

HODGSON QUARRY AND PLANT PTY LIMITED

ROBERTS ROAD MAROOTA SAND QUARRY

GROUNDWATER STUDY REPORT

DUNDON CONSULTING PTY LTD

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1 INTRODUCTION

1.1 Background

The Hodgson Quarry located on Lots 1 & 2, DP228308 and Lot 2, DP312327 at Roberts Road Maroota extracts sand from the Tertiary aged Maroota Sands Formation paleochannel and the underlying/adjacent Triassic Hawkesbury Sandstone. The quarry has been operating for more than 15 years, under a Development Consent granted by the Minister for Urban Affairs and Planning on 31 May 2000 (DA 267-11-99). The 2000 Consent allowed the quarry to operate for 15 years. A Modification approved on 18 August 2015 (MOD 3) extended the project operation until 31 May 2016.

The original approval was based on an operations plan and resource estimate outlined in the original EIS (Nexus, 1999), but since that time the resource estimated has been increased, and certain of the original extraction methods had proved to be inefficient. A Modification Application was lodged on behalf of the owners on 23 September 2015, which sought to extend the life of the quarry from 15 to 25 years, allowing an extension to 31 May 2025. The Modification also included a number of amendments, which are mostly minor or administrative in nature. This Modification (MOD 2) was approved on 18 March 2016.

Figure 1 shows the status of quarrying as at June 2016. The lowest point in the quarry is currently at about 186 mAHD. This is at the location of the pump suction in the Main Process Dam, as surveyed on 12 September 2017). Maximum depth of excavation reached to date is believed to be approximately 180 mAHD, although all parts of the quarry below 186 mAHD have now been backfilled with tailings.

1.2 Purpose of this Report

This document is a Groundwater Study Report, which was required under Conditions 39 and 40 of the Modification Consent dated 18 March 2016. The specific requirements of Conditions 39 and 40 are as follows:

“Groundwater Study and Remediation Works

39. *Within six weeks of the date of approval of Modification 2, the Applicant shall commission a comprehensive groundwater study of the site. This study must:*
- (a) be prepared by suitably qualified and experienced person/s whose appointment has been endorsed by the Secretary and DPI-Water;*
 - (b) consult with DPI-Water;*
 - (c) examine all existing records of groundwater levels at the site;*
 - (d) develop an interim contour map of the wet weather high groundwater level of the regional aquifer, based on all available records (see also Condition 44); and*
 - (e) provide advice and recommendations on the Groundwater Monitoring Program as set out in Condition 43.*
40. *Unless otherwise agreed by the Secretary, the Applicant shall submit a report of the study to the Secretary and DPI-Water within six months of commissioning the study. The report must be accompanied by a Groundwater Management Improvement Program, based on the study’s findings and recommendations which includes a program of proposed timeframes for implementation. Should the Applicant propose not to implement any of the report’s recommendations, it must provide detailed justification to this effect.*

The Groundwater Management Improvement Program must be prepared and implemented to the satisfaction of the Secretary. Progress against the Program shall be reported through Annual Reviews and considered as part of the Independent Environmental Audit."

This report should be read in conjunction with the following additional reports:

- Roberts Road Maroota Sand Quarry – Groundwater Monitoring Program (Dundon Consulting, 2018)
- Roberts Road Maroota Sand Quarry – Groundwater Management Plan (Dundon Consulting, 2018)
- Surface Water Management Plan – Maroota Quarry via Maroota (VGT, 2017).

2 HYDROGEOLOGICAL SETTING

2.1 Rainfall and Evaporation

The monthly average total rainfalls recorded at the nearest Bureau of Meteorology station Number 67014 (Maroota – Old Telegraph Road) are shown in **Table 1**.

Table 1: Monthly Rainfall and Evaporation (mm)

Rainfall	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean	98.3	110.6	104.3	87.7	58.3	93.3	45.6	52.5	53.2	64.8	80.4	80.4	929.4
Median	70.9	82.1	82.4	58.5	42.0	57.4	26.4	22.8	41.3	53.6	70.2	75.8	
Highest	146.1	167.1	220.2	183.1	140.7	172.0	161.0	325.0	110.7	83.1	94.4	92.2	
Mean monthly evaporation	183	138	124	90	65	51	56	84	114	146	150	174	

Station 67014, Maroota (Old Telegraph Road) is located opposite the junction with Roberts Road, and is less than 1 km from the quarry. The station has a long record, covering the period from 1925 to 2018.

The nearest evaporation data available on the BoM website are from Richmond UWS Hawkesbury (Station 067021), and covers the period from 1973 to 2018. Station 067021 is approximately 25 km from the quarry.

2.2 Surface Drainage

The project is located in an incised area of Hawkesbury Sandstone plateau. The topography is therefore quite steeply undulating, with relatively steep valley sides, and steep cliff faces in some places. Within the property on which the quarry is located, the terrain is a moderately undulating valley domain.

The natural drainage of the site was originally in a northerly direction, with the local creek system flowing into Coopers Creek approximately 2 km to the north (Woodward-Clyde, 1999).

The site is currently largely internal draining. There are two dams on DP228308 on the western side of the property, which capture runoff from upslope areas including a limited area off the quarry property. The water in the northernmost dam Dam 3 (**Figure 1**) is used as a water supply source for the nursery located at the north-western corner of the property. Water has at times been pumped from the other water supply dam Dam 4 to supplement the quarry water supply. At other times, water has been transferred from the quarry operations into Dam 4, to assist with ongoing quarry water management.

The main Process Dam 1 (**Figure 1**) is the primary component of quarry water management. Runoff from the quarry area, as well as the water product from the sand washing process, gravitates to Dam 1, from where it is pumped back as required to provide the primary water source for the quarrying operations, mainly for sand washing purposes. Hence Dam 1 acts primarily as a water storage, but collects runoff from the disturbed areas of the quarry site. There is no surface outflow from Dam 1.

Elsewhere on the quarry site, runoff is diverted around the disturbed area via diversion bunds where possible and the natural topography assists. A portion of clean water from the undisturbed areas and properties adjacent to the quarry on Roberts Road does enter the main quarry area. Dirty water

is collected in the disturbed areas into either the main site dam (Dam 1 on **Figure 1**), or into one of the tailings storages, an active Dam 2 and an inactive Dam 3 (**Figure 1**) to allow for settling to occur.

2.3 Geology

The project is located within the Permian to Triassic Sydney Basin. The quarry recovers sands from the Maroota Sands formation, which is of Tertiary age and occupies a paleochannel system incised into the underlying Hawkesbury Sandstone and Ashfield Shale basin sediments. Sand is also recovered from superficial eluvial sands derived from in situ weathering of the Hawkesbury Sandstone, and from the Hawkesbury Sandstone itself.

The general stratigraphy for the Maroota area is shown in **Table 2**.

Table 2: Stratigraphic Sequence at the Maroota Project Site (adapted from AGT (2015), after Woodward-Clyde (1999) and Etheridge (1980))

Age	Unit	Lithology	Comment
Quaternary	Soils	Variable	
Tertiary	Maroota Sands	Sand, gravel, clayey sand and clay	Reworked Hawkesbury Sandstone. Paleochannel sands including clay and ferricrete bands (cemented ironstone). Outcrops at project site and is the target of quarry activities.
Triassic	Ashfield Shale	Shale and laminate	Not present at project site.
	Hawkesbury Sandstone	Quartzose sandstone with shale lenses	Weathered upper profile (eluvial sands) underlain by competent sandstone. Eluvial sands outcrop to north and west of quarry.

2.4 Hydrogeology

Groundwater is present within the Maroota Sands and the underlying Hawkesbury Sandstone. Groundwater in each of these two formations is regionally extensive and forms a regional water table in each. Localised groundwater is also present in perched aquifers within the Maroota Sands, as well as on top of or within the Hawkesbury Sandstone, above the regional water tables. Thus, localised groundwater may be intersected at a number of elevations above the regional water table levels.

Since the original consent in 2000, two groundwater policies affecting these aquifers have been introduced, namely:

- *The Greater Metropolitan Region Groundwater Sources Water Sharing Plan 2011 (WSP)* (NSW Government, 2011); and
- The Aquifer Interference Policy (NSW Office of Water, 2012).

The WSP defines two water sources for the locality –

- the **Maroota Tertiary Sands Groundwater Source (MTSGS)** which includes the total extent of the Maroota Sands paleochannel formation as well as connected Hawkesbury Sandstone eluvium, as defined by a map contained in the WSP; and

- the **Sydney Basin Central Groundwater Source** (SBCGS) which includes the Hawkesbury Sandstone formation over an area defined by a map in the WSP.

Protection measures for both water sources are detailed in the WSP.

The MTS GS is directly recharged by infiltration of rainfall and local runoff, and downward percolation to the water table, or to any perched water table present. The SBCGS is recharged by infiltration of rainfall and runoff in areas where fresh rock outcrops at the ground surface, or through downward leakage from overlying Maroota Sands, alluvium or eluvium. Groundwater levels in both units display fluctuations that relate to episodic recharge associated with major rainfall events. The recharge responses are particularly marked in the Maroota Sands.

No eluvium has been encountered on the Roberts Road Maroota site.

3 GROUNDWATER INVESTIGATIONS

3.1 Site Hydrogeology Revealed from Drilling and Quarry Excavations

Only limited drilling has been undertaken on the site. No drilling specifically for sand resource evaluation has been undertaken during the past 15 years.

Thirteen bores have been drilled for installation of groundwater monitoring piezometers. These have revealed stratigraphic information, including the depths of the interface between Maroota Sands and the underlying Hawkesbury Sandstone, and lithological information including the presence of more clayey zones within the Maroota Sands. The south-western part of the site has been found to be more clayey than the main trunk paleo valley.

The north-eastern corner of the site has been excavated for sand extraction through the full thickness of the Maroota Sands and into the Hawkesbury Sandstone, with the top of the sandstone occurring well above the regional water table levels. The Hawkesbury Sandstone is exposed over the north-eastern portion of the site in the current landform. The presence of Hawkesbury Sandstone above the water table in that area has allowed the eastern boundary of the paleochannel to be delineated accurately.

No significant seepage within the Maroota Sands has been observed during quarrying activity, apart from a small localised persistent seepage at a central location just west of the Tailings Dam 2. This seepage location is marked on **Figure 2**.

Minor seepages are present above the Hawkesbury Sandstone in the north-eastern corner of the site, causing minor flows from gullies into the Process Dam 1. These are believed to be fed by rainfall and local infiltration into residual unconsolidated material on the excavated landform upslope (north-west) from Dam 1. The volume of these inflows is very small, estimated at much less than 1 L/s in total.

3.2 Historical Monitoring Bore Installation

Three (3) monitoring bores (MW1 to MW3¹) were installed on the site in 1998 as part of the groundwater investigations undertaken to support the EIS for the initial project development application. MW2 became blocked in early 2000 by an obstruction above the water level in the bore, and was not able to be monitored thereafter. Bore MW3 was mined out by quarrying activity, and was replaced by MW4, which in turn was also later lost to quarrying.

MW5 was installed in 2013 as a replacement for MW2 at an adjacent site, however it too was found to be blocked and has also been removed from the monitoring network. MW6 was installed in 2015 as a replacement for MW4, and remains in place along with MW1.

Locations of current and former bores are shown on **Figure 2**.

Falling head tests were conducted on bores MW1, MW2 and MW3, but there is no record of hydraulic testing of the replacement bores MW4, MW5 or MW6.

Bores MW1, MW3, MW4 and MW5 were sampled for comprehensive laboratory analysis on limited occasions up until June 2013. No water quality monitoring of groundwater was undertaken between June 2013 and December 2016.

¹ The existing monitoring bores on the quarry site have the nomenclature PT84MW1 to PT84MW6 and the production bores PT84PB1 and PT84PB2. For simplification purposes, throughout this report, the bore nomenclature has been shortened to MW1 to MW6 and PB1 to PB2. The new monitoring bores installed in December 2016 have been named MW7 to MW13, continuing the previous nomenclature.

3.3 Installation of Additional Monitoring Bores – December 2016

A major expansion of the monitoring network was undertaken in December 2016, with seven (7) new monitoring bores installed at locations shown on **Figure 2**. These were installed to meet a compliance requirement of the 2016 MOD 2 approval.

The new bores provide a broader coverage of the site, and allow monitoring of each of the main hydrogeological units, Hawkesbury Sandstone and Maroota Sands.

Two of the new bores were installed at sites where monitoring bores already existed. Two bores were installed at one of the new sites. This has resulted in a cluster of bores at three of the monitoring sites, with separate bores monitoring at different depths, viz:

- MW1 (Maroota Sands) and MW7 (Hawkesbury Sandstone) – near north-west corner of the site;
- MW2 (perched Maroota Sands), MW5 (partially penetrating Maroota Sands), and MW8 (fully penetrating Maroota Sands); supplemented by two of DoI-Water's bores GW075003 and GW075004 (both in Hawkesbury Sandstone) – located near the south-western boundary of the site; and
- MW9 (Hawkesbury Sandstone) and MW13 (Maroota Sands) – located towards the western side of the current quarry, in an area earmarked for extraction in the next 2-3 years.

The locations of these bore clusters can be seen on **Figure 2**. Bore logs are presented for all bores in **Appendix A**. Logs for the DoI-Water bores are presented in **Appendix B**.

Each of the new monitoring bores was subjected to a falling head permeability test, and each one was sampled for a comprehensive laboratory analysis of the major anions and cations, as well as physical parameters. Distribution of Maroota Sands and Hawkesbury Sandstone

The upper surface of the Hawkesbury Sandstone has been encountered at varying depths in the recent drilling program. Some of the earlier drilling did not extend to sufficient depth to fully penetrate the Maroota Sands (MW2, MW3, MW4 and MW5).

The elevations of the top of Hawkesbury Sandstone are shown on **Figure 3**. Sites where the top was not encountered are marked with the maximum possible elevation, although it is almost certainly somewhat deeper at the above bore sites that were not drilled deep enough. The Hawkesbury Sandstone surface elevations shown at two locations near the bank on the eastern side of the main process water dam (Dam 1) are the current surveyed elevations, not the pre-quarrying elevation. The excavated landform is comprised of exposed Hawkesbury Sandstone in the area to the east of Dam 1. The original Hawkesbury Sandstone surface elevations in this area are not known.

Elevations of the top of Maroota Sands and its thickness are plotted on **Figure 4**. As above, the minimum thickness is shown at sites that were not drilled to the base of the Maroota Sands (ie MW2, MW3, MW4 and MW5). At sites where drilling took place within the partly excavated quarry (PB1, MW3 and MW4), the surface elevations at the time of drilling are used.

The elevations and Maroota Sands thickness have not been contoured on **Figures 3 and 4**, as there is minimal off-site data available to allow sensible contouring which takes account of the regional position.

3.4 Hydraulic Properties

The results of falling head permeability tests (slug tests) conducted on each of the recently installed monitoring bores, MW7 to MW13, are presented in **Appendix C**, and summarised in **Table 3**. The results of earlier testing of MW1 to MW3 (Woodward-Clyde, 1999) are also included in **Table 3**.

Table 3: Results of Hydraulic Testing Program

Bore	Aquifer	Date of slug test	Average Hydraulic Conductivity	
			m/s	m/d
MW1	Maroota Sands	26 October 1998	6.7×10^{-7}	0.058
MW2	Maroota Sands	26 October 1998	1.4×10^{-8}	0.0012
MW3	Maroota Sands	26 October 1998	2.9×10^{-6}	0.25
MW7	Hawkesbury Sandstone	16 December 2016	1.7×10^{-8}	0.0015
MW8	Maroota Sands	20 January 2017	1.08×10^{-6} * 2.9×10^{-7}	0.093 *0.025
MW9	Hawkesbury Sandstone	20 January 2017	4.4×10^{-7}	0.038
MW10	Maroota Sands	20 January 2017	1.1×10^{-5} * 6.1×10^{-6}	0.99 *0.53
MW11	Maroota Sands	20 January 2017	4.2×10^{-6}	0.36
MW12	Hawkesbury Sandstone	22 December 2016	3.9×10^{-7}	0.034
MW13	Maroota Sands	16 December 2016	2.0×10^{-7}	0.017

* Late time data, representing conditions further from the bore.

Hydraulic conductivity values determined from testing the Maroota Sands ranged from 0.0012 m/d to 0.99 m/d, with an average value of 0.25 m/d. The Maroota Sands at three of the sites was clayey, and revealed relatively low conductivity values. The three sites where clean Maroota Sands were encountered (MW3, MW10 and MW11) gave much higher conductivity values, more consistent with the typical range for unconsolidated clean sands.

Values for the Hawkesbury Sands ranged from 0.0015 m/d to 0.038 m/d, with an average value of 0.025 m/d.

In summary, the following approximate hydraulic conductivity ranges are considered to apply to the three main hydrogeological units encountered at the site:

- Maroota Sands – clean sands and gravels, and clayey sands/gravels – 0.1 to 1.0 m/d
- Maroota Sands – sandy clays, silty clays, and clays – 0.01 to 0.1 m/d
- Hawkesbury Sandstone – 0.001 to 0.05 m/d.

The deepest excavated depth in the quarry was believed to be approximately 180 mAHD. However, the deepest parts of the quarry have now been backfilled with fines settled from either tailings or recycled process water. There are residual silts and clays in the base of Dams 1 and 2 and the unnamed former tailings dam.

The water-filled Process Dam 1 is now the lowest part of the quarry. A probing survey conducted in September 2017 established the depth to the top of sediment in Dam 1, finding that the water depth over most of the area of Dam 1 is between 0.1m and 0.7m, with a small localised area of greater water depth around the water recovery pump inlet, where water depth reached a measured maximum of 2.95m. Most of Process Dam 1 has a base elevation in the range 187.1 to 187.6 mAHD, with the deepest measured point near the pump inlet being at 184.8 mAHD.

The fines in the Process Dam 1, Tailings Dam 2 and the unnamed former tailings dam to the north of Dam 2 have a very low hydraulic conductivity. Testing of the in situ conductivity of the settled fines has not been possible due to inaccessibility and safety concerns. However, there is clear evidence of the low conductivity, viz:

- There is no evidence for mounding beneath or downgradient from the site;
- Hydrographs show a declining water level trend in both MW10 and MW6 (up-gradient), and MW11 (down-gradient from Dam 1) – see **Figure 5**.
- There is a clear downstream gradient that appears to be unaffected by the Dam (**Figure 5**).
- All four hydrographs depicted in **Figure 5** are responding primarily to the rainfall pattern, with trends conforming generally with the Maroota RCD curve.
- There is at all times a distinct head difference between the dam water levels and the underlying groundwater levels (see **Figure 5**). The relative water levels measured on 5 April 2018 were:
 - Dam 1 - 187.2 mAHD
 - MW6 (up-gradient) - 183.2 mAHD, and
 - MW11 (down-gradient) - 180.4 mAHD.
- The recession trend in the Dam water level is similar to the recession trends in the up-gradient bores (MW6 and MW10), and less steep than in the down-gradient bore MW11 (**Figure 5**).
- The recession trend in MW11 downstream of Dam 1 is much steeper than the recession trends in both the dam water level itself and the upstream bores (**Figure 5**).

The three groundwater bore levels are at all times several metres lower than the Dam 1 water level. Any leakage from the dam would be expected to result in relatively higher groundwater levels beneath and down-gradient from the dam. However, no such mounding on the water table is apparent, and there is no evidence that the groundwater downstream of the Dam is receiving more recharge than is being received upstream.

Leakage from Dam 1 would also be expected to result in a gentler downstream recession trend during periods of low rainfall, due to the recharging effect of the leakage from the Dam. However, the down-stream recession trend at MW11 is steeper than the upstream recession trends and the Dam recession trend.

Any downward leakage from the dam would have been reflected in a mounding beneath the dam, and a recharge effect in the downstream bore MW11. Both these effects are absent, suggesting strongly that there is negligible leakage from Dam 1, and therefore the residual clay and silt in the base of the dam has very low permeability.

3.5 Groundwater Quality

Historically, there has been limited sampling for comprehensive laboratory analysis of major ionic composition. MW1 and MW3 were analysed once in 1998, PB2 was analysed once in 2005, MW1 and MW4 annually from 2010 to 2013, and MW5 once in 2013. Groundwater quality was not monitored in any bore between June 2013 and December 2016.

Samples from each of the new monitoring bores MW7 to MW13 were collected in December 2016 – January 2017, and submitted to ALS for comprehensive water quality analysis. All monitoring bores, PB1 and the dams were sampled in July 2017, January 2018 and April 2018 as part of ongoing monitoring.

3.5.1 Laboratory Analysis Results

The results of laboratory analysis for major ion composition are presented in **Table 4**.

Table 4: Laboratory Water Quality Analysis Results

Bore	Aquifer	Date sampled	pH	EC @ 25°C	TDS @ 180°C	OH alkalinity	CO ₃ alkalinity	HCO ₃ alkalinity	SO ₄	Cl	Ca	Mg	Na	K	Total anions	Total cations	Oil and grease	
Units			pH units	µS/cm	mg/L	mg/L CaCO ₃	mg/L CaCO ₃	mg/L CaCO ₃	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L	mg/L	
MW1	Maroota Sands	23 Oct 98	4.96	246	186	<1	<1	4	3	50	3	3	27	3				
		19 Oct 10	4.24	174	150	<1	<1	3.6	4	30	1	6	12	2				
		22 Jun 11	5.18	122	169	<1	<1	4.8	8	143	5	5	19	2				
		20 Jun 12	4.87	174	320	<1	<1	<1	8	31	1	5	13	6				
		19 Jun 13	4.93	312	820	<1	<1	<1	8	59	6	12	22	6	1.83	2.40		
		27 Jul 17	4.1	355	247			<5	4	47	5	14	25	4				
		11 Jan 18	4.14	396	247*													<5
		5 April 18	4.2	385														
MW3	Maroota Sands	23 Oct 98	5.88	381	266	<1	<1	4	3	50	3	9	27	3				
MW4	Maroota Sands	19 Oct 10	4.58	138	100	<1	<1	2.4	1	29	<1	3	16	<1				
		22 Jun 11	3.23	151	99	<1	<1	2.4	2	33	<1	3	17	1				
		20 Jun 12	4.45	141	123	<1	<1	<1	22	26	<1	4	14	1				
		19 Jun 13	4.49	152	95	<1	<1	<1	<1	36	<1	4	16	1	1.02	1.05		
MW5	Maroota Sands	19 Jun 13	4.13	140	158	<1	<1	<1	1	34	<1	2	15	<1				
		27 Jul 17	5.1	113	61			5	2	22	1	1	13	2				
MW6	Maroota Sands	27 Jul 17	9.3	103	55			19	<1	18	2	1	12	5				
		11 Jan 18	7.09	110	69*													<5
		5 April 18	10.3	406														
MW7	Hawkesbury Sandstone	22 Dec 16	7.00	255	282	<1	<1	50	17	27	4	1	46	<1	2.11	2.28		
		27 Jul 17	5.3	192	215			12	9	29	<0.5	<0.5	59	<0.5				
		11 Jan 18	5.45	170	106*													<5
		5 April 18	5.8	237														

Table 4: Laboratory Water Quality Analysis Results

Bore	Aquifer	Date sampled	pH	EC @ 25°C	TDS @ 180°C	OH alkalinity	CO ₃ alkalinity	HCO ₃ alkalinity	SO ₄	Cl	Ca	Mg	Na	K	Total anions	Total cations	Oil and grease	
MW8	Maroota Sands	20 Jan 17	5.68	161	114	<1	<1	5	1	36	3	3	26	<1	1.14	1.53		
		27 Jul 17	5.1	178	118			8	2	37	4	3	26	<0.5				
		11 Jan 18	4.66	183	114*													<5
MW9	Hawkesbury Sandstone	20 Jan 17	6.71	175	134	<1	<1	18	4	32	8	2	25	<1	1.34	1.34		
		27 Jul 17	4.9	148	96			<5	2	24	3	2	16	0.8				
		11 Jan 18	4.64	183	73*													<5
		5 April 18	4.6	148														
MW10	Maroota Sands	20 Jan 17	5.45	184	104	<1	<1	2	<1	42	1	4	30	<1	1.22	1.22		
		27 Jul 17	4.7	180	108			<5	<1	39	0.6	4	27	0.6				
		11 Jan 18	4.53	186	116*													<5
		5 April 18	4.4	190														
MW11	Maroota Sands	20 Jan 17	6.34	169	98	<1	<1	5	7	34	4	2	24	3	1.20	1.20		
		27 Jul 17	4.7	154	90			<5	<1	32	<0.5	2	19	1				
		11 Jan 18	4.69	158	99*													<5
		5 April 18	4.6	151														
MW12	Hawkesbury Sandstone	22 Dec 16	6.12	156	110	<1	<1	8	12	21	2	<1	23	3	1.00	1.18		
		27 Jul 17	5.3	96	72			11	7	13	2	0.9	12	<0.5				
		11 Jan 18	5.46	103	64*													<5
		5 April 18	5.2	102														
MW13	Maroota Sands	16 Dec 16	6.65	204	105	<1	<1	17	5	34	4	2	26	3	1.40	1.57		
		27 Jul 17	4.9	134	92			<5	1	27	2	2	16	<0.5				
		11 Jan 18	4.52	142	88*													<5
PB1	Hawkesbury Sandstone	27 Jul 17	4.6	148	88			<5	<1	30	<0.5	3	19	0.7				
PB2	Hawkesbury Sandstone	12 Sep 05	4.52	113	77			<1	<1	34	<1	3	17	<1				

Table 4: Laboratory Water Quality Analysis Results

Bore	Aquifer	Date sampled	pH	EC @ 25°C	TDS @ 180°C	OH alkalinity	CO ₃ alkalinity	HCO ₃ alkalinity	SO ₄	Cl	Ca	Mg	Na	K	Total anions	Total cations	Oil and grease	
Process Dam 1	-	27 Jul 17	4.5	134	90			<5	4	25	<0.5	2	16	2				
		5 April 18	4.4	229														
Tailings Dam 2	-	27 Jul 17	4.5	139	75			<5	4	25	<0.5	2	17	3				
		11 Jan 18	4.29	254	159*													<5
		5 April 18	4.3	249														
Nursery Dam 3	-	27 Jul 17	6.61	133	77			13	9	20	3	3	13	4				
		11 Jan 18	7.09	177	111*													<5
		5 April 18	7.8	223														
Farm Dam 4	-	27 Jul 17	6.6	116	63			15	3	20	2	3	13	2				
		11 Jan 18	6.87	165	103*													<5
		5 April 18	8.8	188														
Former Tailings Dam	-	27 Jul 17	4.9	77	49			<5	2	15	<0.5	1	11	1				

* TDS calculated from EC

The groundwater in the Maroota Sands is generally low salinity, with lab measurements of EC ranging from 122 $\mu\text{S}/\text{cm}$ (at MW1 in June 2012) to 381 $\mu\text{S}/\text{cm}$ (at MW3 in October 1998). It is moderately acidic, with laboratory pH values ranging from a low of 3.23 (at MW4 in June 2012) to a high of 5.88 (at MW3 in October 1998).

Groundwater quality in the Hawkesbury Sandstone aquifer system is low salinity (with EC ranging from 156 to 255 $\mu\text{S}/\text{cm}$), and is less acidic than the Maroota Sands groundwater, with near-neutral pH ranging from 6.12 to 7.00.

3.5.2 Monthly Water Quality Monitoring Data

From 1995 until 2013, field measurements of pH, EC and TDS were routinely conducted on samples collected at intervals ranging from monthly to 6-monthly. The results are presented graphically for pH and EC in **Figures 6** and **7**. **Figure 6** shows the full dataset, while **Figure 7** shows the water quality data for the period 2016-2018. Both plots include all available field and lab data.

The pH values range from 3.2 to 10.3, although during 2016-2018, the groundwater samples mostly had pH values in the range 4-7, apart from MW6, which has pH in the range 7-11. The Process Dam 1 and Tailings Dam 2 had pH in a similar range to the groundwater. However, the surface water samples (Nursery Dam 3 and Farm Dam 4) had pH in the range 6.6-8.8.

EC values range from 46 $\mu\text{S}/\text{cm}$ (MW3) to 543 $\mu\text{S}/\text{cm}$ (MW2). During 2016-2018, most values were between about 100 and 250 $\mu\text{S}/\text{cm}$. The exceptions are MW1, which has a consistently higher EC than the other groundwater and surface water samples in the range 350-400 $\mu\text{S}/\text{cm}$.

The April 2018 sample from MW6 appears to be anomalous, with pH and EC both higher than past values (10.3 and 406 $\mu\text{S}/\text{cm}$ respectively). The quality at the up-gradient bore MW10 remained consistent with previous months (pH 4.4 and EC 190 $\mu\text{S}/\text{cm}$). Likewise the water sampled from the Process Dam 1 on that date reported a pH of 4.4 and EC of 190 $\mu\text{S}/\text{cm}$, hence the change in quality at MW6 was not due to leakage from Dam 1.

3.5.3 Groundwater Quality Characterisation

Major ion chemistry has been analysed using a Piper Trilinear Diagram, which uses the concentrations of the major cations (Ca, Mg, Na and K) and major anions (HCO_3 , Cl and SO_4) expressed as milliequivalents per litre (meq/L). The relative concentrations of the cations are plotted on a triangular cation field, and the relative concentrations of the anions on an anion field, and these plotted locations are then projected onto a diamond shaped field that allows the relative ionic concentrations of each sample to be plotted as a unique point.

By comparing the plotted locations of different samples, inferences can be drawn about the sources of different waters, and potential mixing of waters from different sources, as well as proximity to rainfall recharge.

Piper diagrams of all the lab analysis results from the Roberts Rd quarry site are presented as **Figures 8** and **9**. The monitoring bores MW1 to MW13 are plotted in **Figure 8**, while **Figure 9** shows the two production bores PB1 and PB2, and waters sampled from the site dams.

Figures 8 and **9** show only small differences between the Maroota Sands and the Hawkesbury Sandstone groundwaters. All groundwater samples collected from beneath the regional water tables of both aquifers are clustered generally close to the right-hand side of the main field on the Piper diagram, which is characterised by low bicarbonate relative to the other anions, and varying proportions of sodium plus potassium versus calcium plus magnesium among the major cations.

However, there are greater differences between the water chemistry of the regional groundwater and groundwater in perched aquifers.

The perched groundwater in Maroota Sands on this site has more calcium plus magnesium and less sodium plus potassium than the regional Maroota Sands groundwater, but with similar low levels of bicarbonate (**Figure 8**). The perched Hawkesbury Sandstone groundwater differs from the regional Hawkesbury Sandstone groundwater by a higher relative concentration of bicarbonate (15-50% of total anions) than the regional Hawkesbury Sandstone groundwater (less than 5% of total anions).

In summary, the water quality of the Maroota Sands groundwater is characterised by the following:

- Low salinity;
- Acidic pH, in the range 3.5 to 6.5;
- Anionic composition dominated by chloride (generally over 80% of total anions), with very low bicarbonate (less than 10%), and occasional moderately higher concentrations of sulphate (MW4, MW8 and MW12); and
- Cationic composition dominated by sodium + potassium (between 40% and 80%), with low calcium (less than 20%), and magnesium between 10% and 45%.

