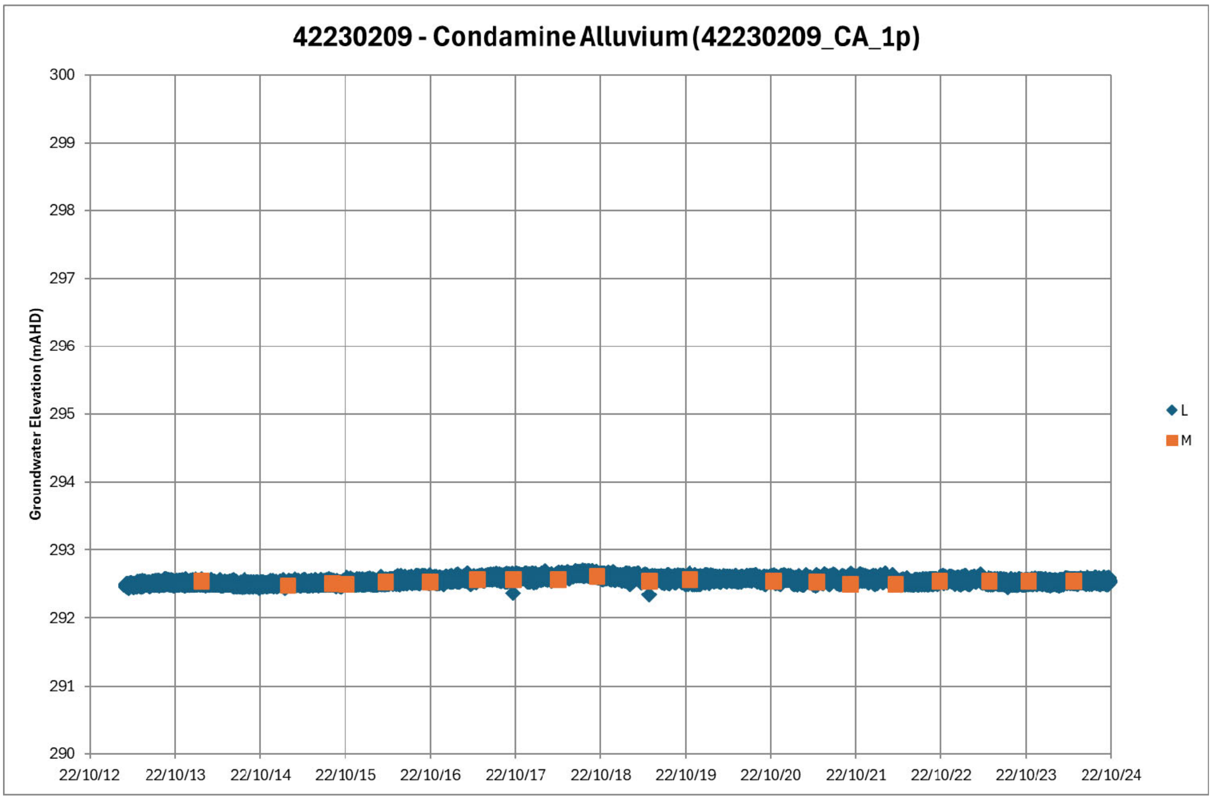
Queensland Water Commission (QWC), 2012. *Underground Water Impact Report for the Surat Cumulative Management Area*. Queensland Government, July 2012.

Appendix A – Groundwater Level Monitoring Bores Hydrographs


41620043 - Upper Juandah CM (41620043_SS_1p)
Groundwater Elevation (mAHD)
405
404.5
404
403.5
403
402.5
402
401.5
401
400.5
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M


42230209 - Condamine Alluvium (42230209_CA_1p)
Groundwater Elevation (mAHD)
300
299
298
297
296
295
294
293
292
291
290
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
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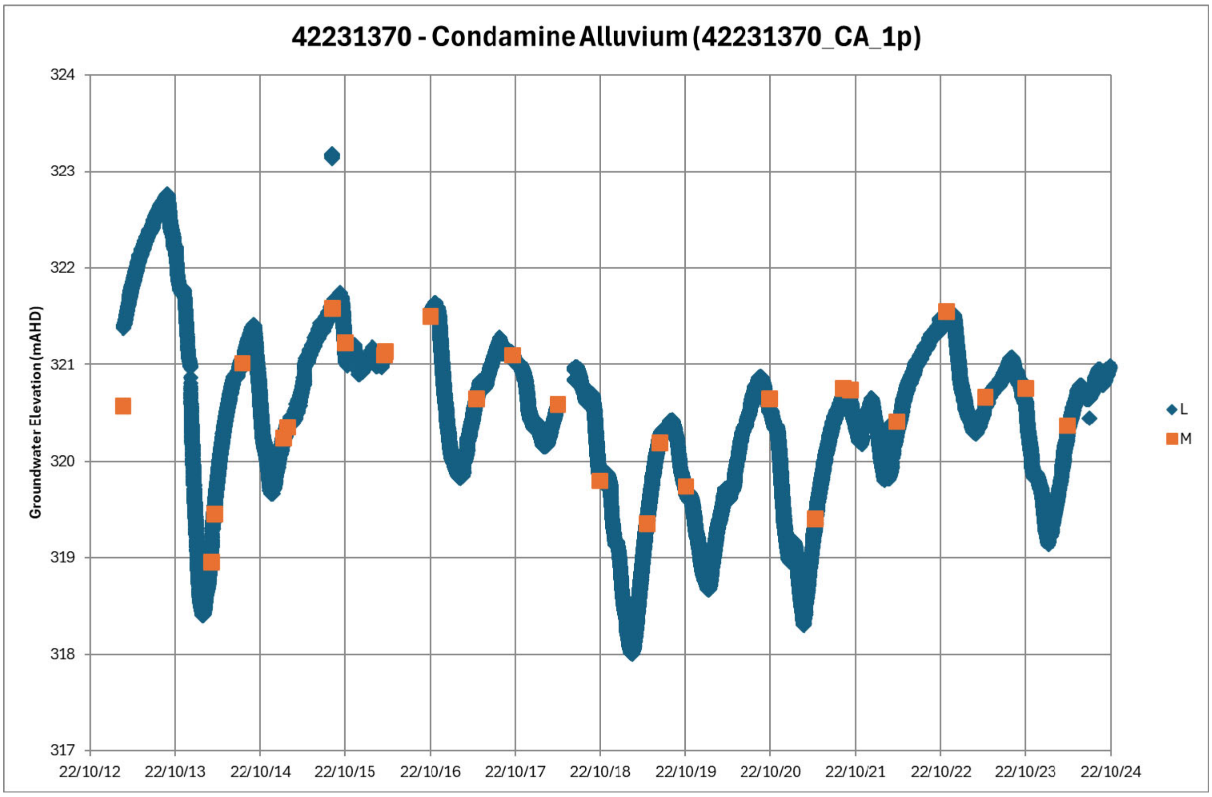
22/10/24
L
M


42231370 - Condamine Alluvium (42231370_CA_1p)
Groundwater Elevation (mAHD)
324
323
322
321
320
319
318
317
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
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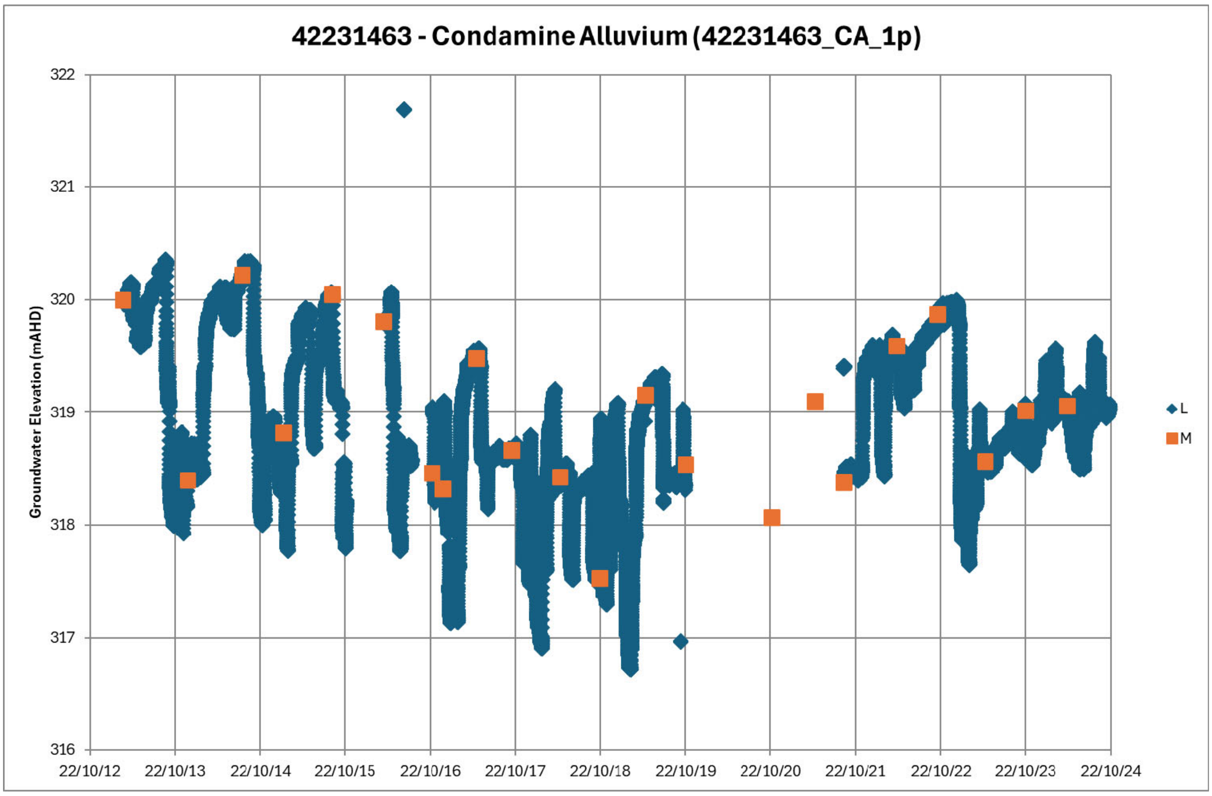
22/10/24
L
M


42231463 - Condamine Alluvium (42231463_CA_1p)
Groundwater Elevation (mAHD)
322
321
320
319
318
317
316
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
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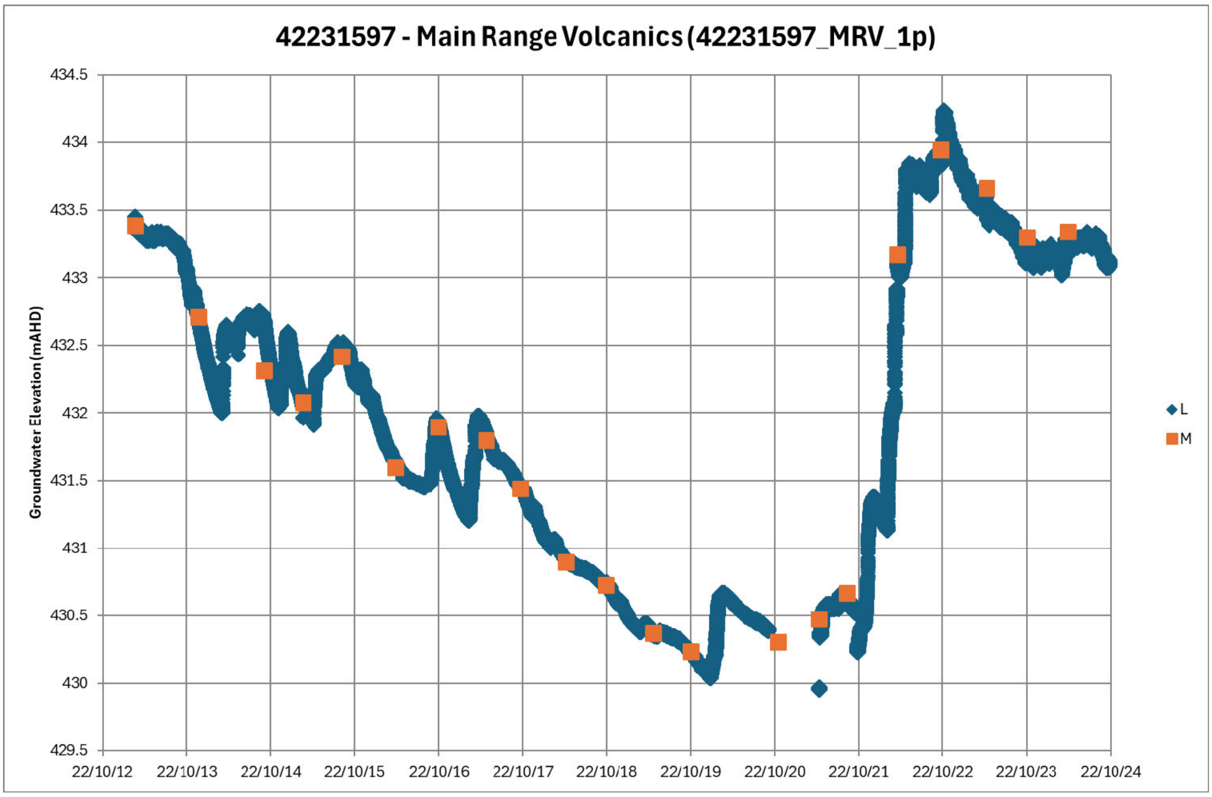
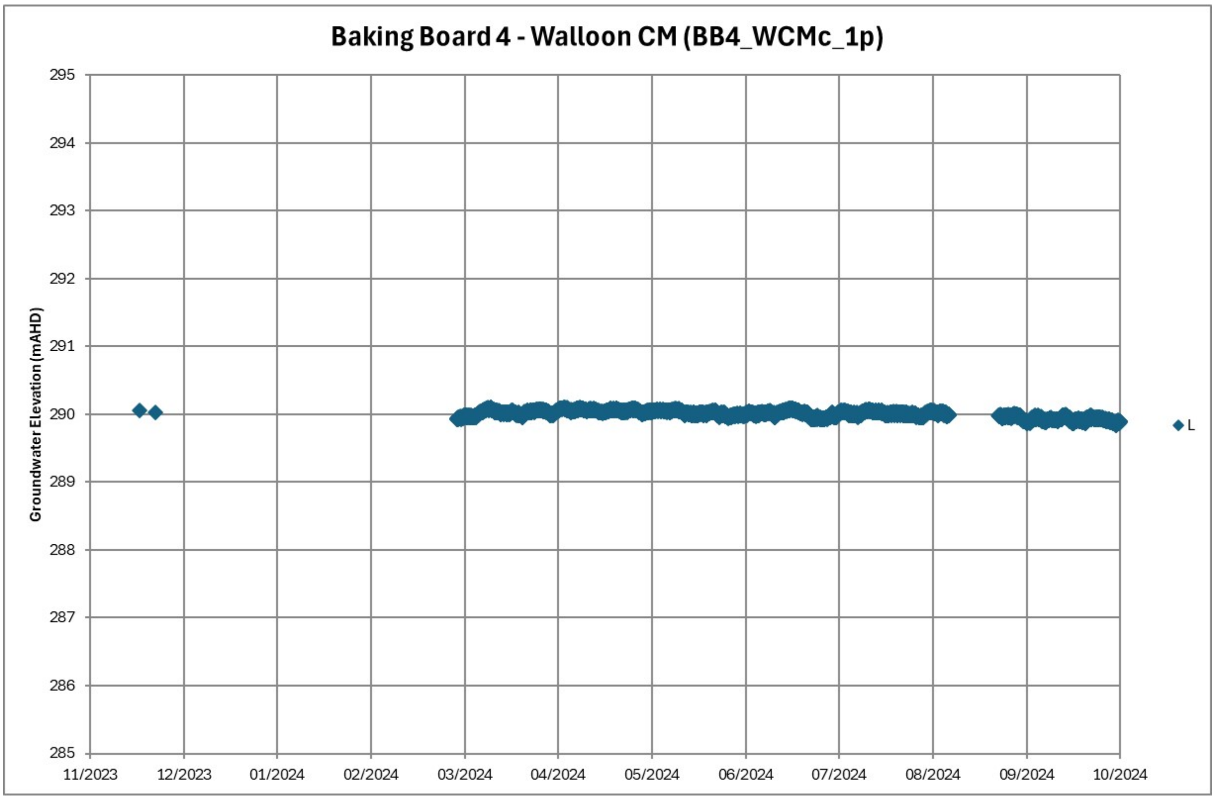
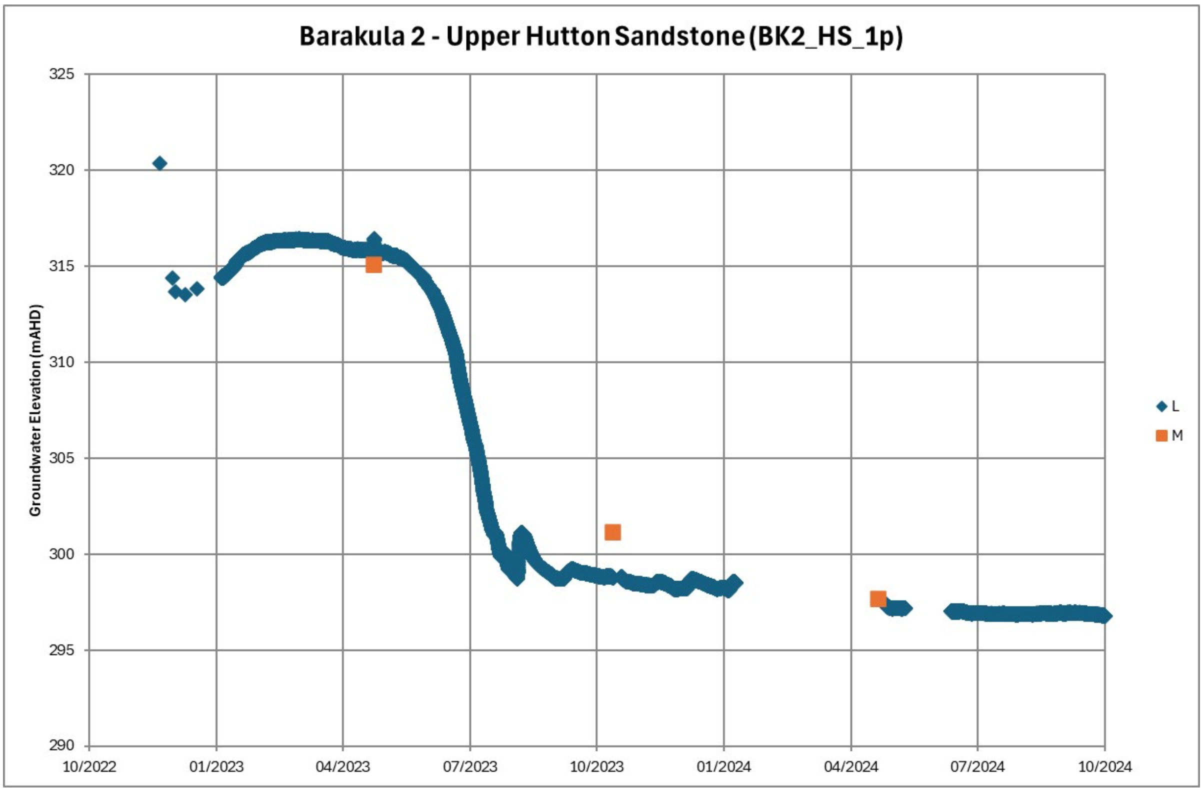
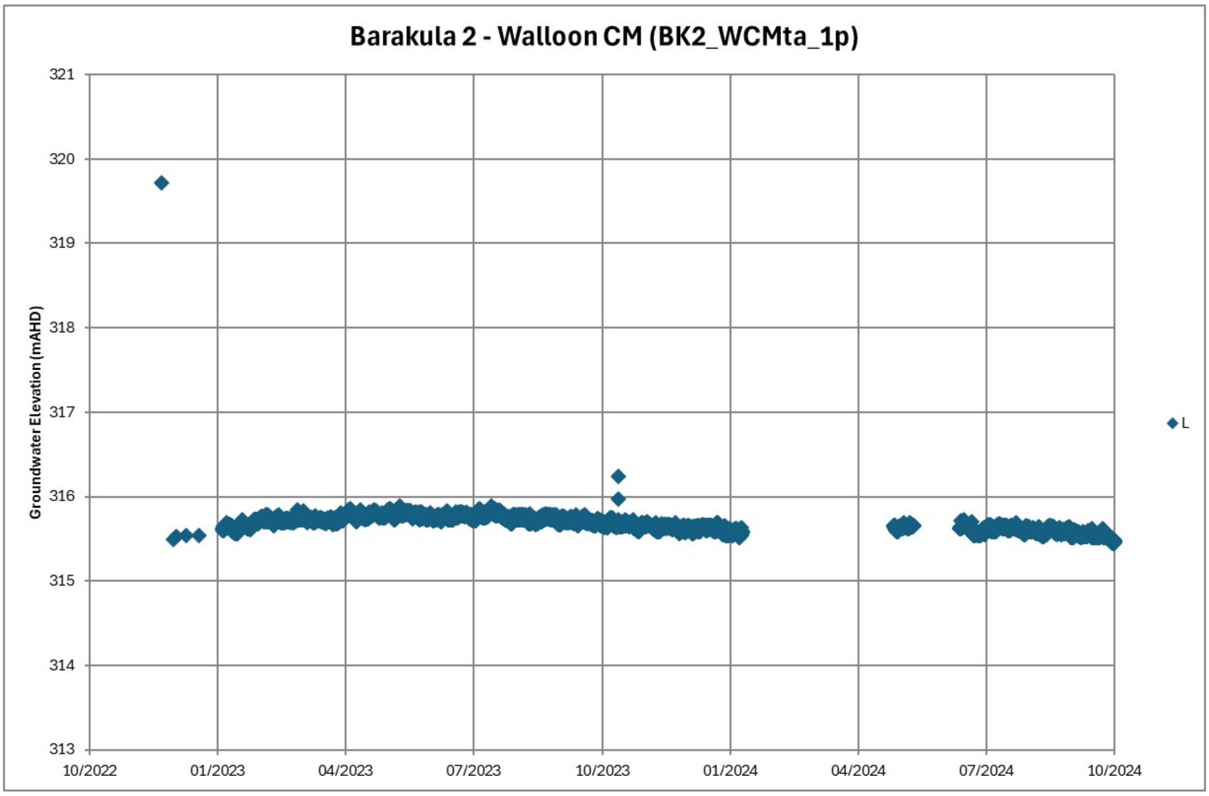
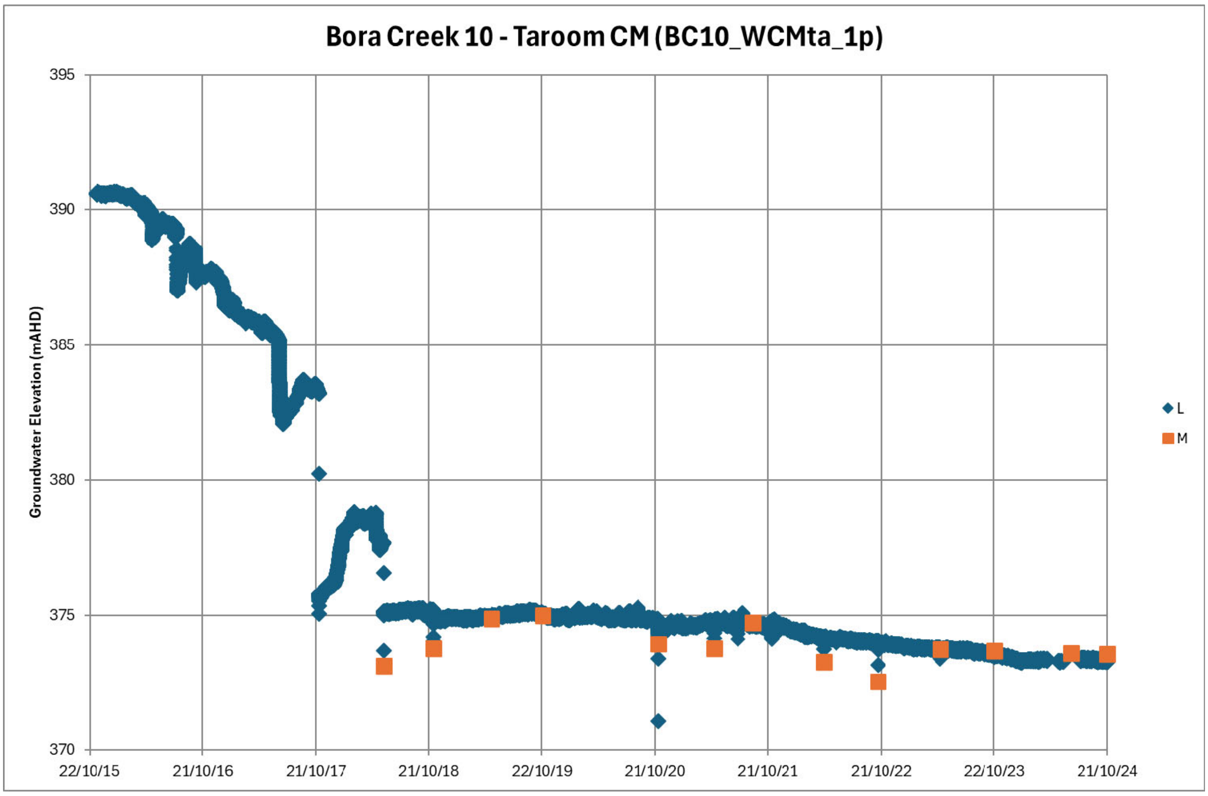
22/10/24
L
M

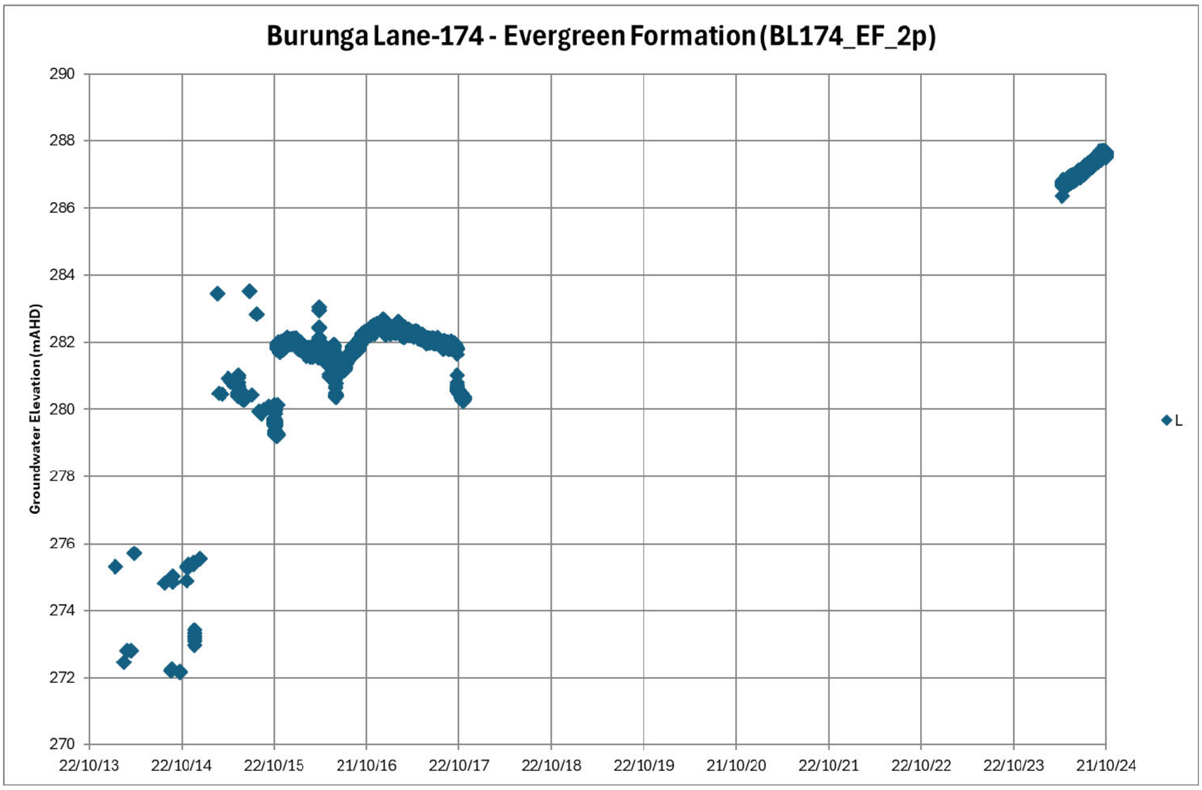

42231597 - Main Range Volcanics (42231597_MRV_1p)
Groundwater Elevation (mAHD)
434.5
434
433.5
433
432.5
432
431.5
431
430.5
430
429.5
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

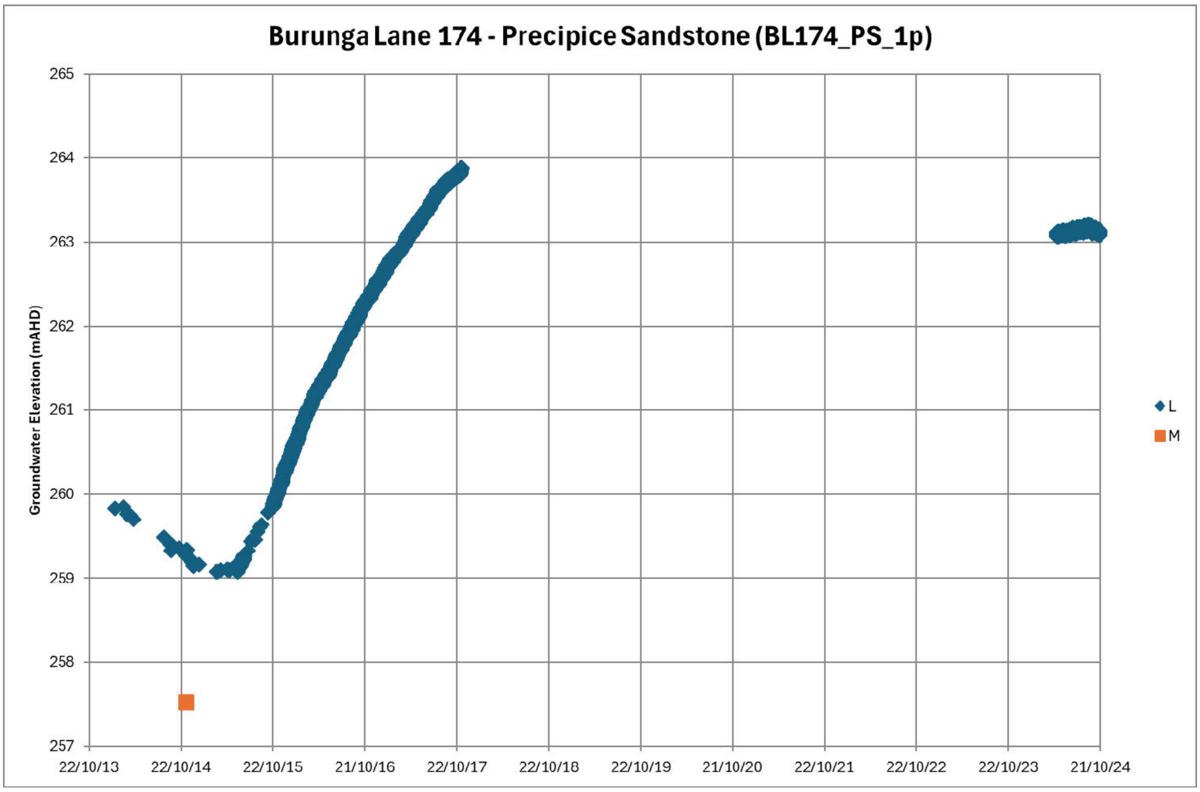

Baking Board 4 - Walloon CM (BB4_WCMc_1p)
Groundwater Elevation (mAHD)
295
294
293
292
291
290
289
288
287
286
285
11/2023
12/2023
01/2024
02/2024
03/2024
04/2024
05/2024
06/2024
07/2024
08/2024
09/2024
10/2024
L

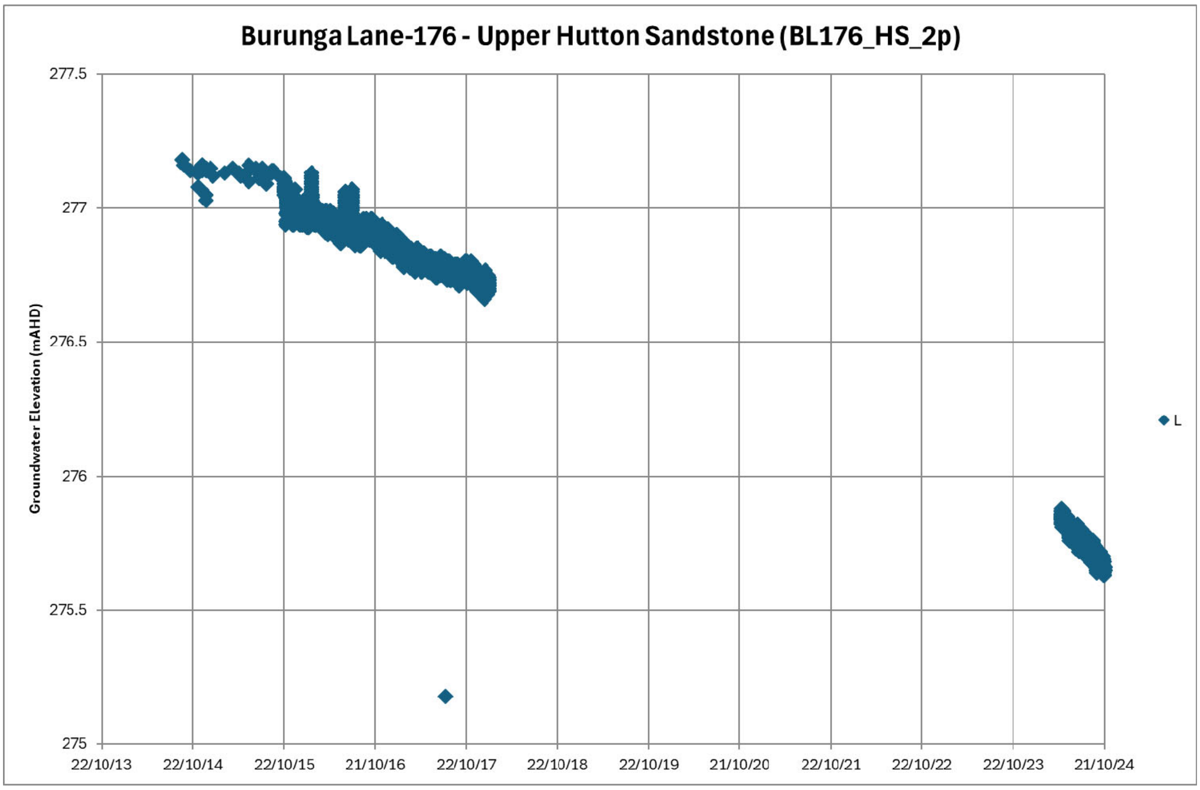

Barakula 2 - Upper Hutton Sandstone (BK2_HS_1p)
Groundwater Elevation (mAHD)
325
320
315
310
305
300
295
290
10/2022
01/2023
04/2023
07/2023
10/2023
01/2024
04/2024
07/2024
10/2024
L
M

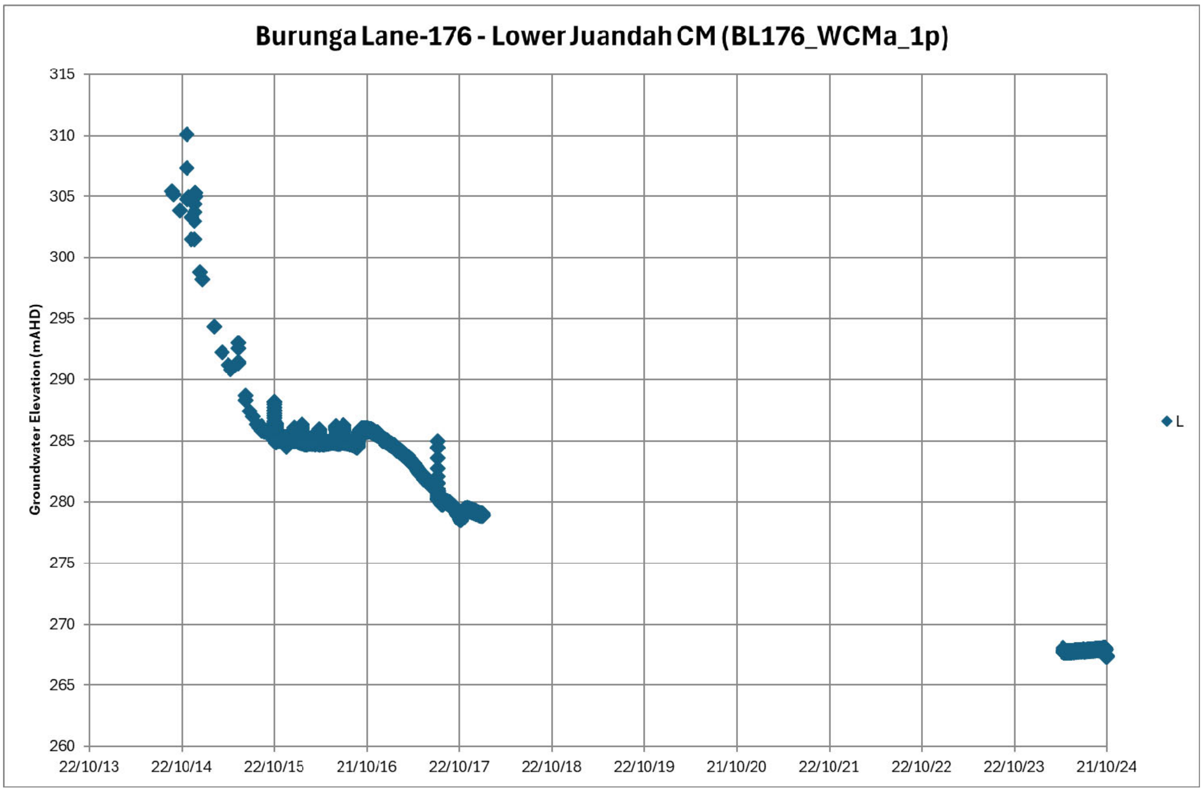

Barakula 2 - Walloon CM (BK2_WCMta_1p)
Groundwater Elevation (mAHD)
321
320
319
318
317
316
315
314
313
10/2022
01/2023
04/2023
07/2023
10/2023
01/2024
04/2024
07/2024
10/2024
L

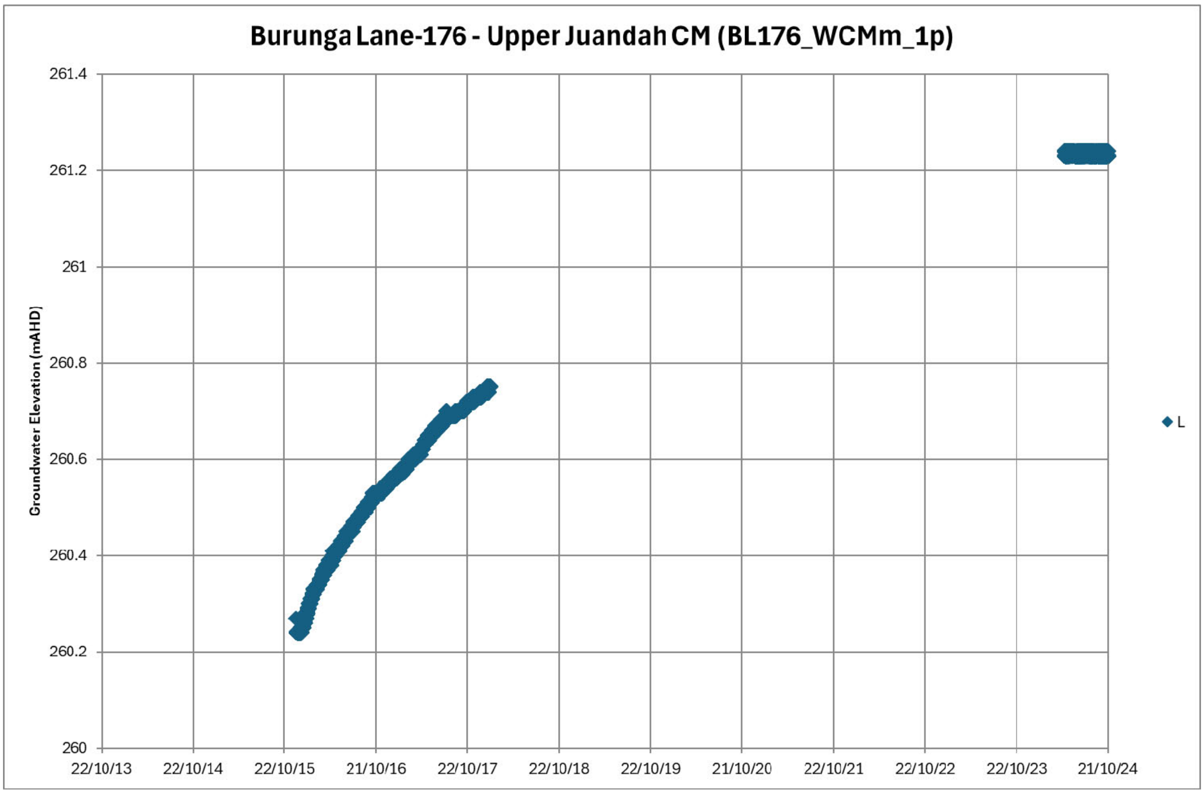

Bora Creek 10 - Taroom CM (BC10_WCMta_1p)
Groundwater Elevation (mAHD)
395
390
385
380
375
370
22/10/15
21/10/16
21/10/17
21/10/18
22/10/19
21/10/20
21/10/21
21/10/22
22/10/23
21/10/24
L
M

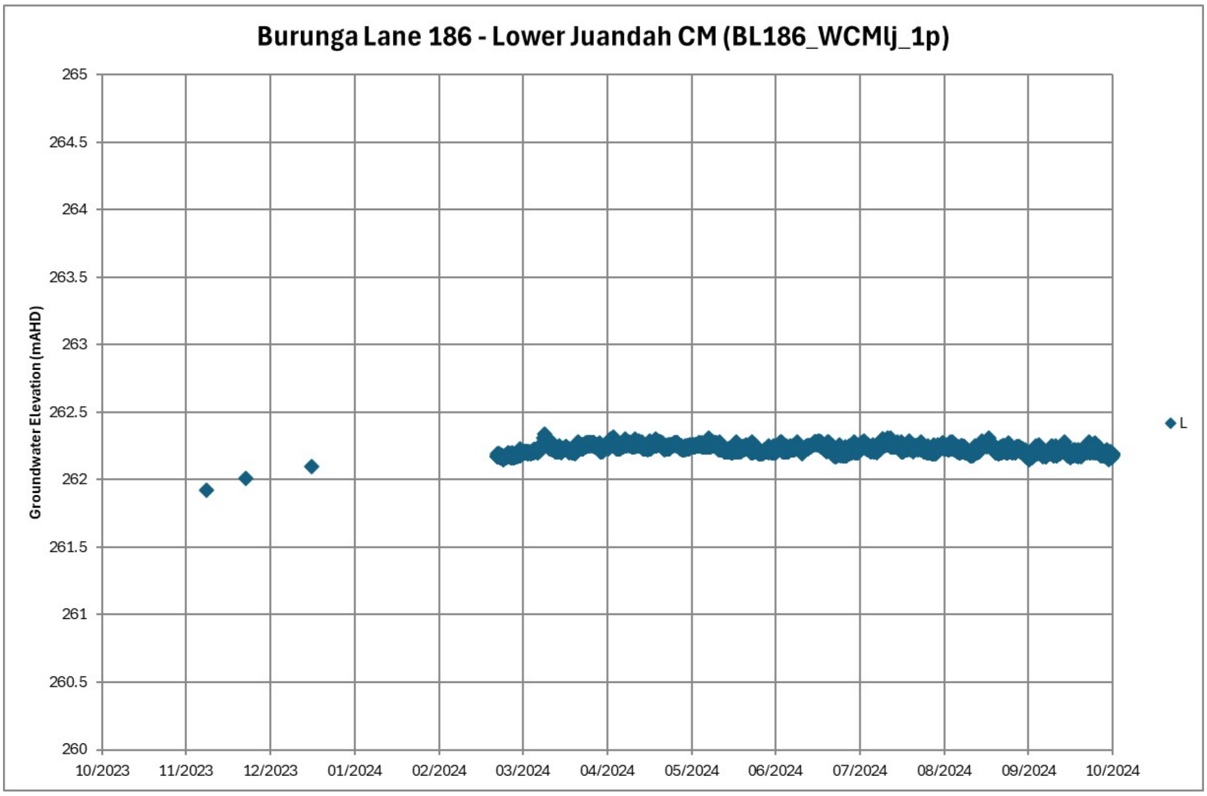

Burunga Lane-174 - Evergreen Formation (BL174_EF_2p)
Groundwater Elevation (mAHD)
290
288
286
284
282
280
278
276
274
272
270
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

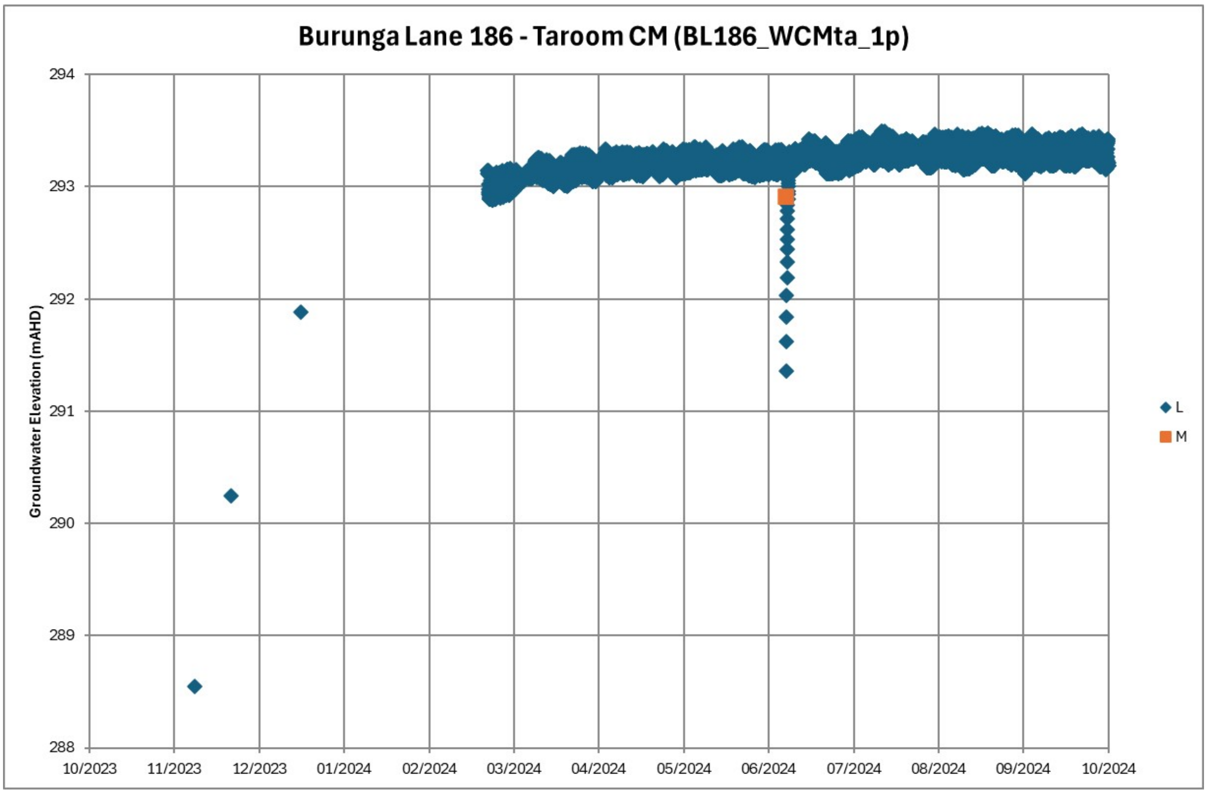

Burunga Lane 174 - Precipice Sandstone (BL174_PS_1p)
Groundwater Elevation (mAHD)
265
264
263
262
261
260
259
258
257
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

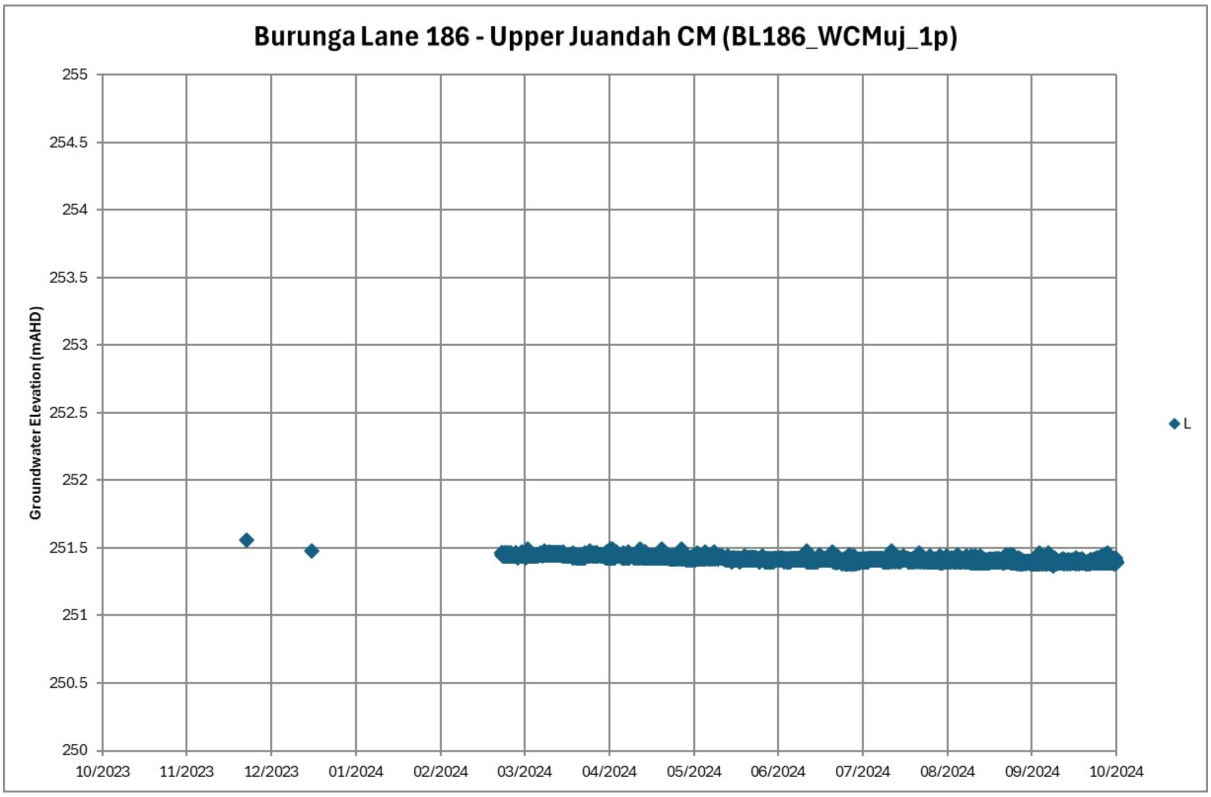

Burunga Lane-176 - Upper Hutton Sandstone (BL176_HS_2p)
Groundwater Elevation (mAHD)
277.5
277
276.5
276
275.5
275
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

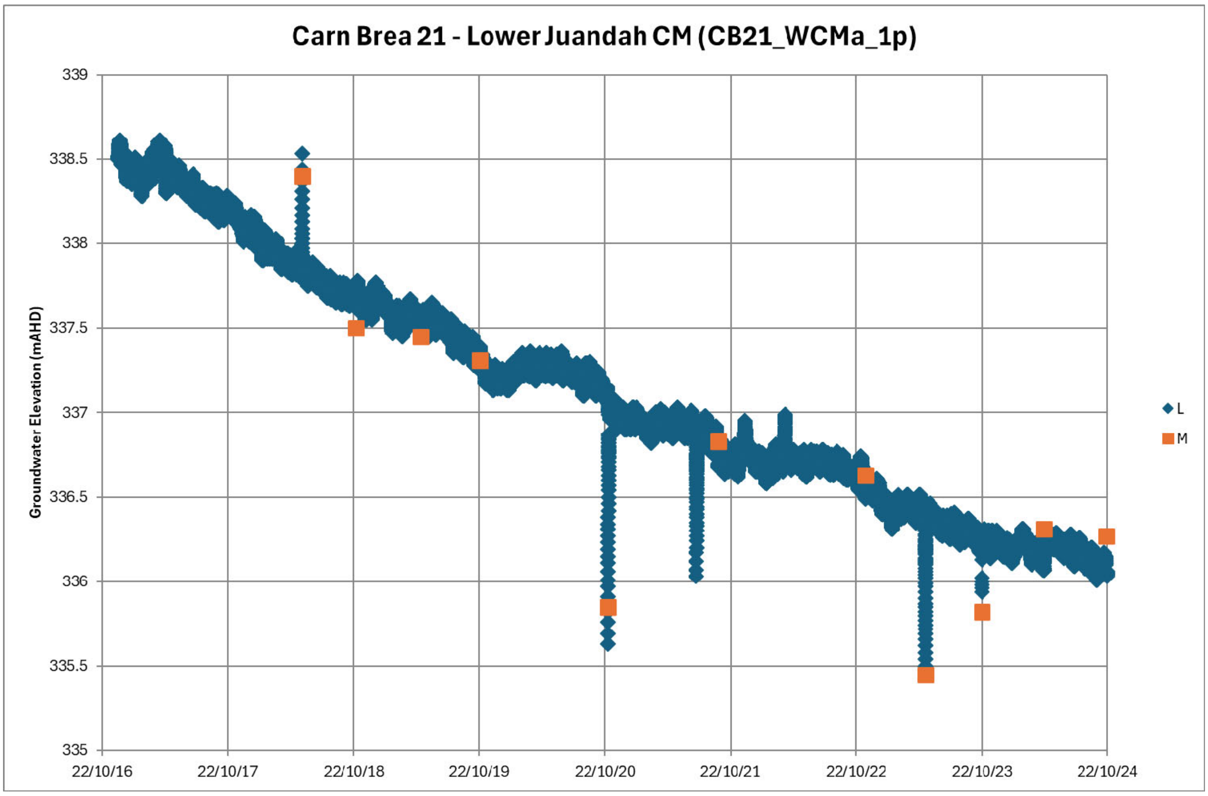

Burunga Lane-176 - Lower Juandah CM (BL176_WCMa_1p)
Groundwater Elevation (mAHD)
315
310
305
300
295
290
285
280
275
270
265
260
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

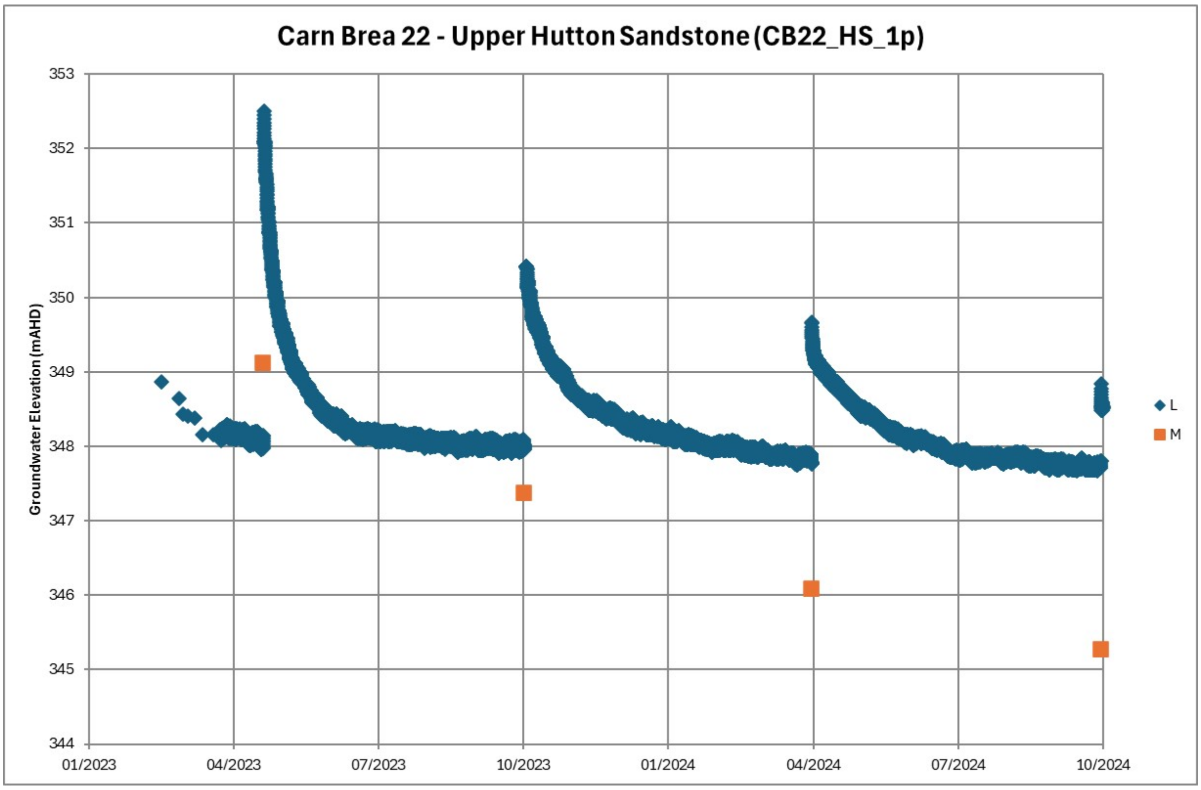

Burunga Lane-176 - Upper Juandah CM (BL176_WCMm_1p)
Groundwater Elevation (mAHD)
261.4
261.2
261
260.8
260.6
260.4
260.2
260
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L


Burunga Lane 186 - Lower Juandah CM (BL186_WCMlj_1p)
Groundwater Elevation (mAHD)
265
264.5
264
263.5
263
262.5
262
261.5
261
260.5
260
10/2023
11/2023
12/2023
01/2024
02/2024
03/2024
04/2024
05/2024
06/2024
07/2024
08/2024
09/2024
10/2024
L

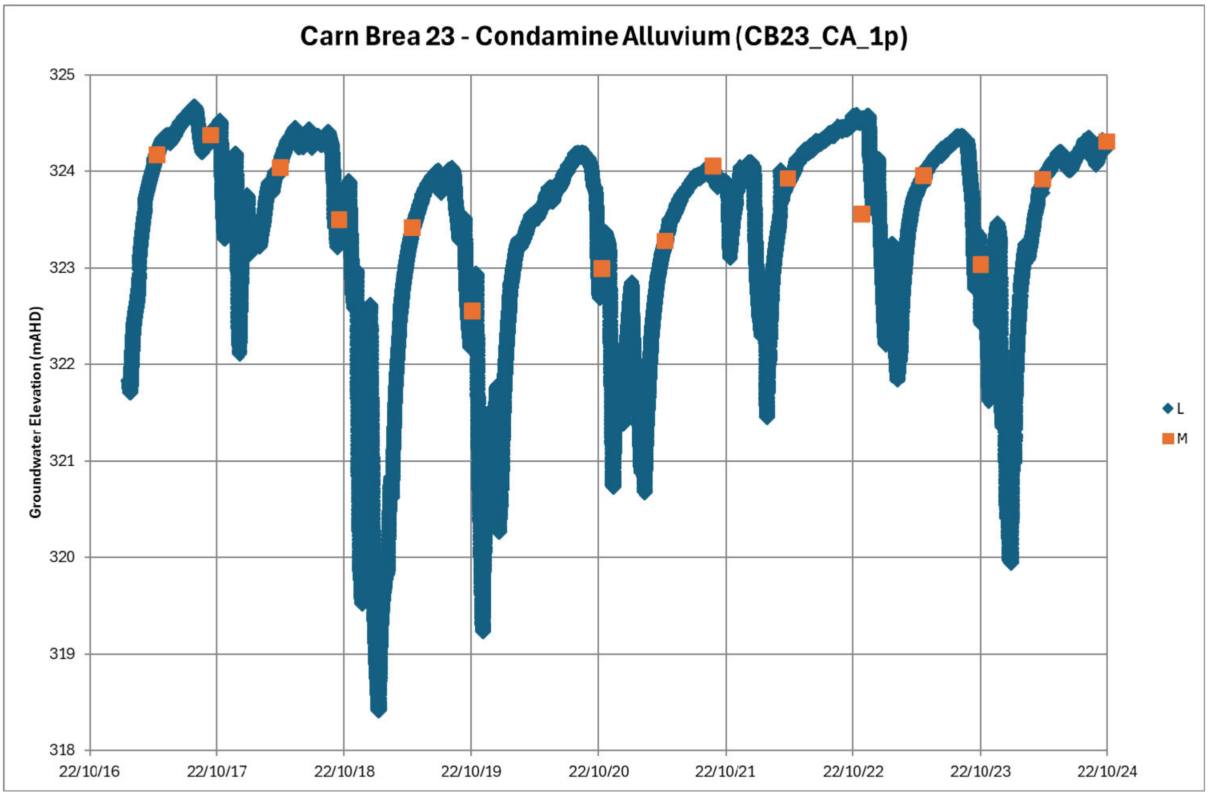

Burunga Lane 186 - Taroom CM (BL186_WCMta_1p)
Groundwater Elevation (mAHD)
294
293
292
291
290
289
288
10/2023
11/2023
12/2023
01/2024
02/2024
03/2024
04/2024
05/2024
06/2024
07/2024
08/2024
09/2024
10/2024
L
M


Burunga Lane 186 - Upper Juandah CM (BL186_WCMuj_1p)
Groundwater Elevation (mAHD)
255
254.5
254
253.5
253
252.5
252
251.5
251
250.5
250
10/2023
11/2023
12/2023
01/2024
02/2024
03/2024
04/2024
05/2024
06/2024
07/2024
08/2024
09/2024
10/2024
L

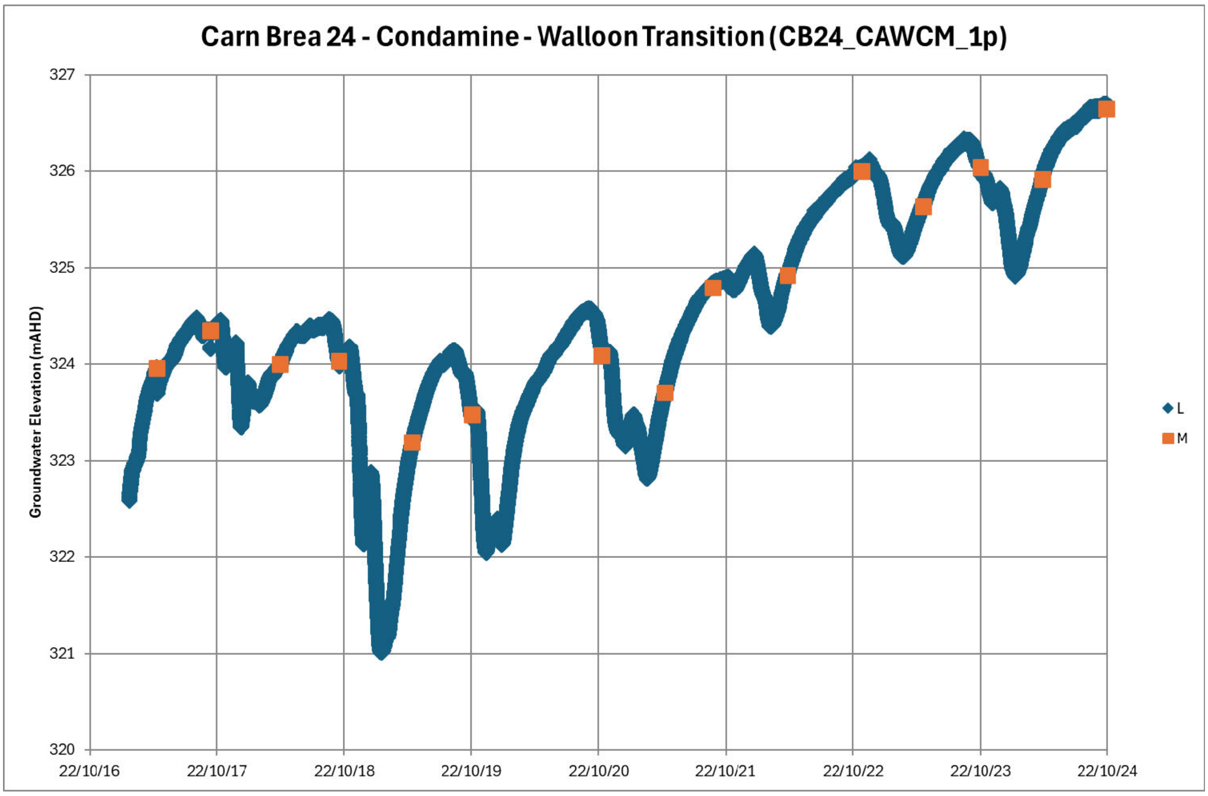

Carn Brea 21 - Lower Juandah CM (CB21_WCMa_1p)
Groundwater Elevation (mAHD)
339
338.5
338
337.5
337
336.5
336
335.5
335
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

