

PF Formation Pty Ltd

Groundwater Report Hitchcock Road Site, Maroota, NSW Annual Groundwater Management Plan 2018 - 2019

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Client: PF Formation Pty Ltd

Project: Groundwater Report
Hitchcock Road Site, Maroota
2018-2019 Annual Groundwater Management Plan

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1 INTRODUCTION

Earth2Water Pty Ltd (E2W) was engaged by PF Formation Pty Ltd (PFF) to provide the Groundwater Report (2018-2019 Annual Groundwater Management Plan) for Hitchcock Road Site, Maroota (Figure 1). The groundwater and surface water sampling[1] and downloading of data loggers (7) was conducted in consultation with Melissa Mass (South East Environmental Pty Ltd) and Joshua Graham (PFF) during July, August and September 2019. URS Australia Pty Ltd (URS) was previously (up to 2013) retained by PFF to prepare the groundwater component of the report.

PF Formation (PFF) is required under the Development Approval conditions set for the Maroota Hitchcock Road property area (Figure 2) to prepare an annual Water Management Plan (WMP) report to the *Department of Planning Industry and Environment* (DPIE). The WMP is part of the overall Environmental Management Plan and addresses the surface water and groundwater aspects of the sand extraction operations at the site. E2W provided an updated WMP (8 January 2018) which included a detailed assessment of the hydrogeology, site survey, pit depths and installation of additional wells and loggers (4).

The WMP for the past year also includes the monitoring data collected from 1996 to July/August/September 2019 for the Hitchcock Road and Portion 198 sites. Additional monitoring data was obtained for the 2018-2019 and included water testing and data logger results from the clean water dam (CWD), Por 167 Dam, and new deep onsite wells (PF167MW2D, PF167MW3D, PF167MW4D) and from an adjacent site (i.e. 4378 Old Northern Rd @ PF-1, PF-2, PF-3). Monthly water levels[2] was undertaken at available monitoring wells at Hitchcock Road and Lot 198 (Figures 1 & 5, Table 3-9, Appendix F).

2 GROUNDWATER AND SURFACE WATER MONITORING NETWORK

During May 2017, six additional monitoring wells were installed to improve the site characterisation of the Hawkesbury Sandstone (i.e. PF166MW-2D, PF167MW-3D, PF167MW-4D, PF167MW-5D) and Maroota Sand Aquifers (PF166MW-2s, PF167MW-4s, refer to Appendix E, Figure-1). The 6 monitoring wells were drilled by TerraTest Pty Ltd under E2W (Dino Parisotto) supervision and utilised to update the groundwater depths and guide the pit extraction depths (Tables 3A & 3B).

The existing wells (PF214MW-1, PFL2HitchMW-1, PF167MW-1 and PF166MW-1) and new wells (PF166MW-2D, PF167MW-3D, PF167MW-4D, PF167MW-5D, PF166MW-2s, PF166MW-4s) were surveyed by Landair Survey Pty Ltd (May 2017, Appendix E). The aerial survey provided an updated aerial photographic plan showing current pit excavation works and site topographic contours (Figure 1). The new and existing monitoring wells were surveyed by a registered surveyor (Mathew Freeburn Pty Ltd) on 29 May 2017 to enable groundwater levels to be reduced to Australian Height Datum (mAHD, Table 2).

[1] Sampling locations (13) include: PF214MW-1, PFL2HitchMW-1, PF167MW-1, PF166MW-1 (dry), Lot198PB-1 & PB-2, and new locations: PF166MW-2D, PF166MW-2s, PF167MW-3D, PF167MW4D, PF167MW4s, and two dams (CWD & Por167).
[2] Measured by Melissa Mass of South East Environmental Pty Ltd (SEE).

During 2018 PFF aquired a new site (4378 Old Northern Rd, Maroota) which is adjacent to the Hitchcock Road sand extraction area (Appendix H). Three existing wells (PF-1, PF-2, PF-3) are situated on the new site and have been monitored by Melissa Mass on a monthly basis since December 2018 (Appendix F).

At the Hitchcock Road site, groundwater was monitored at six existing and six new locations on 30 July 2019 by E2W (download of loggers and water level gauging), and during August and September 2019 by Melissa Mass (SEE). The details of the existing and new wells are presented in Tables 3A and 3B.

Existing Wells (Sampling August /September 2019)

1. Monitoring bore PF167MW1, located in Portion 167 (data logger available but not downloaded due to fault/age). Sampled 2 September 2019 by SEE.
2. Monitoring bore PF166MW1, located in Portion 166 (dry well- no sample),
3. Monitoring bore PFL2HitchMW1, located in Lot 2 (data logger available). Sampled 14 August 2019 by SEE.
4. Monitoring bore PFP214MW1, located in Portion 214 (data logger available). Sampled 14 August 2019 by SEE.
5. Production Bores PF198PB1 and PF198PB2, located in Portion 198. Sampled 14 August 2019 by SEE.

The pumping records are available from the water supply dams (clean water dam, PF167DAM in Portion 167, and by-wash dam in Lot 198) for 2018-2019.

Significant changes to the landform occurred during 2018 to early 2019 in the vicinity of PF167MW5D which is now covered by large bund wall and raised ground levels. A large clay bund wall and holding pond are located upgradient of the boundary well (PFP214MW1). The altered landforms (bund walls, dams) on the southern boundary are used for tailing dam storages and stormwater. Water circulating in the new tailing dam are interpreted to mound the local groundwater levels (e.g. PFP214MW1).

New Wells (Sampling August and September 2019)

6. Monitoring bore PF166MW2D, located in Portion 166. Sampled on 14 August 2019 and 2 September 2019 by SEE.
7. Monitoring bore PF166MW2S, located in Portion 166. Sampled 14 August 2019 by SEE.
8. Monitoring bore PF167MW3D, located in Portion 167 (data logger available). Sampled 14 August 2019 by SEE.
9. Monitoring bore PF167MW4D, located in Portion 167 (data logger available). Sampled 14 August 2019 by SEE.
10. Monitoring bore PF167MW4S, located in Portion 167. Dry well.
11. Monitoring bore PF167MW5D, located in Portion 167. Decommissioned in 2017 due to landform changes**.**

Groundwater sample collection was undertaken at the new and existing wells on 14 August and 2 September 2019 by Melissa Mass of South East Environmental Pty Ltd (SEE). Additional monitoring was conducted by Earth2Water on 30 July 2019 at all wells to check water levels, and to down-load the data loggers (7).

The additional new wells (6) installed in May 2017 improves the definition of the groundwater flow regime at the central and north portion of the site (i.e. PF166MW-2D & PF167MW-3D). The three new wells (PF-1,2,3) on the adjacent site also clarify the groundwater flow regime.

The groundwater data and site topography indicate the presence of a groundwater divide near the highest part of the site which separates the flows to the north and south (RL ~240 m AHD at trig station, Figures 1 & 4).

Groundwater pumping and chemical analyses were also collected from the two water supply bores in Portion 198 (i.e. PF198PB1 & PF198PB2). The bore PB2 was previously treated with iron-floc chemicals due to clogging. The chemical treatment ceased at PB2 in December 2016.

Groundwater monitoring has been carried out at the sites since 1996. Initially, water levels in bores PF166MW1 and PF167MW1 were measured manually at weekly intervals together with chemical field parameters such as pH and Electrical Conductivity (EC). The manual measurements continued until December 1998. In January 1999, the two bores were equipped with Dataflow Systems automatic data loggers (i.e. PF166MW-1; the data logger was removed in 2017).