The Hawkesbury Sandstone groundwater quality from beneath the project site is characterised by the following:

- Low salinity;
- Near neutral pH, in the range 6.1 to 7.0;
- Anionic composition is more variable, with sulphate 5 to 25%, chloride 35 to 70% and bicarbonate less than 5% in regional aquifer and 15 to 50% in perched groundwater; and
- The cations are dominantly sodium + potassium (65 to 90%), with very low magnesium (less than 10%), and low calcium (10 to 30%).

The low EC indicates that both aquifer systems are readily recharged by infiltration of rainfall.

3.6 Groundwater Levels

Measured groundwater levels beneath the Maroota sand quarry property range from around 170 mAHD to around 210 mAHD.

The most recent water level measured in each monitoring bore, including the bores that are no longer available, is listed in **Table 5** and shown on **Figure 10**.

Five cross-sections have been prepared to illustrate the relationship between the observed groundwater levels in the monitoring bores. The cross-sections are presented as **Figures 11 to 15**. The locations of the cross-sections are shown on **Figure 2**.

Cross-sections BB' and CC' have been extended to include relevant information from the adjacent PF Formation quarry to the west of the Roberts Road quarry.

Table 5: Monitoring Bore Water Levels

Bore	Screened Interval (m BGL)	Aquifer	Water Level		
			Date	m BGL	m AHD
MW1	4.9-9.9	Maroota Sands (perched)	5 Apr 2018	7.76	205.66
MW5	32-44	Maroota Sands (perched)	20 Sep 2017	34.31	192.69
MW6	24-29	Maroota Sands	5 Apr 2018	19.29	183.18
MW7	30-36	Hawkesbury Sandstone	5 Apr 2018	29.22	183.74
MW8	37-40	Maroota Sands (perched)	5 Apr 2018	34.52	192.49
MW9	44.5-50.5	Hawkesbury Sandstone	5 Apr 2018	38.55	187.03
MW10	44-47	Maroota Sands	5 Apr 2018	33.04	184.08
MW11	24-28.5	Maroota Sands	5 Apr 2018	11.98	180.37
MW12	23-26	Hawkesbury Sandstone	5 Apr 2018	16.03	194.25
MW13	27.5-30.5	Maroota Sands (perched)	5 Apr 2018	26.58	198.92
MW2*	19.5-25.5	Maroota Sands (perched)	10 Mar 2000	23.75	203.14
			9 Jan 2017	>20.7	<206.2
MW3**	14.9-20.9	Maroota Sands	6 Jul 2009	18.95	183.48
MW4**	19.5-28.5	Maroota Sands	19 Jun 2013	24.06	187.94***
PB1	>28.8	Hawkesbury Sandstone	19 Aug 1999	14.10	179.40***
PB2	>53	Hawkesbury Sandstone	5 Jul 2002	42.11	173.99***
GW75003	72-75	Hawkesbury Sandstone	27 Aug 2015	46.12	178.51
GW75004	54-57	Hawkesbury Sandstone	9 Jan 2017	40.11	185.94

* Bore obstructed at 20.7 m below ground level. Dry to this depth.

** Bore lost to sand extraction.

*** Estimated - surface RL not surveyed.

Red Most recent available water level.

3.6.1 Maroota Sands

Groundwater levels within the Maroota Sands formation range between approximately 180 mAHD (bore MW11) and 206 mAHD (bore MW1).

The deepest reported intersections of Maroota Sands were at MW6, MW10 and MW11, where the top of the Hawkesbury Sandstone was encountered at <173.5 mAHD, 168.1 mAHD and 164 mAHD respectively.

At these locations, the water level in the Maroota Sands on 5 April 2018 was at elevations of 183.2 mAHD, 184.1 mAHD and 180.4 mAHD respectively. All three water levels are lower than the current water level in the main process area dam (Dam 1), which on the same date was 187.2 mAHD. Similar water levels were reported from previous monitoring bores MW3 and MW4 before they were destroyed by the quarry expansion. The water levels in these five bores are believed to be true reflections of the regional water table level within the Maroota Sand aquifer.

Elsewhere on the site, groundwater levels within the Maroota Sands formation are elevated, in the range 192 mAHD to 206 mAHD. In some locations, the perched water levels may be further elevated due to leakage from the various dams on the property, in which the water levels on 5 April 2018 were determined by survey as follows:

- Process area – Dam 1 187.2 mAHD

- Tailings dam – Dam 2 199.11 mAHD
- Former tailings dam north of Dam 2 approx 200 mAHD (estimated from contours)
- Nursery Dam 3 205.40 mAHD
- Farm Dam 4 212.45 mAHD.

A persistent seepage zone has been observed in the active quarry about 120m east of Dam 4, at the location marked “**Seepage**” on **Figure 2**, close to the edge of Tailings Dam 2. This seepage is observed at an elevation of approximately 195 mAHD, ie about 20m lower than the Dam 4 water level. It is currently lower than the water level in the tailings dam (Dam 2), but when first observed it was at least 7m higher than the Dam 2 water level at that time. The seepage has been observed to dry up whenever water is pumped for an extended period from Dam 4 causing the water level in Dam 4 to be lowered, indicating a clear connection between the dam and the seepage.

There is localised perched groundwater present at some sites, either in shallow Maroota Sands where the top of the Hawkesbury Sandstone is above the regional water table elevation (such as on the flanks of the palaeovalley), or above a clayey aquitard within the Maroota Sands itself.

Examples of perched groundwater above shallow Hawkesbury Sandstone include:

- At bore MW1, which was terminated at 11.8m depth in Maroota Sands, and has continuously reported a water level in the range 205 to 209 mAHD. A new bore drilled in December 2016 at this site (MW7) was screened only in Hawkesbury Sandstone, and has a water level at around 184-185 mAHD. The top of Hawkesbury Sandstone was encountered at 14m BGL (199 mAHD) in MW7, and drilling revealed the upper part of the Hawkesbury Sandstone to be dry, between at least 199 and 185 mAHD. There was also no water intersected while the hole was being drilled through the Maroota Sands above 199 mAHD.

The groundwater level in MW1 is clearly a perched aquifer above the top of the Hawkesbury Sandstone surface. The relative water levels at this site are shown on a composite bore log on **Figure 16**, and on cross-section AA' (**Figure 11**).

The MW1 water level on 5 April 2018 (205.66 mAHD) was very similar to the water level at that time in nearby Nursery Dam 3 (205.40 mAHD). It is possible that the water intersected in MW1 may be sustained as a localised perched body hydraulically connected with Dam 3, which is about 75m from MW1 at its nearest point.

- There is a cluster of bores at the site of MW2, MW5 and MW8 (see **Figure 2**), all completed (screened) in Maroota Sands. MW2 was drilled to only 26.5m and screened from 19.5-25.5m, and reported a water level in the range 23.7 to 24.7 m BGL (202-203 mAHD), until the bore was found to be obstructed at shallower depth². Bore MW5 was drilled to 44m and was reported to be still in Maroota Sands at that depth. Bore MW8 was drilled in December 2016 to verify whether the water level in MW5 was perched, as MW8 had not reached the Hawkesbury Sandstone. MW8 was drilled to a depth of 49m BGL, and the top of the Hawkesbury Sandstone was interpreted from the drill cuttings to be at approximately 40m. The bore is screened only in Maroota Sands (see log in **Appendix A**). MW5 and MW8, both screened only in Maroota Sands, have a consistent water level at around 192-193 mAHD, about 10m lower than the level previously measured in MW2. The relative water levels at this cluster site are shown on a composite log **Figure 17**, as well as on cross-section BB' (**Figure 12**).
- Seepage was noted during drilling of bores MW8, MW9 and MW13 at 10-11m below ground surface, however in all three bores the drilling then revealed dry conditions below the seepage zone (see bore logs in **Appendix A**). Two of these bores (MW8 and MW9) are screened in Maroota Sands, and have standing water levels 10-15m below the seepage zone, confirming that the seepage zone is from a local perched aquifer. The relative

² The obstruction was measured at 20.7m BGL on 6 December 2016.

groundwater levels and seepage levels at bores MW9 and MW13 are shown on a composite bore log (**Figure 18**) and on cross-section BB' (**Figure 12**).

The composite log of MW2, MW5 and MW8, also showing the 2 Dol-Water bores GW75003 and GW75004 (**Figure 17**), shows two distinct standing water levels for the Maroota Sands, as well as the seepages reported during drilling, which are believed to indicate three separate perched groundwater occurrences in the Maroota Sands at this location. All Maroota Sands groundwater levels are well above the deeper water levels in the Hawkesbury Sandstone. GW75004 is not as deep as GW75003, and has a higher water level than GW75003. The higher water level in GW75004 may represent a perched aquifer horizon within the Hawkesbury Sandstone itself, or possibly it may be a composite level between the Hawkesbury Sandstone and the overlying Maroota Sands, as the bore annulus is open to the lowermost 10m of the Maroota Sands, albeit well above the screen interval (see cross-section BB' – **Figure 12**).

Taking into account the results of the December 2016 drilling, and considering the water levels in the dams on the site, it is now considered very likely that at least some of the elevated water levels in the Maroota Sands are caused by leakage from the dams which are all at significantly higher elevation than the nearby bore water levels.

Interpreted groundwater contours of the regionally continuous Maroota Sands water table are presented on **Figure 19**. In compiling these contours, the available information from the nearby PF Formation and Dixon Sands sand extraction projects to the west of the Roberts Road quarry has been considered together with the information from the project site.

None of the occurrences of perched groundwater within Maroota Sands is extensive enough to permit contouring. The reason for perched groundwater within the Maroota Sands arises from the varying lithology of the formation, which is formally described as comprising “clayey gravel, gravelly sand, pebbly sand and sand”, but with other horizons described as “clay and silty clay” and “ferruginised sand and pebbly sand”. The “ferruginised sand and pebbly sand” unit appears to be a basal unit, however the “clay and silty clay” unit appears to be gradational and interlayered with the cleaner sands and gravels.

Geological mapping by Etheridge (1980) identified an area of clayey Maroota Sands across the south-western side of the property. This clayey material was drilled as the dominant lithology in bores MW2, MW5, MW8, MW9 and MW13. Elsewhere, horizons of more clayey Maroota Sands were drilled in bores MW3, MW4, MW6, MW7, MW10, MW11 and MW12. The more clayey material would be relatively less permeable than the cleaner lithologies, and would be capable of forming a localised perching layer. In particular, a prominent clay unit close to the base of the paleochannel is reported in the logs of MW3 and MW11, which is believed to form a localised perching layer.

A Quaternary aged eluvial sand was mapped by Etheridge in places overlying the Maroota Sands formation. The eluvial alluvium has been included with the Maroota Sands in the defined MTSGS in the WSP (NSW Government, 2011). However, there is no evidence of any eluvial sands within or near the quarry site.

3.6.2 Hawkesbury Sandstone

Regional groundwater levels within the Hawkesbury Sandstone range between approximately 170 and 195 mAHD.

The regional groundwater level is interpreted to be at 170-180 mAHD (as illustrated by water levels in bores PB2, GW075003 and GW075004). However, like the Maroota Sands, there is perched groundwater within the Hawkesbury Sandstone, either naturally perched above shale bands or possibly artificially elevated by leakage from the site dams. Evidence for the latter is the rising trends seen on the hydrographs for PB2, GW075003 and GW075004 (**Figure 20**).

Interpreted regional groundwater contours of the Hawkesbury Sandstone beneath the quarry site are shown on **Figure 21**.

3.6.3 Groundwater Level Changes with Time

The groundwater levels are presented as hydrographs in **Figures 20 and 22 to 33**.

Figure 22 is a composite plot of all available manual monitoring data. **Figures 20 and 23 to 33** present individual hydrographs plotted against the Monthly Rainfall Cumulative Deviation (RCD) curves for the nearby Maroota BoM rainfall station.

The rainfall cumulative deviation (RCD) curve is derived by calculating the difference between actual monthly total rainfalls and the long-term average monthly rainfalls for the location. These monthly deviations from the average are then accumulated to develop a cumulative deviation curve. A rising trend on the curve results when monthly rainfalls over a period are above the long-term averages, and a downward trend arises when actual rainfalls are below average. The RCD curve for the Maroota BoM station are plotted on **Figures 20 and 23 to 33**.

During periods of below average rainfall, the hydrograph of a bore in an aquifer that receives regular recharge shows an overall downward trend, while still showing short-term rises in response to specific rainfall events. In periods of generally above average rainfall, the hydrograph shows an overall rising trend. By comparing the hydrograph with the RCD curve, it is easy to see whether the hydrograph fluctuations are related to rainfall recharge, or other causes, such as an impact from irrigation use or quarry dewatering.

Most hydrographs display a marked fluctuation in response to episodic rainfall recharge and natural discharge. The shallow groundwater responds quite quickly to recharge from larger rainfall events. This is typified by the hydrograph for bore MW1 (**Figure 18**), which shows short-term sharp rises in water level following many of the larger rainfall events, followed by a steady downward recession trend reflecting natural discharge from the shallow perched aquifer. Superimposed on the short-term fluctuations is a longer-term trend, which reflects the overall climatic conditions.

By contrast, the hydrographs for bores in the regional water tables of either the Maroota Sands or the Hawkesbury Sandstone show a much more attenuated response to specific rainfall events. However, even the deeper Dol-Water's Hawkesbury Sandstone bores GW75003 and GW765004 show a clear similarity between their hydrographs and the RCD curves.

There is no evidence from the hydrographs of any trend that could be attributed to any non-climate activity, apart from the possible effect of leakage from the site dams mentioned above.

At the most recent date of datalogger download (5 April 2018), water levels were at or near historic lows. The Maroota RCD curve has been on an overall downward trend since March 2017, due to mostly below average rainfalls during that time.

3.6.4 Wet Weather High Groundwater Levels

The wet weather high groundwater level (WWHGL) is defined in the Consent as:

'The rolling average of all recorded groundwater level measurements at any monitoring location on the site, as first recorded following any rainfall event of at least 50 mm over any 24-hour period, and as contour mapped using this data'.

For the Roberts Road Maroota site, the WWHGL has been calculated using the water level data from the historical monitoring records for all available monitoring bores on the site, taken immediately after any rainfall exceeding 50mm in any day, as determined using the BoM Maroota (Old Telegraph Road) meteorological station³.

³ During historical monitoring, water levels have not always been available immediately after a 24-hour rainfall of 50mm or more. Where necessary, the first available water level measurement after the rainfall event has been used in the table.

Separate WWHGLs have been determined for the Maroota Sands and the Hawkesbury Sandstone, using data only from bores interpreted to be screened below the respective regional water tables of the two aquifers. The calculations are presented in **Table 6**.

Contours of the wet weather high groundwater level, updated in April 2018, are depicted for the Maroota Sands and the Hawkesbury Sandstone on **Figures 19** and **21** respectively.

It is interpreted that the Maroota Sands regional water table is only present within the central part of the property, as the top of the Hawkesbury Sandstone rises above this water table level across the western and eastern flanks of the paleovalley. The Hawkesbury Sandstone outcrops along the eastern bank of the Main Process Water Dam 1. The lines marking the limit of saturated Maroota Sands are shown on **Figure 19**. West and east of these lines, there may be groundwater present in perched zones within the Maroota Sands, but the recent drilling program has shown that these zones are both limited in area and of limited saturated thickness.

The contours on **Figure 19** suggest a relatively gentle gradient to the north/north-northeast, down the axis of the paleovalley.

The regional water table (or potentiometric surface) of the Hawkesbury Sandstone has been encountered only in three of the deeper bores on site. The water levels in these bores have been used to construct tentative potentiometric surface contours across part of the site (**Figure 21**). These contours suggest a gradient to the northwest. On the eastern and western parts of the quarry site, the regional Hawkesbury Sandstone potentiometric surface lies below the top of the sandstone, whereas within the central zone occupied by the paleovalley, the potentiometric surface in some places is above the top of the Hawkesbury Sandstone. The potentiometric surface is well below the base of the quarry.

Table 6: Wet Weather High Groundwater Levels (18 April 2018)

Year	Date	Rainfall	Comment	Peak water level after >50mm/day rainfall (mAHD)												
				MW1	MW2	*MW3	*MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13
Collar Elevation (mAHD)				213.43	226.89	*202.43	*212.00	227.00	202.47	212.96	227.01	225.58	217.12	192.35	210.28	225.50
Screened Interval (mAHD)				*202-208		*181-187	*183-192	183-195	173-178	177-183	187-190	175-181	170-173	164-168	184-187	195-198
1999	24 October	59.0		208.1	203.1	183.6										
2000	9 March	54.0		207.8		182.8										
	17 November	56.0		207.3		182.5										
2001	31 January	53.0		208.0		182.9										
	6 February	50.0		208.0		182.9										
	20-21 March	55.0	2 day total	208.0		182.9										
2002	5 February	60.0		207.4		183.3										
	30 March	56.0		207.4		183.3										
	10 December	55.0		206.8		181.3										
2004	25-26 February	105.0	2 day total	206.6		181.0										
	21-22 October	61.0	2 day total	-		181.0										
2005	2-3 February	50.0	2 day total	-		180.5										
	21 February	60.0		-		180.7										
	23-27 November	55.0	5 day total	-		181.0										
2006	7 September	65.0		206.2		182.1										

Year	Date	Rainfall	Comment	Peak water level after >50mm/day rainfall (mAHD)												
				MW1	MW2	*MW3	*MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13
2007	13 February	52.2		206.2		182.1										
	9 June	172.0		206.2		182.1										
	20 July	136.5		207.7		183.1										
	6 December	50.6		207.7		183.1										
2008	5 June	51.0		207.7		183.1										
2009	2 April	51.0		206.5		183.5										
	22 May	78.0		206.5		183.5										
2010	7 February	75.0		205.6			186.6									
2011	20 August	74.5		206.0			189.3									
2012	18 April	52.0		206.0			189.3									
2013	29 January	118.0		206.8			187.9									
	23 February	72.0	154.4 mm over 2 days (23-24 February 2013)	206.8			187.9									
	24 February	82.4		206.8			187.9									
2014	19 August	52.6		205.7				192.6								
	7 December	55.0		205.9				192.8								
2015	21 April	161.0	279 mm over 2 days (21 to 22 April 2015)	206.5				192.3	183.4							
	22 April	118.0		206.5				192.3	183.4							
	22 December	63.6		207.4				192.6	185.4							
2016	5 January	108.0	221.2 mm over 4 days (4	207.4				192.6	185.4							

Year	Date	Rainfall	Comment	Peak water level after >50mm/day rainfall (mAHD)												
				MW1	MW2	*MW3	*MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13
	6 January	68.0	to 7 January 2016)	207.4				192.6	185.4							
	5 June	69.0	147.4 mm over 3 days (4	207.1				193.1	185.7							
	6 June	68.0	to 6 June 2016)	207.0				193.0	185.8							
2017	18 March	54.8	149.4 mm over 6 days (14 to 19 March 2017)	206.9				192.6	185.0	184.6	192.8	188.8	185.3	183.9	194.7	199.2
	31 March	55.0		206.9				192.6	185.0	184.6	192.8	188.8	185.3	183.9	194.7	199.2
	8 June	36.0*	*111.4 mm over 5 days (7 to 11 June 2017)	207.0				192.6	185.3	184.4	192.8	188.5	185.7	184.3	194.9	199.4
2018	26 February	66.0		205.7					183.4	183.7	192.5	187.2	184.3	180.4	194.4	198.9
Average peak water level after >50mm/day rainfall event				206.9	203.1	182.4	188.2	192.6	184.8	184.3	192.7	188.3	185.2	183.1	194.7	199.2

4 GROUNDWATER MONITORING

4.1 Monitoring Bore Network

The monitoring bore network comprises nine (9) currently active monitoring bores (MW1 and MW6 to MW13). Six are screened to monitor the Maroota Sands aquifer system, and three the Hawkesbury Sandstone. These are supplemented by two Dol-Water bores completed in the Hawkesbury Sandstone (GW75003 and GW75004).

Three previous monitoring bores are no longer available, MW3 and MW4 having been lost to quarry expansion and MW2 having become blocked by an obstruction above the water level in the bore.

MW5 has also been found to be obstructed, some 9m above its original constructed depth but still below the water level in the bore. Hence, it can still be monitored, however as the nature and cause of the obstruction are unknown, and there is less than 1m of water depth above the obstruction, MW5 has been removed from the monitoring network. Comparison of water levels between MW5 and MW8 (**Figure 27**), both of which are screened in the basal part of the Maroota Sands, shows that these two bores have similar absolute water levels and almost identical trends. Hence, MW8 is considered a suitable replacement for MW5.

The bores installed in December 2016 were designed to provide a broader coverage of the site, and to provide better monitoring of each of the main hydrogeological units, Hawkesbury Sandstone and Maroota Sands (including perched zones).

At three sites, there is now a cluster of bores monitoring at different depths, viz:

- MW1 (perched Maroota Sands) and MW7 (Hawkesbury Sandstone);
- MW5 (Maroota Sands – partially penetrating), and MW8 (Maroota Sands – fully penetrating); supplemented by two of Dol-Water's bores GW075003 and GW075004 (both in Hawkesbury Sandstone); and
- MW13 (Maroota Sands) and MW9 (Hawkesbury Sandstone).

Locations of these bore clusters are shown on **Figure 2**.

Table 7 lists the main construction and completion details of all monitoring bores that have been installed over the life of the project.

Table 7 also includes details of two water supply production bores, one of which (PB1) has been used to supply process water to the quarrying operations. The other (PB2) is used for water supply at the nursery located at the north-western corner of the property, and does not form part of the quarry operations. The two production bores are significantly deeper than the base of the quarry, and draw water from the underlying Hawkesbury Sandstone rather than the Maroota Sands aquifer.

Also listed in **Table 7** are details of the two Dol-Water monitoring bores GW75003 and GW75004, which are located within the property close to MW5 and MW8 near the south-western property boundary.

Borehole Logs for bores MW1 to MW13 and PB1 and PB2 are included in **Appendix A**. Logs for the two Dol-Water bores are presented in **Appendix B**.

Table 7: Monitoring Bores – Completion Details

Bore	Date Drilled	Registered Bore No	Location (MGA)		Ground Level	Stick-up	Bore Depth	Base of Bore	Screen Interval		Formation Screened	Salinity TDS	Water Level (5 April 2018)		Current Status
			Eastings	Northing	mAHD	m	m	mAHD	mBGL	(mAHD)		mg/L	m BGL	mAHD	
MW1	22 Oct 1998	GW101674	313743	6295740	213.43	0.70	11.9	201.43	4.9-10.9	202.5-208.5	Maroota Sands (perched)	186	7.76	205.66	Active
MW5	Apr 2013	GW114208	313893	6295283	227.00	0.80	44.0 (now 35.2)	183.00 (now 191.8)	32.0-44.0	183-195	Maroota Sands (perched)		*34.31	*192.69	No longer monitored
MW6	23 Jan 2015		314200	6295366	202.47	0.72	29.0	173.47	24-29	173.5-178.5	Maroota Sands		19.29	183.18	Active
MW7	9 Dec 2016		313761	6295741	212.96	0.48	37 (sealed below 36)	176.96	30-36	177-183	Hawkesbury Sandstone		29.22	183.74	Active
MW8	6 Dec 2016		313889	6295287	227.00	0.42	49 (sealed below 40)	187.00	37-40	187-190	Maroota Sands		34.52	192.49	Active
MW9	19 Dec 2016		313916	6295356	225.58	0.53	50.5	175.08	44.5-50.5	175-181	Hawkesbury Sandstone		38.55	187.03	Active
MW10	14 Dec 2016		314122	6295187	217.12	0.48	49 (sealed below 47)	170.12	44-47	170-173	Maroota Sands		33.04	184.08	Active
MW11	21 Dec 2016		314176	6295789	192.35	0.71	29 (sealed below 28.5)	163.85	24-28.5	164-168.5	Maroota Sands		11.98	180.37	Active
MW12	8 Dec 2016		313902	6295584	210.28	0.47	27 (sealed below 26)	184.28	23-26	184-187	Hawkesbury Sandstone		16.03	194.25	Active
MW13	7 Dec 2016		313916	6295358	225.50	0.46	31 (sealed below 30.5)	195.00	27.5-30.5	195-198	Maroota Sands		26.58	198.92	Active
PB1	6 Jul 1999	GW105835	314116	6295574	~193.5	0.70	126.1	~67.4	Open hole below 28.8	<164.7	Hawkesbury Sandstone		*14.1	*~179.4	Pumping for water supply

Bore	Date Drilled	Registered Bore No	Location (MGA)		Ground Level	Stick-up	Bore Depth	Base of Bore	Screen Interval		Formation Screened	Salinity TDS	Water Level (5 April 2018)		Current Status
			Easting	Northing	mAHD	m	m	mAHD	mBGL	(mAHD)		mg/L	m BGL	mAHD	
PB2	19 Feb 1999	GW102451	313735	6295514	~212.5	0.30	156.5	~56.0	Open to sandstone below 53	<202.1	Hawkesbury Sandstone		*42.8	*~174.0	Pumping for water supply
	1 Jul 1997	GW075003	313868	6295299	225.48	0.88	109.0	116.48	72-75	150.5-153.5	Hawkesbury Sandstone	90 µS/cm	*46.1	*178.5	DoI-Water monitor bore
	7 Jul 1997	GW075004	313885	6295286	226.95	0.87	60.0	166.95	54-57	170-173	Hawkesbury Sandstone	150 µS/cm	40.11	185.94	DoI-Water monitor bore
Former monitoring bores – no longer available															
MW2	20 Oct 1998	GW101675	313896	6295281	226.89	0.80	26.5 (now 20.75)	200.39 (now 206.1)	18.6-24.6	202.3-208.3	Maroota Sands (perched)		*23.75	*203.1	Obstructed at 20.75m. Dry.
MW3	21 Oct 1998	GW101676	**9802.78	**5916.37	202.43	0.90	21.9	180.53	14.9-20.9	181.5-187.5	Maroota Sands (perched)	266	*18.95	*183.5	Mined out
MW4	Dec 2009	GW114209	314121	6295389	~211.5	0.85	28.5	~183	19.5-28.5	~183-192	Maroota Sands		*24.1	*187.9	Mined out

* Most recent available water levels – MW2 (2000); MW3 (2009); MW4 (2013); MW5 (2017); PB1 (1999); PB2 (2002); GW075003 (2015).

** ISG coordinates.

Italics Survey information approximate.

4.2 Historical Monitoring Program

The monitoring program undertaken to date has included:

- Water levels measured in monitoring bores both manually and using dataloggers (1998 to present);
- Water sampling from bores to enable basic water quality parameters to be measured on a regular basis (from 1998 until 2013). Routine six-monthly water sampling from all bores resumed in January 2017;
- Intermittent measurements of water levels and water quality from water in the main ponds.

The locations of all monitoring bores and other bores on the site are shown on **Figure 2**.

4.3 Availability of Monitoring Bores

The groundwater monitoring data cover the period 1998 to 2018. Availability of bores through this period of time is detailed in **Table 8**.

Table 8: Historical Availability of Monitoring Bores – 1998 to 2018

Year	MW1	MW2	MW3	MW4	MW5	MW6	MW7	MW8	MW9	MW10	MW11	MW12	MW13	PB1	PB2
1998															
1999															
2000															
2001															
2002															
2003															
2004															
2005															
2006															
2007															
2008															
2009															
2010															
2011															
2012															
2013															
2014															
2015															
2016															
2017															
2018															

Since 2013, only bores MW1, MW5 and MW6 have remained operational. MW2 is blocked by an obstruction above the water level, and bores MW3 and MW4 have been mined out by the quarry expansion. MW5 has been found to be obstructed about 9m above its original constructed depth, but just below the water level in the bore. MW5 has been removed from the monitoring network, as its function has now been duplicated by the newly constructed MW8.

All the available groundwater levels are presented as hydrographs on **Figures 20 and 22 to 33**. Data from old bores have been reproduced from past reports prepared by URS (formerly known as Woodward-Clyde, and now part of the Aecom Group).

The water level data includes both manual and datalogger records. Water levels are recorded manually approximately monthly. Automatic dataloggers have been installed in most bores from time to time, and set to record water level once daily, and at the end of 2016 were installed in MW1 and MW5. Dataloggers have now been installed in all monitored bores as well as on the Process Water Dam 1, Tailings Dam 2, Nursery Dam 3 and Farm Dam 4. The dataloggers have all been set to record water level at hourly intervals, so that both longer term fluctuations and diurnal fluctuations (if any) can be detected, as well as any relationship between the fluctuating water levels in the Process Dam and Tailings Dam, and the nearby monitoring bores.

4.4 Ongoing Monitoring Requirements

The Mod 2 Consent included the requirement to prepare a Groundwater Monitoring Program in consultation with DoI-Water, to be submitted for approval by the Secretary. A draft Groundwater Monitoring Program was submitted in August 2016. Following receipt of Agency comments, a revised Groundwater Monitoring Program was submitted in September 2017. Further minor alterations to this plan are currently in preparation.

Under the Consent Approval, sand extraction within the approved quarry will include predominantly Maroota Sands, but also friable sandstone from the Hawkesbury Sandstone. Accordingly, the Consent Conditions are interpreted to require the monitoring network to include both the Maroota Sands and the underlying Hawkesbury Sandstone.

The Consent requires that extraction not take place below a level 2 metres above the wet weather high groundwater level⁴ of the regional aquifer, as measured and mapped on the site. The Consent further requires that the wet weather high groundwater level be updated periodically and reported 6-monthly to DP&E (formerly DoPI) and DOI (formerly DoI-Water).

Contours of the wet weather high groundwater level, updated in April 2018, are depicted for the Maroota Sands and the Hawkesbury Sandstone on **Figures 19 and 21** respectively.

4.5 Monitoring Program

The monitoring program is described in detail in the document Groundwater Monitoring Program (Dundon Consulting, 2017), and is summarised in **Table 9**.

Impact Assessment Criteria are detailed in **Table 10**.

⁴ The Development Consent defines the 'Wet weather high groundwater level' as 'The rolling average of all recorded groundwater level measurements at any monitoring location on the site, as first recorded following any rainfall event of at least 50 mm over any 24-hour period, and as contour mapped using this data'.