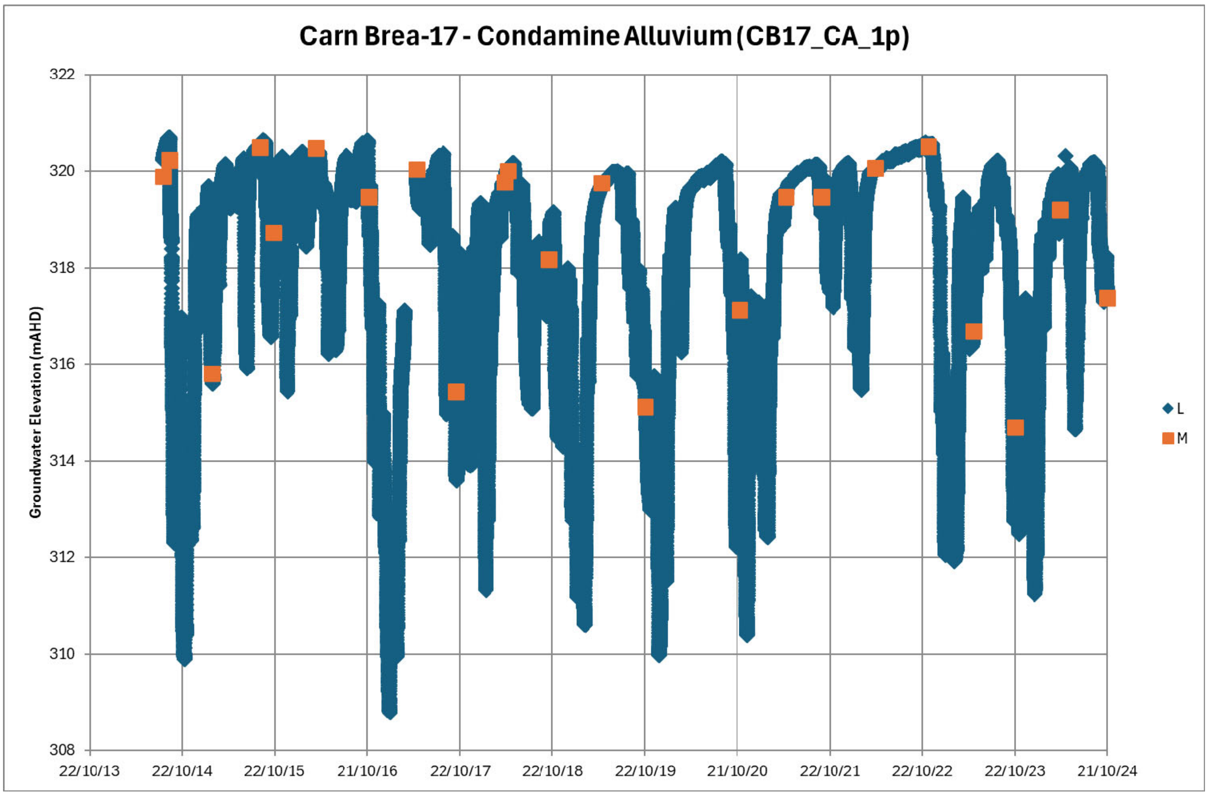


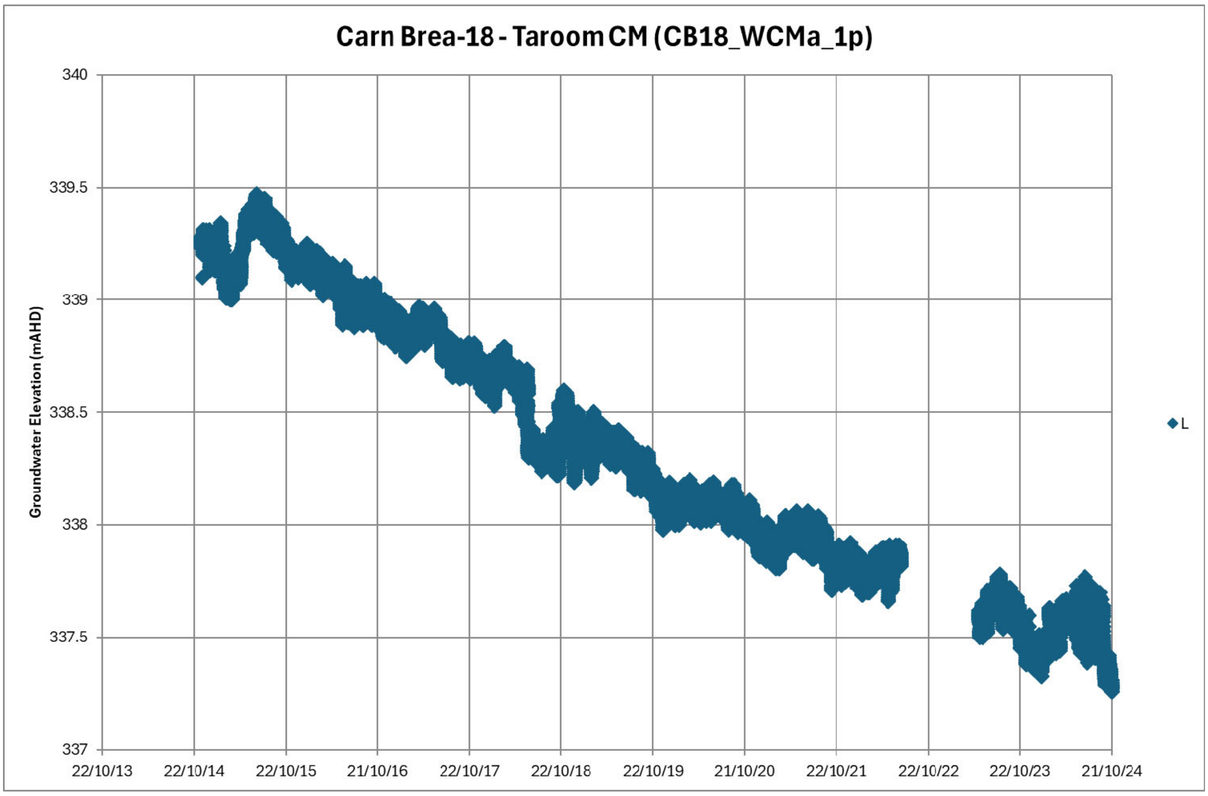
Carn Brea 22 - Upper Hutton Sandstone (CB22_HS_1p)
Groundwater Elevation (mAHD)
353
352
351
350
349
348
347
346
345
344
01/2023
04/2023
07/2023
10/2023
01/2024
04/2024
07/2024
10/2024
L
M

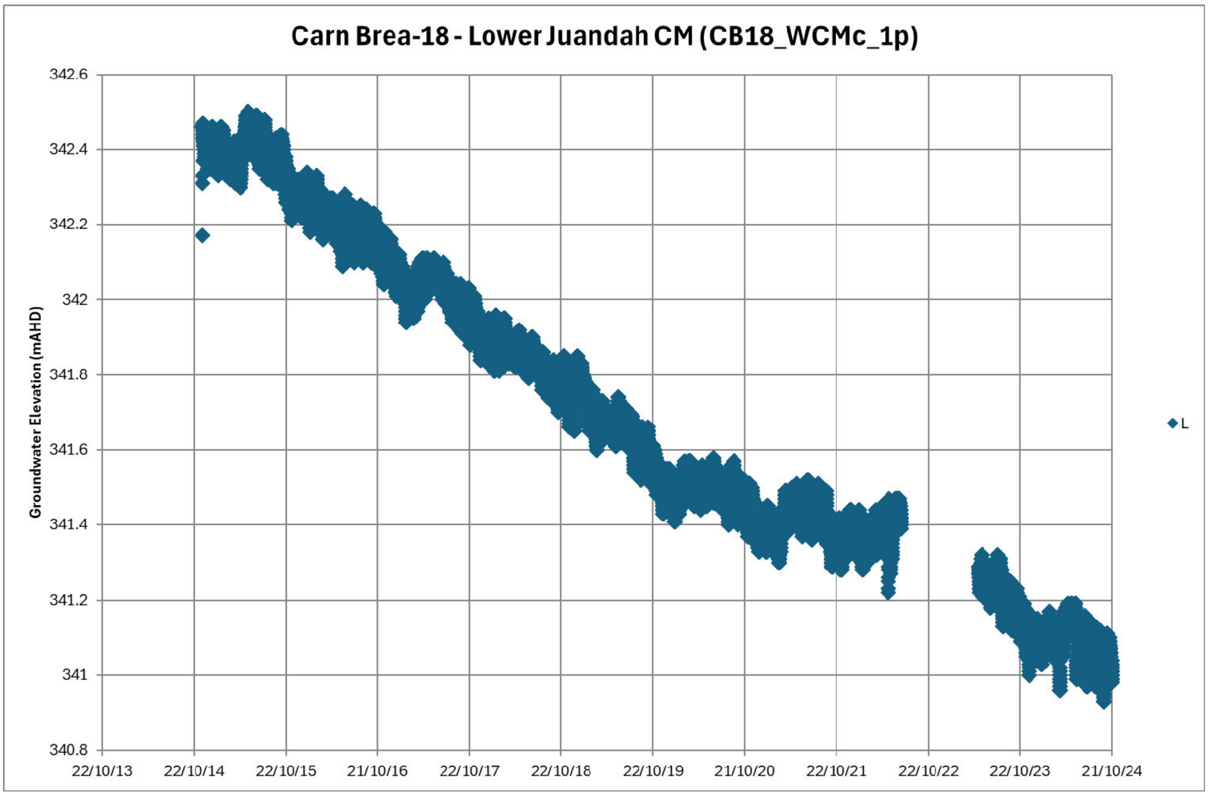


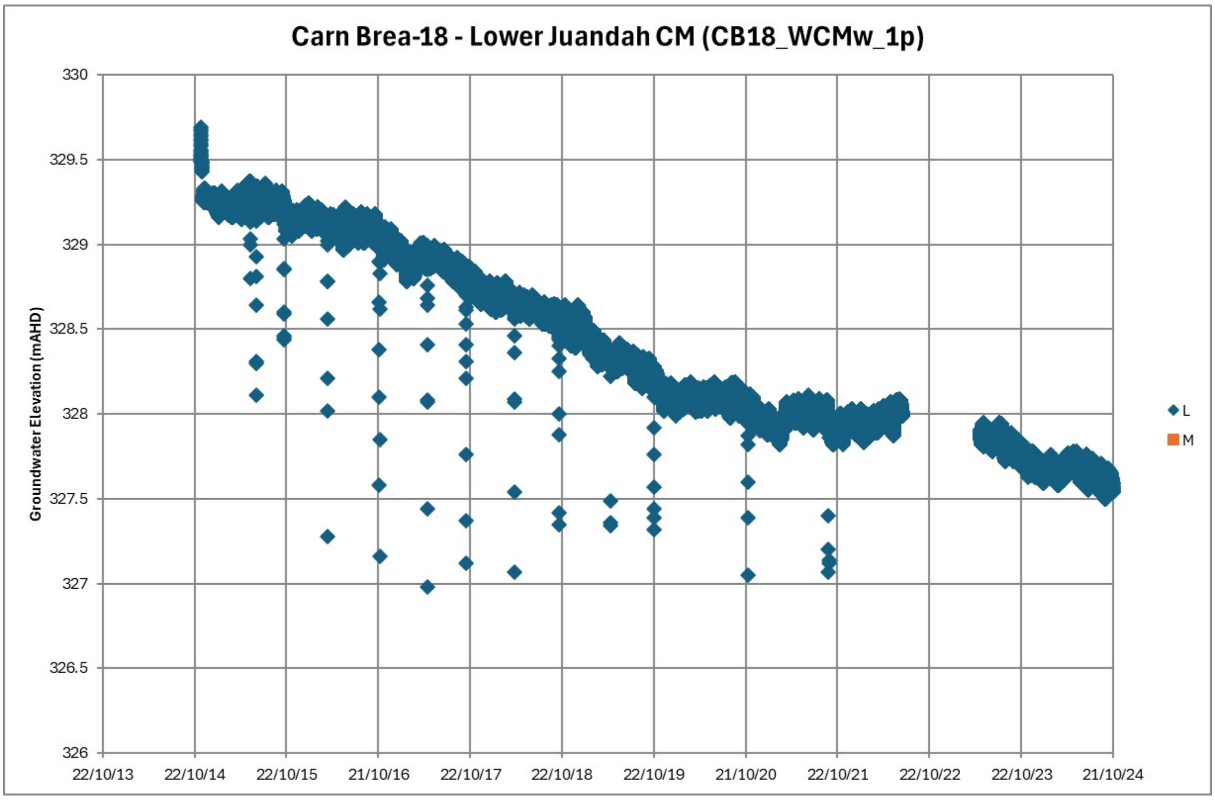
Carn Brea 23 - Condamine Alluvium (CB23_CA_1p)
Groundwater Elevation (mAHD)
325
324
323
322
321
320
319
318
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

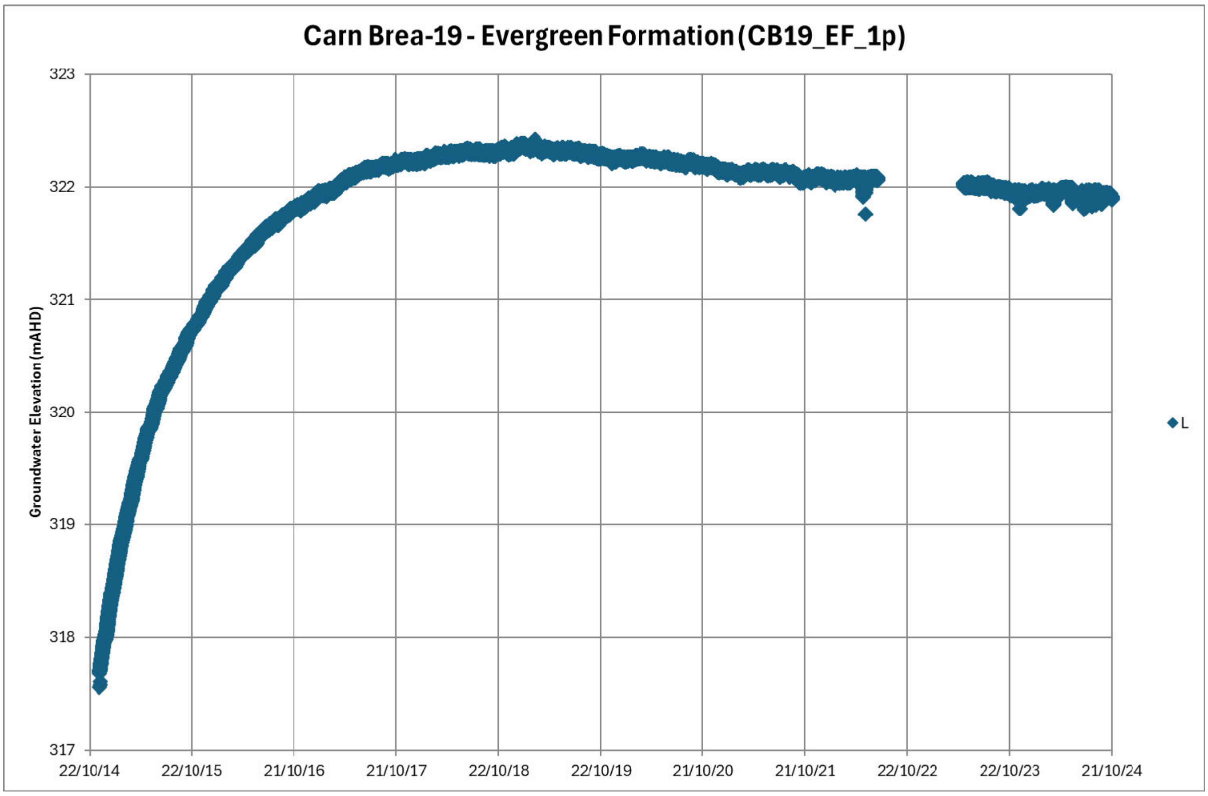

Carn Brea 24 - Condamine - Walloon Transition (CB24_CAWCM_1p)
Groundwater Elevation (mAHD)
327
326
325
324
323
322
321
320
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

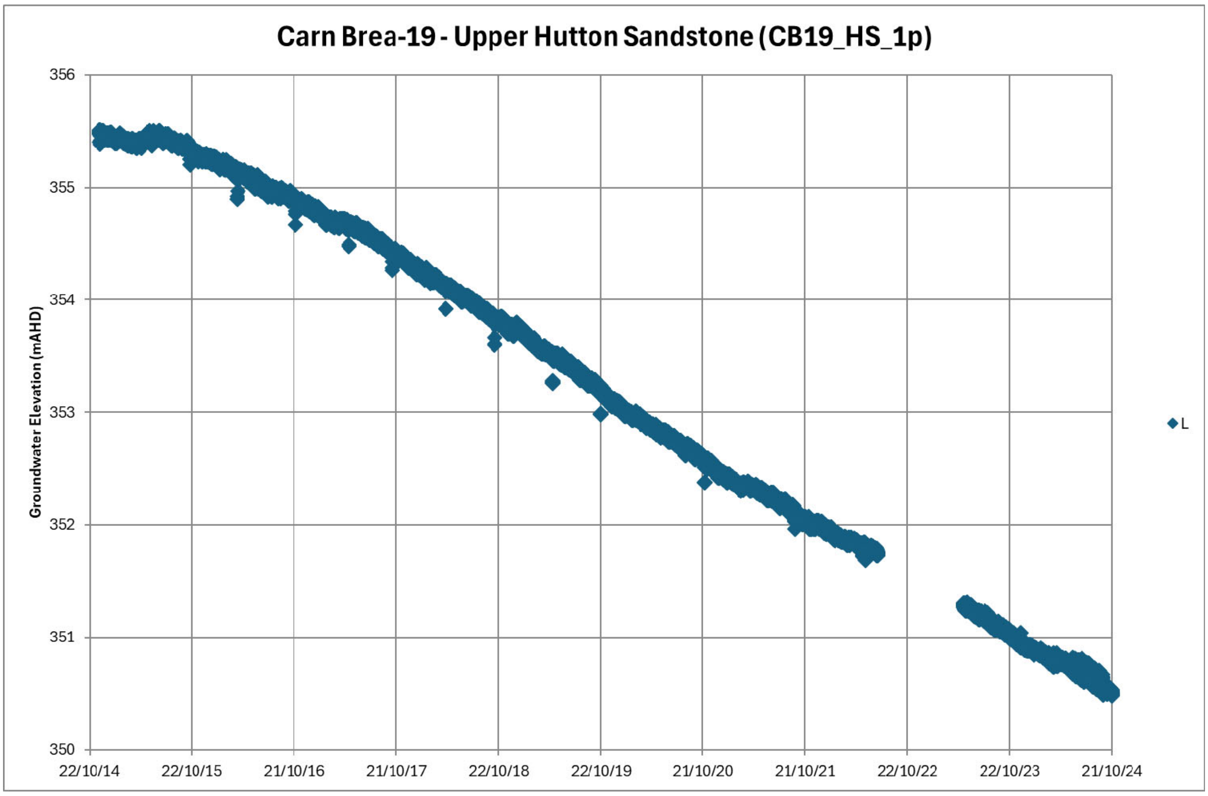

Carn Brea-17 - Condamine Alluvium (CB17_CA_1p)
Groundwater Elevation (mAHD)
322
320
318
316
314
312
310
308
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

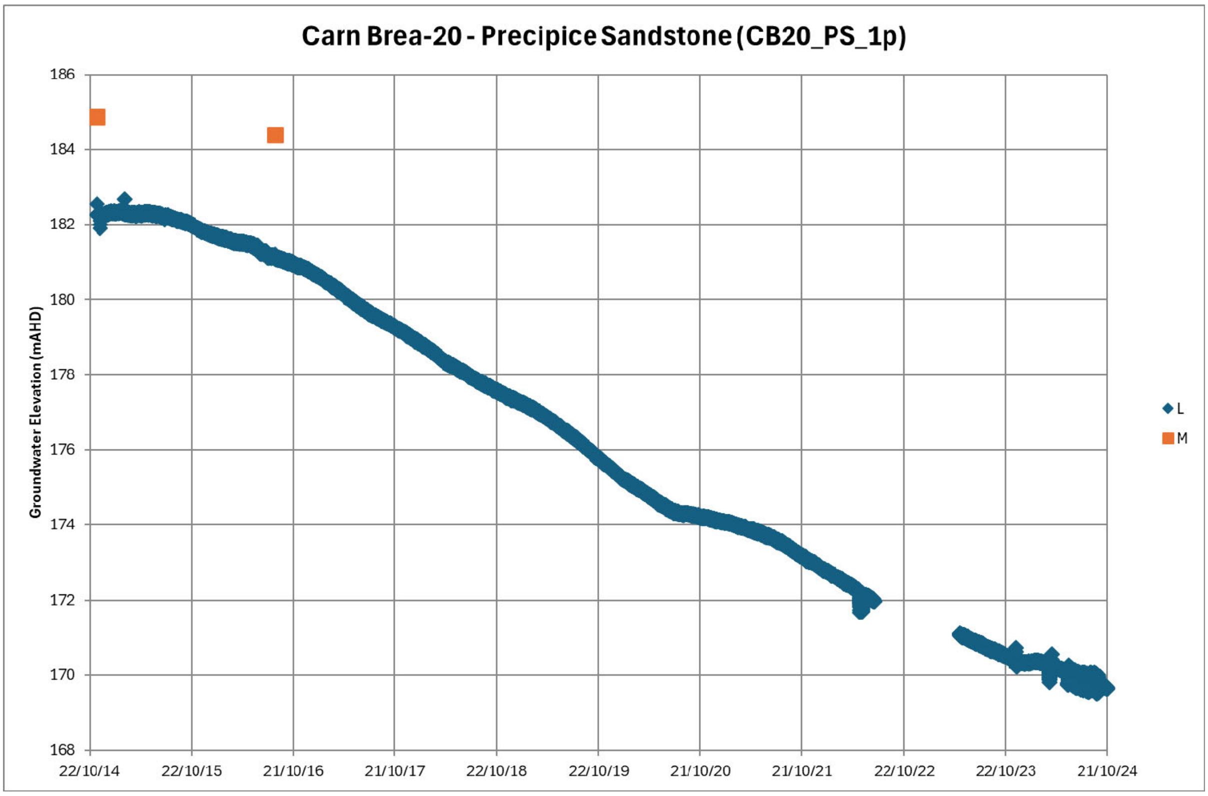

Carn Brea-18 - Taroom CM (CB18_WCMa_1p)
Groundwater Elevation (mAHD)
340
339.5
339
338.5
338
337.5
337
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

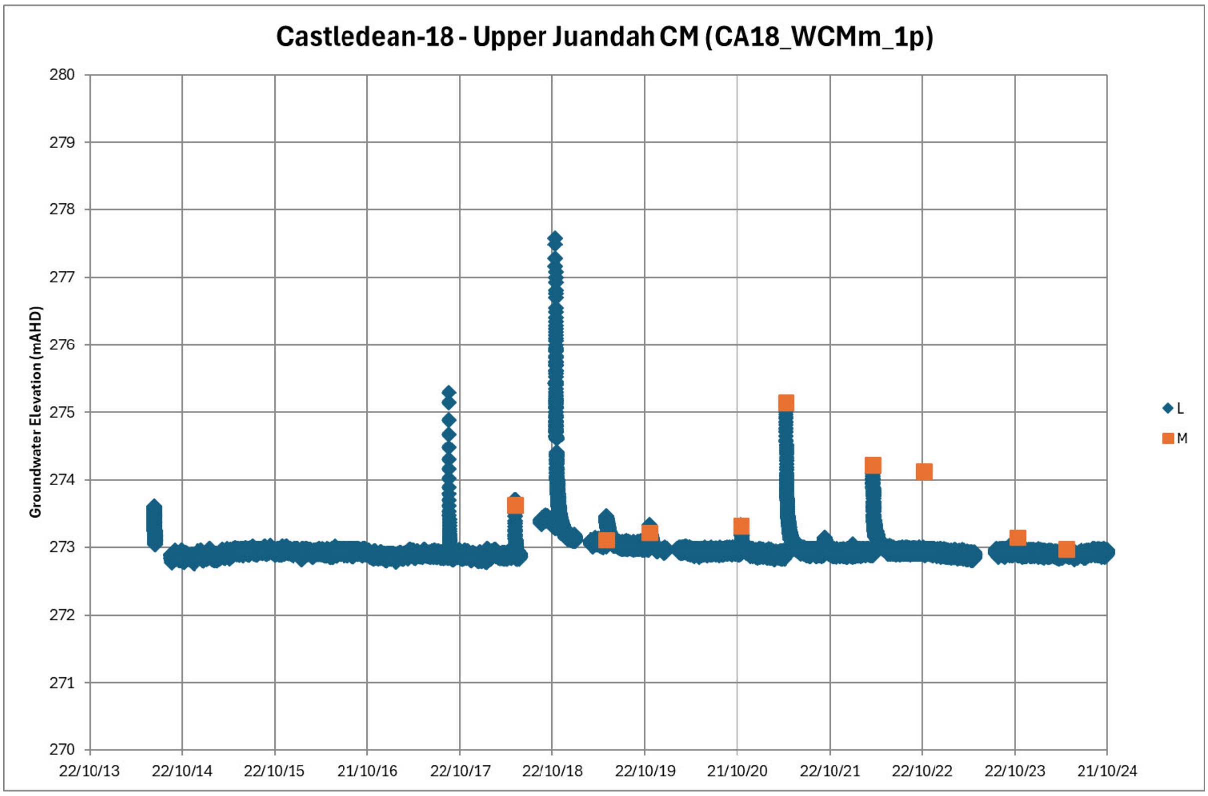

Carn Brea-18 - Lower Juandah CM (CB18_WCMc_1p)
Groundwater Elevation (mAHD)
342.6
342.4
342.2
342
341.8
341.6
341.4
341.2
341
340.8
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

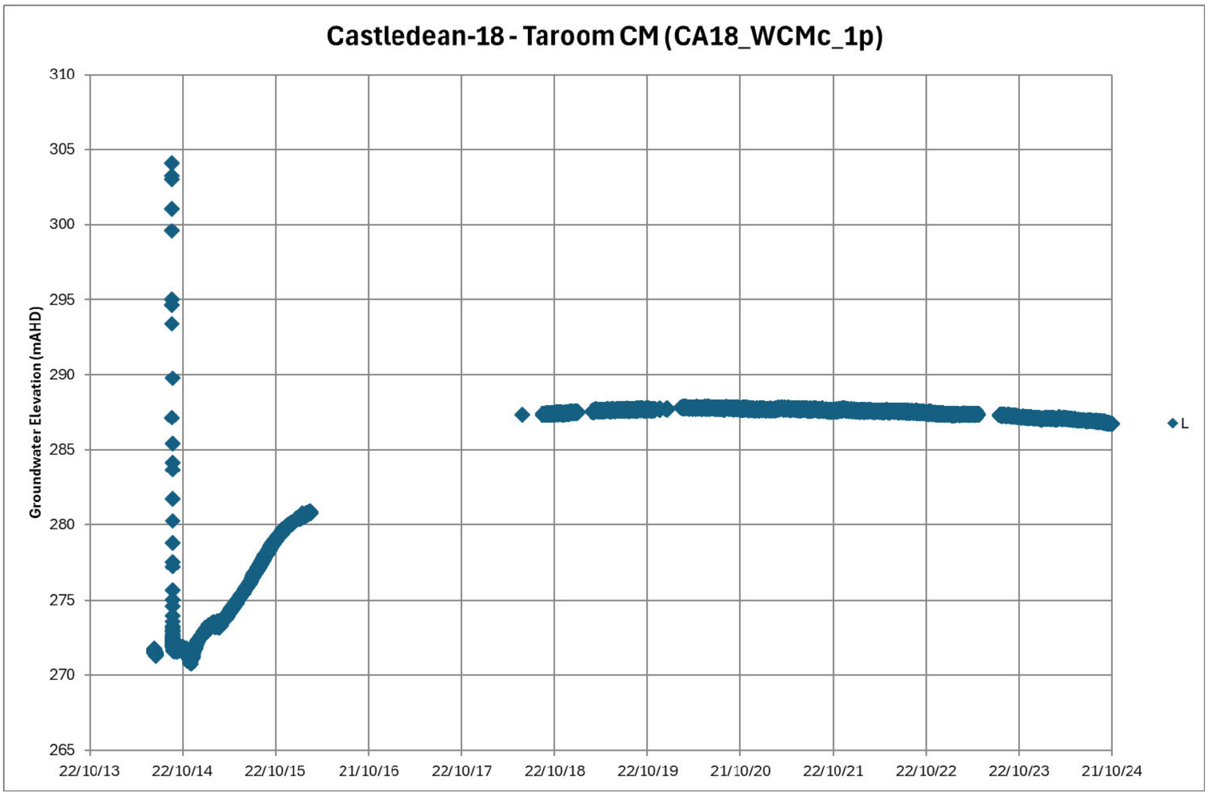

Carn Brea-18 - Lower Juandah CM (CB18_WCMw_1p)
Groundwater Elevation (mAHD)
330
329.5
329
328.5
328
327.5
327
326.5
326
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

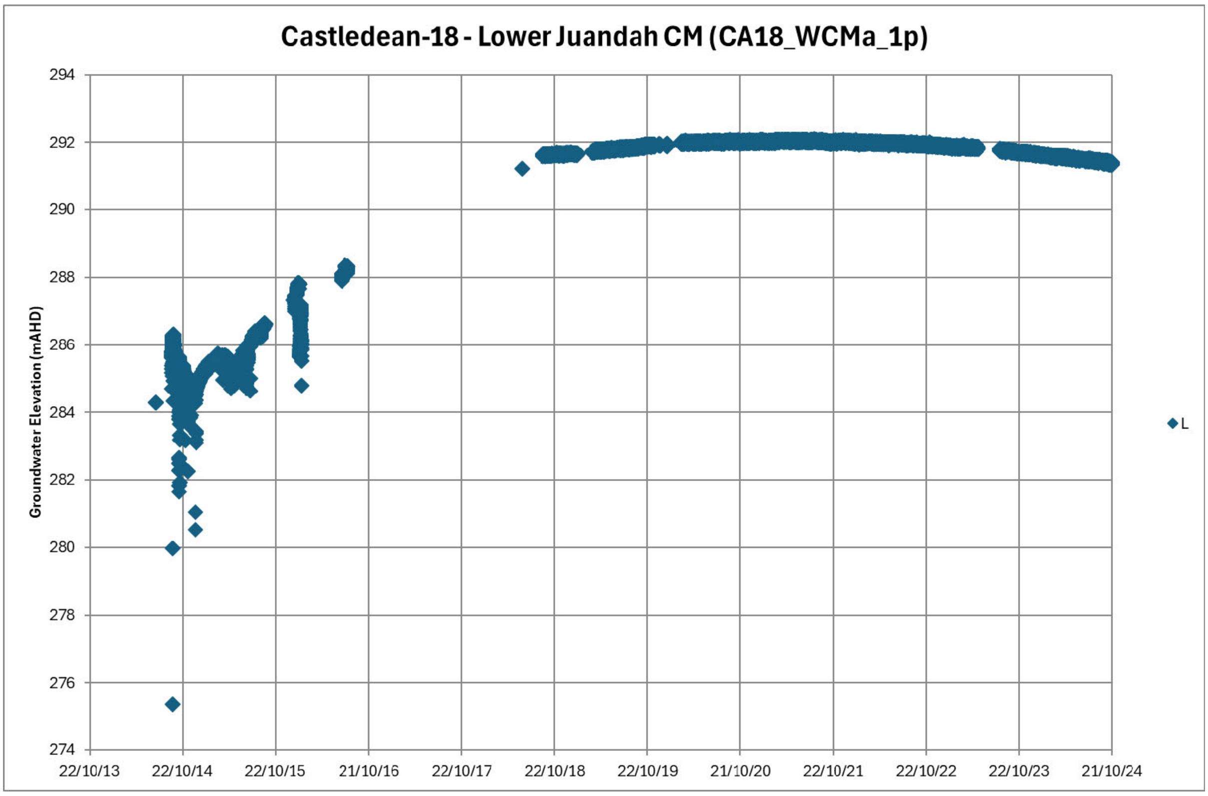

Carn Brea-19 - Evergreen Formation (CB19_EF_1p)
Groundwater Elevation (mAHD)
323
322
321
320
319
318
317
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L


Carn Brea-19 - Upper Hutton Sandstone (CB19_HS_1p)
Groundwater Elevation (mAHD)
356
355
354
353
352
351
350
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L

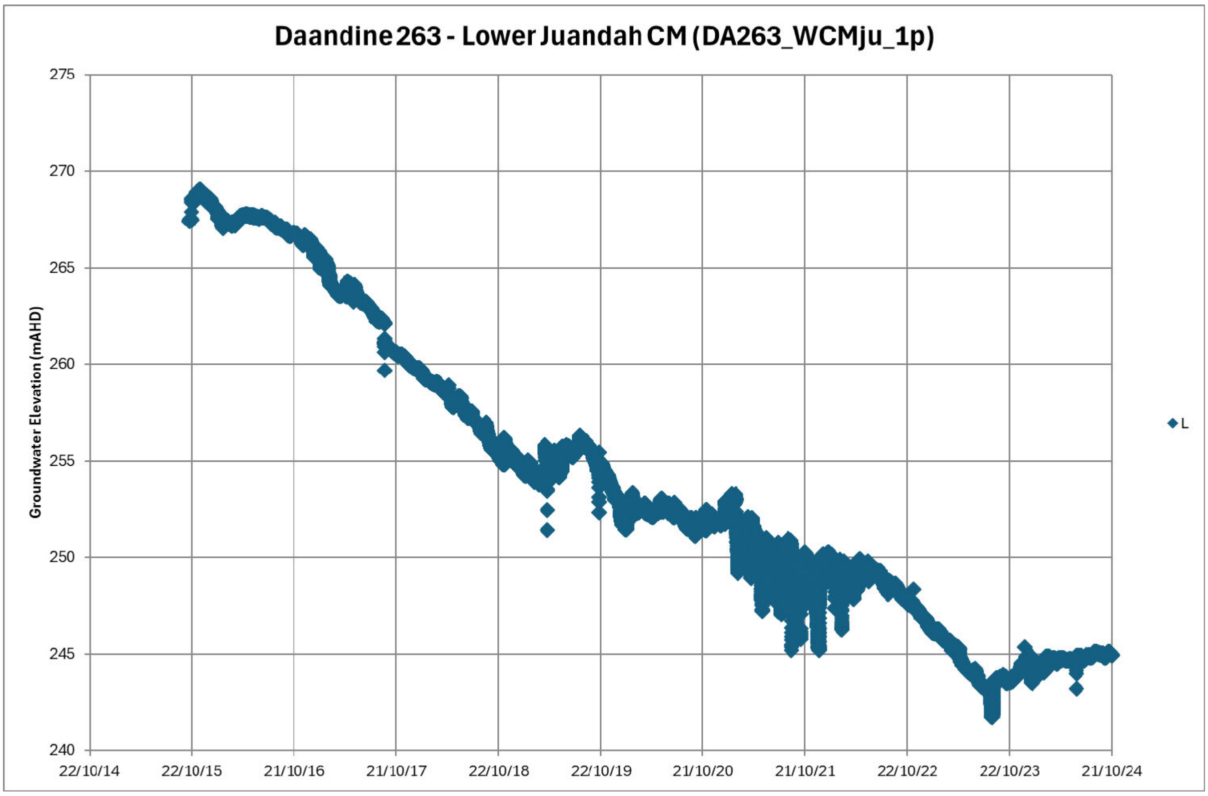

Carn Brea-20 - Precipice Sandstone (CB20_PS_1p)
Groundwater Elevation (mAHD)
186
184
182
180
178
176
174
172
170
168
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L
M

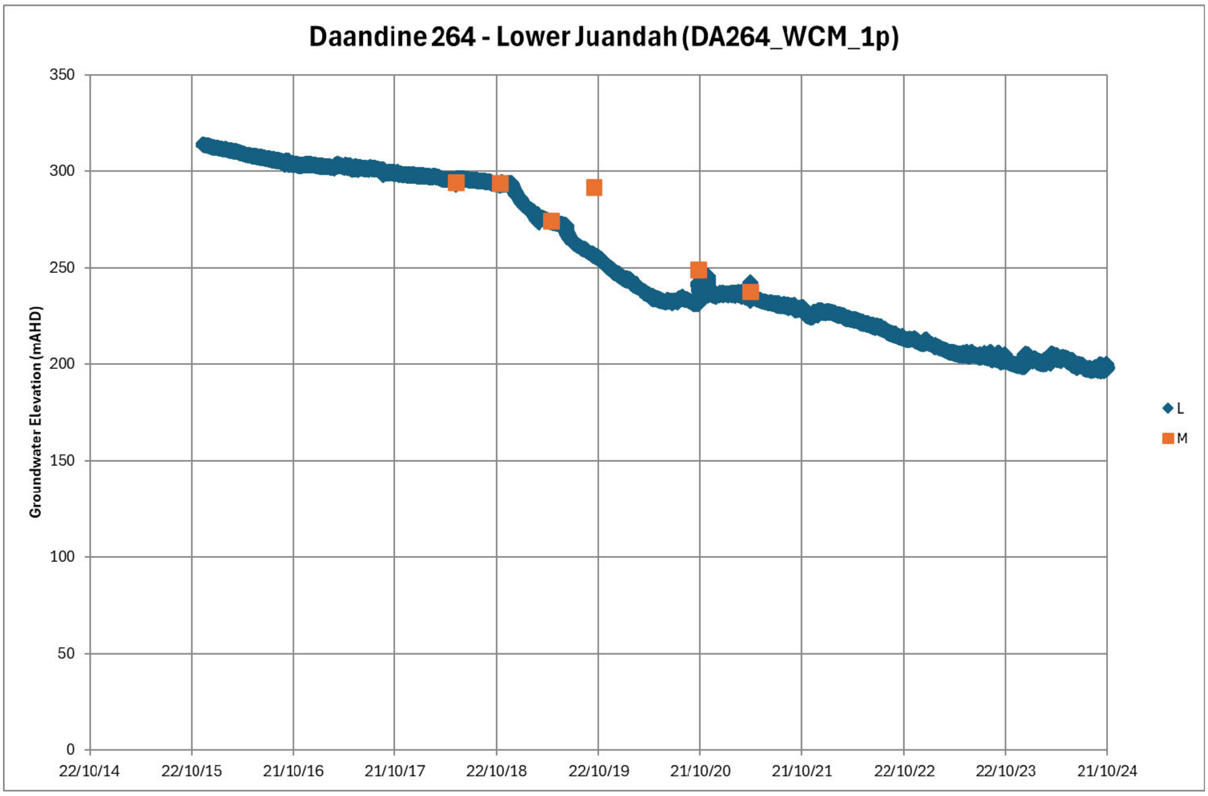

Castledean-18 - Upper Juandah CM (CA18_WCMm_1p)
Groundwater Elevation (mAHD)
280
279
278
277
276
275
274
273
272
271
270
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

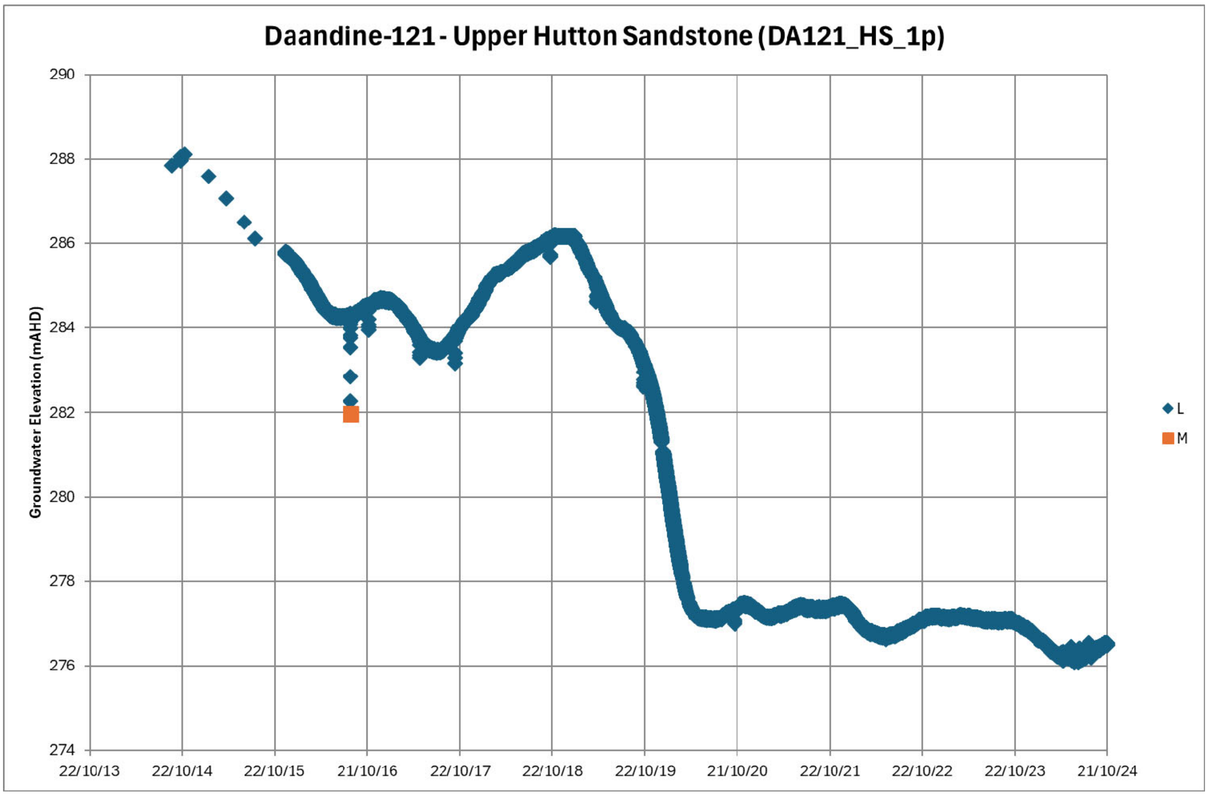

Castledean-18 - Taroom CM (CA18_WCMc_1p)
Groundwater Elevation (mAHD)
310
305
300
295
290
285
280
275
270
265
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

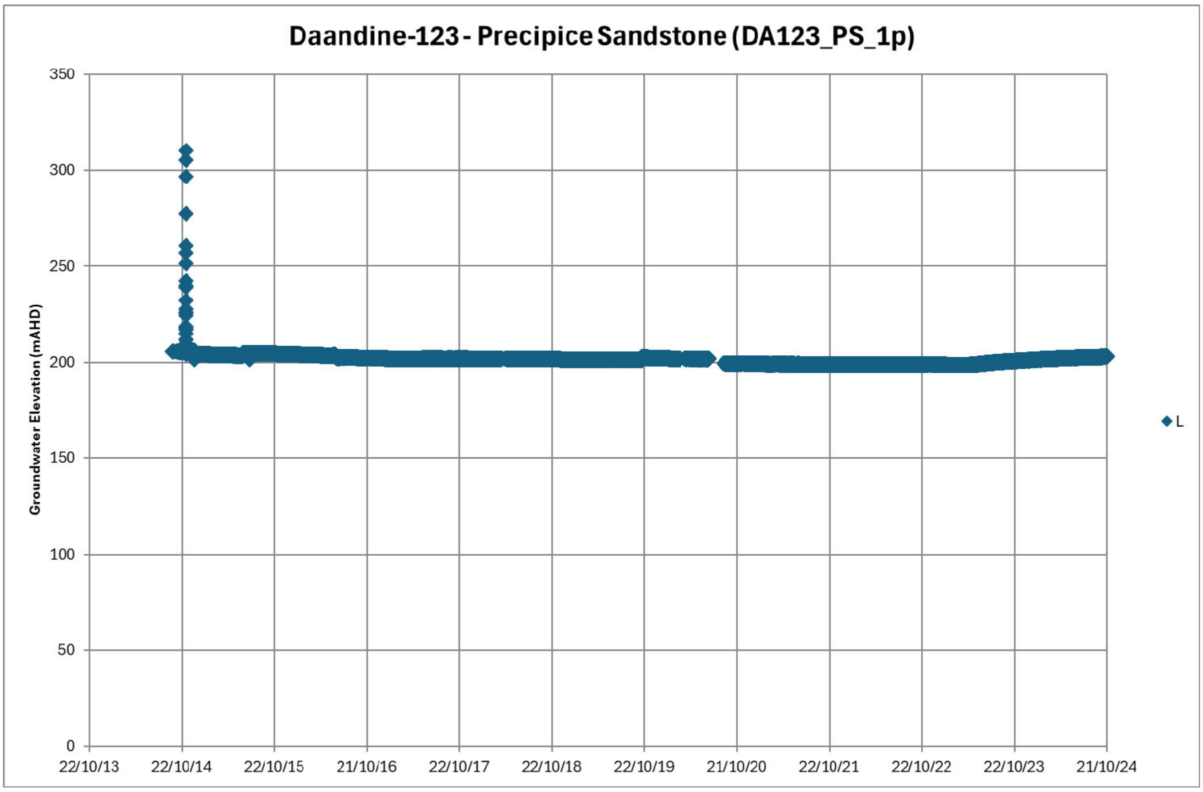


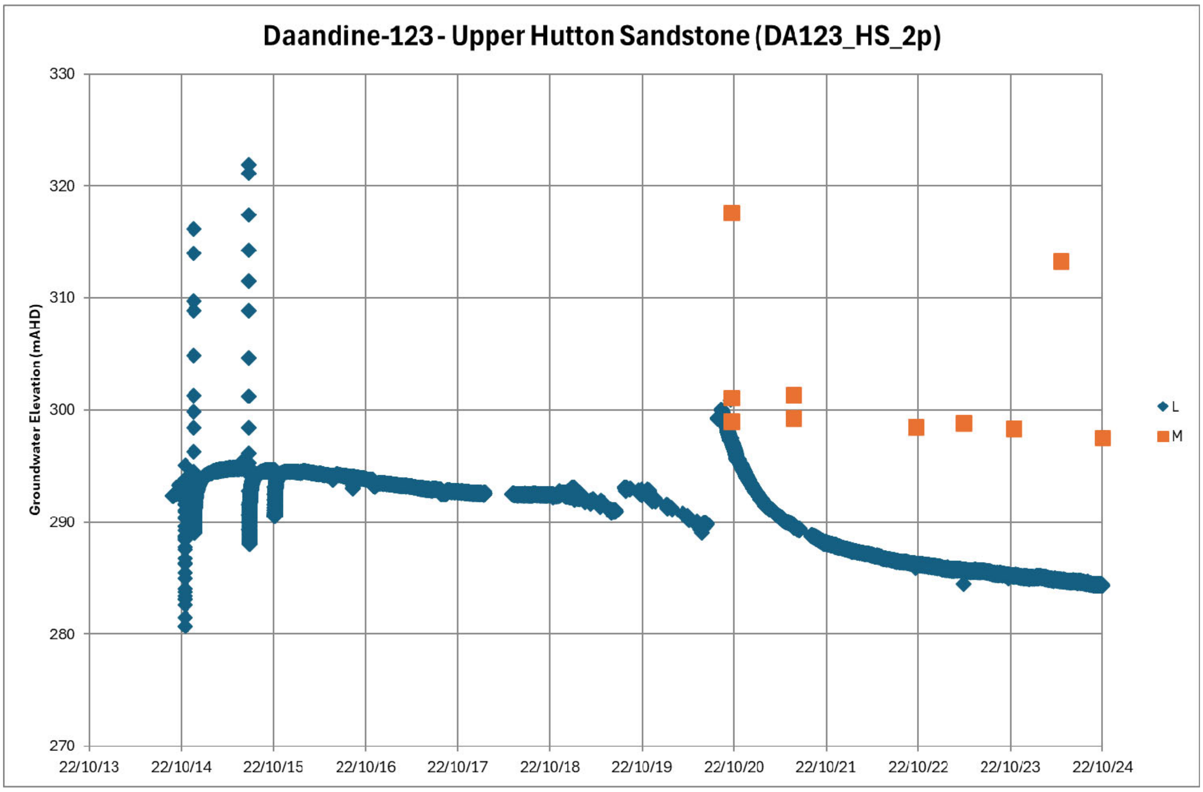
Castledean-18 - Upper Springbok Sandstone (CA18_SS_1p) is dry

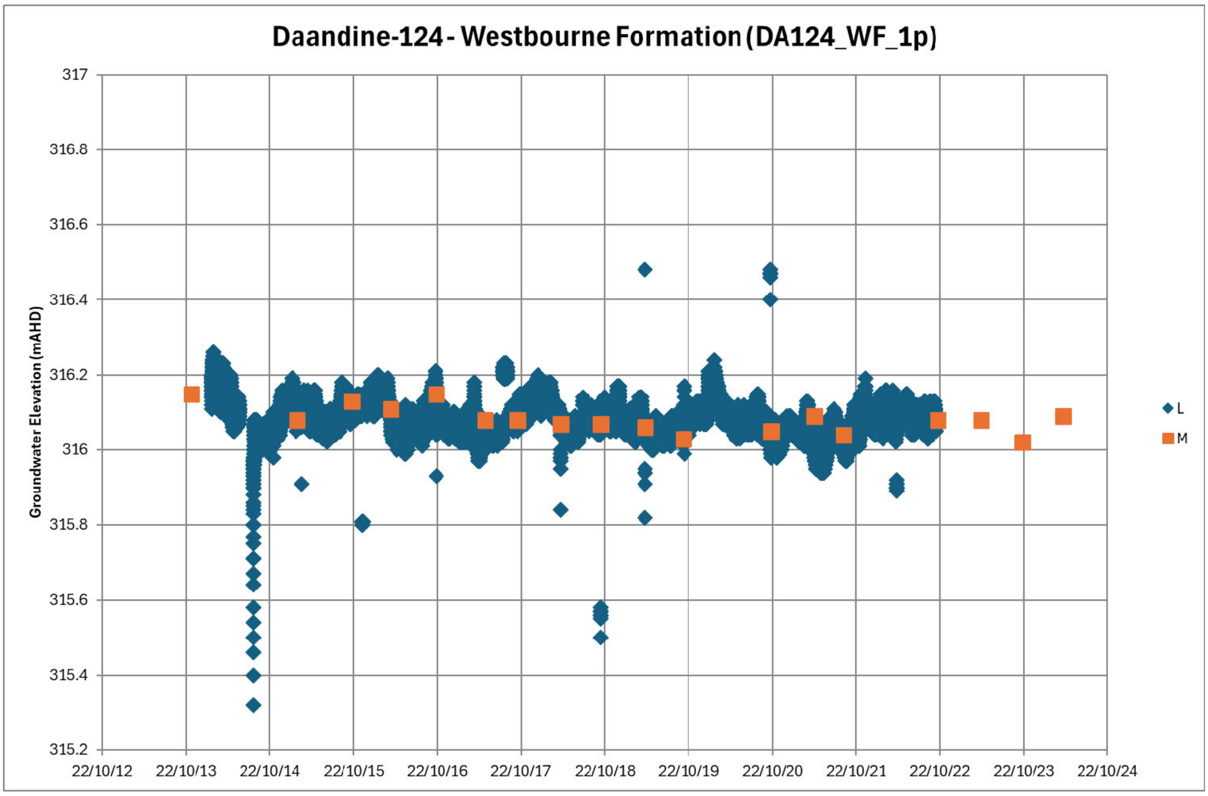


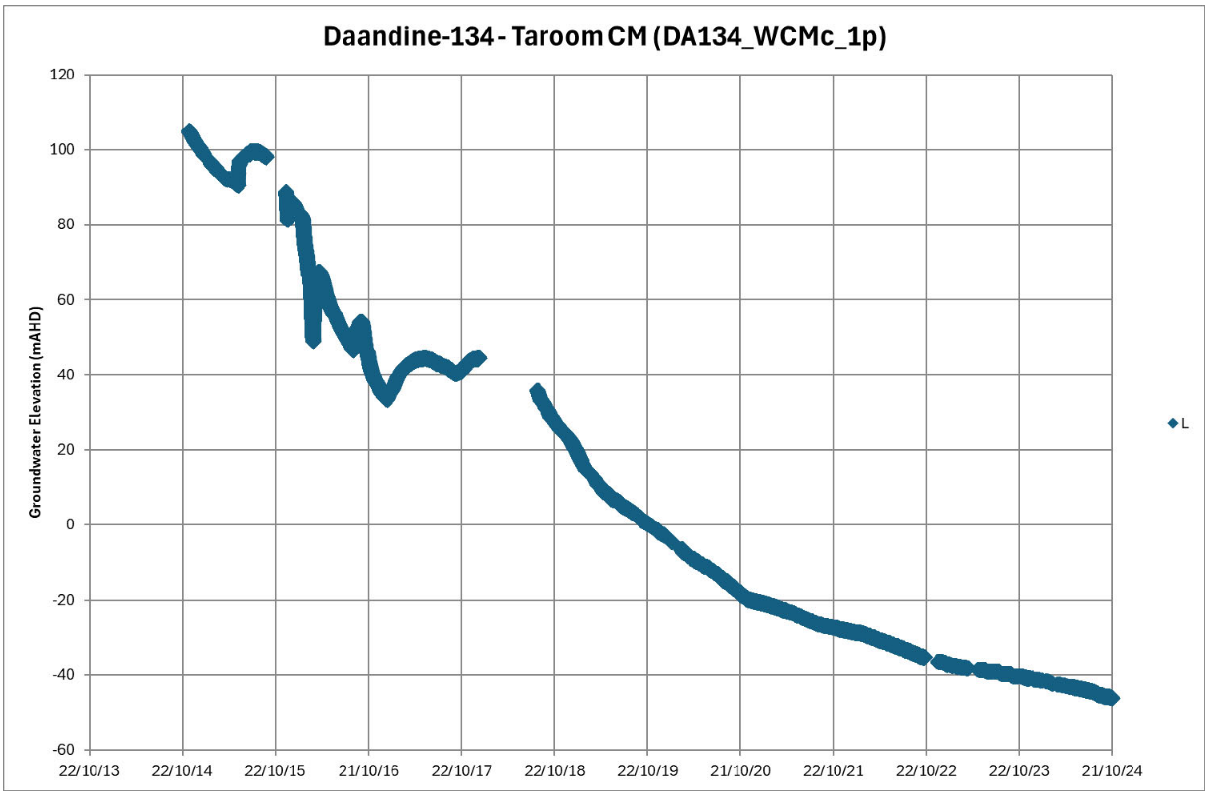

Daandine 264 - Lower Juandah (DA264_WCM_1p)
Groundwater Elevation (mAHD)
350
300
250
200
150
100
50
0
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L
M

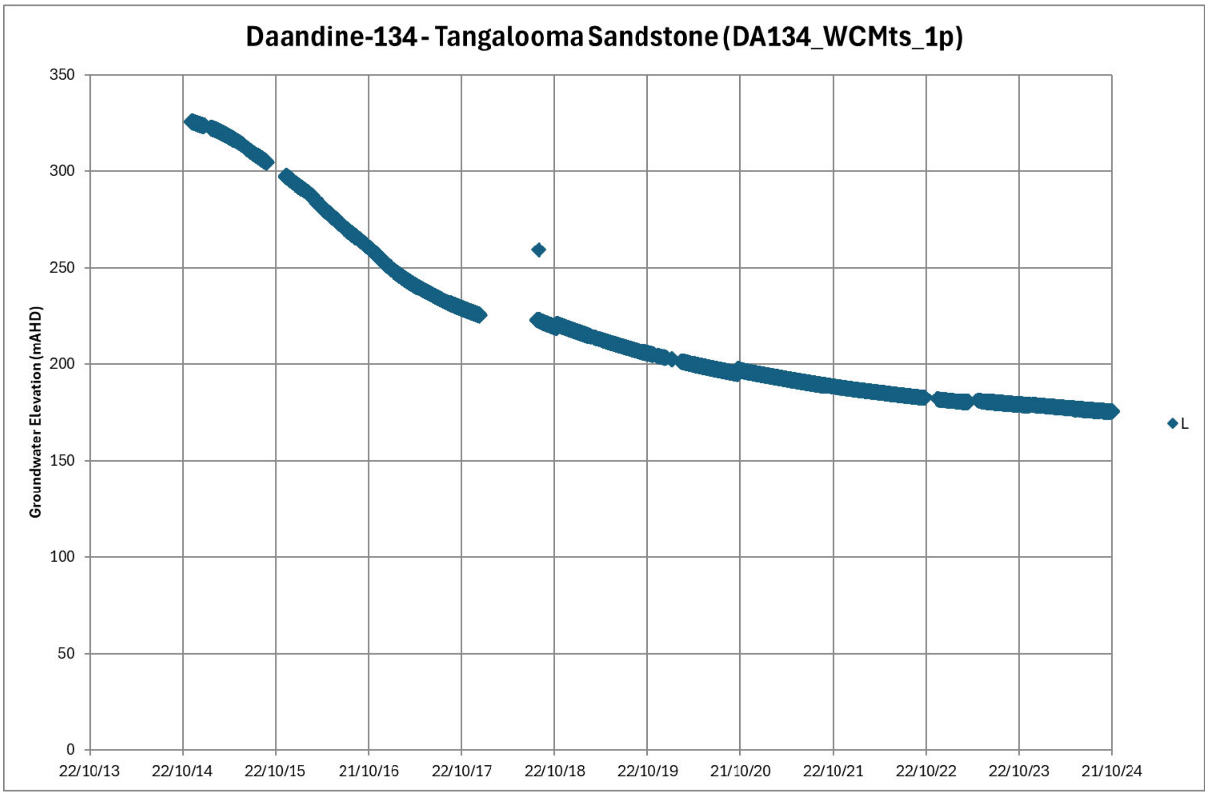

Daandine-121 - Upper Hutton Sandstone (DA121_HS_1p)
Groundwater Elevation (mAHD)
290
288
286
284
282
280
278
276
274
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

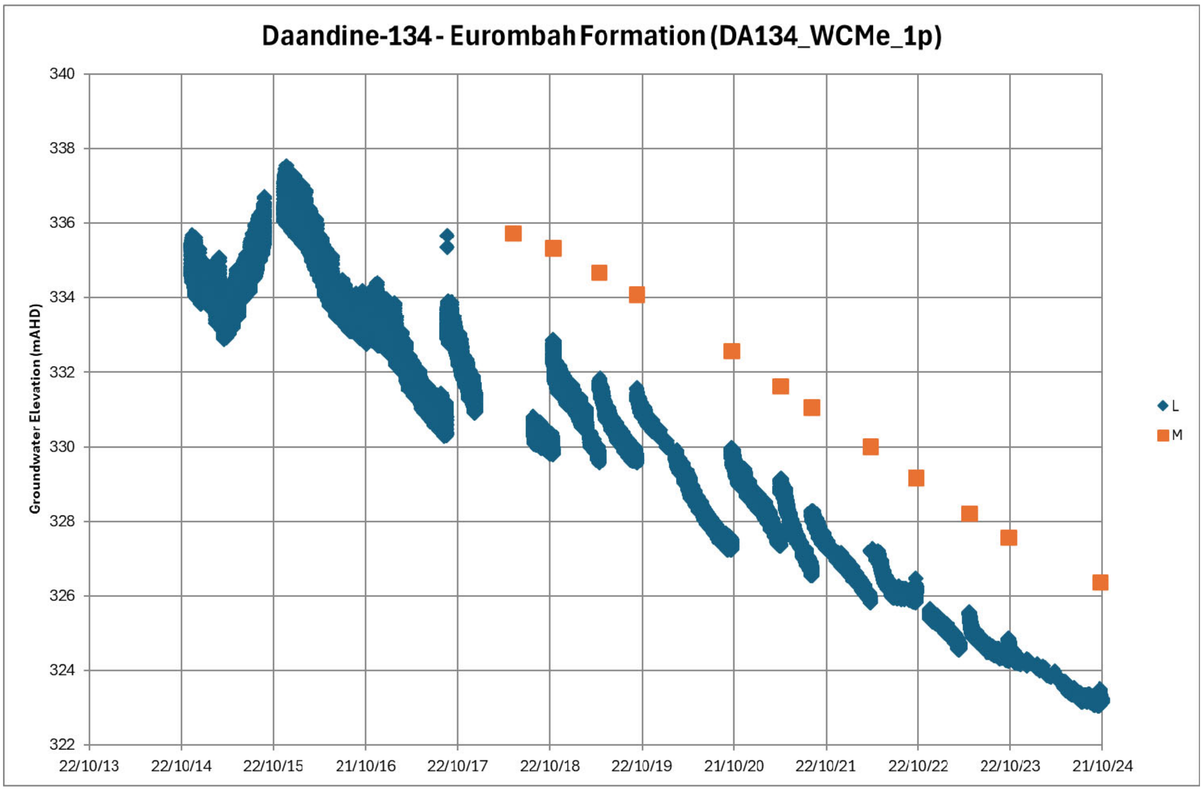

Daandine-123 - Precipice Sandstone (DA123_PS_1p)
Groundwater Elevation (mAHD)
350
300
250
200
150
100
50
0
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

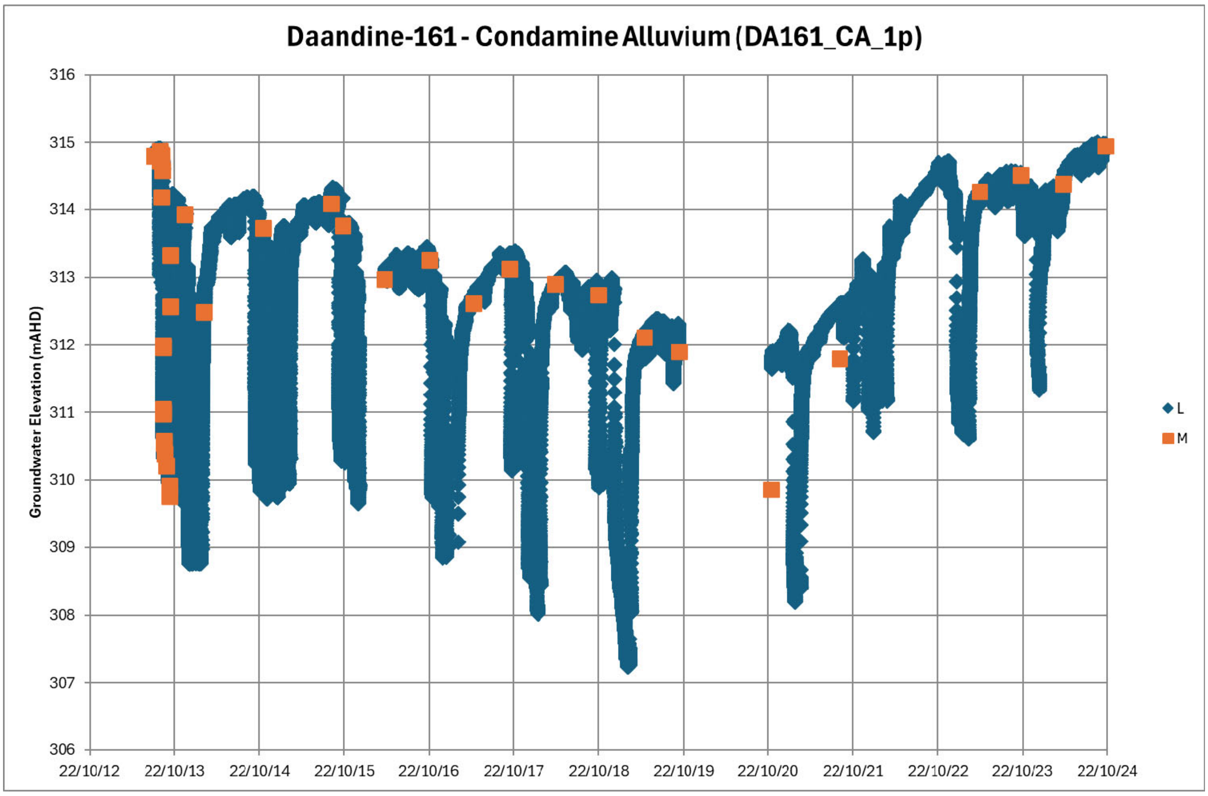

Daandine-123 - Upper Hutton Sandstone (DA123_HS_2p)
Groundwater Elevation (mAHD)
330
320
310
300
290
280
270
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M


Daandine-124 - Westbourne Formation (DA124_WF_1p)
Groundwater Elevation (mAHD)
317
316.8
316.6
316.4
316.2
316
315.8
315.6
315.4
315.2
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

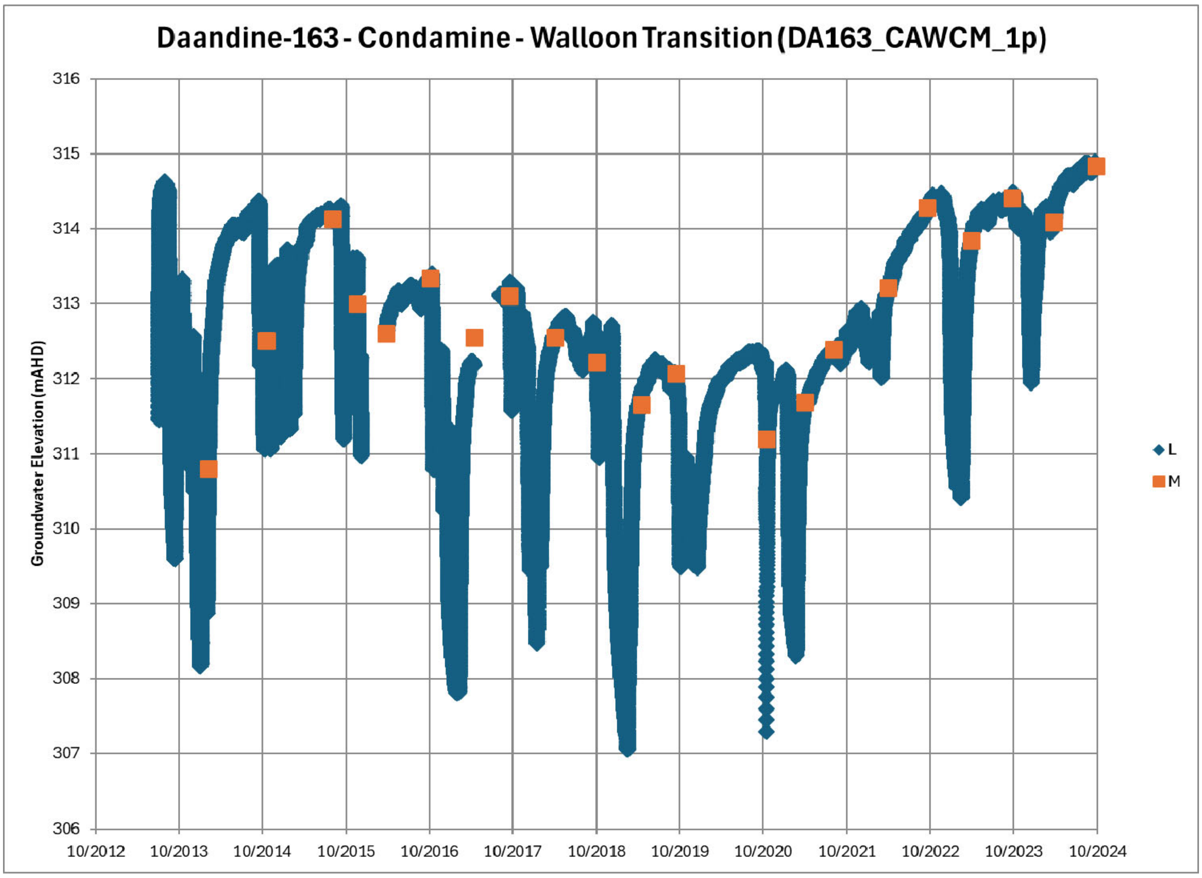

Daandine-134 - Taroom CM (DA134_WCMc_1p)
Groundwater Elevation (mAHD)
120
100
80
60
40
20
0
-20
-40
-60
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L


Daandine-134 - Tangalooma Sandstone (DA134_WCMts_1p)
Groundwater Elevation (mAHD)
350
300
250
200
150
100
50
0
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

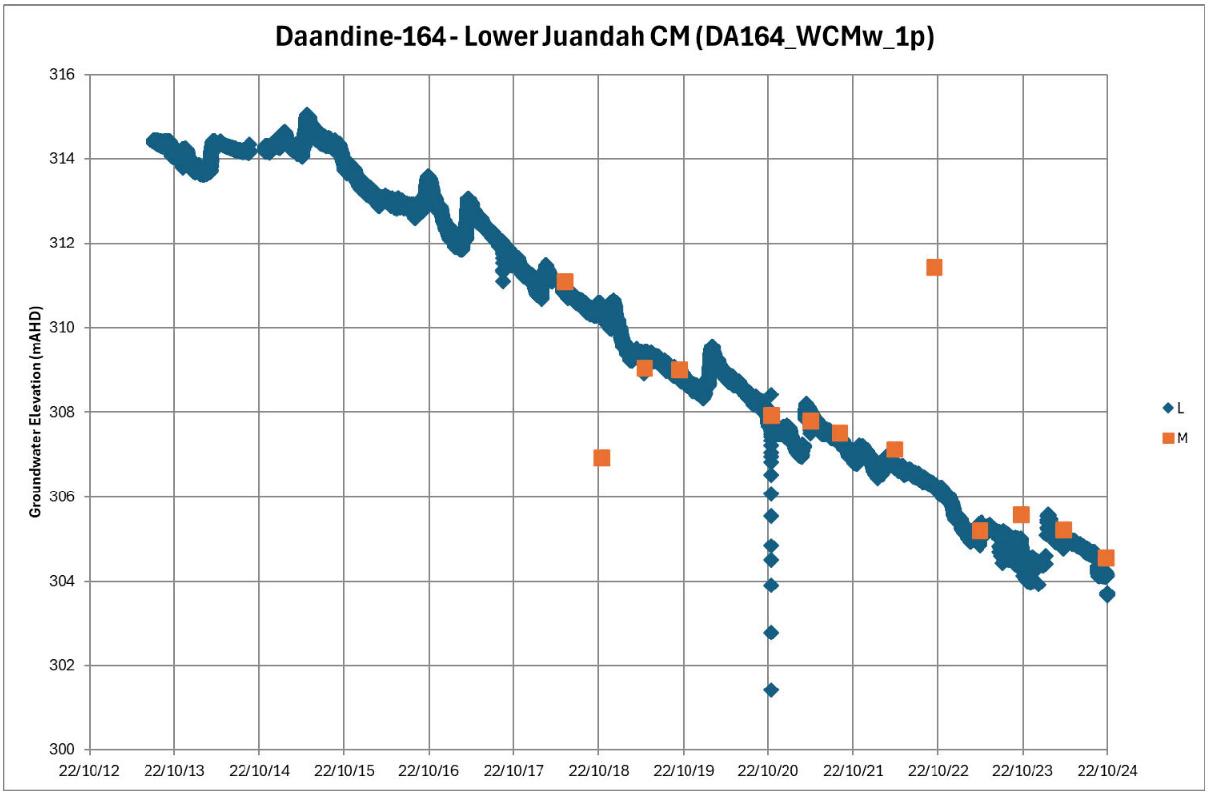

Daandine-134 - Eurombah Formation (DA134_WCMe_1p)
Groundwater Elevation (mAHD)
340
338
336
334
332
330
328
326
324
322
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