Data loggers have been downloaded quarterly between January 1999 and June 2000. Since June 2000, the dataloggers have been downloaded biannually. In January 2006, the old style Dataflow dataloggers were replaced with Solinst Levelogger 3001 units, capable of storing 40,000 readings in the memory, with a battery life span of around 10 years. The Solinst dataloggers allow the data for annual downloading, a monitoring interval (once daily) started on July 2006. E2W downloaded the aged data loggers on 17 July 2017, however the data was only recorded from one (PF167MW1) out of the four loggers (*note*. No data was not able to be downloaded from loggers at PFL2HitchMW1, PFP214MW1, PF166MW1 in the 2016 to 2017 period. Loggers are >10 yrs old).

Data logger information was retrieved from PF167MW-1 for the 2017 to 2018 period, including the two loggers (PFL2HitchMW1, PFP214MW1). The loggers from the two wells (PF166MW1 in 2018, and PF167MW-1 in 2019) was not able to be programmed and decommissioned.

Groundwater level information at all available wells was also collected using an acoustic water level probe on a monthly basis (August 2017 to 2019) by Melissa Mass of South East Environmental Pty Ltd. The monthly water level measurements (& annual sampling) are conducted at new and existing wells by South East Environmental, whilst training, and the annual gauging and download of loggers is conducted by E2W (Dino Parisotto).

New Solinst data loggers (4) were installed at four locations (Por 167 dam, clean water dam, PF167MW3D, PF167MW4D) on 9 August 2017 to assist with the groundwater management and guiding of pit extraction depths. The four loggers were downloaded on 30 July 2019 as part of the annual report.

Field chemistry (EC, PH, T, DO, Redox) was measured using a calibrated field meter hired from AES Environmental Pty Ltd (Geologic YSI professional series) at the 11 bores (PF167MW1, PFL2HitchMW1, PFP214MW1, PF167MW4D, PF167MW4s, PF167MW2D, PF167MW2s), Lot 198PB-01, Lot 198 PB-2, and PF-1/PF-2 at 4378 Old Northern Rd on 14 August 2019. Sampling was conducted at the 2 dams (CWD, Por167 Dam) and PF166MW-2D on 2 September 2019. The deep well (PF166MW-2D) was re-sampled due to the turbid water and anomalous initial results (i.e. Oil & Grease).

Groundwater samples were collected by South East Environmental Pty Ltd and E2W (Dino Parisotto) in consultation with PFF (Joshua Graham) in August and September 2019. All water samples were submitted for chemical analyses under Chain of Custody procedures to Australian Laboratory Services Pty Ltd (ALS-Sydney).

Samples were collected from a total of 11 bores and 2 dams;

- Existing Wells: PFL2HitchMW1, PFP214MW1, PF167MW1, PF166MW1 (dry), Lot198PB-1 & Lot198PB-2.
- New Wells: PF167MW3D, PF167MW4D, PF167MW4s, PF167MW2D, PF167MW2s.
- 4378 Old Northern Rd; PF-1, PF-2 (note: PF-3 was a dry well).
- Artificial water storages (CWD & Por167 dam).

Note: Two bores were not sampled (i.e. PF166MW1 a dry well and PF167MW5D-decommissioned). Water samples were collected from the production bores PF198PB1 & PB2 (August 2019) are from water supply/pumping bores. The 2017 survey and monthly water level measurements have been used to adjust the data logger results (i.e. adjusted RL of logger).

The laboratory reports are presented in Appendix B-1. The analytical results have been plotted on individual graphs that are updated annually to assess trends over time (Graphs 1 to 6 and Appendix C).

The analytical list for all bores, which was discussed and agreed upon with the DLWC (now the NSW Office of Water) has included:

- pH, Electrical Conductivity and Total Dissolved Solids;
- Calcium, Magnesium, Sodium and Potassium;
- Chloride, Sulphate, Bicarbonate; and
- Oil & Grease.

2.1 Surface Water Monitoring

The recent Water Management Plan (January 2018) outlines the surface water monitoring requirements.

The surface water monitoring program was undertaken in compliance with Condition 19 of Schedule 3 of the Project Approval. Surface water quality monitoring was monitored on a quarterly basis when the creek sample locations were flowing. Samples were taken from water at the existing monitoring site (a spring on Hitchcock Rd) and on the creek below Lot 198 DP752025 (Appendix B-2, Table 3-10).

Condition 19.

The Surface Water Monitoring Program shall include:

(a) detailed baseline data on surface water flows and quality in downstream watercourses that could be affected by the project;

(b) surface water quality and stream health assessment criteria, including trigger levels for investigating any potentially adverse surface water impacts; and

(c) a program to monitor:

• surface water flows, quality, and impacts on water users;

• stream health; and

• channel stability.

Monitoring of channel stability will be based on visual inspections undertaken at the same time. The assessment will include analysis applying to the following trigger levels:

• PH;	+/-1 UNIT FROM BACKGROUND
• ELECTRICAL CONDUCTIVITY;	<1,500 µS/CM
• TOTAL SUSPENDED SOLIDS;	<50 MG/L
• OIL AND GREASE.	<10 MG/L

Note: Exceedance of trigger levels would trigger an investigation into the cause will be undertaken immediately so action can be taken to return levels to within average range. No additional investigations were conducted after the monitoring undertaken on 3 dates (September 2018, December 2018, and April 2019) as no water quality/bank observation issues or guideline exceedances were noted (Tables 3-9A, 3-9B).

Samples were taken and analysed following heavy rain events and any incidents on Lot 198 DP752025 which could have an impact on water quality.

Surface water monitoring was undertaken by Melissa Mass (SEE) at two locations on the Hitchcock Road site (Lot 198 creek, and Little Catai Creek). Creek water samples were obtained and analysed in September 2018, December 2018, and April 2019 (refer to Appendix B-2).

2.2 Monitoring Bore PF167MW1

Groundwater monitoring at bore PF167MW1 commenced in March 1996. The data between March 1996 and December 1998 (manual collection) have been plotted in the graph of Figure 2, together with EC and rainfall records collected by PFF (Appendix C). An automated weather station has been installed by PFF in 2010 and in early 2017 (including barometric pressure).

The Figure HG-2 (2013-2018, 2019 not available due to a logger fault) presents the combined Solinst datalogger records for bore PF167MW1 (previous records are presented in Appendix C). The monthly water level gauging graphs is presented in Figure HG-8, and Appendix F.

Previous minor data gaps exist and a slight difference between the manual data and the start of the automatic recording is evident in the previous data, which are due to the time intervening between the end of the manual and start of the automatic recording methods (Appendix C, URS, 2013).

2.3 Monitoring Bore PF166MW1

Groundwater monitoring at bore PF166MW1 (Figure HG-3 shows 2013 to 2016 monitoring data) commenced in March 1998 in the same manner as for bore PF167MW1. The data between March 1998 and December 1998 (manual collection) have been plotted in the graph of Figure 4 (Appendix C), together with EC and rainfall records collected by PFF.

Refer to Table 2 for water level gauging results. Logger data is not available for 2016-2017 (logger now decommissioned due to age >10 yrs). The monthly water level gauging graph is presented in Figure HG-8 (2017 to 2019), and Appendix F. The well is currently dry and no samples were collected in 2019.

2.4 Monitoring Bore PFP214MW1

Bore PFP214MW1 was installed in March 2009 as part of an extended groundwater monitoring network following the Development Approval for Portion 214, located at the southern boundary of the Hitchcock Road site.

A datalogger was installed in the bore in early April 2009 (Solinst Levelogger Gold 3001, serial no. 51040540). Refer to Table 2 for the recent water level gauging results.

Bore PFP214MW1 hydrograph is presented in Figure HG-4 (showing 2013 to 2019 monitoring data). Logger data is not available for 2016-2017 due to technical issues with the aged logger. The monthly water level gauging graph is presented in Figure HG-4.