Table 9: Monitoring Regime

Monitoring Bores and Ponds	Purpose	Continuous	Weekly	Three-Monthly	Six-monthly	Annually
MW1, MW6, MW7, MW8, MW9, MW10, MW11, MW12 and MW13. Process area pond (Dam 1), tailings dam (Dam 2); nursery dam (Dam 3) and farm dam (Dam 4).	Ensure base level of quarry does not exceed 2m above regional wet weather high groundwater levels	Automatic piezometers with datalogger		Manual water level to confirm and calibrate datalogger		
	Ensure water quality of MTSGS and SBCGS are not adversely impacted				Field measurements of EC, TDS, pH	Lab analysis of oil and grease
	Ensure no seepage inflows (other than perched groundwater)	Daily observation to detect any seepage	If observed, sample for water quality. If measurable, monitor volume of seepage inflows			
Bores MW9, MW12 and MW13, and future Stage bores as detailed in Consent.	Establish baseline levels of regional water table in future quarry stages	Automatic piezometer with datalogger		Manual water level to confirm and calibrate datalogger		

Table 10: Impact Assessment Criteria

Potential Impact	Impact Observed	Criteria for Response Action	Response Action
Groundwater inflows to quarry	Observed seepage from the quarry walls or floor	Any observed seepage.	Investigate source to confirm or eliminate perched groundwater, or seepage from site dams.
Groundwater levels	Cumulative change in regional groundwater levels greater than the natural pre-quarrying climatic variation	Cumulative change in groundwater levels more than 10% greater than pre-quarrying natural climatic variation.	Investigate to confirm the quarry as the cause of impact. Develop a mitigation strategy and consult with DOI-Water for approval.
Groundwater quality	Change in water quality	Observed water quality that changes the beneficial use value of a water sample, exhibited by a salinity more than 20% above the long-term maximum salinity value, or pH more than 10% above or below the historical range, in two consecutive monitoring events.	Investigate to confirm the quarry as the cause of impact. Develop a mitigation strategy and consult with DOI-Water for approval.
Other groundwater users	Reported decrease in yield or groundwater level, or water quality	Reported loss of more than 10% of pre-quarrying yield; observed water quality parameter	Investigate to confirm the quarry as the cause of impact. Develop a mitigation strategy and consult with DOI-Water for approval.

5 FUTURE SAND EXTRACTION AND POST-CLOSURE REHABILITATION

The staged extraction plan as presented in the EA is shown on **Figure 34**. As at April 2018, extraction is occurring mostly in the Phase 1A, 1B and 2A areas. Future sand extraction will progress through Phases 2B; 3A and 3B; 4A, 4B and 4C; 5A and 5B; and finally 6A and 6B.

The final depth of extraction will be as dictated by the maximum depth of extraction allowed by the Consent, which is not less than 2m above the Wet Weather High Groundwater Levels (WWHGWLs) for the Maroota Sands and the Hawkesbury Sandstone. The quarry floor will comprise Maroota Sands in the north-eastern part, and Hawkesbury Sandstone in the south-western part. For consistency, the same extraction depth has been applied to both the Hawkesbury Sandstone and the Maroota Sands, although a deeper extraction of the Hawkesbury Sandstone would be permitted under the consent, due to the deeper WWHGWL for the Hawkesbury Sandstone relative to the Maroota Sands.

The currently proposed contours of final depth of extraction are shown in **Figure 35**, and range between 187 and 188mAHD. The final extraction depth may ultimately be higher in parts of the quarry, if substantial areas of clayey Maroota Sands, or other material which may be uneconomic, are revealed during future excavation.

The conceptual post-extraction rehabilitation plan has been prepared in draft form by VGT (2018). In summary,

- the existing nursery infrastructure in the north-western corner of the site will be retained;
- the Process Dam will be maintained as a permanent water storage;
- the landform will slope gently away from the tree screens along Old Northern Road towards the dam in the north-eastern corner of the site; and
- the final extracted land surface will be revegetated with locally-occurring native species.

The rehabilitated landform will overall have essentially the same shape as the final extraction landform depicted in **Figure 35**.

The water quality monitoring to date suggests that the quarry operations will continue to be benign with respect to the groundwater quality, both through to the remaining quarry life and also post-rehabilitation.

Post-rehabilitation, the groundwater in both the Maroota Sands and the Hawkesbury Sandstone are predicted to be unaffected by either the quarry operations or the final landform. There may be a very small downward component of leakage from the water storage occupying the remnant Process Dam that may cause a slight mounding effect on the Maroota Sands water table. However, as the fines backfilling the deepest parts of the Process Dam are apparently of such low permeability as to be effectively preventing any significant leakage from the current Process Dam, it is anticipated that any leakage from the final dam will be very low, and less than the potential losses from the existing Nursery Dam 3 and Farm Dam 4.

6 GROUNDWATER MANAGEMENT IMPROVEMENT PROGRAM

It is anticipated that the expanded monitoring network may provide opportunities over time for groundwater improvement measures.

However, at the present time, there are no obvious groundwater improvement measures.

Possible future actions may include:

- Backfilling with clays any excavation found to be below the wet weather high groundwater levels of either the Maroota Sands or the Hawkesbury Sandstone as appropriate. At the present time, all areas of the quarry that were previously excavated below this level have been backfilled with tailings, which are believed to be effectively impermeable.
- Containment of all quarry affected water within the quarry water management system.
- Post-quarry rehabilitation measures (yet to be determined).

7 SUMMARY AND CONCLUSIONS

The groundwater study has included a review of all previous investigations and monitoring records extending back to 1998, as well as a program of work undertaken in December 2016 and January 2017, and monitoring data collected since that time. The recent program included the installation of seven new monitoring bores.

The available reports from the nearby sand quarrying operations of Dixon Sands and PF Formation (both located to the west of the Roberts Road quarry site, have also been evaluated for relevance to the Roberts Road quarry operations. These reports are those that are on the public record, and were able to be downloaded from the respective companies' websites.

Groundwater is present in both the Maroota Sands and the underlying/adjacent Hawkesbury Sandstone. The Maroota Sands is a paleochannel deposit present within a paleovalley incised into the Hawkesbury Sandstone surface in the Tertiary time.

There are numerous occurrences of perched groundwater in both the Maroota Sands and the Hawkesbury Sandstone. The perched groundwater in the Maroota Sands is in some instances perched above the upper surface of the Hawkesbury Sandstone where it shallows (on the flanks of the paleovalley) and rises above the regional groundwater level of the Maroota Sands. However, there is also perched groundwater present in the Maroota Sands at zones well above the Hawkesbury Sandstone, which is believed to be perched above less permeable parts of the Maroota Sands. Some of the perched groundwater may also be artificially elevated by seepage from one or more of the site dams, all of which have water levels that are higher than the nearby groundwater levels.

There is also evidence of perching within the Hawkesbury Sandstone, possibly due to the presence of less permeable shale or clayey interbeds within the sandstone sequence.

Accordingly, there is only limited presence of the regionally extensive Maroota Sands groundwater table within the central portion of the site, within the deeper parts of the paleovalley. This regional water table is observed in monitoring bores MW6, MW10 and MW11, and was previously monitored in former bores MW3 and MW4. The regional water table level as measured in August 2017 was approximately in the range 184 mAHD to 186 mAHD. Across the western third or so of the site, and east of the main Process Dam, the top of the Hawkesbury Sandstone lies above this elevation, and any groundwater present in the Maroota Sands in that part of the site is believed to be perched. Hawkesbury Sandstone outcrops along the eastern side of the process dam.

The Hawkesbury Sandstone regional water table (more correctly the potentiometric surface) is observed in only three bores, PB1, PB2 and GW75003, and is at approximately 175 mAHD to 180 mAHD, with an apparent gradient to the northwest. However, the water levels in all three bores are old measurements, from 2015 in the case of GW75003 and from 2003 or earlier in the case of PB1 and PB2.

Other reported groundwater levels from the Hawkesbury Sandstone are believed to be from perched aquifer zones within the sandstone.

Groundwater in both the Maroota Sands and the Hawkesbury Sandstone is of low salinity. The Maroota Sands groundwater is acidic, with pH generally in the range 3 to 6, while the Hawkesbury Sandstone pH is closer to neutral, in the range 6 to 7.

There is evidence for seepage from at least one of the site dams. All dam water levels are higher than the nearby groundwater, and seepage from the dams may account for some of the observed perched groundwater within the site.

All of the new monitoring bores have been equipped with dataloggers, as well as the four site dams, and they have been set to record at hourly interval. The currently installed monitoring network is

comprehensive and is considered adequate for ongoing monitoring for both climatic (rainfall recharge) effects and to detect any possible influences from the quarrying operations.

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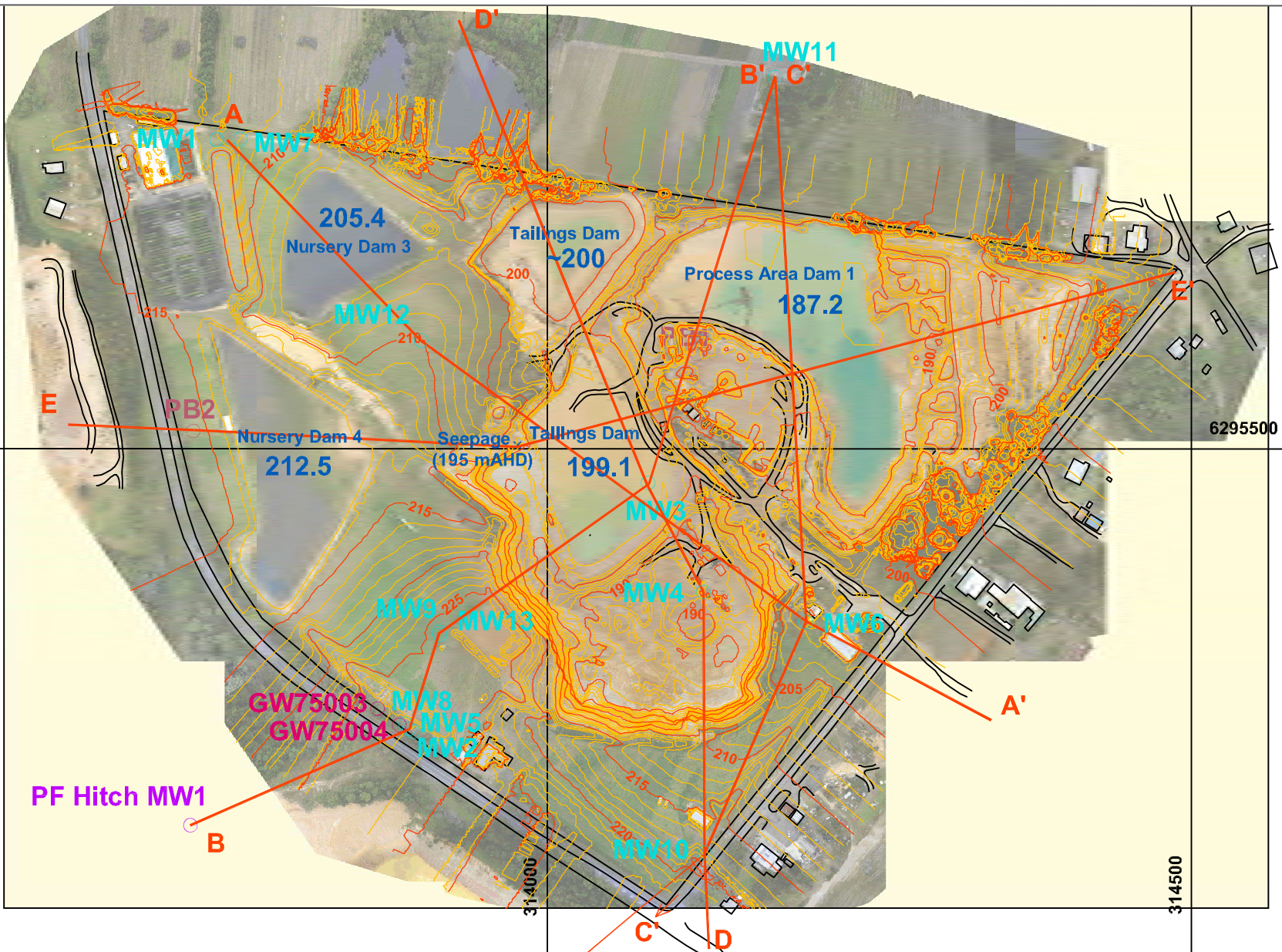
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LEGEND:	
	Surface contours - 5m
	Surface contours - 1m
	Site Dams
	Dam water level at 5 April 2018 (mAHD)

DATE:	15 April 2018	SCALE:	
PROJECT NO:	06-0318	AUTHOR:	PD
DRAWING NO:	06-0318-001c	REVISION:	C
Dundon Consulting Pty Ltd			

Hodgson Quarry and Plant Pty Ltd	
ROBERTS ROAD MAROOTA SAND QUARRY	
Surface Contours and Quarry Status	
at June 2016	
Figure 1	



LEGEND:	
	Hodgson Monitoring Bores
	Hodgson Production Bores
	DPI-Water Monitoring Bores
	P F Formation Bores
	Cross Sections

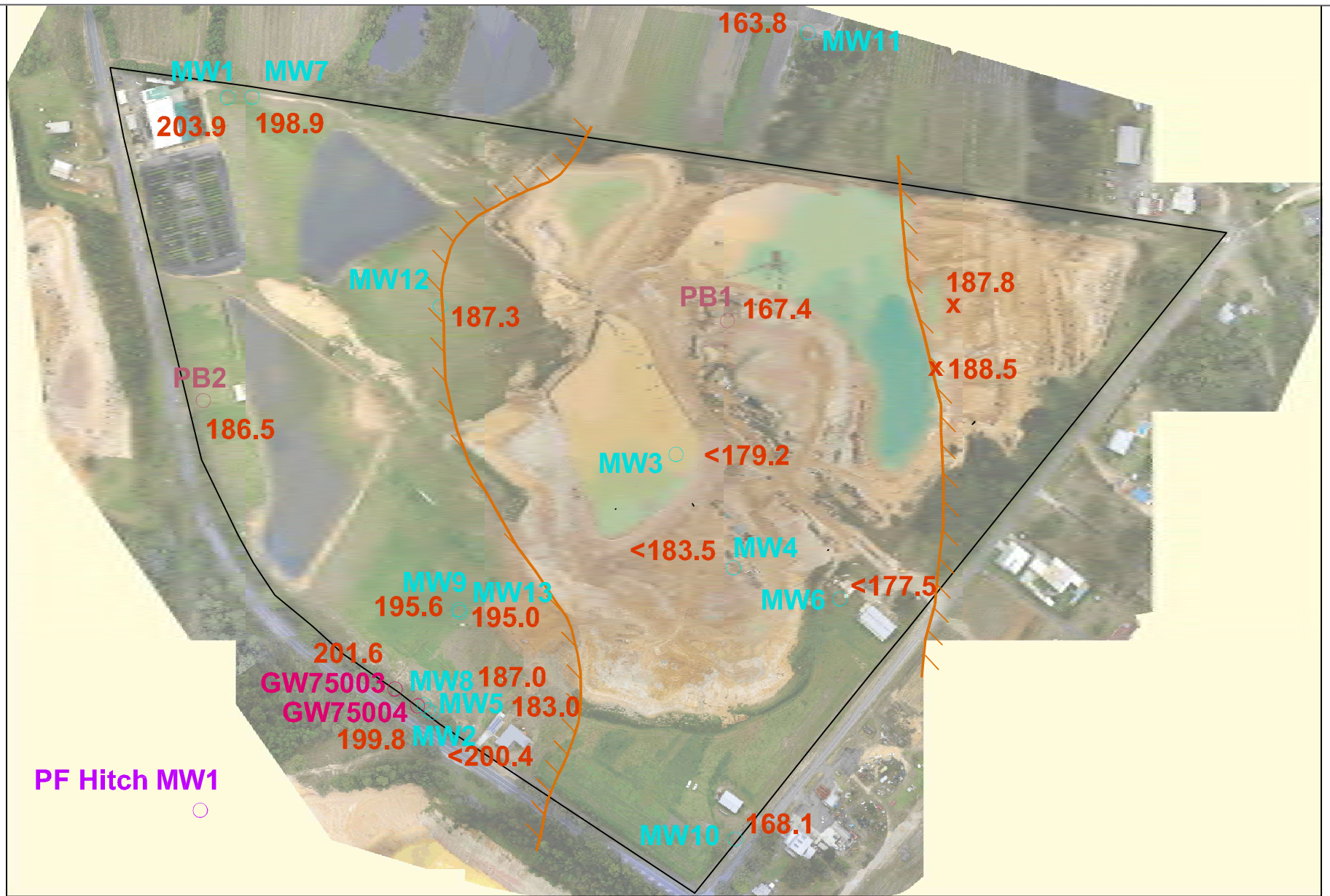
DATE:	15 April 2018	SCALE:	
PROJECT NO:	06-0318	AUTHOR:	PD
DRAWING NO:	06-0318-002c	REVISION:	C
Dundon Consulting Pty Ltd			

Hodgson Quarry and Plant Pty Ltd

ROBERTS ROAD MAROOTA SAND QUARRY

Bore Locations

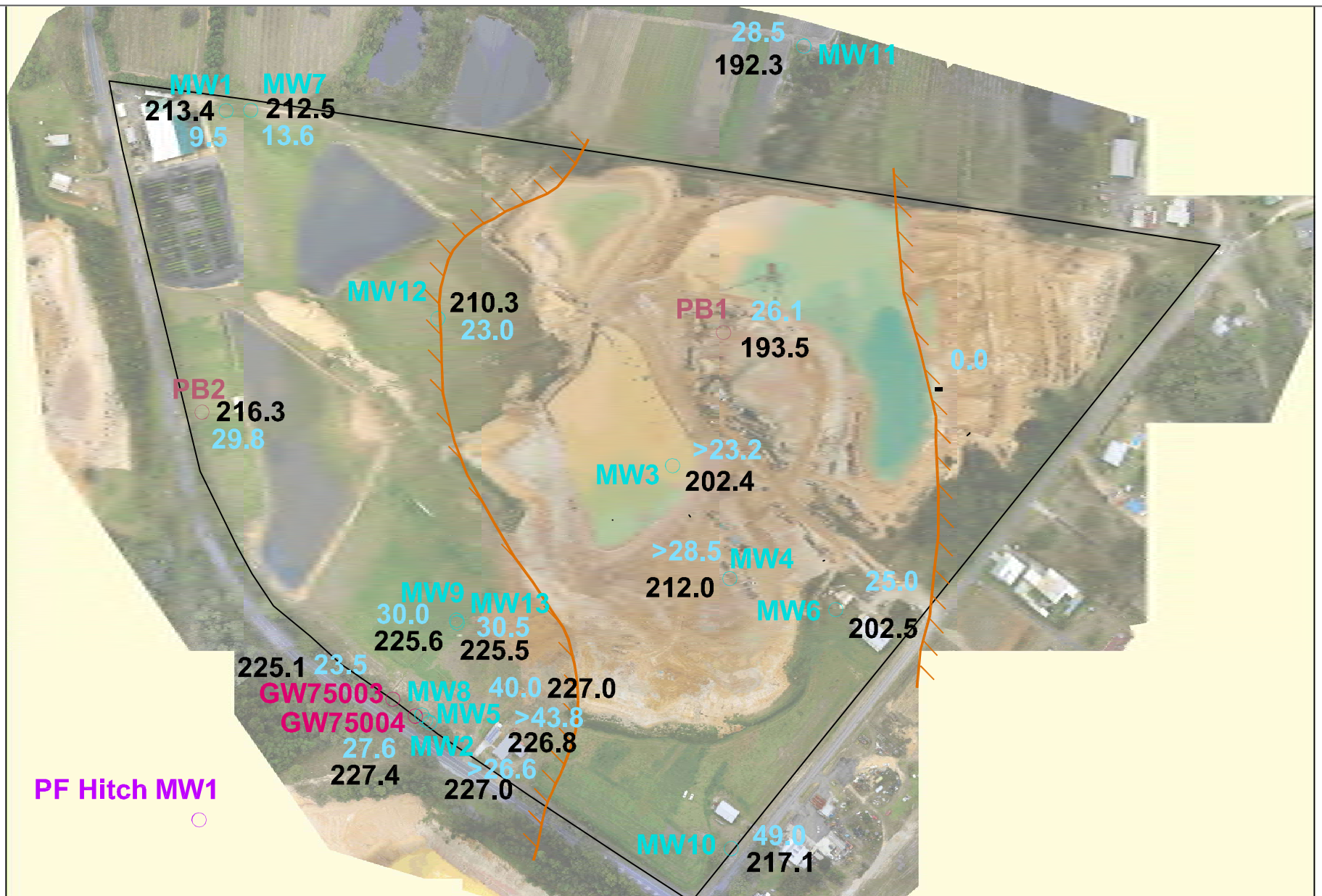
Figure 2



LEGEND:
 Hodgson monitoring bore
 Hodgson production bore
185.2 Hawkesbury Sandstone Surface RL (mAHD)
 Edge of saturated Maroota Sands (top of Hawkesbury Sandstone above MS WL)

DATE: 15 April 2018 SCALE:
 PROJECT NO: 06-0318 AUTHOR: PD
 DRAWING NO: 06-0318-071 REVISION: 0
Dundon Consulting Pty Ltd

Hodgson Quarry and Plant Pty Ltd
ROBERTS ROAD MAROOTA SAND QUARRY
 Elevations of the Hawkesbury Sandstone Surface (mAHD)
 Figure 3



LEGEND:

- Hodgson monitoring bore
- Hodgson production bore
- 185.2** Maroota Sands surface (mAHD)
- 29.2** Maroota Sands thickness (m)
- ┌──┐ Edge of saturated Maroota Sands

DATE:	15 April 2018	SCALE:	
PROJECT NO:	06-0318	AUTHOR:	PD
DRAWING NO:	06-0318-072	REVISION:	0
Dundon Consulting Pty Ltd			

Hodgson Quarry and Plant Pty Ltd

ROBERTS ROAD MAROOTA SAND QUARRY
Maroota Sands Surface Elevations (mAHD)
and Thickness (m)

Figure 4

Hydrograph - MW10, MW6, Process Dam, MW11

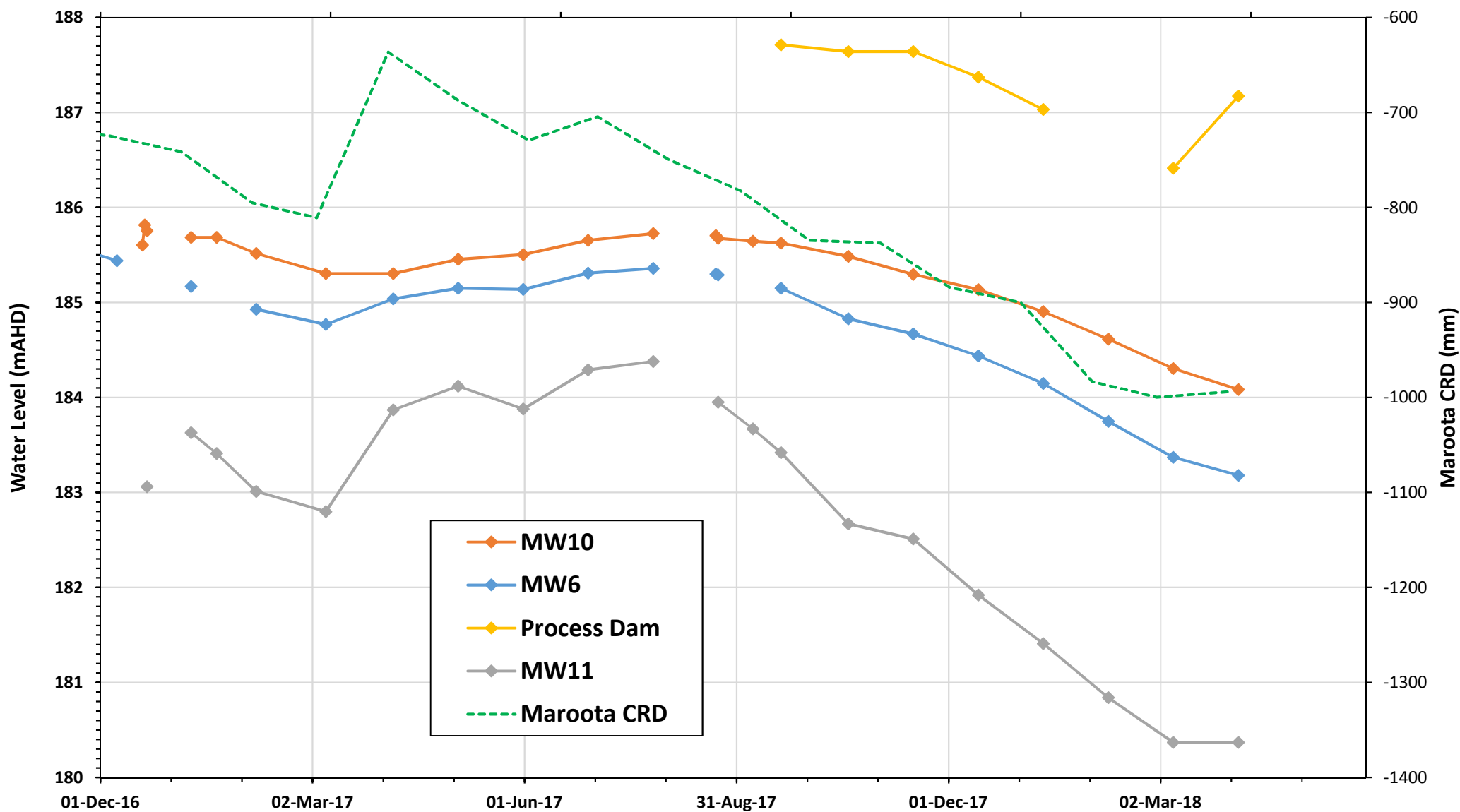
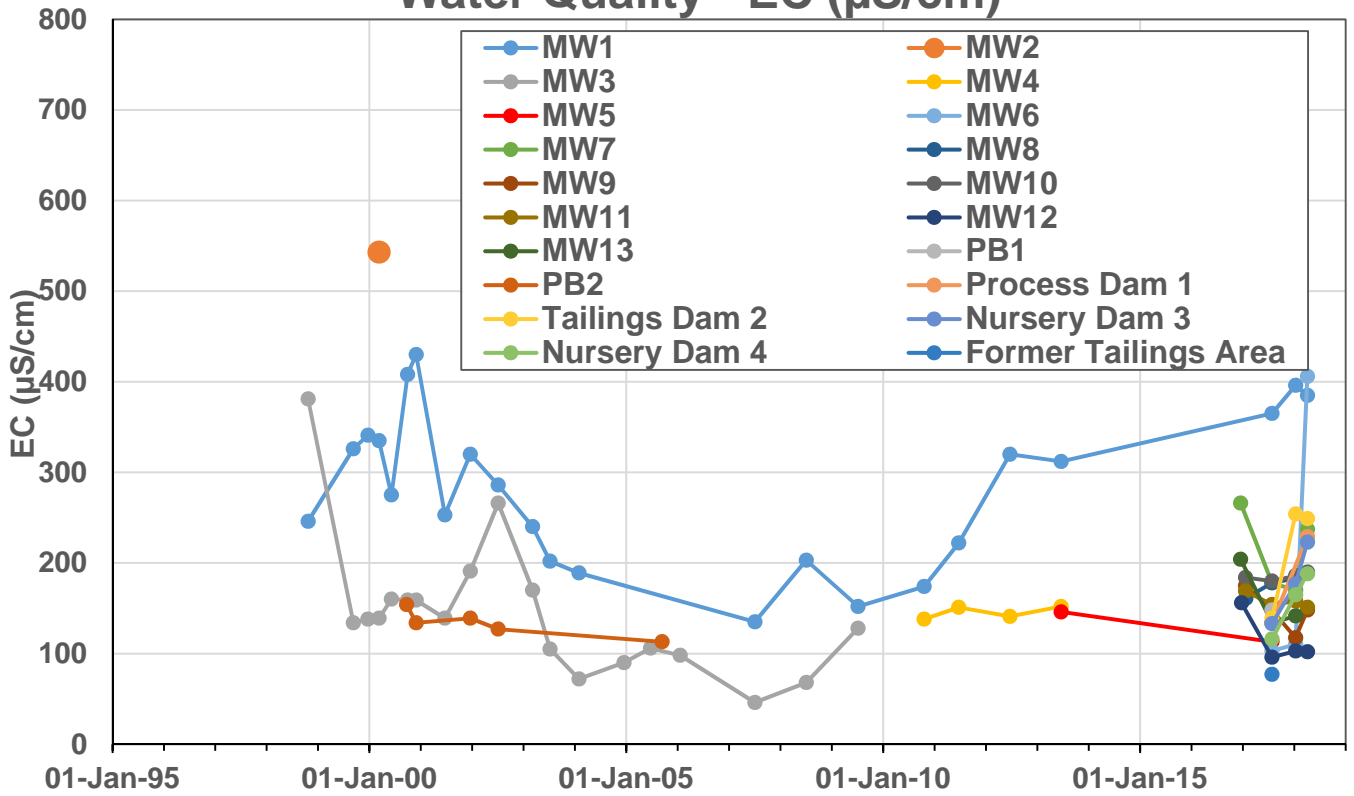
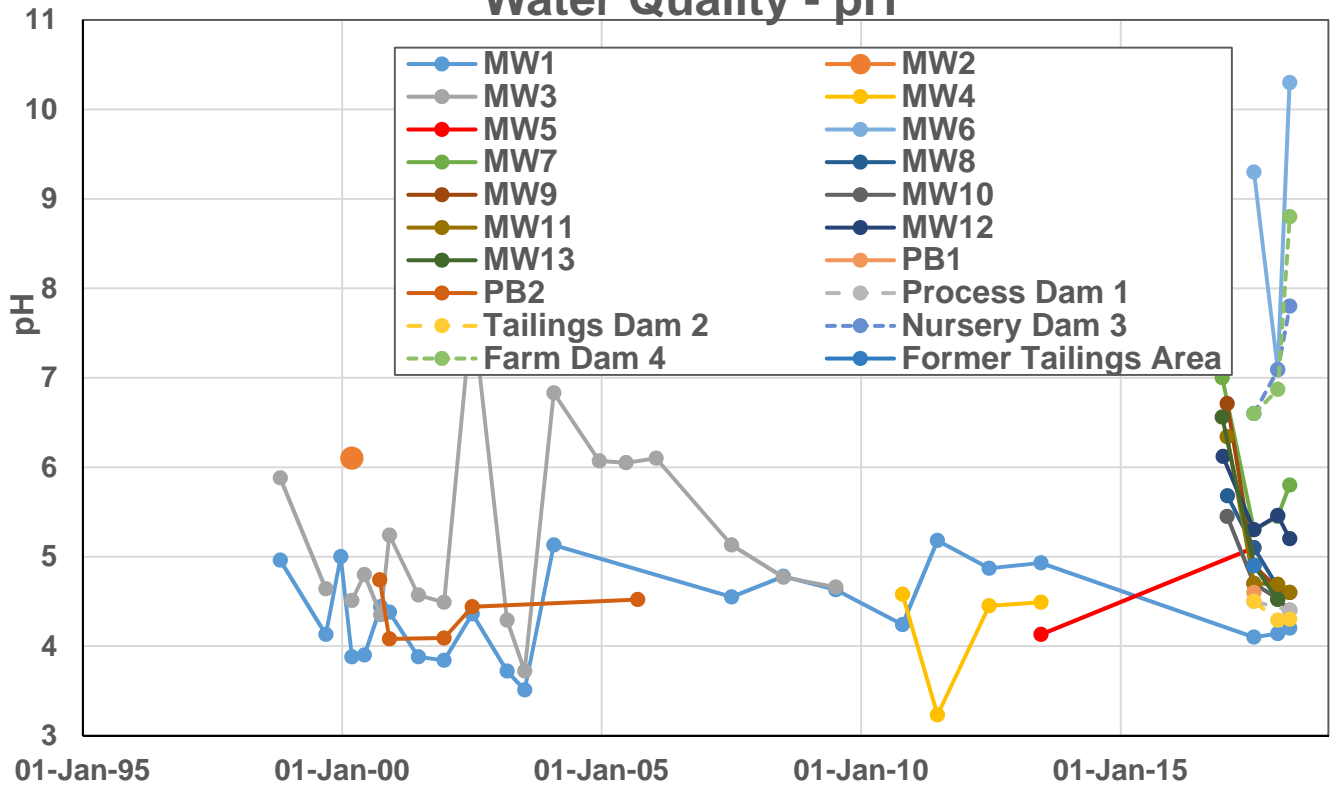