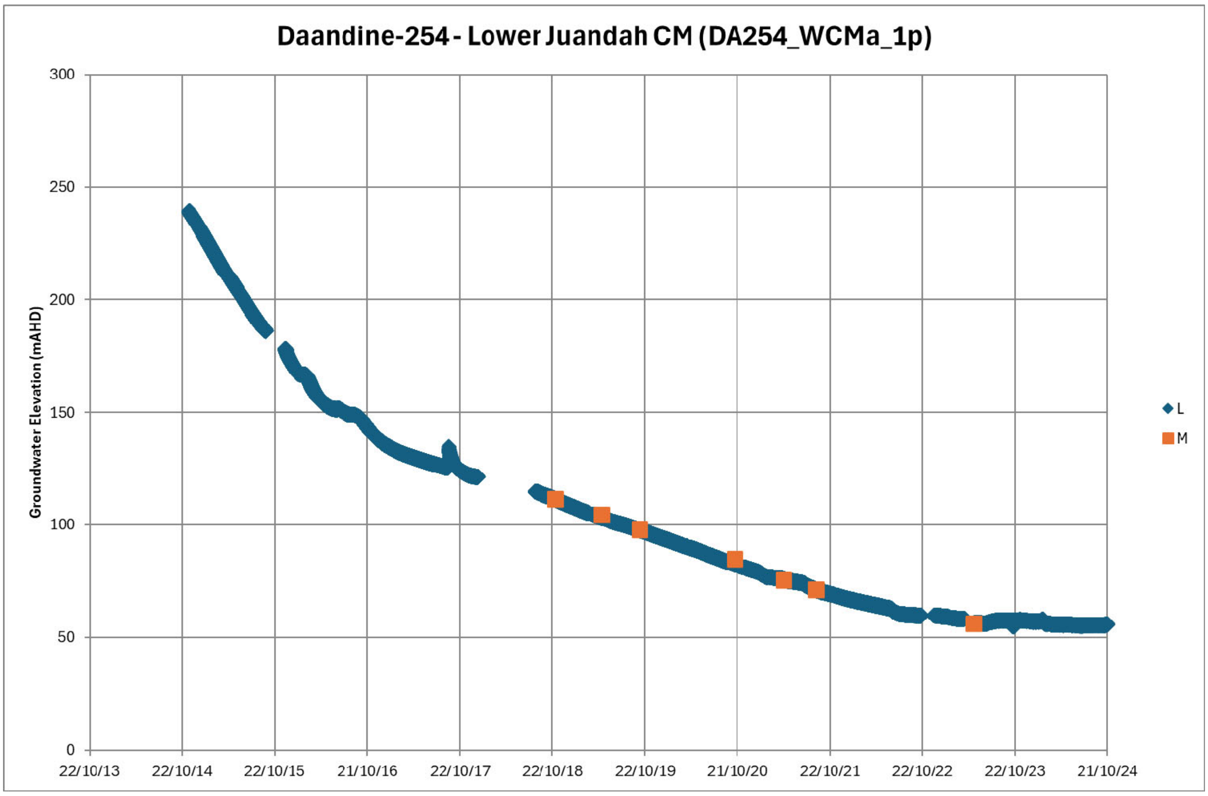


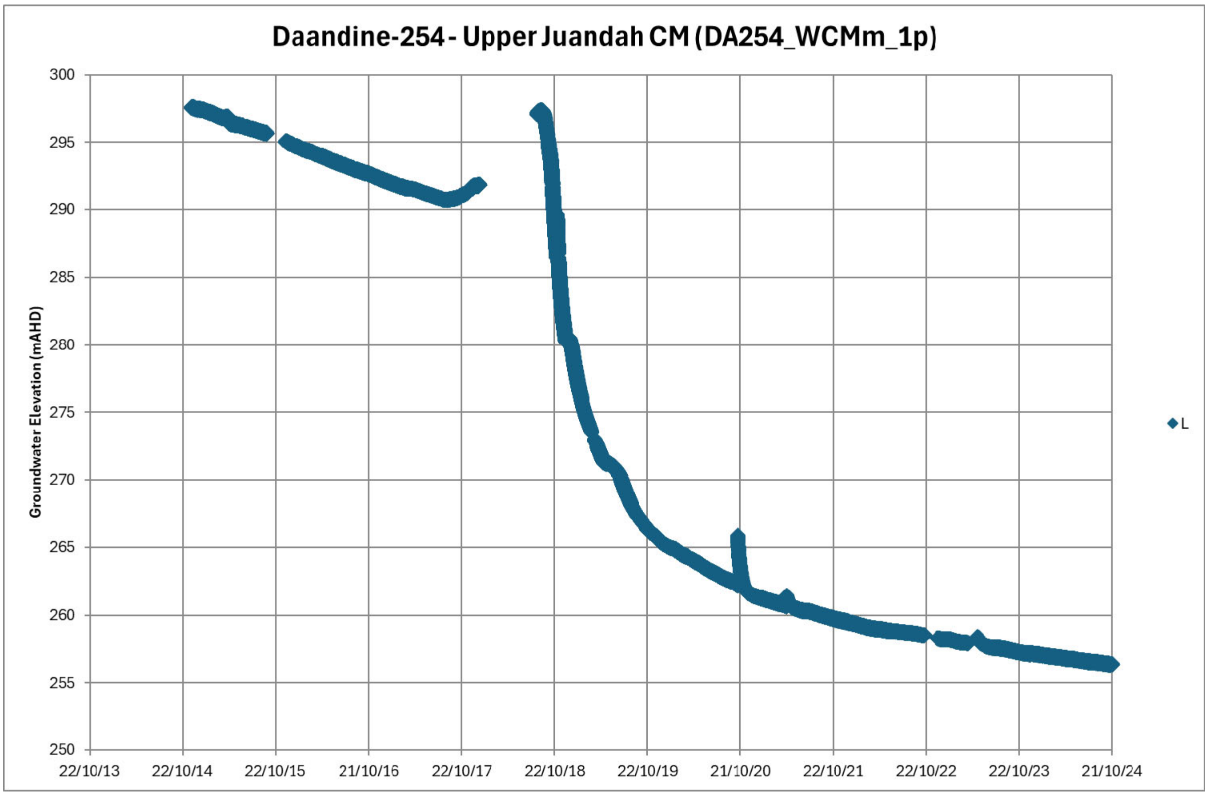
Daandine-161 - Condamine Alluvium (DA161_CA_1p)
Groundwater Elevation (mAHD)
316
315
314
313
312
311
310
309
308
307
306
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

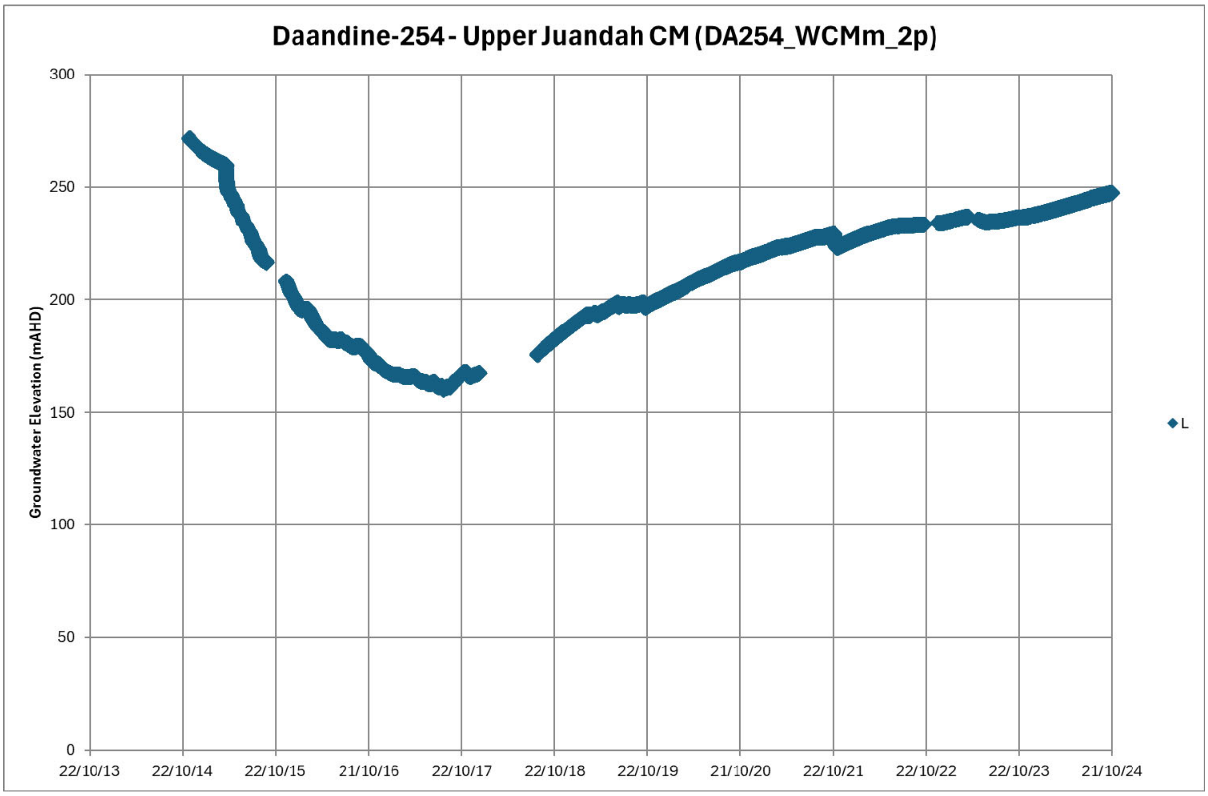


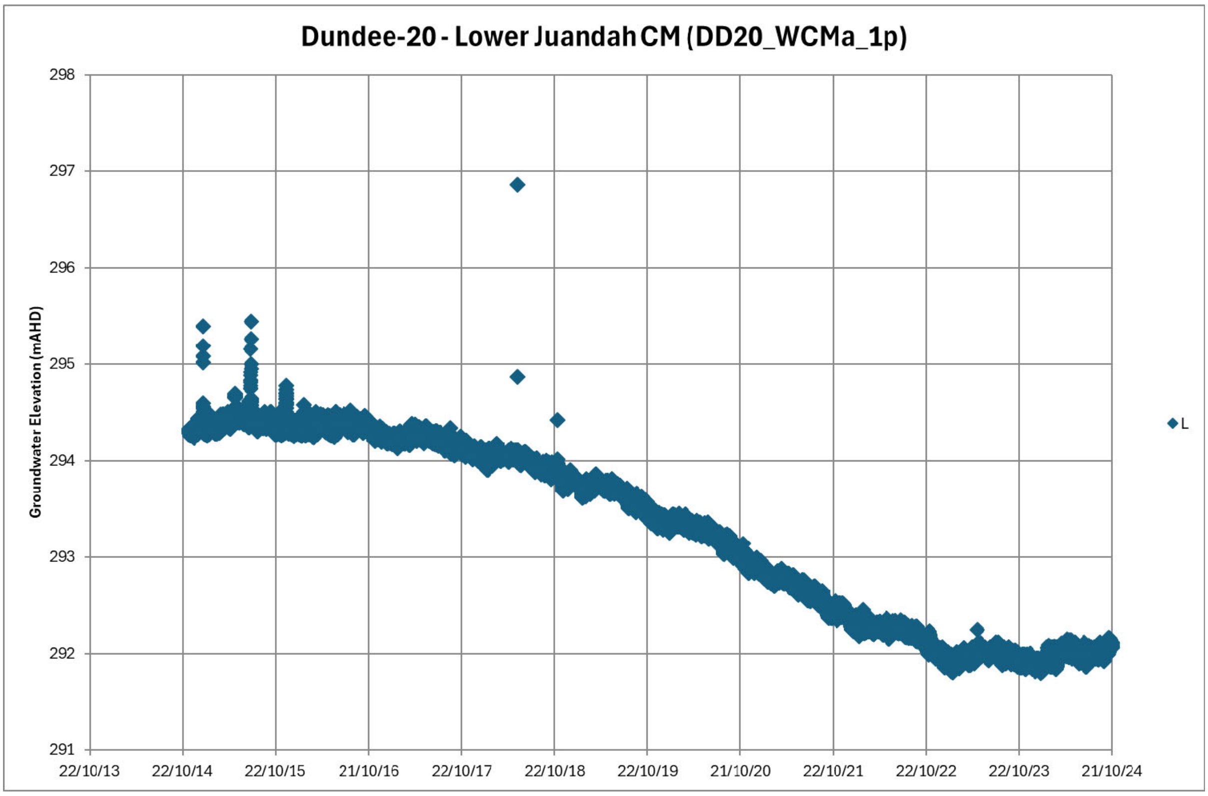
Daandine-163 - Condamine - Walloon Transition (DA163_CAWCM_1p)
Groundwater Elevation (mAHD)
316
315
314
313
312
311
310
309
308
307
306
10/2012
10/2013
10/2014
10/2015
10/2016
10/2017
10/2018
10/2019
10/2020
10/2021
10/2022
10/2023
10/2024
L
M

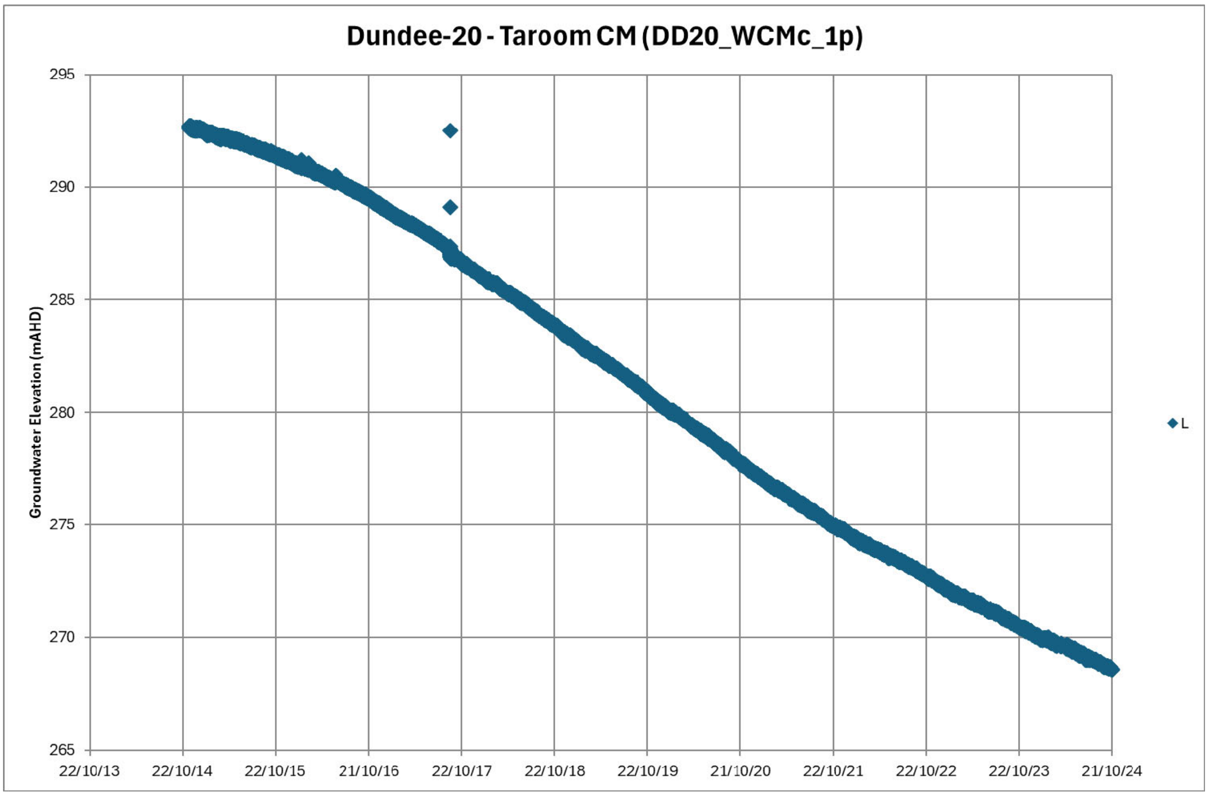

Daandine-164 - Lower Juandah CM (DA164_WCMw_1p)
Groundwater Elevation (mAHD)
316
314
312
310
308
306
304
302
300
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

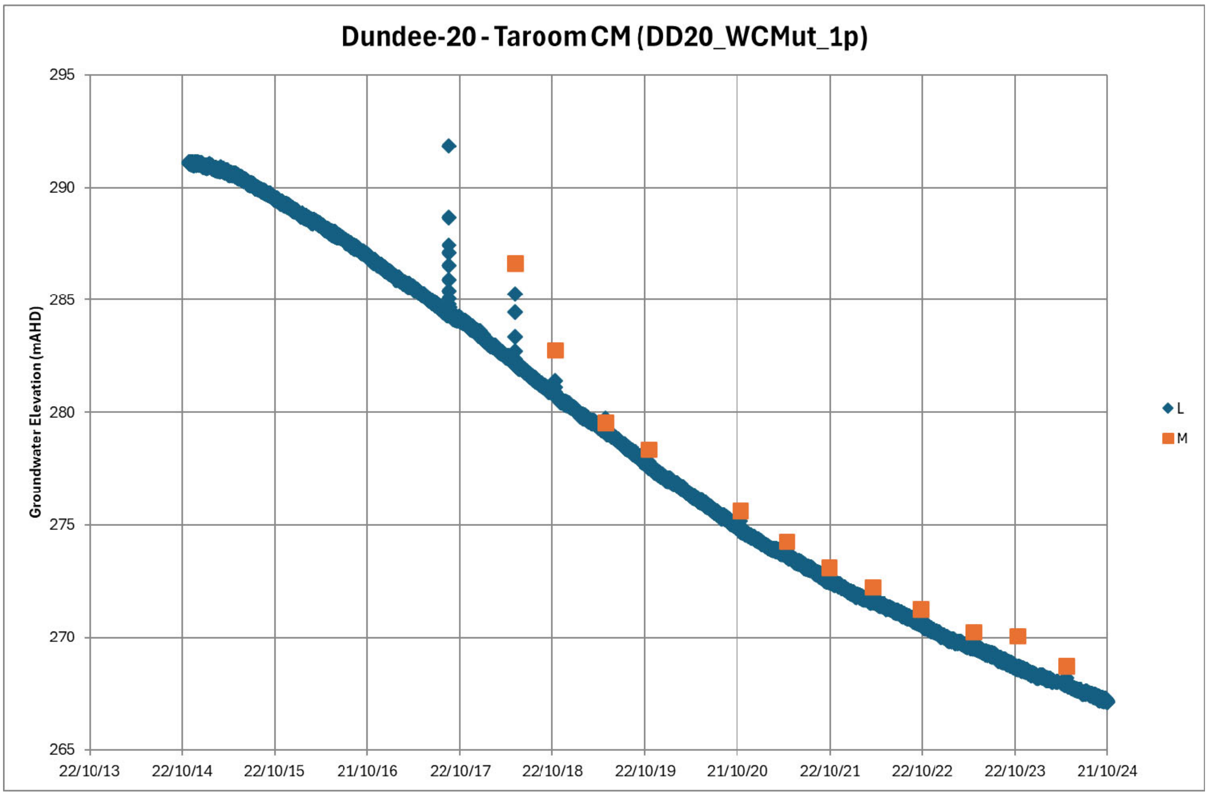

Daandine-254 - Lower Juandah CM (DA254_WCMa_1p)
Groundwater Elevation (mAHD)
300
250
200
150
100
50
0
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

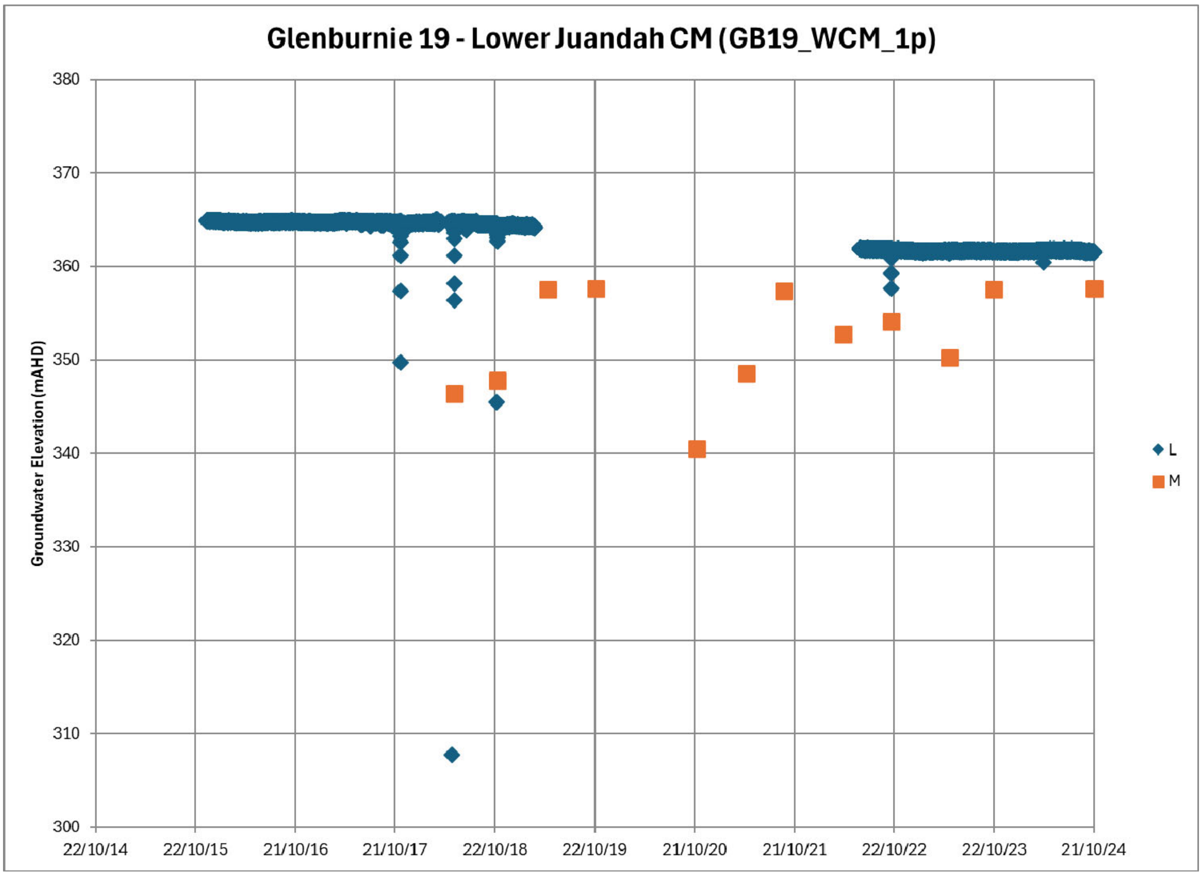

Daandine-254 - Upper Juandah CM (DA254_WCMm_1p)
Groundwater Elevation (mAHD)
300
295
290
285
280
275
270
265
260
255
250
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

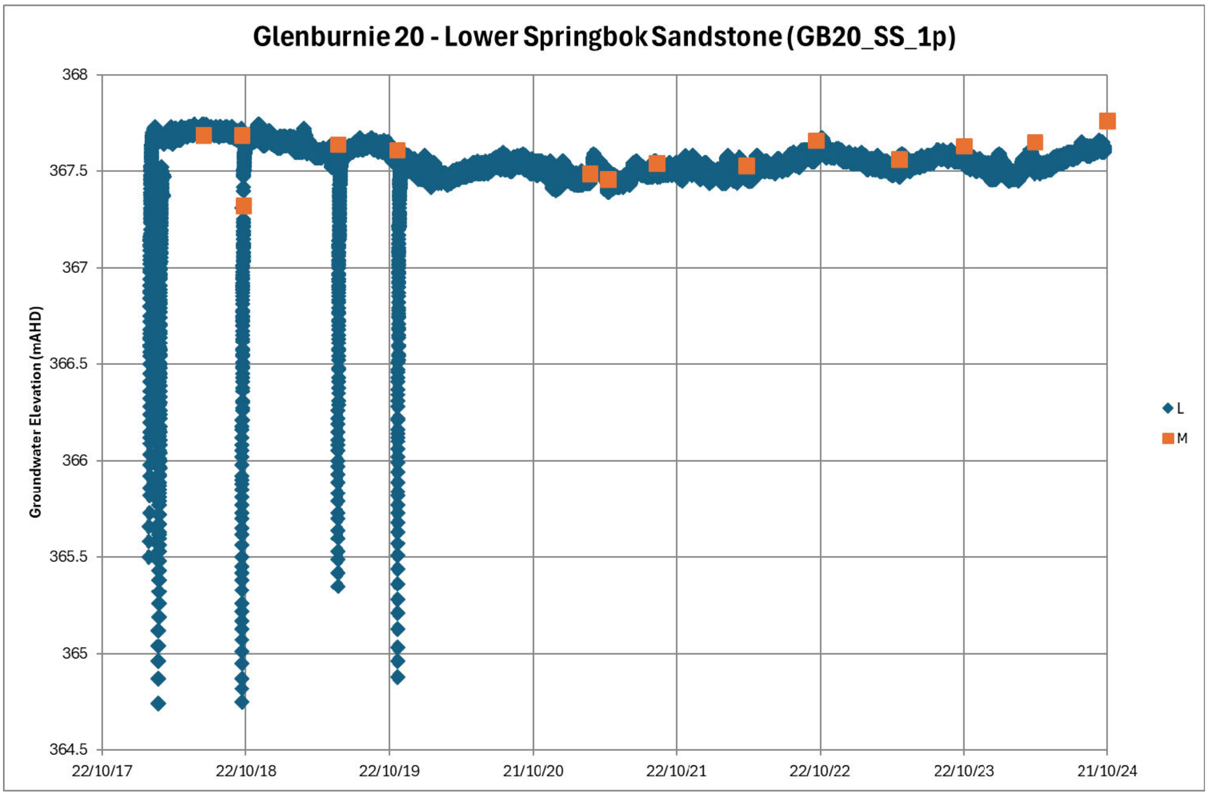

Daandine-254 - Upper Juandah CM (DA254_WCMm_2p)
Groundwater Elevation (mAHD)
300
250
200
150
100
50
0
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

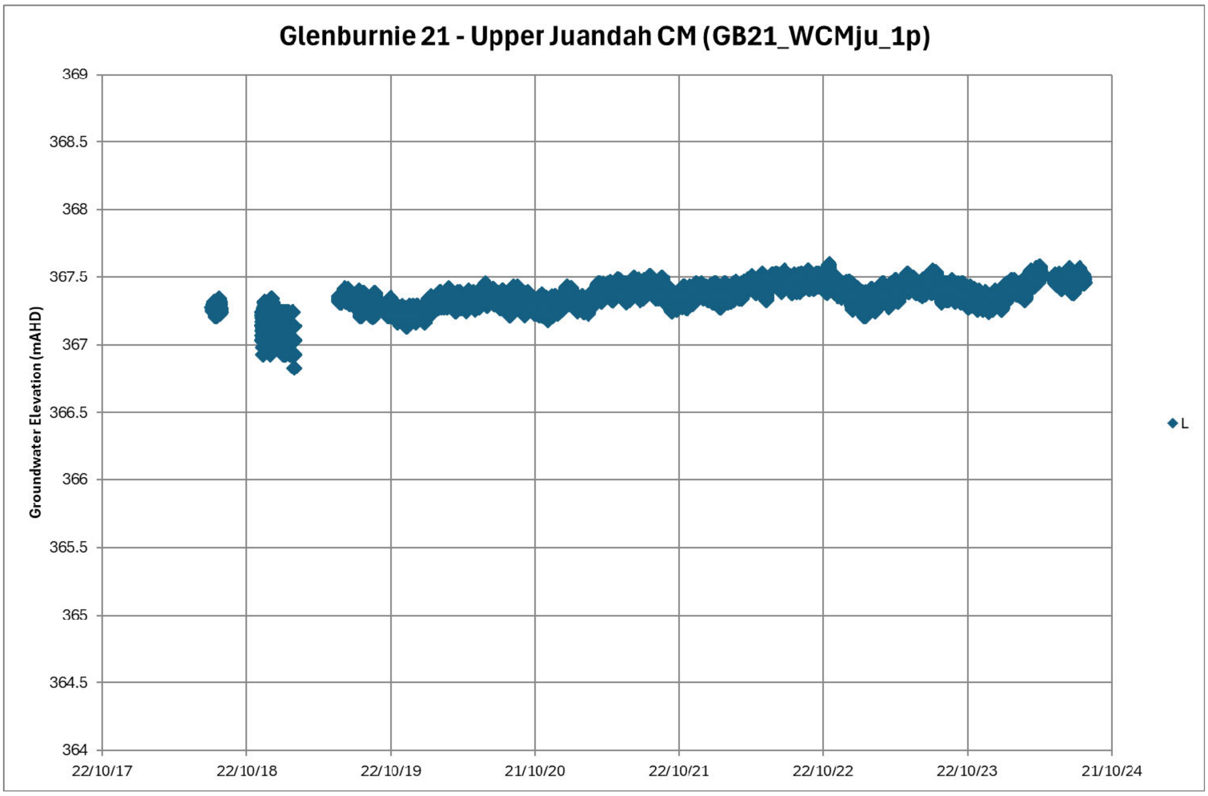

Dundee-20 - Lower Juandah CM (DD20_WCMa_1p)
Groundwater Elevation (mAHD)
298
297
296
295
294
293
292
291
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

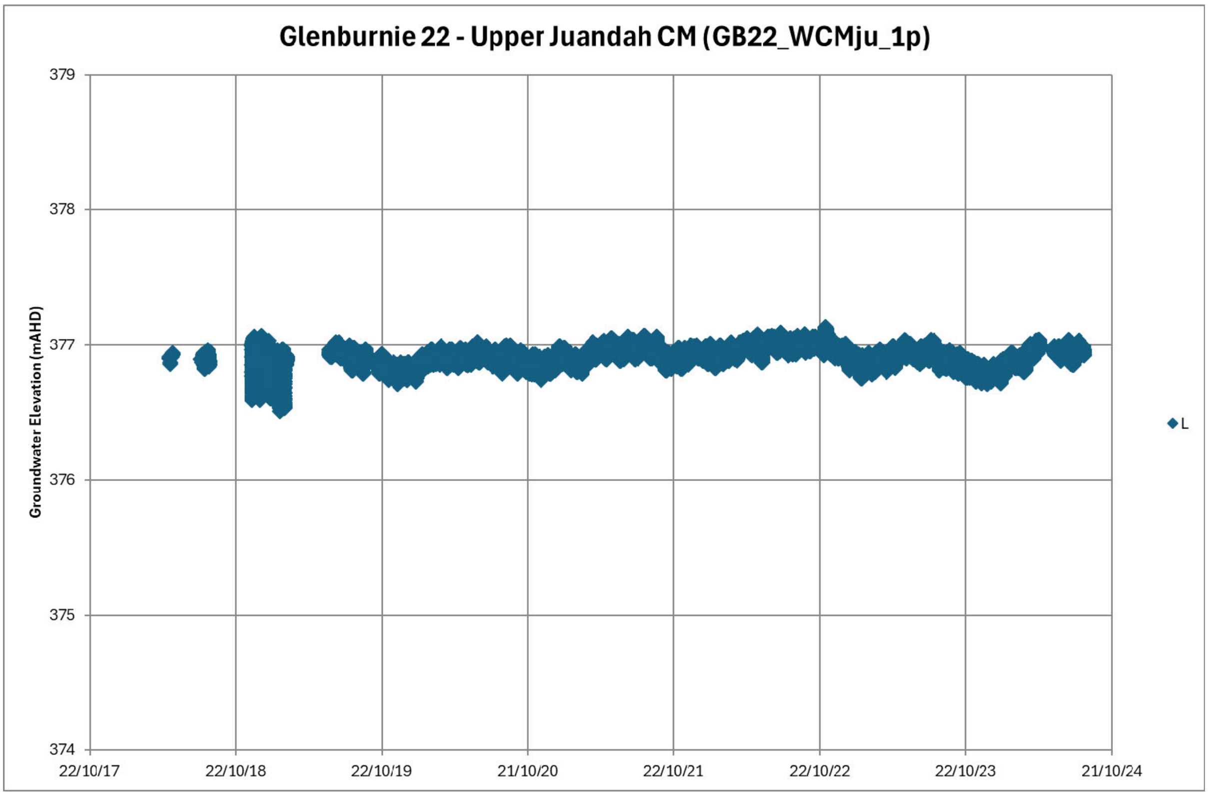

Dundee-20 - Taroom CM (DD20_WCMc_1p)
Groundwater Elevation (mAHD)
295
290
285
280
275
270
265
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

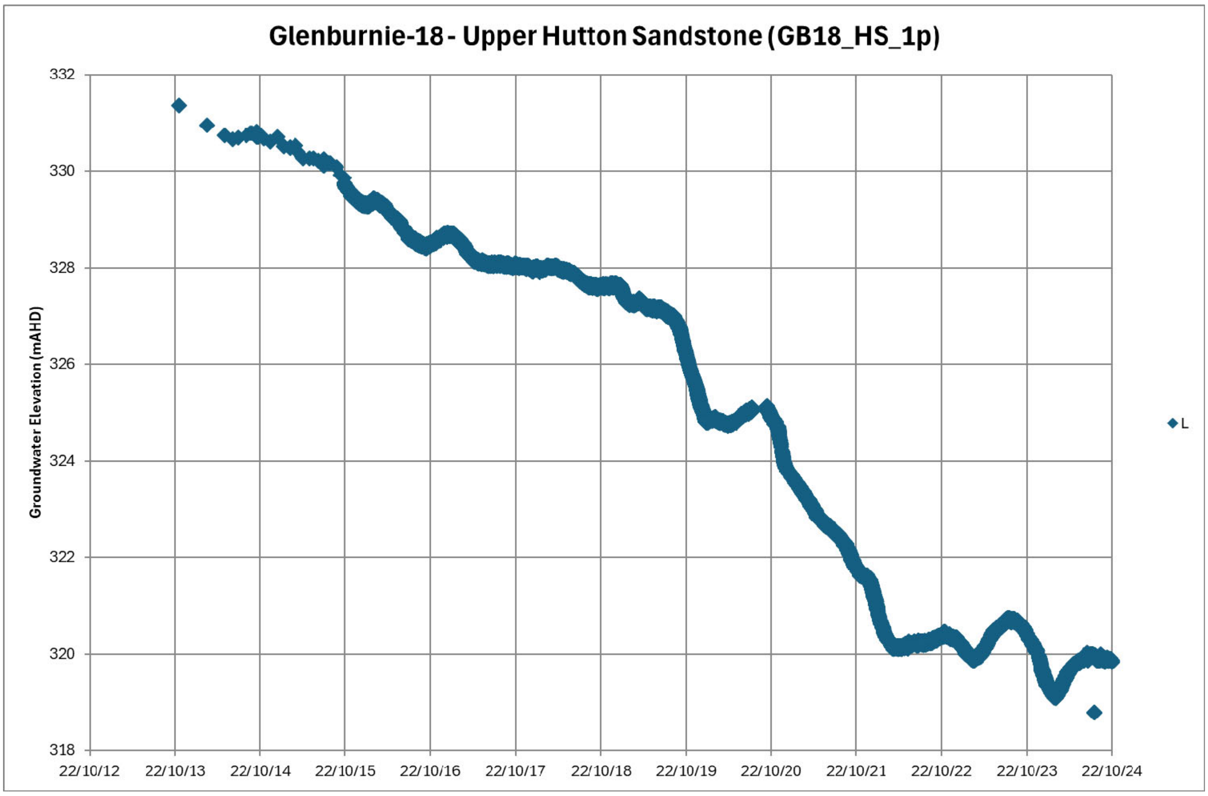

Dundee-20 - Taroom CM (DD20_WCMut_1p)
Groundwater Elevation (mAHD)
295
290
285
280
275
270
265
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

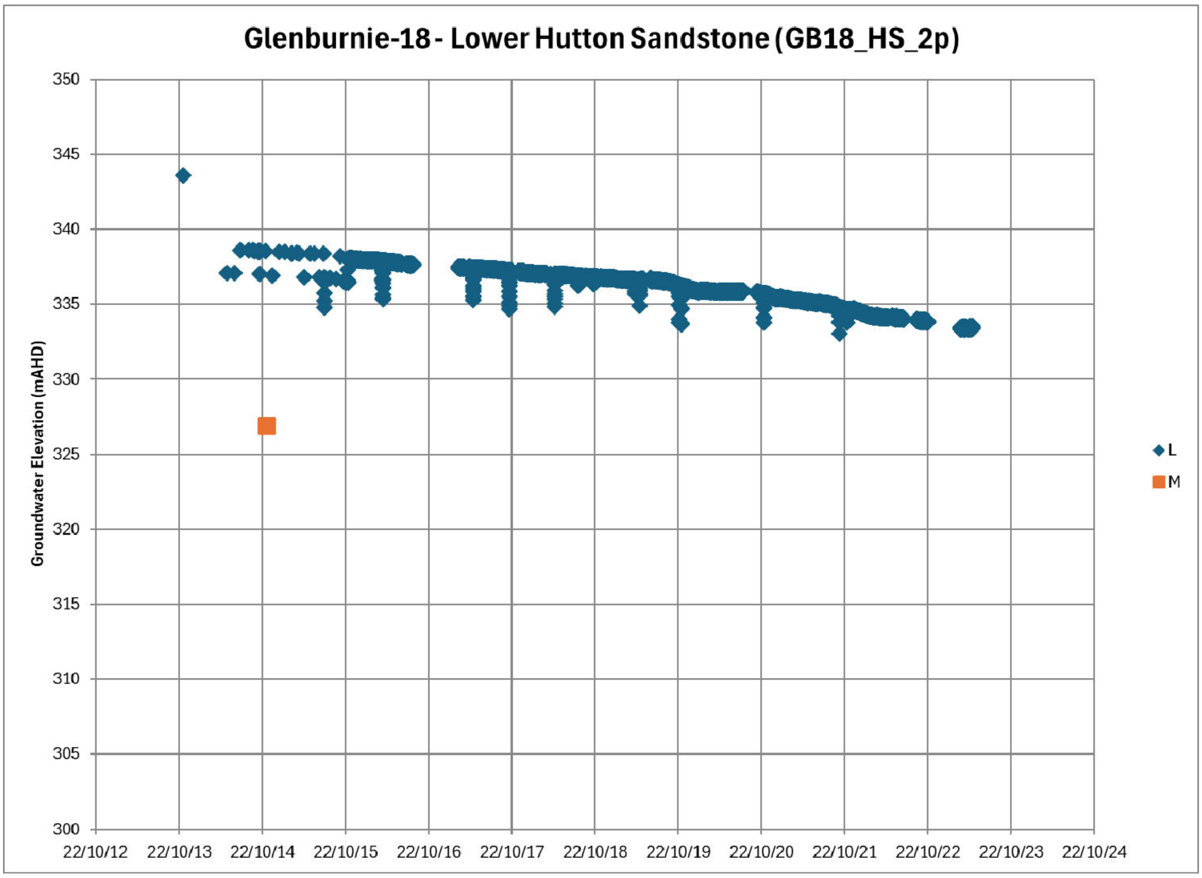

Glenburnie 19 - Lower Juandah CM (GB19_WCM_1p)
Groundwater Elevation (mAHD)
380
370
360
350
340
330
320
310
300
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L
M

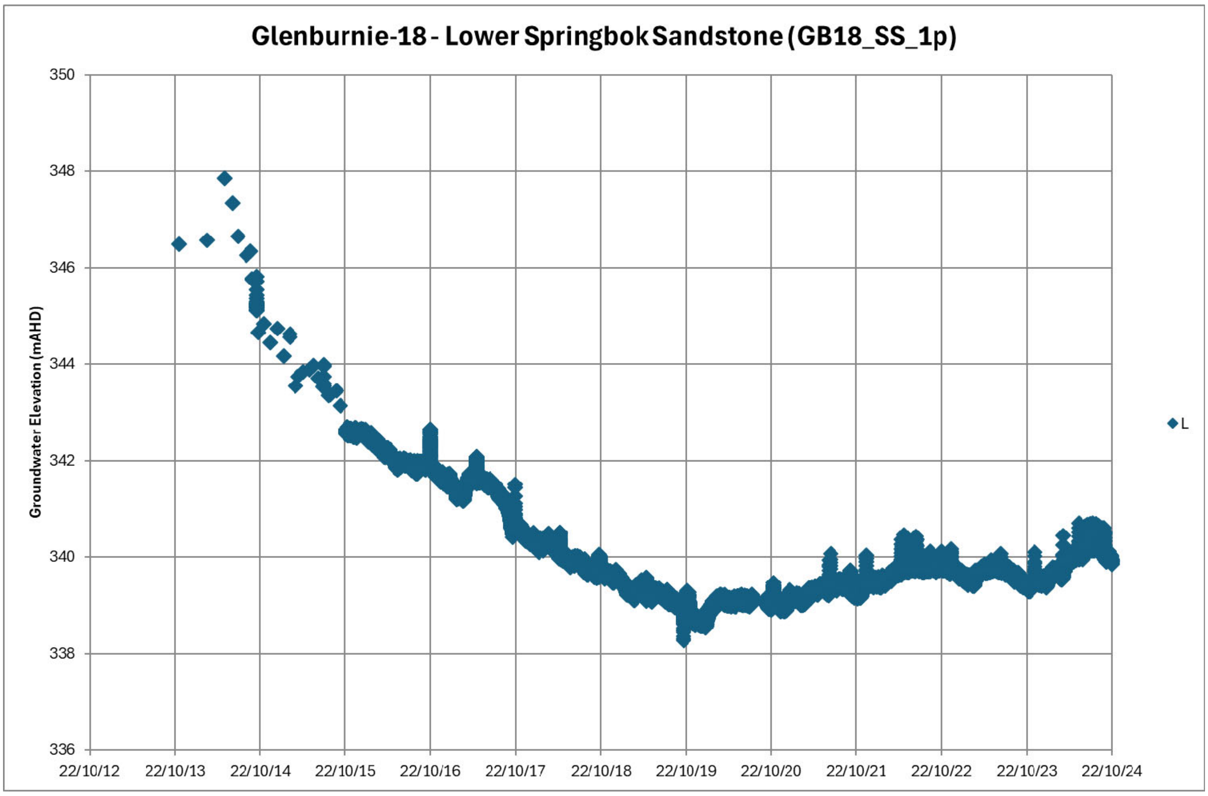

Glenburnie 20 - Lower Springbok Sandstone (GB20_SS_1p)
Groundwater Elevation (mAHD)
368
367.5
367
366.5
366
365.5
365
364.5
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

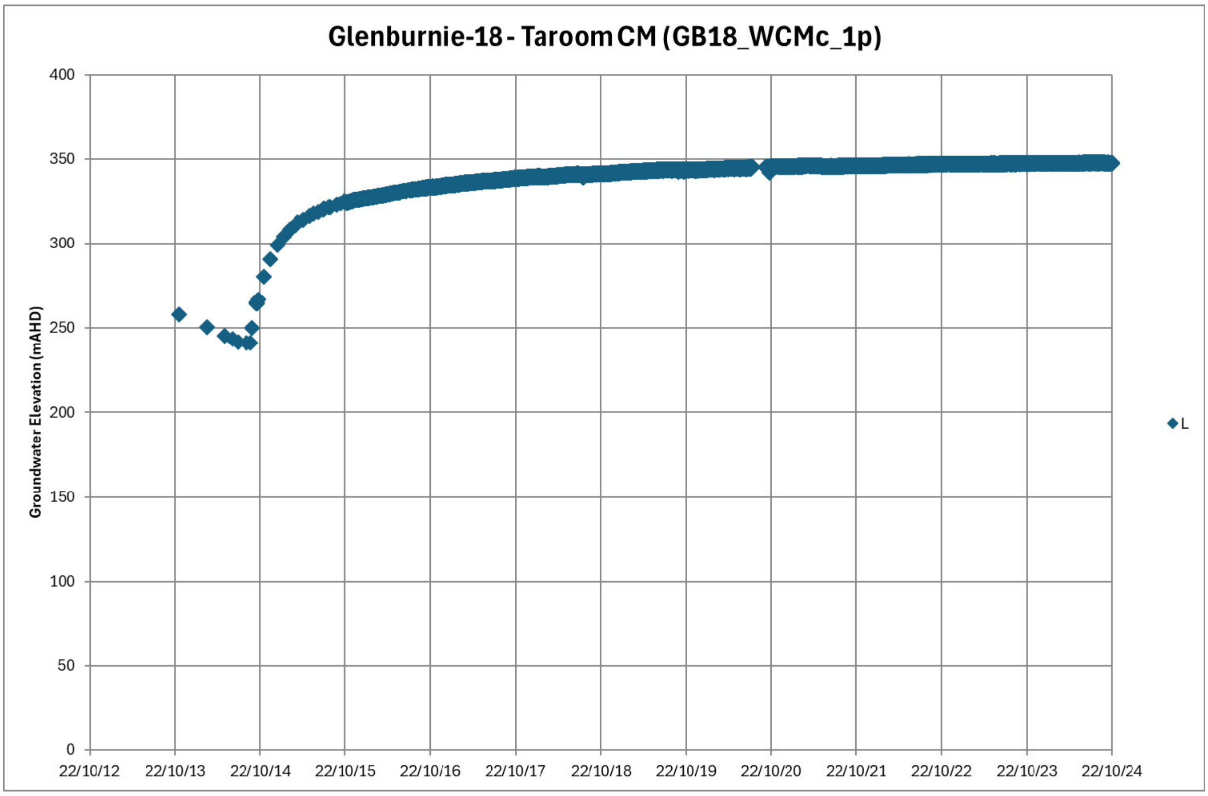

Glenburnie 21 - Upper Juandah CM (GB21_WCMju_1p)
Groundwater Elevation (mAHD)
369
368.5
368
367.5
367
366.5
366
365.5
365
364.5
364
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

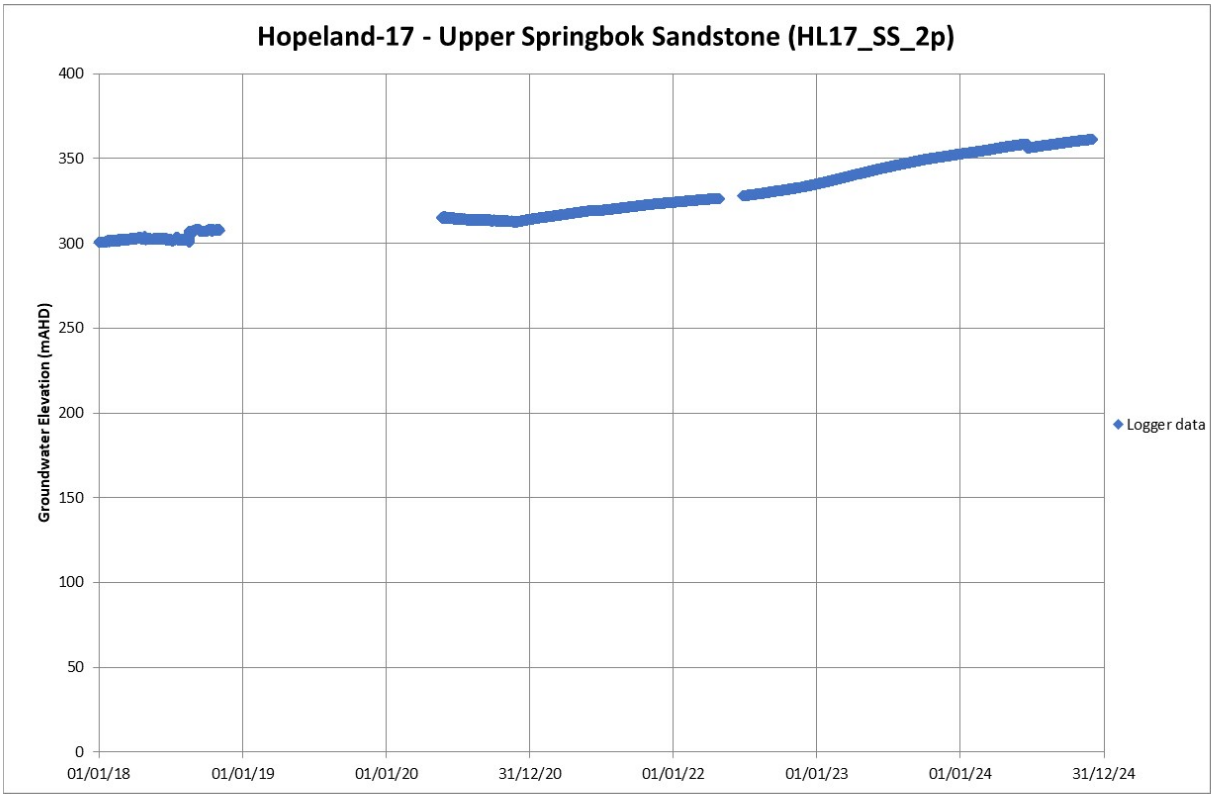

Glenburnie 22 - Upper Juandah CM (GB22_WCMju_1p)
Groundwater Elevation (mAHD)
379
378
377
376
375
374
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

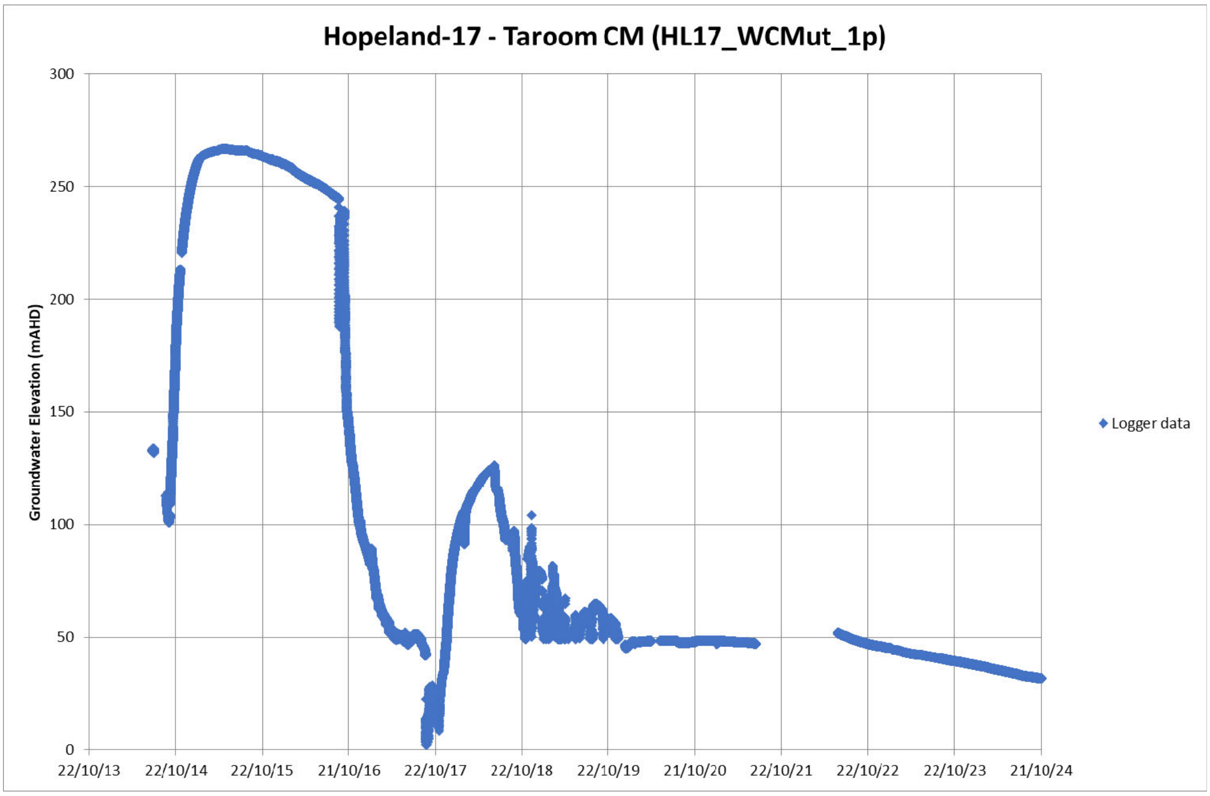

Glenburnie-18 - Upper Hutton Sandstone (GB18_HS_1p)
Groundwater Elevation (mAHD)
332
330
328
326
324
322
320
318
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L

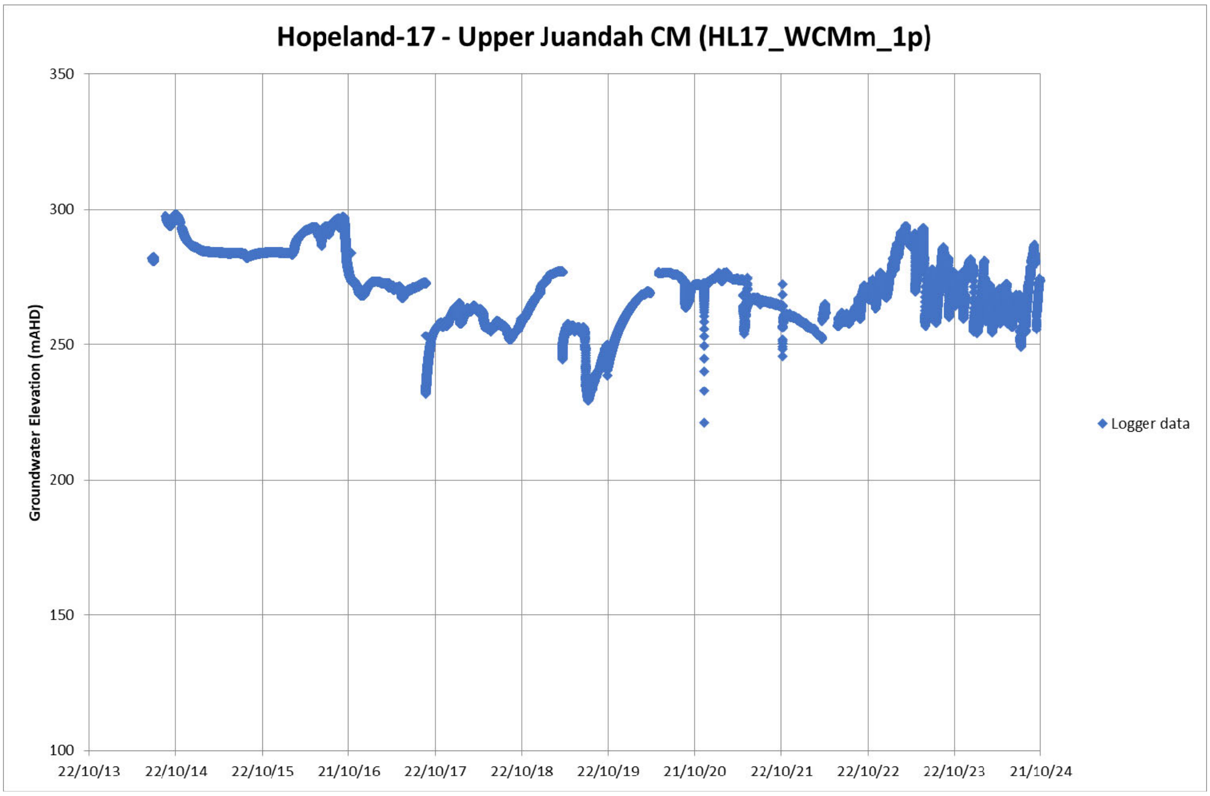

Glenburnie-18 - Lower Hutton Sandstone (GB18_HS_2p)
Groundwater Elevation (mAHD)
350
345
340
335
330
325
320
315
310
305
300
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

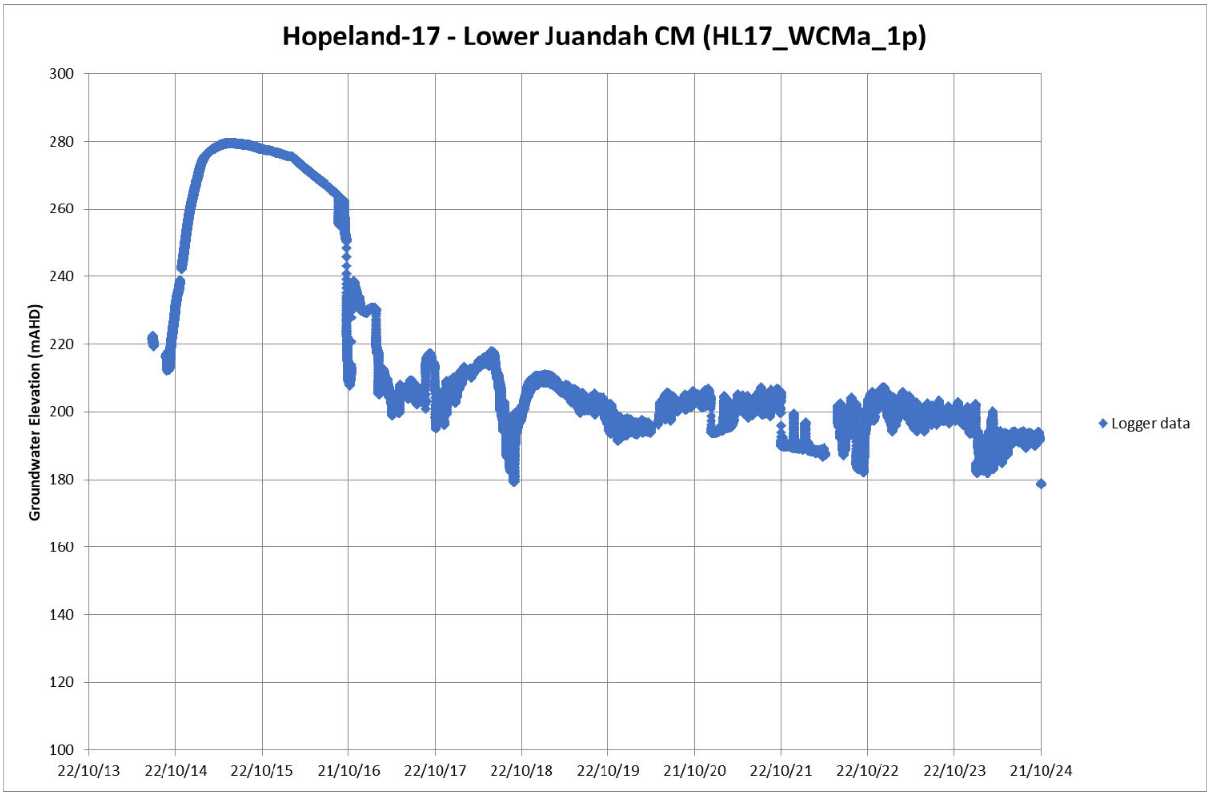

Glenburnie-18 - Lower Springbok Sandstone (GB18_SS_1p)
Groundwater Elevation (mAHD)
350
348
346
344
342
340
338
336
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L

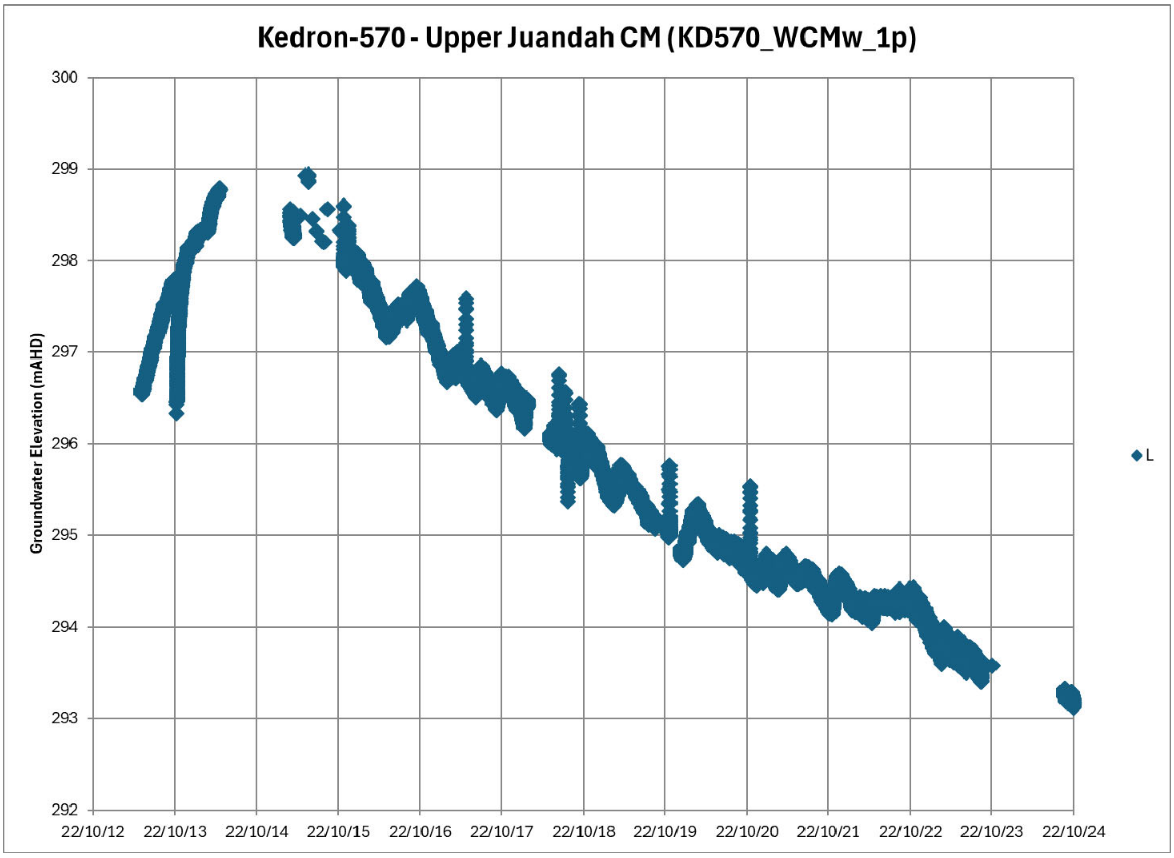

Glenburnie-18 - Taroom CM (GB18_WCMc_1p)
Groundwater Elevation (mAHD)
400
350
300
250
200
150
100
50
0
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L


Hopeland-17 - Upper Springbok Sandstone (HL17_SS_2p)
Groundwater Elevation (mAHD)
400
350
300
250
200
150
100
50
0
01/01/18
01/01/19
01/01/20
31/12/20
01/01/22
01/01/23
01/01/24
31/12/24
Logger data

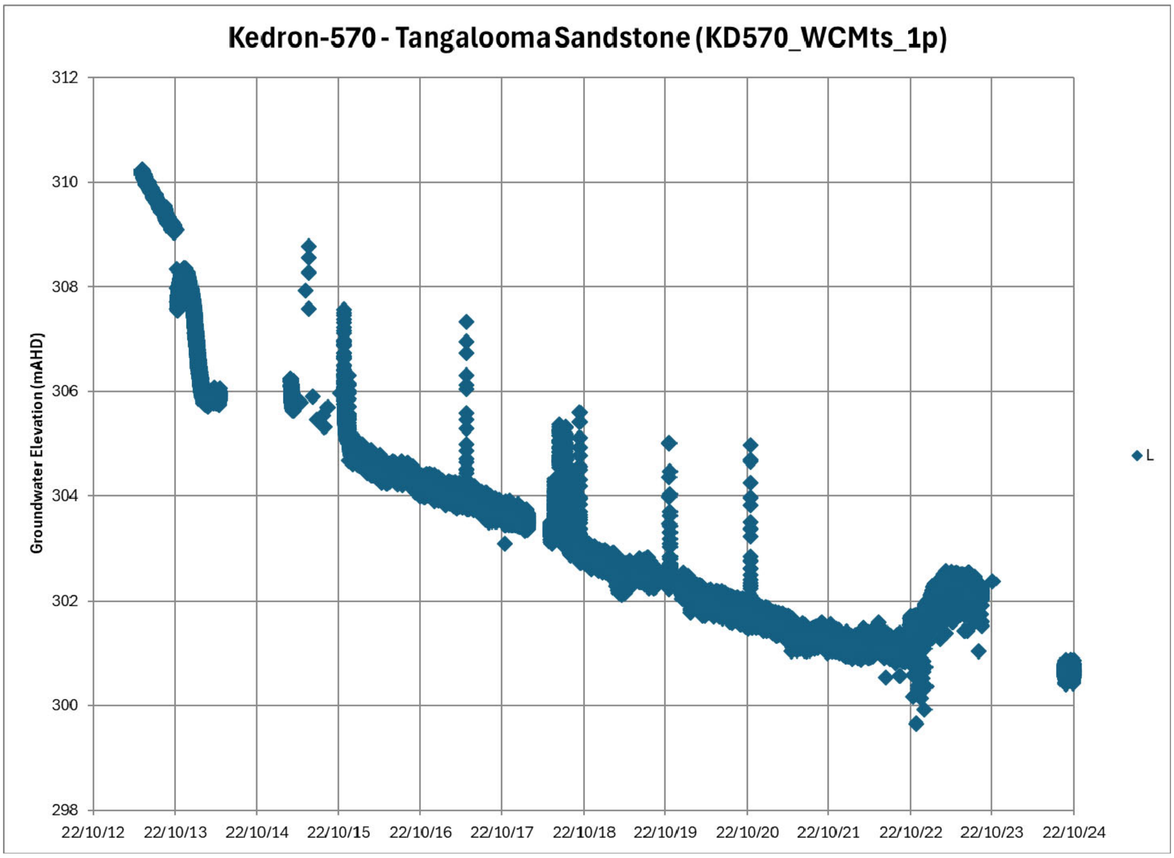

Hopeland-17 - Taroom CM (HL17_WCMut_1p)
Groundwater Elevation (mAHD)
300
250
200
150
100
50
0
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
Logger data