The monthly water level gauging graph is presented in Figure HG-8 (2017 to 2019), and Appendix F.

2.5 Monitoring Bore PFL2HitchMW1

Bore PFL2HitchMW1 was also installed in March 2009. This bore is located midway along the eastern boundary of the Hitchcock Site and monitors the full sequence of the Maroota Sand. A datalogger was installed in the bore in early April 2009 (Solinst Levelogger Gold 3001, serial no. 510405840). Refer to Table 2 for water level gauging results.

Bore PFL2HitchMW1 hydrograph is presented in Figures HG-5, HG-8 (2017 to 2019), and Appendix F.

2.6 New Monitoring Bores (2017-2019)

Seven new monitoring wells (PF167MW-3D, PF167MW-4D, PF167MW-4s, PF167MW-2D, PF167MW-2s, PF167MW-5D[3]) were installed at the site in 2017 to assist with the assessment of the sandstone and Maroota Sands aquifers.

Data loggers were installed in August 2017 at two deep wells (PF167MW-4D, PF167MW-3D, refer to Figure HG-6 and HG-7) to assist with the pit extraction depths. Results for the new wells are in presented in Table 3-9, Figure HG-8, and Appendix F.

The four existing wells (PFL2HitchMW1, PFP214MW1, PF167MW1, PF166MW1[4]) were sampled in July/August 2019 to assist with the groundwater study at the site. Three additional bores (PF-1,2,3) on the adjacent property were included with the monitoring program (monthly monitoring and annual sampling) from December 2018 to August 2019.

2.7 Portion 167 Dam

At the early stages of the site development, an excavation (PF167DAM) was carried out to the top of the Hawkesbury Sandstone to an approximate level of 178m AHD. The excavation collects groundwater and surface water run-off and was eventually licensed by the DLWC (No.10BL157308) as part of the water supply of the operation. Water levels measured against surveyed pegs have been collected at the dam since September 1996 and pumpage records kept since January 1997.

[3] PF167MW5D was decommissioned in early 2018 during the construction of the tailings dam.
[4] PF166MW-1 is currently a dry well.

Water quality in the dam is generally not monitored because the dam collects incident rainfall, run-off and groundwater and, as a result, water quality would vary according to the proportion of each component at the time of measurement.

Due to high rainfall in 2014-2015 (1321.5 mm) no monitoring or pumping was required from the Portion 167 Dam. Pumping was undertaken by PFF from Portion 167 Dam during the 2018-2019 (drought period) and summarised in Table 3-7 (Total of 26.009 ML).

The pumpage was due to the lower rainfall (557.4 mm for 2018-2019) and moderate volume of sand extraction (note: water level monitoring is not required for the licence).

Water level monitoring is not required in the license conditions, however a data logger was installed in August 2017 to assist with the site water balance and assessment. Water samples and field chemistry were collected in August 2019 for the site water balance and assessment (Figure HG-10 and Table 3-9). The data logger readings are provided as raw data in Figure HG-10 (*note: logger data requires adjustment with barometric pressure, evaporation and pumping influences. To be provided in separate documentation*).

2.8 Clean Water Dam (Portion 167)

Water quality in the dam is not previously monitored because the dam collects incident rainfall, run-off and recycled water from the wash plant and tailings.

Water level monitoring is not required in the license conditions, however a data logger was installed in August 2017 to assist with the site water balance. Water samples and field chemistry were collected in August 2019 to assist with the site water balance and assessment (Figure HG-9 and Table 3-9). The data logger readings are provided as raw data in Figure HG-9 (*note: logger data requires adjustment with barometric pressure, evaporation and pumping influences. To be provided in separate documentation*).

2.9 Portion 198 Water Supply Bores

The two water supply bores in Portion 198 (PF198PB-1 and PF198PB-2) have been monitored manually since their installation in March 1998. Groundwater samples have been collected quarterly for the last four quarters to March 2000, biannually up to July 2006 and annually since then. Pumpage records are collected and totalised weekly. (*Note: Pump in bore PF198PB1 was out of service for most of 2012-2013*).

Water quality data have been plotted for selected parameters and the graphs (5 & 6) and the laboratory reports in Appendix B. Monthly water levels were measured during the 2017 -2019 period by South East Environmental (Melissa Mass, Figure HG-1).

The bores were operational and sampling from PF198PB-1 & PF198PB-2 discharge outlet occurred in August 2019. A water sample was collected from PF198PB1 & 2 for the chemical assessment and field chemistry by E2W (Tables 3-5 & 3-6).

Note: Chemical treatment for clogging (Fe-floc) at PB-2 ceased in December 2016.

3 GROUNDWATER DATA ASSESSMENT

The groundwater assessment for the site has been conducted by E2W in collaboration with PFF (Josh Graham) and Melissa Mass (South East Environmental Pty Ltd- SEE). The analytical reports by ALS Environmental are presented in Appendix B-1, whilst the monthly water level measurements by SEE are included in Appendix F.

Additional monitoring locations are included in the 2018 to 2019 operating period due to the installation of six new wells (May 2017), inclusion of 3 new wells (PF-1,2,3) on the adjacent property, and assessment of the clean water dam (CWD) and Por 167 dam (Appendix H). The additional testing locations relate to the revised water management plan (January 2018).

The quarterly surface water testing (September 2018, December 2018, April 2019) has been included at two locations (Lot 198, Little Catai Creek) in the annual water monitoring program (Table 3-10, Appendix B-2).

3.1 New Monitoring Wells

During May 2017, six additional monitoring wells were installed to improve site coverage and better assess water levels in the Hawkesbury Sandstone (PF166MW-2D, PF167MW-3D, PF167MW-4D, PF167MW-5D) and Maroota Sand Aquifers (PF166MW-2s, PF167MW-4s Figures 1 &2, Tables 2, 3A & 3B). The 6 monitoring wells were drilled by TerraTest Pty Ltd under E2W (Dino Parisotto) supervision and testing (Table 3B).

The inferred hydrogeological cross sections for the site are presented in Figures 3 &4. The new monitoring wells (6) and recent survey (aerial and well RL details) were used to better assess the pit extraction depths and the groundwater buffer zone (2m requirement).

The previous water level contour map provided by URS (June 2011) is presented in Appendix D. E2W note that the URS water contour map is based on a limited well network comprising three monitoring wells over the 100 ha site. The additional new wells (6) installed at the site in May 2017 provide a better depiction of the groundwater flow regime, particularly in the north (e.g. area of PF166MW-2D). The additional wells (PF-1,2,3) on the adjacent property improve characterisation of the flow regime on the eastern site boundary.

The groundwater data and site topography indicate the presence of a groundwater divide at the highest point of the site (RL ~240 mAHD at trig station located near PF166MW-3D and PFL2HitchMW-1). Refer to Figures 1 to 4.

A decline in groundwater levels is evident across the site due to the prevailing drought conditions (i.e. rainfall =557.4 mm during 2018-2019).

3.2 Groundwater Levels

Groundwater levels in the Hawkesbury Sandstone and Maroota Sand aquifers indicate the presence of perched and regional water tables (Tables; 2, 3A, 3B).

The plots of bore PF167MW1, which taps the full saturated thickness of the Maroota Sand, and bore PF166MW1, which taps an unconfined aquifer (Maroota Sand) perched at a higher elevation, indicate a general rapid response to periods of sustained rainfall (Appendix C).

Records for the two new monitoring bores, PFP214MW1 and PFL2HitchMW1, indicate a subdued and moderate response to rainfall.