Figure 5: Composite Hydrograph - MW10, MW6, Process Dam and MW11

Water Quality - EC ($\mu\text{S/cm}$)

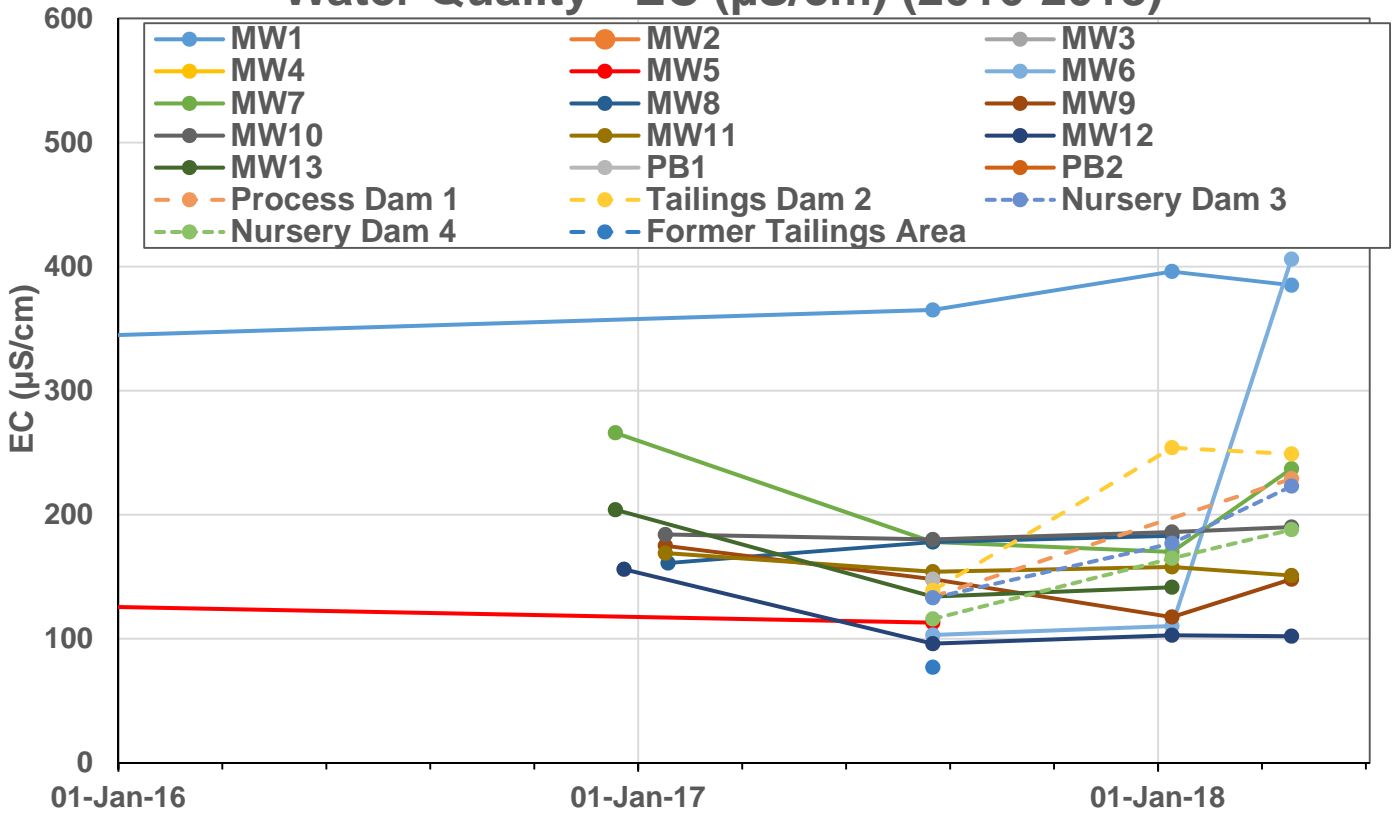


Water Quality - pH

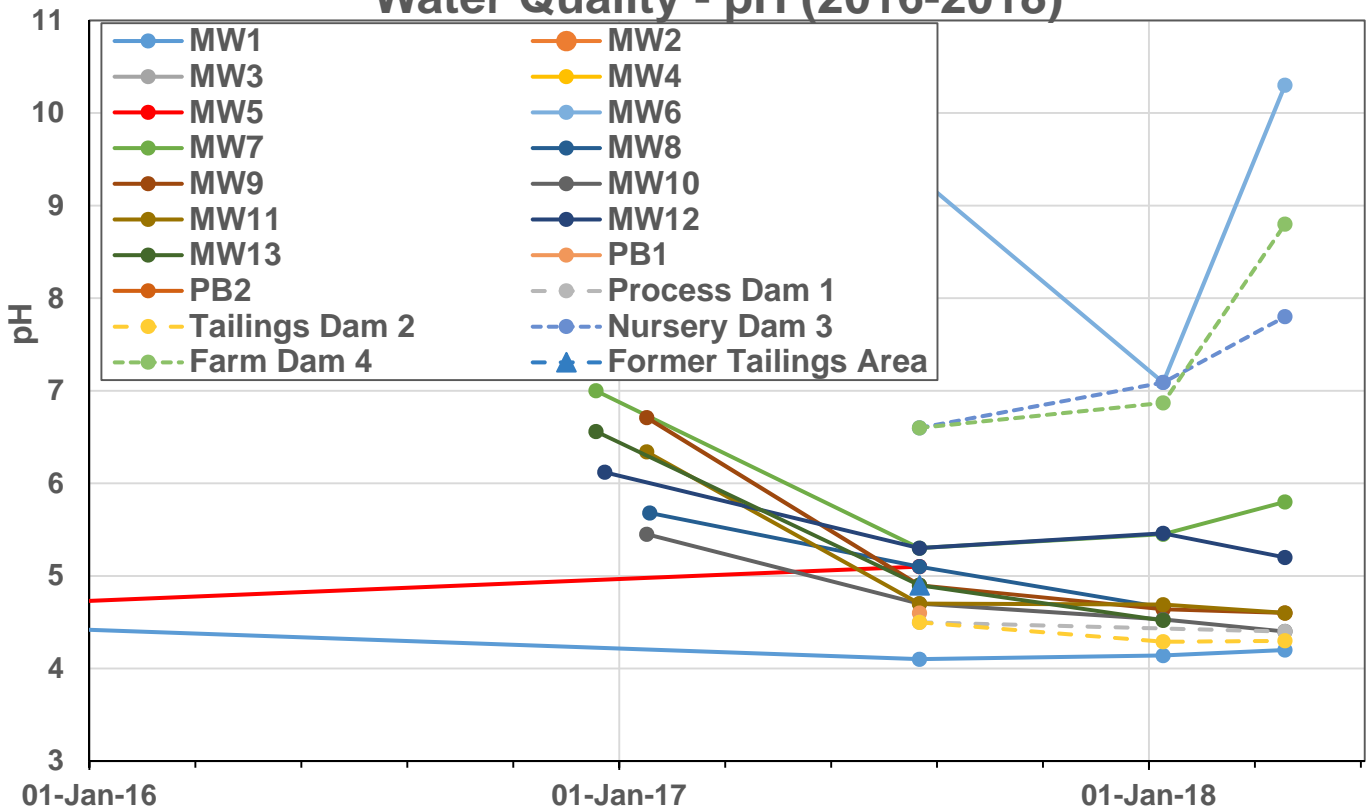


Date: 15 April 2018		Scale: as shown	Hodgson Quarry and Plant Pty Limited ROBERTS ROAD MAROOTA SAND QUARRY Water Quality Data Plots – EC and pH (1998-2018)
Author: PD	Checked: PD	Project No: 16-0318	
Dwg No: 0318-075	Revision: 0		
Dundon Consulting Pty Ltd		Figure 6	

Water Quality - EC ($\mu\text{S}/\text{cm}$) (2016-2018)

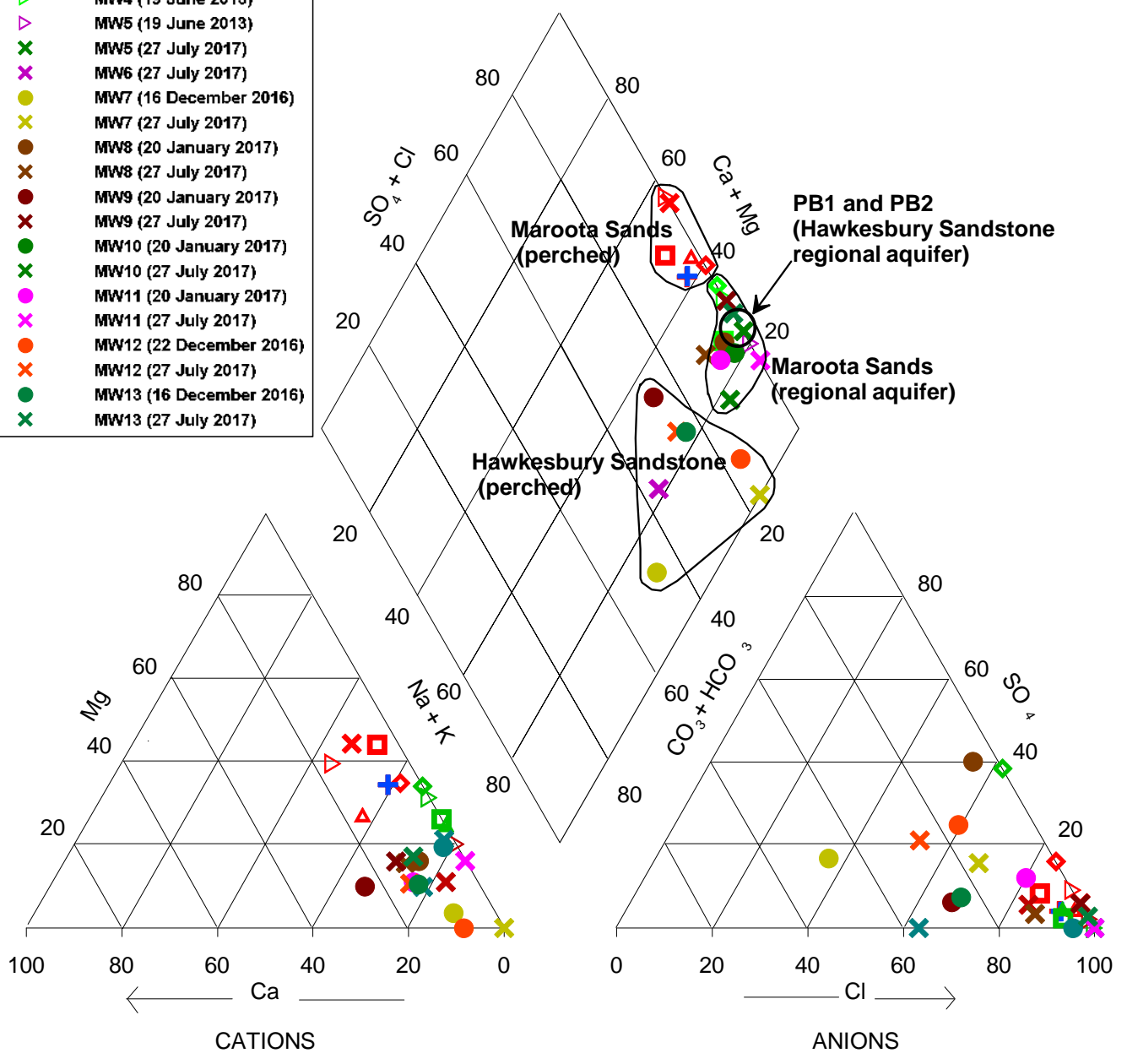


Water Quality - pH (2016-2018)



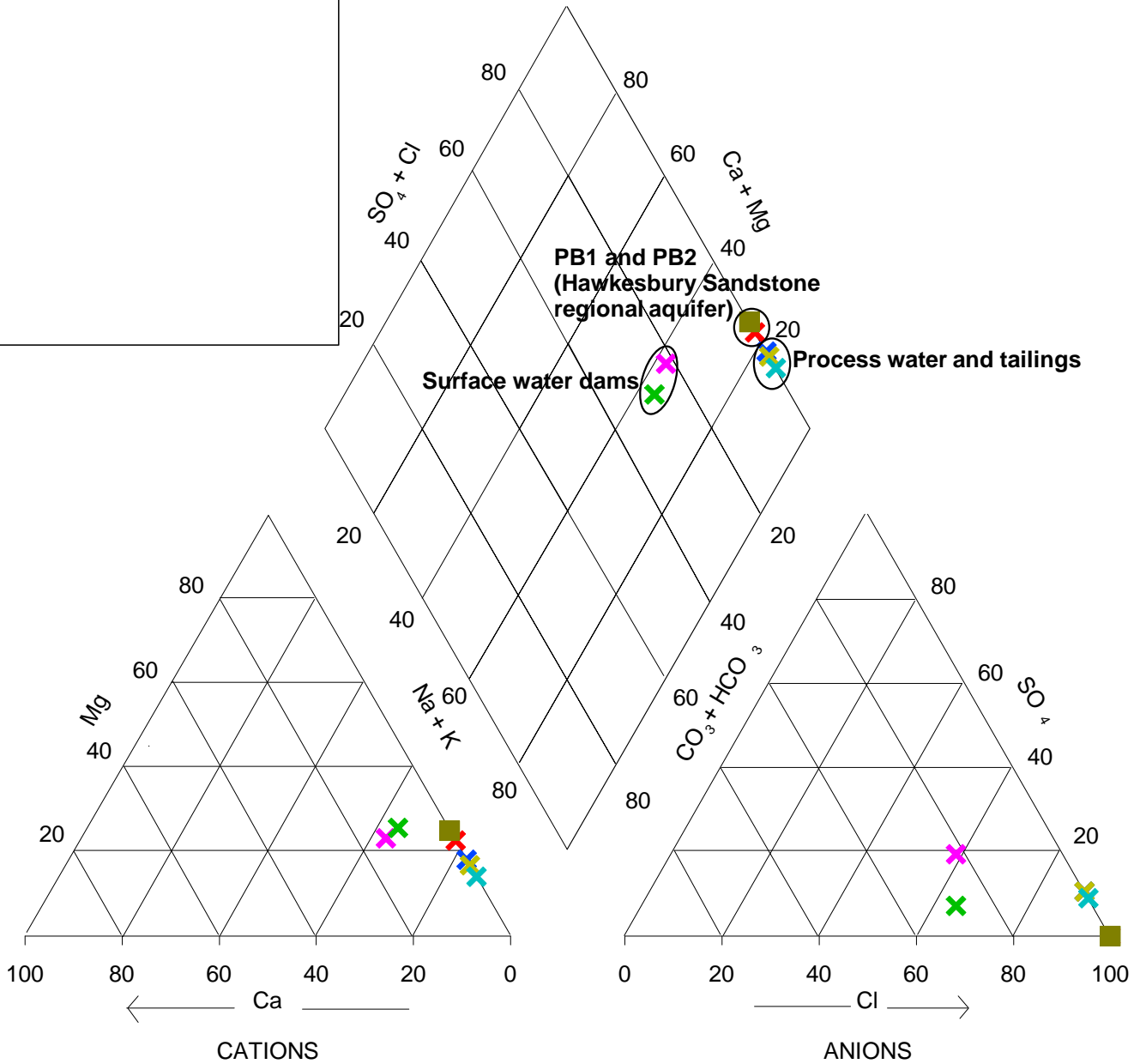
Date: 15 April 2018		Scale: as shown	Hodgson Quarry and Plant Pty Limited ROBERTS ROAD MAROOTA SAND QUARRY Water Quality Data Plots – EC and pH (2016-2018)
Author: PD	Checked: PD	Project No: 16-0318	
Dwg No: 0318-076	Revision: 0		
Dundon Consulting Pty Ltd		Figure 7	

- + MW1 (23 October 1998)
- MW1 (19 October 2010)
- ◇ MW1 (20 June 2012)
- △ MW1 (22 Jun 2012)
- ▽ MW1 (19 July 2013)
- × MW1 (27 July 2017)
- + MW3 (23 October 1998)
- MW4 (19 October 2010)
- ◇ MW4 (20 June 2012)
- △ MW4 (22 June 2012)
- ▽ MW4 (19 June 2013)
- × MW5 (27 July 2017)
- × MW6 (27 July 2017)
- MW7 (16 December 2016)
- × MW7 (27 July 2017)
- MW8 (20 January 2017)
- × MW8 (27 July 2017)
- MW9 (20 January 2017)
- × MW9 (27 July 2017)
- MW10 (20 January 2017)
- × MW10 (27 July 2017)
- MW11 (20 January 2017)
- × MW11 (27 July 2017)
- MW12 (22 December 2016)
- × MW12 (27 July 2017)
- MW13 (16 December 2016)
- × MW13 (27 July 2017)

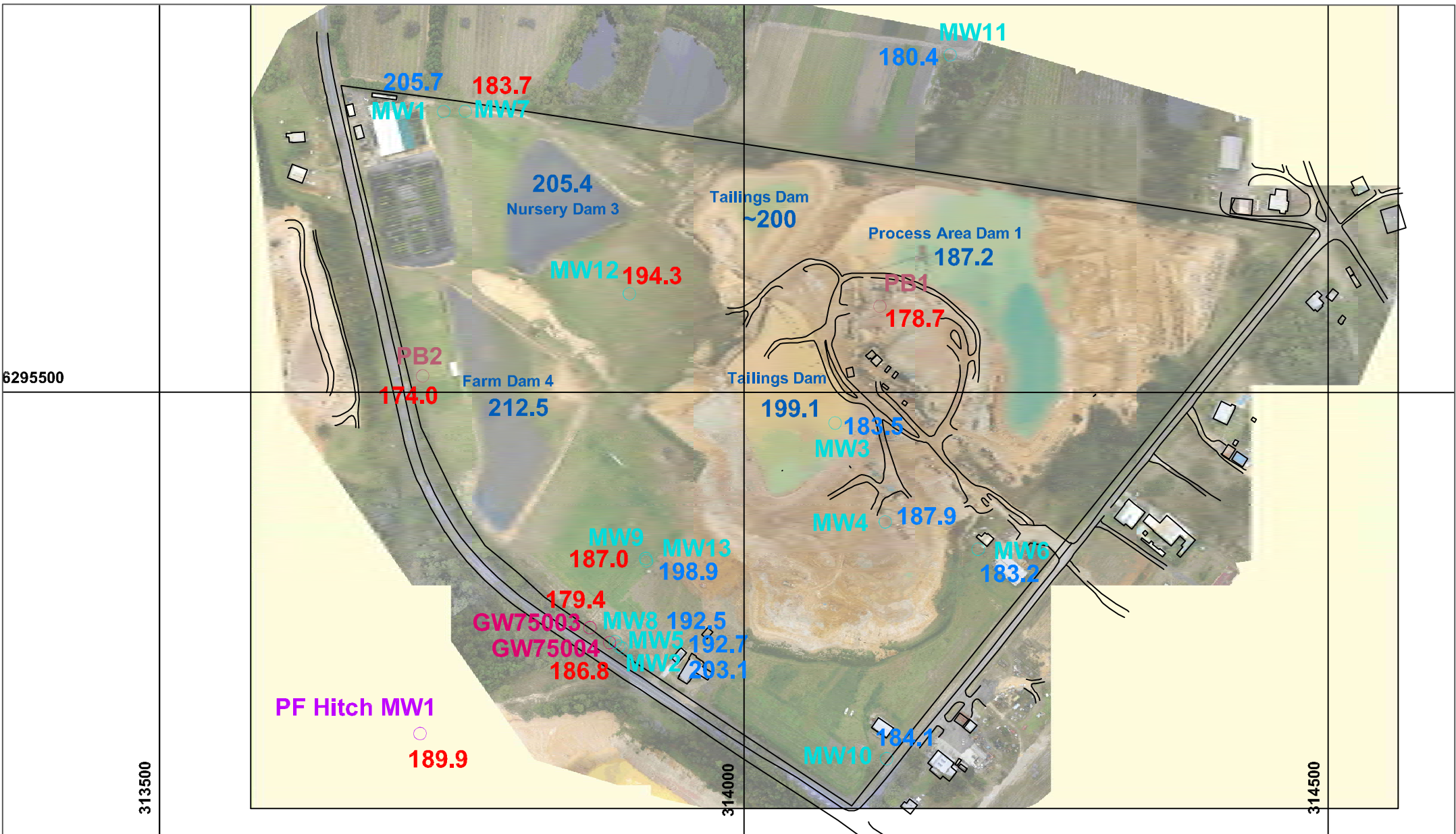


<p>Dundon Consulting Pty Ltd 12 Dakara Close Pymble NSW 2073 phone +61 2 9988 4449</p> <p>mobile + 61 418 476 799 pjdundon@ozemail.com.au</p>	CLIENT Hodgson Quarry & Plant P/L		PROJECT HODGSON ROBERTS RD QUARRY	
	DRAWN PJD	DATE 15 April 2018	TITLE PIPER TRILINEAR DIAGRAM Maroota Quarry - MW1 to MW13	
	CHECKED	DATE		
	SCALE As Shown Dwg 16-0318-050 A4		PROJECT No 16-0318	Figure 8

- ✕ PB1 (27 July 2017)
- PB2 (12 September 2005)
- ✕ Process Dam 1 (27 July 2017)
- ✕ Tailings Dam 2 (27 July 2017)
- ✕ Nursery Dam 3 (27 July 2017)
- ✕ Farm Dam 4 (27 July 2017)
- ✕ Former Tailings Area (27 July 2017)



<p>Dundon Consulting Pty Ltd 12 Dakara Close Pymble NSW 2073 phone +61 2 9988 4449</p> <p>mobile + 61 418 476 799 pj@dundon@ozemail.com.au</p>	CLIENT Hodgson Quarry & Plant P/L	PROJECT HODGSON ROBERTS RD QUARRY		
	DRAWN PJD	DATE 15 April 2018	TITLE PIPER TRILINEAR DIAGRAM	
	CHECKED	DATE	Maroota Quarry - PB1/PB2, surface water, tailings/process water	
	SCALE As Shown	Dwg 16-0318-051	A4	PROJECT No 16-0318
			Figure 9	



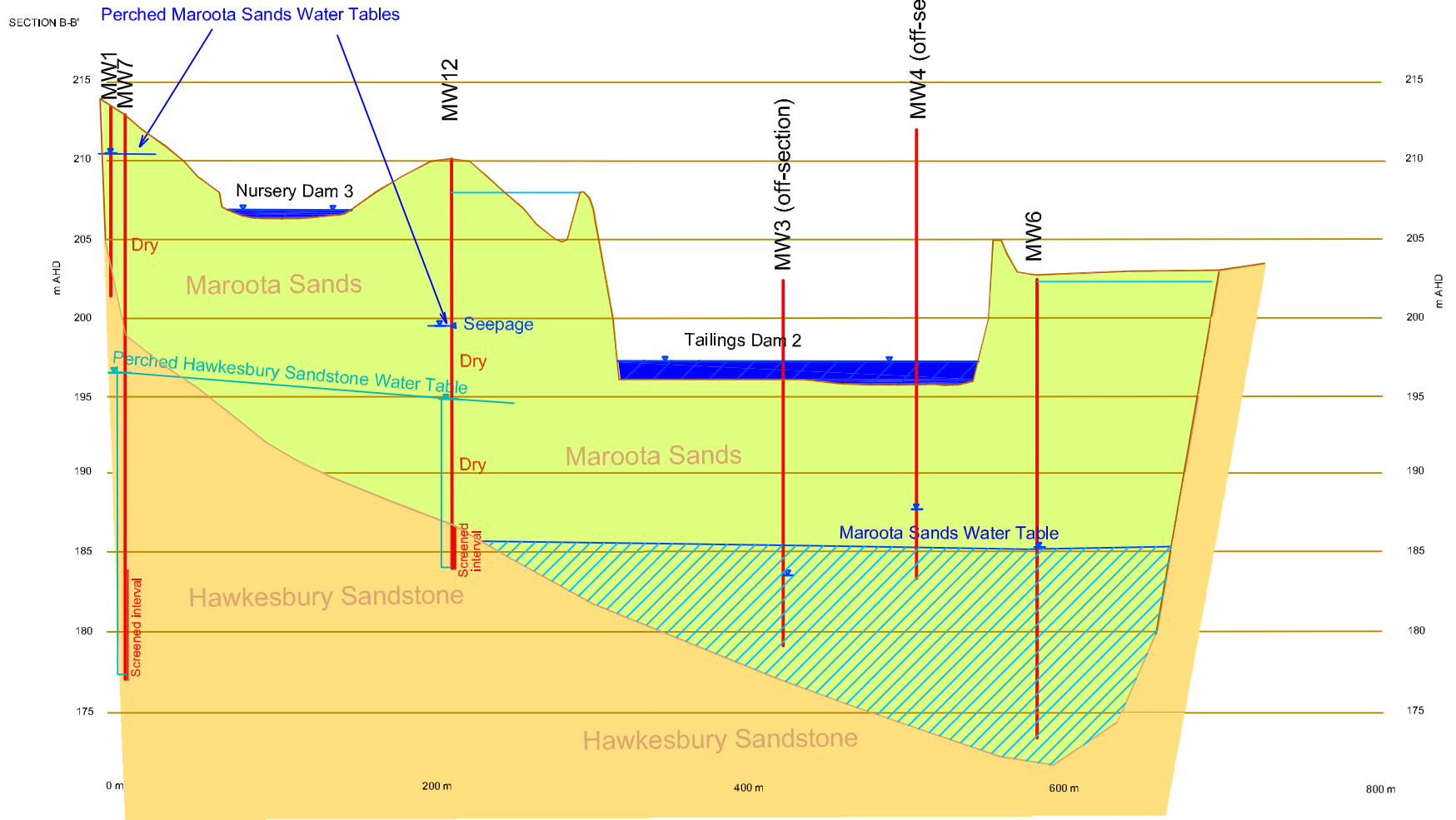
LEGEND:

- Hodgson Monitoring Bores
- Hodgson Production Bores
- DPI-Water Monitoring Bores
- P F Formation Bores
- 185.1 Maroota Sands GW Level
- 178.7 Hawkesbury Sandstone GW Level

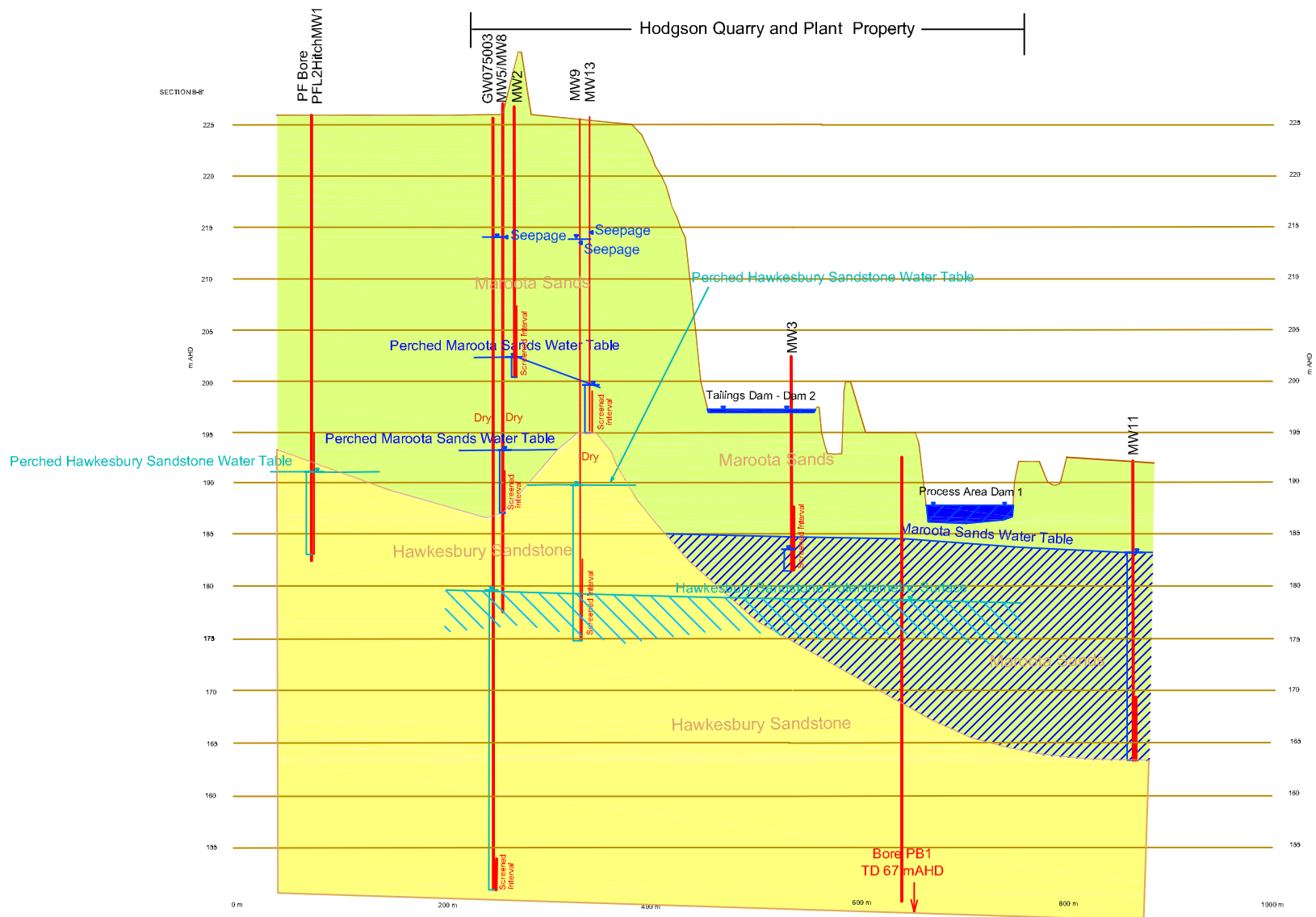
DATE: 15 April 2018	SCALE:
PROJECT NO: 06-0318	AUTHOR: PD
DRAWING NO: 06-0318-002d	REVISION: D
Dundon Consulting Pty Ltd	