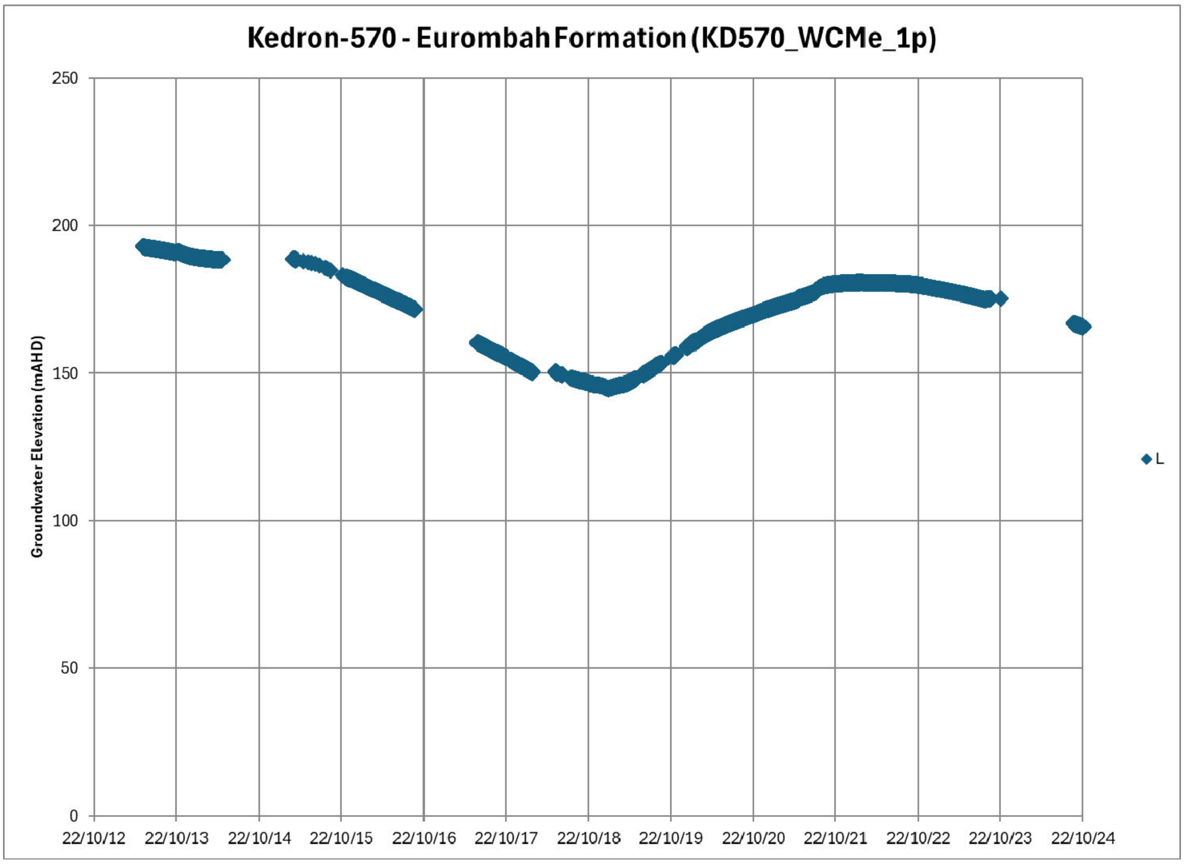

Hopeland-17 - Upper Juandah CM (HL17_WCMm_1p)
Groundwater Elevation (mAHD)
350
300
250
200
150
100
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
Logger data

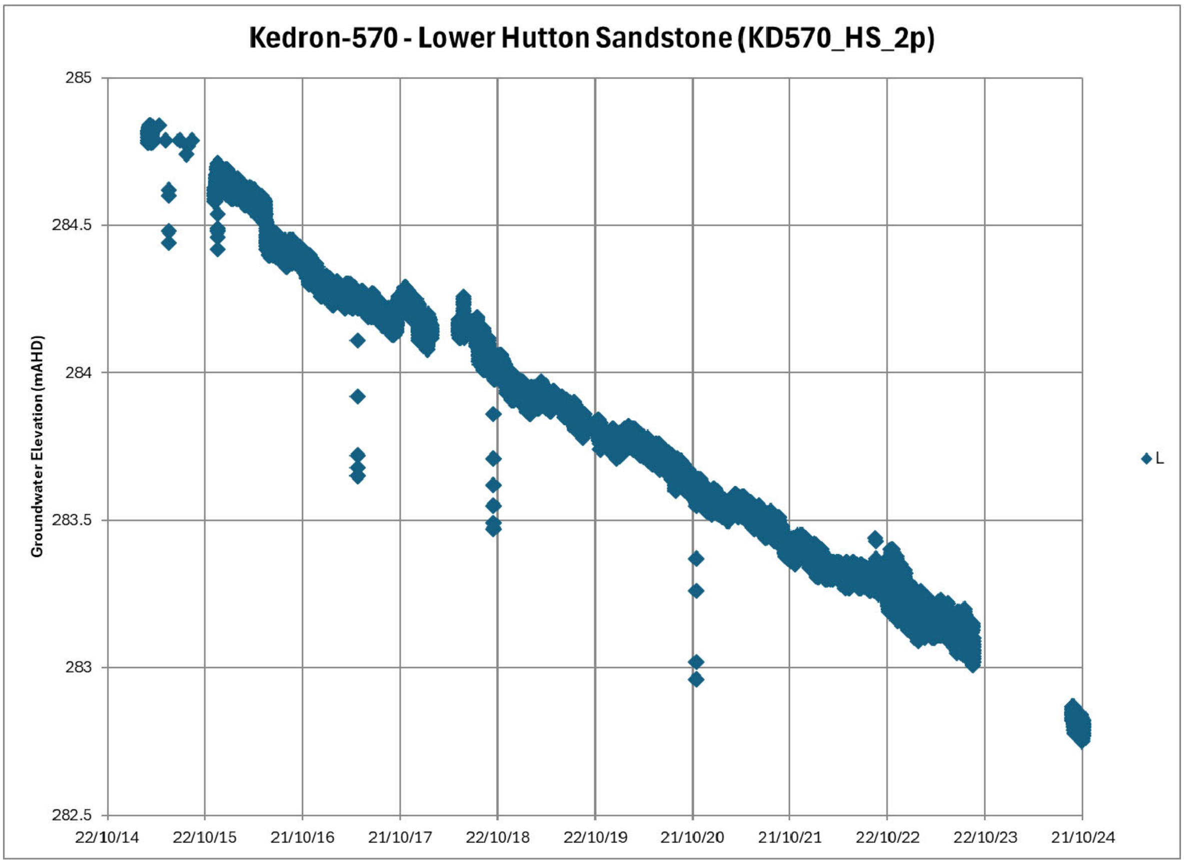


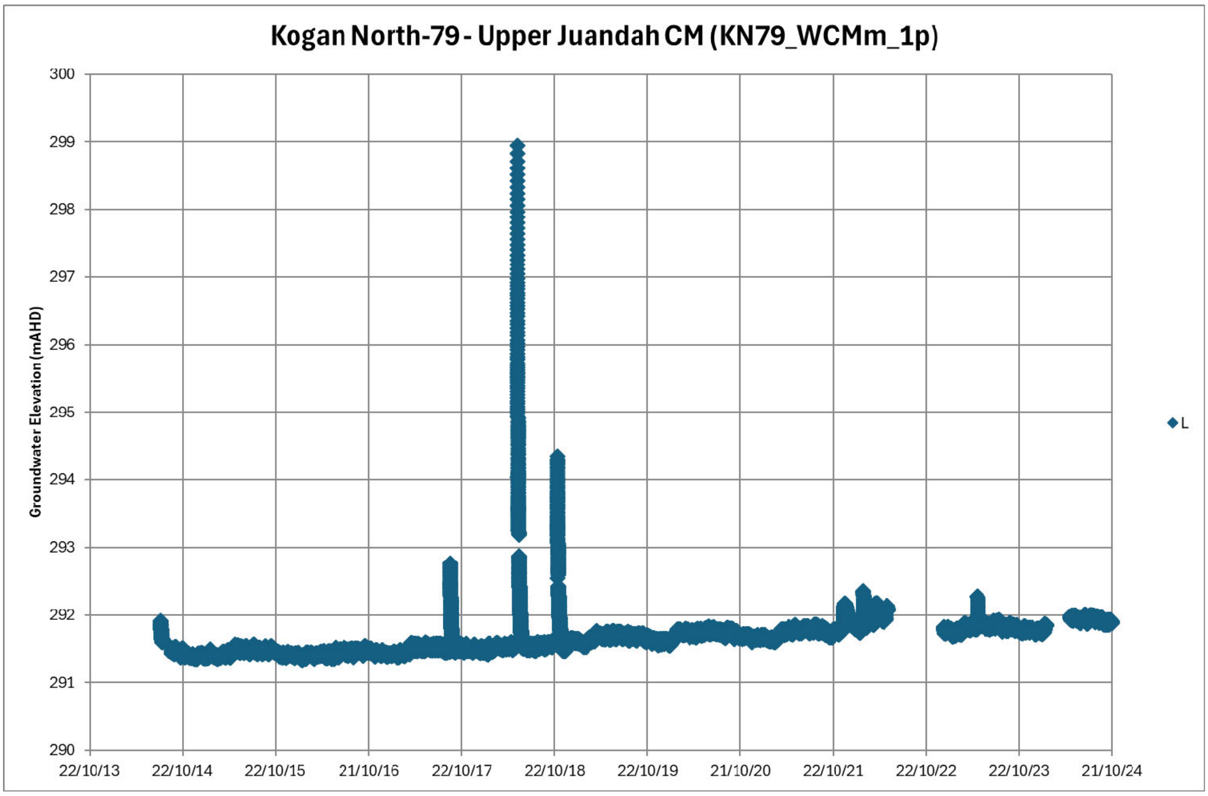


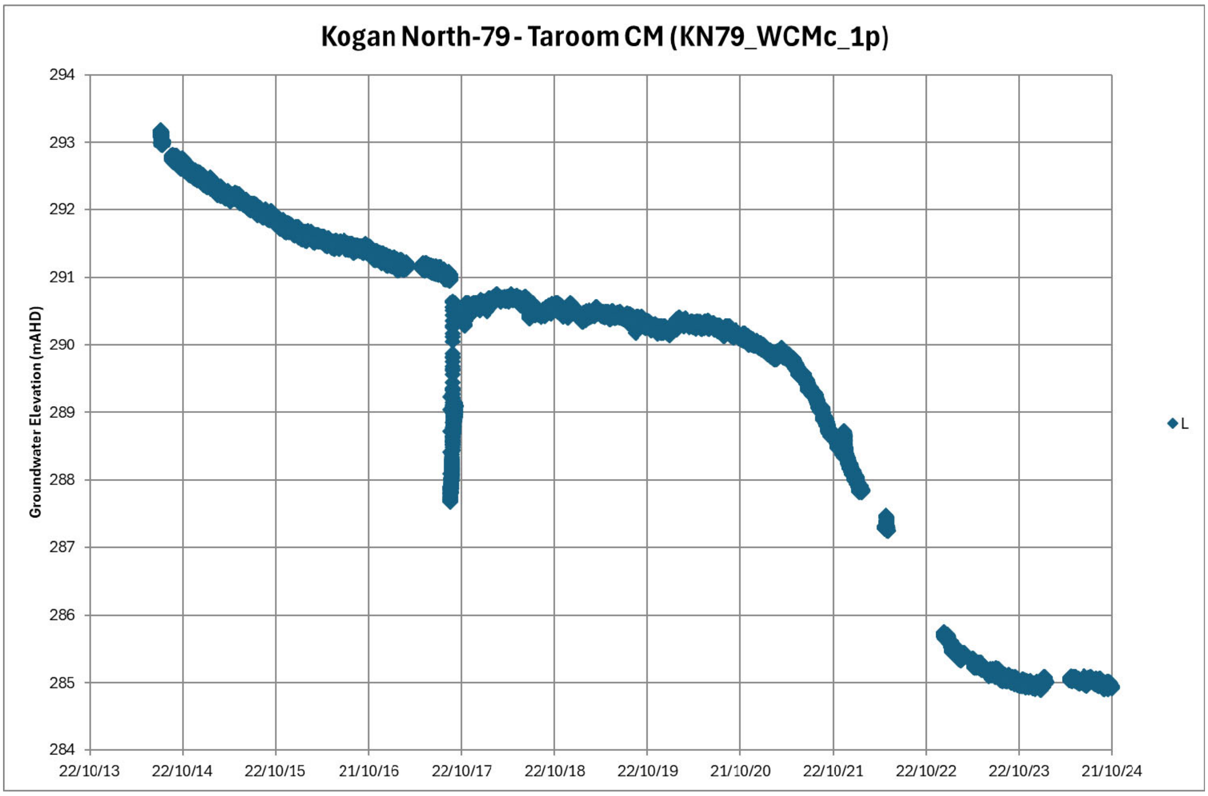
arrow energy
go further

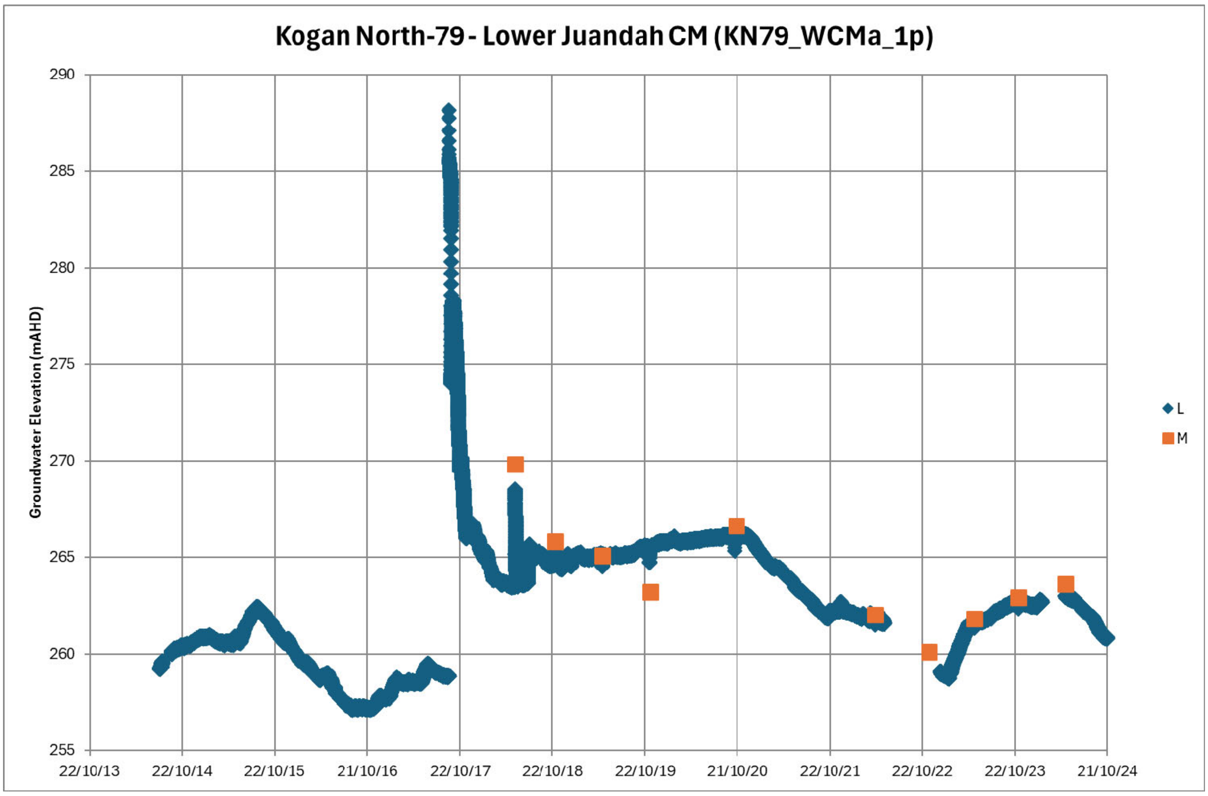

Kedron-570 - Tangalooma Sandstone (KD570_WCMts_1p)
Groundwater Elevation (mAHD)
312
310
308
306
304
302
300
298
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L

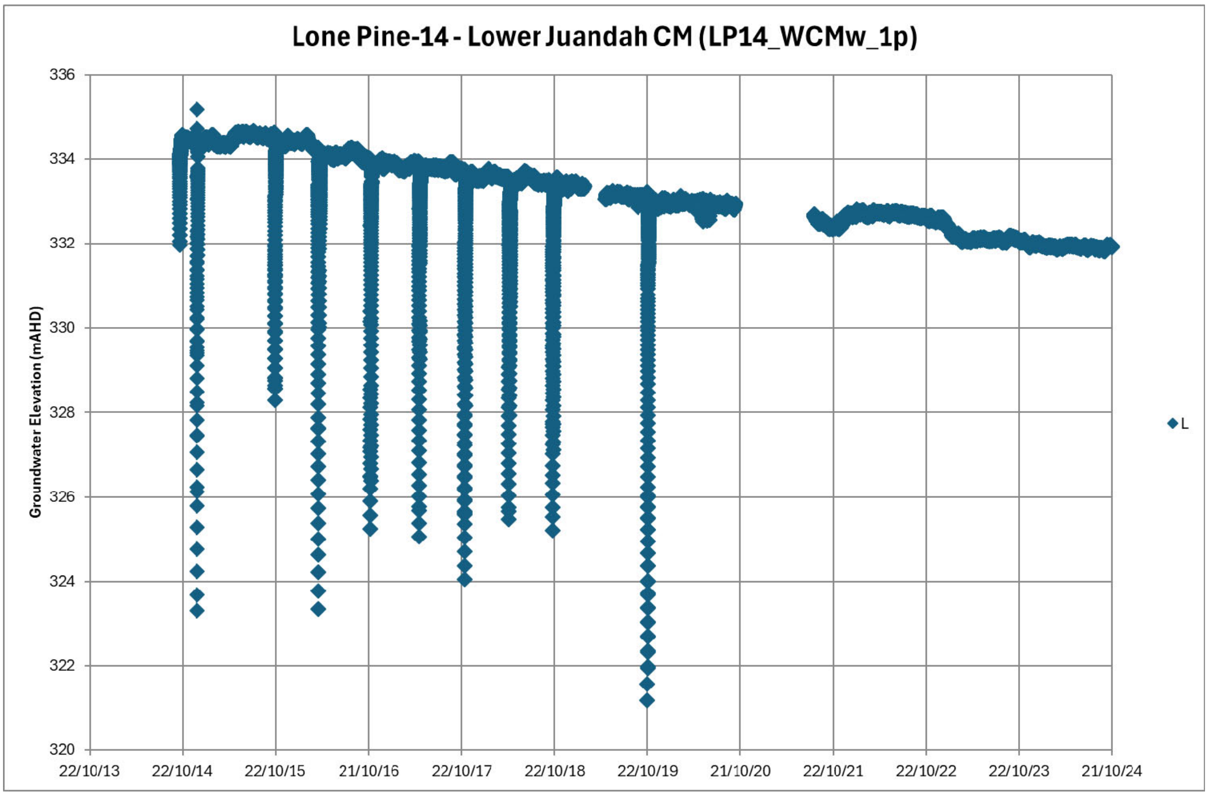

Kedron-570 - Eurombah Formation (KD570_WCMe_1p)
Groundwater Elevation (mAHD)
250
200
150
100
50
0
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L

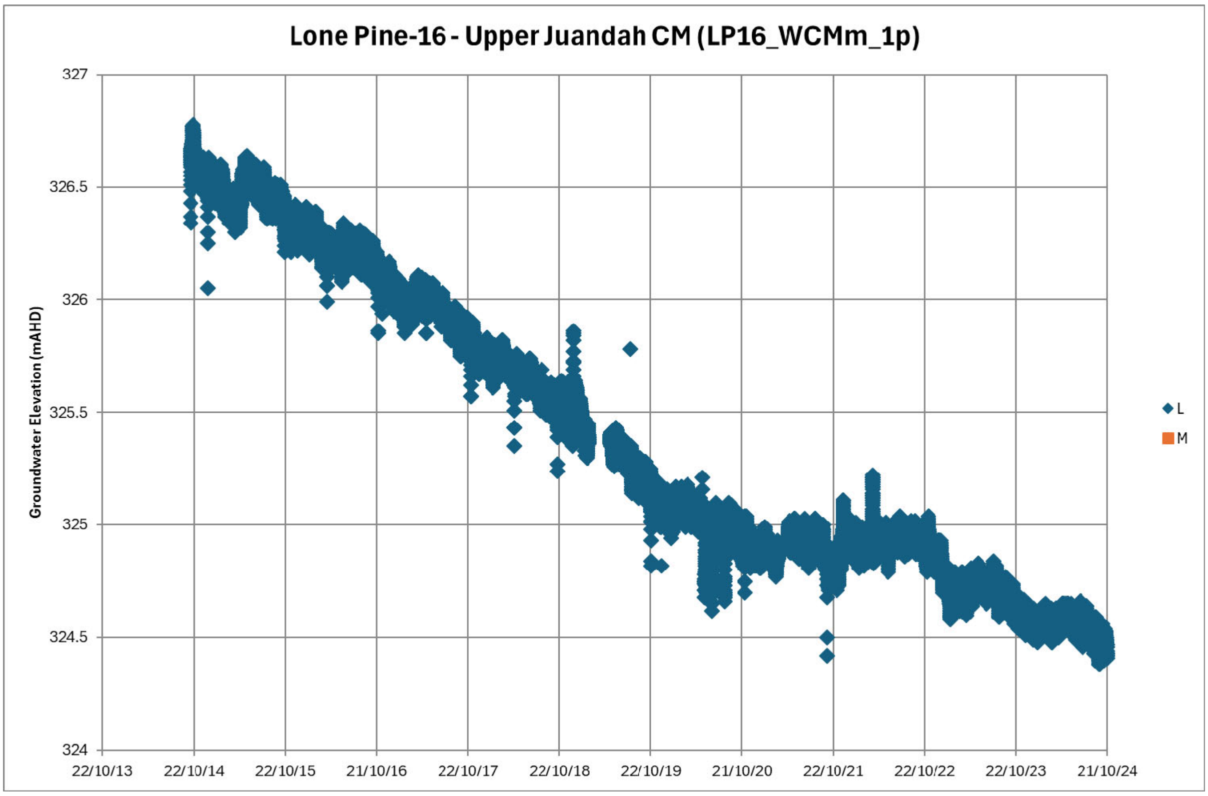

Kedron-570 - Lower Hutton Sandstone (KD570_HS_2p)
Groundwater Elevation (mAHD)
285
284.5
284
283.5
283
282.5
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L

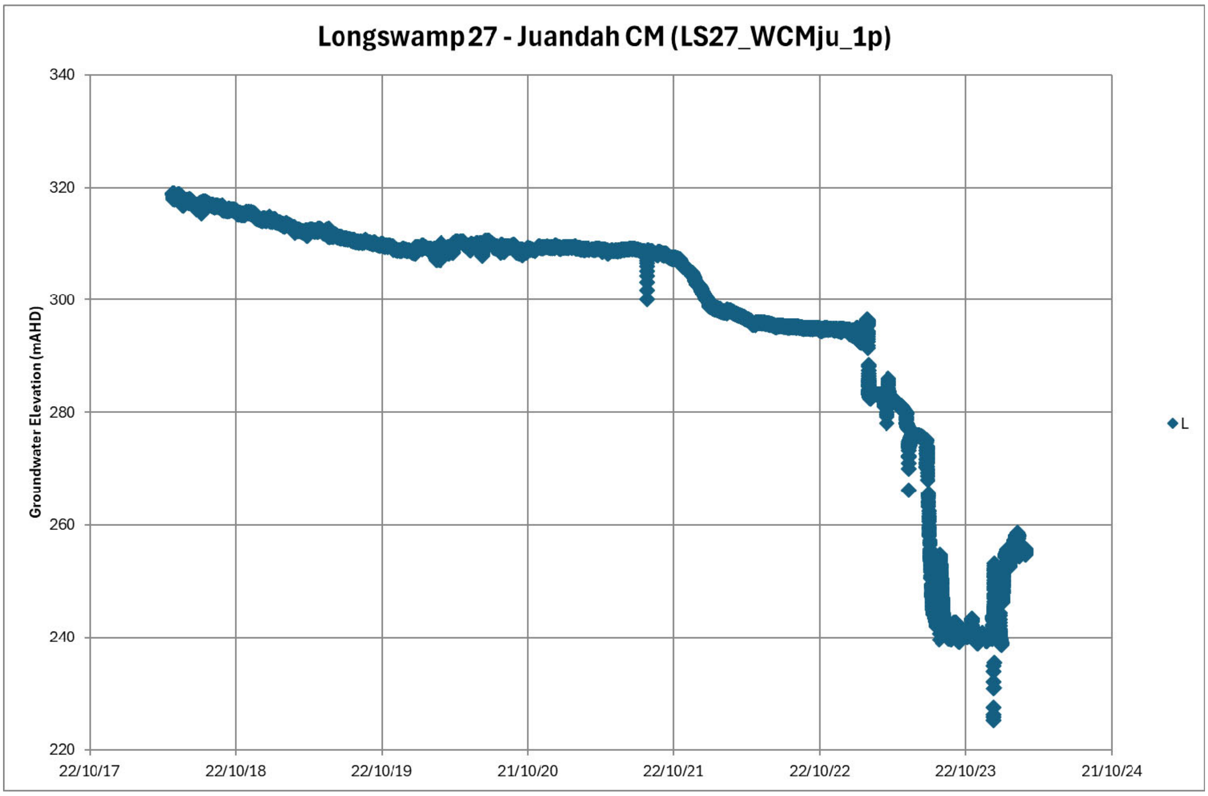

Kogan North-79 - Upper Juandah CM (KN79_WCMm_1p)
Groundwater Elevation (mAHD)
300
299
298
297
296
295
294
293
292
291
290
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

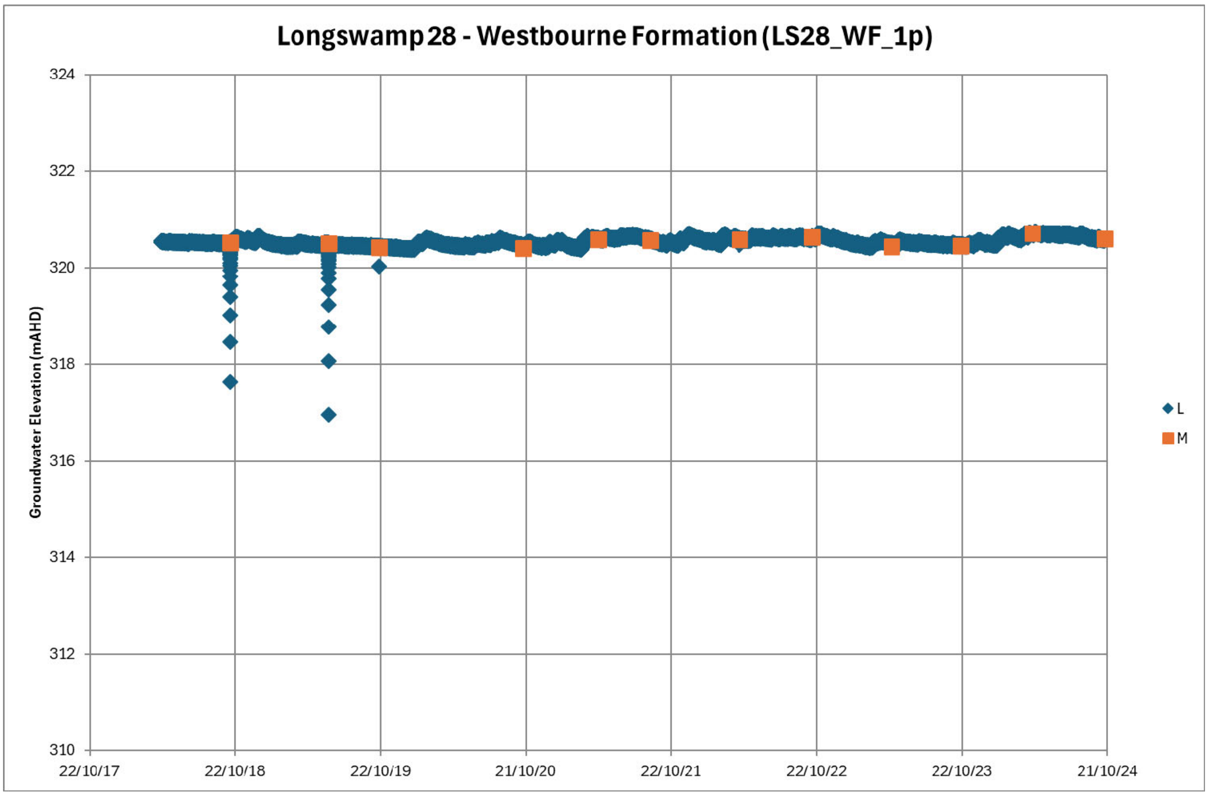

Kogan North-79 - Taroom CM (KN79_WCMc_1p)
Groundwater Elevation (mAHD)
294
293
292
291
290
289
288
287
286
285
284
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

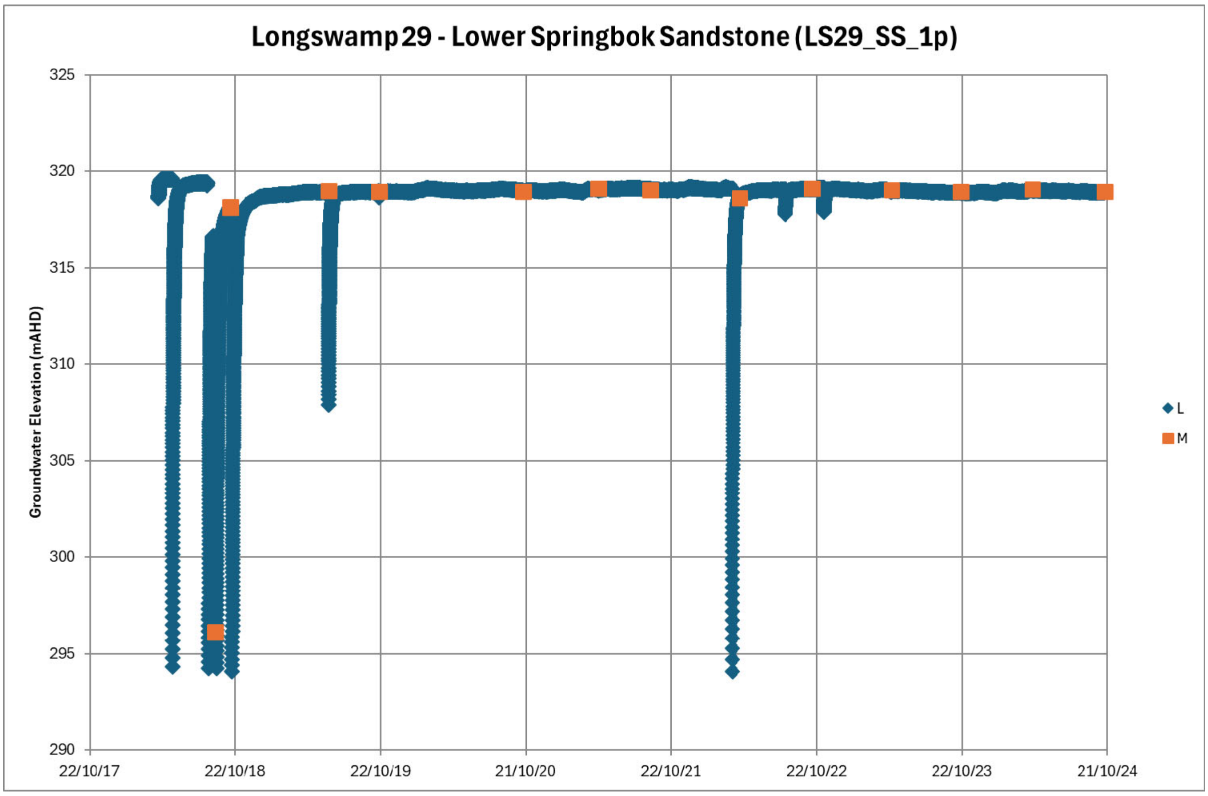

Kogan North-79 - Lower Juandah CM (KN79_WCMa_1p)
Groundwater Elevation (mAHD)
290
285
280
275
270
265
260
255
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

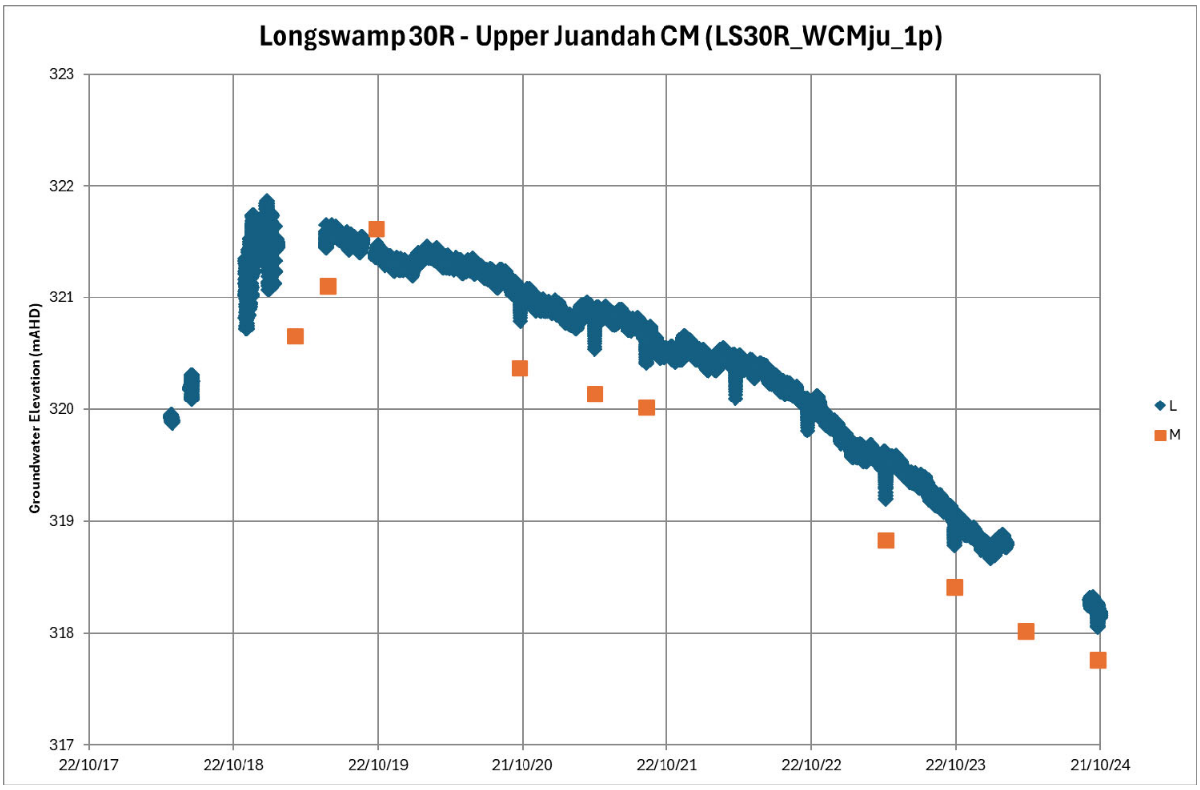

Lone Pine-14 - Lower Juandah CM (LP14_WCMw_1p)
Groundwater Elevation (mAHD)
336
334
332
330
328
326
324
322
320
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

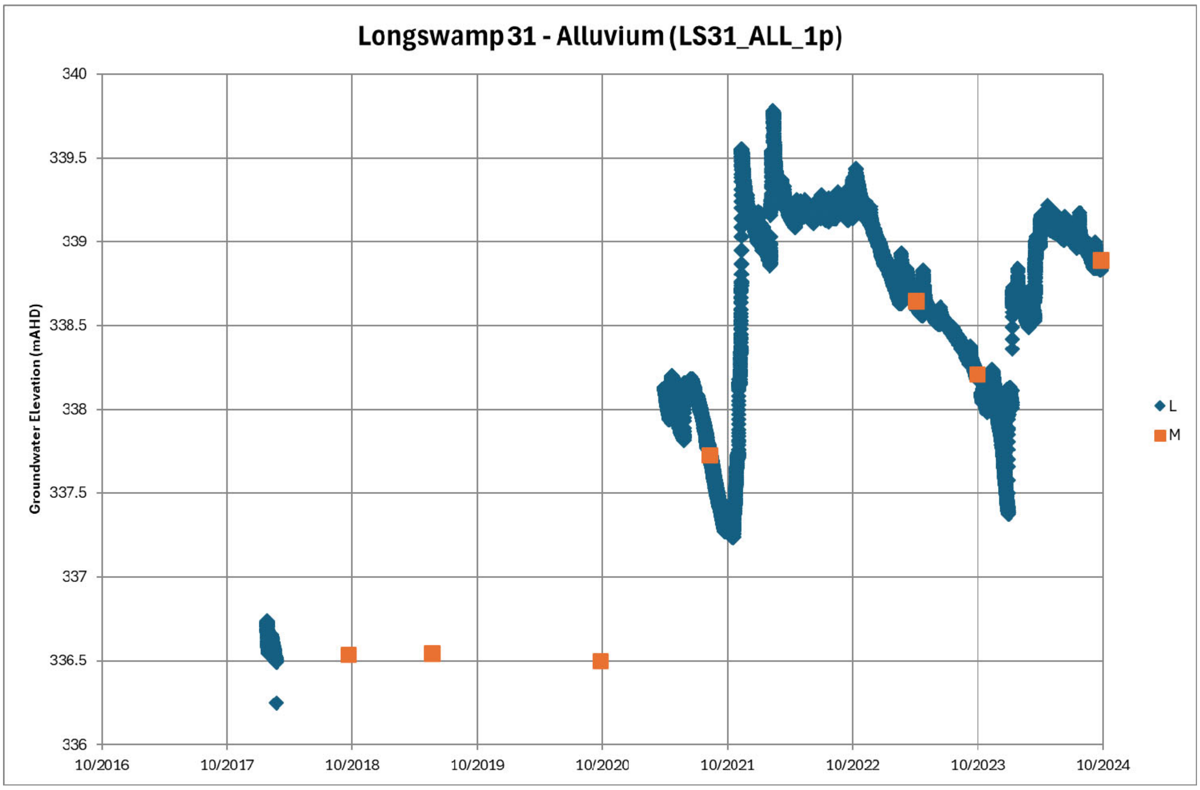

Lone Pine-16 - Upper Juandah CM (LP16_WCMm_1p)
Groundwater Elevation (mAHD)
327
326.5
326
325.5
325
324.5
324
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

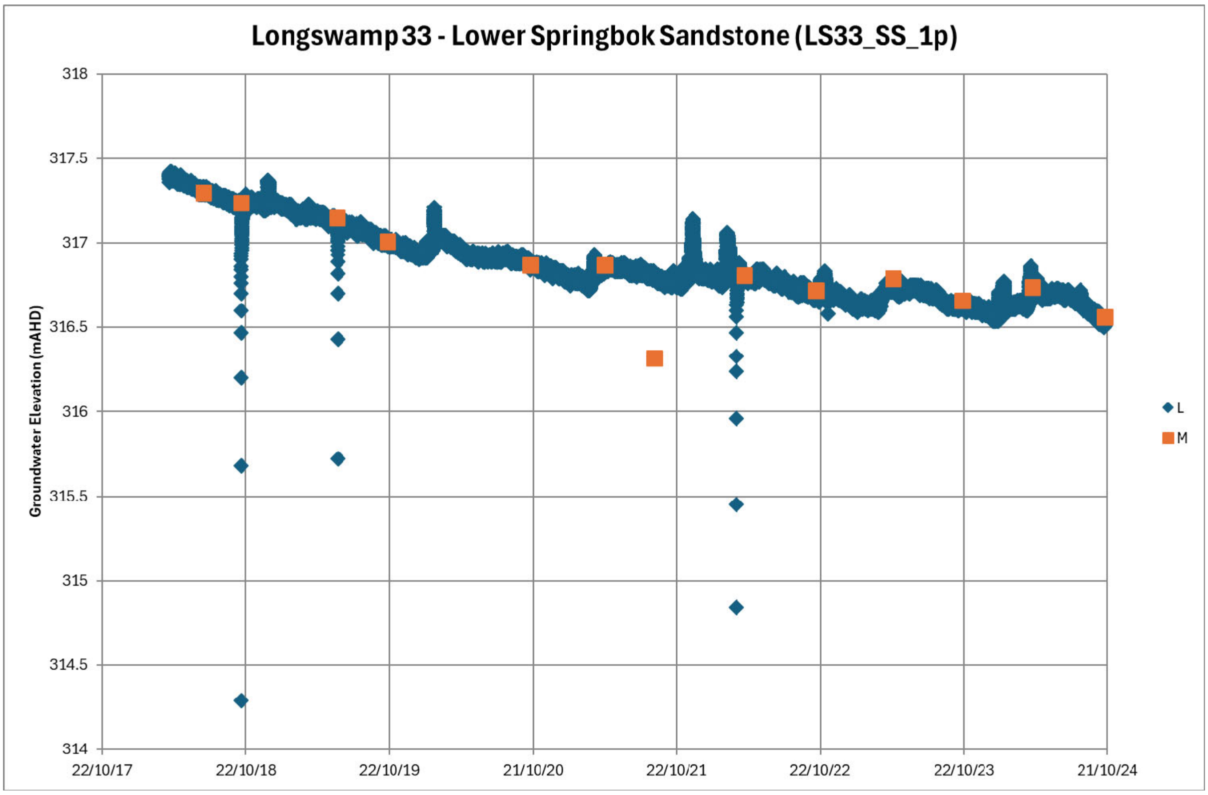

Longswamp 27 - Juandah CM (LS27_WCMju_1p)
Groundwater Elevation (mAHD)
340
320
300
280
260
240
220
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

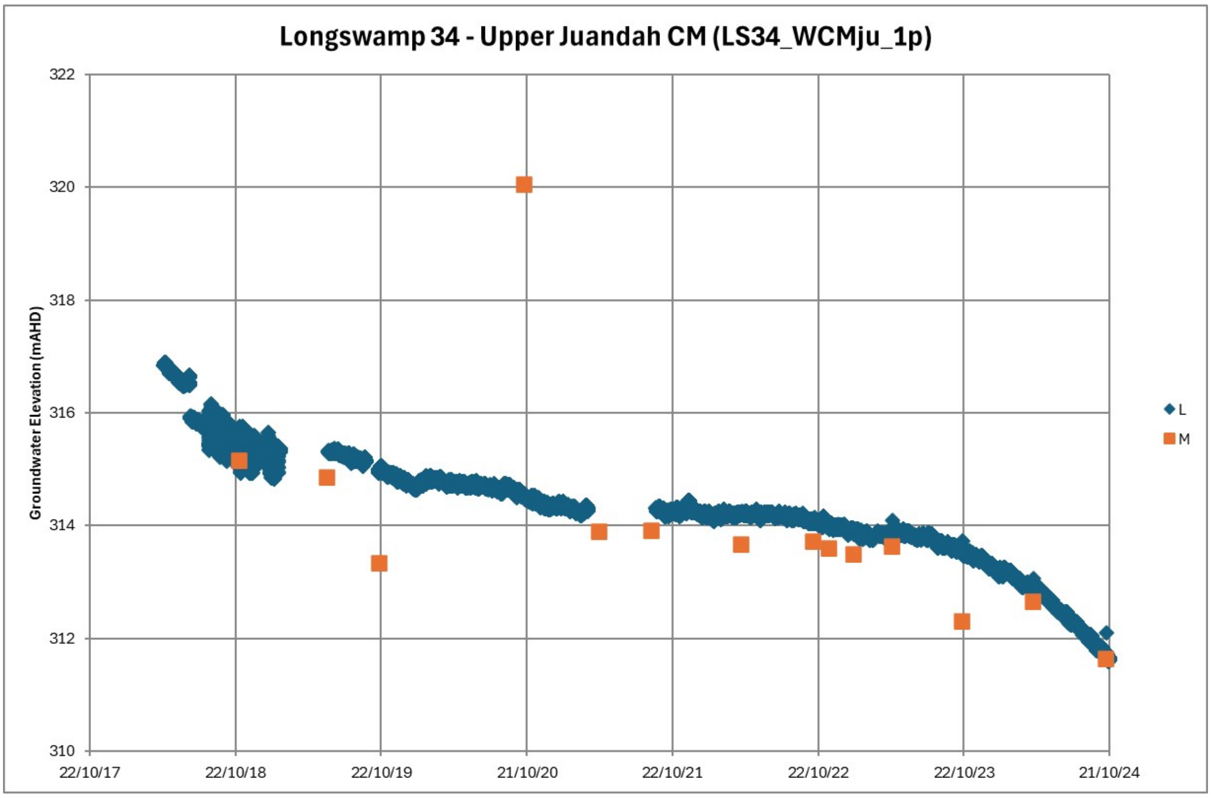

Longswamp 28 - Westbourne Formation (LS28_WF_1p)
Groundwater Elevation (mAHD)
324
322
320
318
316
314
312
310
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M


Longswamp 29 - Lower Springbok Sandstone (LS29_SS_1p)
Groundwater Elevation (mAHD)
325
320
315
310
305
300
295
290
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

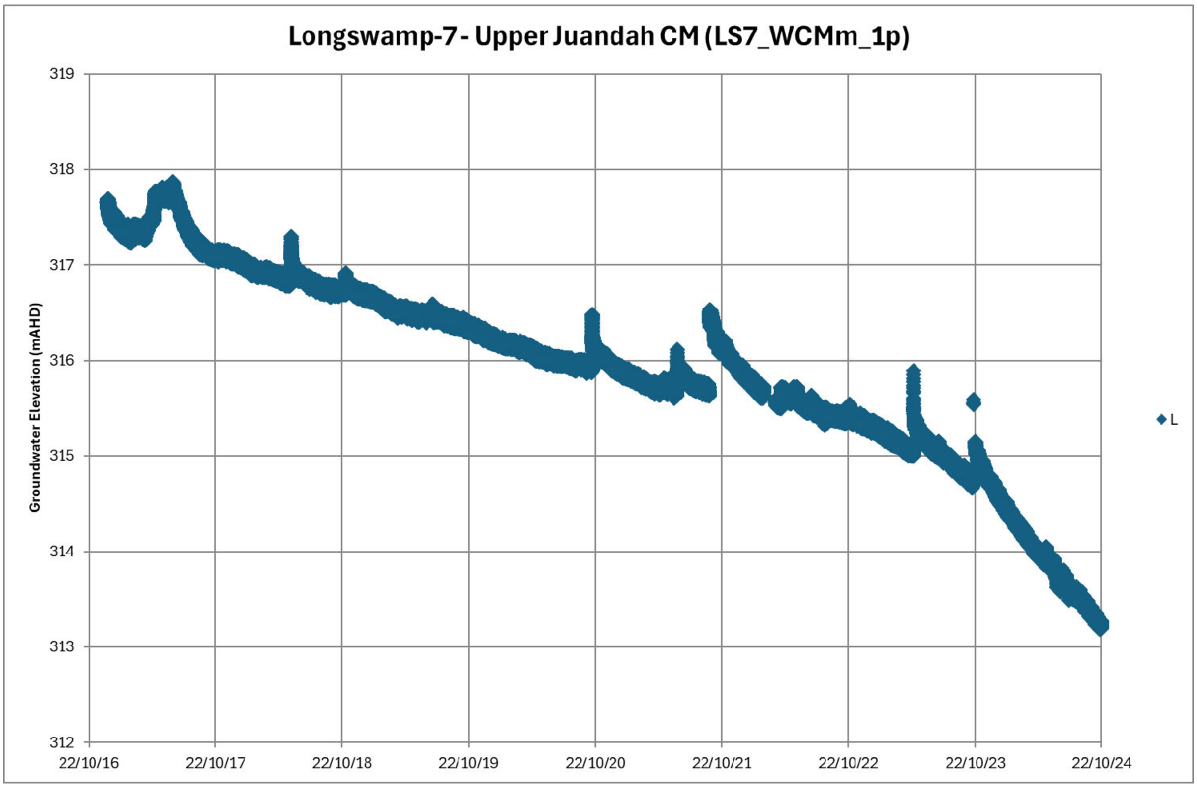

Longswamp 30R - Upper Juandah CM (LS30R_WCMju_1p)
Groundwater Elevation (mAHD)
323
322
321
320
319
318
317
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M


Longswamp 31 - Alluvium (LS31_ALL_1p)
Groundwater Elevation (mAHD)
340
339.5
339
338.5
338
337.5
337
336.5
336
10/2016
10/2017
10/2018
10/2019
10/2020
10/2021
10/2022
10/2023
10/2024
L
M

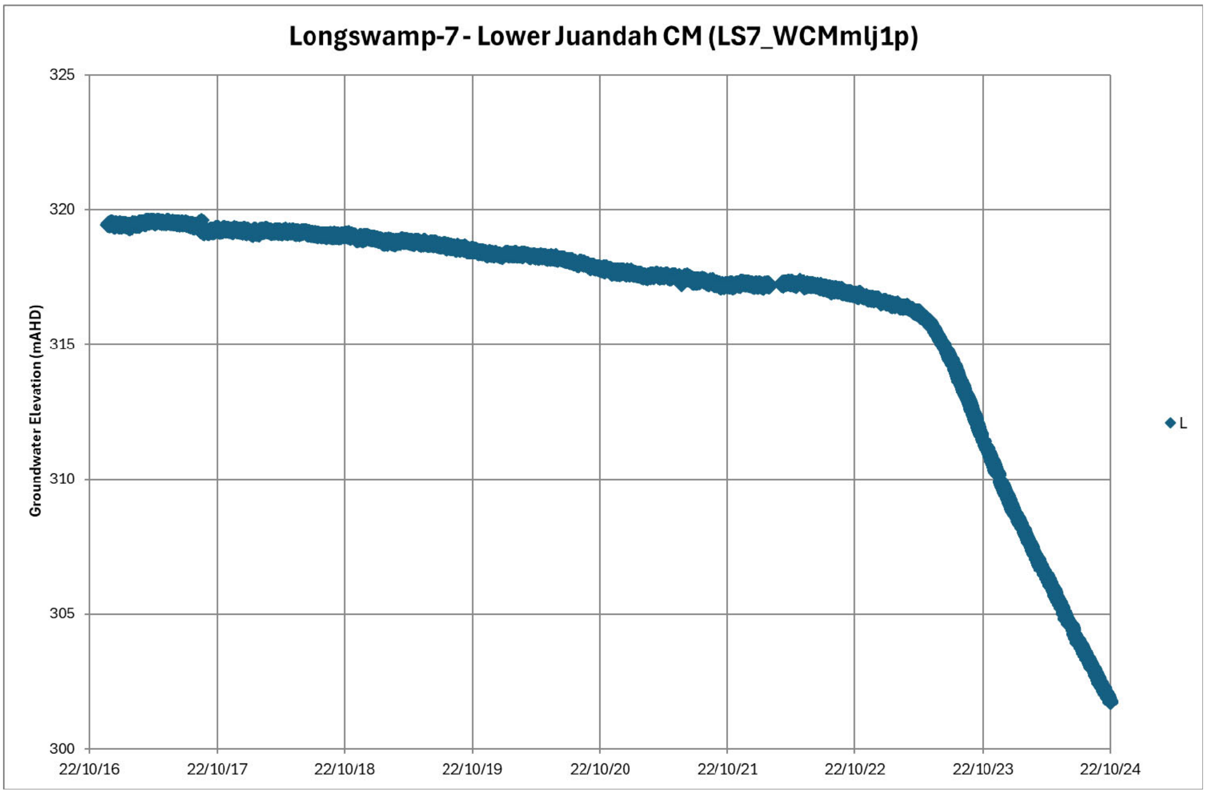

Longswamp 33 - Lower Springbok Sandstone (LS33_SS_1p)
Groundwater Elevation (mAHD)
318
317.5
317
316.5
316
315.5
315
314.5
314
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

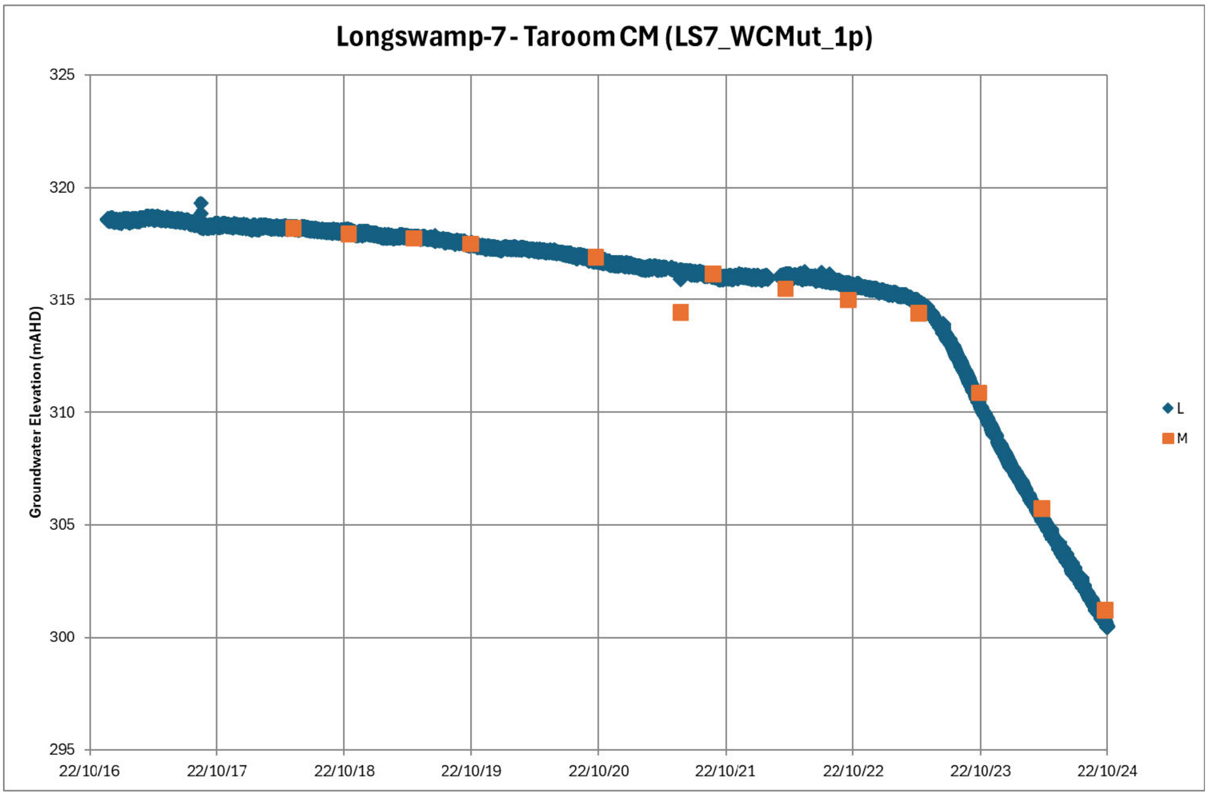


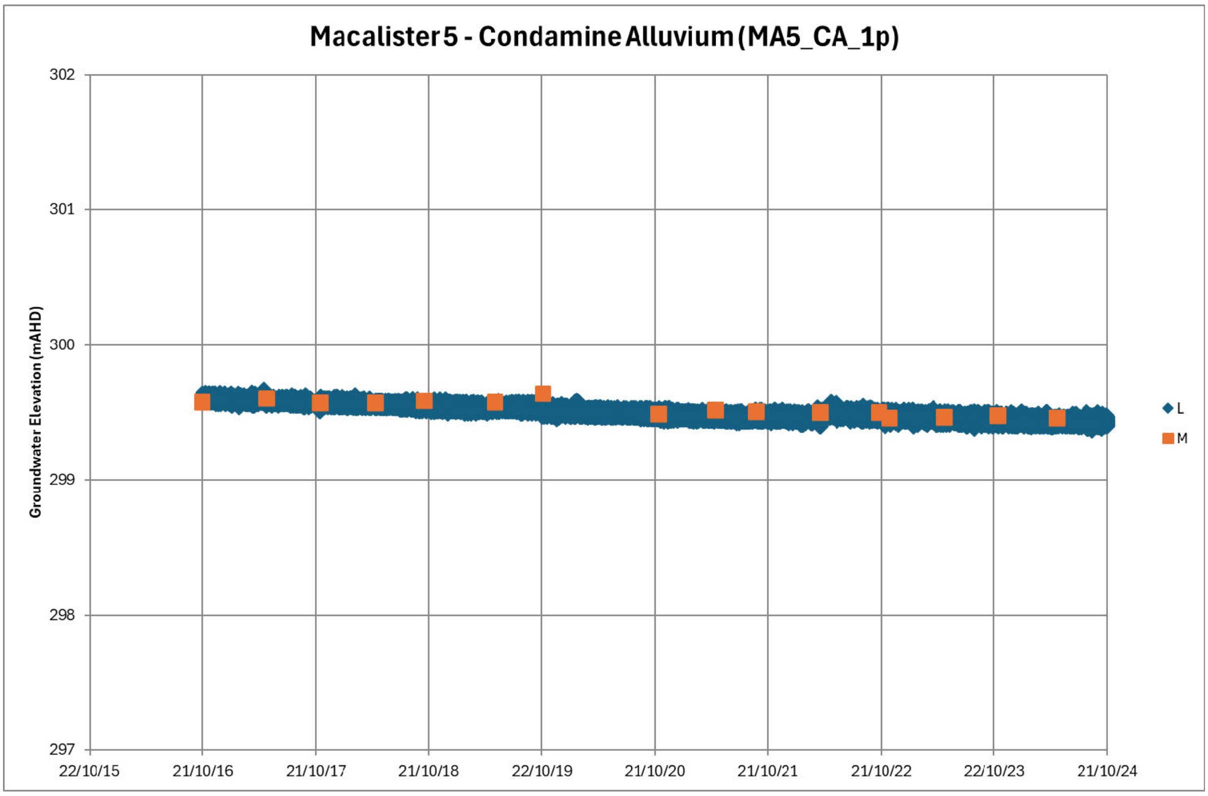
Longswamp 34 - Upper Juandah CM (LS34_WCMju_1p)
Groundwater Elevation (mAHD)
322
320
318
316
314
312
310
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

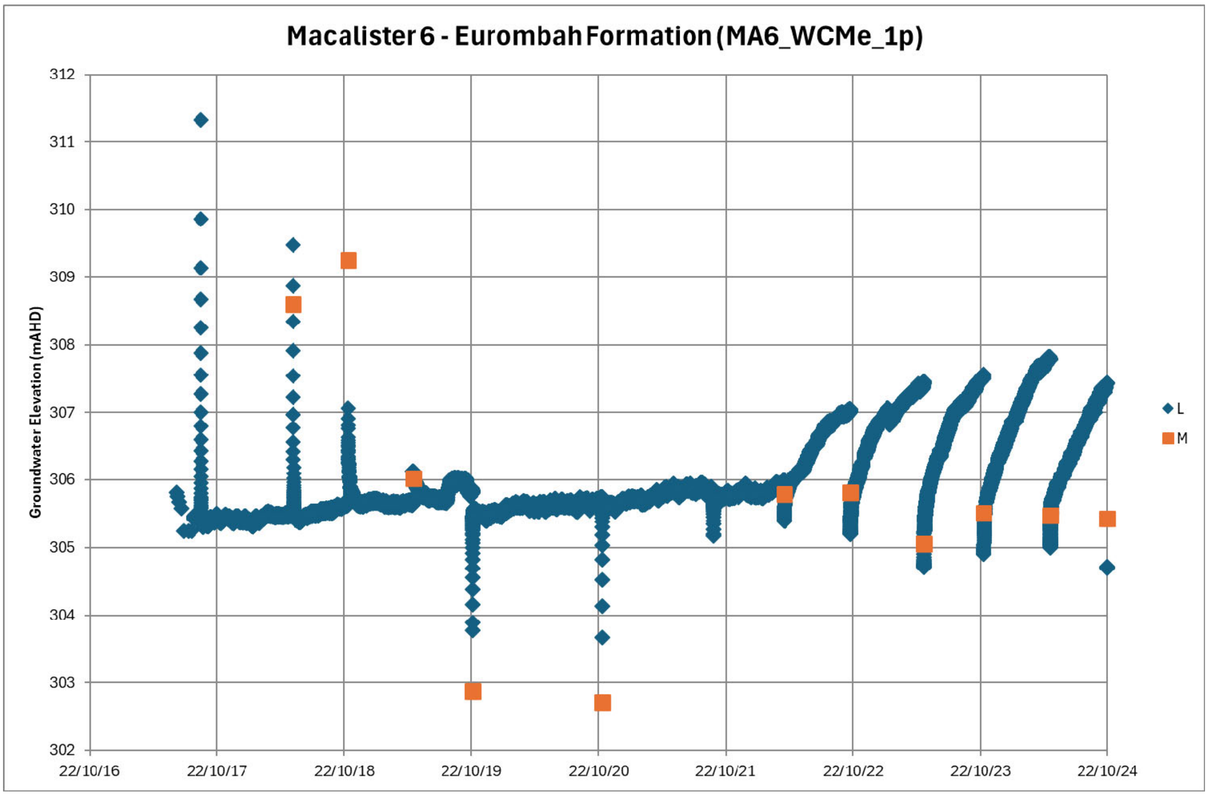


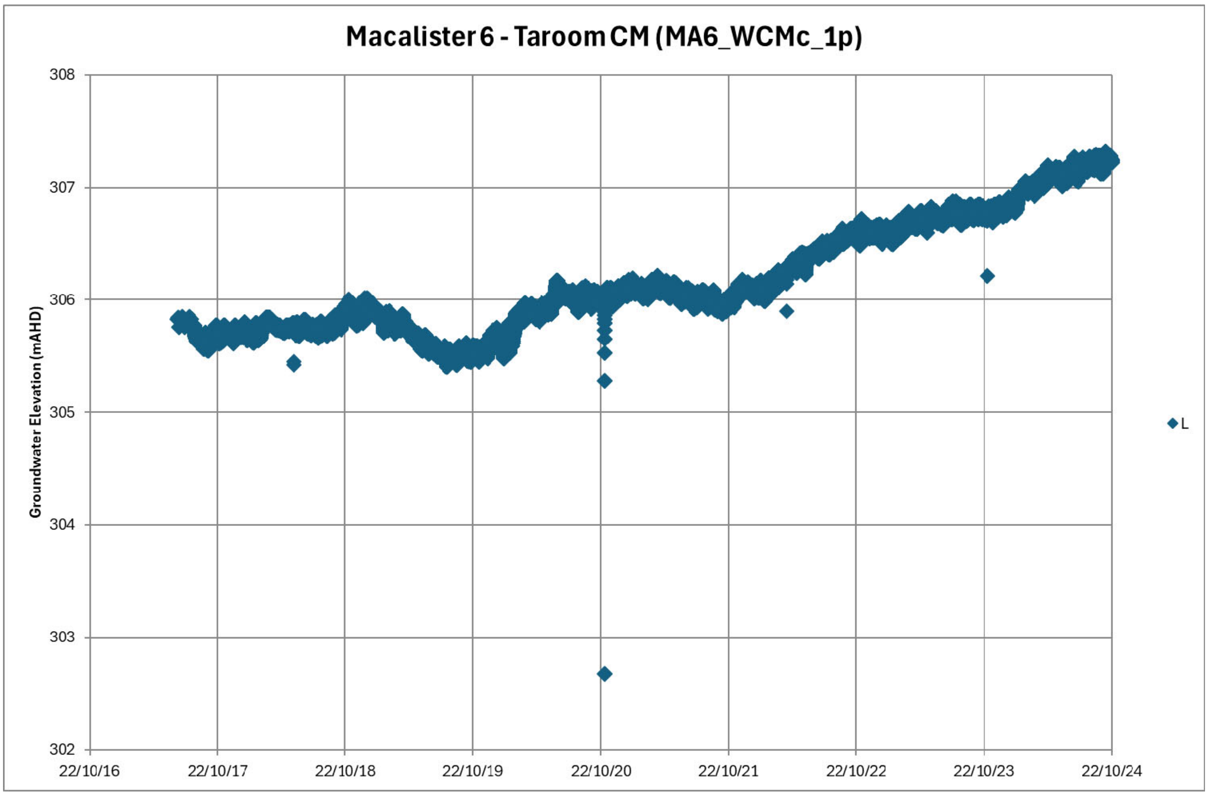
Longswamp-7- Upper Juandah CM (LS7_WCMm_1p)
Groundwater Elevation (mAHD)
319
318
317
316
315
314
313
312
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L

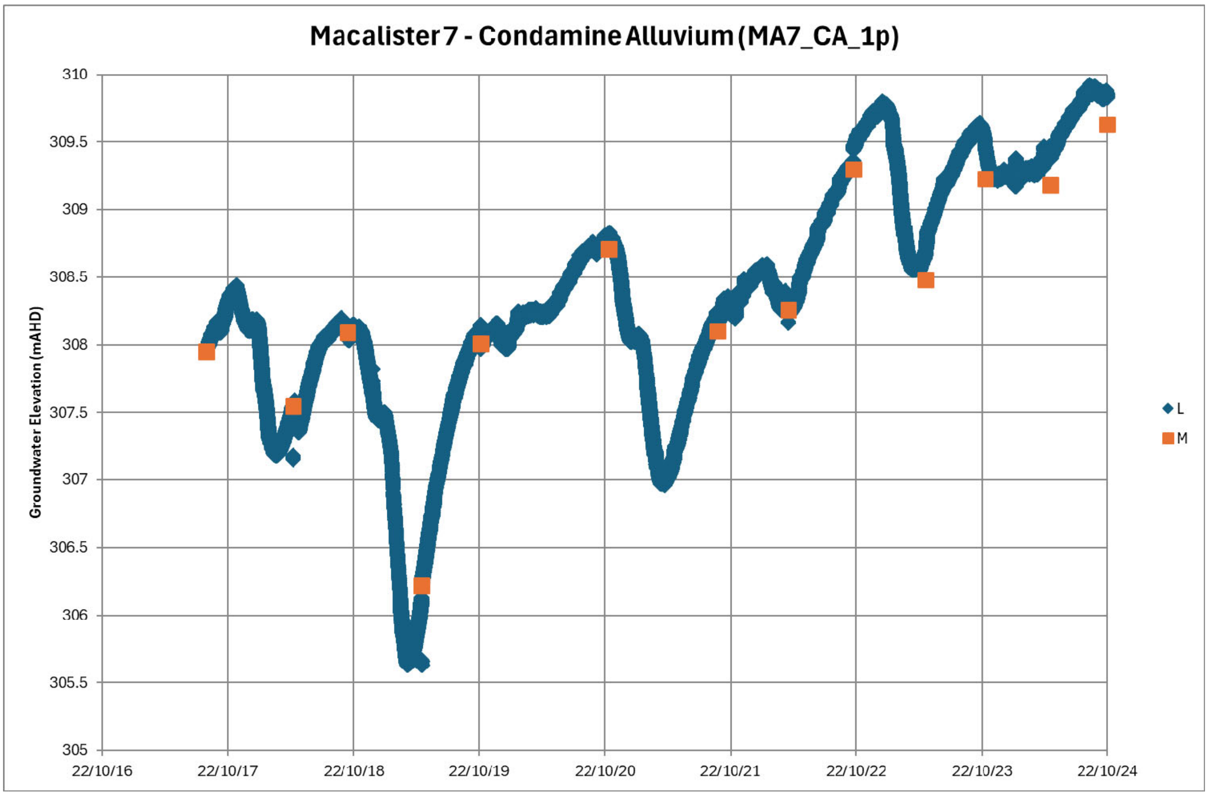

Longswamp-7 - Lower Juandah CM (LS7_WCMmlj1p)
Groundwater Elevation (mAHD)
325
320
315
310
305
300
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L


Longswamp-7 - Taroom CM (LS7_WCMut_1p)
Groundwater Elevation (mAHD)
325
320
315
310
305
300
295
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