The yearly rainfall for the year 2010 (1015.1mm), for the year 2011 (1115.4 mm) and for the year 2012 (984 mm) have been considerably above the long term average of 910.3 mm (to June 2013). Rainfall for the year July 2013- June 2014 has been just 595.5 mm, indicating that the rainfall for year is below the yearly long term average (Note: These rainfall data are reported from the BOM weather station No. 67014 located on Old Telegraph Road).

Rainfall for July 2014 to June 2015 was 1321.5 mm and above the annual average. The above average rainfall for 2014-2015 and high monthly rainfall during April 2015 (422 mm) has stabilised water levels associated with the previous year of low rainfall and subsequently caused a rising of the water table in all bores. Rainfall for July 2015 to June 2016 was 1176 mm and above the annual average.

The average rainfall for July 2016 to June 2017 was 957.4 mm, with a substantial 276.8 mm occurring in the month of March 2017. The groundwater table rose approximately 1m in the sandstone aquifer (PF167MW-1) following March 2017.

The rainfall for July 2017 to June 2018 was 473 mm, whilst for July 2018 to June 2019 was 557.4 mm which are below the annual average (drought conditions). All deep wells and shallow wells show a general decline in the groundwater levels reflecting the prevailing low rainfall and drought conditions.

3.3 Bore PF167MW1

After a significant rain event in June 2007, the water level rose by 4.5 m and similar to the highest recorded value in mid-2000 (Figure HG-2, and Appendix C).

Since June 2011 to 2014, after a period of variable and a slow decline, the water level in this bore has been rising steadily following the above average rainfall up to 2013 (2014 is below annual average). The level from rainfall in 2014-2015 is similar in the year 2000. Water levels were stable in 2014 and then rose sharply (approximately 1.5 m, 183.8 m AHD) after the high recharge event of April 2015 (rainfall 422 mm, Figure HG-2).

Following the April 2015 rainfall event other recharges occurred in early and mid 2016 causing groundwater levels to rise between 183 and 184 m AHD (June 2016 ~ 183.4 m AHD).

Water levels were approximately 183.5 AHD during July 2017 and ranged from ~182.5 to 184 m AHD during 2016-2017. Spikes in water levels relate to storm events, such as the high rainfall in March 2017 (Figure HG-2). The groundwater table rose approximately 1m in the sandstone aquifer (PF167MW-1) following March 2017 rainfall.

The water levels manually measured from August 2016 to August 2018 ranged from 183.12 m AHD to 181.1 m AHD (August 2018), and a gradual lowering (approximately 1m) to August 2019 (180.24 m AHD). Refer to Table 2, Figures HG-8 & HG-2.

3.4 Bore PF166MW1

Since March 2011, the water level in this bore has been rising steadily, although it shows a slight fall during a low rainfall period in the second half of 2012, followed by a rise as a result

of the high rainfall at the beginning of 2013. Bore PF166MW1 taps a perched aquifer with variable responses to major and sustained rainfall events and periods (Figure 3, Appendix C).

The water level declines during 2014 and then rises steadily in 2015 due to the above average rainfall and high April 2015 rainfall (422 mm, Figure 3). Following the April 2015 rainfall event other recharge events occurred in early 2016 causing groundwater levels to rise and peak at approximately 200.8 m AHD in April 2016 (Figure 2).

The water levels manually measured from August 2016 to August 2018 ranged from 199.55 m AHD to below 199 m AHD in May 2018 (Figure HG-8, Table 2). The well has been dry since 2018 to date. The water levels in the Maroota Sand are perched above the sandstone aquifer and have declined to its lowest elevation due to the prevailing drought.

3.5 Bore PFP214MW1

Bore PFP214MW1 taps the full thickness of the Maroota Sand at the southern edge of the quarry area. Since its installation in March 2009, the water level has shown a slow declining trend up to end of February 2011. Since that time the water level has risen in response to the above average rainfall (Figure 4, Appendix C).

Water levels fluctuated slightly (<1m) during 2014 (181.6 m to 180.3 AHD) and then rises slightly and stabilises (180.3 to 181.2 m AHD) with minor fluctuations during 2015 and 2016. Water levels also showed minor fluctuation during 2017 to 2018 with an overall decline. Water levels ranged from approximately 180.2 to 179.5 m AHD (August 2018, Figure HG-4).

The water levels manually measured from August 2016 to August 2018, ranged from 179.41 mAHD to 179.54 mA HD (August 2018). The water levels continued to fluctuate during 2018 to 2019 (178.06 to 179.69 m AHD), reflecting nearby water storages, and bund wall constructions.

Some disturbance (e.g. lifting for water level gauging) of the logger may have occurred during the logging period. Refer to Table 2 and Figure HG-8. The recent water levels (depth below ground) are deeper (<1m) than the previous 2017 levels.

PFF conducted a survey of new and existing wells (Freeburn Surveying Pty Ltd) in May 2017 as part of updating the well network. An adjustment (1.16m elevation) of the well casing RL at PF214MW-1 was required and presented in Table 2, Appendix E.

3.6 Bore PFL2HitchMW1

Bore PFL2HitchMW1 is the deepest bore in the Hitchcock Road site, as it in the vicinity of the former trigonometric station, which is the highest elevation on the site and taps the full thickness of the Maroota Sand aquifer.

The hydrograph shows that after an initial settlement period after drilling, the water level stabilised at an RL level of 189.6 m AHD without any significant response to the rainfall events until September 2012, after which time it shows a steady rise in response to the above average rainfall (Figure HG-5, Appendix C).

Since 2013, the water level shows a slight consistent decline to approximately December 2014, followed by a stable to gently rising water table after April 2015 to mid 2016 where it stabilises at approximately 189.95 m AHD (Figure HG-5). The water levels decline gently from August

2017 to August 2018, ranging from approximately 189.7 to 189.4 m AHD, respectively. The water levels from Aug 2018 to July 2019 show a relatively stable and decreasing water level (189.85 to 189.5 m AHD) reflecting below average rainfall.

The water levels manually measured from August 2016 to August 2018 and ranged from 189.6 m AHD to 189.85 m AHD (Table 2, Figure HG-8). The water levels from September 2018 to July 2019 show a relatively stable and decreasing water level (190.01 to 189.91 m AHD) reflecting below average rainfall.

3.7 Portion 167 Dam

Records of pump operation have been kept from PF167DAM since January 1997. The Figure 7 (in Appendix C) shows the monthly summary of the pumpage from the dam. Due to the above average rainfall over previous years (2011-2013 and 2014-2015) no pumping has been necessary from this source, however below average rainfall has occurred in early 2014, and 2017-2018, with some pumping necessary. No pumping occurred from July 2014 to June 2015.

Pumpage occurred (46.829 ML) from Portion 167 Dam during 2015 to 2016. Pumpage occurred (38.407 ML) from Portion 167 Dam during 2016 to 2017, and **48.953 ML** for 2017-2018. Pumpage occurred (26.009 ML) from Portion 167 Dam during 2018 to 2019.

The licensed limit for the Portion 167 dam is 50 ML/year which are not exceeded for 2019. Pumping records are provided in Table 3-7.

The rainfall recorded at the BOM station since 2010 has been above the long-term annual average of 910.3 mm. No water levels have been recorded at this site during the 2011 - 2013, 2014 - 2015 years, as the dam and the pump have been under water for most of the recording period due to the above average rainfall and resulting run-off experienced in the Maroota area during the 2001-2013 and, in particular, during the period May-June 2013 when the water level peaked briefly at 189 m AHD, returning to 180 m AHD at the end of June 2013.

The water level in the dam reduced by approximately 2 m (184.5 m to 182.5 mAHD) during the past year (2017-2018) due to the low rainfall and high pumpage (i.e. **48.953 ML/yr).** During 2018 to 2019 levels were at low levels (30 July 2019 @ 183.63 mAHD) due to the drought conditions.