Hodgson Quarry and Plant Pty Ltd	
ROBERTS ROAD MAROOTA SAND QUARRY	
Most Recent Recorded Groundwater Levels	
(mostly 5 April 2018)	
Figure 10	

Hodgson Quarry and Plant Property



DATE:	15 April 2018	SCALE:	N/A	Hodgson Quarry and Plant Pty Ltd	
AUTHOR: PD	CHECKED: PD	PROJECT NO:	16-318	ROBERTS ROAD MAROOTA SAND QUARRY CROSS-SECTION A-A' (through piezometers MW1, MW7, MW12, MW3, MW4 and MW6)	
DRAWING NO:	0318-008a	REVISION:	A		
Dundon Consulting Pty Ltd					
				Figure 11	

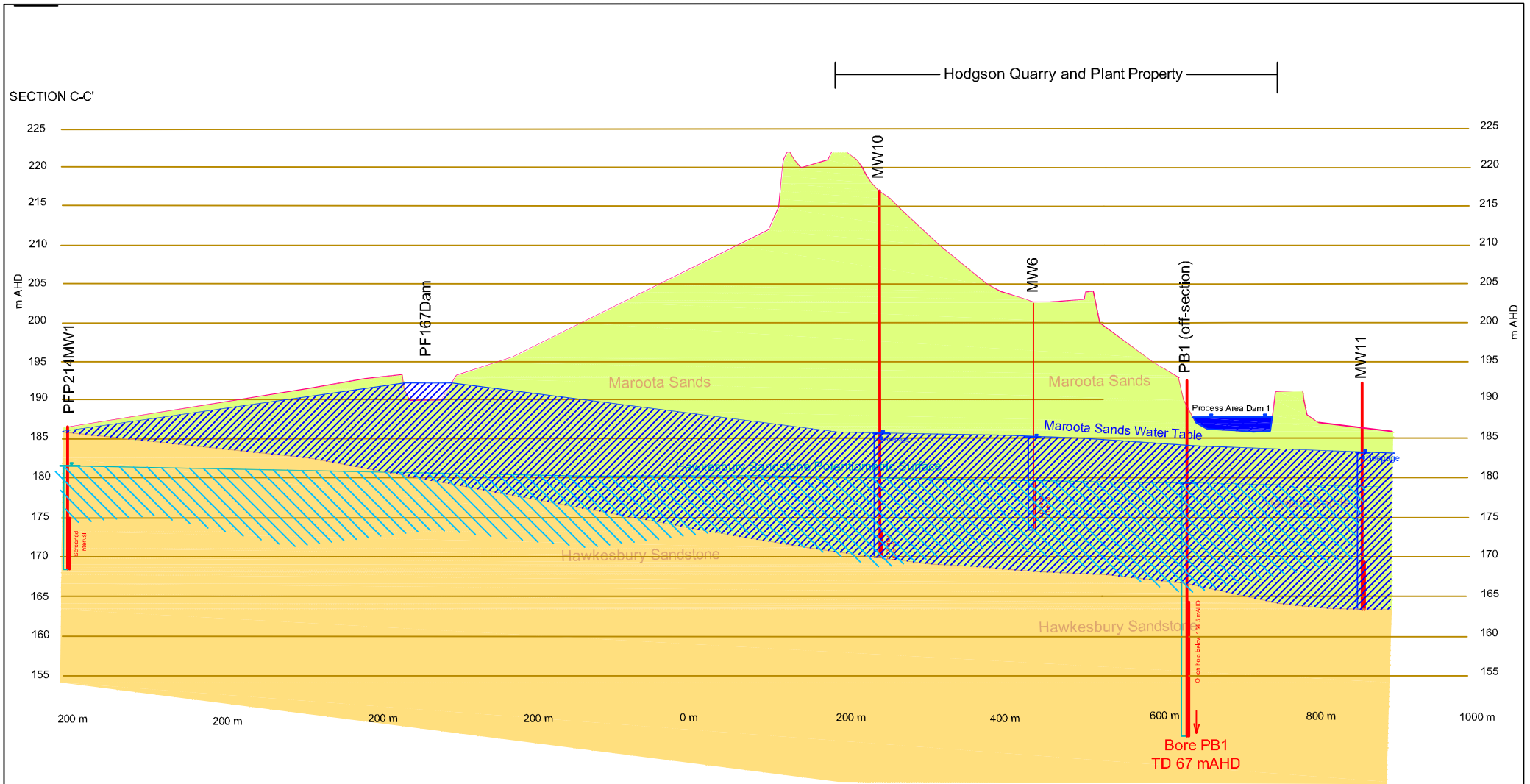


DATE:	5 April 2018	SCALE:	N/A
AUTHOR: PD	CHECKED: PD	PROJECT NO:	16-318
DRAWING NO:	0318-015d	REVISION:	D
Dundon Consulting Pty Ltd			

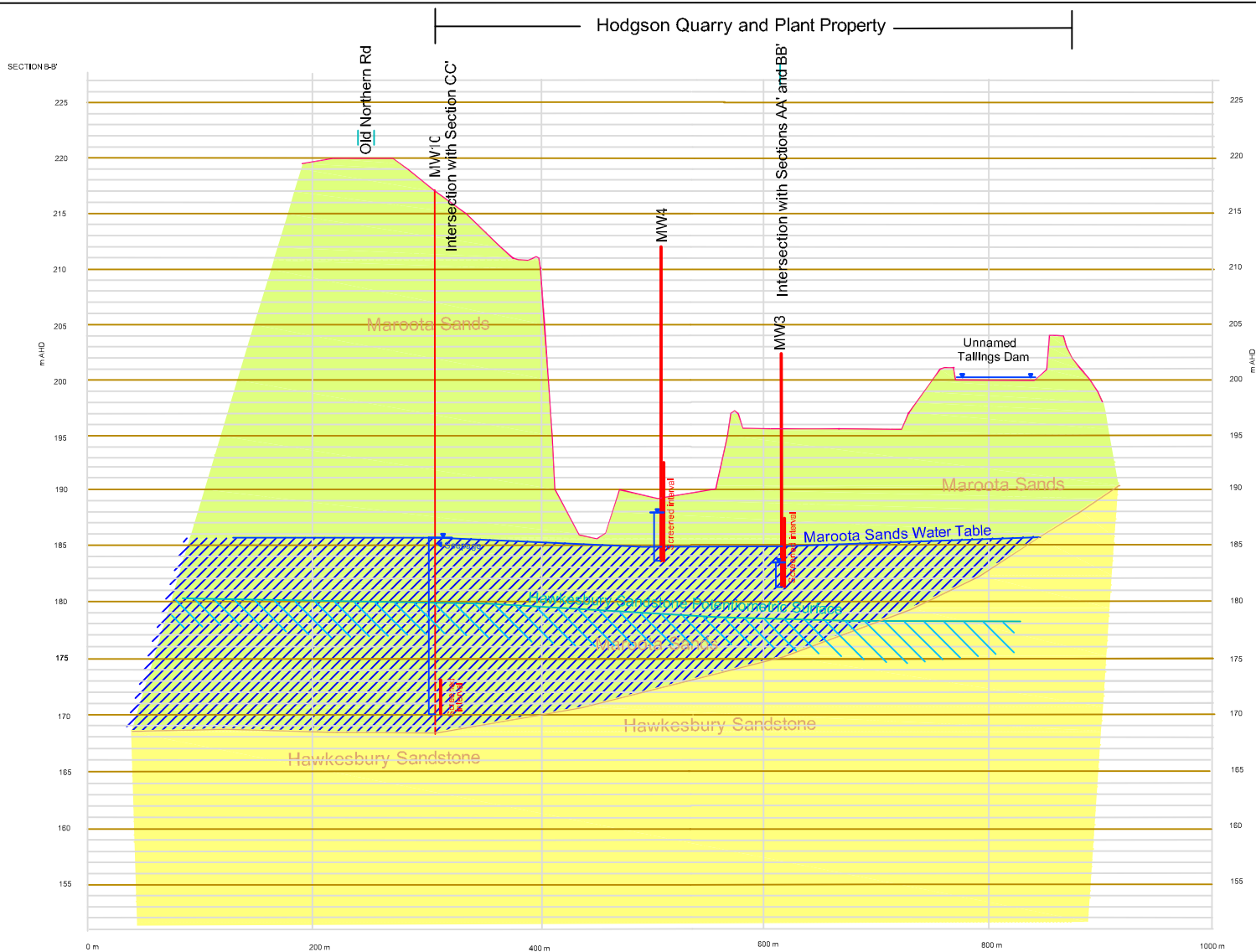
Hodgson Quarry and Plant Pty Ltd

ROBERTS ROAD MAROOTA SAND QUARRY
CROSS-SECTION B-B'
 (through piezometers PFHitchMW1, MW5,
 MW8, MW9, MW13, MW3 and MW11)

Figure 12



DATE:	15 April 2018	SCALE:	N/A	Hodgson Quarry and Plant Pty Ltd ROBERTS ROAD MAROOTA SAND QUARRY CROSS-SECTION C-C' (through piezometers PF214MW1, PF166Dam, MW10, MW6 and MW12)
AUTHOR: PD	CHECKED: PD	PROJECT NO:	16-318	
DRAWING NO:	0318-010d	REVISION:	D	
Dundon Consulting Pty Ltd				Figure 13

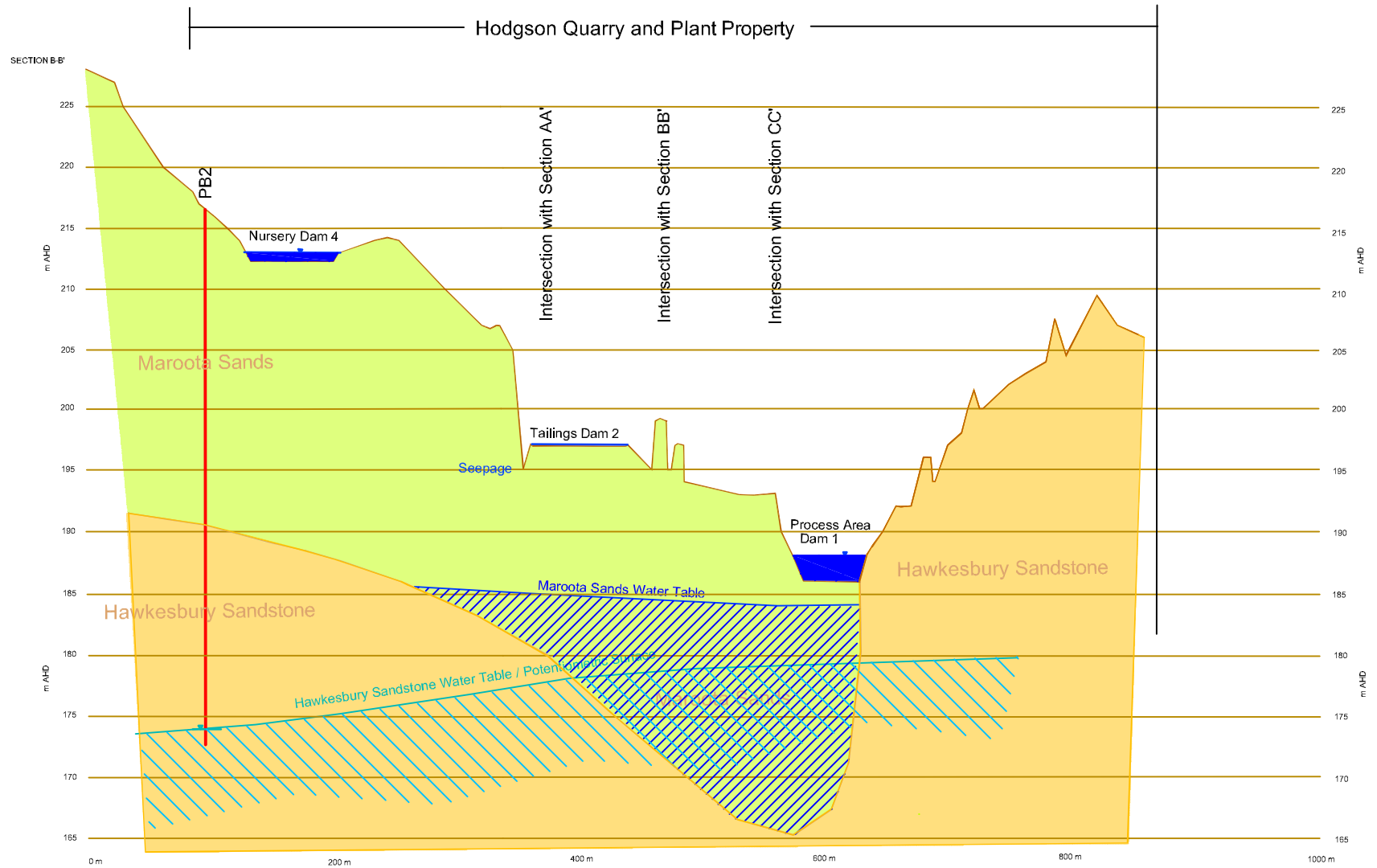


DATE:	15 April 2018	SCALE:	N/A
AUTHOR: PD	CHECKED: PD	PROJECT NO:	16-318
DRAWING NO:	0318-010d	REVISION:	D
Dundon Consulting Pty Ltd			

Hodgson Quarry and Plant Pty Ltd

**ROBERTS ROAD MAROOTA SAND QUARRY
CROSS-SECTION D-D'
(through piezometers MW3, MW4 and MW10)**

Figure 14



DATE:	15 April 2018	SCALE:	N/A
AUTHOR: PD	CHECKED: PD	PROJECT NO:	16-318
DRAWING NO:	0318-011e	REVISION:	E
Dundon Consulting Pty Ltd			

Hodgson Quarry and Plant Pty Ltd
ROBERTS ROAD MAROOTA SAND QUARRY CROSS-SECTION EE' (through bore PB1, seepage, tailings dam and main dam)
Figure 15

Logging Sheet

Project No: **16-0318**

Client: Hodgson Quarry and Plant Pty Ltd	Bore: MW7	Elevation (GL): 212.96 mAHD	Elevation (TOC): 213.44 mAHD	Stickup: 0.48m	Drilling Contractor: Ultra Drilling	Date Started: 09-Dec-16	Date Finished: 12-Dec-16
Location: Roberts Rd Maroota Quarry	MW1	213.43m AHD	214.13 mAHD	0.70m	Intertech	22-Oct-98	22-Oct-98

Hole depths:
As shown

Supervised By:
SRR (1998); M Ayre (2016)

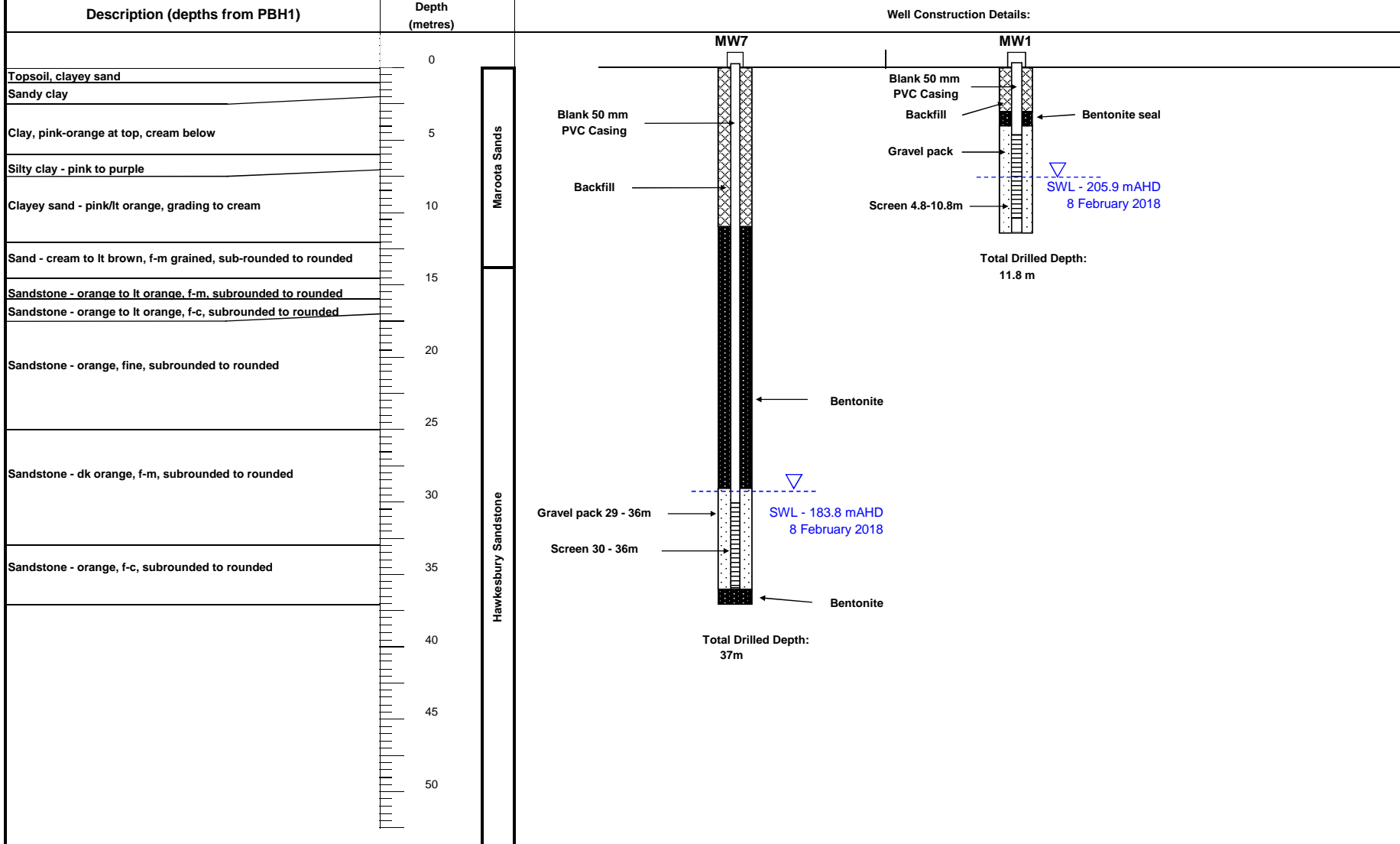


Figure 16: Composite Bore Logs - MW1 and MW7

Logging Sheet

Client: Hodgson Quarry and Plant Pty Ltd		Bore: MW8	Elevation (GL): 227.005 mAHD	Elevation (TOC): 227.425 mAHD	Stickup: 0.42m	Drilling Contractor: Ultra Drilling	Date Started: 05-Dec-16	Date Finished: 07-Dec-16
Location: Roberts Rd Maroota Quarry		MW2	226.893 mAHD	227.693 mAHD	0.83m	Intertech	20-Oct-98	20-Oct-98
		MW5	226.996 mAHD	227.796 mAHD	0.80m	Ultra Drilling	11-Apr-13	11-Apr-13
		GW075003	225.484 mAHD	226.384 mAHD	0.88m	J H Iselt Pty Ltd	01-Jul-97	01-Jul-97
		GW075004	226.945 mAHD	227.795 mAHD	0.85m	J H Iselt Pty Ltd	07-Jul-97	07-Jul-97
				Hole depths: As shown	Supervised By: SRR (1998); F Carosone (2013); P Dundon/M Ayre (2016)			

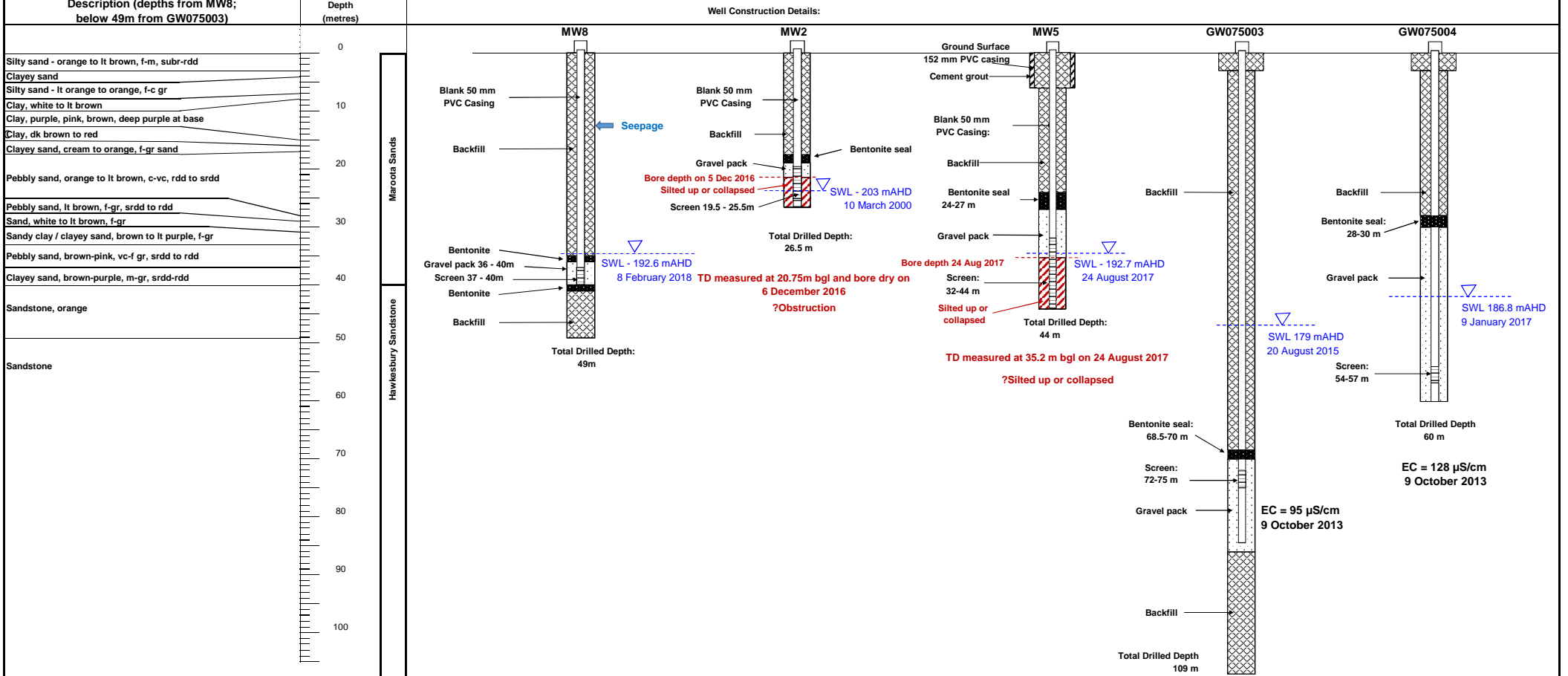


Figure 17: Composite Bore Logs - MW2, MW5, MW8, GW075003 and GW075004

Logging Sheet

					Project No: 16-0318		
Client:	Bore:	Elevation (GL):	Elevation (TOC):	Stickup:	Drilling Contractor:	Date Started:	Date Finished:
Hodgson Quarry and Plant Pty Ltd	MW9	225.577 mAHD	226.04 mAHD	0.46m	Ultra Drilling	19-Dec-16	19-Dec-16
Location:	MW13	225.497 mAHD	226.20 mAHD	0.70m	Ultra Drilling	07-Dec-16	07-Dec-16
					Hole depths:		Supervised By:
					As shown		M Ayre

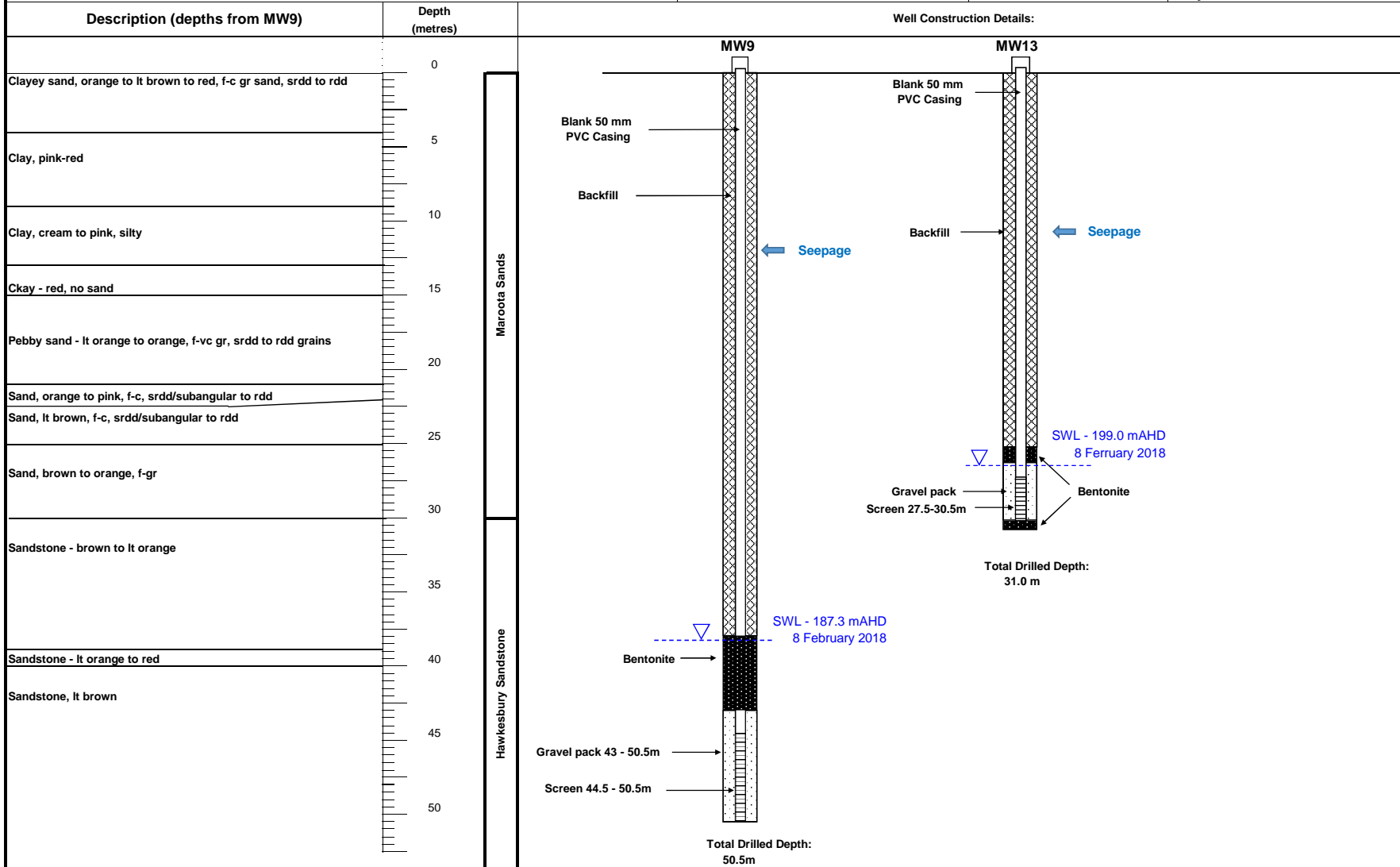
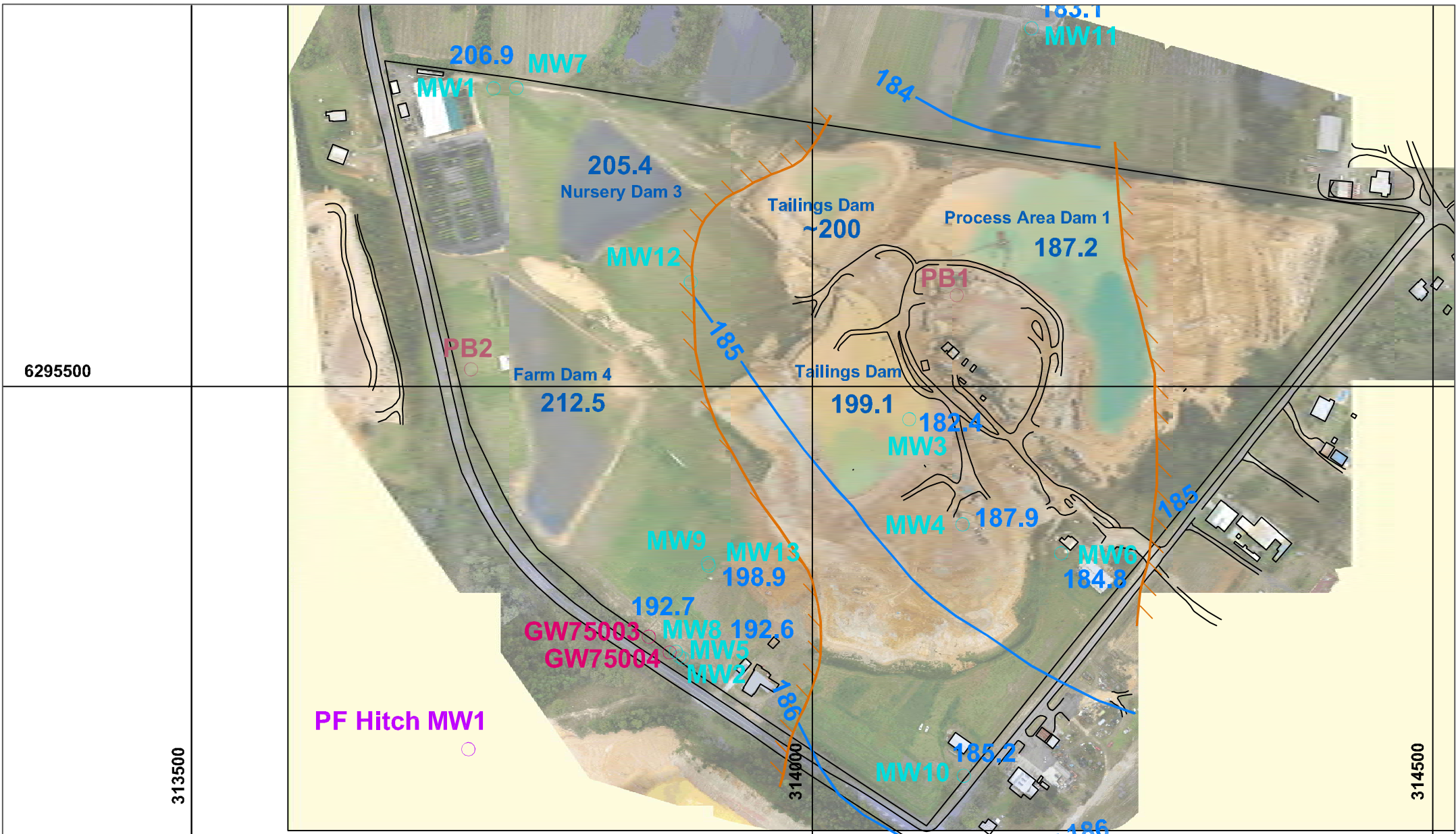


Figure 18: Composite Bore Logs - MW9 and MW13



LEGEND:	
	Hodgson monitoring bore
	Hodgson production bore
185.2	Maroota Sands WWHGWL (mAHD)
	Contours of wet weather high GW level
	Edge of saturated Maroota Sands