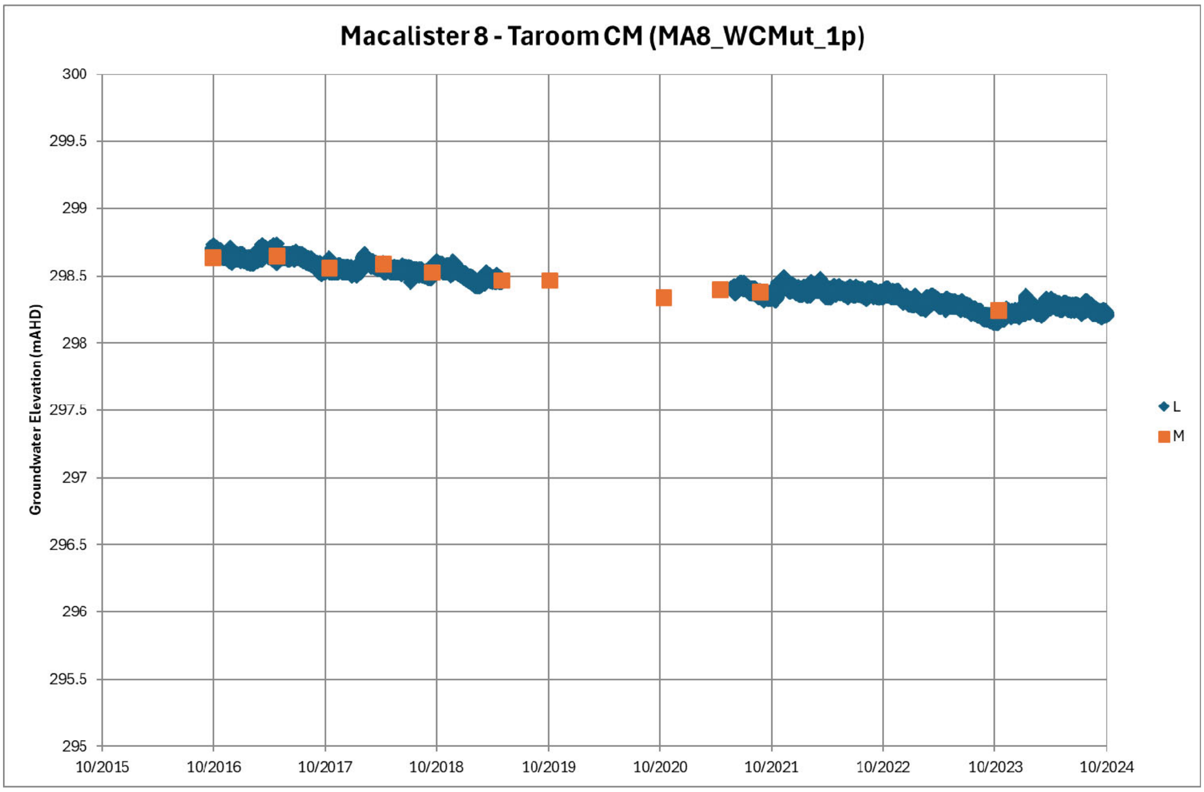

Macalister 5 - Condamine Alluvium (MA5_CA_1p)
Groundwater Elevation (mAHD)
302
301
300
299
298
297
22/10/15
21/10/16
21/10/17
21/10/18
22/10/19
21/10/20
21/10/21
21/10/22
22/10/23
21/10/24
L
M

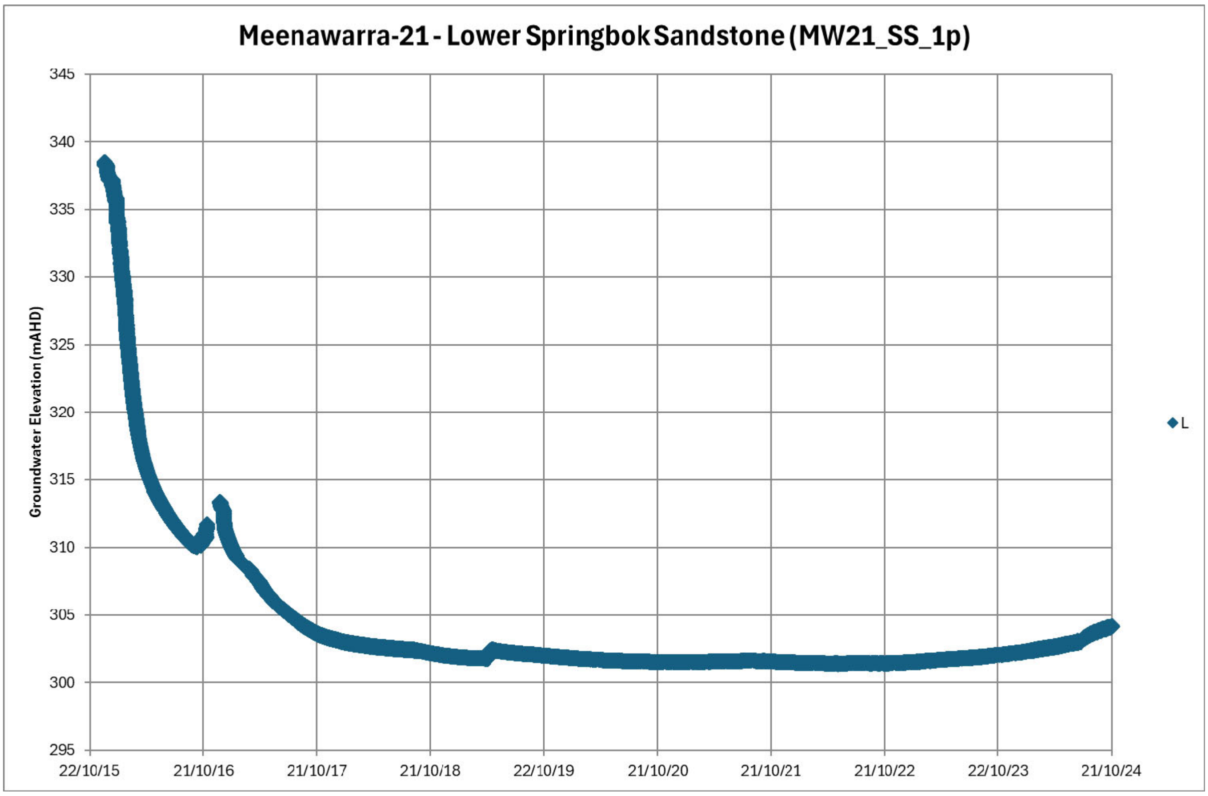

Macalister 6 - Eurombah Formation (MA6_WCMe_1p)
Groundwater Elevation (mAHD)
312
311
310
309
308
307
306
305
304
303
302
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

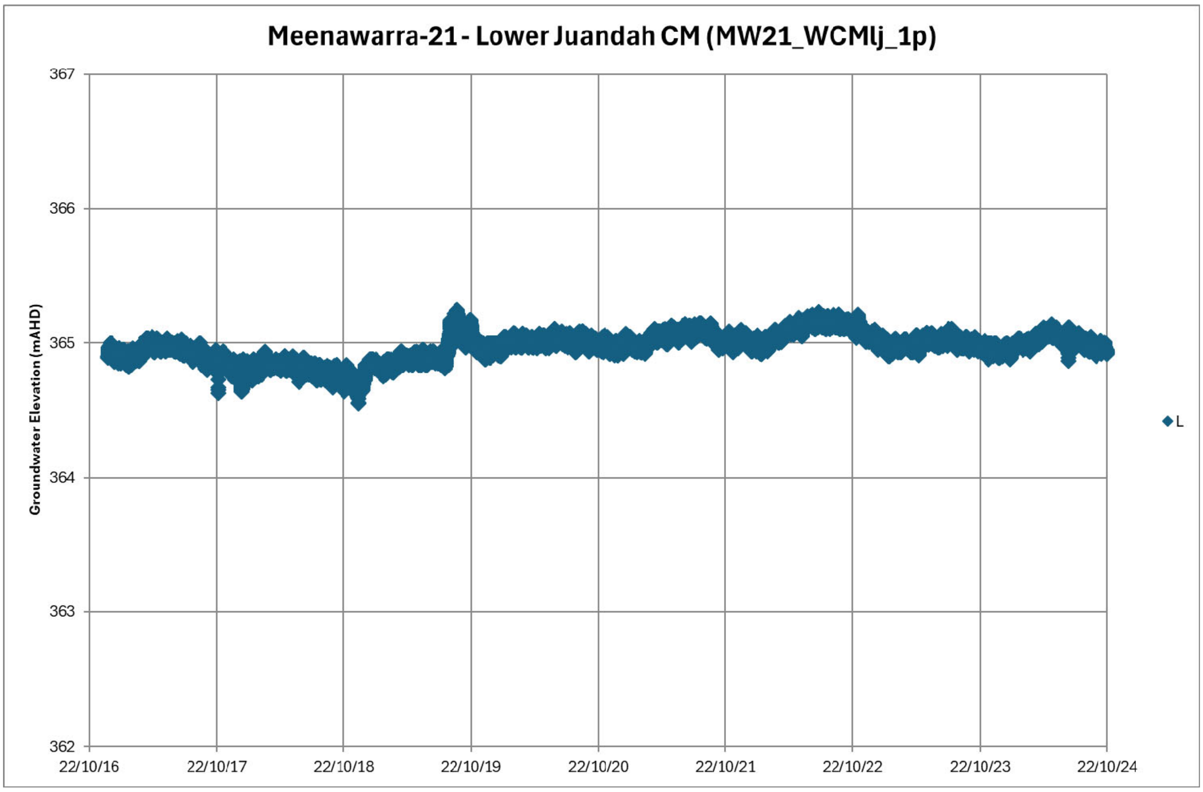




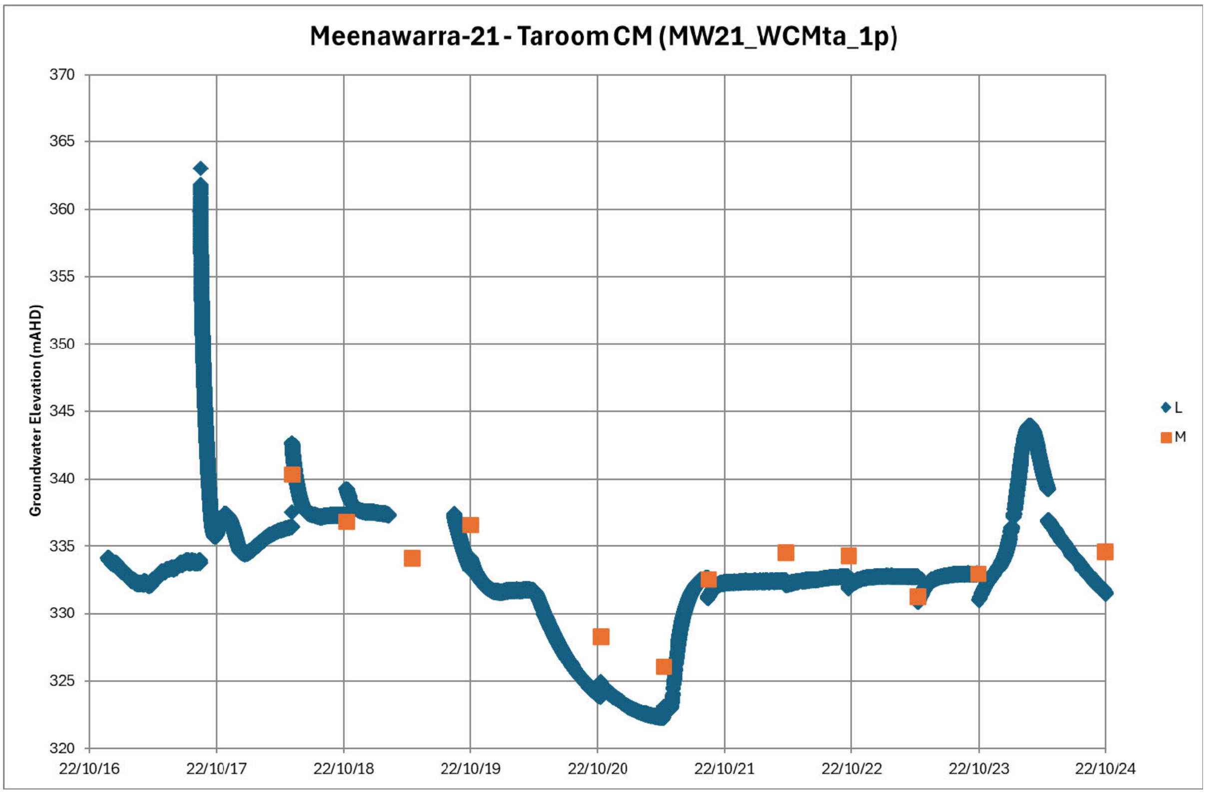
arrow energy
go further


Macalister 8 - Taroom CM (MA8_WCMut_1p)
Groundwater Elevation (mAHD)
300
299.5
299
298.5
298
297.5
297
296.5
296
295.5
295
10/2015
10/2016
10/2017
10/2018
10/2019
10/2020
10/2021
10/2022
10/2023
10/2024
L
M

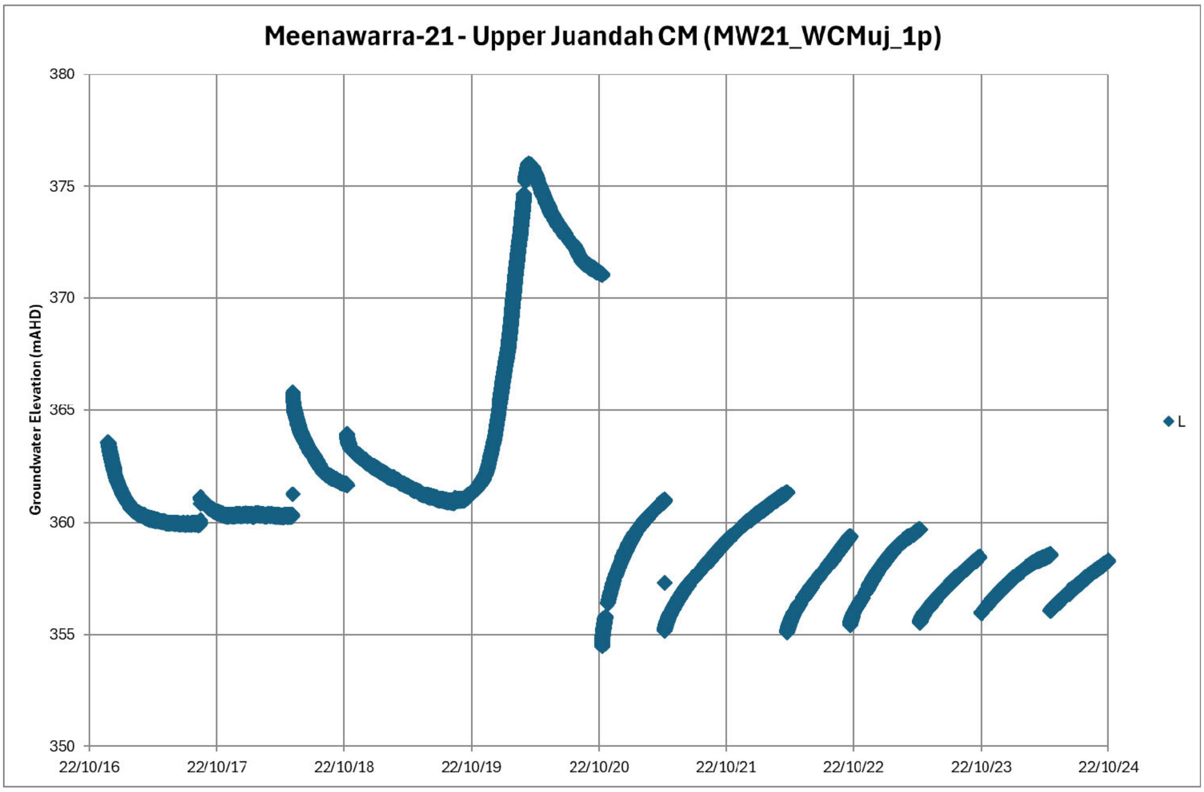

Meenawarra-21 - Lower Springbok Sandstone (MW21_SS_1p)
Groundwater Elevation (mAHD)
345
340
335
330
325
320
315
310
305
300
295
22/10/15
21/10/16
21/10/17
21/10/18
22/10/19
21/10/20
21/10/21
21/10/22
22/10/23
21/10/24
L

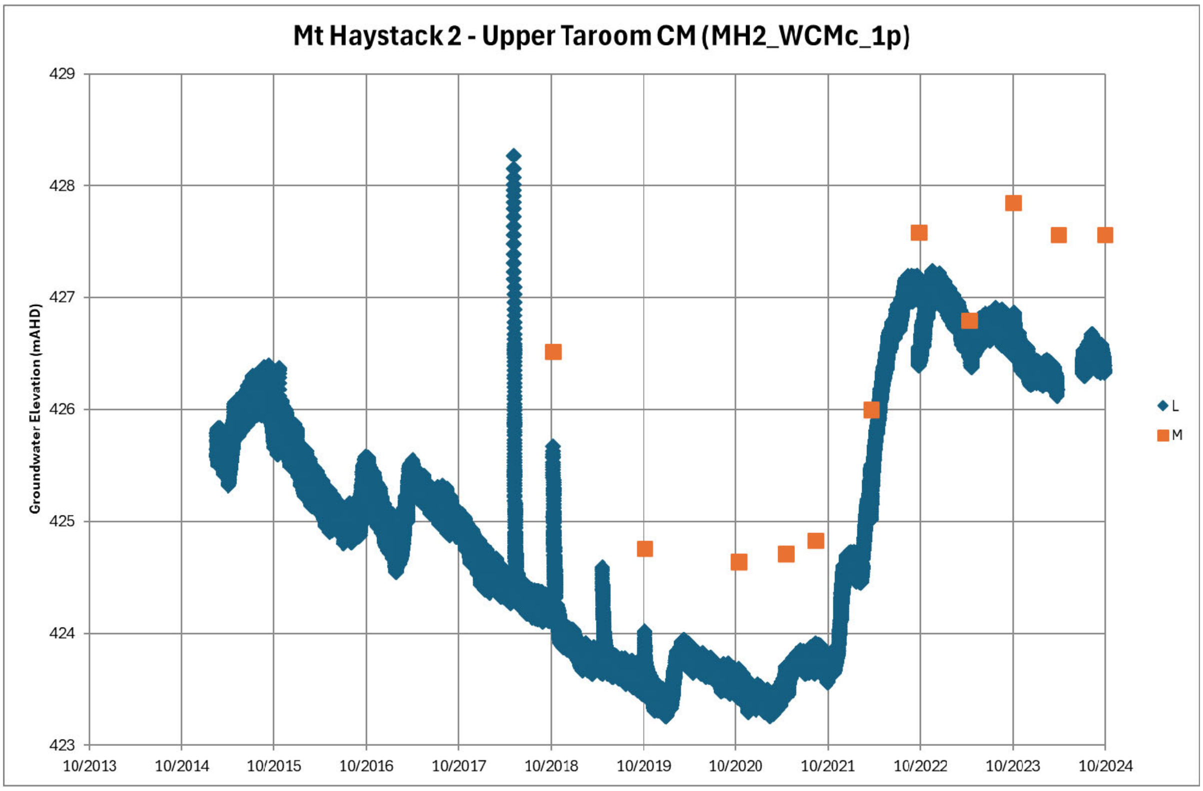


Meenawarra-21 - Lower Juandah CM (MW21_WCMlj_1p)
367
366
365
364
363
362
Groundwater Elevation (mAHD)
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L

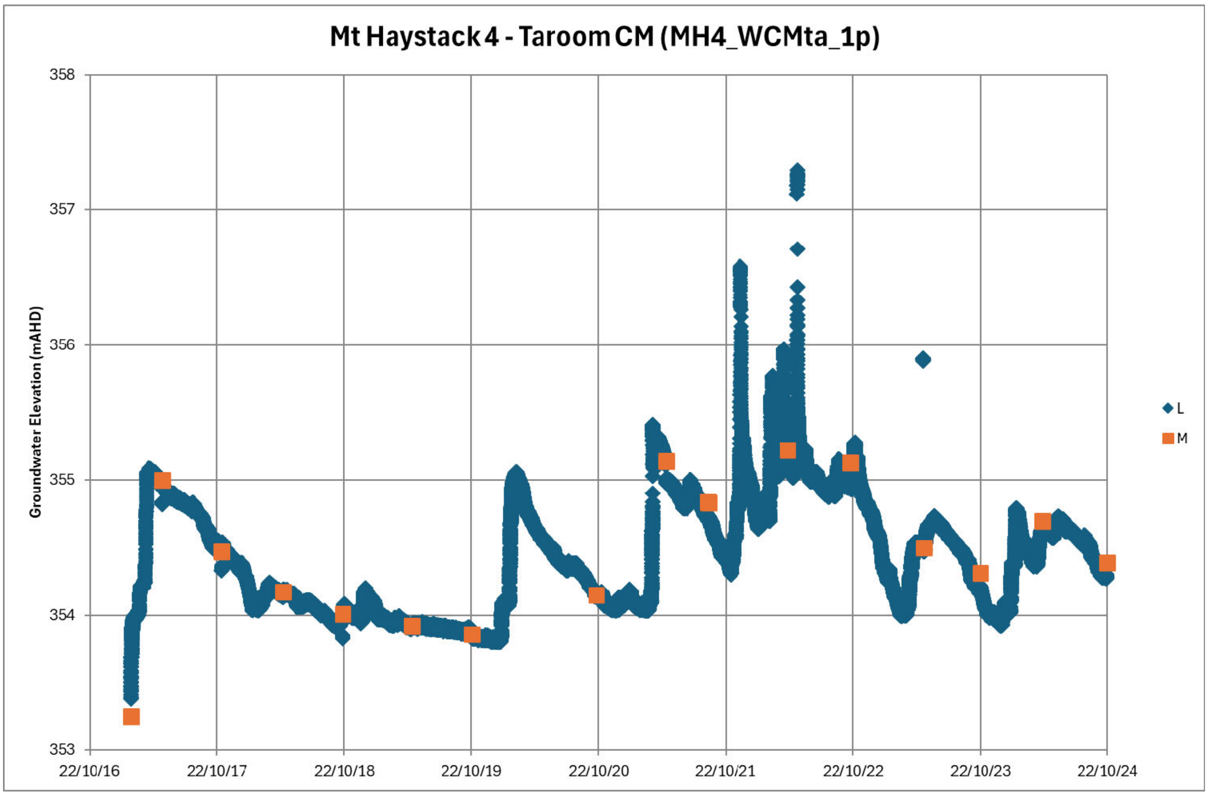


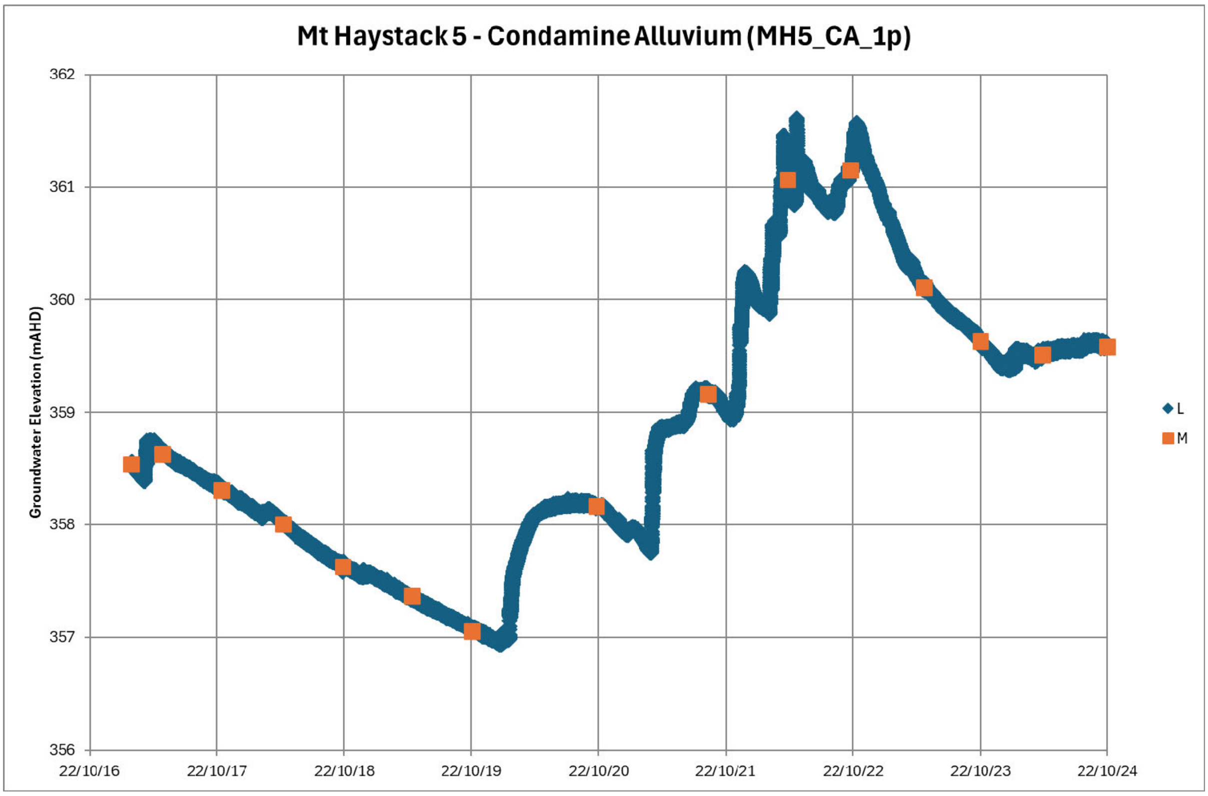
Meenawarra-21 - Taroom CM (MW21_WCMta_1p)
370
365
360
355
350
345
340
335
330
325
320
Groundwater Elevation (mAHD)
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

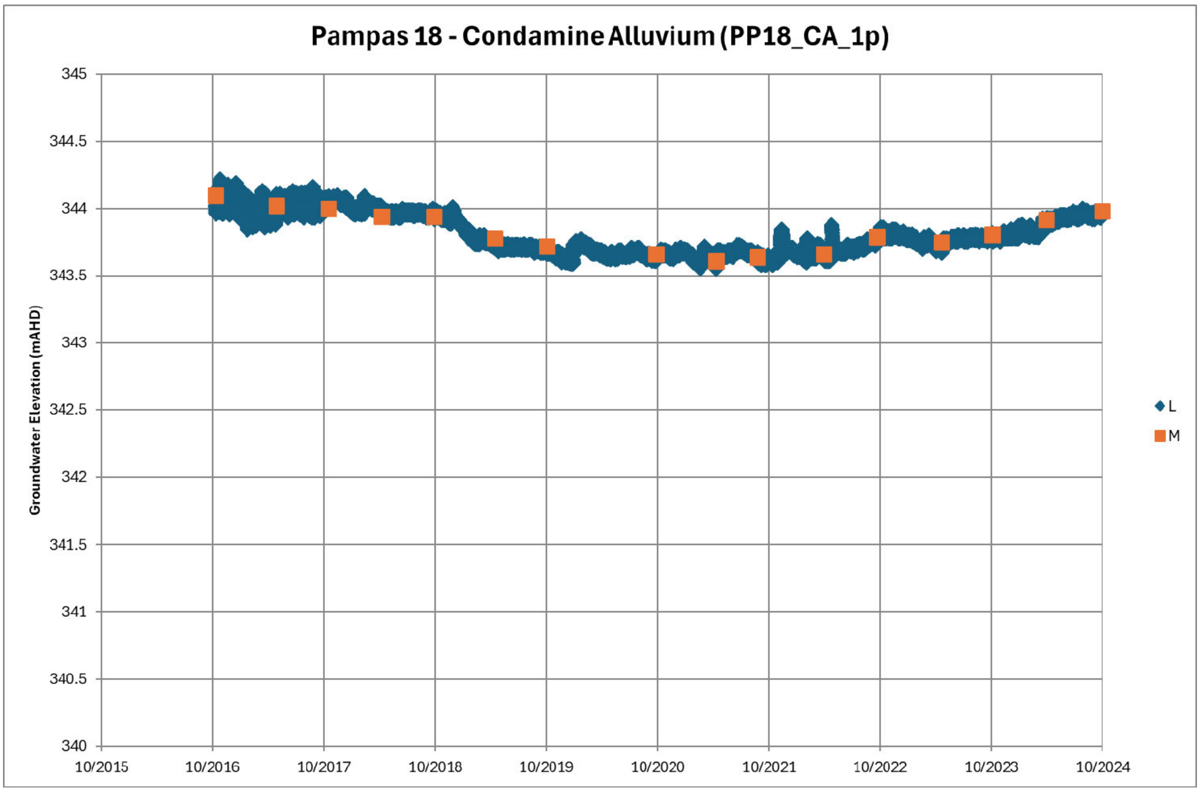


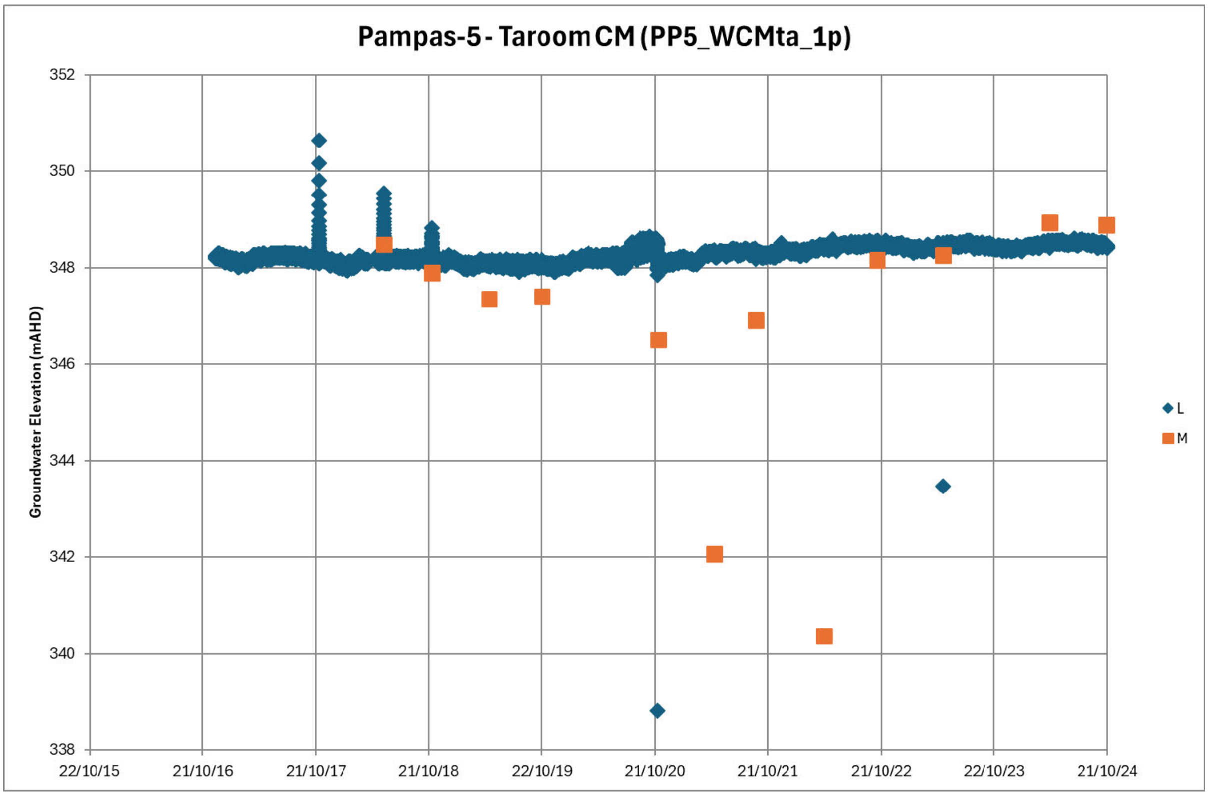


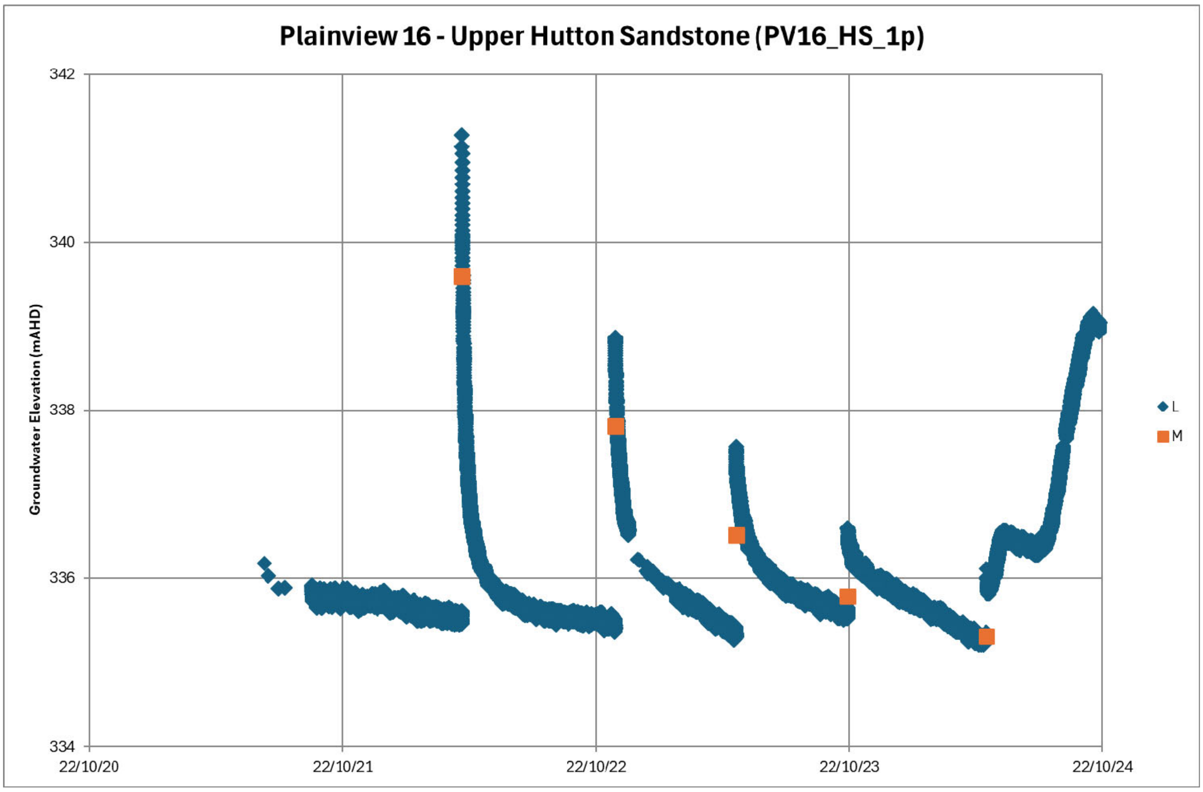
arrow energy go further

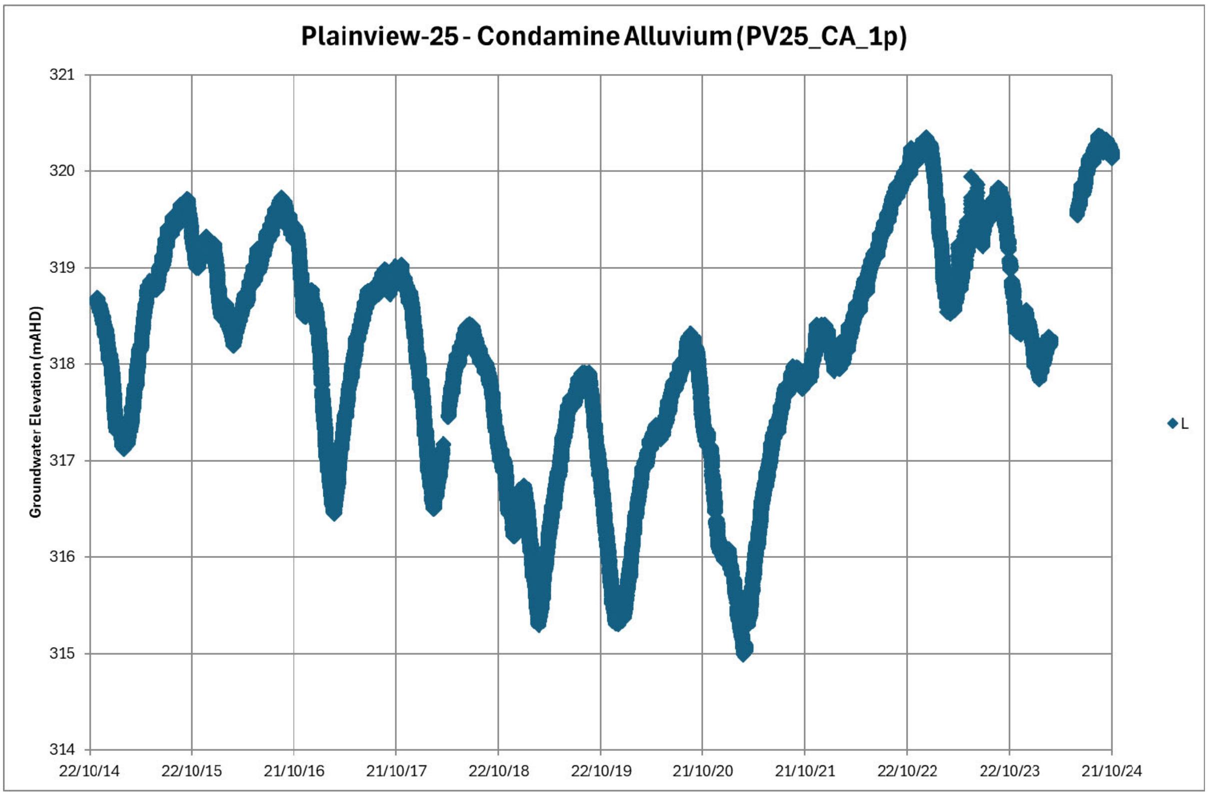

Mt Haystack 4 - Taroom CM (MH4_WCMta_1p)
Groundwater Elevation (mAHD)
358
357
356
355
354
353
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

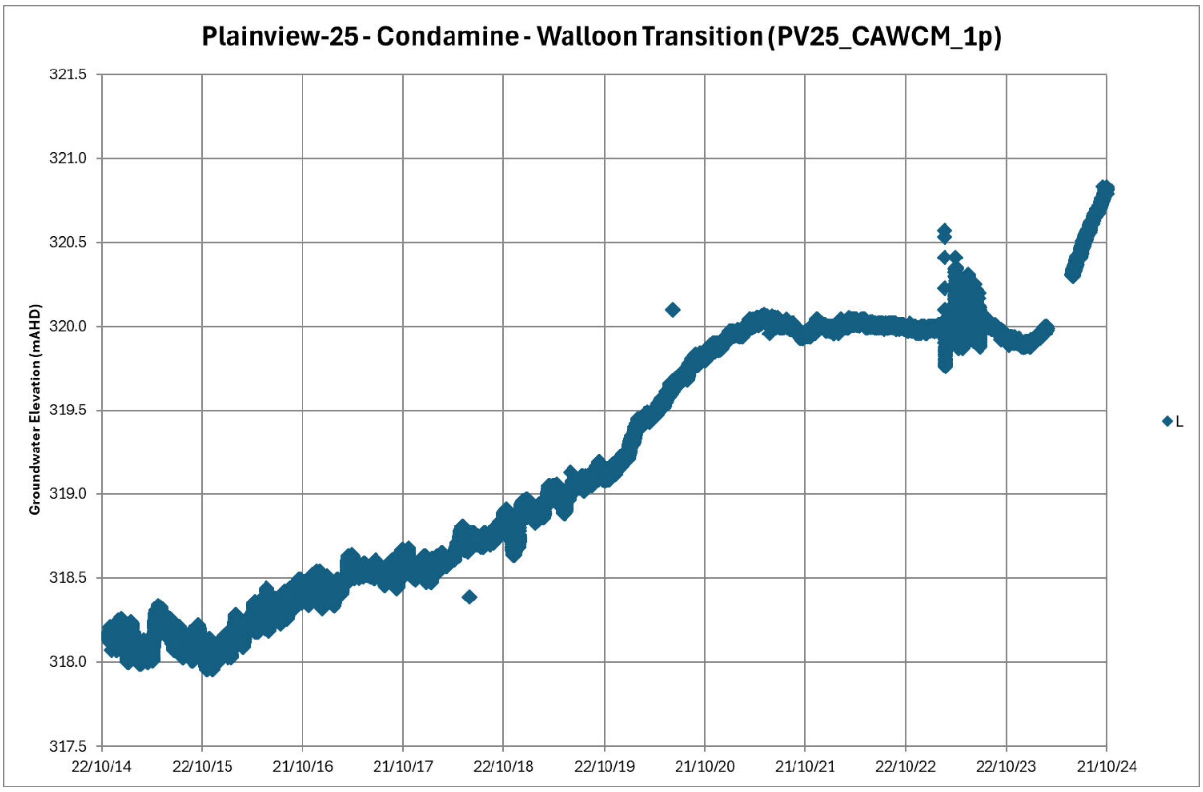

Mt Haystack 5 - Condamine Alluvium (MH5_CA_1p)
Groundwater Elevation (mAHD)
362
361
360
359
358
357
356
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

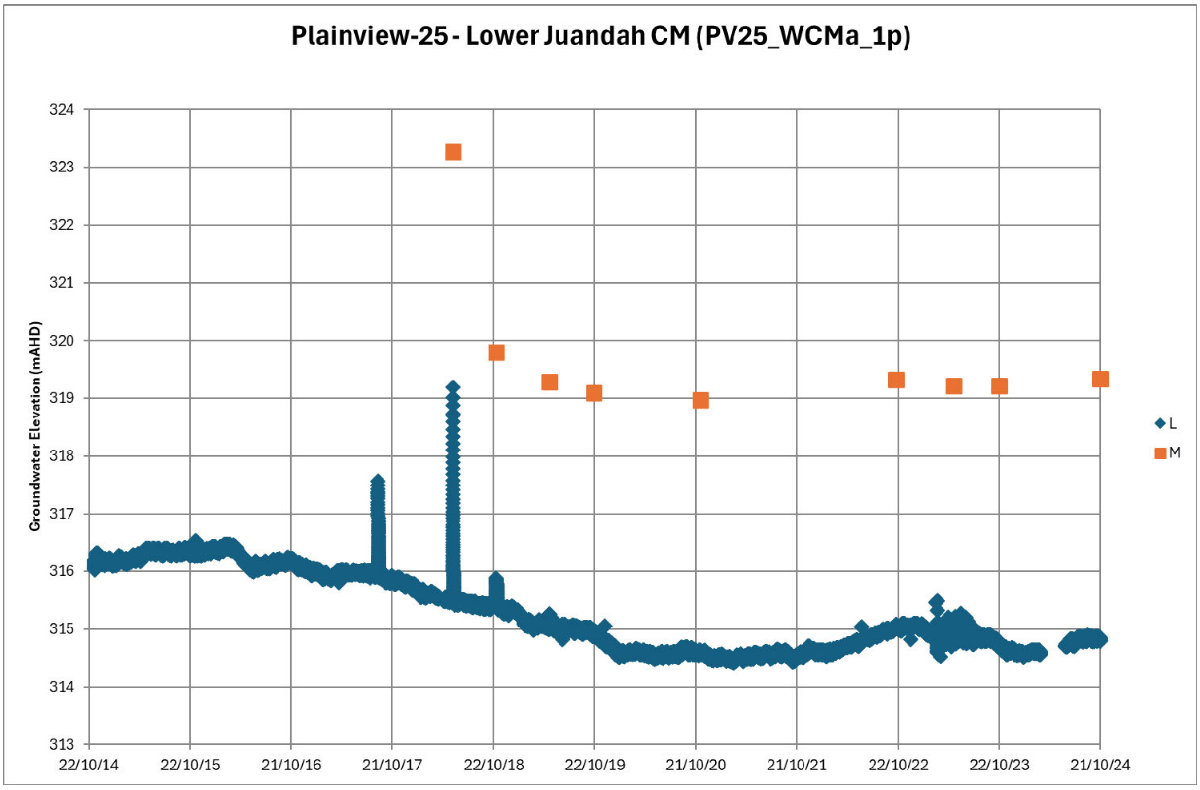

Pampas 18 - Condamine Alluvium (PP18_CA_1p)
Groundwater Elevation (mAHD)
345
344.5
344
343.5
343
342.5
342
341.5
341
340.5
340
10/2015
10/2016
10/2017
10/2018
10/2019
10/2020
10/2021
10/2022
10/2023
10/2024
L
M

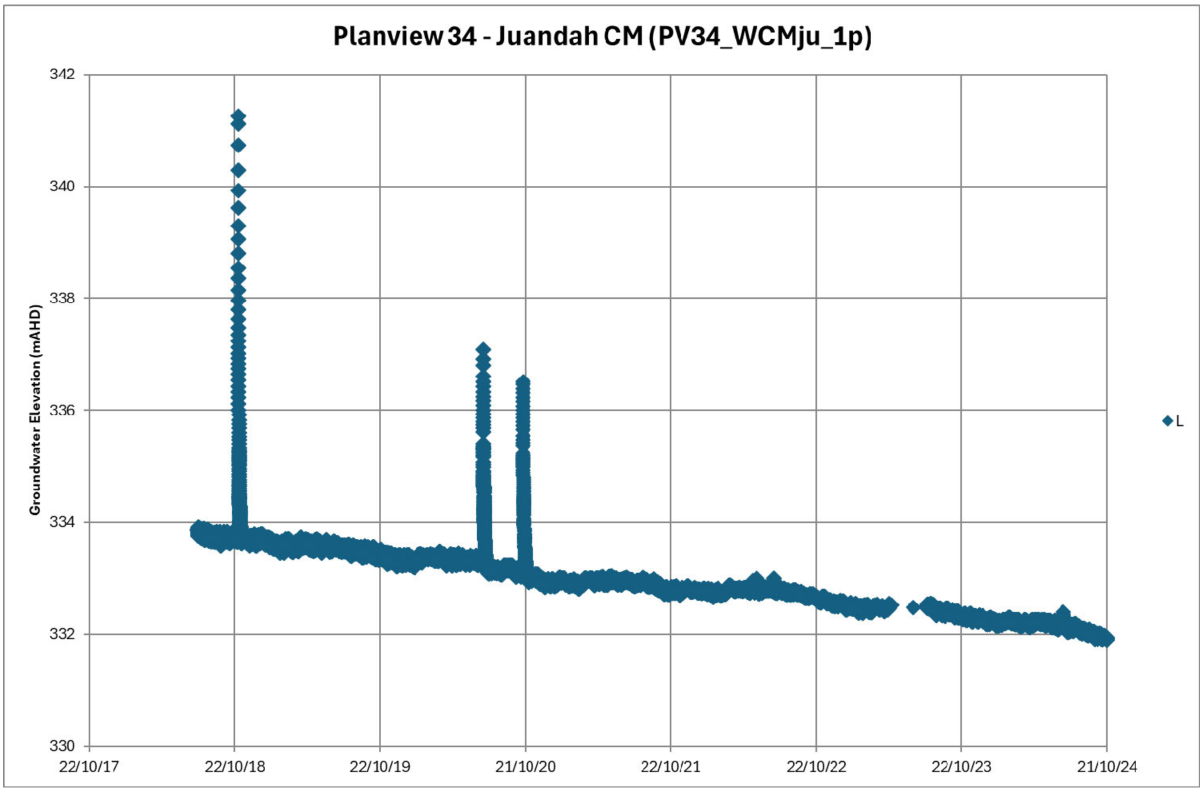

Pampas-5 - Taroom CM (PP5_WCMta_1p)
Groundwater Elevation (mAHD)
352
350
348
346
344
342
340
338
22/10/15
21/10/16
21/10/17
21/10/18
22/10/19
21/10/20
21/10/21
21/10/22
22/10/23
21/10/24
L
M

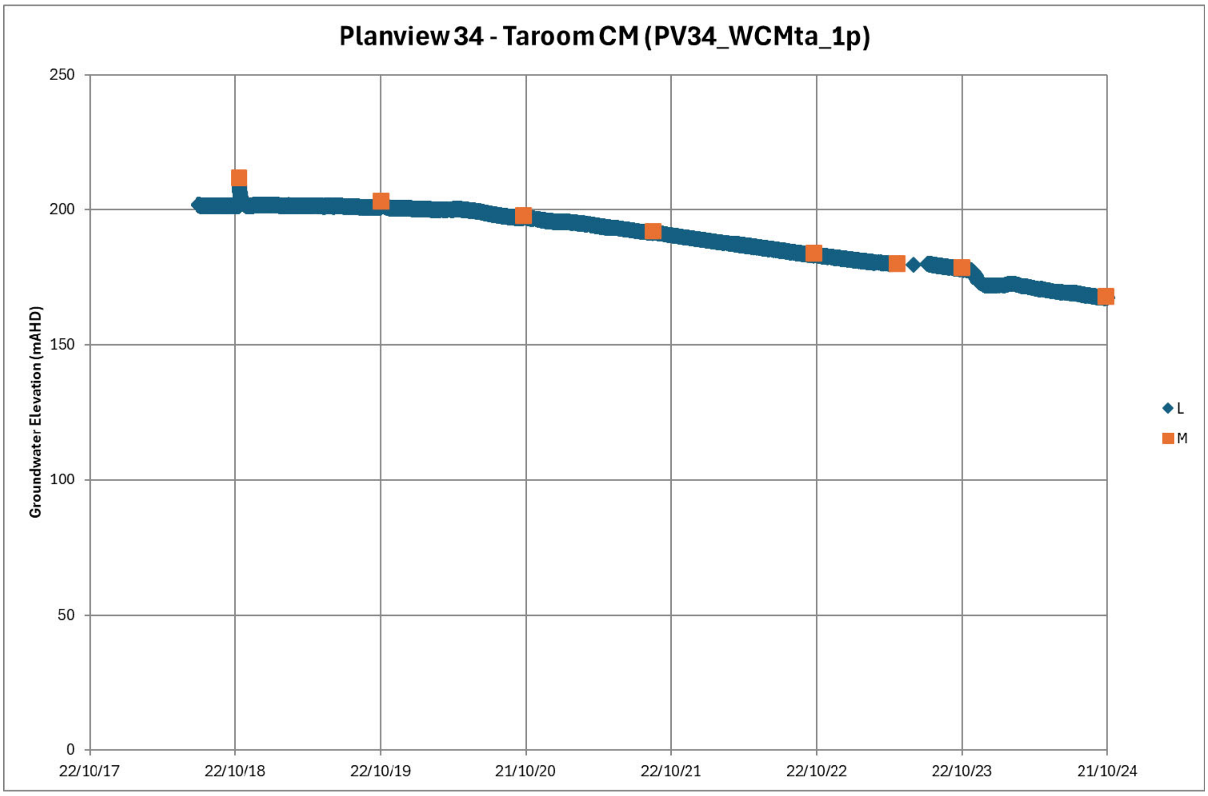

Plainview 16 - Upper Hutton Sandstone (PV16_HS_1p)
Groundwater Elevation (mAHD)
342
340
338
336
334
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

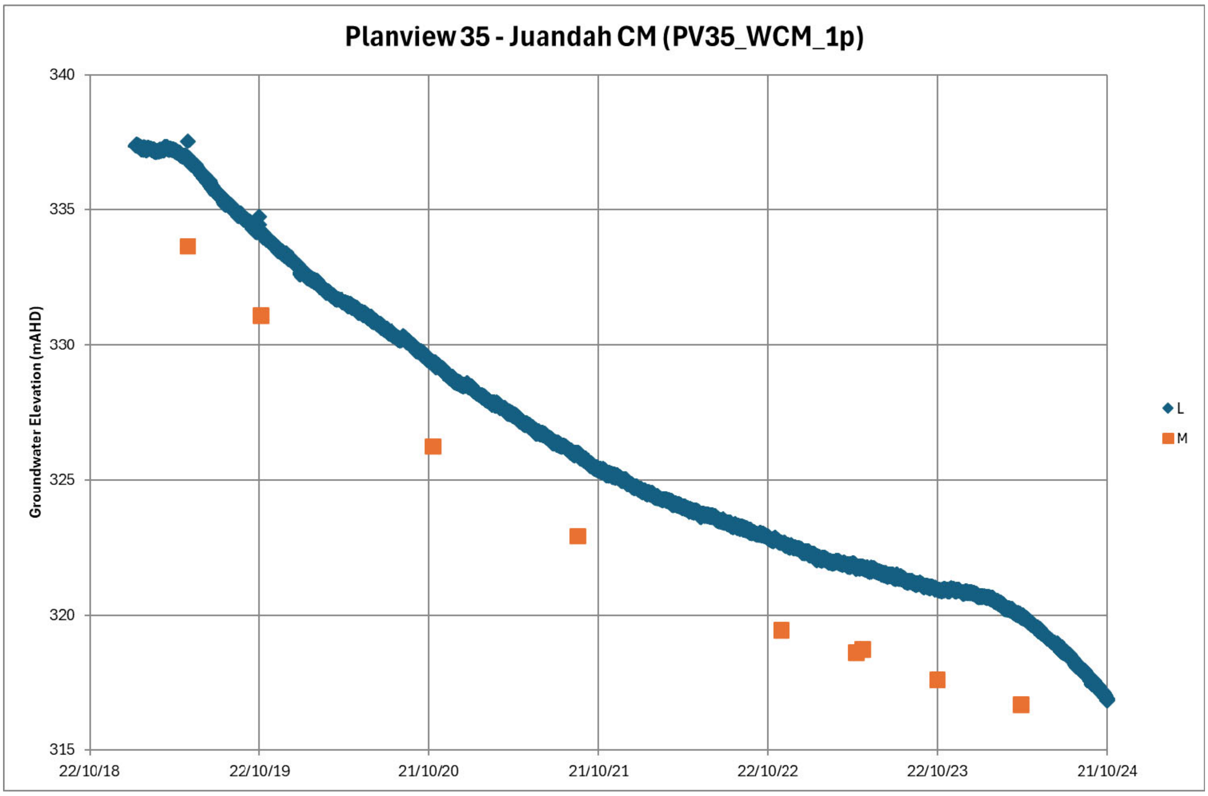

Plainview-25 - Condamine Alluvium (PV25_CA_1p)
Groundwater Elevation (mAHD)
321
320
319
318
317
316
315
314
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L

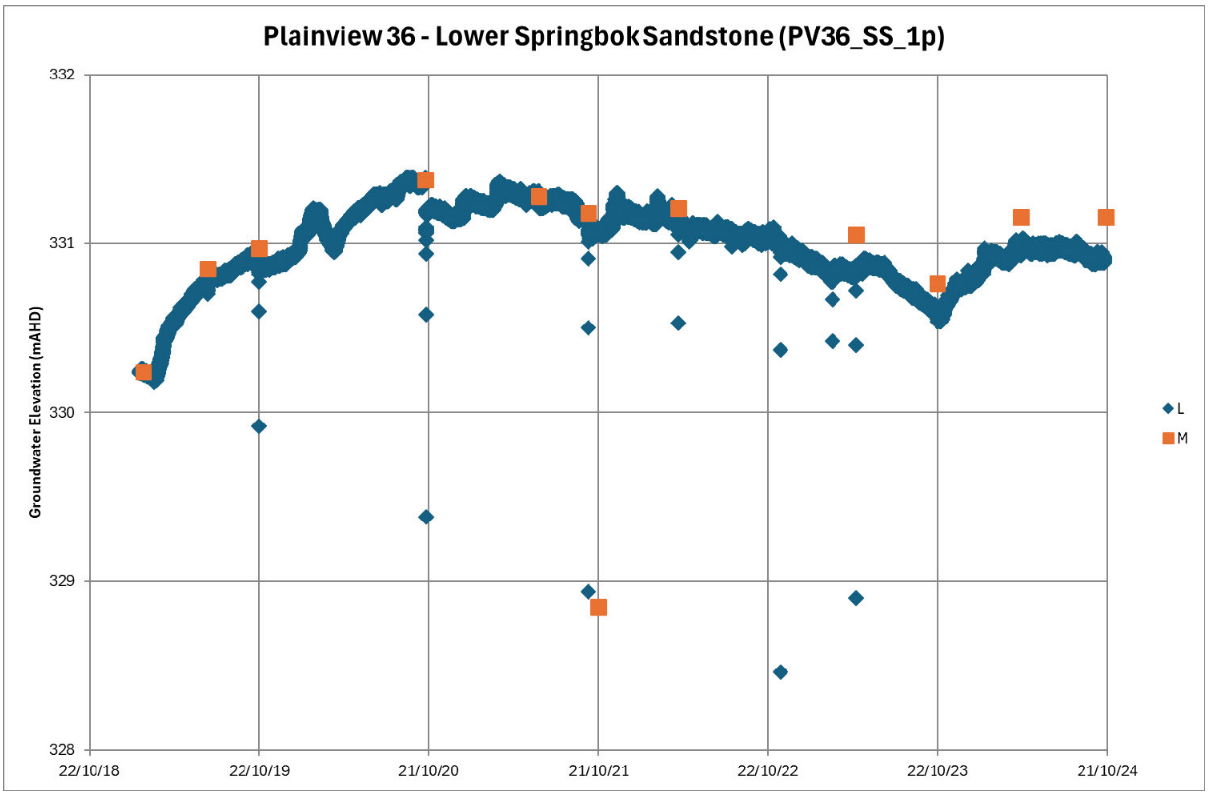

Plainview-25 - Condamine - Walloon Transition (PV25_CAWCM_1p)
Groundwater Elevation (mAHD)
321.5
321.0
320.5
320.0
319.5
319.0
318.5
318.0
317.5
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L

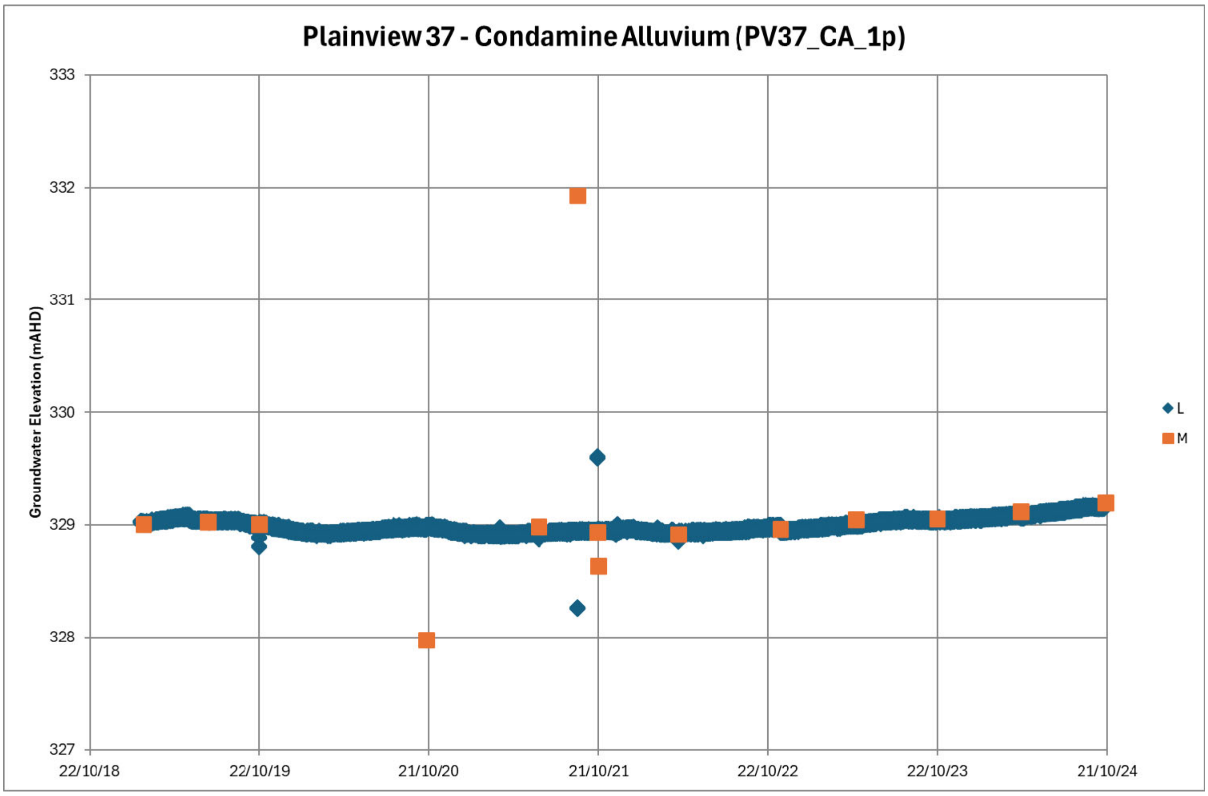

Plainview-25 - Lower Juandah CM (PV25_WCMa_1p)
Groundwater Elevation (mAHD)
324
323
322
321
320
319
318
317
316
315
314
313
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L
M

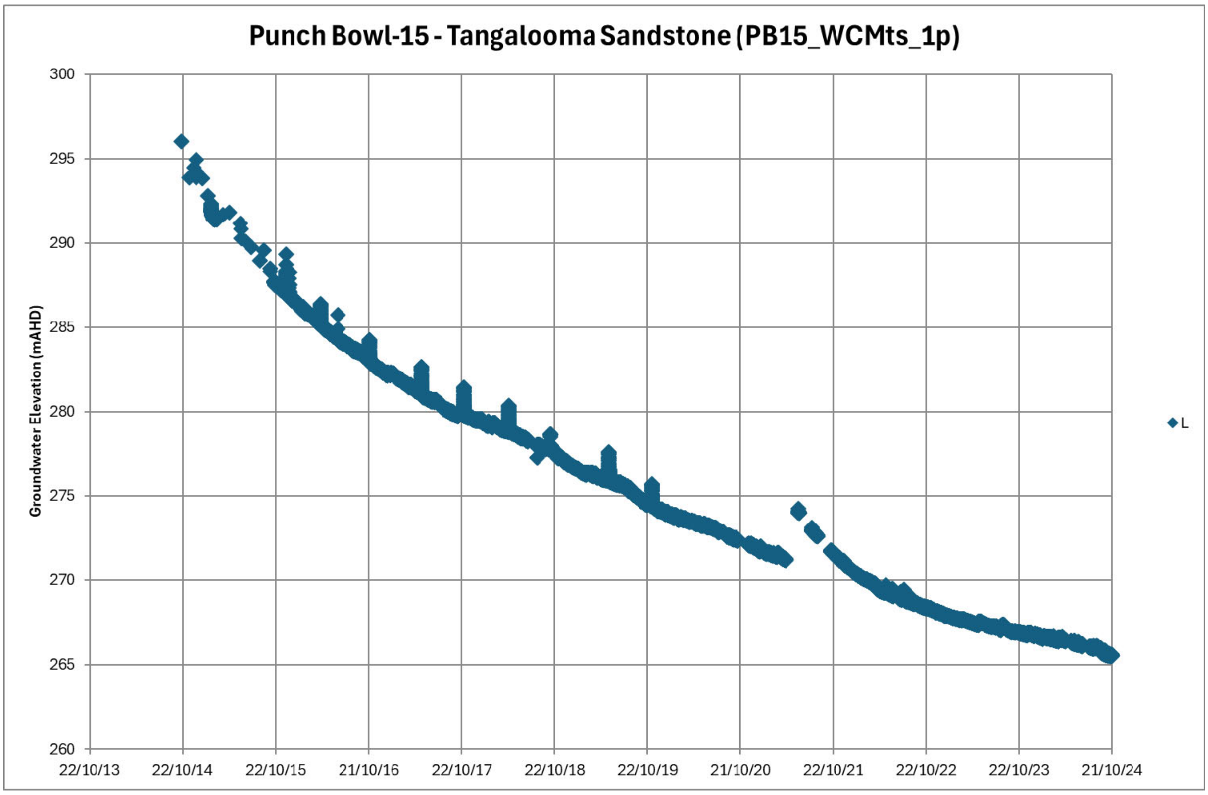

Planview 34 - Juandah CM (PV34_WCMju_1p)
Groundwater Elevation (mAHD)
342
340
338
336
334
332
330
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

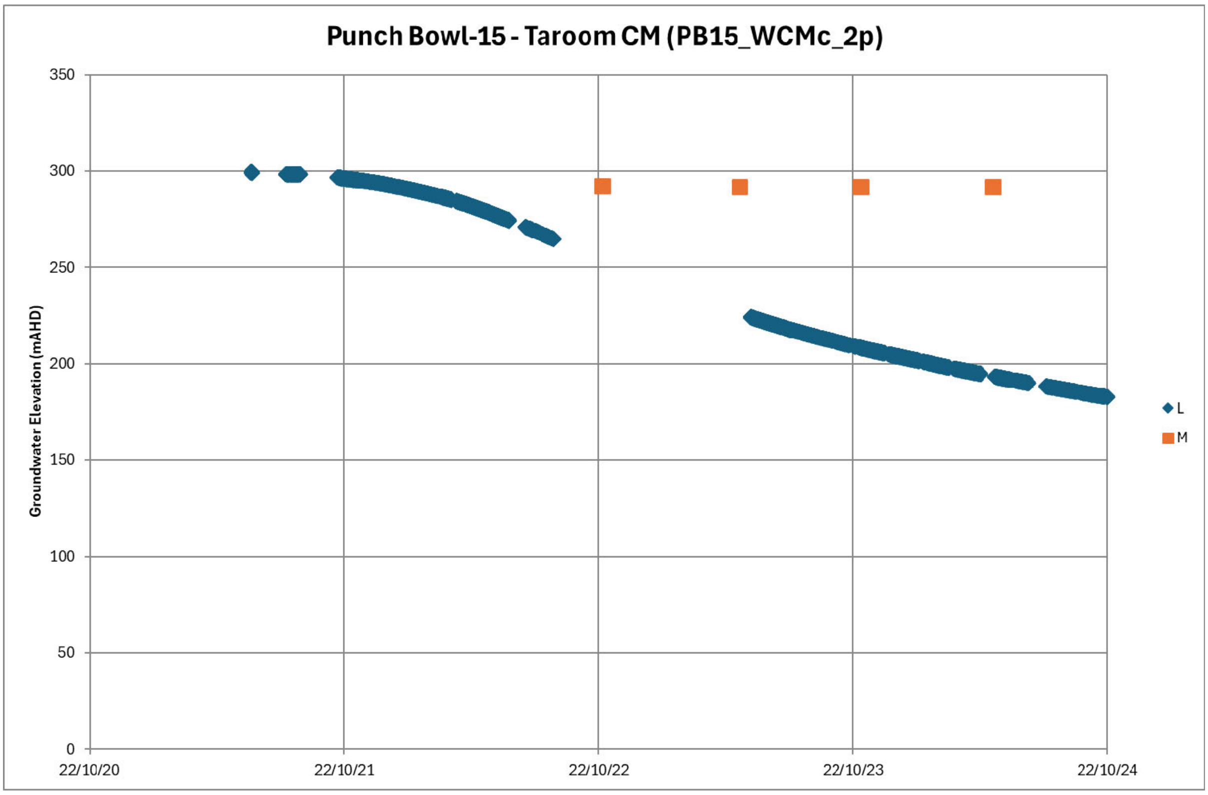

Planview 34 - Taroom CM (PV34_WCMta_1p)
Groundwater Elevation (mAHD)
250
200
150
100
50
0
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