The water levels in the dam also appear to be affected by significant evaporation losses during summer and combined contributions from rainfall and groundwater recharge (Figure HG-10). The dam is hydraulically connected to the Maroota Sands aquifer and aquifer recharge patterns closely linked to climate.

The quarry area is internally draining and, therefore, the dam collects all incident rainfall on the site.

Although water is pumped from the dam for a variety of purposes, such as dust suppression and irrigation of rehabilitated areas and, more recently, for sand slurrying, records show that water levels return rapidly to the average values indicated above, even after higher levels are experienced after heavy rainfall and consequential run-off.

The data logger was installed in the dam during a period of high levels in August 2017.

Due to the low rainfall and declining water levels, the logger was shifted to a deeper part of the dam by 2.295m on 12 April 2018. The logger data indicates a lowered water table due to the drought conditions. Previous records suggest that the Maroota Sand aquifer at the site can sustain the required pumpage even under the lower rainfall recharge conditions.

3.8 Clean Water Dam (CWD in Portion 167)

Water quality in the dam (1 Ha ~1.5m maximum depth) was not previously monitored because the dam collects incident rainfall, run-off and recycled water from the wash plant and tailings. The data logger was installed in the dam during a period of high levels in August 2017 (187.635 mAHD). The water levels have decreased by approximately 1m from 2017 to 2018 (186.5 mAHD) due to a lack of rainfall, summer evaporation losses and through operational activities. The water levels fluctuated by approximately 1m from 2018 to 2019.

The water level on 30 July 2019 was 186.77 m AHD and similar to August 2018 (Figure HG-9). Pumping records are provided in Table 3-12.

Water level monitoring is not required in the new license conditions, however a data logger was installed in August 2017 to assist with the site water balance. Water samples and field chemistry were collected in August 2018 to assist with the site water balance and assessment (Figure HG-9 and Table 3-9).

3.9 Water Supply Bores (PB1 & PB2; Portion 198)

Pumping records for the two water supply bores in Portion 198 for the year July 2017 to June 2018 are tabulated in Table 3-8. In previous years, during 2014-2015 pumpage was 21.8 ML, whilst during 2013-2014 the total pumpage was 33.6 ML and still significantly below the combined annual allocation of 60 ML. This lower consumption rate is due to the non-operational status of bore PF198PB1 for part of the year 2013, and overall improved efficiency of the plant (including in 2014).

During 2015 to 2016 and given the above average rainfall the available pumping records (PB1 & 2) indicate a usage of 16.841 ML. Pumpage during 2016 to 2017 from PB1 & 2 indicate a combined usage of 16.507 ML. Pumpage during 2017 to 2018 from PB1 & 2 indicate a combined usage of 13.622 ML.

Pumpage during 2018 to 2019 from PB2 had a usage of 9.947 ML (note: PB1 was not used). Groundwater usage is below the combined annual allocation of 60 ML (Table 3-8).

3.10 Water Quality

The water quality obtained from the existing (4), new wells (7) and dams (2) are presented in hydrochemical diagrams (Piper & Durov, Appendix G) and time series graphs (Graphs 1 to 6).

Water quality in bores PF167MW1 and PF166MW1 has been monitored for pH and EC since monitoring started. Since June 1999 groundwater quality has been analysed for a range of analytical parameters and for Oil and Grease to obtain background data.

Since July 2009, groundwater quality data have also become available from the newly installed monitoring bores, PFP214MW1 and PFL2HitchMW1. Historical and recent analytical results for the other samples from the monitoring sites are summarised in Tables 3-1 to 3-6, and have been plotted in the graphs (1-6). The laboratory reports are presented in Appendix B.

The graphs (1&2) show EC time series trends with water levels and rainfall for the initial monitoring period (March 1996 to January 1999 for bore PF167MW1 and March 1998 to January 1999 for bore PF166MW1), before the installation of the dataloggers (refer to Appendix C for previous graphs presented in URS 2013). The EC graphs show a sympathetic variation with rainfall, indicating the effects of dilution generated by recharge (decrease in EC) and by lower water table. In the latter case, the improved EC is interpreted as the effect of aquifer recharge by fresher water.

The graphs (1 to 6) confirm the dependence of the aquifer upon rainfall to maintain storage and supply. No analysis has been carried out of the water from the Portion 167 Dam because extraneous influences, such as direct rainfall and run-off, make the water in the dam not representative of the groundwater at that site.

Groundwater quality has also been monitored at bores PF198PB1 (Graph-5) and PF198PB2 (Graph-6), the two processing plant water supply bores. The water in these bores is derived from the Hawkesbury Sandstone aquifer. Water quality records are summarised in Tables 3-5 and 3-6 and have been graphed (Refer to Graphs 1 to 6, and in Appendix C, URS 2013). The groundwater levels in the production bores (PF198PB1 & PB2) are presented in Table 3-8.

The waters in the Maroota Sand aquifer monitoring bores are similar and have a characteristic rain composition, with low pH (acidic), low TDS and a Sodium-Chloride water type. The samples were also analysed for Oil and Grease to monitor the possible effect of the sand extraction operations. Concentrations of Oil & Grease were not detected in all bores for the August 2018, and previous four monitoring events (2017, 2016, 2015, 2014).

The deep Hawkesbury Sandstone pumping bores groundwater display a slightly different character from that in the shallow Maroota Sand aquifer in the Hitchcock Road area and from the shallow Hawkesbury Sandstone aquifer in other areas of Maroota. The deeper groundwater has a slightly higher TDS, pH and Bicarbonate content (PF198PB1& 2) than the shallower Maroota Sand groundwater; however, its overall low salinity content and sodium-chloride rain composition indicate a dynamic groundwater regime with regular and rapid rainfall recharge.

An increasing EC/TDS trend is evident in two bores (PFL2HitchMW1, PF214MW1) from 2013 to 2017, and inferred to relate to variable aquifer characteristics and rainfall recharge patterns. The EC/TDS at the two bores is interpreted to have stabilised in the past 2 years (2017-2019).

The water quality of the deep new bores (MW-3D, MW-4D, MW-2D) within the sandstone are similar to the existing bores. The water quality in the dams (CWD and Por 167 spring) is similar to shallow bores (MW-4s) situated within the Maroota Sands. The deeper bores (MW-4D) are similar in major ion composition (Na-Cl rich) to shallower bores and dams, however have slightly higher TDS (Appendix G, Piper & Durov diagrams).

Overall, all the site monitoring bores in both the Hawkesbury Sandstone and in the Maroota Sand show a marginal decrease in Total Dissolved Solids over time, the deeper bores showing a more constant character. The general groundwater flow regime with the sandstone is shown in Figures 1 to 4, and in Appendix D (URS, groundwater regime in 2011).

3.11 Quality Control

The laboratory quality control samples (ALS laboratory duplicates, procedure blanks and control spikes) returned results within the required limits and acceptance criteria. The quality control data generated by the laboratory are presented with the laboratory certificates in Appendix B.

Based on the evaluation of the data, it is assessed that the accuracy and precision of the analytical data generated in the sampling round, as reported by the analytical laboratory, are acceptable as a basis for interpretation.