DATE:	8 March 2018	SCALE:	
PROJECT NO:	06-0318	AUTHOR:	PD
DRAWING NO:	06-0318-020d	REVISION:	D
Dundon Consulting Pty Ltd			

Hodgson Quarry and Plant Pty Ltd	
ROBERTS ROAD MAROOTA SAND QUARRY	
Wet Weather High Groundwater Level	
Maroota Sands (February 2018)	
Figure 19	

Groundwater Level Hydrographs - Hawkesbury Sandstone

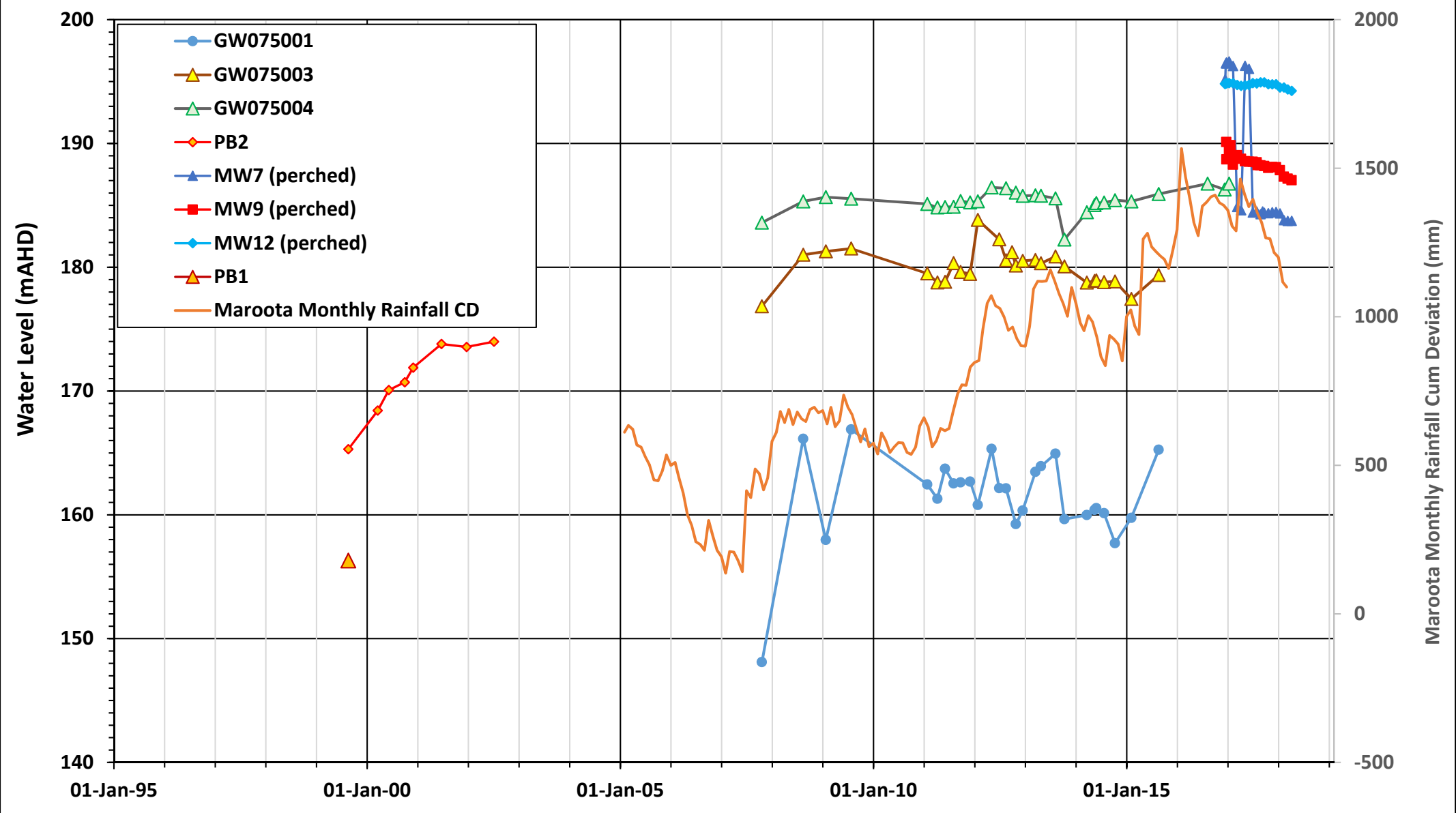
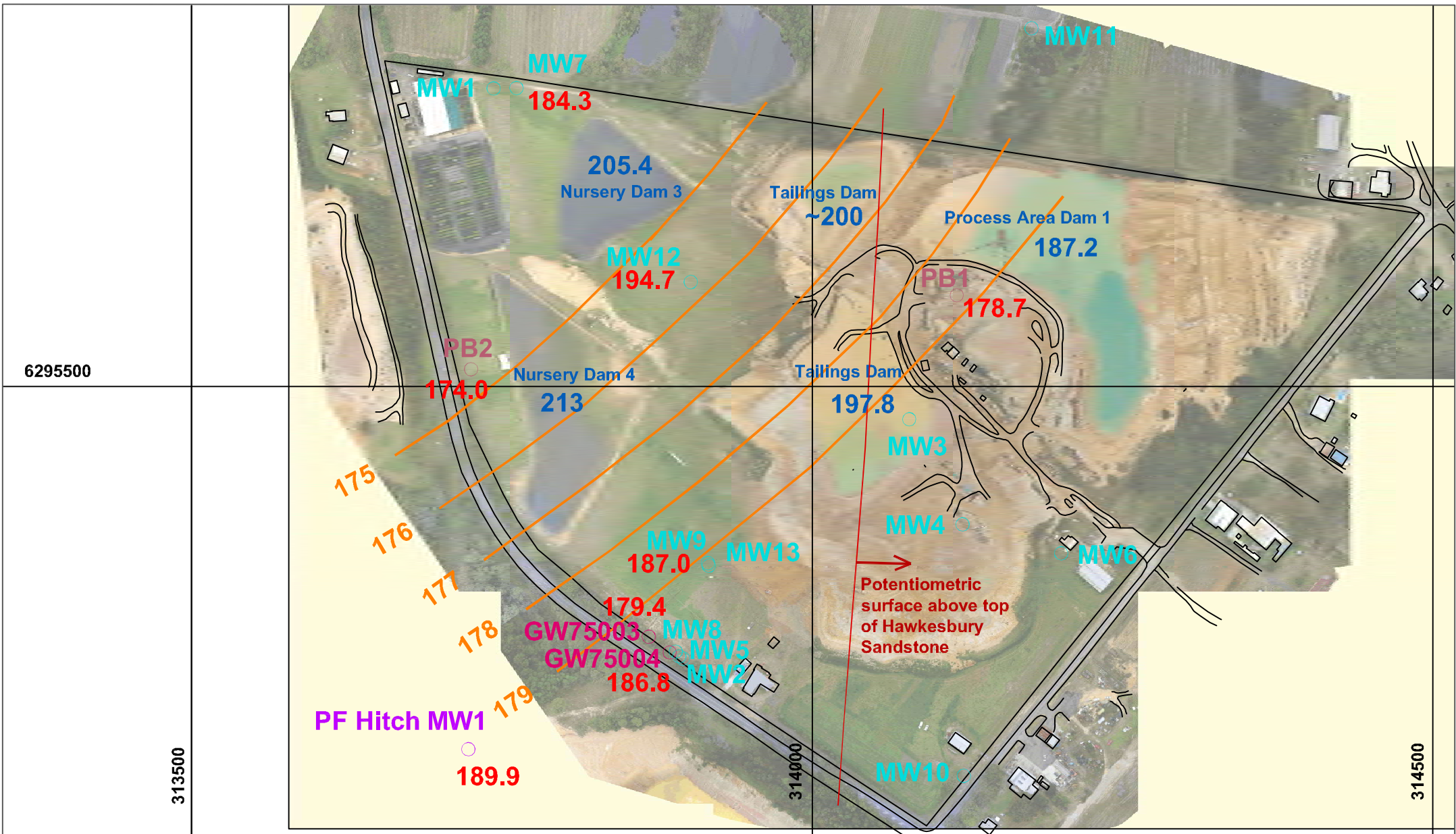


Figure 20: Bore Water Level Hydrographs - Hawkesbury Sandstone Bores



LEGEND: Hodgson monitoring bore Hodgson production bore 174.0 Hawkesbury Sandstone water level Contours of wet weather high GW level Potentiometric surface above top of HS	DATE: 15 April 2018 SCALE:	Hodgson Quarry and Plant Pty Ltd ROBERTS ROAD MAROOTA SAND QUARRY Wet Weather High Groundwater Level Hawkesbury Sandstone (February 2018)
	PROJECT NO: 06-0318 AUTHOR: PD	
	DRAWING NO: 06-0318-021e REVISION: E	
	Dundon Consulting Pty Ltd	