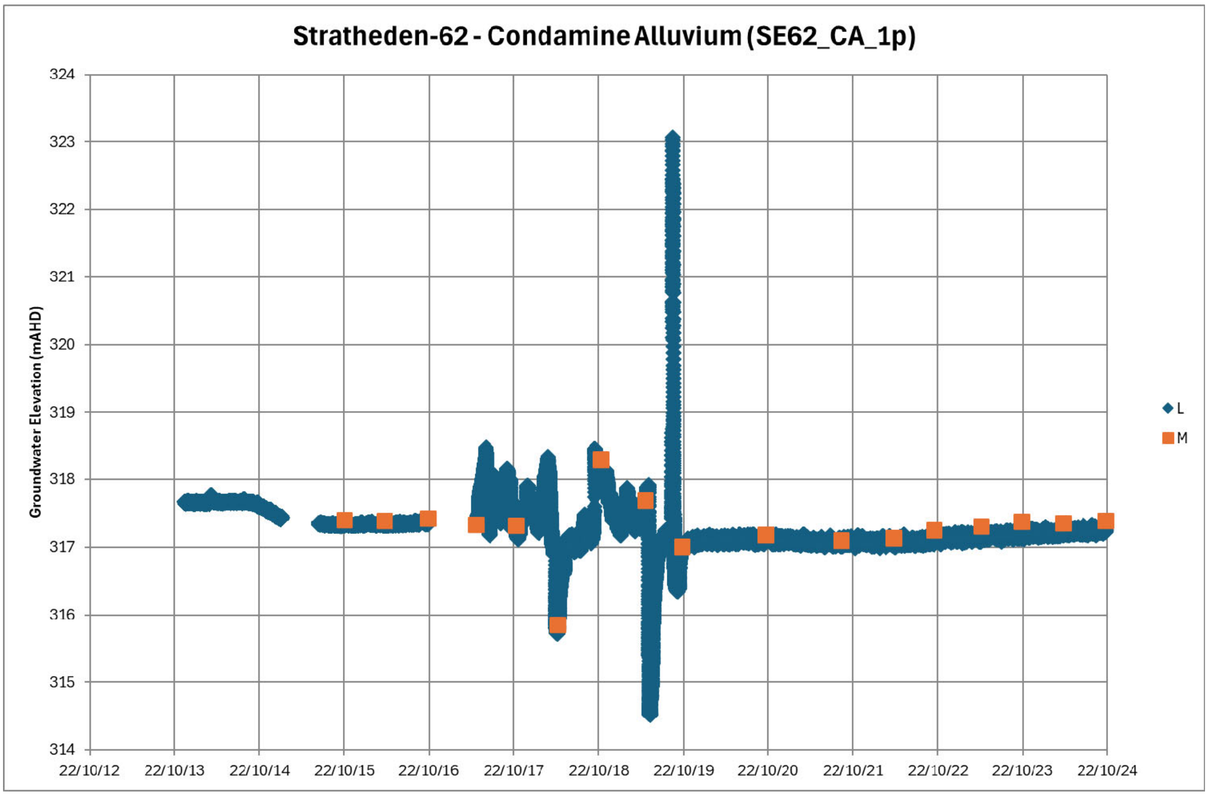

Planview 35 - Juandah CM (PV35_WCM_1p)
Groundwater Elevation (mAHD)
340
335
330
325
320
315
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L
M

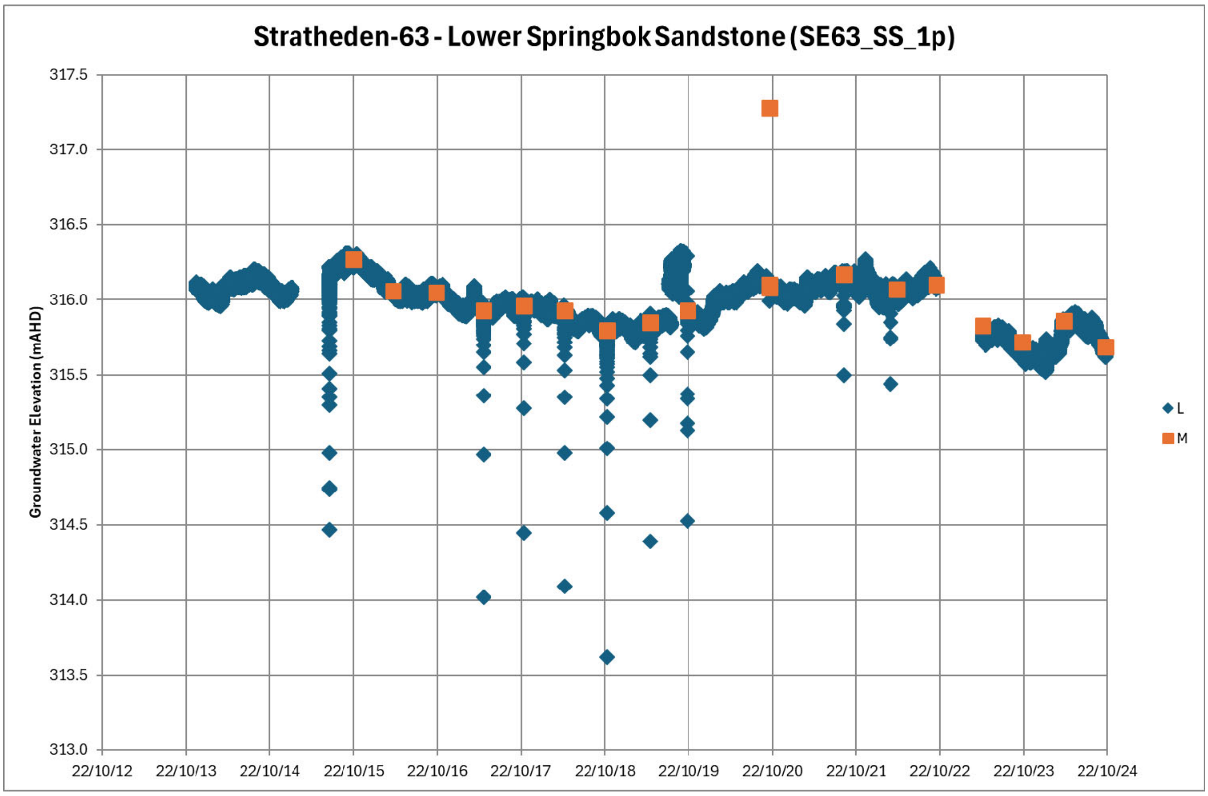

Plainview 36 - Lower Springbok Sandstone (PV36_SS_1p)
Groundwater Elevation (mAHD)
332
331
330
329
328
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L
M

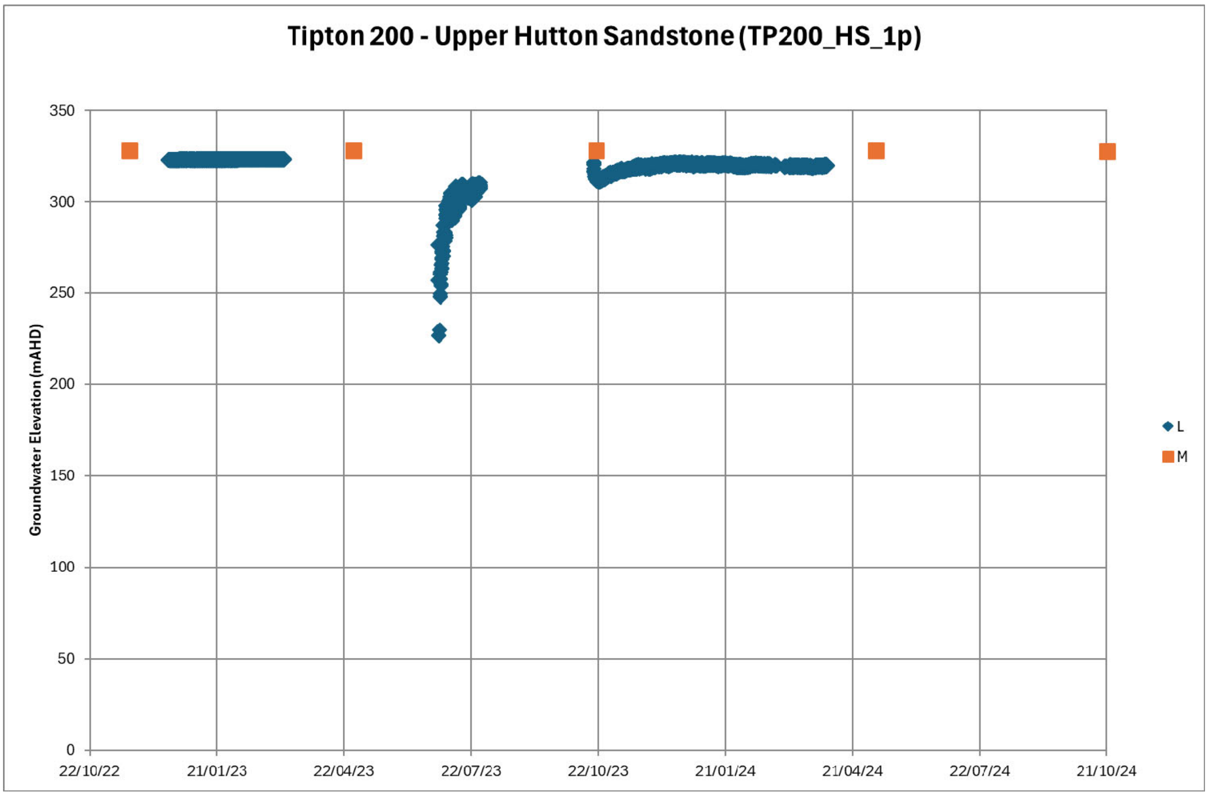

Plainview 37 - Condamine Alluvium (PV37_CA_1p)
Groundwater Elevation (mAHD)
333
332
331
330
329
328
327
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L
M

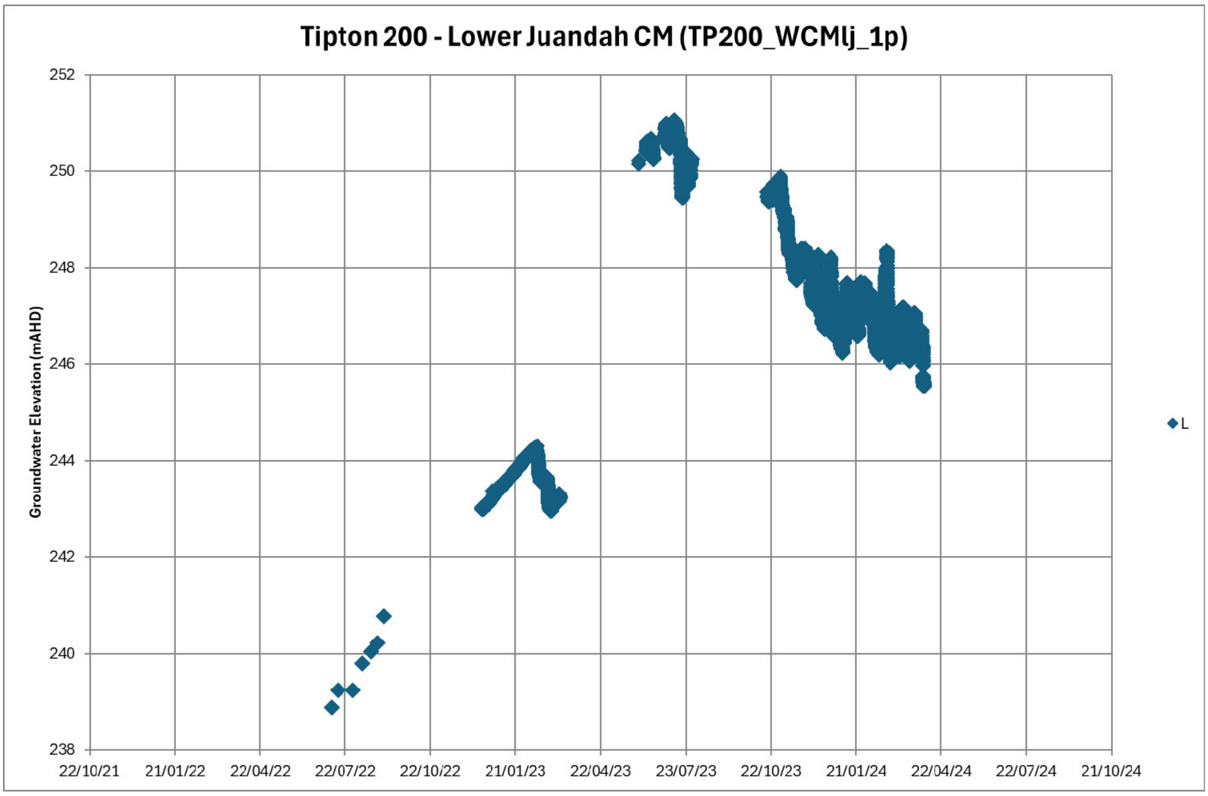

Punch Bowl-15 - Tangalooma Sandstone (PB15_WCMts_1p)
Groundwater Elevation (mAHD)
300
295
290
285
280
275
270
265
260
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

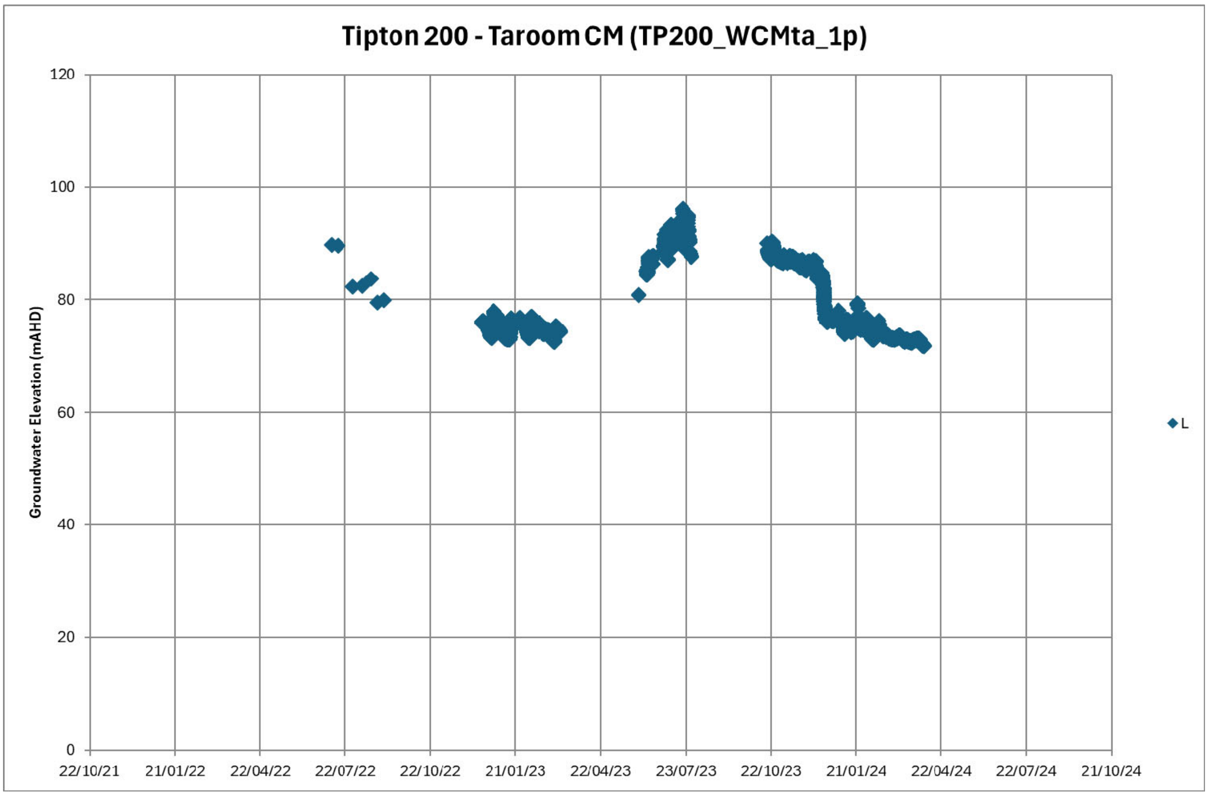

Punch Bowl-15 - Taroom CM (PB15_WCMc_2p)
Groundwater Elevation (mAHD)
350
300
250
200
150
100
50
0
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

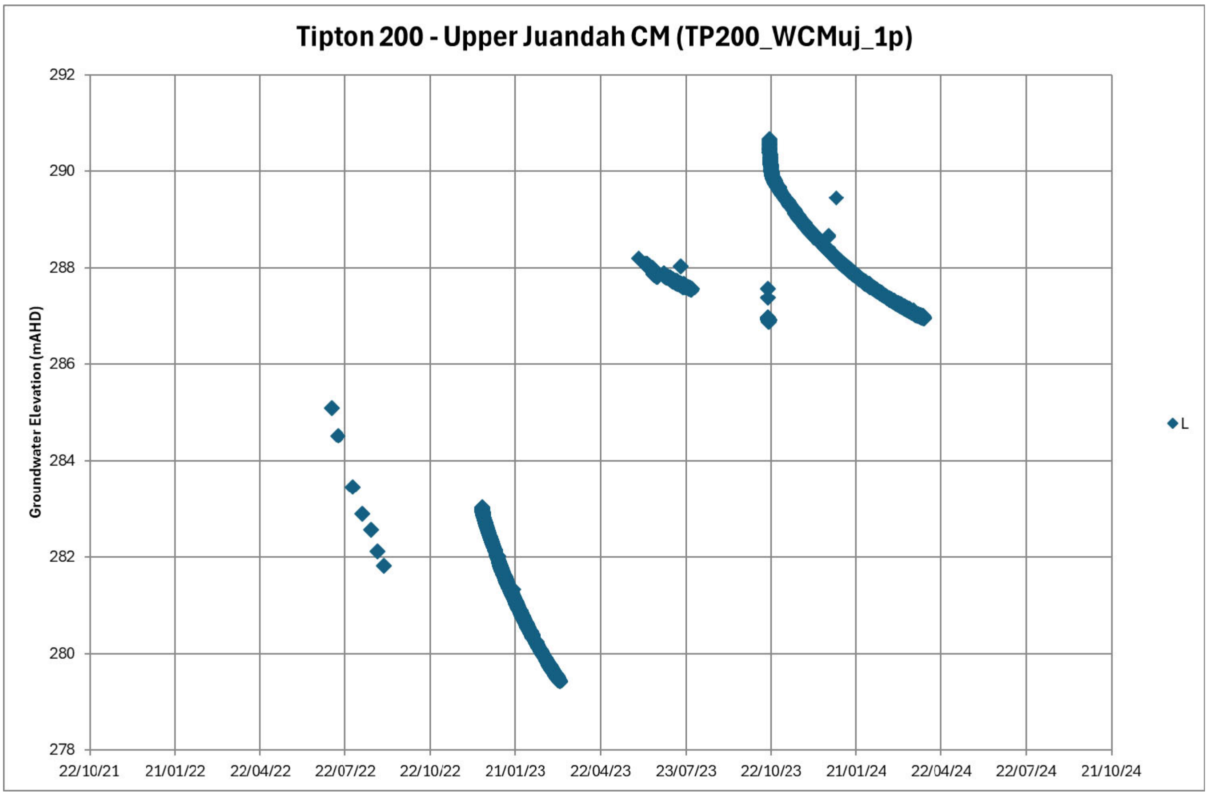

Stratheden-62 - Condamine Alluvium (SE62_CA_1p)
Groundwater Elevation (mAHD)
324
323
322
321
320
319
318
317
316
315
314
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

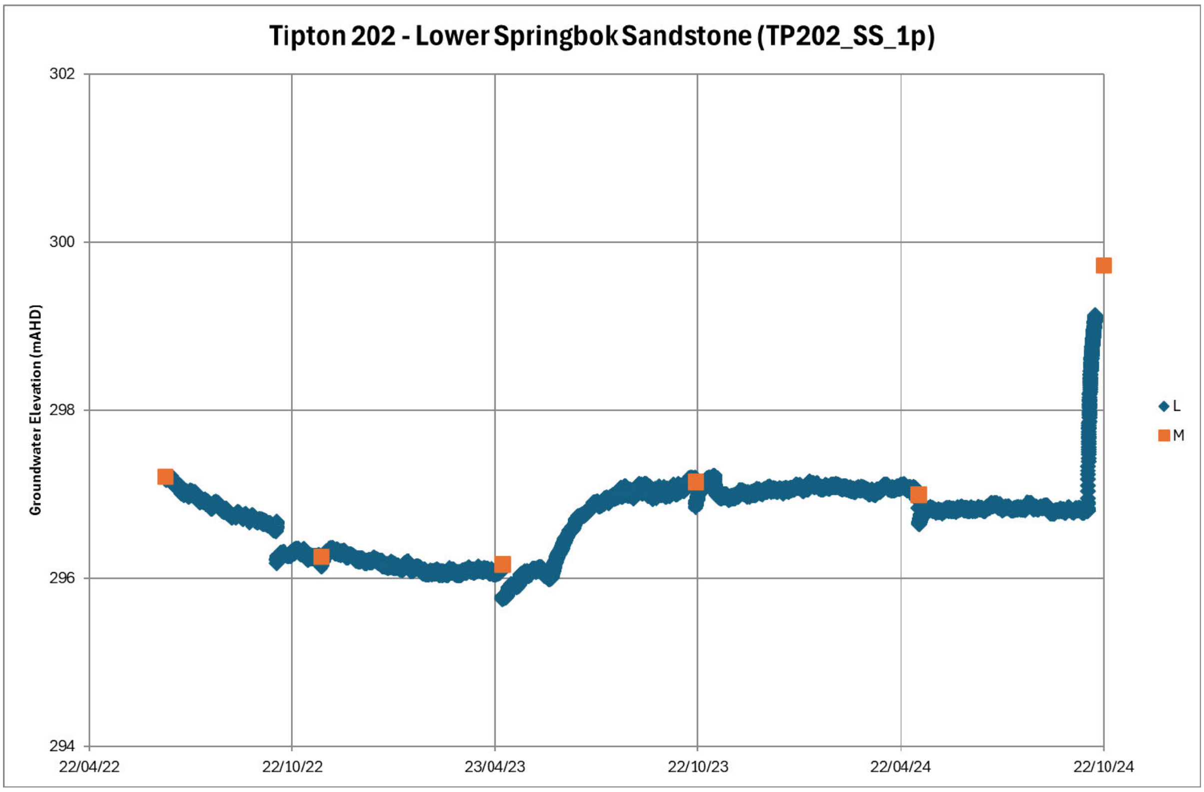

Stratheden-63 - Lower Springbok Sandstone (SE63_SS_1p)
Groundwater Elevation (mAHD)
317.5
317.0
316.5
316.0
315.5
315.0
314.5
314.0
313.5
313.0
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

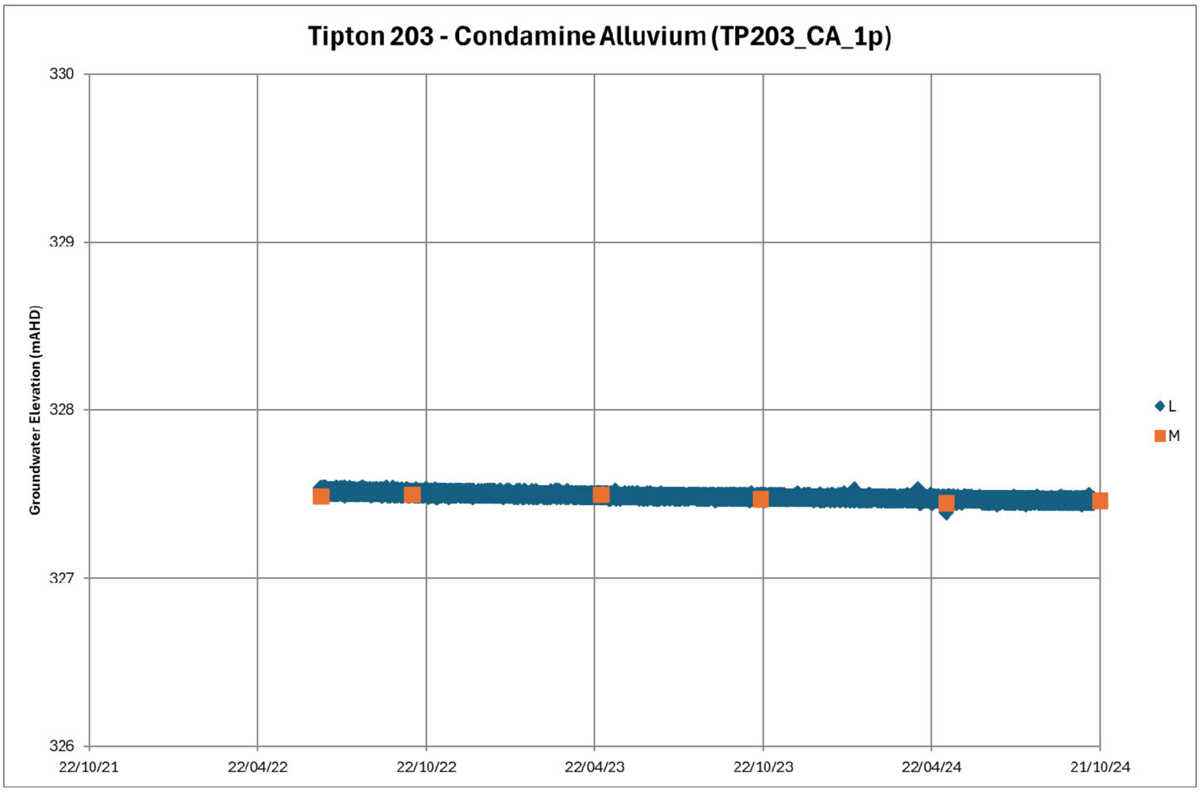

Tipton 200 - Upper Hutton Sandstone (TP200_HS_1p)
Groundwater Elevation (mAHD)
350
300
250
200
150
100
50
0
22/10/22
21/01/23
22/04/23
22/07/23
22/10/23
21/01/24
21/04/24
22/07/24
21/10/24
L
M

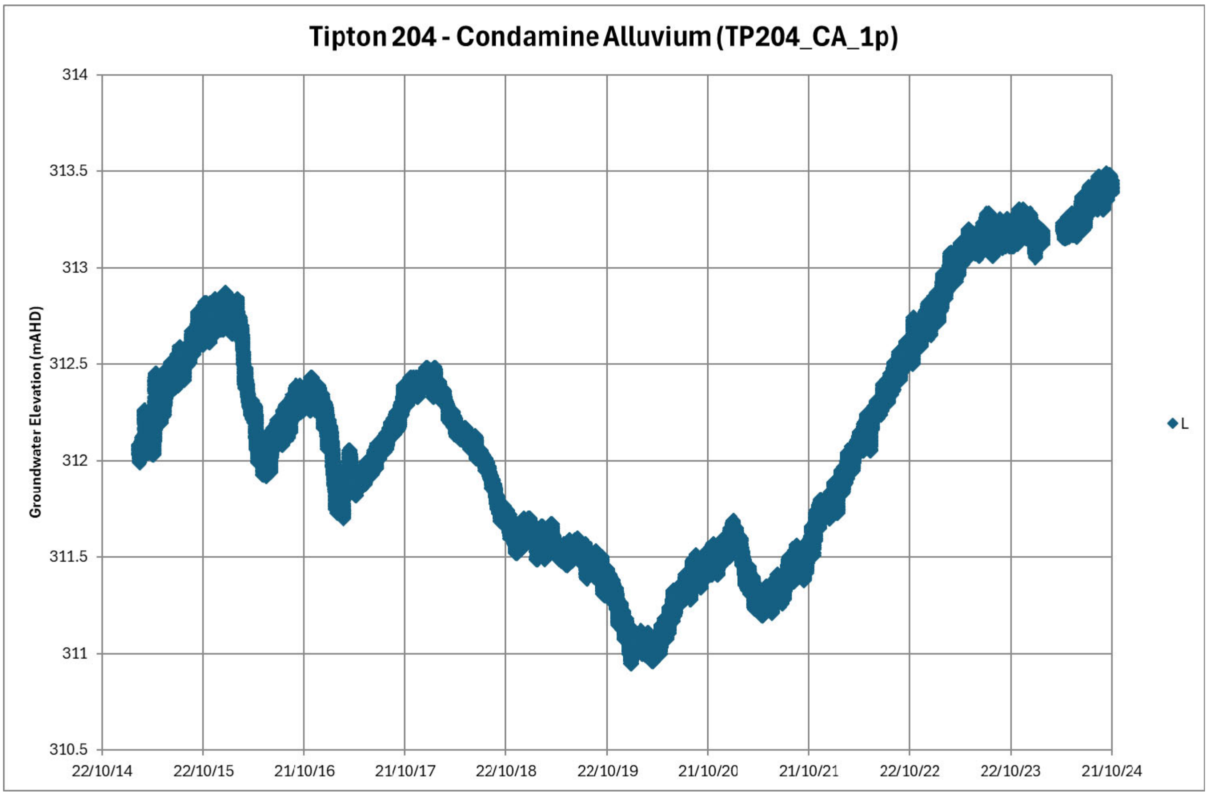

Tipton 200 - Lower Juandah CM (TP200_WCMlj_1p)
Groundwater Elevation (mAHD)
252
250
248
246
244
242
240
238
22/10/21
21/01/22
22/04/22
22/07/22
22/10/22
21/01/23
22/04/23
23/07/23
22/10/23
21/01/24
22/04/24
22/07/24
21/10/24
L

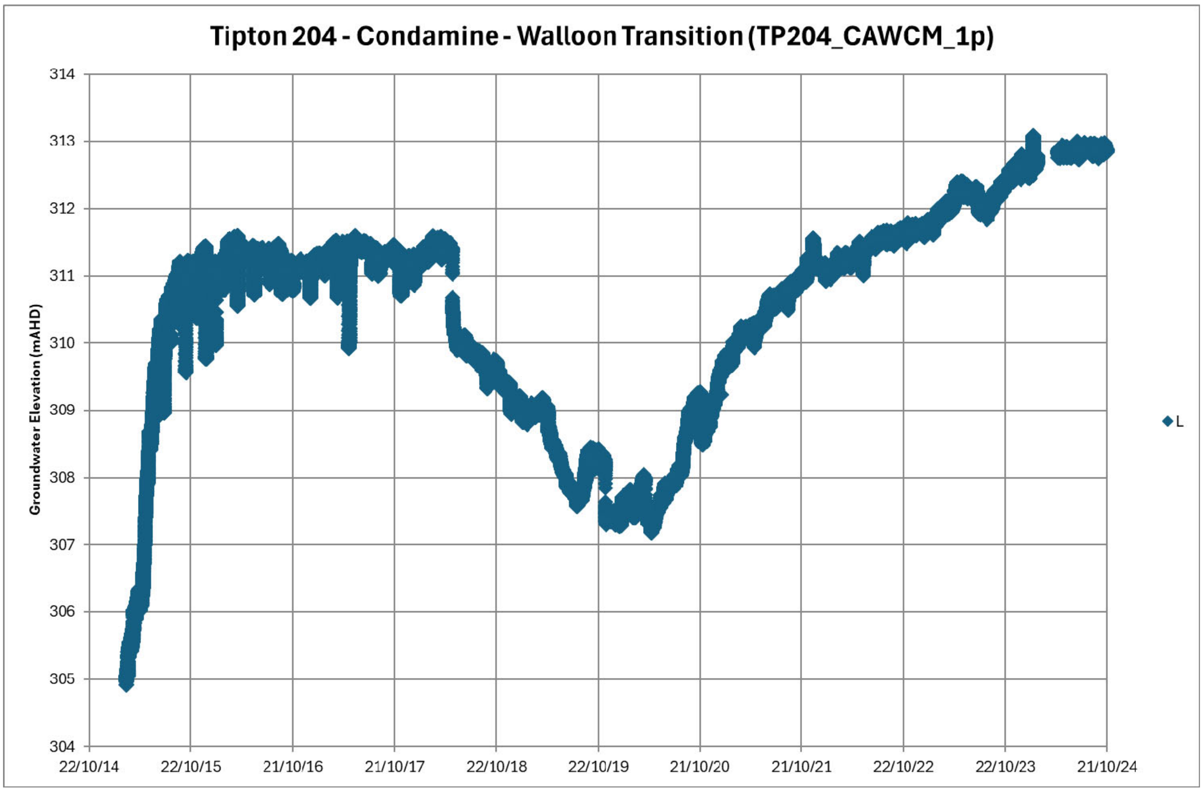

Tipton 200 - Taroom CM (TP200_WCMta_1p)
Groundwater Elevation (mAHD)
120
100
80
60
40
20
0
22/10/21
21/01/22
22/04/22
22/07/22
22/10/22
21/01/23
22/04/23
23/07/23
22/10/23
21/01/24
22/04/24
22/07/24
21/10/24
L

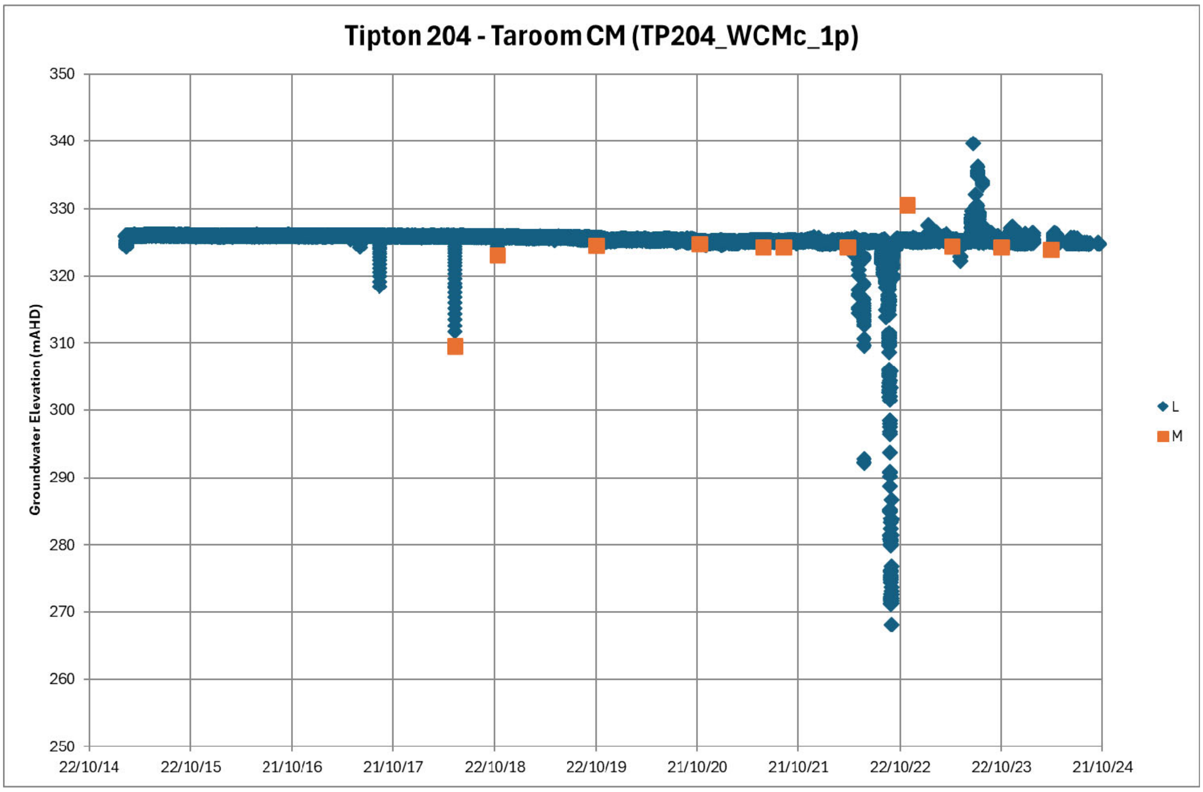

Tipton 200 - Upper Juandah CM (TP200_WCMuj_1p)
Groundwater Elevation (mAHD)
292
290
288
286
284
282
280
278
22/10/21
21/01/22
22/04/22
22/07/22
22/10/22
21/01/23
22/04/23
23/07/23
22/10/23
21/01/24
22/04/24
22/07/24
21/10/24
L

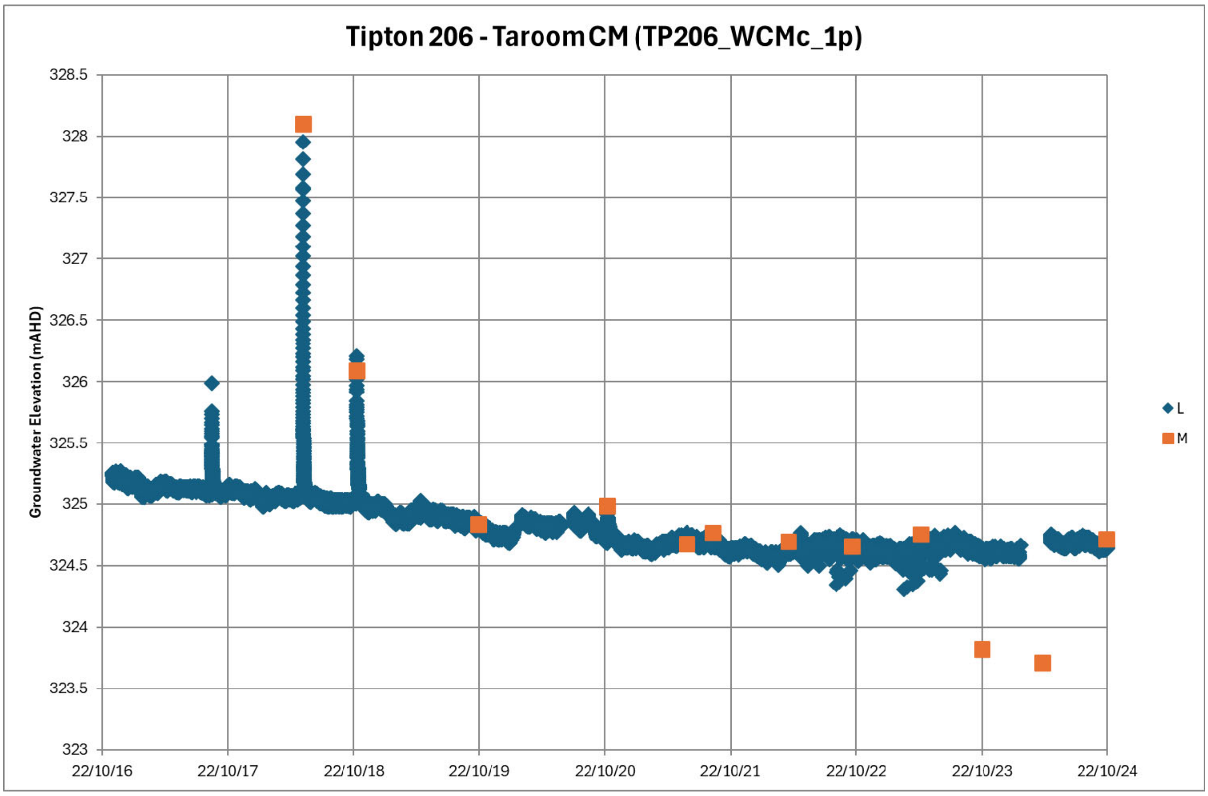

Tipton 202 - Lower Springbok Sandstone (TP202_SS_1p)
Groundwater Elevation (mAHD)
302
300
298
296
294
22/04/22
22/10/22
23/04/23
22/10/23
22/04/24
22/10/24
L
M

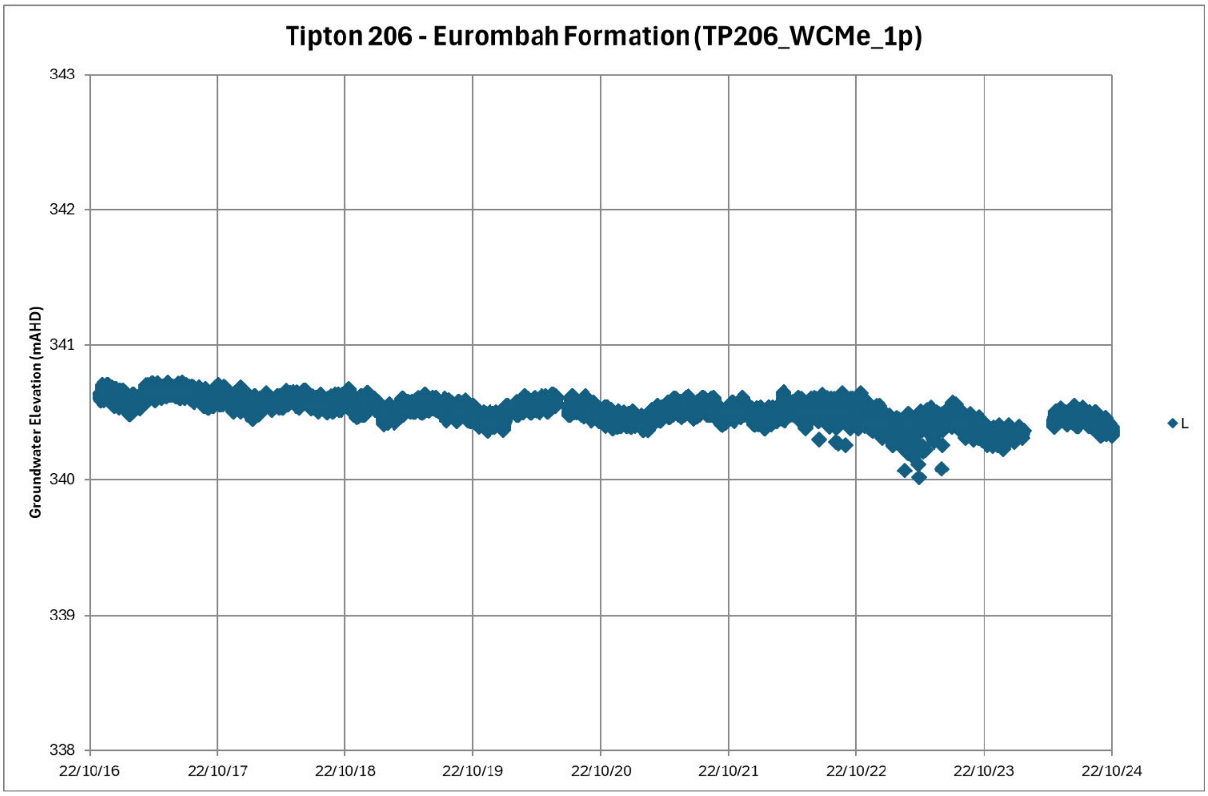

Tipton 203 - Condamine Alluvium (TP203_CA_1p)
Groundwater Elevation (mAHD)
330
329
328
327
326
22/10/21
22/04/22
22/10/22
22/04/23
22/10/23
22/04/24
21/10/24
L
M

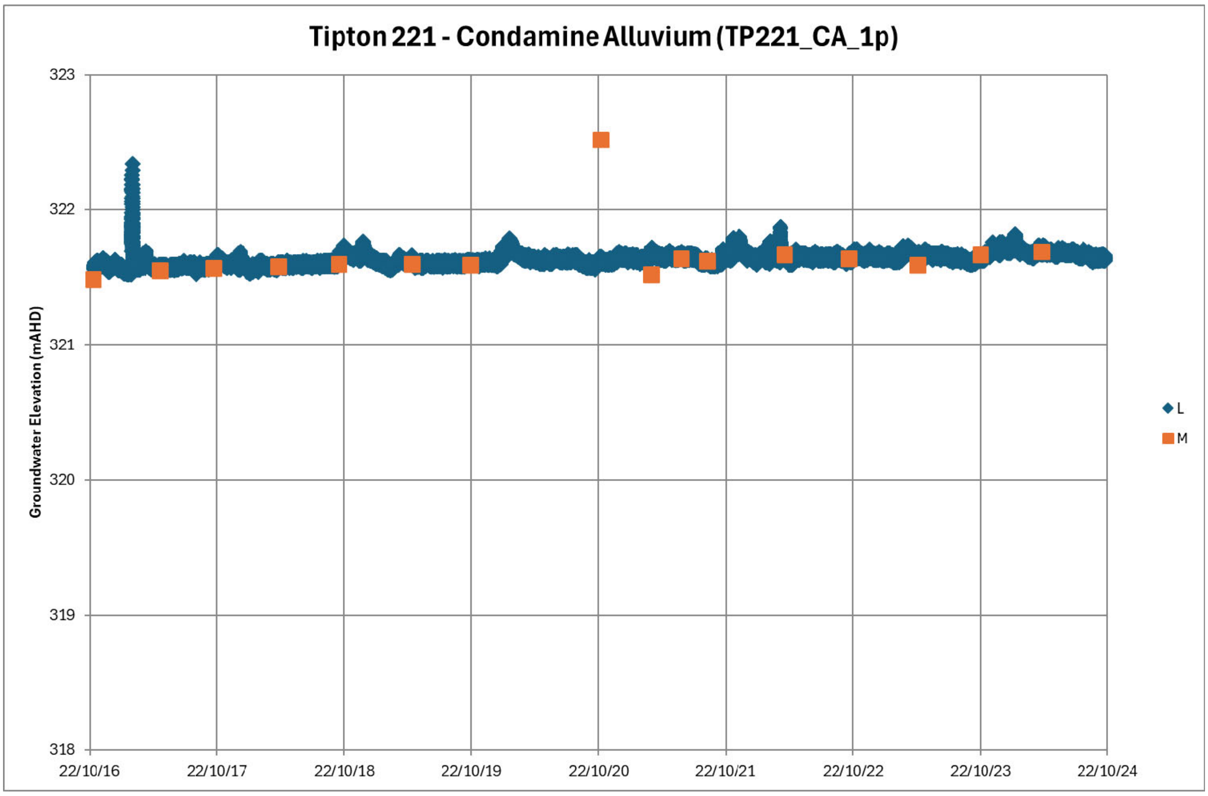

Tipton 204 - Condamine Alluvium (TP204_CA_1p)
Groundwater Elevation (mAHD)
314
313.5
313
312.5
312
311.5
311
310.5
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L

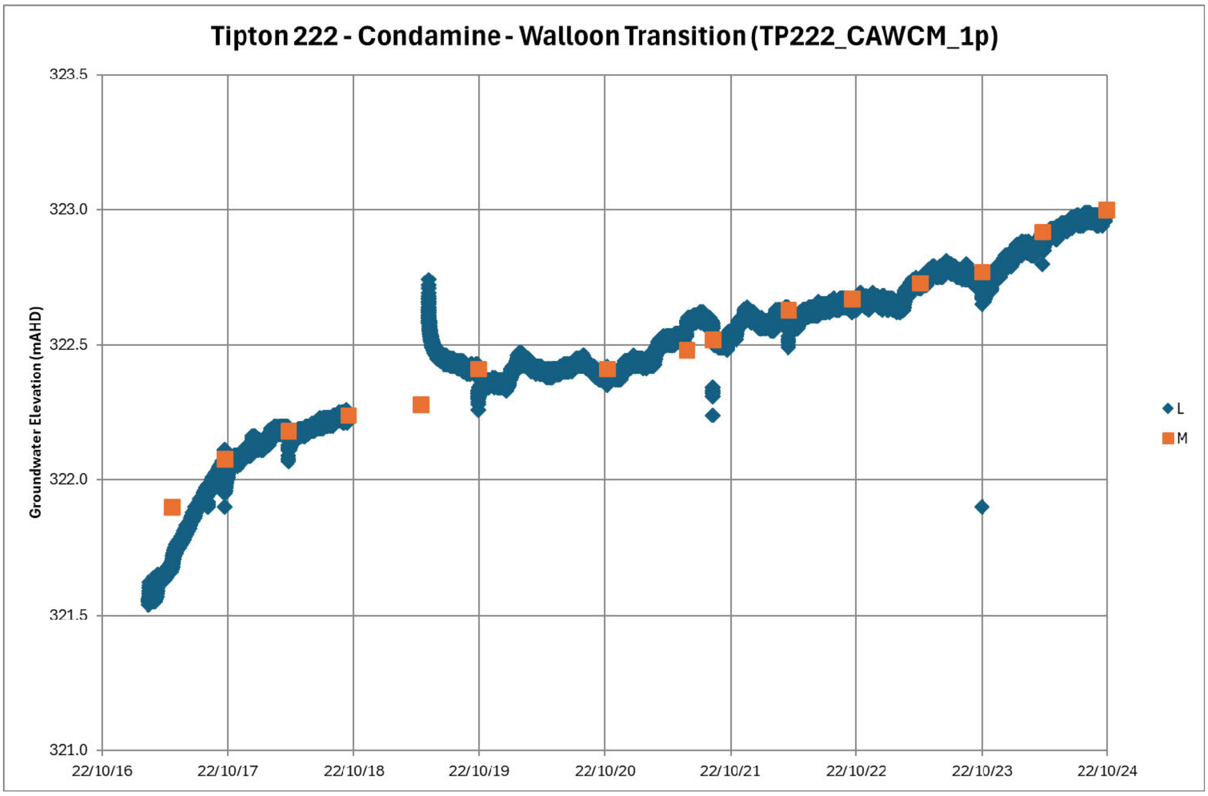

Tipton 204 - Condamine - Walloon Transition (TP204_CAWCM_1p)
Groundwater Elevation (mAHD)
314
313
312
311
310
309
308
307
306
305
304
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L

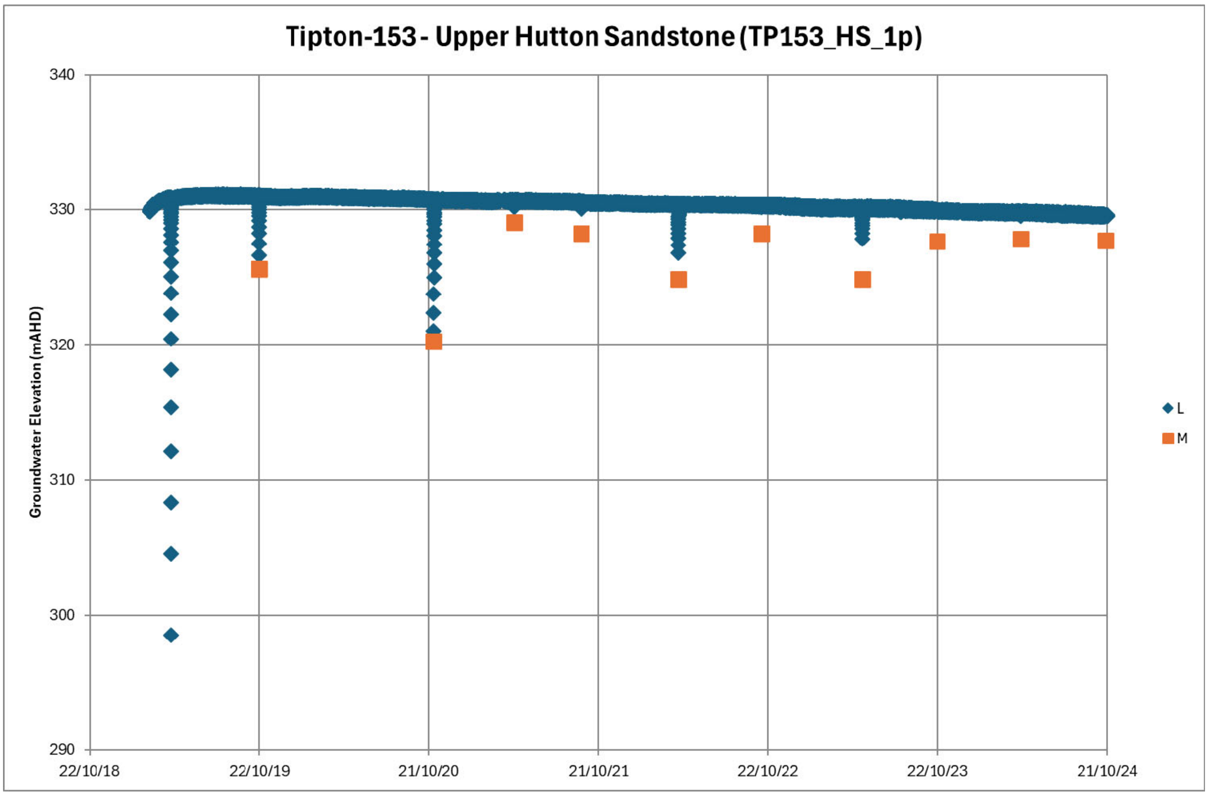

Tipton 204 - Taroom CM (TP204_WCMc_1p)
Groundwater Elevation (mAHD)
350
340
330
320
310
300
290
280
270
260
250
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L
M

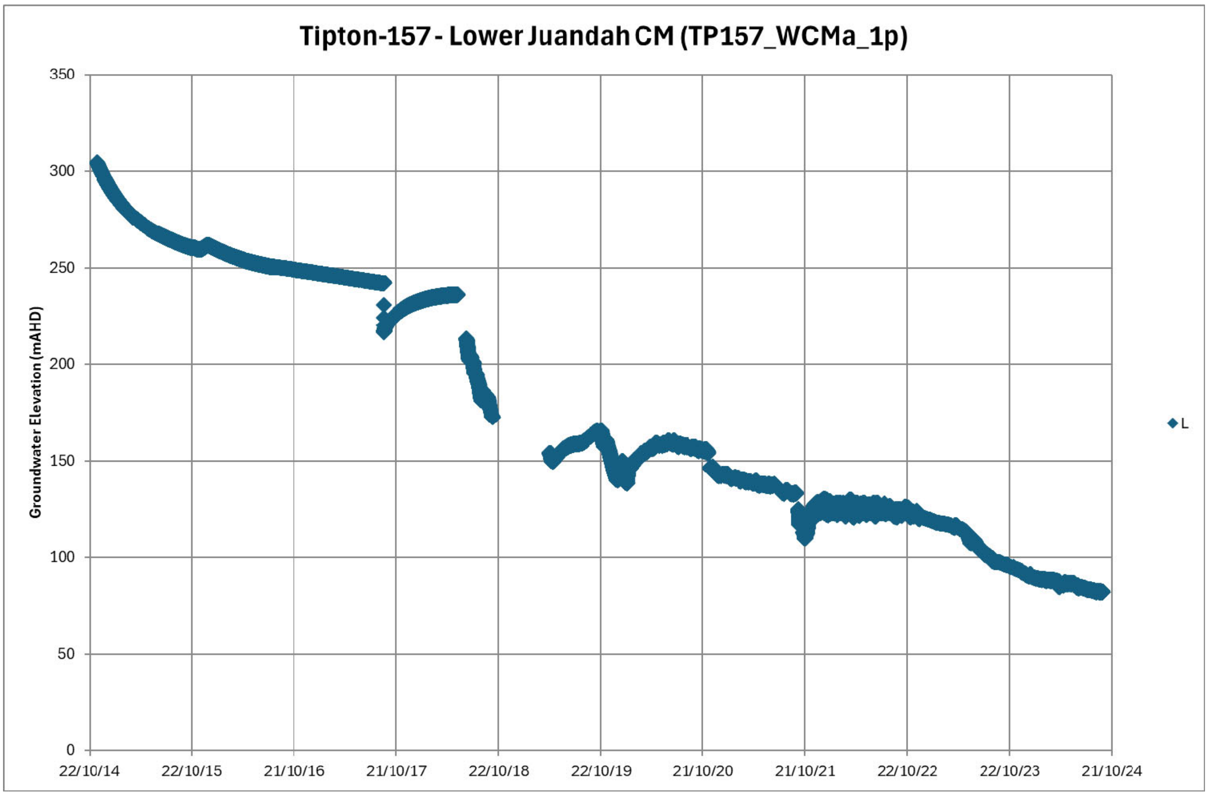

Tipton 206 - Taroom CM (TP206_WCMc_1p)
Groundwater Elevation (mAHD)
328.5
328
327.5
327
326.5
326
325.5
325
324.5
324
323.5
323
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

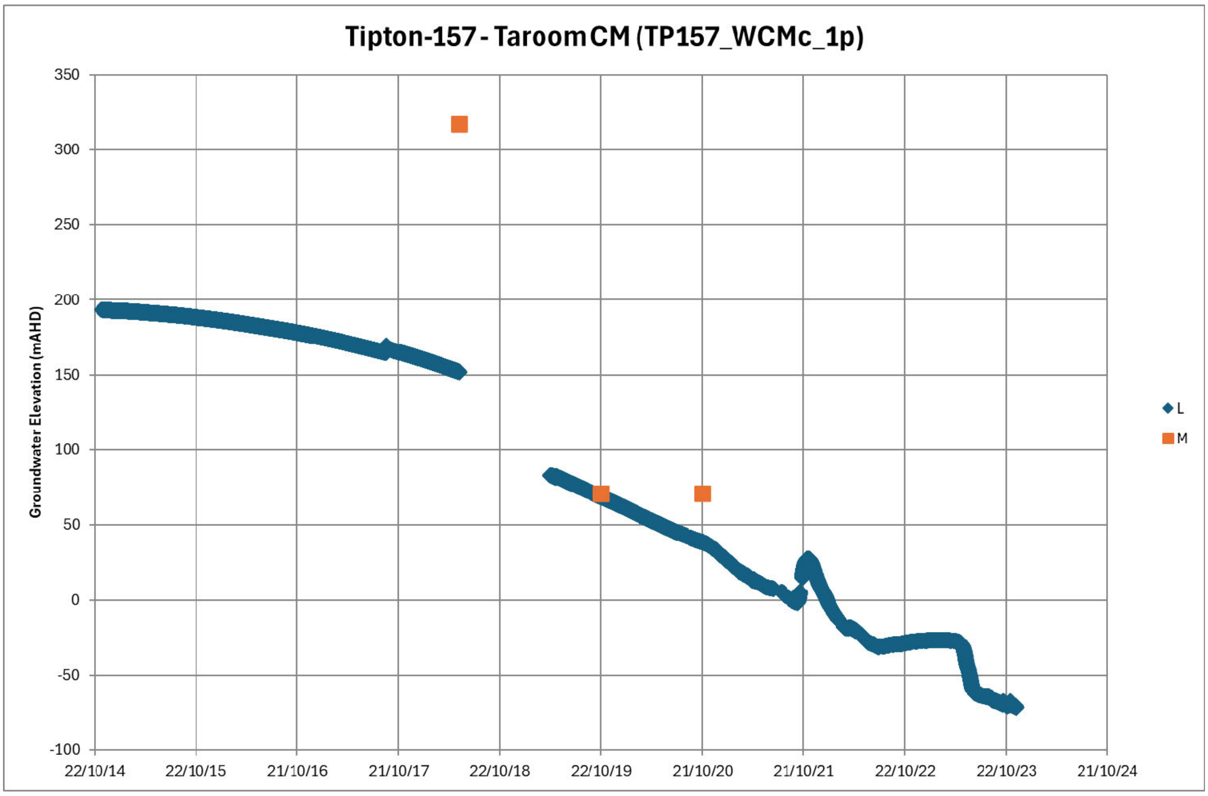

Tipton 206 - Eurombah Formation (TP206_WCMe_1p)
Groundwater Elevation (mAHD)
343
342
341
340
339
338
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L

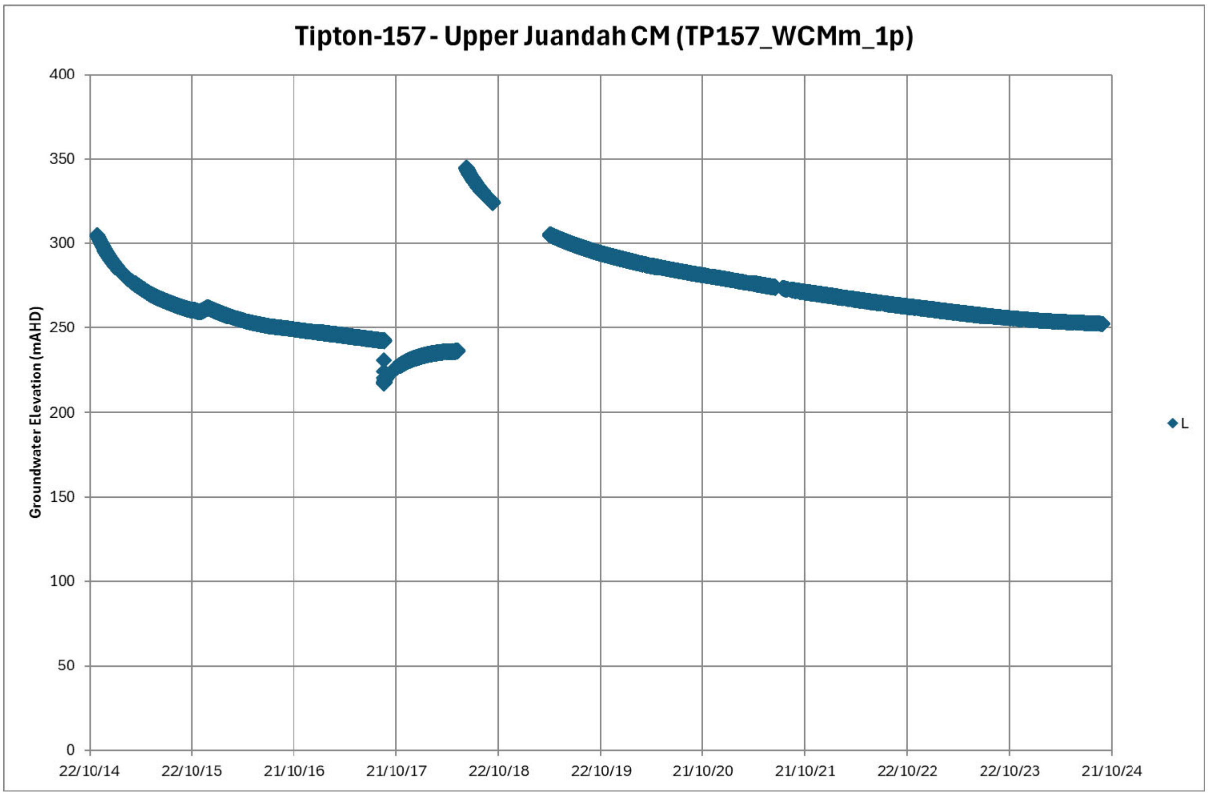

Tipton 221 - Condamine Alluvium (TP221_CA_1p)
Groundwater Elevation (mAHD)
323
322
321
320
319
318
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

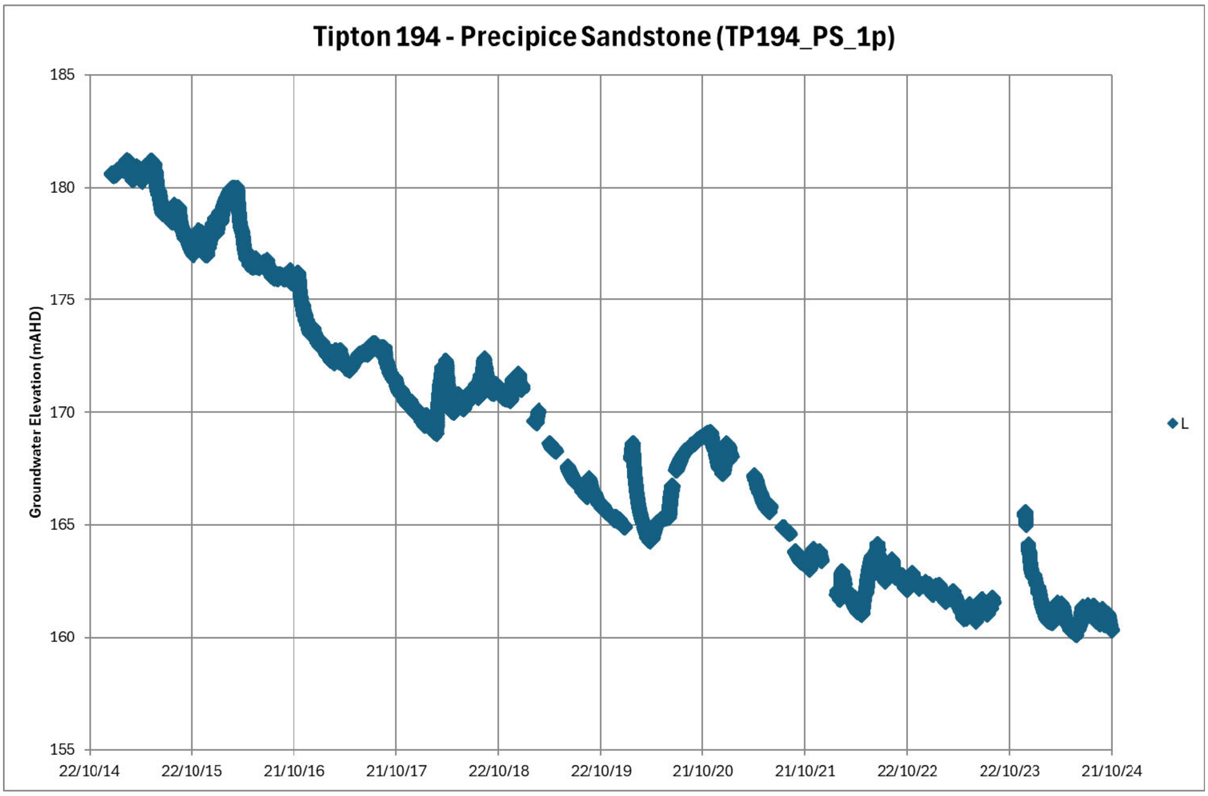

Tipton 222 - Condamine - Walloon Transition (TP222_CAWCM_1p)
Groundwater Elevation (mAHD)
323.5
323.0
322.5
322.0
321.5
321.0
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

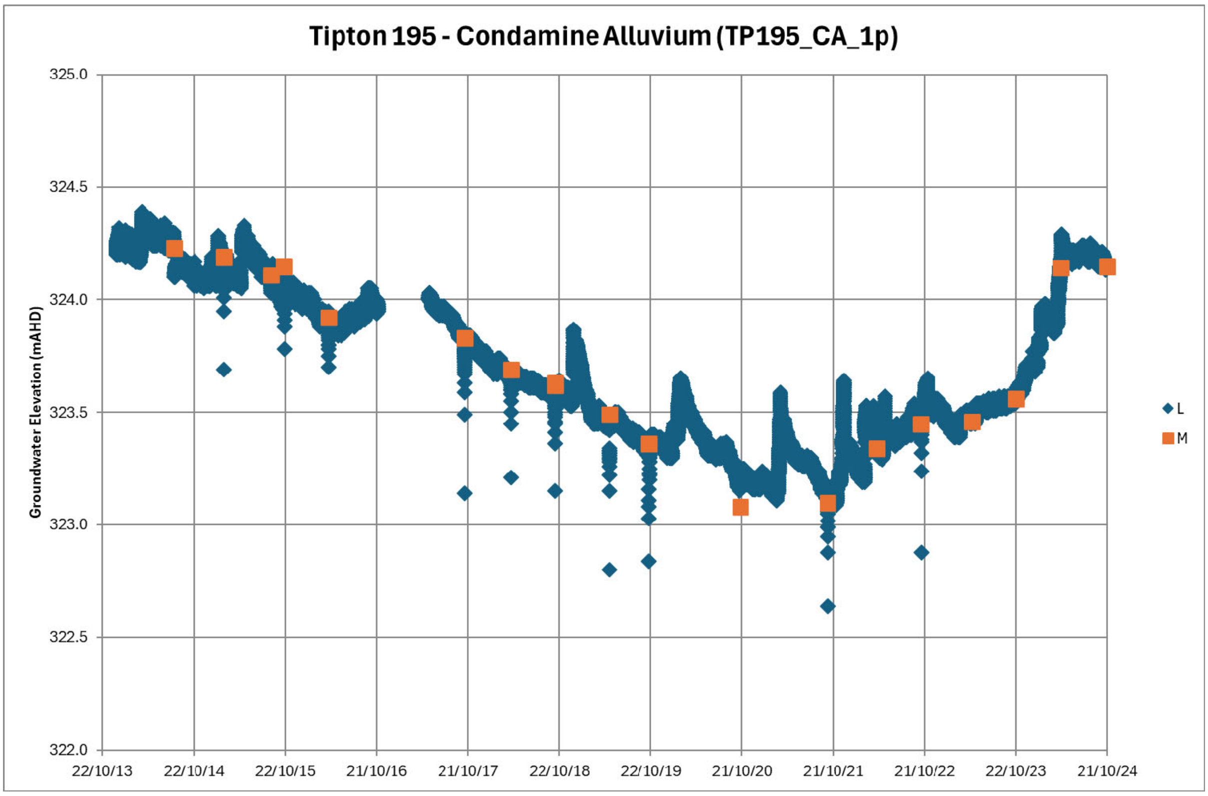

Tipton-153 - Upper Hutton Sandstone (TP153_HS_1p)
Groundwater Elevation (mAHD)
340
330
320
310
300
290
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L
M