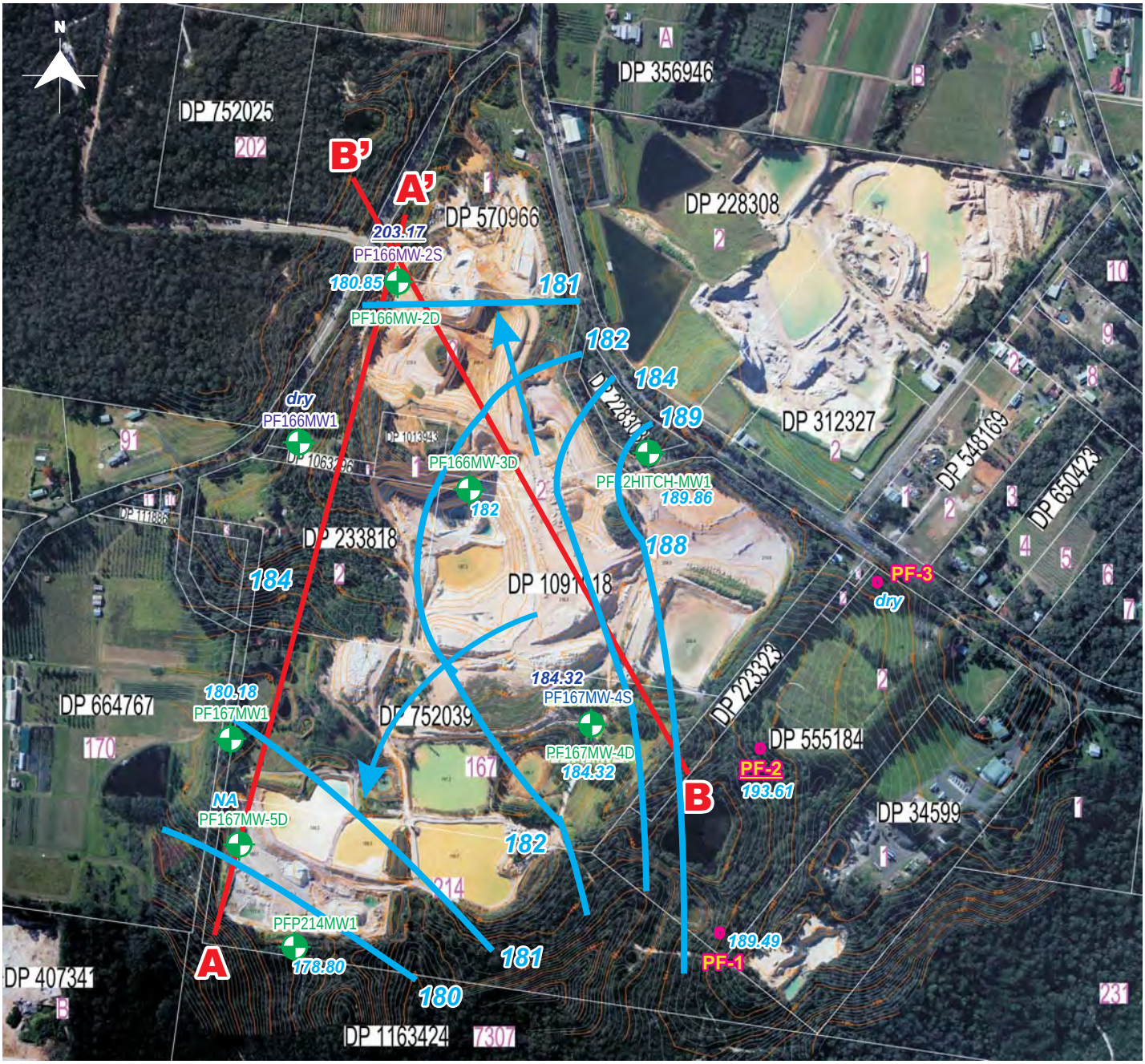
4 CONCLUSIONS

The assessment of the data collected on the groundwater levels and quality in the Maroota Hitchcock Road site, some of which represent the oldest data available to the groundwater study carried out by the DLWC (now Office of Water) in the area, indicate that:

- Water levels in the Maroota Sand aquifer generally respond to the rainfall pattern. The rainfall during 2018 to 2019 of 557.4 mm was substantially below the annual average.
- Water quality in the Maroota Sand aquifer varies with rainfall recharge (slight increasing EC/TDS trends are visible in two deep bores (PFL2HitchMW1, PF214MW1) due to variations in aquifer characteristics and rainfall from 2013 to 2017. The recent 2018-2019 sampling indicates a stabilisation of EC/TDS trends in the two bores.
- Water was pumped from the dam in Portion 167 (26.009 ML) and below the PFF allocation (50 ML).
- Groundwater pumpage occurred from the two deep water supply bores in Portion 198 (16.841 ML in 2015-2016, 21.8 ML in 2014-2015, 2016-2017 was 16.507 ML). Pumpage records for the two production bores (PF198PB1=12.027 ML, and PF198PB2=1.595 ML) in 2017-2018 was 13.622 ML, whilst during the 2018-2019 period was 9.947 ML. Annual pumpage are consistently below the allocation of 60 ML/year (i.e. combined PB-1 & PB-2).
- The chemical composition of the groundwater in the deep aquifer of the Hawkesbury Sandstone (water supply bores in Portion 198) has an overall character that indicates that rainfall recharge occurs readily.
- The new monitoring wells (6) installed in May 2017, and three additional wells (PF-1, PF-2, PF-3) and recent survey (aerial and well RL details) were used to better assess groundwater levels, flow regime, groundwater divide and pit extraction depths. E2W understand that two previous pit extraction areas (locations near PF167MW-3D and PF167MW-5D) were backfilled in 2017-2019 to meet the required groundwater buffer zone (i.e. >2m above high water table).
- The current sand extraction operations in the Hitchcock Road area operate in a manner that does not appear to have an adverse impact upon the groundwater sustainability and meets the DA Approval Conditions.

The data collected during the year are available to the NSW Office of Water for their continued study in the area.

FIGURES



Base source: Landair Surveys

0 100 200 300 m
Scale

LEGEND

- PF167MW-4S — Well location (Maroota Sands)
- PF167MW-4D — Well location (Sandstone aquifer)
- 179.41 — SWL (mAHD) - sandstone (14-8-2018)
- Inferred groundwater flow (sandstone)
- Inferred groundwater flow contour (sandstone @ 14-8-2018)
- A-A' — Line of cross section
- PF-1 — Well Location (new site, 2019)

Perched Water Table (Maroota Sand):
PFMW-2s, PFMW-4s, PF166MW1, PF-2

Site Plan & Inferred Groundwater Flow Regime (30 July 2019)