Groundwater Level Hydrographs

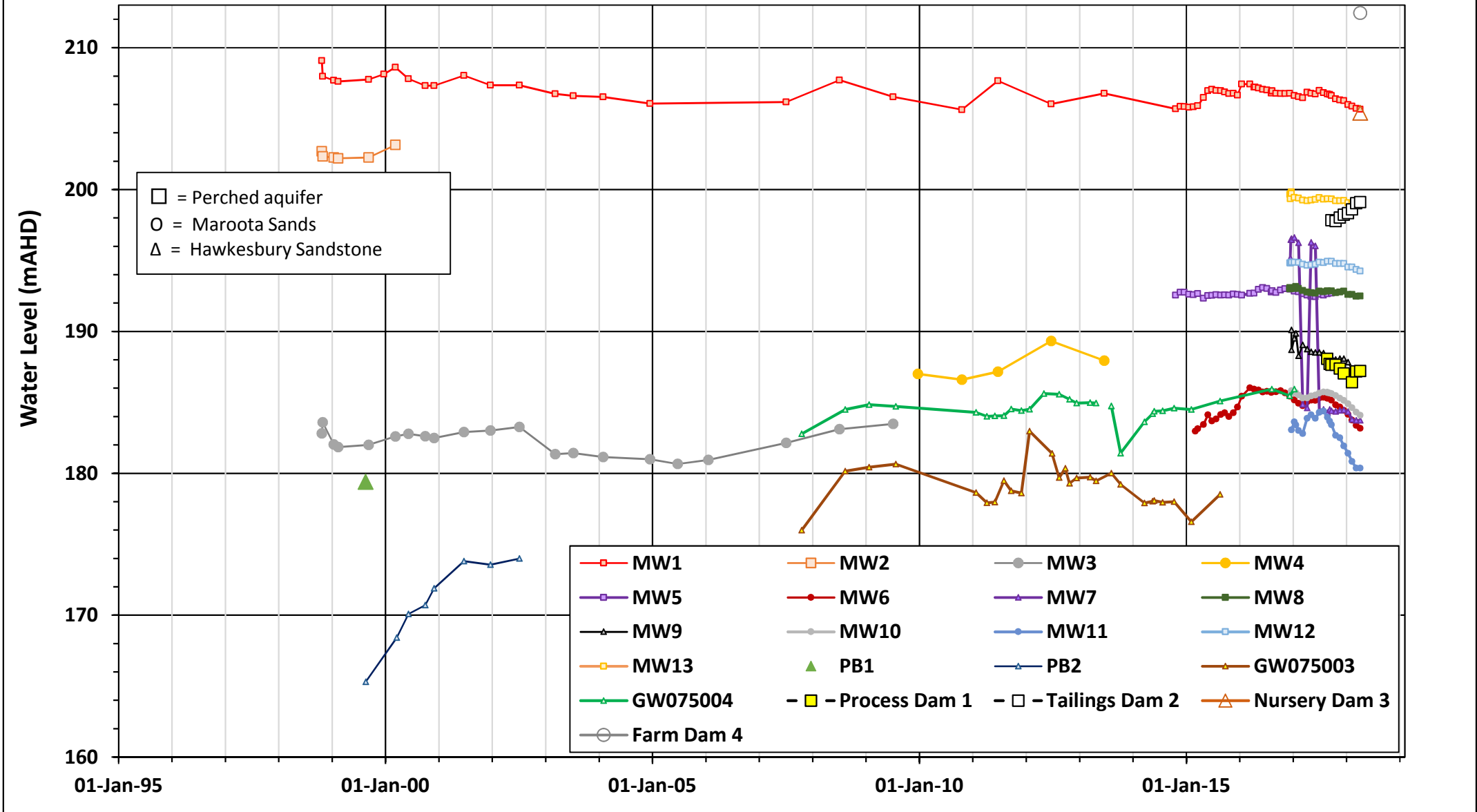


Figure 22: Bore Water Level Hydrographs - Composite Plot

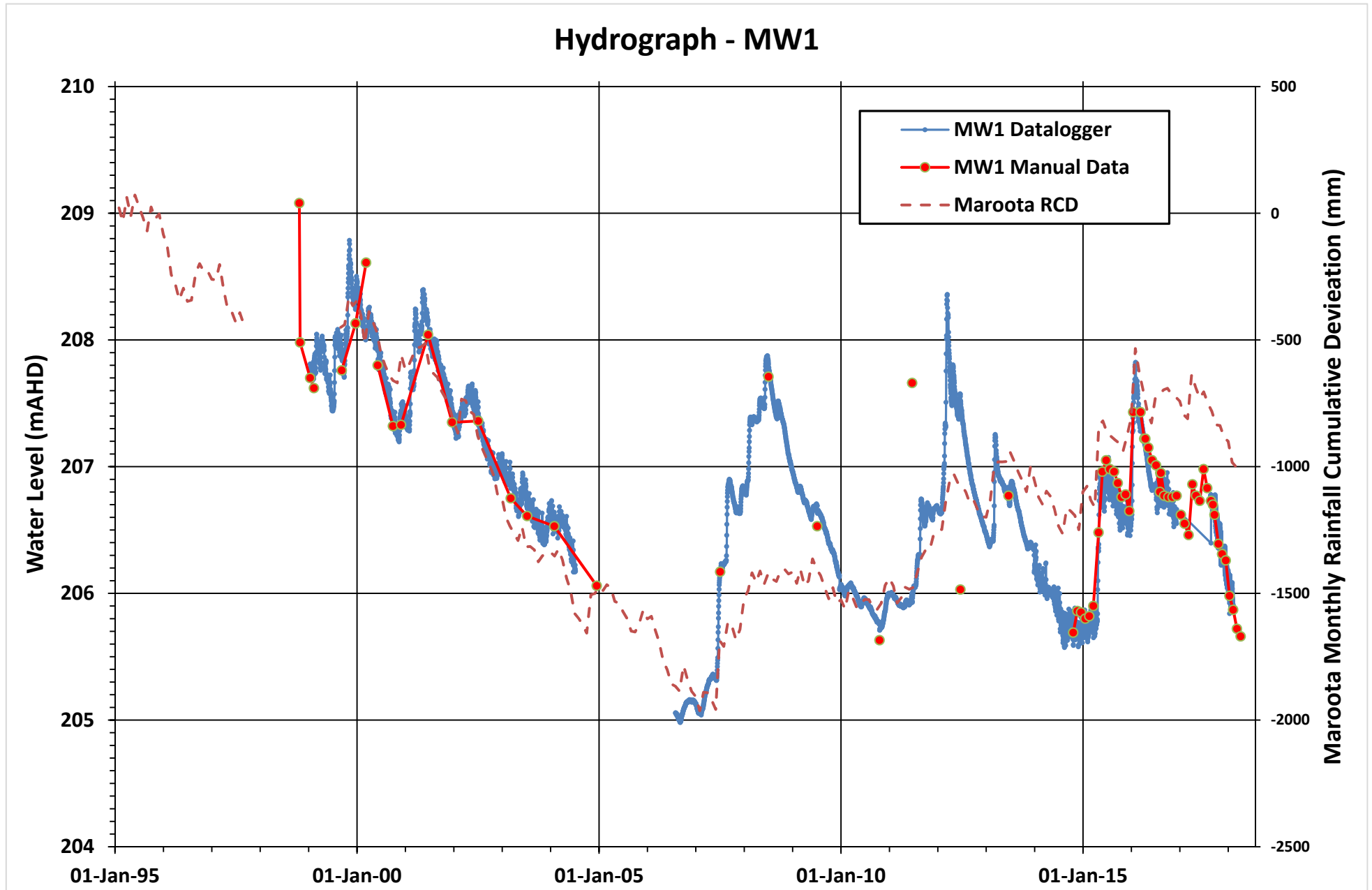


Figure 23: Bore Water Level Hydrograph - MW1

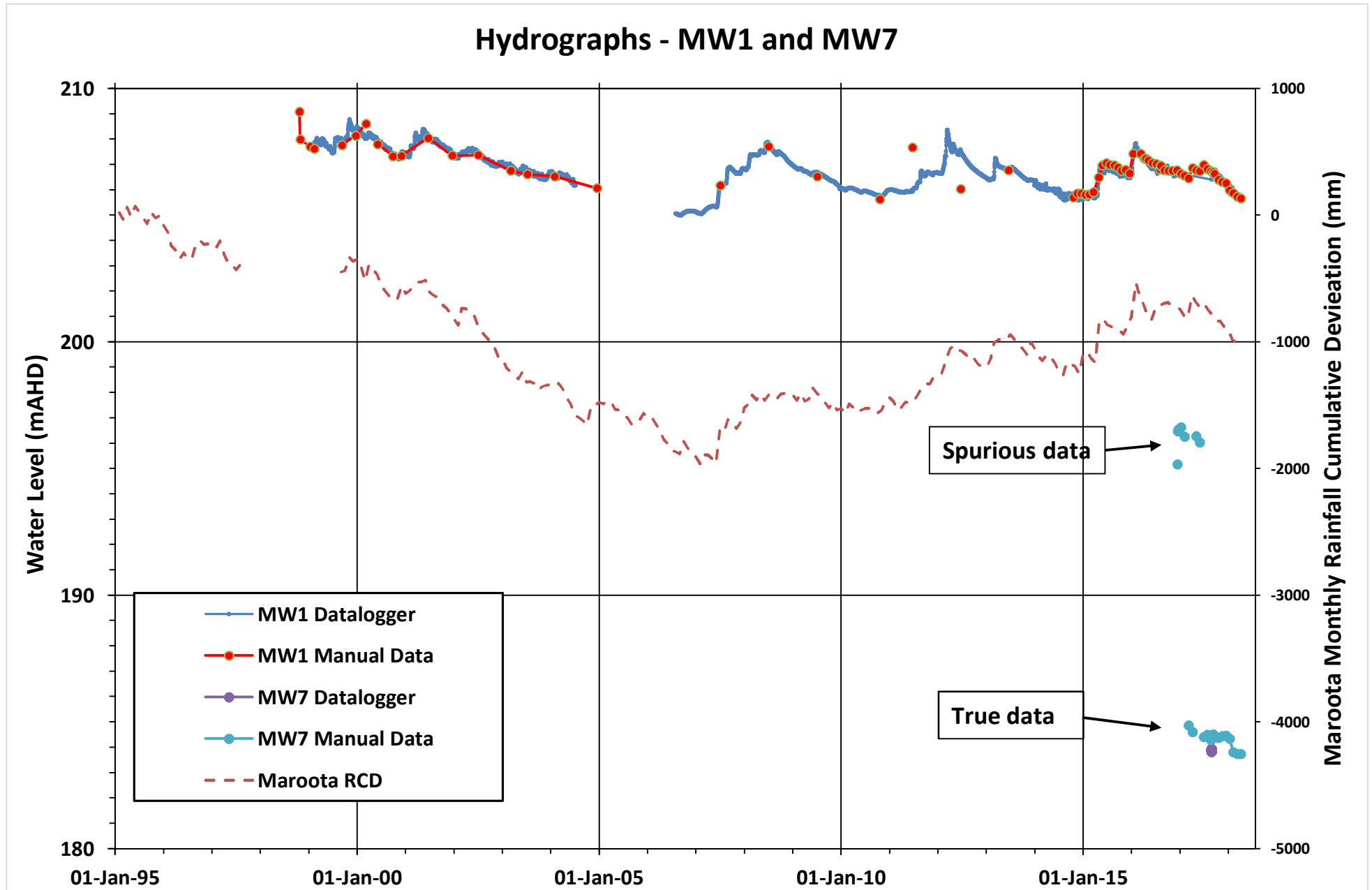


Figure 24: Bore Water Level Hydrographs - MW1 and MW7

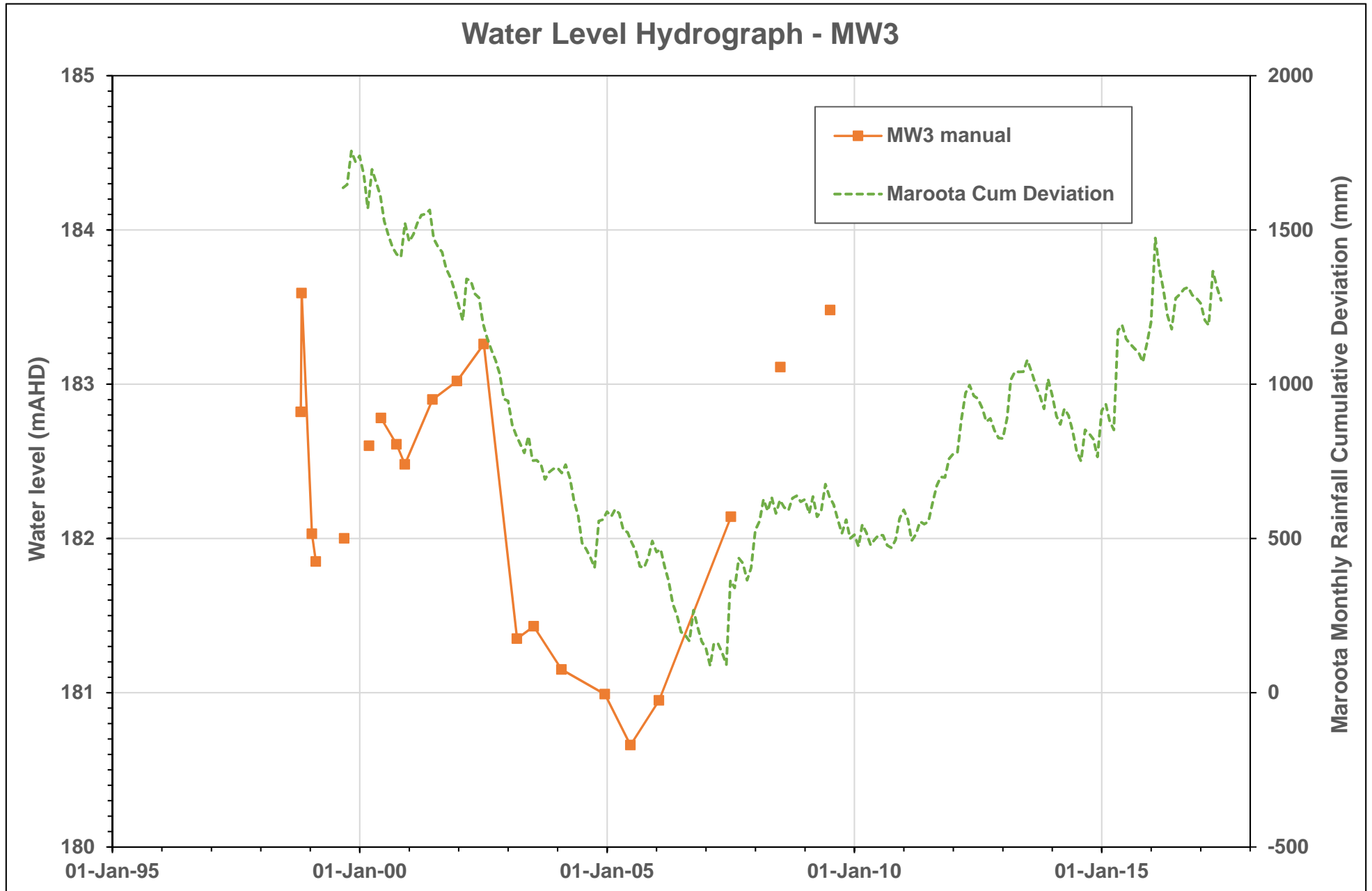


Figure 25: Water Level Hydrograph - MW3

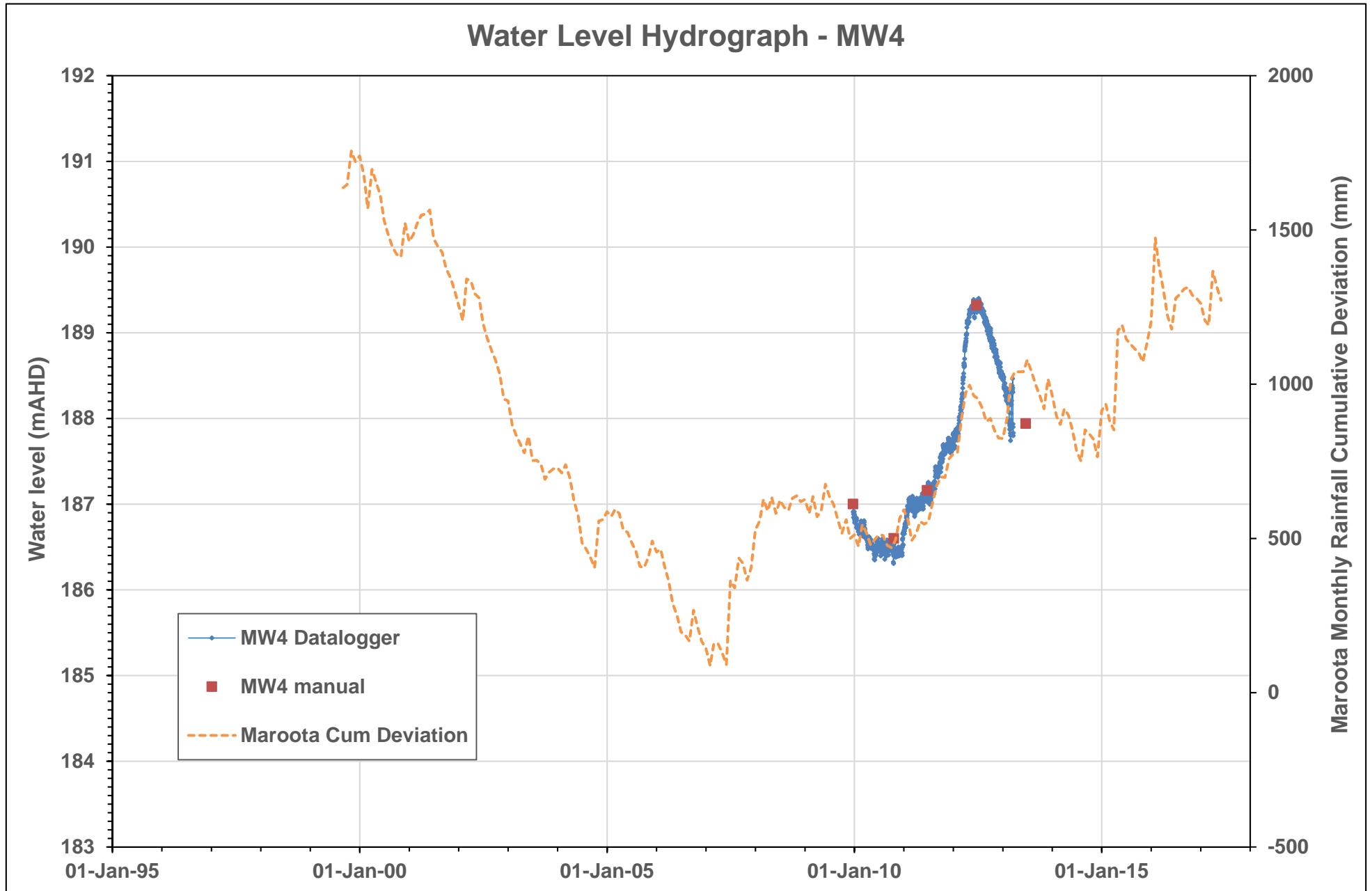


Figure 26: Water Level Hydrograph - MW4

Hydrographs - MW5 and MW8

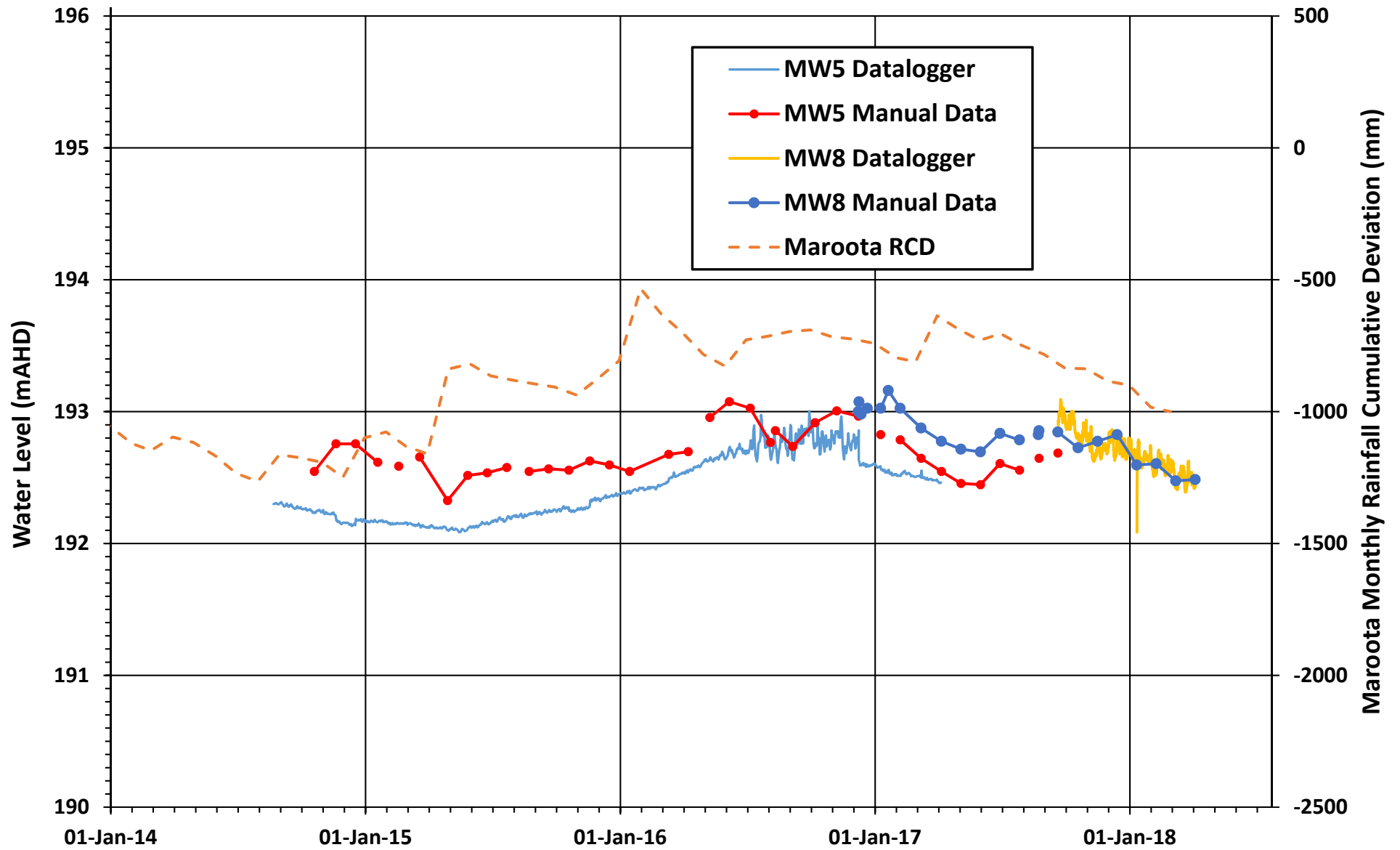


Figure 27: Bore Water Level Hydrographs - MW5 and MW8

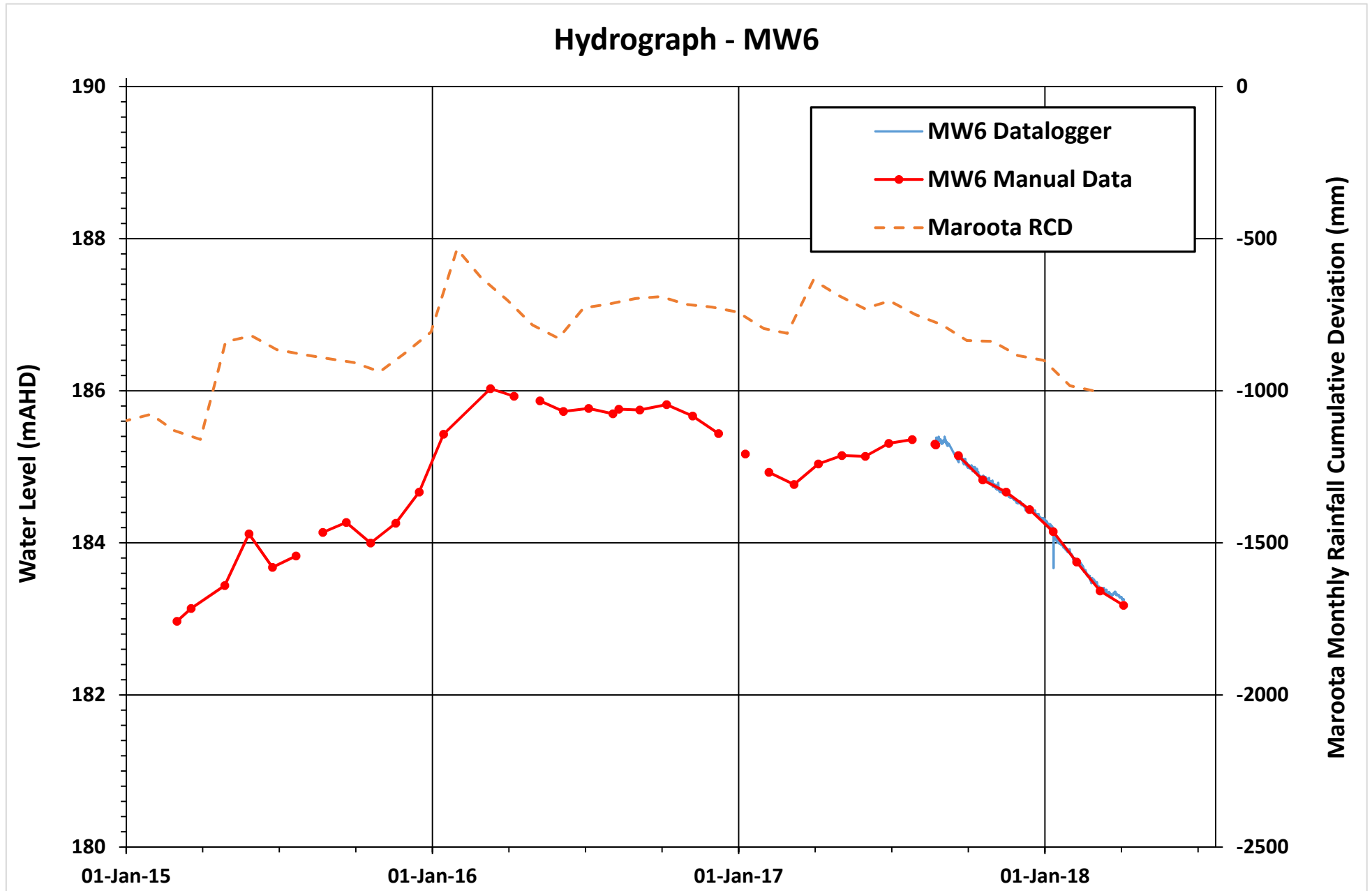


Figure 28: Water Level Hydrograph - MW6

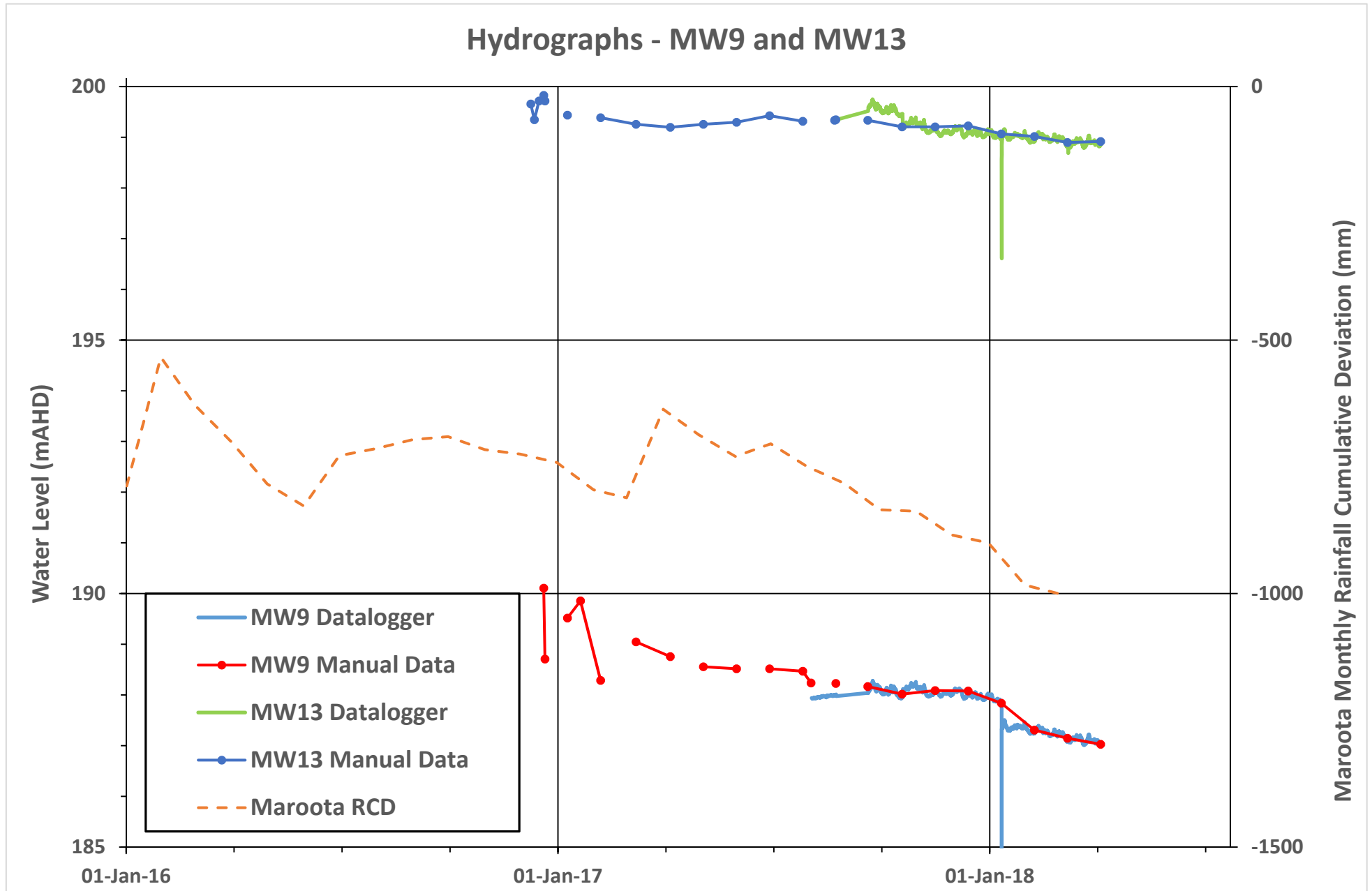


Figure 29: Bore Water Level Hydrographs - MW9 and MW13

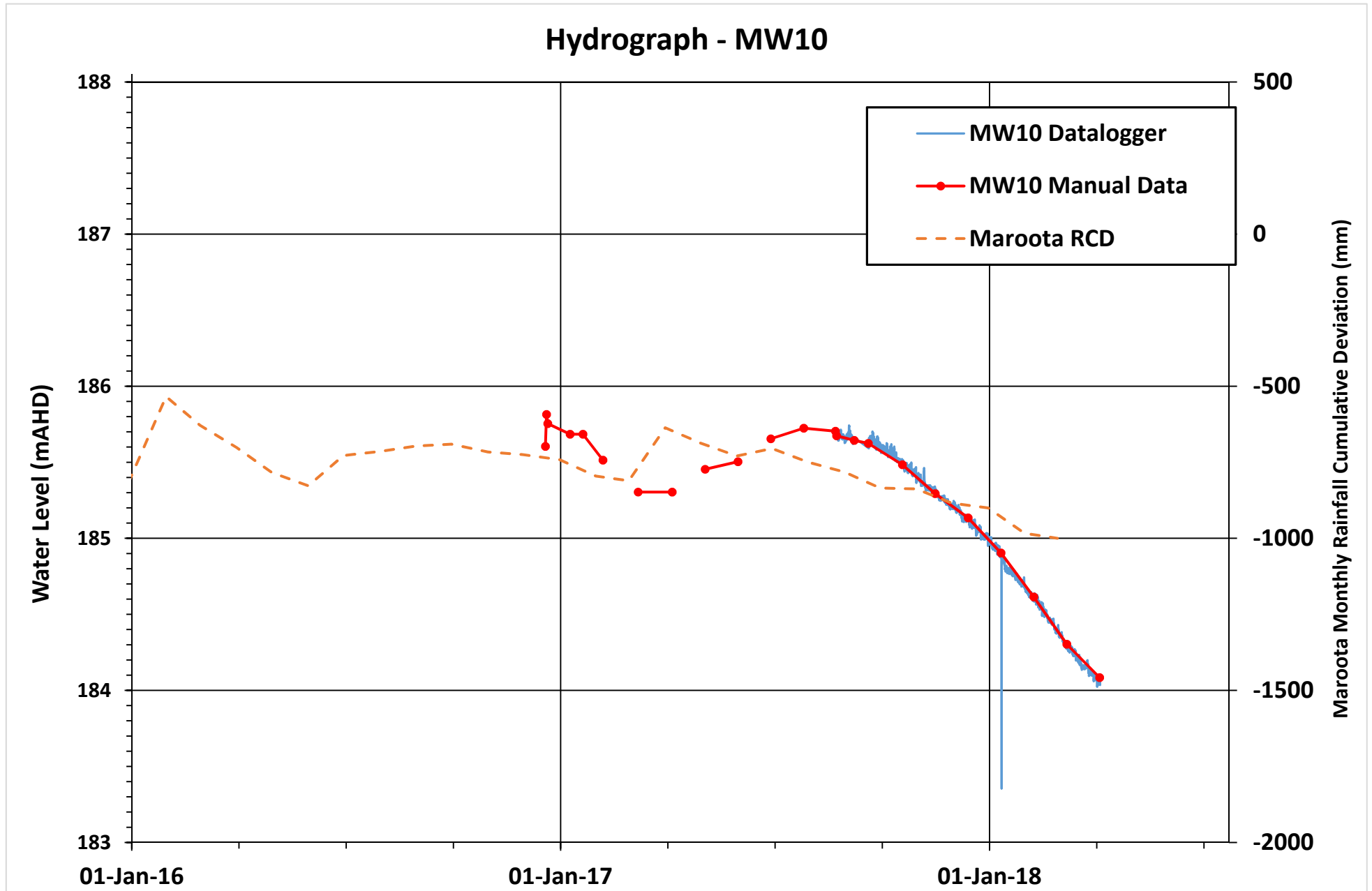


Figure 30: Bore Water Level Hydrograph - MW10

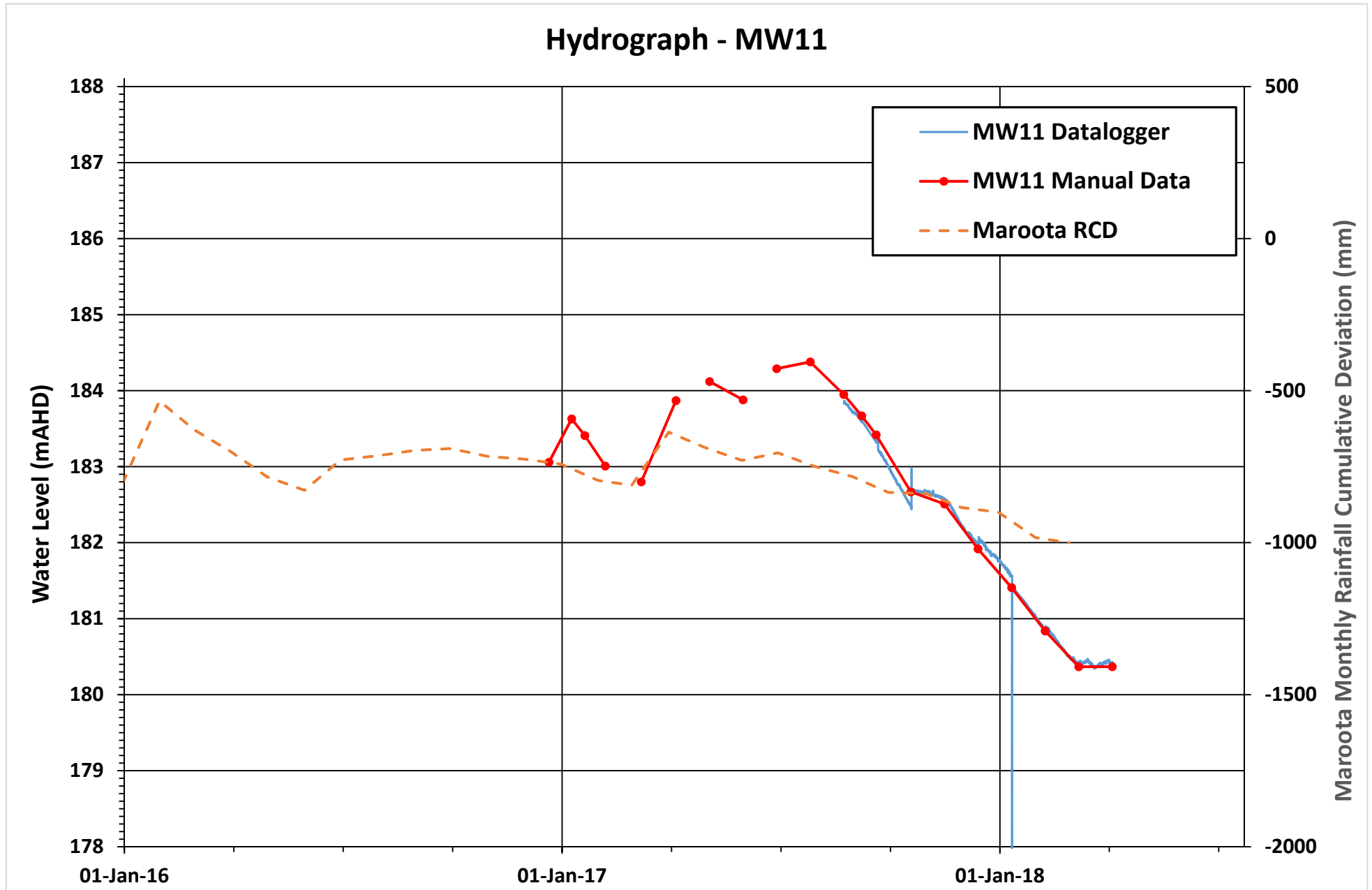


Figure 31: Bore Water Level Hydrograph - MW11

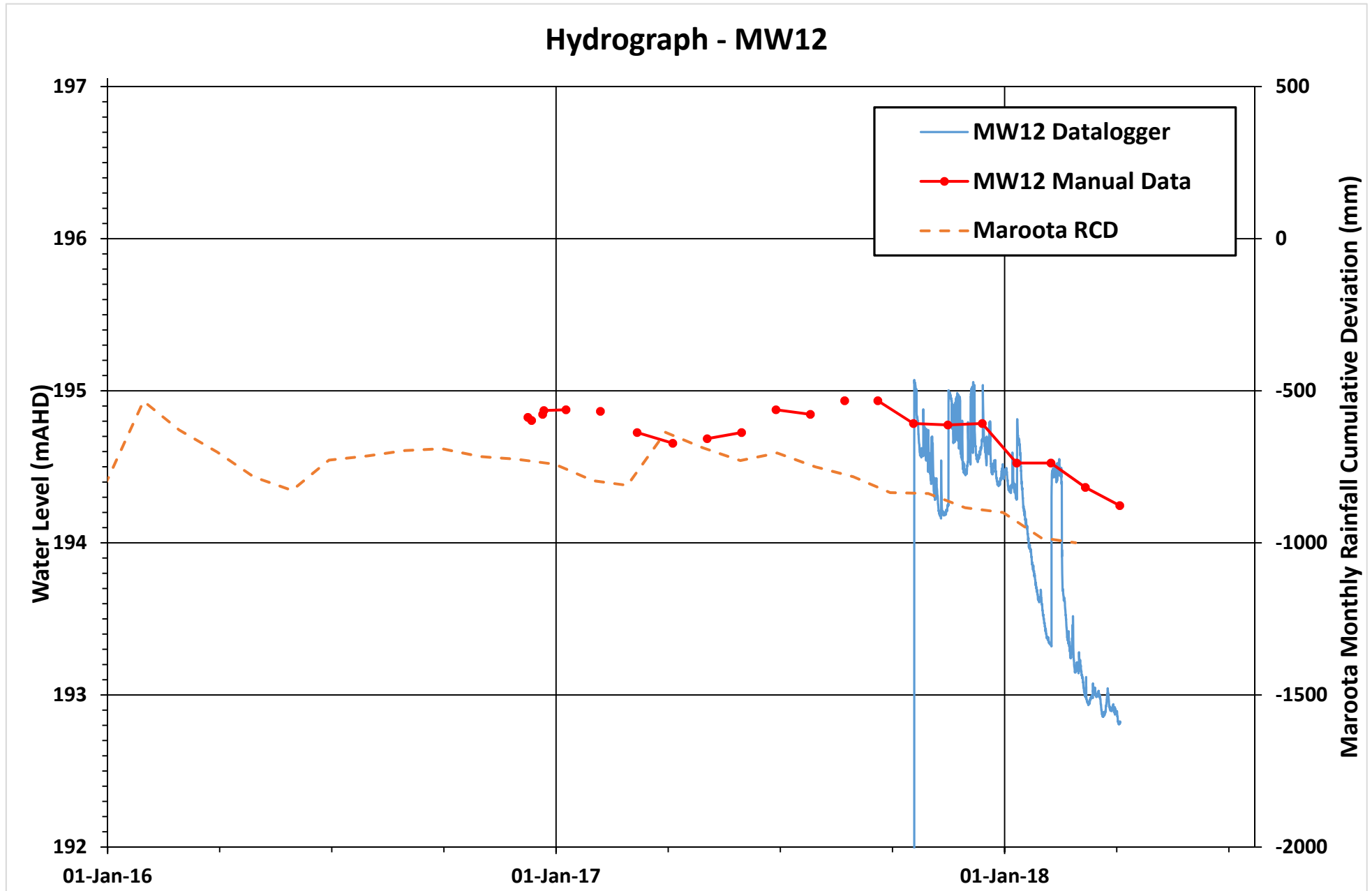


Figure 32: Bore Water Level Hydrograph - MW12

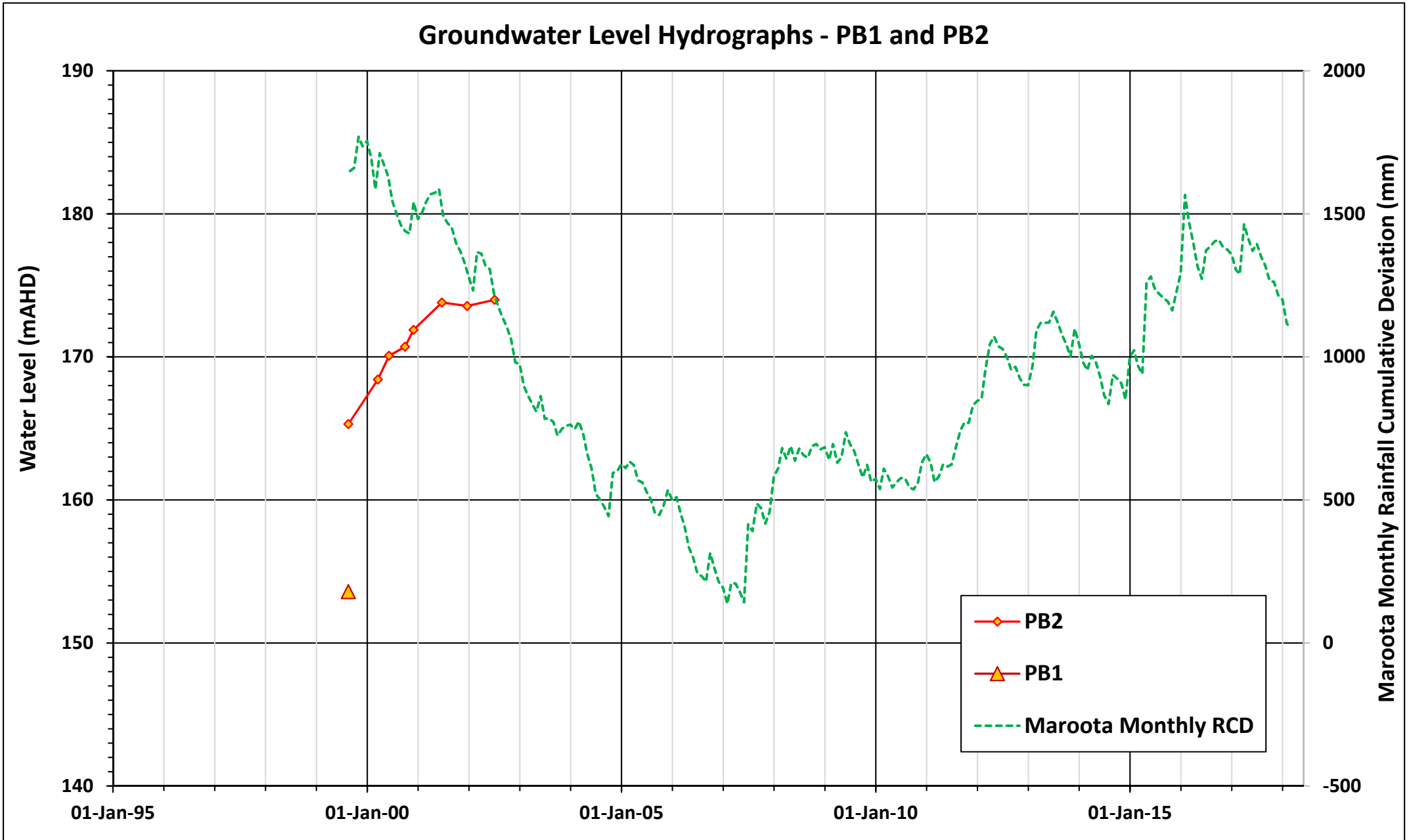
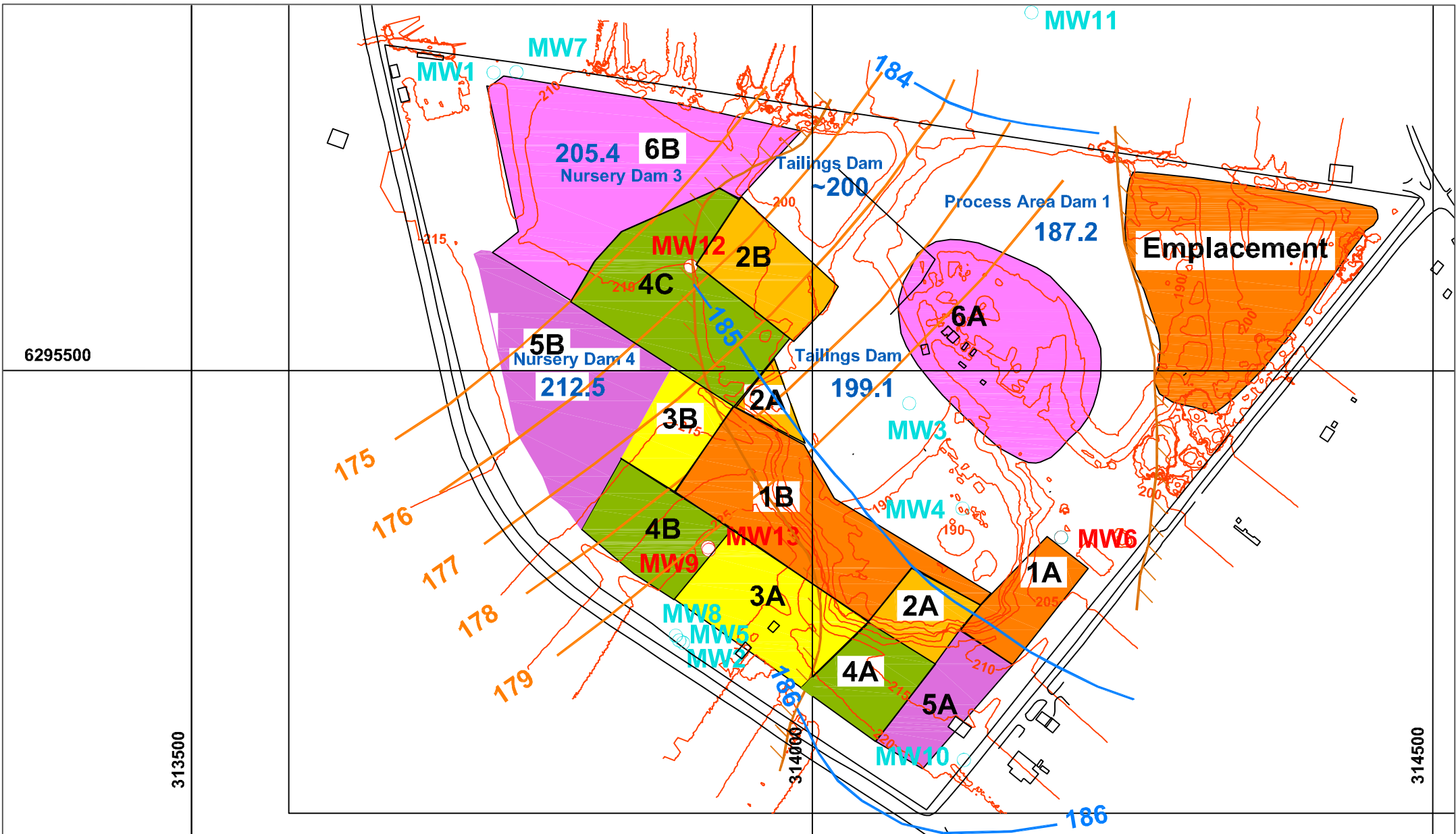


Figure 33: Bore Water Level Hydrographs - PB1 and PB2



LEGEND:

	Surface contours - 5m
	Site Dams
	Dam water level - April 2018 (mAHD)
	Extraction Schedule - Phase Number
	Monitoring Bore - Extraction Phases
	Wet Weather High GW Level - Maroota Sands
	Wet Weather High GW Level - Hawkesbury Sst
	Edge of Saturated Maroota Sands

DATE: 15 April 2018	SCALE:
PROJECT NO: 06-0318	AUTHOR: PD
DRAWING NO: 06-0318-071b	REVISION: B
Dundon Consulting Pty Ltd	


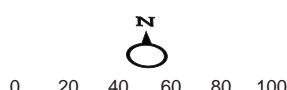
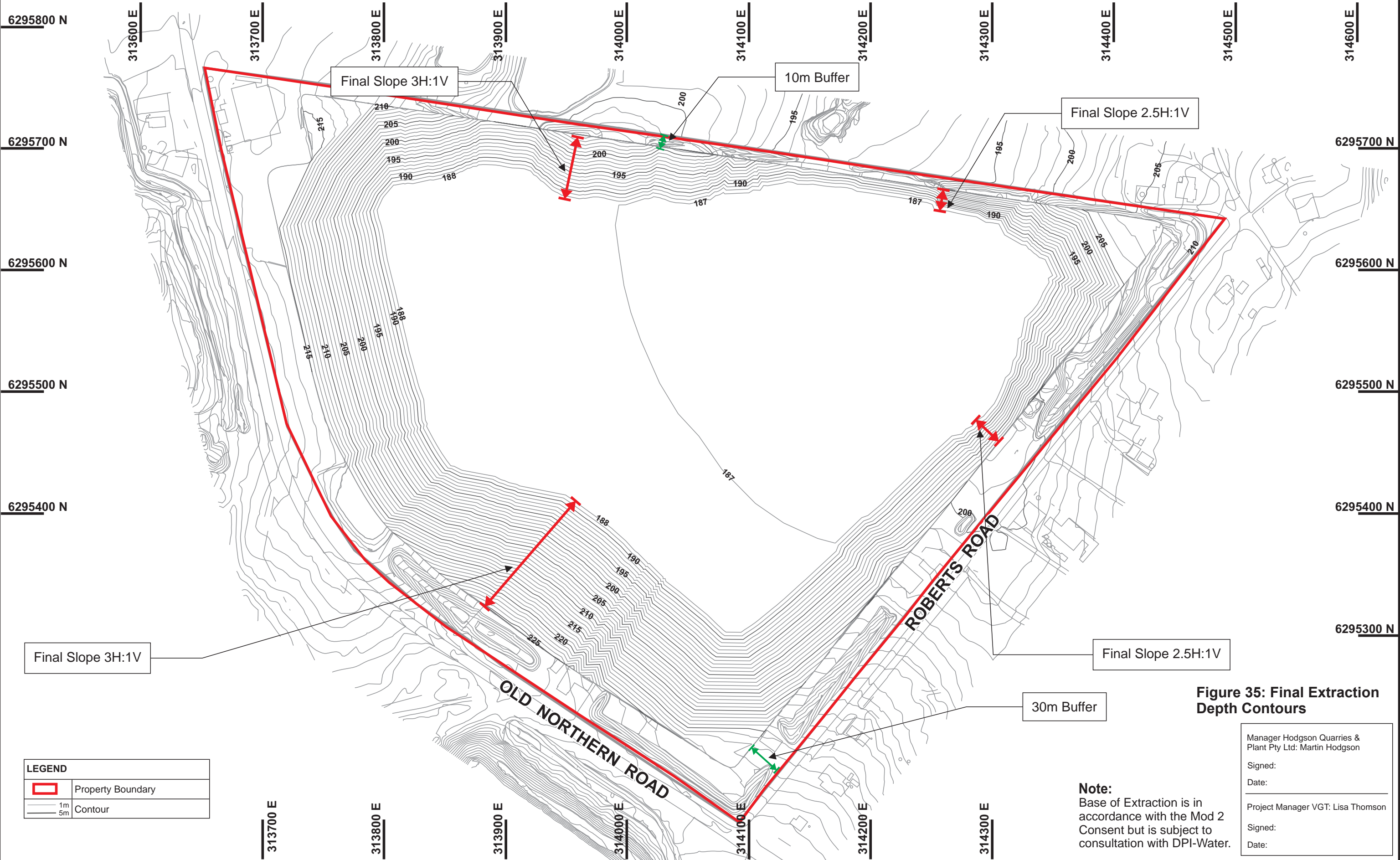
Hodgson Quarry and Plant Pty Ltd

ROBERTS ROAD MAROOTA SAND QUARRY
Sand Extraction Schedule

Figure 34

Plan of:	Roberts Rd Maroota Sand Quarry Rehabilitation Plan 2017 - Final Landform	Location:	Maroota Quarry, Roberts Road, Maroota, NSW	Source:	Google Earth Pro - Image Date 5 September 2017	Our Ref:	5072_HMA_EMP_RP17_C001_V4_F1.cdr
Figure:		Council:	Hills Shire Council	Survey:	Integral Surveying	Plan By:	LT/JD
Sheet:	1 of 1	Tenures:	N/A	Projection:	MGA	Project Manager:	LT
Version/Date:	V4 13/03/2018	Client:	Hodgson Quarries & Plant Pty Ltd	Contour Interval:	1m	Office:	Thornton

This figure may be based on third party data which has not been verified by vgt and may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and vgt does not warrant its accuracy.