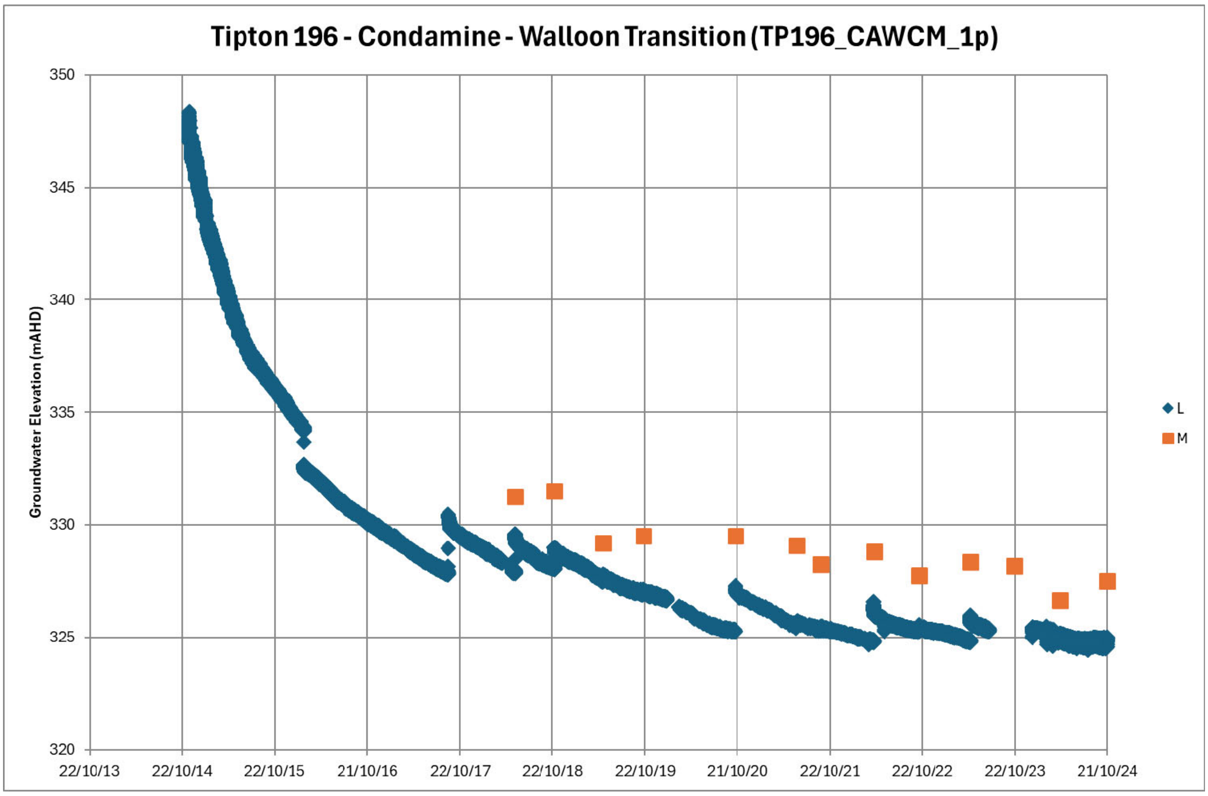

Tipton-157 - Lower Juandah CM (TP157_WCMa_1p)
Groundwater Elevation (mAHD)
350
300
250
200
150
100
50
0
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L

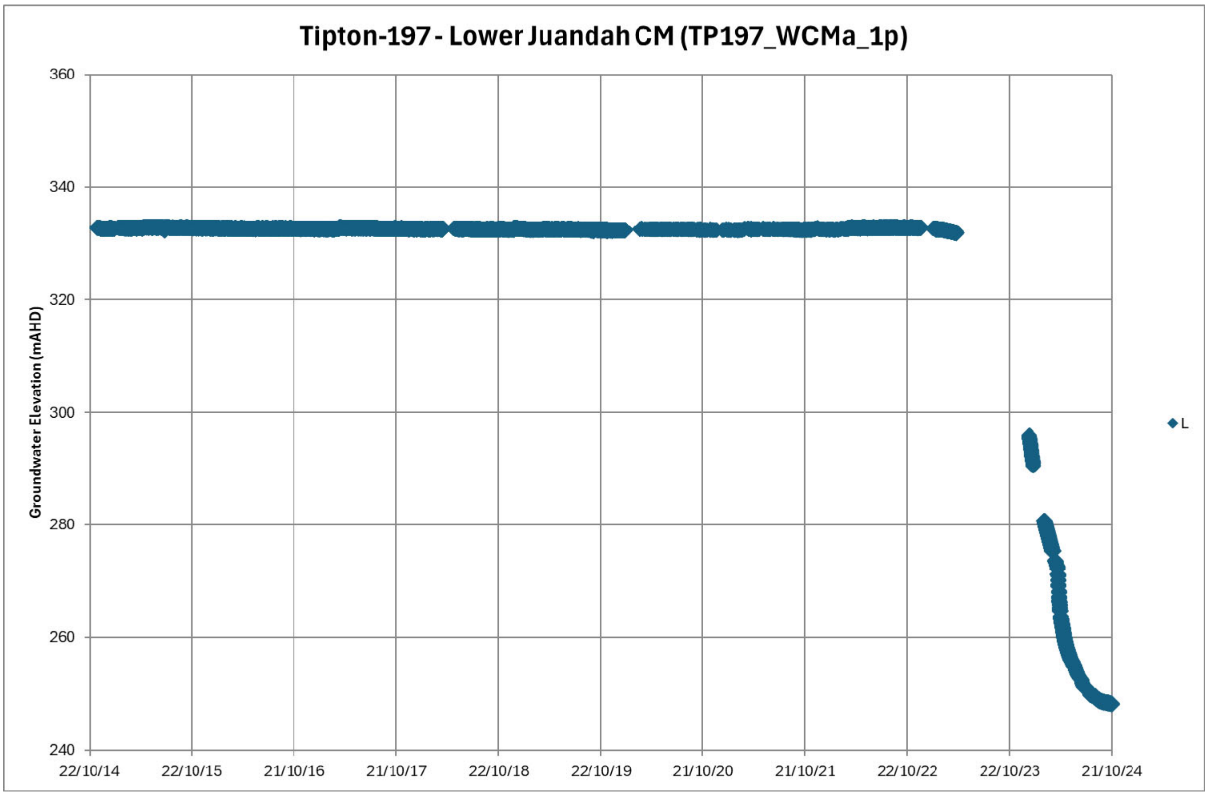

Tipton-157 - Taroom CM (TP157_WCMc_1p)
Groundwater Elevation (mAHD)
350
300
250
200
150
100
50
0
-50
-100
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L
M

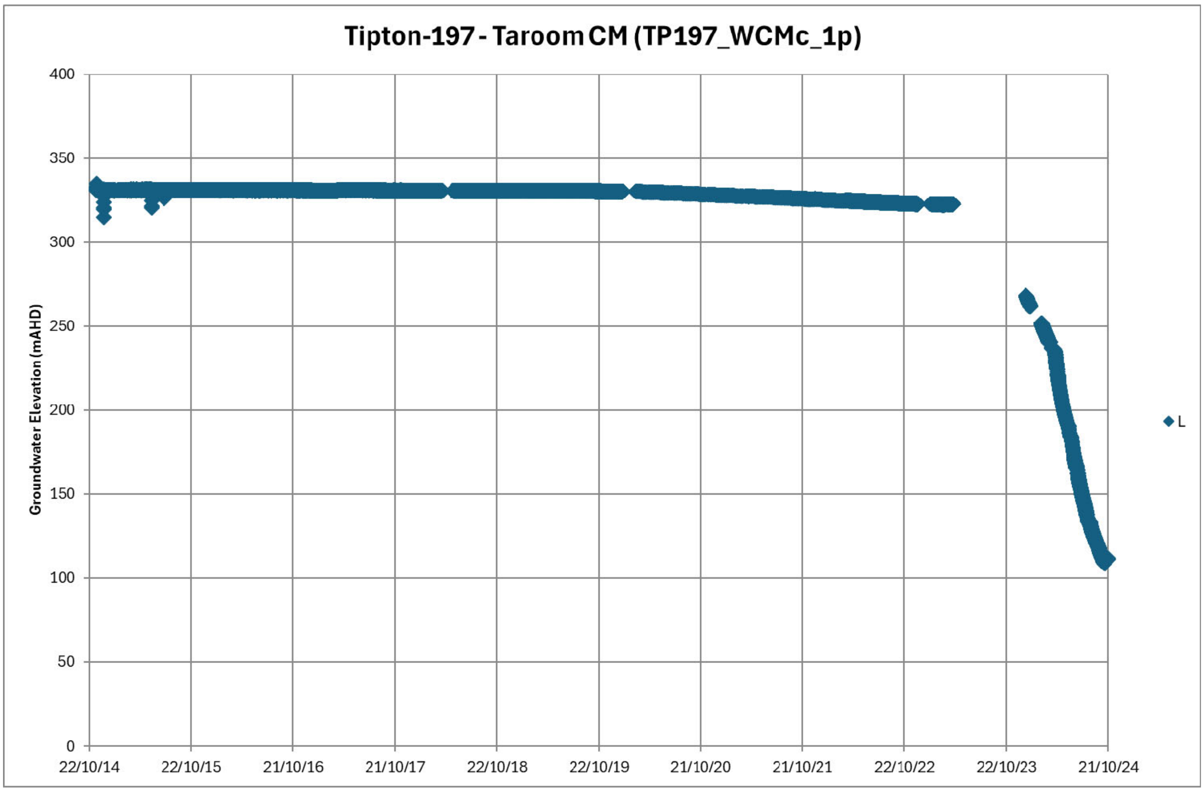

Tipton-157 - Upper Juandah CM (TP157_WCMm_1p)
Groundwater Elevation (mAHD)
400
350
300
250
200
150
100
50
0
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L

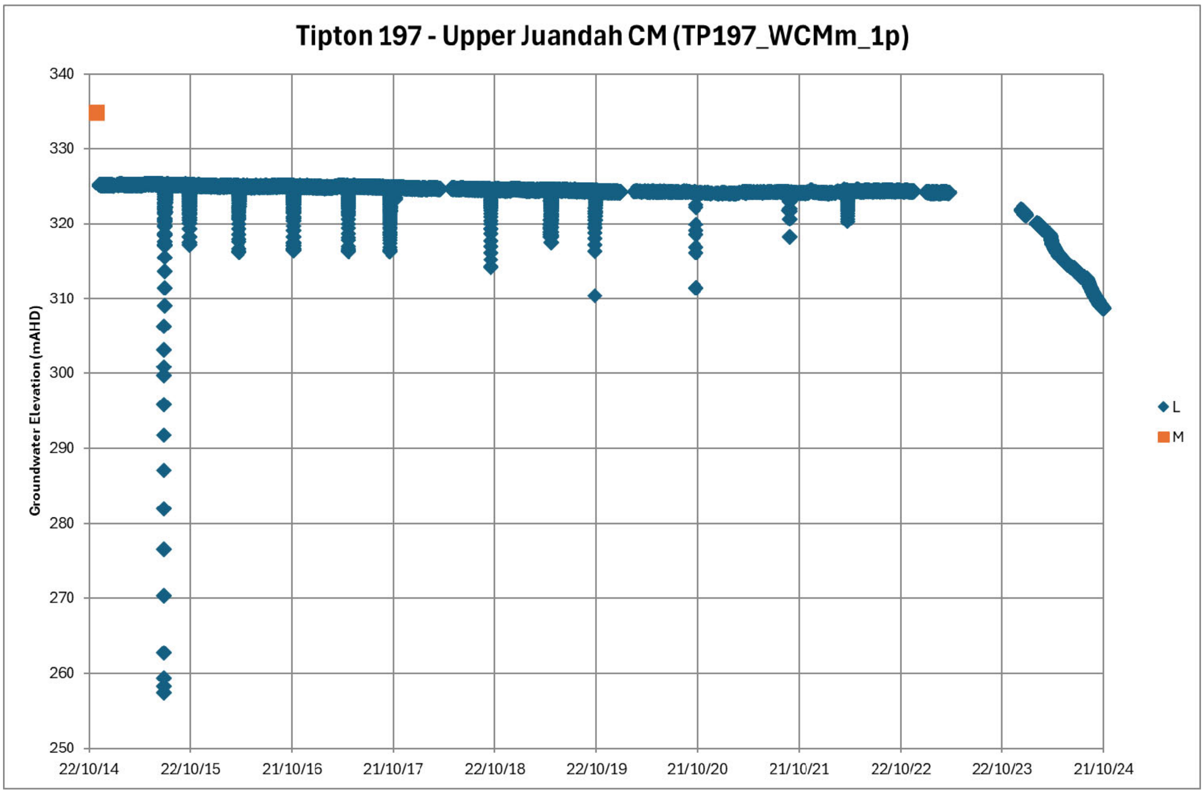

Tipton 194 - Precipice Sandstone (TP194_PS_1p)
Groundwater Elevation (mAHD)
185
180
175
170
165
160
155
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L

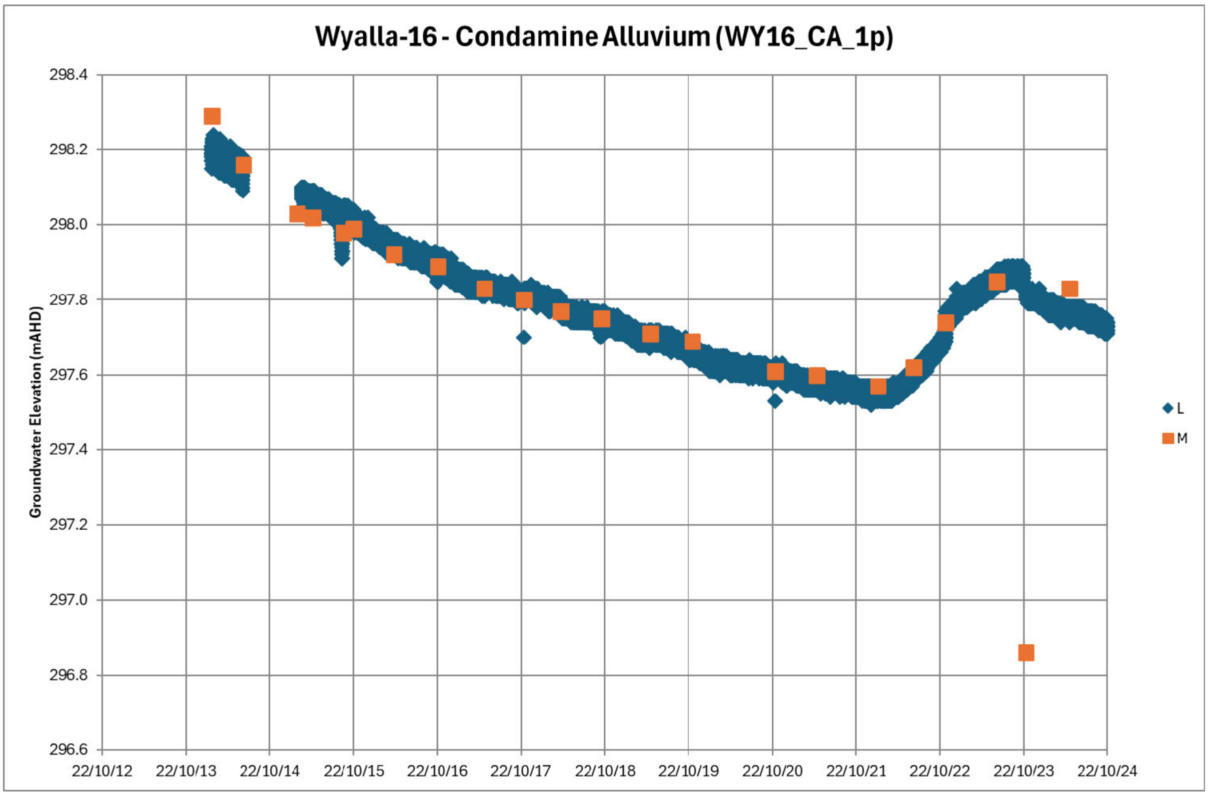

Tipton 195 - Condamine Alluvium (TP195_CA_1p)
Groundwater Elevation (mAHD)
325.0
324.5
324.0
323.5
323.0
322.5
322.0
22/10/13
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
21/10/22
22/10/23
21/10/24
L
M


Tipton 196 - Condamine - Walloon Transition (TP196_CAWCM_1p)
Groundwater Elevation (mAHD)
350
345
340
335
330
325
320
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

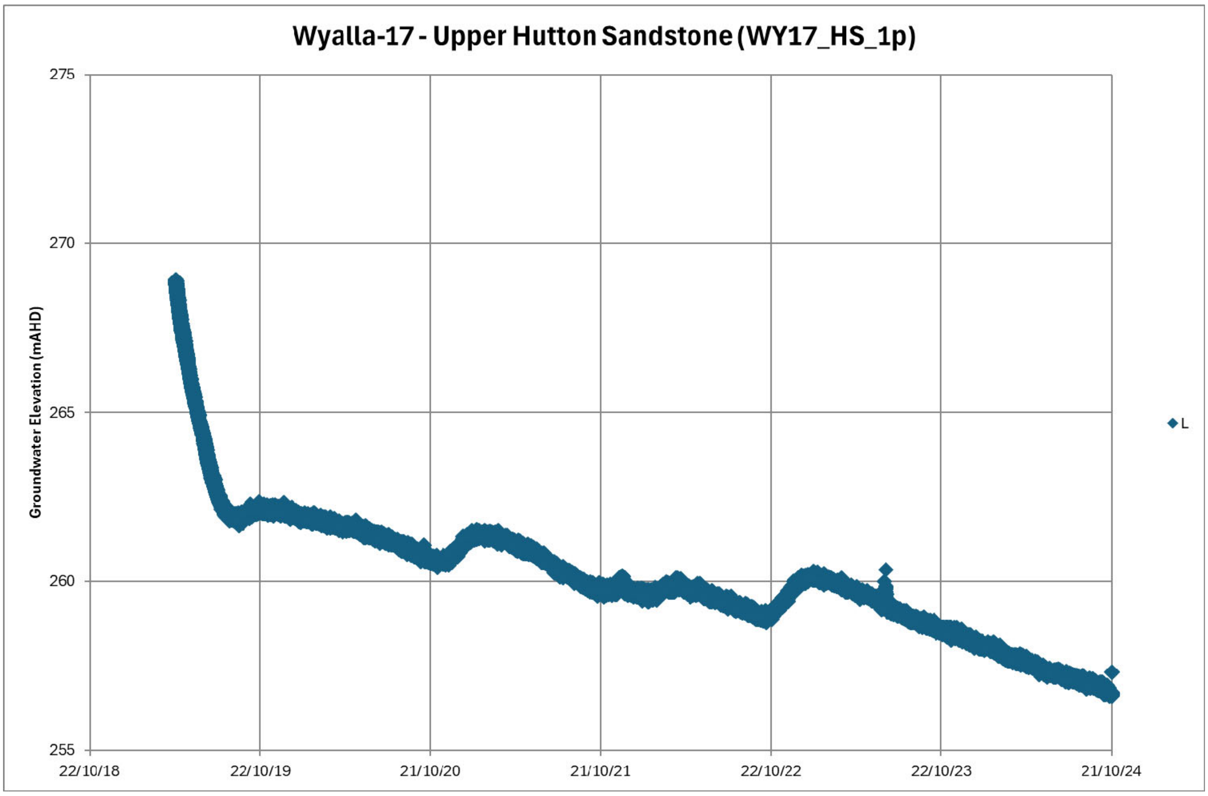

Tipton-197 - Lower Juandah CM (TP197_WCMa_1p)
Groundwater Elevation (mAHD)
360
340
320
300
280
260
240
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L


Tipton-197 - Taroom CM (TP197_WCMc_1p)
Groundwater Elevation (mAHD)
400
350
300
250
200
150
100
50
0
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L

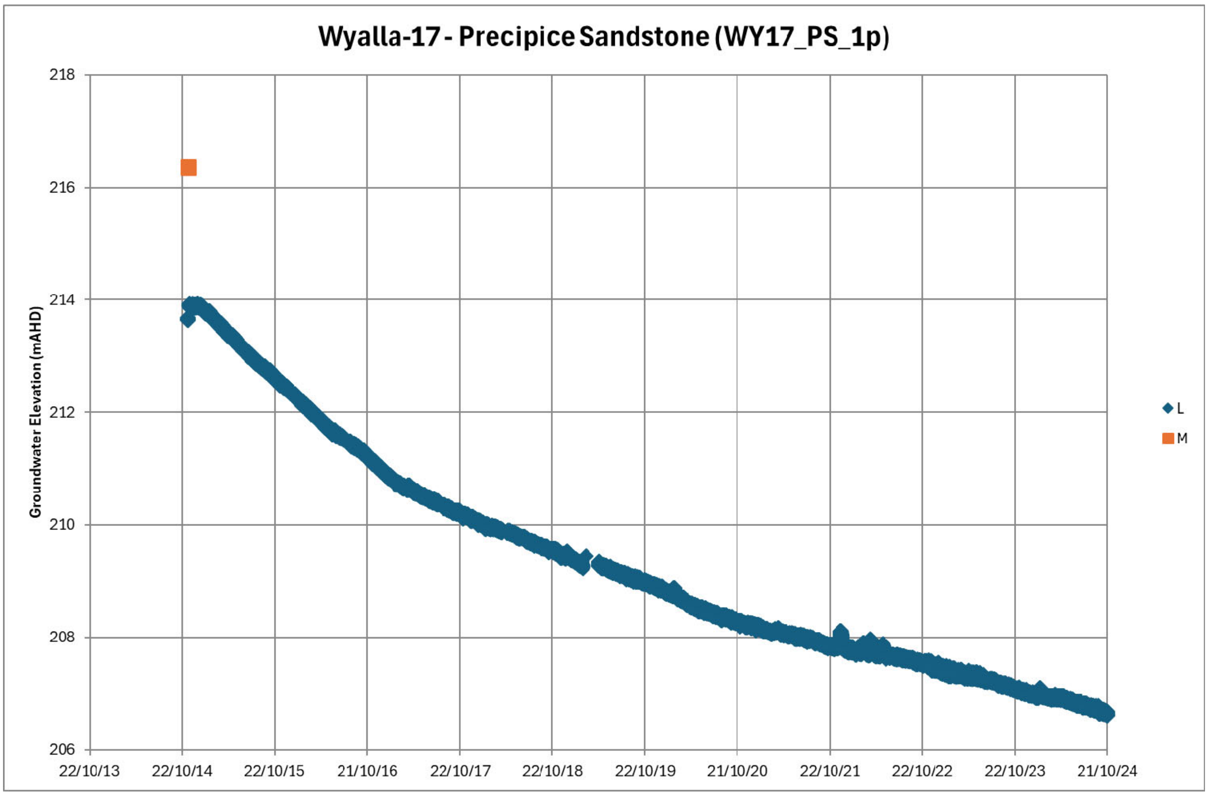

Tipton 197 - Upper Juandah CM (TP197_WCMm_1p)
Groundwater Elevation (mAHD)
340
330
320
310
300
290
280
270
260
250
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L
M

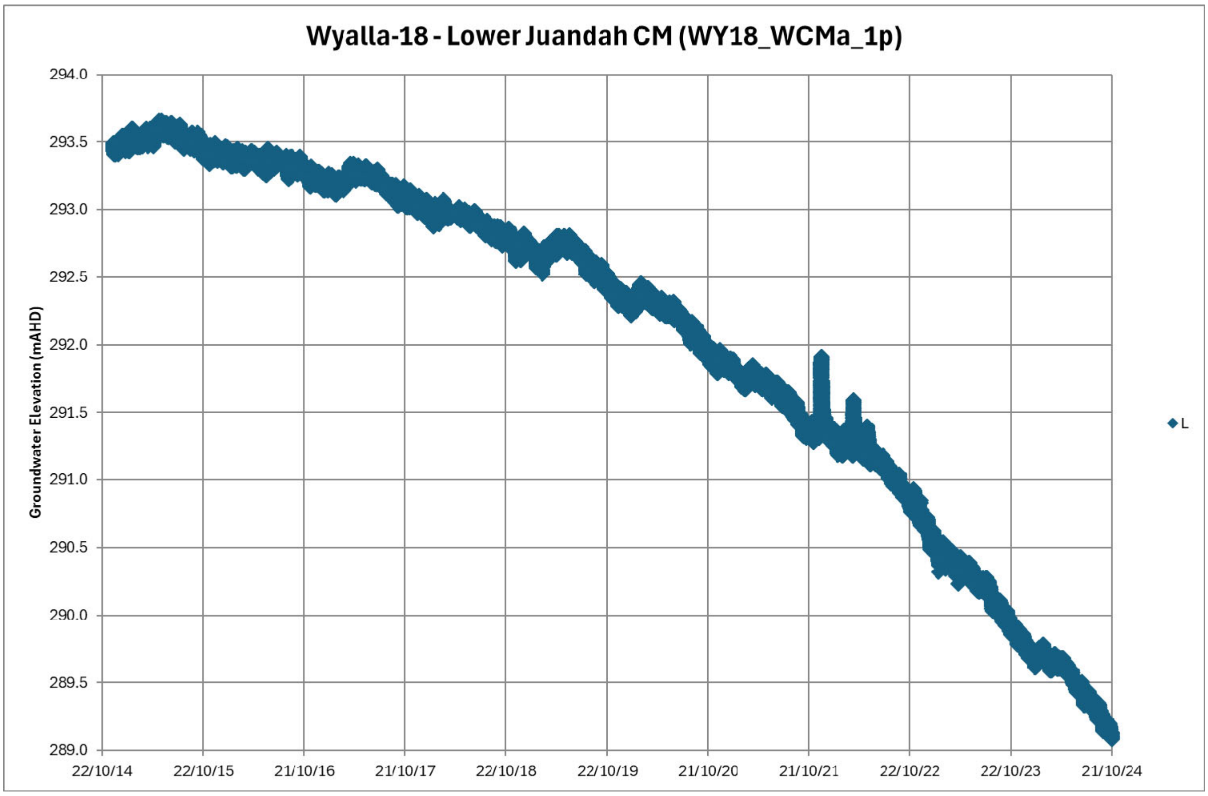


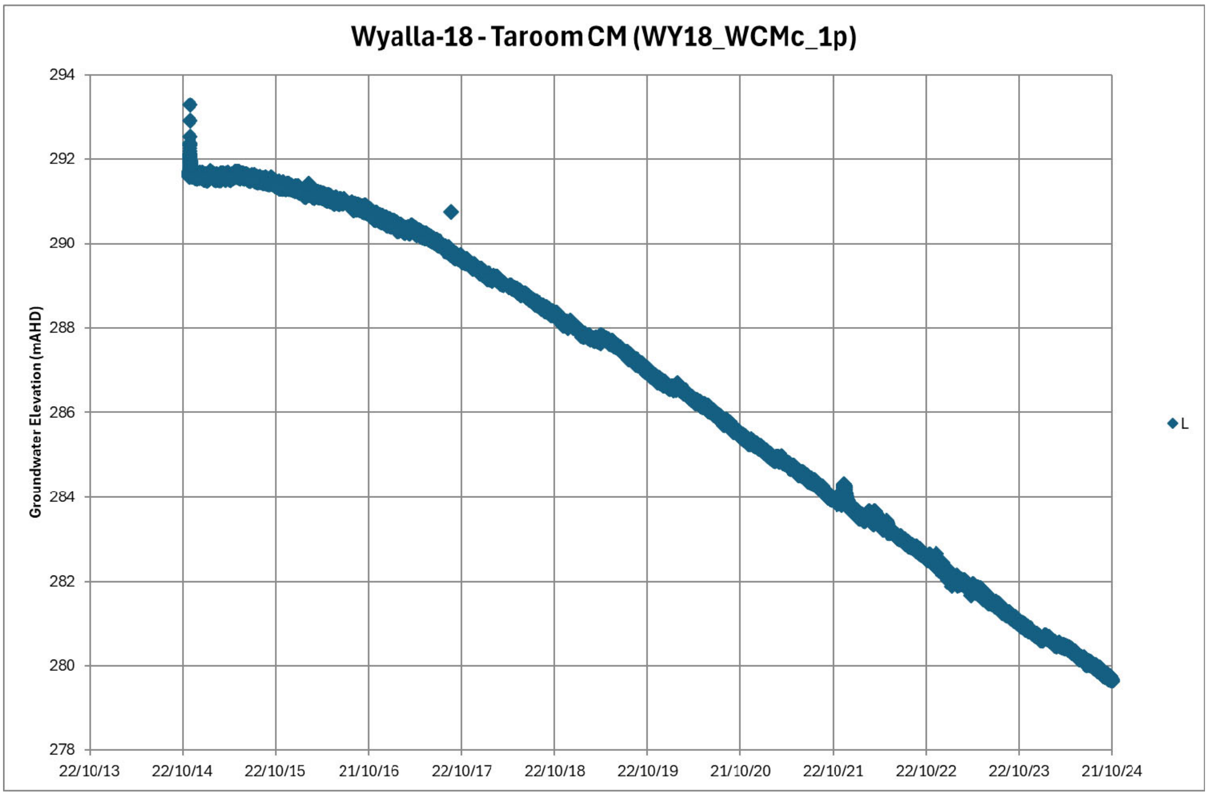
Wyalla-16 - Condamine Alluvium (WY16_CA_1p)
Groundwater Elevation (mAHD)
298.4
298.2
298.0
297.8
297.6
297.4
297.2
297.0
296.8
296.6
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

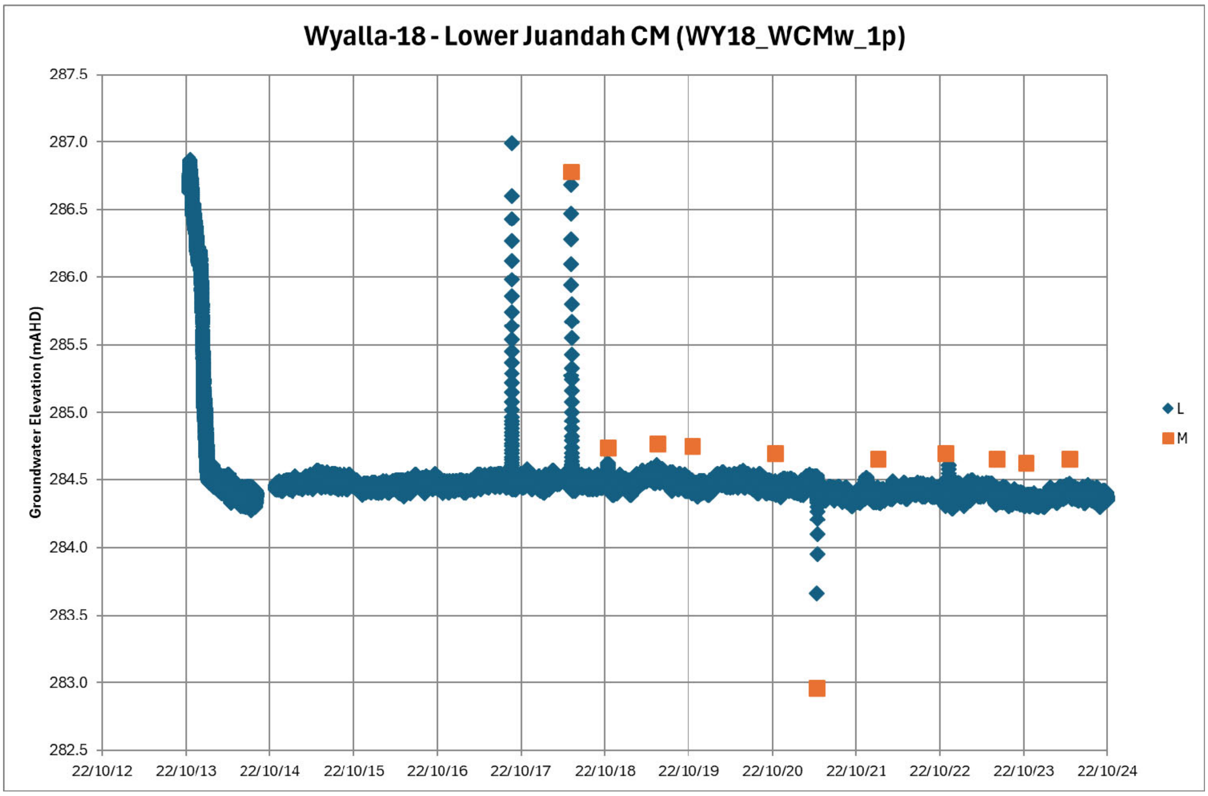


Wyalla-17 - Upper Hutton Sandstone (WY17_HS_1p)
Groundwater Elevation (mAHD)
275
270
265
260
255
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L

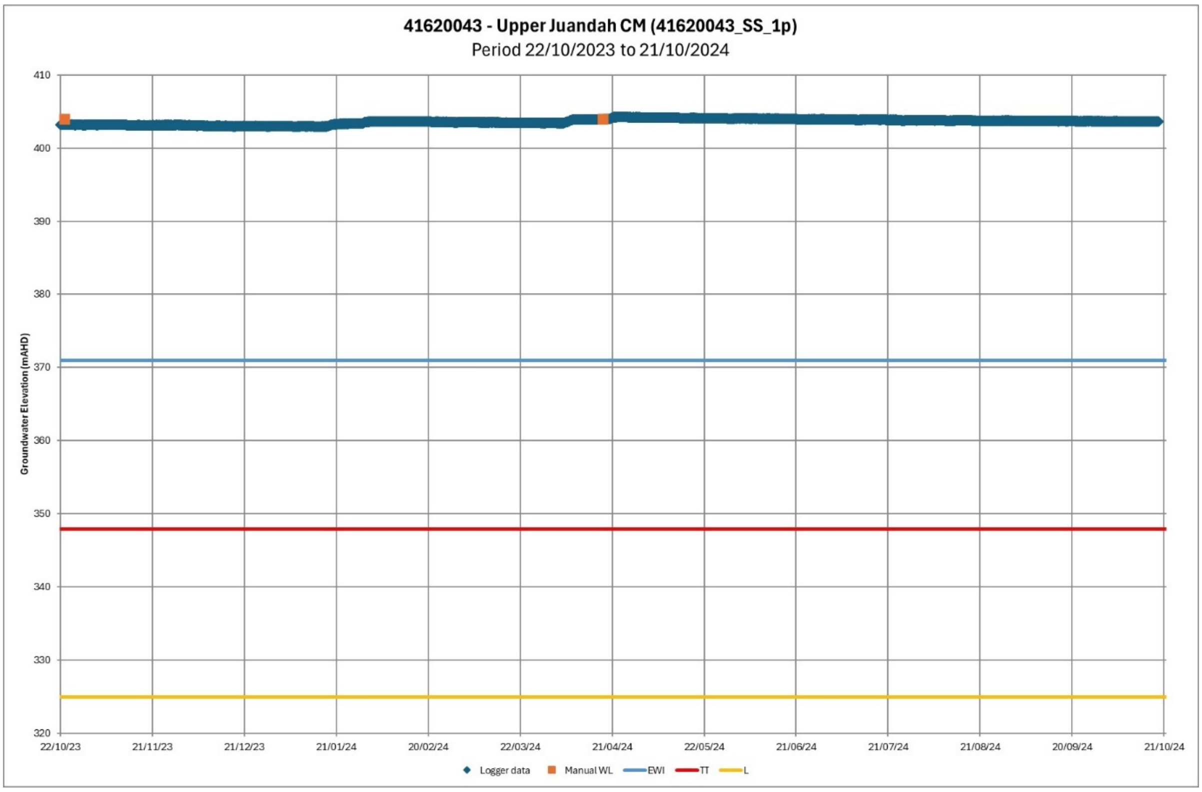

Wyalla-17 - Precipice Sandstone (WY17_PS_1p)
Groundwater Elevation (mAHD)
218
216
214
212
210
208
206
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L
M

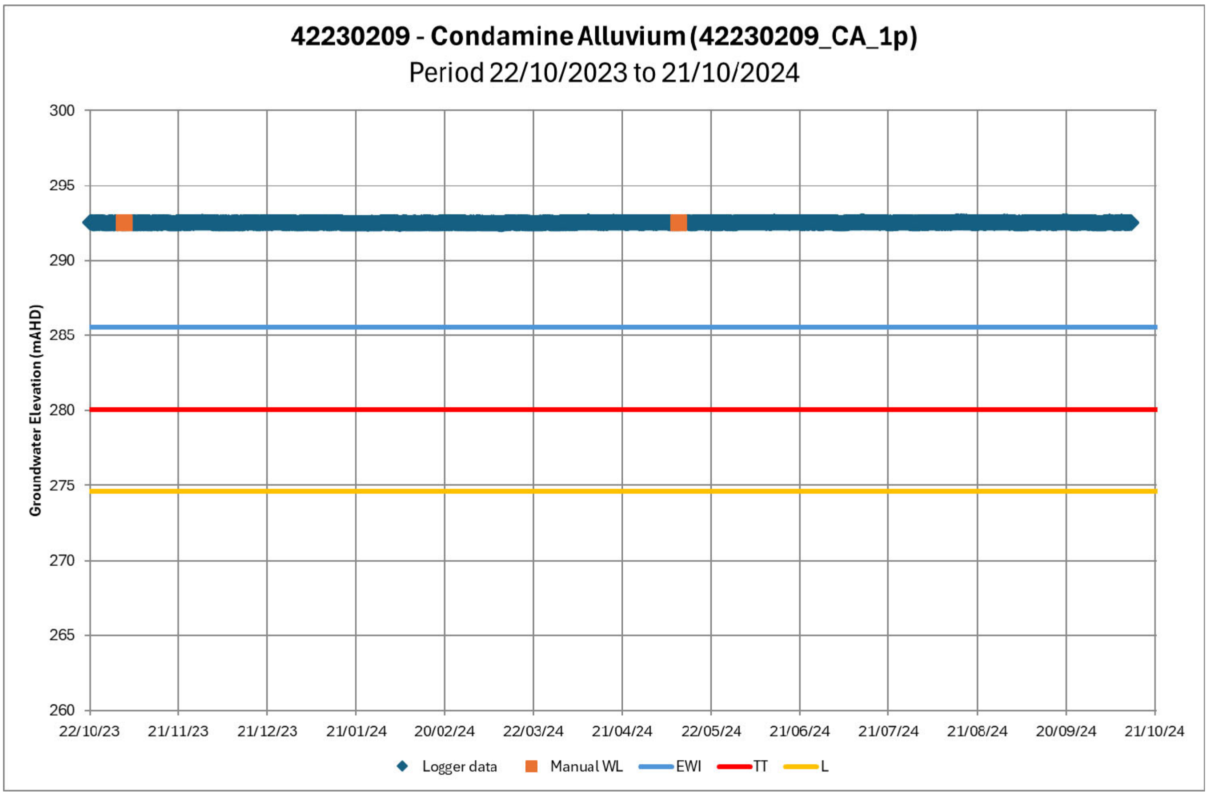

Wyalla-18 - Lower Juandah CM (WY18_WCMa_1p)
Groundwater Elevation (mAHD)
294.0
293.5
293.0
292.5
292.0
291.5
291.0
290.5
290.0
289.5
289.0
22/10/14
22/10/15
21/10/16
21/10/17
22/10/18
22/10/19
21/10/20
21/10/21
22/10/22
22/10/23
21/10/24
L

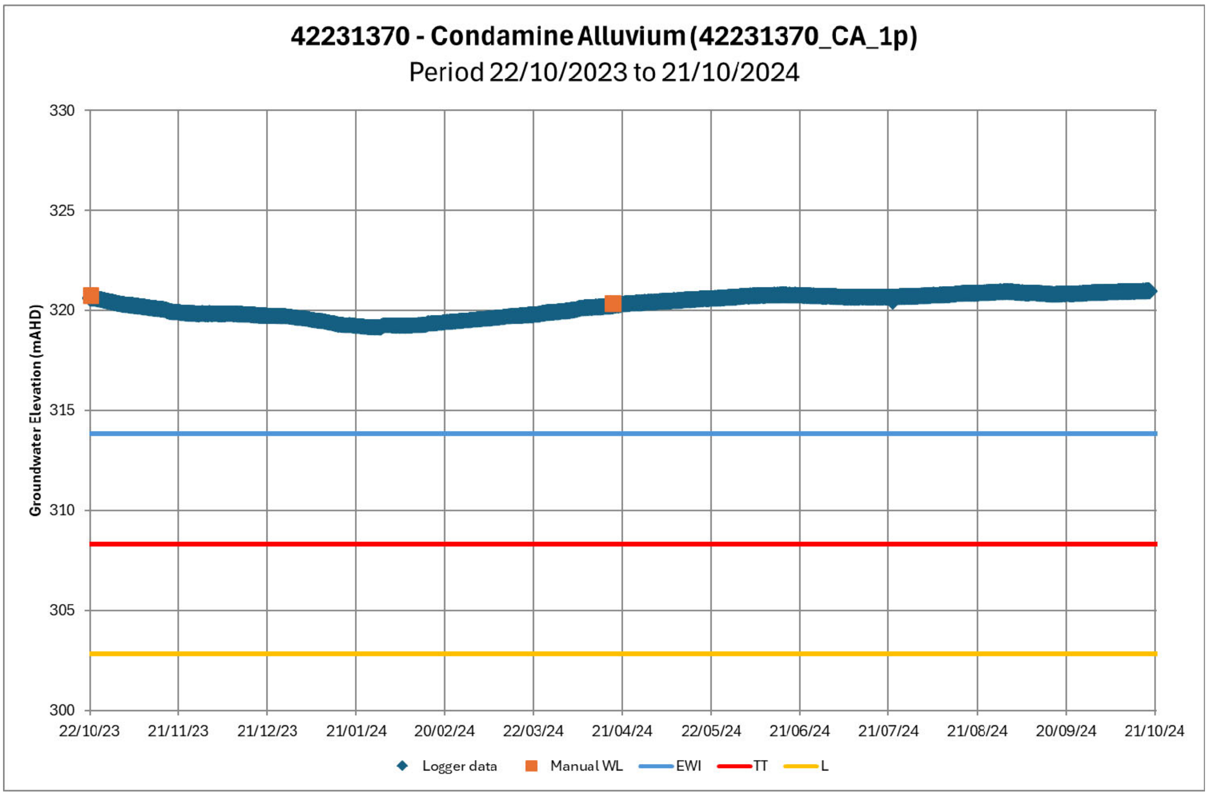

Wyalla-18 - Taroom CM (WY18_WCMc_1p)
Groundwater Elevation (mAHD)
294
292
290
288
286
284
282
280
278
22/10/13
22/10/14
22/10/15
21/10/16
22/10/17
22/10/18
22/10/19
21/10/20
22/10/21
22/10/22
22/10/23
21/10/24
L

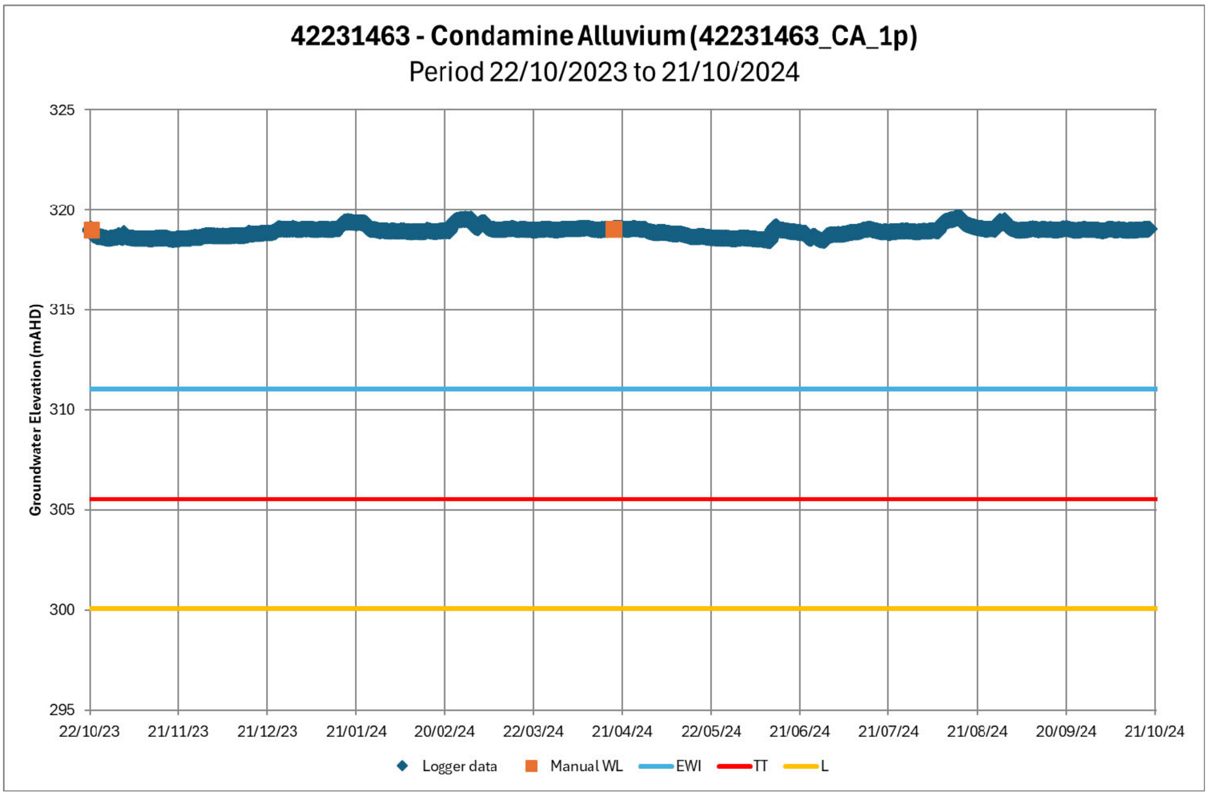

Wyalla-18 - Lower Juandah CM (WY18_WCMw_1p)
Groundwater Elevation (mAHD)
287.5
287.0
286.5
286.0
285.5
285.0
284.5
284.0
283.5
283.0
282.5
22/10/12
22/10/13
22/10/14
22/10/15
22/10/16
22/10/17
22/10/18
22/10/19
22/10/20
22/10/21
22/10/22
22/10/23
22/10/24
L
M

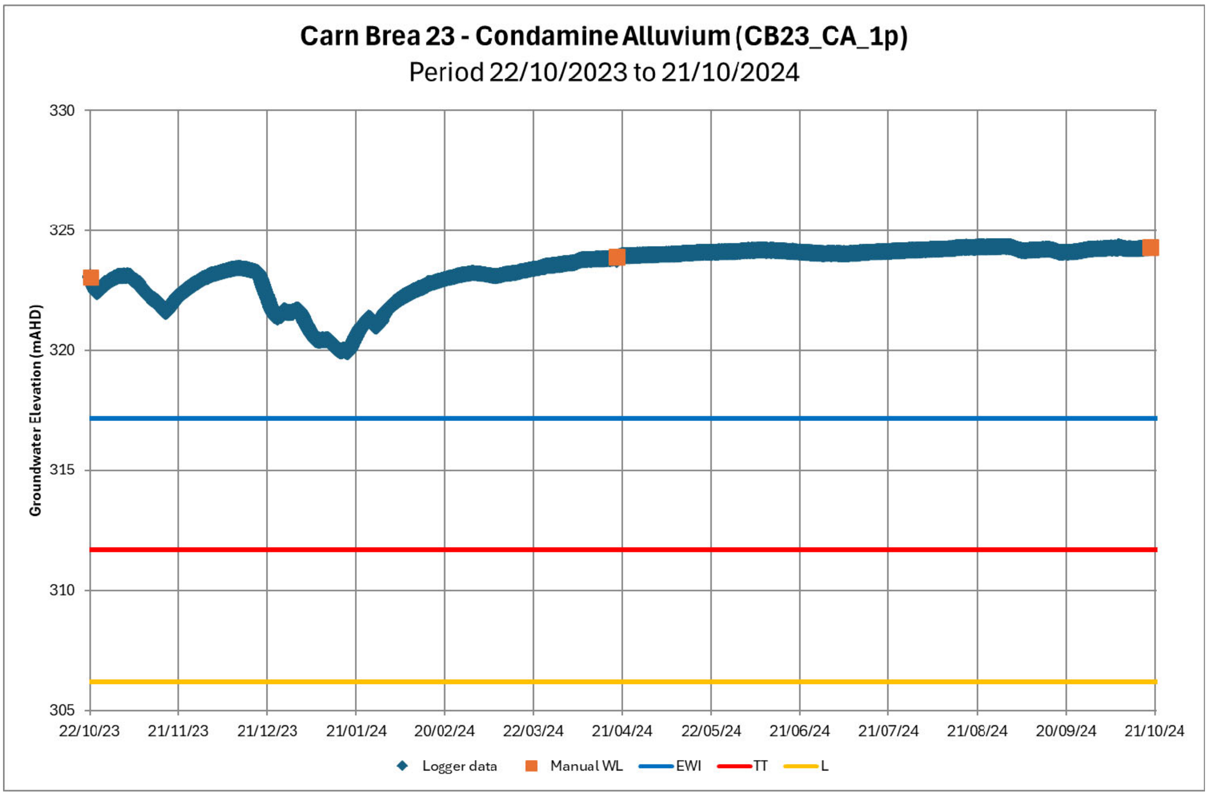
Early Warning Management System Hydrographs



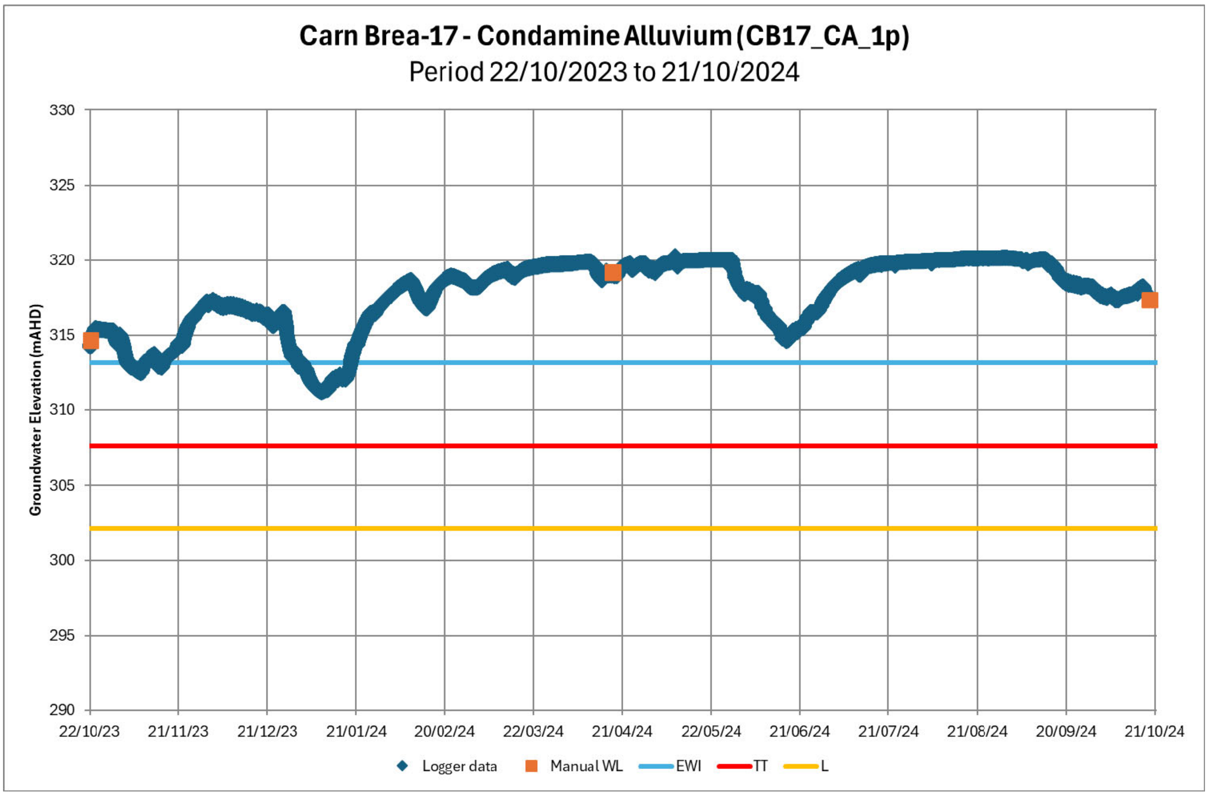



42231370 - Condamine Alluvium (42231370_CA_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
330
325
320
315
310
305
300
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
Manual WL
EWI
TT
L

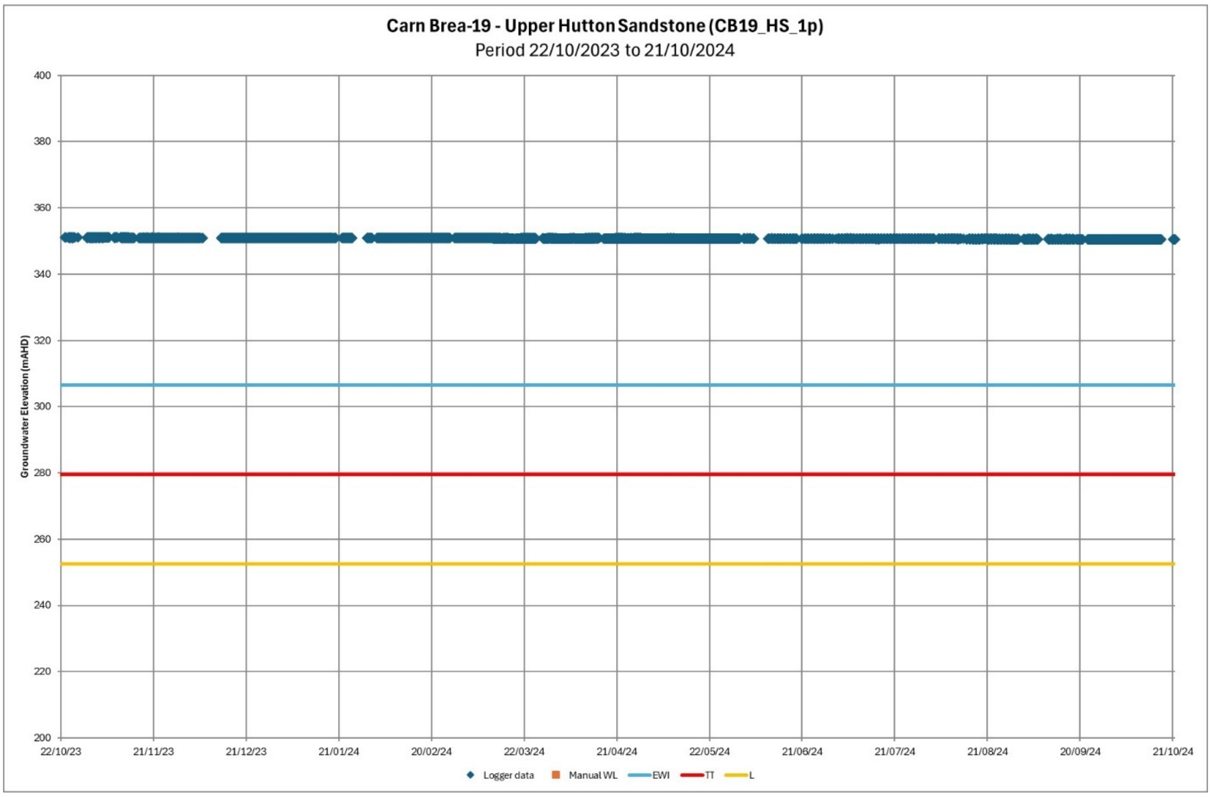

42231463 - Condamine Alluvium (42231463_CA_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
325
320
315
310
305
300
295
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
Manual WL
EWI
TT
L

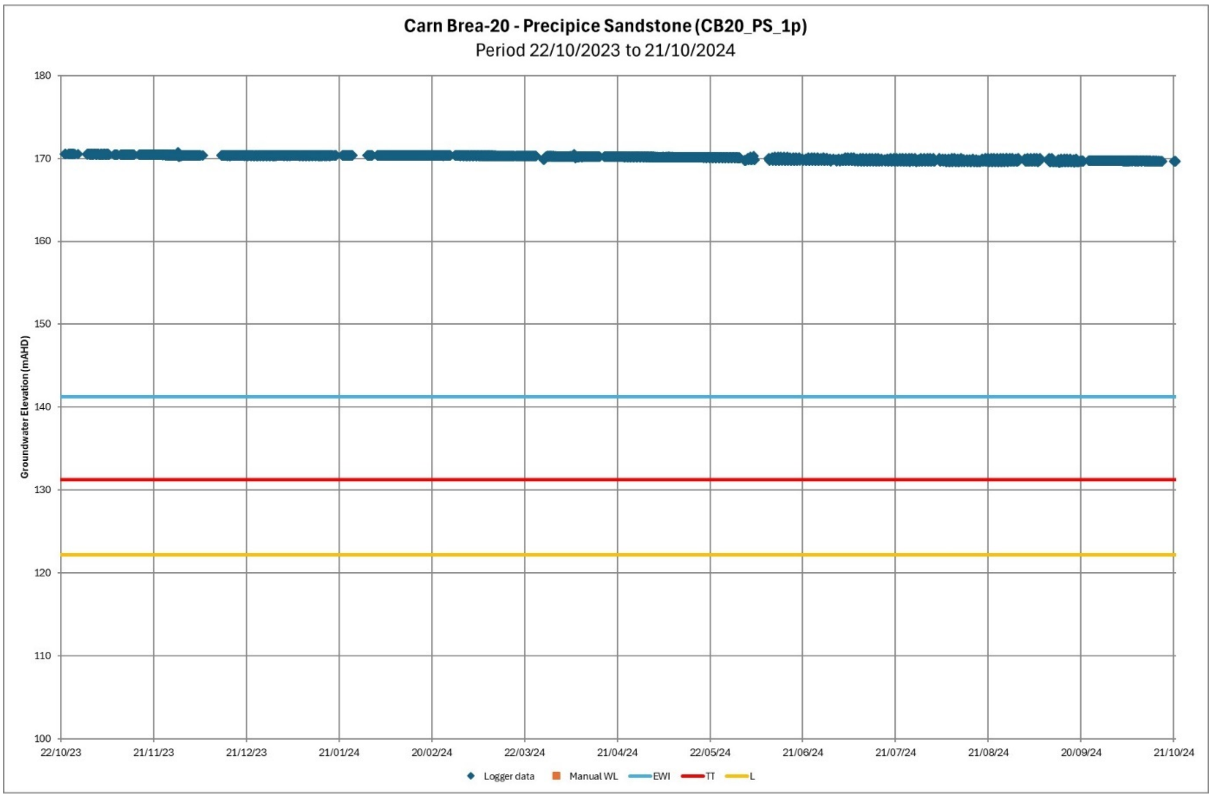


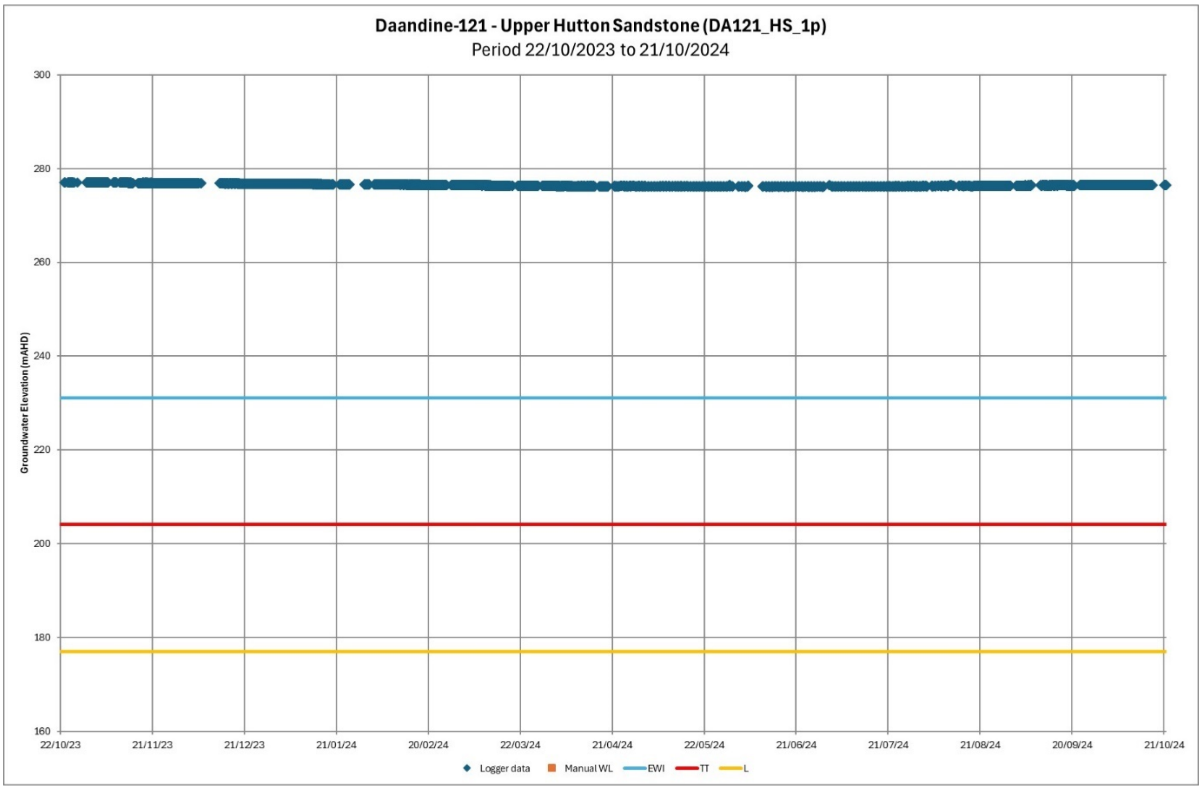
Carn Brea 23 - Condamine Alluvium (CB23_CA_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
330
325
320
315
310
305
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
Manual WL
EWI
TT
L

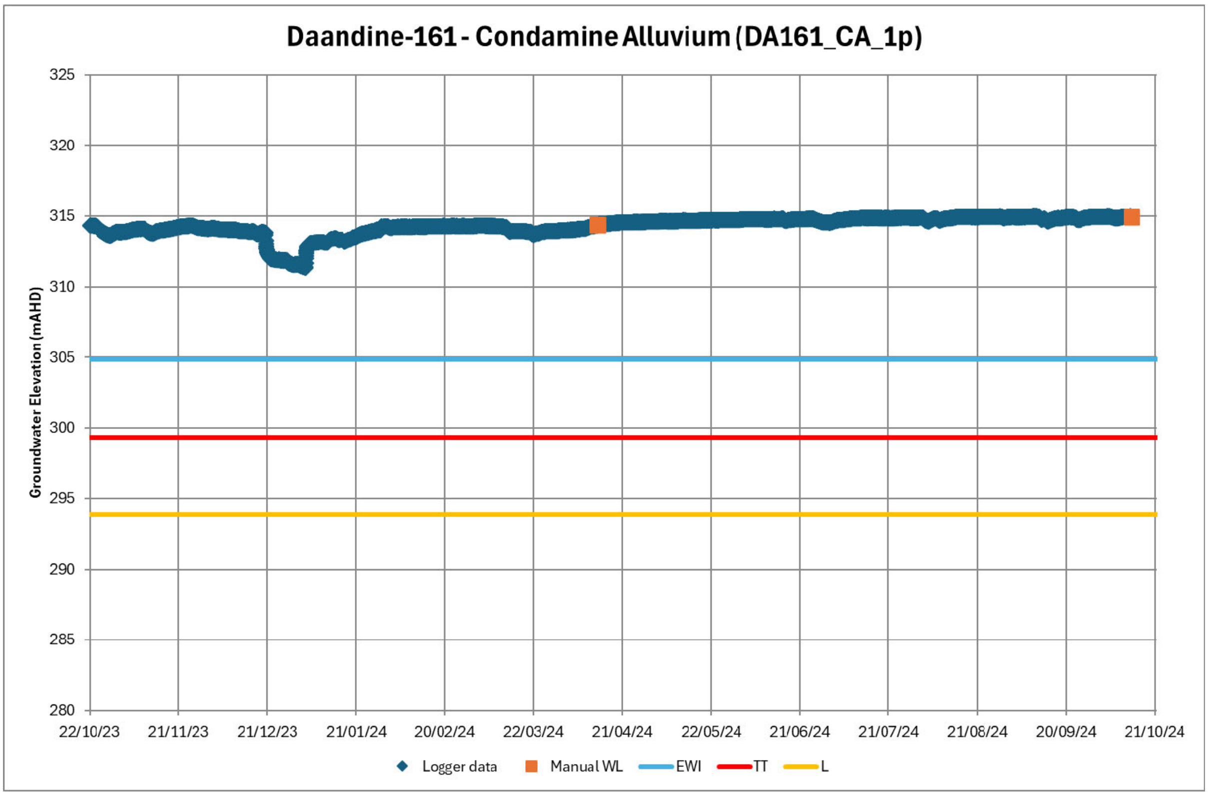


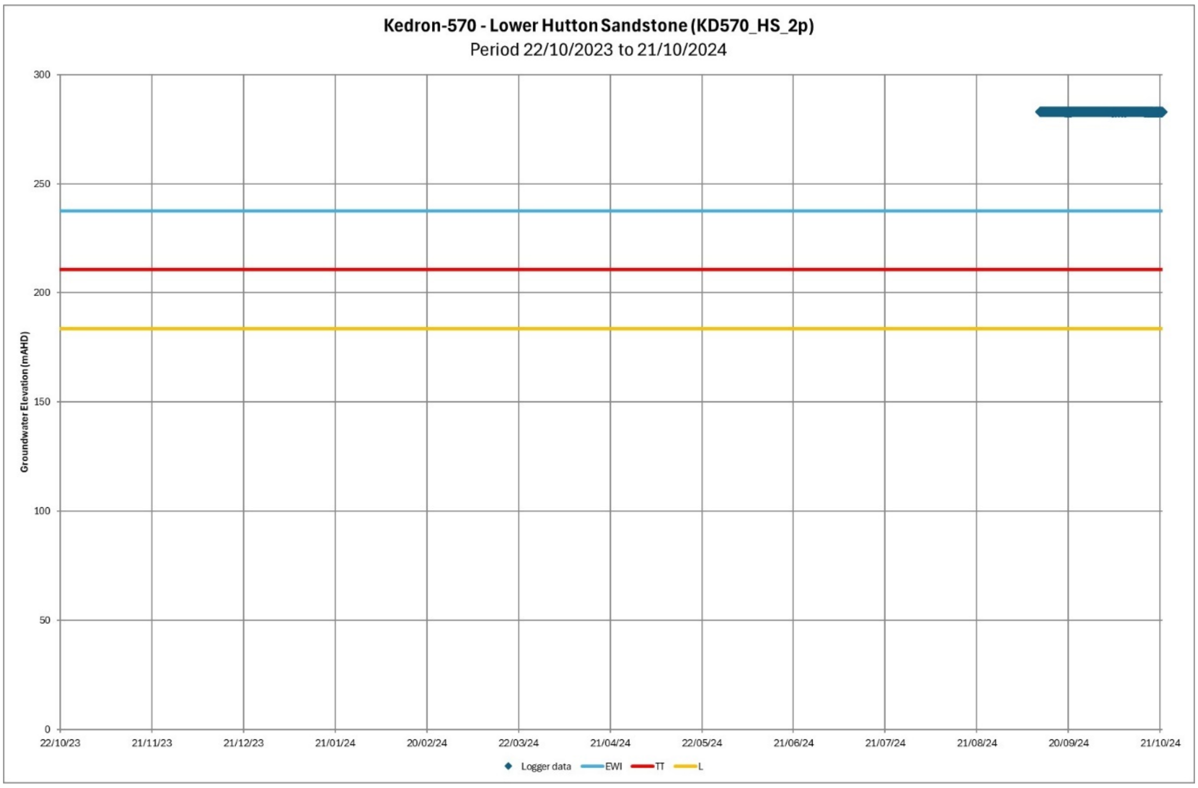
Carn Brea-17 - Condamine Alluvium (CB17_CA_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
330
325
320
315
310
305
300
295
290
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
Manual WL
EWI
TT
L