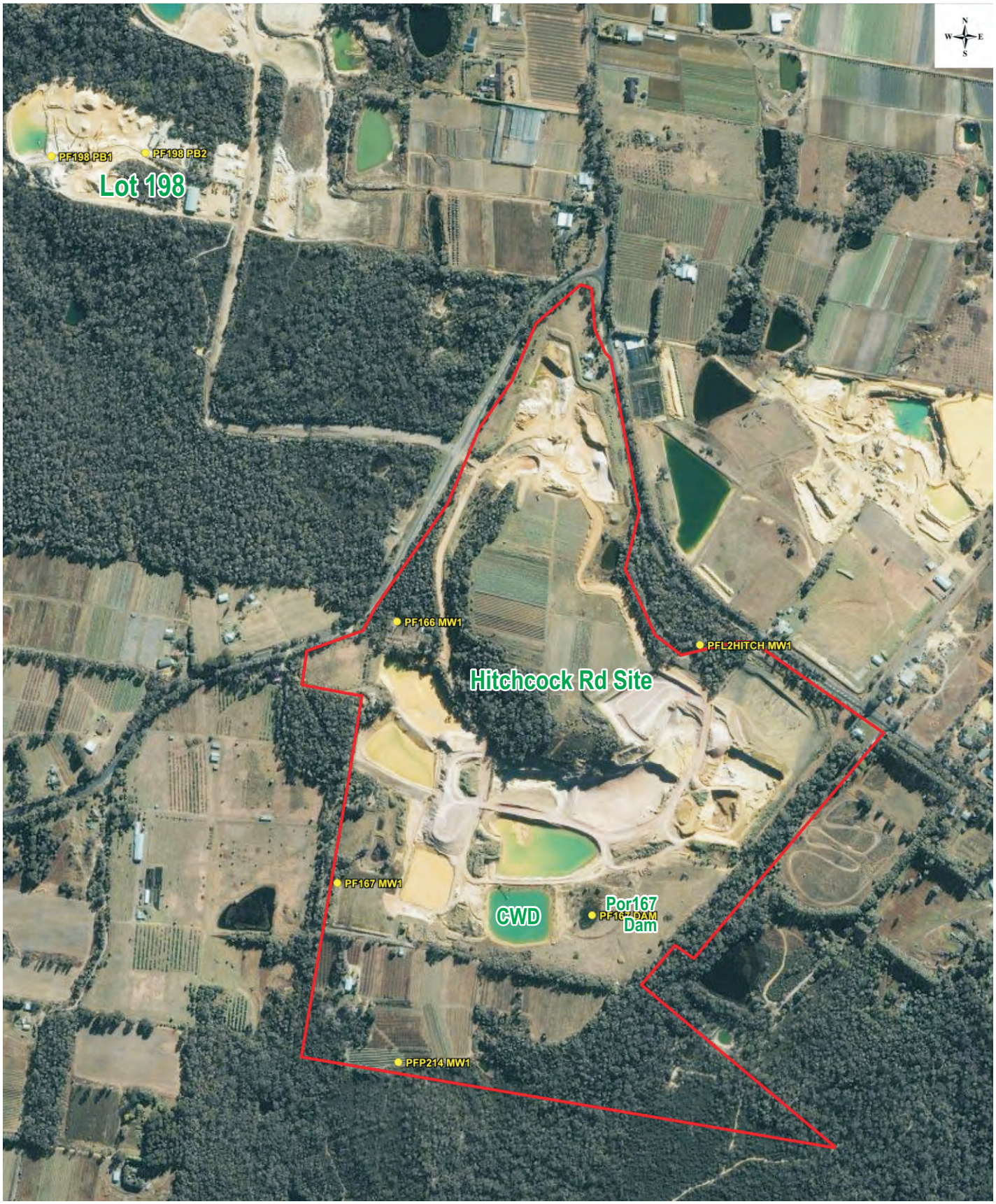
Date: *Aug 2019*

MAROOTA - HITCHCOCK ROAD SITE

Reference: *E2W_224_15.cdr*

Figure 1

earth2water
Pty Ltd
Environmental & Groundwater Consulting



LEGEND

Site Boundary

Groundwater Monitoring Location

0 254.4
metres

Source: URS

SITE LOCATION- Hitchcock Rd & Lot 198 (August 2019)

Date: *Aug 2019*

Reference: *E2W_224_07.cdr*

PF FORMATION - Hitchcock Road, Maroota

Figure 2

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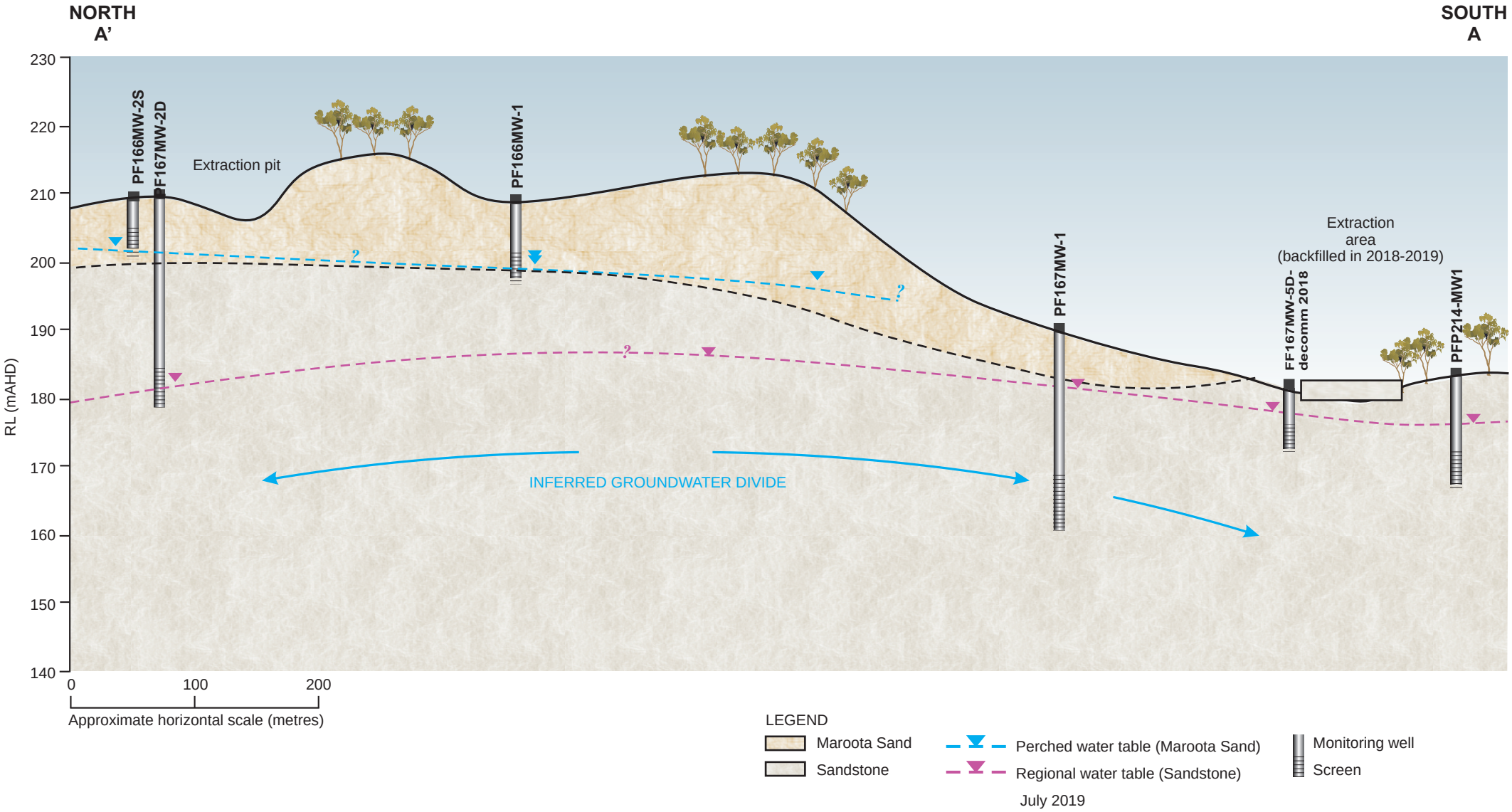


INFERRED HYDROGEOLOGICAL SECTION (N-S)

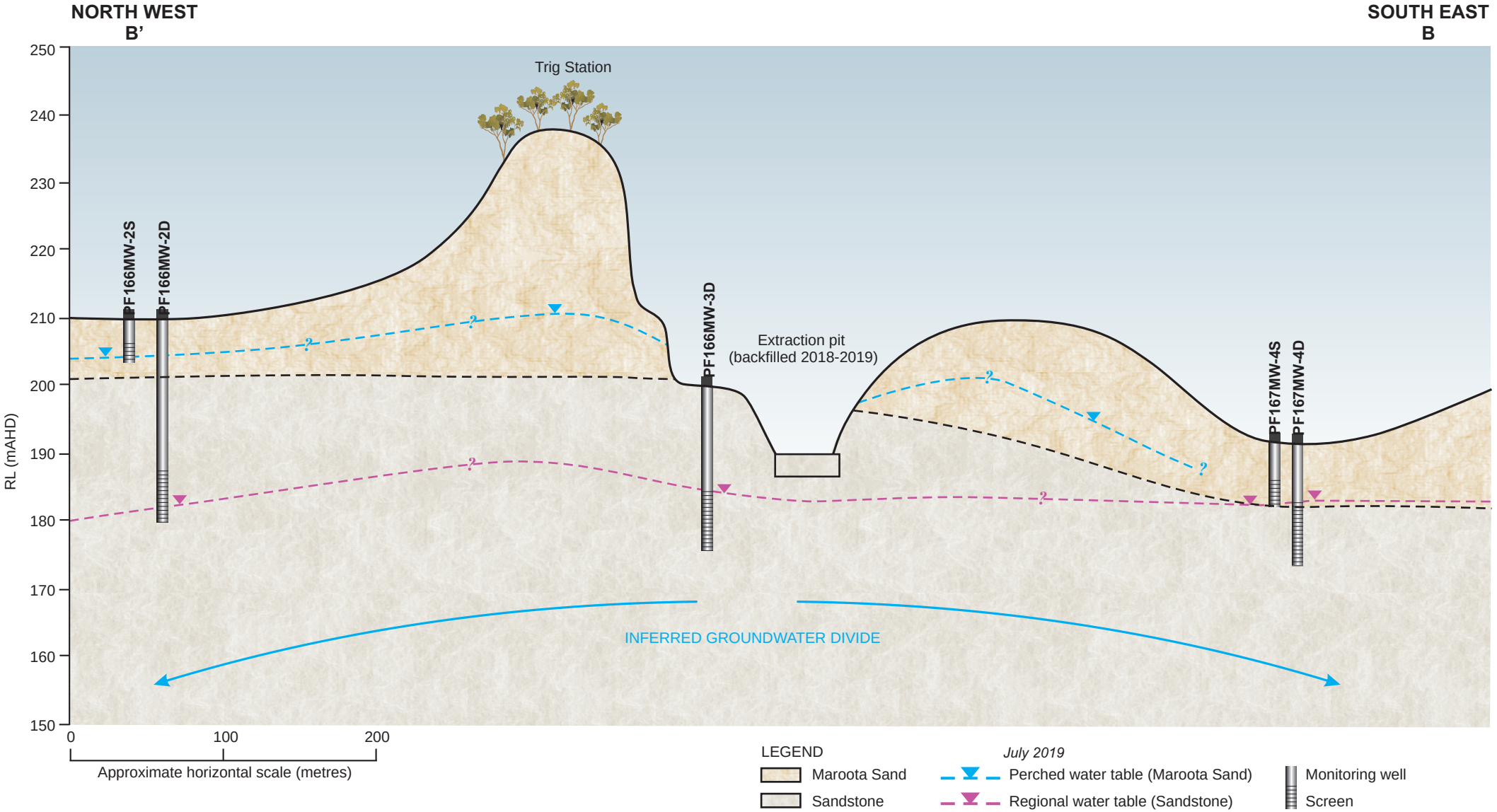
Date: Oct 2019

Reference: E2W_224_17.cdr

MAROOTA - HITCHCOCK ROAD SITE

Figure 3

earth2water Pty Ltd
Environmental & Groundwater Consulting



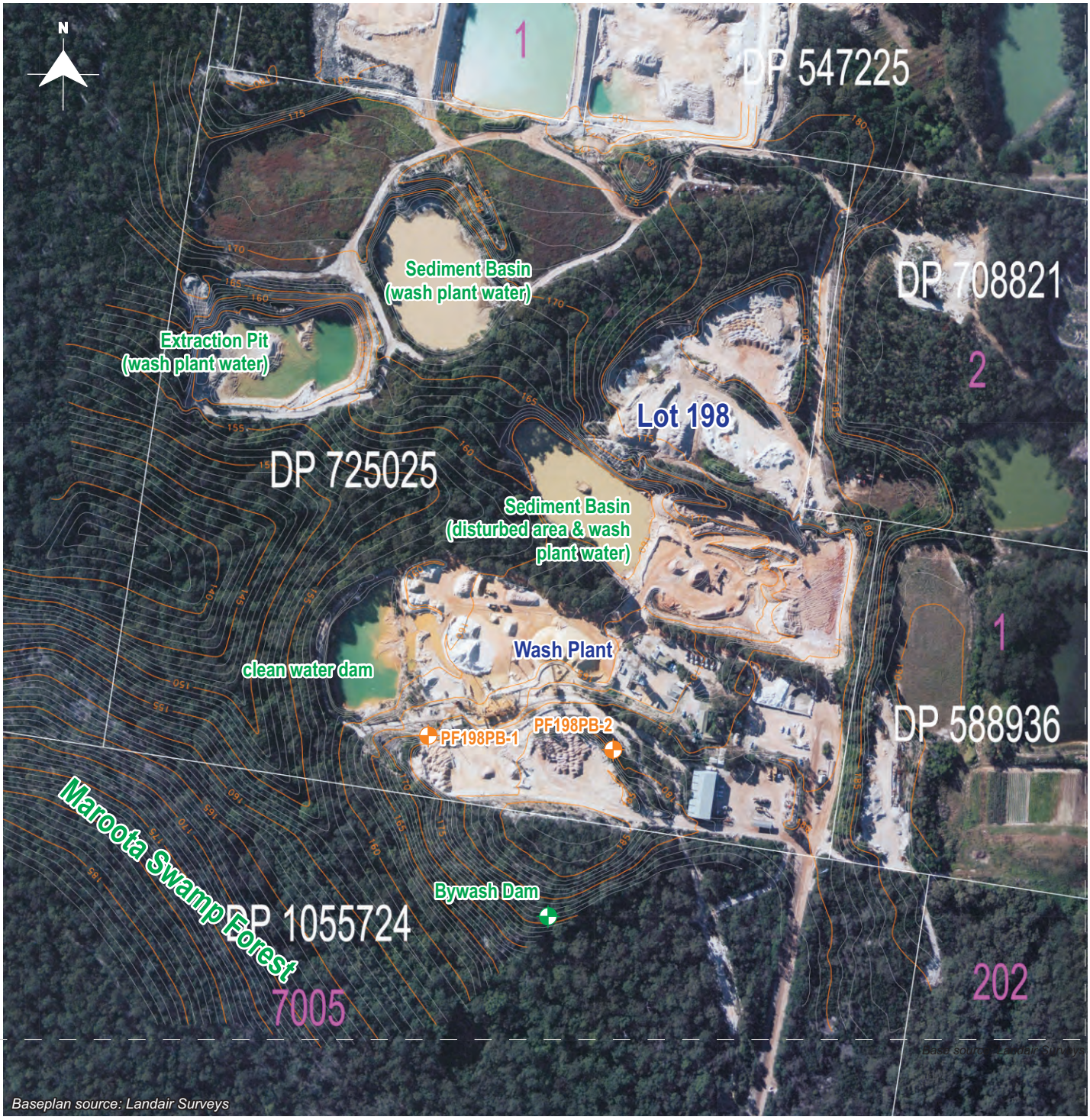
INFERRED HYDROGEOLOGICAL SECTION (NW-SE)

Date: Oct 2019

Reference: E2W_224_16.cdr

MAROOTA - HITCHCOCK ROAD SITE

Figure 4



0 30 60 90 120 150
Scale (metres)

LEGEND

PF198PB-1 Production Bore (sandstone aquifer)

Site Layout for Lot 198 (August 2019)

Date: *29 August 2019*

Reference: *E2W_224_22.cdr*

PF Formation: Maroota -Lot 198 Site

Figure 5