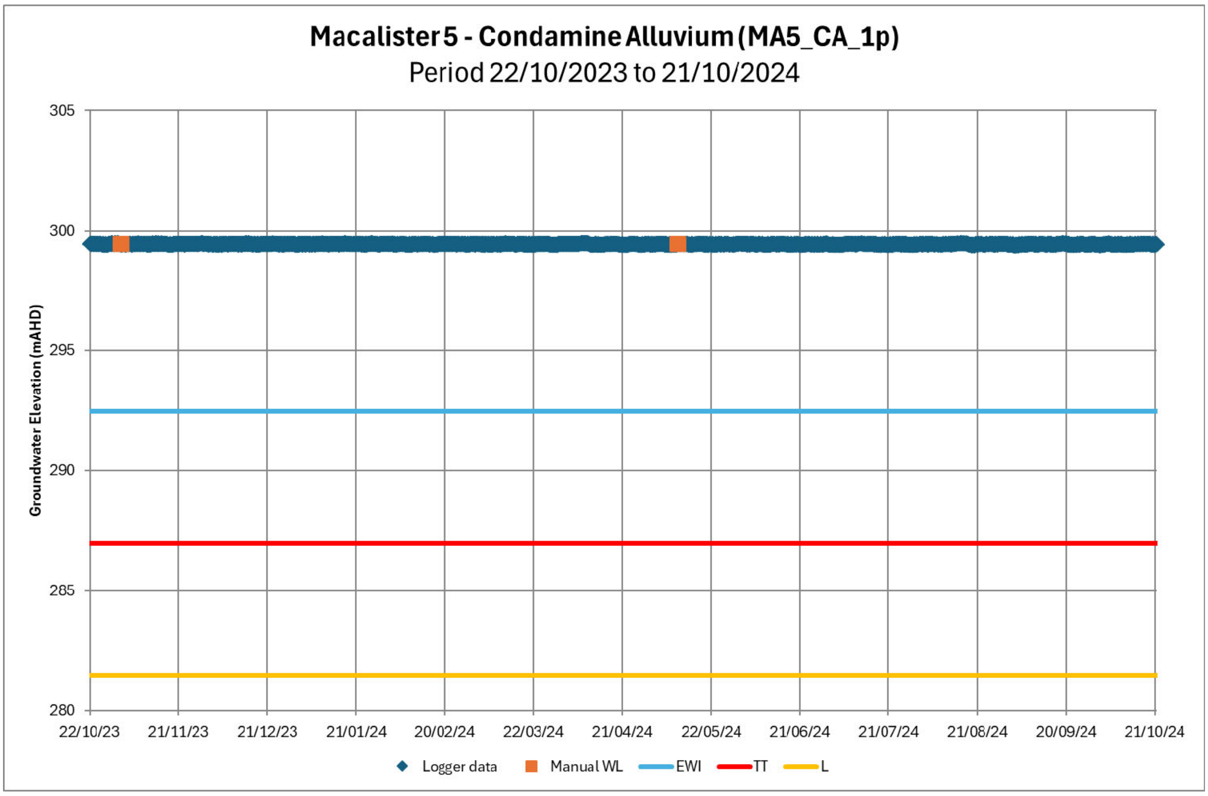

Carn Brea-19 - Upper Hutton Sandstone (CB19_HS_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
400
380
360
340
320
300
280
260
240
220
200
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
Manual WL
EWI
TT
L

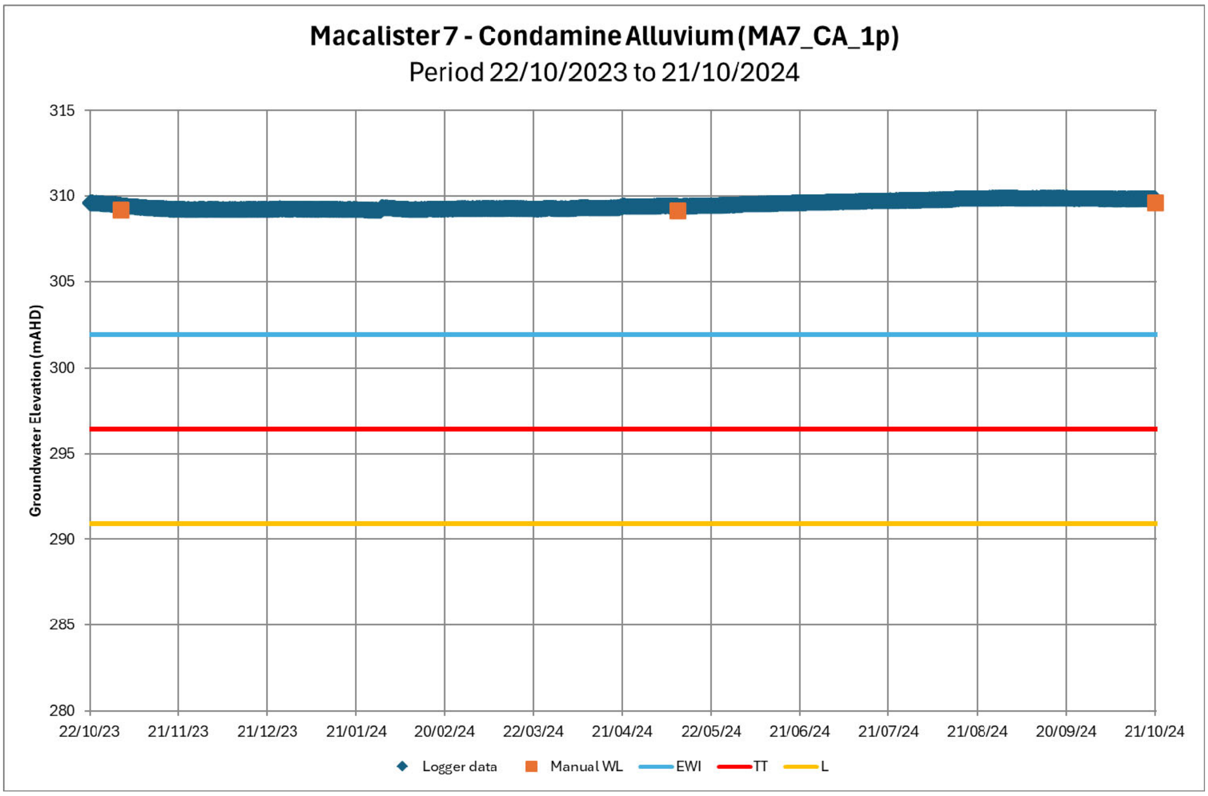

Carn Brea-20 - Precipice Sandstone (CB20_PS_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
180
170
160
150
140
130
120
110
100
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
Manual WL
EWI
TT
L

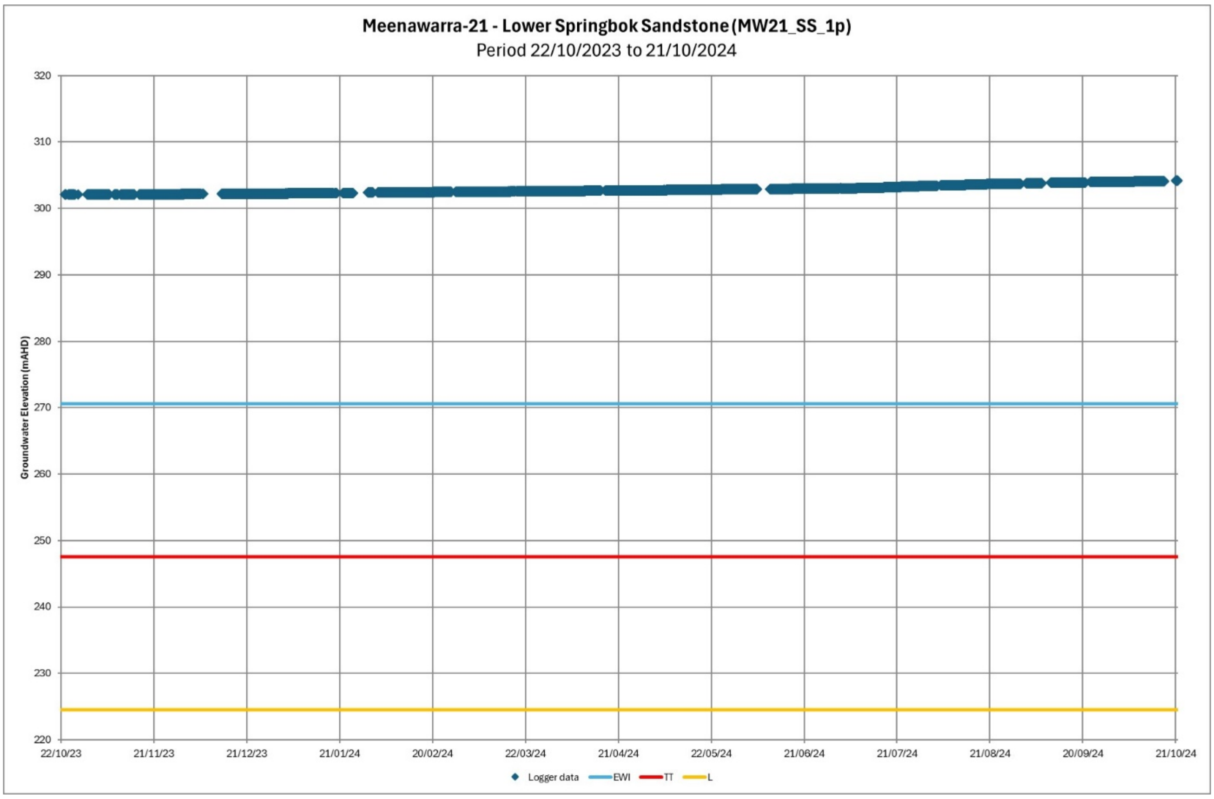

Daandine-121 - Upper Hutton Sandstone (DA121_HS_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
300
280
260
240
220
200
180
160
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
Manual WL
EWI
TT
L

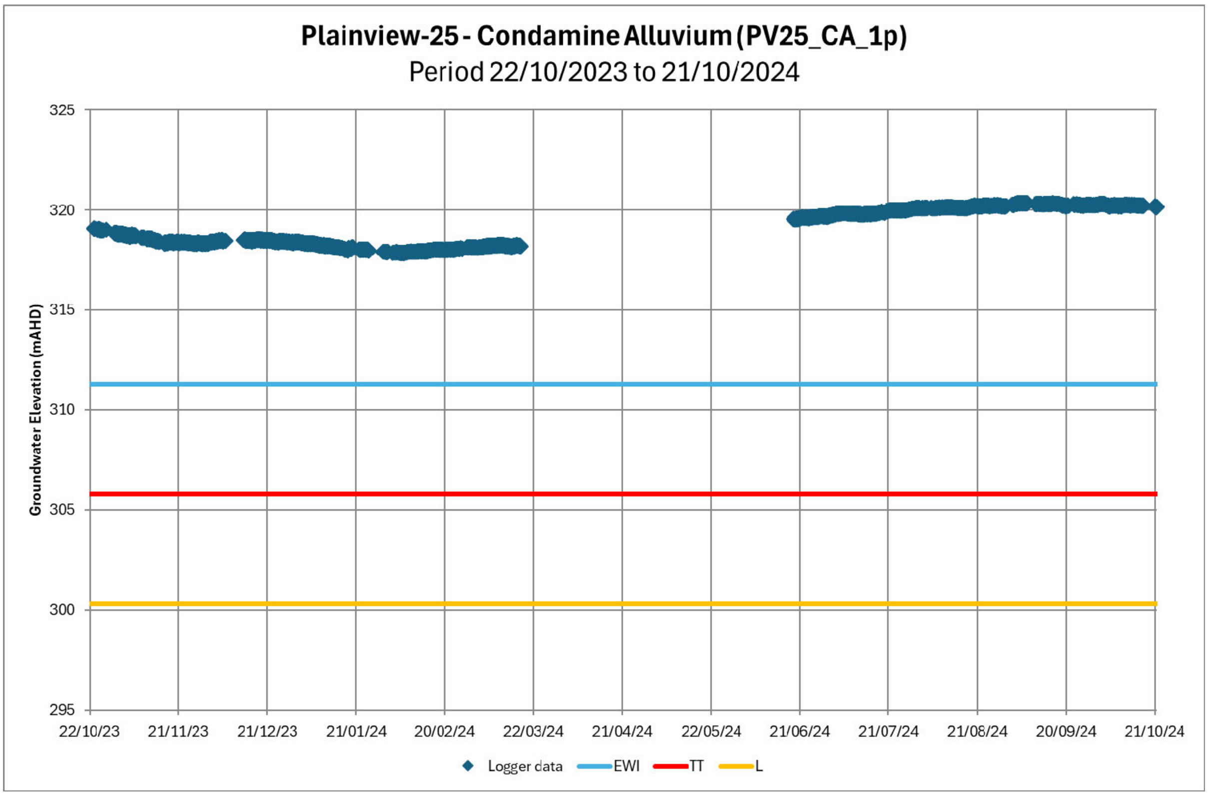

Daandine-161 - Condamine Alluvium (DA161_CA_1p)
Groundwater Elevation (mAHD)
325
320
315
310
305
300
295
290
285
280
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
Manual WL
EWI
TT
L

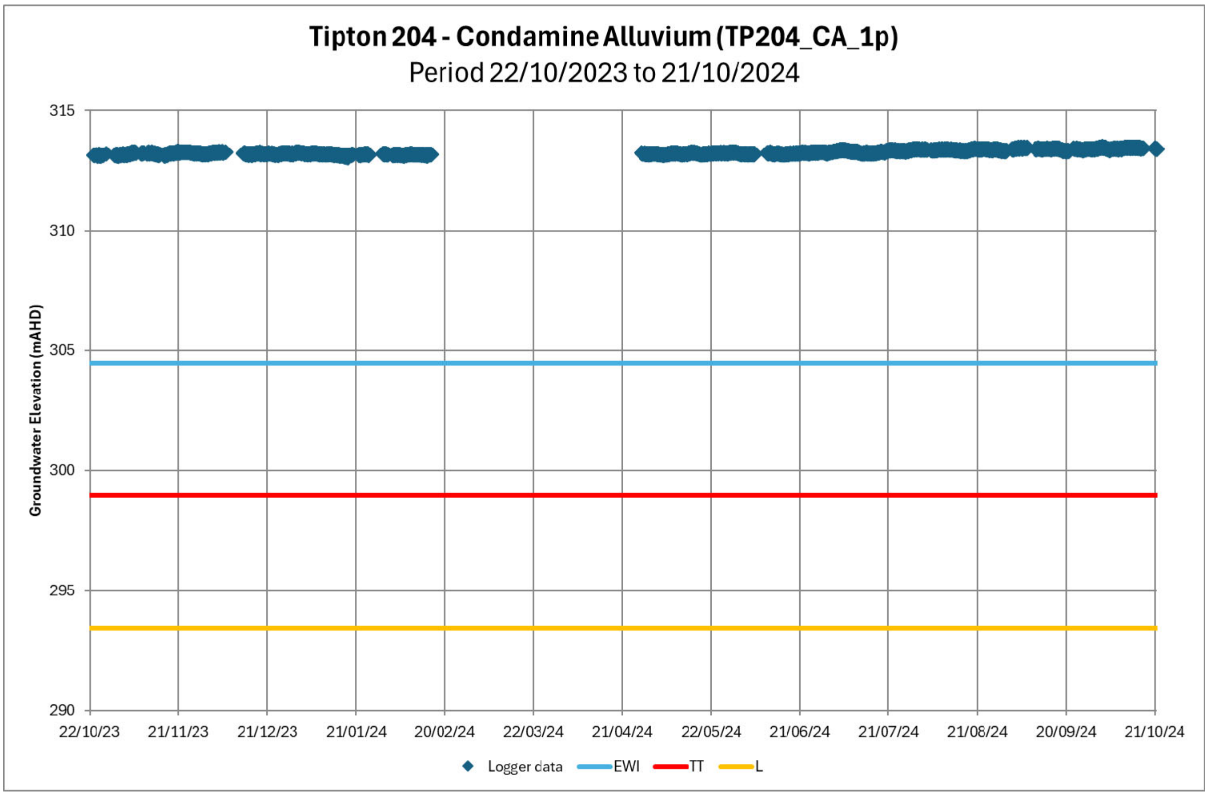

Kedron-570 - Lower Hutton Sandstone (KD570_HS_2p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
300
250
200
150
100
50
0
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
EWI
TT
L

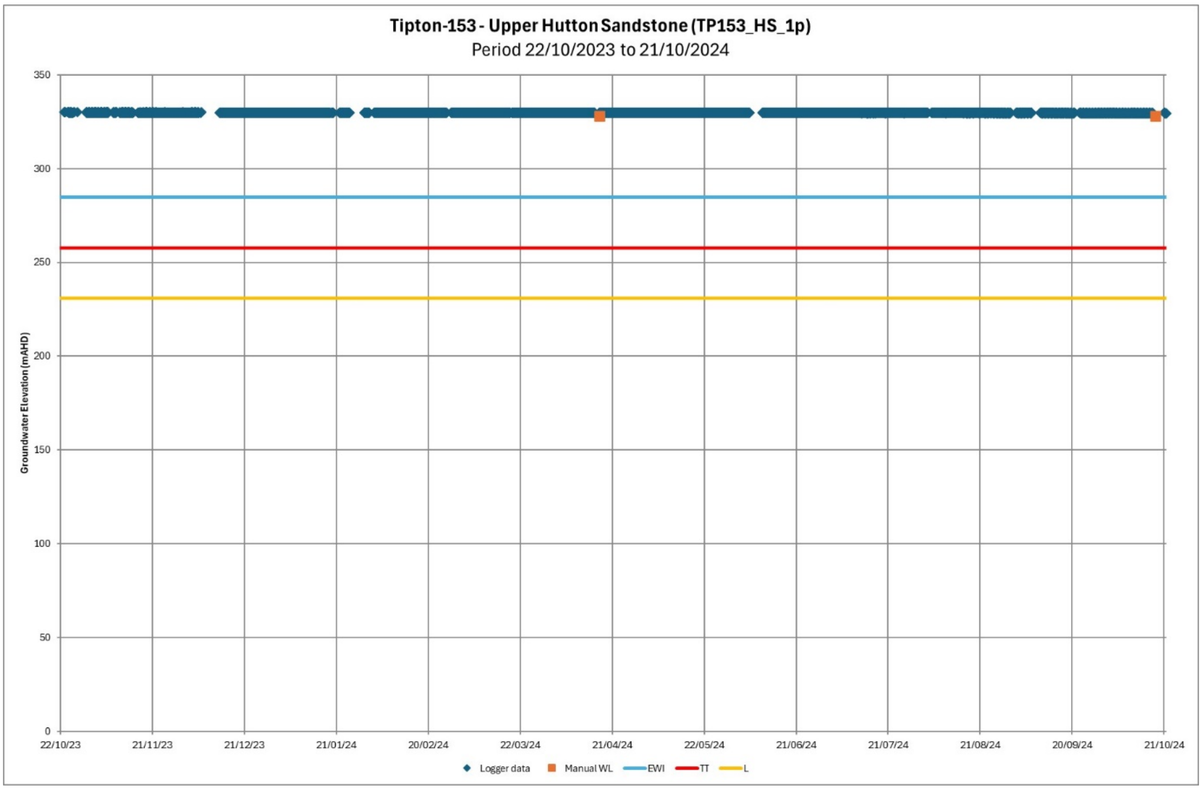

Macalister 5 - Condamine Alluvium (MA5_CA_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
305
300
295
290
285
280
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
Manual WL
EWI
TT
L

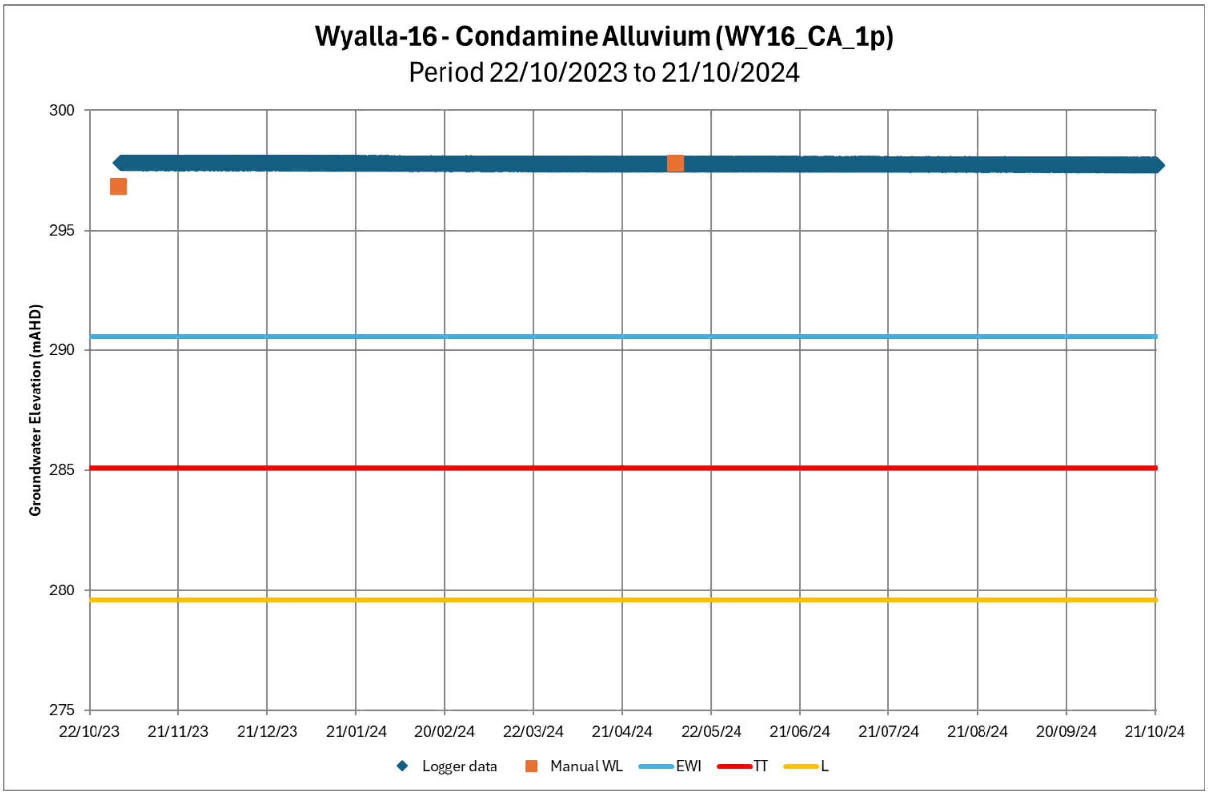

Macalister 7 - Condamine Alluvium (MA7_CA_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
315
310
305
300
295
290
285
280
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
Manual WL
EWI
TT
L

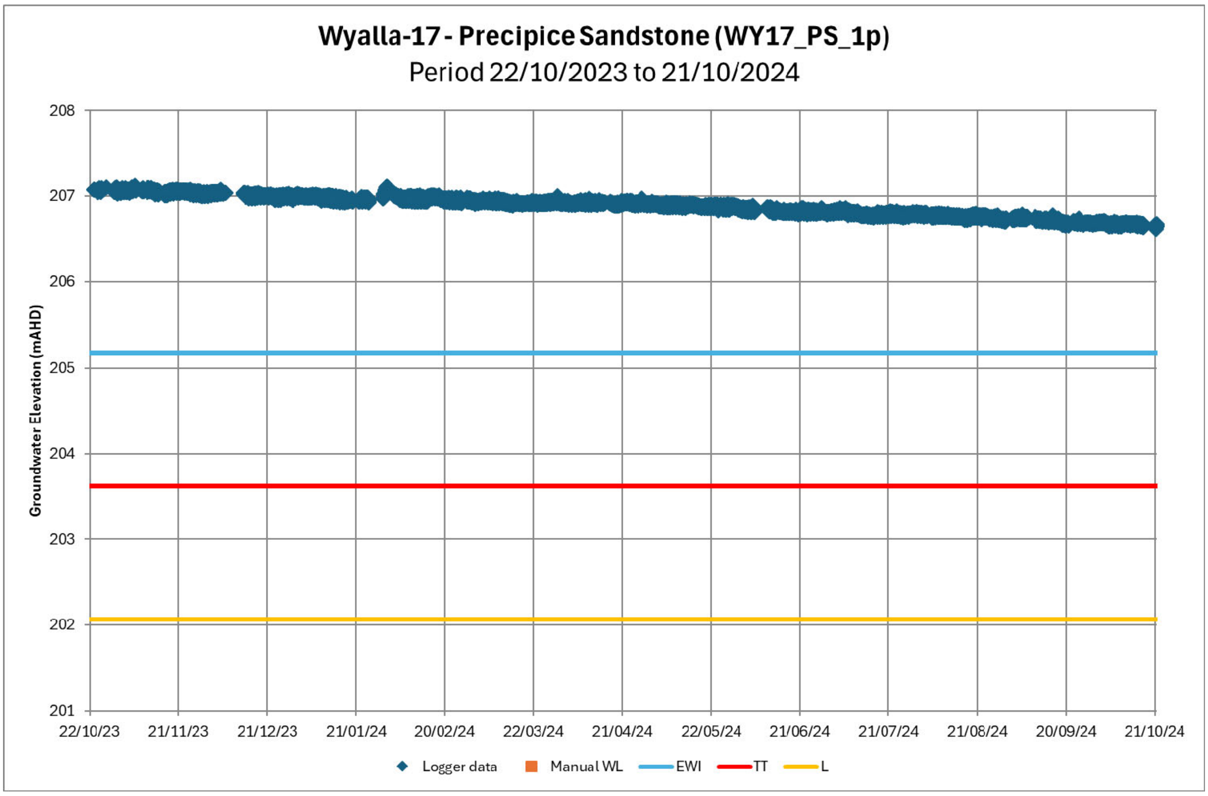

Meenawarra-21 - Lower Springbok Sandstone (MW21_SS_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
320
310
300
290
280
270
260
250
240
230
220
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
EWI
TT
L


Plainview-25 - Condamine Alluvium (PV25_CA_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
325
320
315
310
305
300
295
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
EWI
TT
L


Tipton 204 - Condamine Alluvium (TP204_CA_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
315
310
305
300
295
290
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
EWI
TT
L


Tipton-153 - Upper Hutton Sandstone (TP153_HS_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
350
300
250
200
150
100
50
0
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
Manual WL
EWI
TT
L


Wyalla-16 - Condamine Alluvium (WY16_CA_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
300
295
290
285
280
275
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
Manual WL
EWI
TT
L


Wyalla-17 - Precipice Sandstone (WY17_PS_1p)
Period 22/10/2023 to 21/10/2024
Groundwater Elevation (mAHD)
208
207
206
205
204
203
202
201
22/10/23
21/11/23
21/12/23
21/01/24
20/02/24
22/03/24
21/04/24
22/05/24
21/06/24
21/07/24
21/08/24
20/09/24
21/10/24
Logger data
Manual WL
EWI
TT
L

Appendix B – Groundwater quality results

	Water quality guidelines			Plainview 36					Tipton 202					Stratheden-63					All bores				
Parameter	Stock water	Drinking water (ADWG)	Aquatic (ANZG 95%)	Count	Count below LOR	20th	50th	80th	Count	Count below LOR	20th	50th	80th	Count	Count below LOR	20th	50th	80th	Count	Count below LOR	20th	50th	80th
87Sr/86Sr				5	0	0.70407	0.70409	0.70410	4	0	0.70608	0.70656	0.70708	1	0	0.70481	0.70481	0.70481	9	0	0.70409	0.70481	0.70648
Arsenic - Dissolved	0.5	0.01	0.013	6	6	0.001	0.001	0.001	3	3	0.001	0.001	0.001	9	9	0.001	0.001	0.001	16	16	0.001	0.001	0.001
Barium - Dissolved		2		6	0	0.127	0.131	0.137	3	0	0.244	0.316	0.346	9	0	0.462	0.540	0.623	16	0	0.165	0.404	0.579
Bicarbonate Alkalinity as CaCO3			165-283-677	6	0	411	424	448	4	4	0.6	1	1	9	1	15	46	63.6	19	5	1	60	415.4
Boron - Dissolved	5	4	0.94	6	0	0.15	0.16	0.17	3	2	0.1	0.05	0.1	9	0	0.10	0.13	0.18	16	2	0.1	0.15	0.18
Cadmium - Dissolved	0.01	0.002	0.0002	6	6	0.0001	0.0001	0.0001	3	3	0.0001	0.0001	0.0001	9	9	0.0001	0.0001	0.0001	16	16	0.0001	0.0001	0.0001
Calcium - Dissolved			2-20-86	6	0	10	10.5	12	3	0	180.6	291	397.8	9	0	42	66	119	18	0	11.4	49.5	141.8
Carbonate Alkalinity as CaCO3				6	1	22	25.5	28	4	0	52	61	104	9	4	1	5	13.2	19	5	1	22	48
Chloride		5	186-737-2939	6	0	185	194	199	4	0	358.2	428	488	9	0	1,072	1,170	1,420	19	0	197.4	500	1210
Chromium - Dissolved	1	0.05	0.001	6	6	0.001	0.001	0.001	3	0	0.021	0.029	0.06	9	9	0.001	0.001	0.001	16	13	0.001	0.001	0.001
Cobalt - Dissolved	1			6	6	0.001	0.001	0.001	3	3	0.001	0.001	0.001	9	9	0.001	0.001	0.001	16	16	0.001	0.001	0.001
Copper - Dissolved	0.4 to 5	1	0.0014	6	3	0.001	0.001	0.001	3	2	0.001	0.001	0.001	9	9	0.001	0.001	0.001	16	13	0.001	0.001	0.001
Fluoride	2	1.5		6	0	0.2	0.3	0.3	3	0	0.5	0.6	0.7	9	0	0.2	0.2	0.2	18	0	0.2	0.25	0.3
Iron - Dissolved		0.3		6	3	0.05	0.06	0.15	3	3	0.05	0.05	0.05	9	9	0.05	0.05	0.05	16	13	0.05	0.05	0.05
Lead - Dissolved	0.1	0.01	0.0034	6	6	0.001	0.001	0.001	3	3	0.001	0.001	0.001	9	9	0.001	0.001	0.001	16	16	0.001	0.001	0.001
Magnesium - Dissolved			2-8-82	6	0	4	4	4	3	3	1	1	1	9	1	7	9	12	18	4	2.2	4	10.2
Manganese - Dissolved		0.1	1.9	6	0	0.051	0.058	0.066	3	3	0.001	0.001	0.001	9	1	0.002	0.005	0.0094	16	4	0.001	0.005	0.051
Mercury - Dissolved	0.002	0.001	0.0006	6	6	0.0001	0.0001	0.0001	3	3	0.0001	0.0001	0.0001	9	9	0.0001	0.0001	0.0001	16	16	0.0001	0.0001	0.0001
Methane				6	0	2090	2630	3530	4	0	3368	5660	8702	8	0	8538	11600	16800	16	0	2240	8275	12800
Nickel - Dissolved	1	0.02	0.011	6	1	0.002	0.0025	0.005	3	3	0.001	0.001	0.001	9	6	0.001	0.001	0.0014	16	9	0.001	0.001	0.002
Potassium - Dissolved				6	0	4	4	4	3	0	7	9	14	9	0	5	6	7	18	0	4	5.5	7
Selenium - Dissolved	0.02	0.01	0.011	6	6	0.01	0.01	0.01	3	3	0.01	0.01	0.01	9	9	0.01	0.01	0.01	16	16	0.01	0.01	0.01
Sodium - Dissolved		180	246-677-1821	6	0	294	298.5	316	3	0	325.2	336	340	9	0	669	712	729	18	0	306.4	487	718
Strontium - Dissolved				6	0	0.37	0.37	0.41	3	0	0.99	1.35	1.87	9	0	1.37	1.79	2.83	16	0	0.45	1.37	2.22
Sulfate as SO4 - Turbidimetric - Dissolved		250	1-8-47	6	5	1	1	1	3	0	2	3	3.6	9	0	10	21	27	18	5	1	6	21.6
Total Alkalinity as CaCO3			195-309-790	6	0	435	446	454	4	0	173.8	393	1008	9	0	18	62	77	19	0	55.6	157	450.4
Total Dissolved Solids @180°C	2000 to 5000	600		6	0	727	754	801	4	0	1060	1290	1814	9	0	1968	2210	2692	17	0	842.6	1950	2386
Zinc - Dissolved	20	3	0.008	6	0	0.019	0.033	0.080	3	2	0.005	0.005	0.007	9	9	0.005	0.005	0.005	16	11	0.005	0.005	0.019

Note the ADWG adopted is generally for health, in instances where aesthetic or recreational values are lower, these are shown. Irrigation values show a range in some instances representing the long-term and short-term criteria. Where there are multiple values in the aquatic ecosystem column, this represents the 20th percentile – 50th percentile-80th percentile values.

Original Chemical Name	Sample_Id	analysis_date	result_value	result_unit	detection_limit	technical_reference
FIELD DISS OX	Tipton-202 08/05/2024	8/05/2024	0.600000024	%		Field Measurement
FIELD EC	Tipton-202 08/05/2024	8/05/2024	2093	us/cm		Field Measurement
FIELD pH	Tipton-202 08/05/2024	8/05/2024	11.36999989			Field Measurement
FIELD REDOX	Tipton-202 08/05/2024	8/05/2024	-236.899994	mv		Field Measurement
FIELD TEMP	Tipton-202 08/05/2024	8/05/2024	22.20000076	degree		Field Measurement
87Sr/86Sr	Tipton-202 08/05/2024	8/05/2024	0.705984		0.01	Sr_ISOTOPE: Ratio of 87Sr and 86Sr analysis
Arsenic - Dissolved	Tipton-202 08/05/2024	8/05/2024	<0.001	mg/L	0.001	EG020A-F: Dissolved Metals by ICP-MS - Suite A
Barium - Dissolved	Tipton-202 08/05/2024	8/05/2024	0.027	mg/L	0.001	EG020A-F: Dissolved Metals by ICP-MS - Suite A
Bicarbonate Alkalinity as CaCO3	Tipton-202 08/05/2024	8/05/2024	<1	mg/L	1	ED037-P: Alkalinity by Auto Titrator
Boron - Dissolved	Tipton-202 08/05/2024	8/05/2024	0.13	mg/L	0.05	EG020A-F: Dissolved Metals by ICP-MS - Suite A
Butane	Tipton-202 08/05/2024	8/05/2024	<10	µg/L	10	EP033: C1 - C4 Gases
Butene	Tipton-202 08/05/2024	8/05/2024	<10	µg/L	10	EP033: C1 - C4 Gases
Cadmium - Dissolved	Tipton-202 08/05/2024	8/05/2024	<0.0001	mg/L	0.0001	EG020A-F: Dissolved Metals by ICP-MS - Suite A
Calcium - Dissolved	Tipton-202 08/05/2024	8/05/2024	6	mg/L	1	ED093F: Major Cations - Dissolved
Carbonate Alkalinity as CaCO3	Tipton-202 08/05/2024	8/05/2024	158		1	ED037-P: Alkalinity by Auto Titrator
Chloride	Tipton-202 08/05/2024	8/05/2024	500	mg/L	1	ED045G: Chloride by Discrete Analyser
Chromium - Dissolved	Tipton-202 08/05/2024	8/05/2024	<0.001	mg/L	0.001	EG020A-F: Dissolved Metals by ICP-MS - Suite A
Cobalt - Dissolved	Tipton-202 08/05/2024	8/05/2024	<0.001	mg/L	0.001	EG020A-F: Dissolved Metals by ICP-MS - Suite A
Copper - Dissolved	Tipton-202 08/05/2024	8/05/2024	<0.001	mg/L	0.001	EG020A-F: Dissolved Metals by ICP-MS - Suite A
Ethane	Tipton-202 08/05/2024	8/05/2024	<10	µg/L	10	EP033: C1 - C4 Gases
Ethene	Tipton-202 08/05/2024	8/05/2024	<10	µg/L	10	EP033: C1 - C4 Gases
Fluoride	Tipton-202 08/05/2024	8/05/2024	0.4	mg/L	0.1	EK040P: Fluoride by Auto Titrator
Hydroxide Alkalinity as CaCO3	Tipton-202 08/05/2024	8/05/2024	27	mg/L	1	ED037-P: Alkalinity by Auto Titrator
Ionic Balance	Tipton-202 08/05/2024	8/05/2024	5.66	%	0.01	EN055 - PG: Ionic Balance by PCT DA and Turbi SO4 DA
Iron - Dissolved	Tipton-202 08/05/2024	8/05/2024	<0.05	mg/L	0.05	EG020A-F: Dissolved Metals by ICP-MS - Suite A
Lead - Dissolved	Tipton-202 08/05/2024	8/05/2024	<0.001	mg/L	0.001	EG020A-F: Dissolved Metals by ICP-MS - Suite A
Magnesium - Dissolved	Tipton-202 08/05/2024	8/05/2024	<1	mg/L	1	ED093F: Major Cations - Dissolved
Manganese - Dissolved	Tipton-202 08/05/2024	8/05/2024	0.001	mg/L	0.001	EG020A-F: Dissolved Metals by ICP-MS - Suite A
Mercury - Dissolved	Tipton-202 08/05/2024	8/05/2024	<0.0001	mg/L	0.0001	EG035F: Dissolved Mercury by FIMS
Methane	Tipton-202 08/05/2024	8/05/2024	5350	µg/L	10	EP033: C1 - C4 Gases
Nickel - Dissolved	Tipton-202 08/05/2024	8/05/2024	<0.001	mg/L	0.001	EG020A-F: Dissolved Metals by ICP-MS - Suite A
Potassium - Dissolved	Tipton-202 08/05/2024	8/05/2024	4	mg/L	1	ED093F: Major Cations - Dissolved
Propane	Tipton-202 08/05/2024	8/05/2024	<10	µg/L	10	EP033: C1 - C4 Gases
Propene	Tipton-202 08/05/2024	8/05/2024	<10	µg/L	10	EP033: C1 - C4 Gases
Selenium - Dissolved	Tipton-202 08/05/2024	8/05/2024	<0.01	mg/L	0.01	EG020A-F: Dissolved Metals by ICP-MS - Suite A
Sodium - Dissolved	Tipton-202 08/05/2024	8/05/2024	357	mg/L	1	ED093F: Major Cations - Dissolved
Strontium - Dissolved	Tipton-202 08/05/2024	8/05/2024	0.128	mg/L	0.001	EG020B-F: Dissolved Metals by ICP-MS - Suite B
Sulfate as SO4 - Turbidimetric - Dissolved	Tipton-202 08/05/2024	8/05/2024	2	mg/L	1	ED041G: Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser
Total Alkalinity as CaCO3	Tipton-202 08/05/2024	8/05/2024	185	mg/L	1	ED037-P: Alkalinity by Auto Titrator
Total Anions	Tipton-202 08/05/2024	8/05/2024	17.8	meq/L	0.01	EN055 - PG: Ionic Balance by PCT DA and Turbi SO4 DA
Total Cations	Tipton-202 08/05/2024	8/05/2024	15.9	meq/L	0.01	EN055 - PG: Ionic Balance by PCT DA and Turbi SO4 DA
Total Dissolved Solids @180°C	Tipton-202 08/05/2024	8/05/2024	985	mg/L	10	EA015H: Total Dissolved Solids (High Level)
Zinc - Dissolved	Tipton-202 08/05/2024	8/05/2024	0.012	mg/L	0.005	EG020A-F: Dissolved Metals by ICP-MS - Suite A

Appendix C – Field assessment of potential TGDEs related to the SGP WMMP using the 2019 UWIR

FILE NOTE

FROM:	Arrow Energy	REF:	
SUBJECT:	Summary of field verification of Wilkie Creek and Juandah Creek potential terrestrial groundwater dependent ecosystems sites as identified in Updated WMMP desktop assessment		

The purpose of this File Note is to provide a summary of the field assessment undertaken at the two sites identified as potential terrestrial groundwater dependent ecosystems (TGDE) potentially at impact from the Action.

1. Juandah Creek, is located 10 km southeast of Wandoan on PL494 and the potential TGDE is predominantly associated with riparian vegetation flanking a defined reach of Juandah Creek.

2. Wilkie Creek is located 28 km northwest of Dalby on PL194 and PL230 and the potential TGDE is predominantly associated with riparian vegetation flanking

These two sites were identified through the desktop assessment undertaken by Arrow Energy based on the 2019 Underground Water Impact Report (UWIR) and documented in the File Note presented in the 2022 Updated Water Monitoring and Management Plan (WMMP) Annual Report (available at arrowenergy.com.au).

Juandah Creek

An ecological and hydrogeological field survey of the Wilkie Creek mapped TGDE was undertaken over a 2-day period (11 – 13th October 2021). The assessment coincided with a rainfall event in the region with 35.2mm falling at Miles (60km to the south) on the 12th and 13th October, although no rainfall was received at the study site. In total, four targeted sites were assessed during the field assessment.

Field assessment methods

Assessment of the Juandah Creek site comprised a desktop assessment followed by a field assessment which included:

- Descriptions of creek hydrology, geomorphology and ecology;
- Measurements of Leaf Area Index (LAI) using an automated canopy imaging camera (C110 Plant Canopy Imager);
- Pre-dawn leaf water potential (LWP) measurements from mature Forest Red Gum (Eucalyptus tereticornis) using a Scholander LWP Meter;
- Surface water sample collection for measurement of field water quality parameters and laboratory analysis of a standard water quality suite and ^{222}radon;
- Advancement of hand auger holes within alluvium within and on the levees of Juandah Creek using an AMS hand auger, aiming to intersect the groundwater table, or until indurated sedimentary basement rock was intersected;
- Description of the geological profile encountered;
- Collection of groundwater samples from hand auger bores for measurement of field water quality parameters; and

- Collection and analysis of soil, leaf water, surface water and groundwater from hand augers for analysis of stable isotopes of oxygen and deuterium.

Eco-hydrogeological conceptual site model

The reach of Juandah Creek mapped as a potential TGDE has been categorised as a mid-catchment alluvial system. Quaternary alluvial deposits of primarily sand with some clay extend along the Juandah Creek study area, with maximum cross-sectional width of 500 metres and anticipated maximum depths of less than 15 metres, but generally <5m.

Juandah creek traverses and shallowly incises the regionally south-westerly dipping Great Artesian Basin (GAB) sequence, including the Walloon Coal Measures (WCM) at the far northern end of the mapped TDGE, Springbok Sandstone in the central to northern section of the TGDE and Westbourne Formation at the southernmost end of the TDGE.

Available data indicates the basal alluvial system forms a predominantly continuously saturated system (below ground level), likely recharged primarily from rainfall directly infiltrating the alluvium in addition to surface water run off / stream flow.

Regional groundwater pressure monitoring in the upper WCM members (Macalister) across the northern half of the mapped TGDE show that the groundwater pressures are near-surface, respond positively to rainfall recharge events and are therefore likely to locally comprise recharge intake beds during periods of prolonged and above-average rainfall. It is possible that during low rainfall, drying periods, relatively high pressures within the upper WCM may provide an ongoing source of moisture to the alluvium and deeper-rooted vegetation that may extend to the basal alluvium and into the upper WCM. Further assessment during a prolonged dry period would be required to fully test this hypothesis. It however cannot be discounted given heavy rainfall in the months prior to the assessment, which could have resulted in dilution of the geochemical signature of bedrock aquifers at the base of the alluvium.

Shallow groundwater levels of <10 mbGL in the WCM across the northern half of the mapped TDGE (if present) would, in theory, provide a direct water source for vegetation where the WCM sequence outcrops or the shallow alluvium is unsaturated. The salinity of any groundwater leakage into the rooting zone of riparian vegetation may however limit its capacity to stimulate vegetative growth or productivity.

Three eco-hydrogeological conceptualisations of the Juandah Creek site were developed based on the available data and are summarised here:

1. Dry season: this conceptualisation indicates a dry season scenario whereby groundwater perched in the channel sands is being utilised by riparian vegetation along the margins of the drainage. In this scenario, while the potentiometric surface of the bedrock aquifers intrudes into (or above) the base level of the alluvium, there is no leakage due to the tightness of the sandstone bedrock and lack of fracturing. Perched groundwater in the alluvium and GAB aquifers are vertically isolated by a low permeability GAB regolith interburden, and do not mix. Vegetation moisture sources are being supplied by the perched aquifer and soil moisture alone.

2. Dry season with vertical upward leakage: Provides a variation on the dry season conceptualisation, where upward leakage of bedrock aquifers is occurring into the base of the alluvium in the dry season, which is acting to support floodplain vegetation where other sources of moisture have been depleted. The capacity of this leakage to stimulate vegetation growth and vigour is dependent to a degree on the groundwater salinity of the leaking aquifers. It is not possible to predict the

extent to which this is occurring without more detailed assessment during a drier climatic period. It is however conceptualised to be restricted to discrete areas and pockets where the function is supported by underlying geology, rather than occurring more extensively across the landscape.

3. Post-flooding / Wet season: a post-flooding / wet season conceptualisation where the perched aquifer at the base of the Juandah Creek floodplain alluvium has been replenished by seasonal rainfall and / or overbank flow. Any leakage of GAB aquifers into the base of the alluvium would be diluted by the perched groundwater table, making it difficult to differentiate based on groundwater geochemistry.

Any response of riparian vegetation to CSG extraction would be variable and difficult to predict, depending on a number of factors including:

- The extent of bedrock aquifer leakage into the alluvium, including leakage volumes and wetted area;
- Salinity of GAB aquifer leakage; and
- Climatic factors including periods of extended drought and rainfall recharge.

River red gum, and its closely allied species forest red gum (Eucalyptus tereticornis which is the dominant species is the assessment area) is an adaptable species that is adapted to arid and semi-arid environments and will go through alternate phases of shedding and regaining its crown, depending on the availability of water. It is adapted to do so over time and across the flood frequency classes. River red gum have the capacity to self-regulate and adjust their transpiration rates to match the average flood return interval (Colloff 2014). The species is considered opportunistic in its water use, sourcing water according to osmotic and matric water potential and source reliability (Thorburn et al., 1993; Mensforth et al., 1994; Holland et al., 2006; Doody et al., 2009) with the water requirements obtained from three main sources being groundwater, rainfall, and river flooding. Doody et al. (2015) demonstrated that soil moisture alone can sustain the health of Eucalyptus camaldulensis through periods of drought for up to six years before significant decline in tree health is noted. With these ecological considerations, and based on the conceptualisations above, impacts on riparian vegetation are likely to be discrete and difficult to detect above current base levels of tree senescence caused by long-term drought alone.

Conclusions

It is considered highly likely that vegetation within the identified reach of Juandah Creek is dependent on groundwater within the shallow alluvium. The field assessment was undertaken during a relatively wet period and there was no information gathered during the survey that supported the hypothesis that trees were sourcing groundwater from deeper GAB aquifers at the time of the assessment. Most lines of evidence supported that the deeper-rooted trees assessed were utilising relatively fresh and isotopically enriched groundwater from the basal alluvium.

Hypotheses are provided for GDE water requirements as well as likely responses to changes in the groundwater regime through an assessment of water sources and pathways within an eco-hydrogeological conceptual site model. Such hypotheses need further testing through additional assessment during a prolonged dry period to address critical research gaps and subsequent refinement of the eco-hydrogeological conceptual model.

Wilkie Creek

An ecological and hydrogeological field survey of the Wilkie Creek mapped TGDE was undertaken over a 2.5-day period (13th, 14th and 15th October 2021). The assessment coincided with a rainfall event with 44 mm falling in Dalby on the 14th of October (prior to surface water quality sampling) which introduced some ambiguity into the results of water quality and geochemical sampling. Attempts were made throughout 2022 to return to the area for a follow up survey however the above average rainfall experienced throughout the year inhibited the ability to conduct a survey that would not be influenced by recent rainfall.

Field assessment methods

Assessment of the Wilkie Creek site comprised a desktop assessment followed by a field assessment which included:

- Descriptions of creek hydrology, geomorphology and ecology;
- Measurements of Leaf Area Index (LAI) using an automated canopy imaging camera (C110 Plant Canopy Imager);
- Pre-dawn leaf water potential measurements from mature River Red Gums using a Scholander Leaf Water Potential Meter;
- Surface water sample collection for measurement of field water quality parameters and laboratory analysis of a standard water quality suite and ^{222}radon;
- Advancement of hand auger bores within alluvium on each side of the creek using an AMS hand auger to a depth below the groundwater table (if present), or until the indurated sedimentary basement rock was intersected;
- Description of the geological profile encountered;
- Collection of groundwater samples from hand auger bores for measurement of field water quality parameters and laboratory analysis of a standard water quality suite, ^{222}radon; and
- Collection and analysis of soil, leaf water, surface water and groundwater from hand augers for analysis of stable isotopes of oxygen and deuterium.

Eco-hydrogeological conceptual site model

Lines of evidence drawn from data and observations from both the desktop and field assessments has culminated in the preparation of a preliminary eco-hydrogeological conceptual site model for the potential Wilkie Creek TGDE.

The reach of Wilkie Creek mapped as a potential TGDE forms the western margin of the Condamine River Alluvium (CRA) Quaternary alluvial deposits which thicken eastwards and northwards towards the Condamine River.

There is a strong association with the position and orientation of Wilkie Creek and the underlying geology. Notably, the potential TGDE reach of Wilkie Creek follows the contact between elevated regolith of Jurassic bedrock (and associated colluvial cover sediments) to the west which emerges from lower elevation alluvium of the Wilkie Creek and broader Condamine River Alluvium to the east. The current position of Wilkie Creek is relatively hard-up against the toe of the eastward slope off the bedrock regolith, and therefore follows the bedrock/alluvium geological contact in a south-to-north orientation.

A shallow anticline underlies the north-western elevated portion of the mapped TGDE, with the roughly 25m rise in the topography a subdued expression of the underlying subsurface structure. Here, Wilkie Creek runs parallel on the eastern side of the anticline with is intersected by a series of fault-bounded graben block structures and sub-vertical thrust faults, some of which extend through the full Surat Basin sequence to surface. Vertical throws across a number of the faults is interpreted to be up to 40 metres.

North of the Dalby-Kogan Road, WCM groundwater pressures are likely to be >10 mbGL across most of the study area. However, anomalous elevated groundwater levels (above Wilkie Creek) appear to be present across the elevated plateau west of Wilkie Creek, upon which the Wilkie Creek Coal Mine is located. The presence of numerous sub-vertical faults and "keystone structures" are likely to result in complexities and disruptions to the regional groundwater hydraulic regime. Faults may both enhance vertical flow, resulting in cross-formational mixing of groundwater, and also provide barriers to lateral flow resulting in compartmentalisation of the groundwater flow system. Barriers to groundwater lateral flow and enhanced vertical flow in some hydrogeological settings may result in anomalous pressure gradients and vertical discharges of mixed groundwater to surface (springs or stream baseflow).

Supporting the hypothesis for the presence of a mixing zone is groundwater quality and hydrogeochemistry analyses which show distinctive similarities between surface water and WCM and CRA groundwaters north of Dalby-Kogan Road. Supporting the hypothesis of a groundwater discharge zone into Wilkie Creek and/or the Wilkie Creek alluvium is the presence of ^{222}radon in Wilkie Creek surface water.

Also of possible relevance is that the CRA sequence within the study area is relatively thin (shallow depth to bedrock) and is dominated by finer-grained (silt/clay-rich) sediments. This may result in lower recharge infiltration volumes and therefore limited dilution of laterally-discharging saline groundwater from the WCM. This is evident through review of lithological descriptions within bore logs and the lack of high flow rate irrigation bores present within the study area. Relatively low CRA permeabilities and limited extraction may also result in higher CRA and laterally-adjacent WCM pressures.

Given that there is evidence within the DRDMW groundwater database of the presence of both saline groundwater and elevated groundwater pressures in the area prior to the mine operation, it is considered most likely that these anomalies are due primarily to natural structural complexities in the geological setting.

However the onset of vegetation dieback around 1990 coinciding with other activities in the area and drought suggests the possibility of non-CSG stressors causing critical changes in hydrogeological conditions, likely related to shallow groundwater salinity levels.

Conclusions

Prior to commencement of significant identified hydrological and hydrogeological alteration which commenced in 1990, it is considered likely that vegetation within portions of the identified reach of Wilkie Creek and an extension downstream to the north was dependant, at least seasonally, on groundwater. This is consistent with the classification of river red gum as a facultative phreatophyte.

However severe degradation of the ecosystem including widespread mature tree dieback, likely due to exposure to shallow saline groundwater, has resulted in ecosystem collapse. In the current hydrologeological regime, no trees within the affected reach were identified as being groundwater reliant. Elevated groundwater salinity is considered the major factor contributing to the poor ecological health of the reach of Wilkie Creek that is subject to this assessment. The riparian vegetation is still relatively intact immediately north of Dalby-Kogan Road where the preferential source of water appeared to be shallow soil moisture at the time of assessment.

The conceptual model identifies numerous potential stressors to the riparian ecosystem on Wilkie Creek which appear to have commenced from 1990 and are likely a result of activities otherthan Arrow's operations. Such hypotheses require further testing through additional work to address critical research gaps and subsequent refinement of the eco-hydrogeological conceptual model.

References

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Thorburn, P. J, and Walker G. R (1994) Variations in stream water uptake by Eucalyptus camaldulensis with differing access to stream water. Oecologia, 100, 293-301.

Appendix D – Ground Movement Investigation Summary

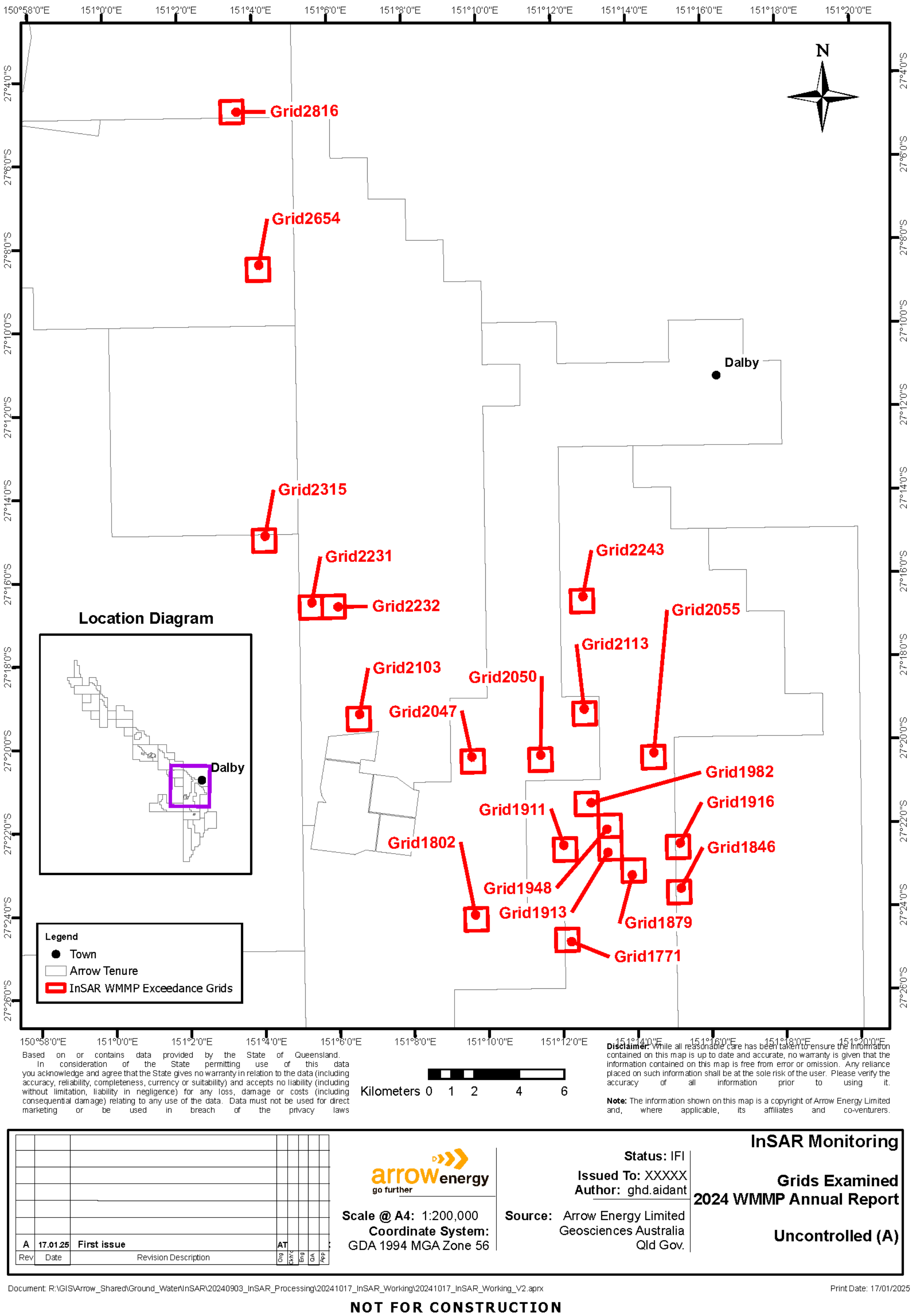

Figure D-1: 1x1km Grid Cells (20 off) subject to investigation level assessment

Table D-1: Profile analysis summary from investigation level assessment

Grid ID	Line Number	Raster Label	Slope_percent	Difference_percent	Difference_m/m
Grid1802	1	2023_05 10m DEM	-0.122		
Grid1802	1	2024_05 10m DEM	-0.124	-0.0022	0.0000
Grid1802	2	2023_05 10m DEM	-0.069		
Grid1802	2	2024_05 10m DEM	-0.059	0.0101	0.0001
Grid1802	3	2023_05 10m DEM	-0.123		
Grid1802	3	2024_05 10m DEM	-0.121	0.0019	0.0000
Grid1802	4	2023_05 1m DEM	-0.410		
Grid1802	4	2024_05 1m DEM	-0.330	0.0802	0.0008
Grid1802	5	2023_05 1m DEM	0.051		
Grid1802	5	2024_05 1m DEM	-0.009	-0.0603	-0.0006
Grid2055	1	2023_05 10m DEM	-0.372		
Grid2055	1	2024_05 10m DEM	-0.367	0.0056	0.0001
Grid2055	2	2023_05 10m DEM	-0.112		
Grid2055	2	2024_05 10m DEM	-0.113	-0.0013	0.0000
Grid2055	3	2023_05 10m DEM	-0.280		
Grid2055	3	2024_05 10m DEM	-0.282	-0.0018	0.0000
Grid2055	4	2023_05 10m DEM	-0.246		
Grid2055	4	2024_05 10m DEM	-0.248	-0.0013	0.0000
Grid2055	5	2023_05 10m DEM	-0.429		
Grid2055	5	2024_05 10m DEM	-0.434	-0.0052	-0.0001
Grid2231	1	2023_05 1m DEM	0.182		
Grid2231	1	2024_05 1m DEM	0.157	-0.0247	-0.0002
Grid2231	2	2023_05 1m DEM	0.101		
Grid2231	2	2024_05 1m DEM	0.050	-0.0514	-0.0005
Grid2231	3	2023_05 1m DEM	0.149		
Grid2231	3	2024_05 1m DEM	0.126	-0.0237	-0.0002
Grid2231	4	2023_05 10m DEM	-0.065		
Grid2231	4	2024_05 10m DEM	-0.071	-0.0061	-0.0001
Grid2231	5	2023_05 1m DEM	-0.011		
Grid2231	5	2024_05 1m DEM	0.003	0.0142	0.0001
Grid2231	6	2023_05 10m DEM	-0.297		
Grid2231	6	2024_05 10m DEM	-0.285	0.0123	0.0001
Grid2232	1	2023_05 1m DEM	0.104		
Grid2232	1	2024_05 1m DEM	0.099	-0.0046	0.0000
Grid2232	2	2023_05 1m DEM	0.012		
Grid2232	2	2024_05 1m DEM	0.006	-0.0062	-0.0001
Grid2232	3	2023_05 10m DEM	-0.545		
Grid2232	3	2024_05 10m DEM	-0.545	-0.0001	0.0000
Grid2232	4	2023_05 10m DEM	-0.118		
Grid2232	4	2024_05 10m DEM	-0.133	-0.0153	-0.0002
Grid2232	5	2023_05 1m DEM	-0.218		
Grid2232	5	2024_05 1m DEM	-0.211	0.0065	0.0001
Grid2232	6	2023_05 10m DEM	-0.129		
Grid2232	6	2024_05 10m DEM	-0.129	0.0001	0.0000
Grid2232	7	2023_05 10m DEM	-0.501		
Grid2232	7	2024_05 10m DEM	-0.493	0.0073	0.0001
Grid2315	1	2023_05 10m DEM	0.122		
Grid2315	1	2024_05 10m DEM	0.123	0.0004	0.0000
Grid2315	2	2023_05 1m DEM	0.006		
Grid2315	2	2024_05 1m DEM	0.026	0.0207	0.0002
Grid2315	3	2023_05 1m DEM	-0.049		
Grid2315	3	2024_05 1m DEM	-0.040	0.0092	0.0001
Grid2315	4	2023_05 10m DEM	-0.172		
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Grid2315	5	2023_05 10m DEM	-0.029		
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Grid2315	6	2023_05 10m DEM	0.014		
Grid2315	6	2024_05 10m DEM	0.018	0.0041	0.0000
Grid1771	1	2023_05 10m DEM	0.048		
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Grid1771	2	2023_05 10m DEM	-0.038		
Grid1771	2	2024_05 10m DEM	-0.049	-0.0110	-0.0001
Grid1771	3	2023_05 10m DEM	-0.059		
Grid1771	3	2024_05 10m DEM	-0.055	0.0041	0.0000
Grid1771	4	2023_05 10m DEM	-0.113		
Grid1771	4	2024_05 10m DEM	-0.106	0.0075	0.0001
Grid1771	5	2023_05 10m DEM	-0.070		
Grid1771	5	2024_05 10m DEM	-0.069	0.0012	0.0000

Grid1771	6	2023_05 10m DEM	-0.044		
Grid1771	6	2024_05 10m DEM	-0.048	-0.0032	0.0000
Grid1846	1	2023_05 10m DEM	-0.023		
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Grid1846	2	2023_05 10m DEM	0.035		
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Grid1846	4	2023_05 10m DEM	0.009		
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Grid1846	5	2023_05 10m DEM	-0.055		
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Grid1879	2	2024_05 10m DEM	0.011	0.0028	0.0000
Grid1879	3	2023_05 10m DEM	-0.001		
Grid1879	3	2024_05 10m DEM	-0.006	-0.0054	-0.0001
Grid1879	4	2023_05 10m DEM	-0.041		
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Grid1911	2	2023_05 10m DEM	-0.042		
Grid1911	2	2024_05 10m DEM	-0.044	-0.0014	0.0000
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Grid1911	4	2023_05 10m DEM	-0.044		
Grid1911	4	2024_05 10m DEM	-0.043	0.0013	0.0000
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Grid2050	1	2023_05 10m DEM	-0.091		
Grid2050	1	2024_05 10m DEM	-0.080	0.0112	0.0001
Grid2050	2	2023_05 10m DEM	0.067		
Grid2050	2	2024_05 10m DEM	0.060	-0.0074	-0.0001
Grid2050	3	2023_05 10m DEM	-0.072		
Grid2050	3	2024_05 10m DEM	-0.076	-0.0038	0.0000
Grid2050	4	2023_05 10m DEM	-0.103		
Grid2050	4	2024_05 10m DEM	-0.096	0.0068	0.0001
Grid2050	5	2023_05 10m DEM	-0.032		
Grid2050	5	2024_05 10m DEM	-0.025	0.0075	0.0001
Grid2050	6	2023_05 10m DEM	-0.145		
Grid2050	6	2024_05 10m DEM	-0.135	0.0098	0.0001
Grid2050	7	2023_05 10m DEM	0.021		
Grid2050	7	2024_05 10m DEM	0.027	0.0056	0.0001
Grid2050	8	2023_05 10m DEM	0.095		
Grid2050	8	2024_05 10m DEM	0.123	0.0281	0.0003
Grid2050	9	2023_05 10m DEM	0.112		
Grid2050	9	2024_05 10m DEM	0.110	-0.0018	0.0000
Grid2103	1	2023_05 10m DEM	-0.004		
Grid2103	1	2024_05 10m DEM	-0.006	-0.0019	0.0000
Grid2103	2	2023_05 10m DEM	0.036		
Grid2103	2	2024_05 10m DEM	0.032	-0.0038	0.0000
Grid2103	3	2023_05 10m DEM	0.024		
Grid2103	3	2024_05 10m DEM	0.024	-0.0004	0.0000
Grid2103	4	2023_05 10m DEM	0.023		
Grid2103	4	2024_05 10m DEM	0.025	0.0013	0.0000
Grid2103	5	2023_05 10m DEM	0.005		
Grid2103	5	2024_05 10m DEM	0.005	0.0008	0.0000
Grid2103	6	2023_05 10m DEM	-0.017		
Grid2103	6	2024_05 10m DEM	-0.014	0.0034	0.0000
Grid2113	1	2023_05 10m DEM	-0.010		
Grid2113	1	2024_05 10m DEM	-0.009	0.0010	0.0000
Grid2113	2	2023_05 10m DEM	-0.275		
Grid2113	2	2024_05 10m DEM	-0.275	-0.0005	0.0000
Grid2113	3	2023_05 10m DEM	0.022		
Grid2113	3	2024_05 10m DEM	0.026	0.0038	0.0000

Grid2113	4	2023_05 10m DEM	-0.021		
Grid2113	4	2024_05 10m DEM	-0.018	0.0027	0.0000
Grid2243	1	2023_05 10m DEM	-0.003		
Grid2243	1	2024_05 10m DEM	-0.011	-0.0072	-0.0001
Grid2243	2	2023_05 10m DEM	-0.254		
Grid2243	2	2024_05 10m DEM	-0.244	0.0105	0.0001
Grid2243	3	2023_05 10m DEM	0.159		
Grid2243	3	2024_05 10m DEM	0.154	-0.0051	-0.0001
Grid2243	4	2023_05 10m DEM	-0.077		
Grid2243	4	2024_05 10m DEM	-0.074	0.0027	0.0000
Grid2654	1	2023_05 10m DEM	0.026		
Grid2654	1	2024_05 10m DEM	0.027	0.0015	0.0000
Grid2654	2	2023_05 10m DEM	-0.109		
Grid2654	2	2024_05 10m DEM	-0.125	-0.0162	-0.0002
Grid2654	3	2023_05 10m DEM	-0.054		
Grid2654	3	2024_05 10m DEM	-0.069	-0.0150	-0.0002
Grid2654	4	2023_05 10m DEM	0.067		
Grid2654	4	2024_05 10m DEM	0.064	-0.0025	0.0000
Grid2654	5	2023_05 10m DEM	-0.052		
Grid2654	5	2024_05 10m DEM	-0.055	-0.0027	0.0000
Grid2816	1	2023_05 10m DEM	-0.116		
Grid2816	1	2024_05 10m DEM	-0.112	0.0033	0.0000
Grid2816	2	2023_05 10m DEM	0.056		
Grid2816	2	2024_05 10m DEM	0.061	0.0050	0.0001
Grid2816	3	2023_05 10m DEM	-0.088		
Grid2816	3	2024_05 10m DEM	-0.090	-0.0019	0.0000