LEGEND	
	Property Boundary
	1m Contour
	5m Contour

Figure 35: Final Extraction Depth Contours

Manager Hodgson Quarries & Plant Pty Ltd: Martin Hodgson
Signed: _____
Date: _____

Project Manager VGT: Lisa Thomson
Signed: _____
Date: _____

Note:
Base of Extraction is in accordance with the Mod 2 Consent but is subject to consultation with DPI-Water.

APPENDIX A

BORE LOGS – MONITORING BORES AND PRODUCTION BORES

Groundwater Monitoring Bore FIELD LOG



Woodward-Clyde

Borehole No:
PT84MW1

Sheet: 1 of 1

CLIENT: Nexus Environmental Planning Pty Ltd	JOB NUMBER: A8602019/1
PROJECT: Proposed Extractive Industry, PT84	DATE COMMENCED: 22/10/98
LOCATION: cnr Old Northern Rd & Roberts Rd, Maroota	DATE COMPLETED: 22/10/98
DRILL CONTRACTOR: Intertech	LOGGED BY: SRR

Drill Model: Intertech 750	Hole Angle: 90 deg.	Bore Size: 150mm	RL: 213.43	m AHD
Drilling Fluid: Biogel	Orientation: deg.	Co-ords: E 8422.49	N 6132.88	ISG

Drilling Info.		Material Properties			Field Records/Construction Information					
Method	Casing Top resistance Penetration Pressure Water	Depth (m)	Graphic Log	Classification	Material Description	Moisture Condition Consistency Rel. Density	Scale	Sampling Testing PID (ppm)	Comments/Construction	Well Diagram
Air Drilling	170mm	0-1	[Hatched pattern]	CL	silty SAND/sandy SILT, topsoil, low plasticity, brown					
		1-2	[Hatched pattern]		silty CLAY, medium plasticity, orange brown - some gravel fragments (rounded to sub-angular)					
		2-4.5	[Hatched pattern]		- 1.7m, light grey and red-brown iron-oxidised bands - 4.5m, mainly light grey, clayey gravel/gravelly clay, with quartz silica sub-rounded gravel				Backfill	[Well diagram showing backfill zone]
		4.5-5.3	[Hatched pattern]						50mm PVC Casing	[Well diagram showing casing zone]
		5.3-6	[Hatched pattern]						bentonite seal	[Well diagram showing bentonite seal]
		6-7	[Dotted pattern]	GC CH	sandy GRAVEL, fine to medium grained quartz gravel, brown/orange brown, iron-oxidised, sub-rounded in sandy matrix				2mm gravel backfill	[Well diagram showing gravel backfill]
		7-10	[Dotted pattern]		CLAY, medium plasticity, light grey with some gravel (3-4mm) sub-rounded					
		10-11.8	[Dotted pattern]		SANDSTONE, extremely weathered, light grey, fine to medium grained - increasing in strength with depth - slow progress with blade bit from 10.5m				50mm PVC Class 18, Machine Slotted	[Well diagram showing slotted casing]
		11.8-12	[Dotted pattern]		Borehole Discontinued at 12.0m (limit of investigation)				sump	[Well diagram showing sump]
		12-15	[Dotted pattern]						TD 11.8m	[Well diagram showing total depth]

Produced By: SRR
Checked By:

Groundwater Monitoring Bore FIELD LOG



Woodward-Clyde PT84MW2

Borehole No:
PT84MW2

Sheet: 1 of 2

CLIENT: Nexus Environmental Planning Pty Ltd	JOB NUMBER: A8802019/1
PROJECT: Proposed Extractive Industry, PT84	DATE COMMENCED: 20/10/98
LOCATION: cnr Old Northern Rd & Roberts Rd, Maroota	DATE COMPLETED: 20/10/98
DRILL CONTRACTOR: Intertech	LOGGED BY: SRR

Drill Model: Intertech 750	Hole Angle: 90 deg.	Bore Size: 150mm	RL: 226.8	m AHD
Drilling Fluid: Biogel	Orientation: deg.	Co-ords: E 9637.10	N 5698.78	ISG

Drilling Info.		Material Properties			Field Records/Construction Information				
Method	Casing (no resistance) Penetration Rate (mm/min)	Depth (m)	Graphic Log	Classification	Moisture Condition Consistency Rel. Density	Scale	Sampling Testing P10 (ppm)	Comments/Construction	Well Diagram
Air Drilling	170mm	0-1.5	[Graphic Log]	CL					
		1.5-2.0	[Graphic Log]	SH					
		2.0-5.5	[Graphic Log]						
		5.5-6.0	[Graphic Log]	CH					
		6.0-7.0	[Graphic Log]	CH					
		7.0-8.0	[Graphic Log]						
Casing Advancer		8.0-15.0	[Graphic Log]						

Backfill

50mm PVC Casing

Produced By: SRR
Checked By:

Groundwater Monitoring Bore
FIELD LOG



Woodward-Clyde

Borehole No:
PT84MW2

Sheet: 2 of 2

CLIENT: Nexus Environmental Planning Pty Ltd	JOB NUMBER: A8602019/1
PROJECT: Proposed Extractive Industry, PT84	DATE COMMENCED: 20/10/98
LOCATION: cnr Old Northern Rd & Roberts Rd, Maroota	DATE COMPLETED: 20/10/98
DRILL CONTRACTOR: Intertech	LOGGED BY: SRR
Drill Model: Intertech 750	Hole Angle: 90 deg. Bore Size: 150mm RL: 228.8 m AHD
Drilling Fluid: Biogel	Orientation: deg. Co-ords: E 9637.10 N 5098.76 ISG

Drilling Info.			Material Properties				Field Records/Construction Information							
Method	Casing No. resistance penetration vel. (m/s)	Water	Depth (m)	Graphic Log	Classification	Material Description	Moisture Condition	Consistency	Rel. Density	Scale	Sampling Testing PID (ppm)	Comments/Construction	Well Diagram	
Casing Advancer	[Hatched casing diagram]	[Water level diagram]	16	[Graphic log symbols]	SH	SAND, fine to medium grained, light grey							[Well diagram with labels: bentonite seal, 2mm gravel backfill, 50mm PVC Class 18, Machine Slotted, sump, TD 26.50m]	
			17											
			18				- medium to coarse grained from 17.5m (coarser with depth)							
			19											
			20											
			21											
			22				GP	GRAVEL, fine to medium grained quartz gravel, brown and grey, sub-rounded						
			23											
			24											
			25											
			26			Borehole Discontinued at 26.5m (limit of investigation)								
			27											
			28											
			29											
			30											

Produced By: SRR
Checked By:

Groundwater Monitoring Bore FIELD LOG



Woodward-Clyde Borehole No: **PT84MW3**

Sheet: 1 of 2

CLIENT: Nexus Environmental Planning Pty Ltd
 PROJECT: Proposed Extractive Industry, PT84
 LOCATION: cnr Old Northern Rd & Roberts Rd, Maroota
 DRILL CONTRACTOR: Intertech

JOB NUMBER: A8802019/1
 DATE COMMENCED: 21/10/98
 DATE COMPLETED: 21/10/98
 LOGGED BY: SRR

Drill Model: Intertech 750 Hole Angle: 90 deg. Bore Size: 150mm RL: 202.43 m AHD
 Drilling Fluid: Biogel Orientation: deg. Co-ords: E 9802.78 N 5916.37 ISG

Drilling Info.			Material Properties				Field Records/Construction Information									
Method	Casing (no resistance) (penetration) (m)	Water	Depth (m)	Graphic Log	Classification	Material Description	Moisture Condition	Consistency	Rel. Density	Scale	Sampling	Testing	PID (ppm)	Comments/Construction	Well Diagram	
Air Drilling	170mm		1		CL	type, plasticity/particle size, colour, secondary/minor components silty SAND/sandy SILT, topsoil, low plasticity, brown silty CLAY, low plasticity, orange brown - increasing stiffness with depth										
			2			- some quartz silica gravel bands (2-4mm)										
Rotary Mud Drilling	50mm PVC Casing		3			gravelly CLAY, low plasticity, yellow brown with rounded to sub-angular quartz gravel - some red-brown banding - increasing gravel content with depth								Back fill		
			4													
			5													
			6													
			7			GC	clayey GRAVEL, medium grained quartz silica gravel (3-4mm), brown silty clay matrix									
			8			SW	SAND, coarse grained, light grey, silica sand, sub-rounded - grading to medium grained with depth									
			9			SC	clayey SAND, medium grained, yellow-brown									
			10			SW	SAND, coarse grained, light grey with quartz gravel fragments, sub-rounded									
			11				- from 11.5m, fine grained									
			12				- from 12.0m, medium to coarse grained with some quartz gravel sub-rounded (3-4mm)									
			13													
			14													
			15													

Produced By: SRR
 Checked By:

Groundwater Monitoring Bore
FIELD LOG



Woodward-Clyde Borehole No: PT84MW3

Sheet: 2 of 2

CLIENT: Nexus Environmental Planning Pty Ltd
PROJECT: Proposed Extractive Industry, PT84
LOCATION: cnr Old Northern Rd & Roberts Rd, Maroota
DRILL CONTRACTOR: Intertech

JOB NUMBER: A8602019/1
DATE COMMENCED: 21/10/98
DATE COMPLETED: 21/10/98
LOGGED BY: SRR

Drill Model: Intertech 750 Hole Angle: 90 deg. Bore Size: 150mm RL: 202.43 m AHD
Drilling Fluid: Biogel Orientation: deg. Co-ords: E 9802.78 N 5016.37 ISG

Drilling Info.				Material Properties				Field Records/Construction Information							
Method	Casing	Log Description	Depth (m)	Graphic Log	Classification	Material Description	Moisture Condition	Consistency	Rel. Density	Scale	Sampling	Testing	PTD (ppm)	Comments/Construction	Well Diagram
Rotary Mud Drilling			16		SR	- 15.5-15.7m, medium plasticity, light grey clay band - from 16.5m, coarse grained								2mm gravel backfill	
			17												
			18												
			19												
			20												
			21		GW	GRAVEL, fine to medium grained, red-brown iron-oxidised/cemented									
			22		CH	CLAY, medium to high plasticity, red-brown and grey									
			23		GW	GRAVEL, fine to medium grained quartz gravel, brown and grey, sub-rounded (3-4mm)									
			24			Borehole Discontinued at 23.2m (limit of investigation)									
			25												
			26												
			27												
			28												
			29												
			30												

Produced By: SRR
Checked By:

PROJECT : HB Maroota Monitoring Bore
 LOCATION: Roberts Road, Maroota
 SUPERVISOR F.Carosone

JOB NO.: 43167795
 DATE STARTED: 21/12/2009
 DATE COMPLETED: 22/12/2009

DRILLED BY: Intertech Drilling Services
 RIG: Intertech 850
 DATUM: 0.57 m above concrete/ground
 EASTING: 314121

METHOD: Mud rotary
 TOTAL DEPTH : 28.5 m
 SWL: m b.datum
 NORTHING: 6295389

DIAMETER: 140 mm
 R.L. CONCRETE: mAHD
 R.L. STEEL PLATE: mAHD
 R.L. SWL :

WELL NUMBER: PT84MW4

Lithological Log	Remarks	Depth (m)	Bore Construction
			<p>Datum 152 mm monument Concrete pad sand backfill 200 mm HFA hole 152 mm diam. steel casing Rigid foam seal PVC Blank Casing, 60mm OD, 50mm ID cl 18 bentonite pellets seal back-fill 140 mm diam.hole 2 mm washed sand gravel pack PVC screens 60mm OD, 50mm ID cl 18, 0.45 mm slot bottom cap bottom of the hole</p>
0 - 0.5	SOIL: brown, sandy.		
0.5 - 6	SAND: orange/brown, fine, clayey, sorted subrounded quartz grains becoming lighter colour below 3 m.	1	
		2	
		3	
		4	
		5	
6 - 6.9	SAND: orange, gravelly medium/coarse subangular quartz grains	6	
6.9 - 8	SAND: grey, gravelly, medium/coarse subangular quartz grains.	7	
8 - 9	SAND: orange, gravelly medium/coarse subangular quartz grains.	8	
9 - 10	CLAY: grey, soft, sandy.	9	
10 - 12	CLAY: grey and orange.	10	
		11	
12 - 14	GRAVEL: grey, sandy, with some clay, fine, subrounded, clear and white quartz grains.	12	
		13	
14 - 15	CLAY: grey and red, layered, some sand.	14	
15 - 17	CLAY: grey and white, soft, some sand.	15	
		16	
17 - 20	GRAVEL: grey and white with some white clay, 2-5 mm quartz grains.	17	
		18	
		19	
20 - 25.5	SAND: red, gravelly medium/coarse subangular quartz grains.	20	
		21	
		22	
		23	
		24	
		25	
25.5 - 27.5	SAND: grey, gravelly, angular to subangular quartz grains	26	
		27	
27.5 - 28.5	Ironstone, red with dark red clay, very hard.	28	
28.5	Bottom of the hole	29	

PROJECT : Hodgson Quarries and Plant
 LOCATION: Roberts Road, Maroota
 SUPERVISOR F.Carosone

JOB NO.: 43167954
 DATE STARTED: 11/04/2013
 DATE COMPLETED: 11/04/2013

DRILLED BY: Ultra Drilling
 RIG: Mayhew 1000
 DATUM: 0.73 m above concrete/ground
 EASTING: 313896

METHOD: Air rotary
 TOTAL DEPTH : 44 m
 SWL: 34.6m b.datum
 NORTHING: 6295313

DIAMETER: 120mm
 R.L. CONCRETE: mAHD
 R.L. STEEL PLATE: mAHD
 R.L. SWL :

WELL NUMBER: PT84MW5

Lithological Log		Remarks	Depth (m)	Bore Construction
0 - 4	SAND: red/orange, fine to medium rounded quartz grains, clayey		1	
			2	
			3	
4 - 8	SAND + CLAY: grey and brown, fine grained with grey clay		4	
			5	
			6	
			7	
8-13	CLAY: grey, brown and dark red, stiff, dry		8	
			9	
			10	
			11	
			12	
13 -15	SAND: red, dark red, iron stained, fine, sorted, subrounded to rounded quartz grains		13	PVC Blank Casing, 60mm OD, 50mm ID cl 18
			14	
15- 17	SAND: grey, light grey and buff coloured, fine, sorted, subrounded to rounded quartz grains		15	
			16	
17 - 21	SAND: orange to dark orange, fine to medium, sorted, subrounded quartz grains		17	
			18	backfill
			19	
			20	
21 - 30	GRAVEL: orange, Fe stained, medium to coarse, subrounded, with white poorly sorted quartz grains. Becoming fine @ 26 m		21	
			22	
			23	
			24	
			25	
			26	120 mm diam.hole
			27	
			28	
			29	bentonite pellets seal
			30	
30 - 44	SAND: gray/ brown, fine to medium, subrounded to subangular some clear quartz grains. Traces of grey clay.		31	
			32	
			33	2 mm washed sand gravel pack
			34	
			35	
			36	
			37	
			38	
			39	PVC screens 60mm OD, 50mm ID cl 18, 0.45 mm slot
			40	
			41	
			42	
			43	
44	Bottom of the hole		44	bottom cap bottom of the hole

Logging Sheet

Project No: **16-0318**

Client: Hodgson Quarry Products Pty Ltd	Bore: MW6	Elevation (GL): 202.468 mAHD	Elevation (TOC): 203.17 mAHD	Stickup: 0.70m
Location: Roberts Rd Maroota Quarry				
	Drilling Contractor: Ultra Drilling	Date Started:	Date Finished: 23-Jan-15	Supervised By: ?? Driller
			Hole depths: As shown	

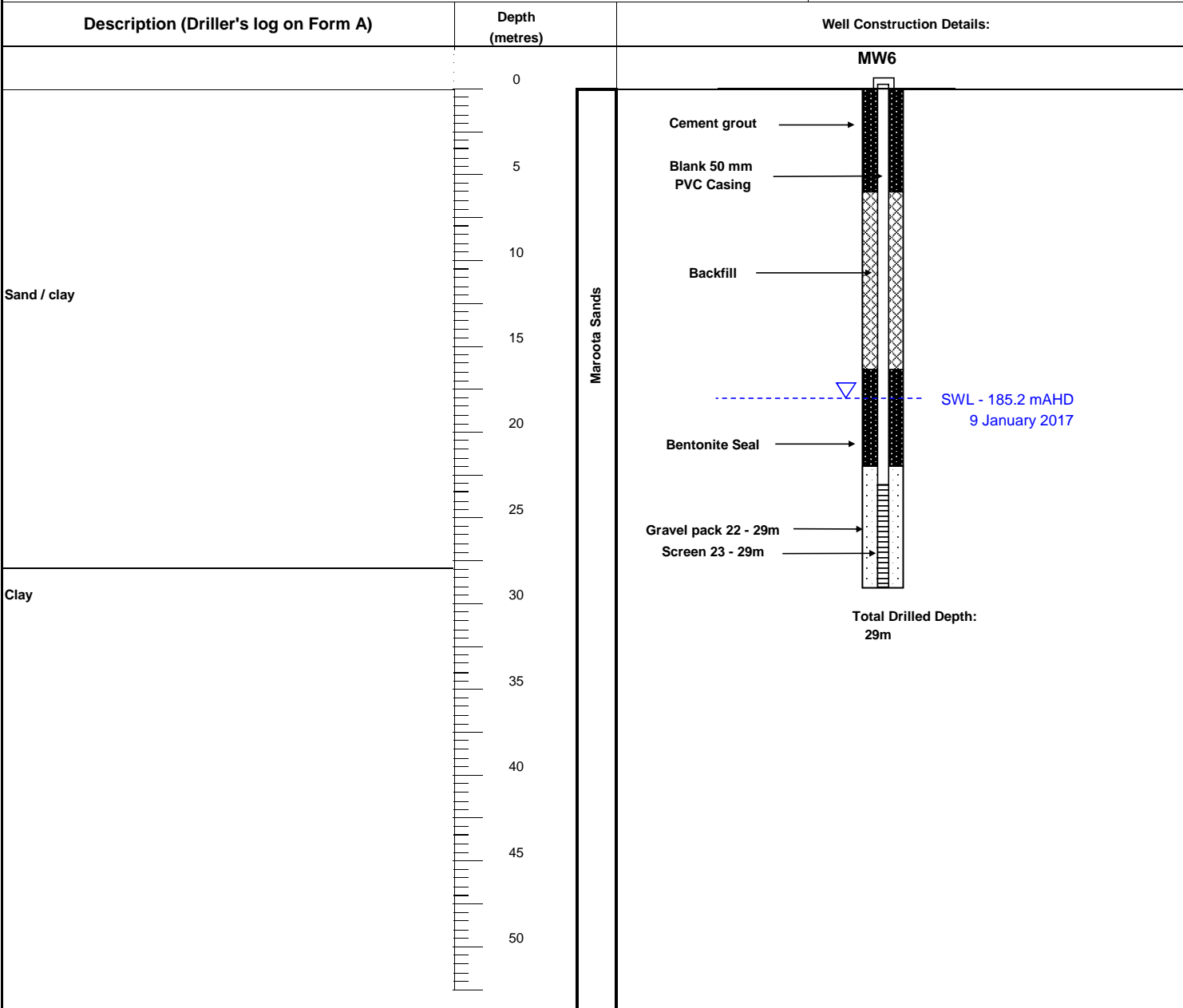


Figure xx: Bore Log - MW6

BOREHOLE LOG

Name of Hole: MW7

Project Number: 2801

Client: Hodgson Quarry Products and Plant

Project: Drilling Operations/ Groundwater Study

Location: Off Roberts Road, Maroota, NSW

Logged by: MA

MAROOTA

Date Commenced: 09/12/2016

Date Completed: 09/12/2016

Surface RL: 212.9m AHD

Collar Height: 0.48m

Coordinates: 313761 6295740

Drilling Contractor: Ultra Drilling Waterbores



Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Blade Bit	212	0				Topsoil/Clayey Sand- orange to borwn, fine to coarse grained, sub-rounded to rounded grains	
	211	1				Sandy Clay- orange to red, coarse grained sand, sub rounded to rounded	1.5m colour change
	210	2				Clay- Pink to cream	
	209	3				Clay- orange to cream	
	208	4				Clay- Cream	Some sand
	207	5				Clay- Cream	
	206	6				Silty Clay- Pink to Purple	
	205	7				Clayey Sand- pink to light orange, fine grained, sub rounded to rounded grains	7.2m Colour change
	204	8				Clayey Sand- cream, fine grained, subrounded to rounded grains	Water injected
	203	9				Clayey Sand- cream, fine grained, subrounded to rounded grains	
	202	10				Clayey Sand- cream, fine grained, subrounded to rounded grains	
Hammer Bit	201	11				Sand- creamto light brown, fine to medium grained, sub rounded to rounded grains	
	200	12				Sandstone- Orange, red to brown, fine to medium grained, subrounded to rounded grains	Feruginised Chips at top of sequence
	199	13				Sandstone- orange, fine to medium grained, subrounded to rounded grains	
	198	14				Sandstone- light orange, fine to coarse grained, ssubrounded to rounded grains	
	197	15				Sandstone- orange, fine to medium grained, subrounded to rounded grains	
	196	16				Sandstone- light orange, fine to coarse grained, ssubrounded to rounded grains	
	195	17				Sandstone- orange, fine grained, subrounded to rounded grains	
	194	18				Sandstone- orange, fine grained, subrounded to rounded grains	
	193	19				Sandstone- orange, fine grained, subrounded to rounded grains	
	192	20				Sandstone- orange, fine grained, subrounded to rounded grains	

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By: GT (12/1/2017)	Version: 2801_HMA_DO_LOG_MW7_V2
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BOREHOLE LOG

MARROOTA



Name of Hole: MW7

Date Commenced: 09/12/2016

Project Number: 2801

Date Completed: 09/12/2016

Client: Hodgson Quarry Products and Plant

Surface RL: 212.9m AHD

Project: Drilling Operations/ Groundwater Study

Collar Height: 0.48m

Location: Off Roberts Road, Marroota, NSW

Coordinates: 313761 6295740

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	191	21				Sandstone-orange, fine grained, subrounded to rounded grains	
	190	22					
	189	23					
	188	24					
	187	25					
	186	26				Sandstone- dark orange, fine to medium grained, subrounded to rounded grains	
	185	27					
	184	28					
	183	29					
	182	30					
	181	31					
	180	32					
	179	33					
178	34						
177	35				Sandstone- orange, fine to coarse grained, subrounded to rounded grains		
176	36						
175	37						
	174	38				Hole Terminated in Hawkebury Sandstone	

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
 Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

BOREHOLE LOG

MARROOTA

Name of Hole: MW8

Date Commenced: 5/12/2016

Project Number: 2801

Date Completed: 6/12/2016

Client: Hodgson Quarry Products and Plant

Surface RL: 227.005m

Project: Drilling Operations/ Groundwater Study

Collar Height: 0.42m

Location: Off Roberts Road, Maroota, NSW

Coordinates: 313889 6295287

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores



Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information	
Hammer Bit	227	0				Silty Sand- orange to light brown, fine to medium grained, subrounded to rounded grains	Feruginised fragments and some clay	
	226	1				Silty Sand- orange, fine to medium grained, subrounded to rounded grains	Feruginised fragments and some clay	
	225	2					Clayey Sand- orange to light orange, fine grained, subrounded to rounded	
	224	3					Silty Sand- light orange to orange, fine to coarse grained subrounded to rounded	Hammer bit not firing
	223	4					Silty Sand- orange, fine to coarse grained, subrounded to rounded grains	Hammer bit not firing
	222	5					Clay- white to light brown	Hammer bit not firing
	221	6					Clay- purple to pink	
	220	7					Clay- Deep purple	
	219	8					Clay-Purple to light brown	Water seepage @ 13m
	218	9					Clay- Deep purple	Hammer bit not firing
	217	10					Clay- light brown to purple	Hammer bit not firing
	216	11					Clay- dark brown to red	Hammer bit not firing
	215	12					Clayey Sand- cream to orange, fine grained, subrounded to rounded grains	Hammer bit not firing
	214	13						
	213	14						
	212	15						
	211	16						
	210	17						
	209	18						
	208	19						
207	20							

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By: GT (12/01/2017)	2801_HMA_DO_LOG_MW8_V2
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BOREHOLE LOG

MARROOTA



Name of Hole: MW8

Date Commenced: 5/12/2016

Project Number: 2801

Date Completed: 6/12/2016

Client: Hodgson Quarry Products and Plant

Surface RL: 227.005m

Project: Drilling Operations/ Groundwater Study

Collar Height: 0.42m

Location: Off Roberts Road, Marroota, NSW

Coordinates: 313889 6295287

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information		
Hammer Bit	206	21				Pebbly Sand - orange to light brown, coarse to very coarse, rounded to subrounded	Hammer bit not firing to 20.5m, some clay		
	205	22							
	204	23							
	203	24							
	202	25							
	201	26							
	200	27							
	199	28							
	198	29							
	197	30						Sand- white to light brown, fine grained, subrounded to rounded	Some clay
	196	31						Sandy Clay- brown to light purple, fine grained, subrounded to rounded	Water injected
	195	32						Clayey Sand- brown to light brown, fine grained, subrounded to rounded	
194	33				Pebbly Sand- brown to pink, very coarse to fine , subrounded to rounded	Feruginised fragments			
193	34								
192	35								
191	36				Clayey Sand- brown to purple, medium grained, subrounded to rounded grains	Hardness increasing			
190	37								
189	38								
188	39								
187	40								

Other Information:GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By: GT (12/01/2017)	2801_HMA_DO_LOG_MW8_V2
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BOREHOLE LOG

MARROOTA



Name of Hole: MW8

Date Commenced: 5/12/2016

Project Number: 2801

Date Completed: 6/12/2016

Client: Hodgson Quarry Products and Plant

Surface RL: 227.005m

Project: Drilling Operations/ Groundwater Study

Collar Height: 0.42m

Location: Off Roberts Road, Maroota, NSW

Coordinates: 313889 6295287

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
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Hammer Bit	186	41				Sandstone - orange	Interbedded shale laminations
	185	42					
	184	43					
	183	44					
	182	45					
	181	46					
	180	47					
	179	48					
	178	49					

177	50						
176	51						
175	52						

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
 Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By: GT (12/01/2017)	2801_HMA_DO_LOG_MW8_V2
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BOREHOLE LOG

MARROOTA

Name of Hole: MW9

Date Commenced: 19/12/2016

Project Number: 2801

Date Completed: 19/12/2016

Client: Hodgson Quarry Products and Plant

Surface RL: 225.577 m

Project: Drilling Operations/ Groundwater Study

Collar Height: 0.52m

Location: Off Roberts Road, Maroota, NSW

Coordinates: 313916 6295355

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores



Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information		
Auger	225	0				Clayey Sand- orange to brown, fine to coarse grained, subrounded to rounded grains	Topsoil 0 - 0.3m		
	224	1				Clayey sand- light brown to red, coarse grained, subrounded to rounded grains	Feruginised chips		
Blade Bit	223	2				Clayey Sand- red to light orange, fine to coarse grained, subrounded to rounded grains			
	222	3				Clayey Sand- red to light brown, fine to coarse grained, rounded to subrounded grains	Feruginised Chips		
	221	4				Clay- Pink to red	Some cream clay		
	220	5				Clay- Pink to red	Some silt		
	219	6							
	218	7							
	217	8							
	216	9							
	215	10							
	Hammer Bit	214	11				Clay- Cream to pink- silty	Water seepage @12m	
		213	12						
		212	13						
		211	14						Clay- Red, no sand
		210	15						
		209	16						Pebbly Sand- light orange, fine to very coarse grained, subrounded to rounded grains
		208	17						
		207	18						Pebbly Sand- orange to light orange, fine to very coarse grained, subrounded to rounded grains
		206	19						
		20							

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration. Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By GT (12/01/2017)	Version: 2801_HMA_DO_LOG_MW9
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BOREHOLE LOG

MARROOTA



Name of Hole: MW9

Date Commenced: 19/12/2016

Project Number: 2801

Date Completed: 19/12/2016

Client: Hodgson Quarry Products and Plant

Surface RL: 225.577 m

Project: Drilling Operations/ Groundwater Study

Collar Height: 0.52m

Location: Off Roberts Road, Marroota, NSW

Coordinates: 313916 6295355

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	205	21				Sand- orange to pink, fine to coarse grained, subrounded/subangular to rounded grains	
	204	22					
	203	23				Sand- light brown, fine to coarse grained, subrounded/subangular to rounded grains	Feruginised chips
	202	24					
	201	25					
	200	26					
	199	27					
	198	28				Sand- brown to orange, fine grained	Feruginised chips
	197	29					
	196	30					
	195	31					
	194	32					
	193	33					
	192	34					
	191	35				Sandstone- brown to light orange	Hardness progressively increasing
	190	36					
	189	37					
	188	38					
	187	39					
		186	40				Sandstone- light orange to red

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
 Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By GT (12/01/2017)	Version: 2801_HMA_DO_LOG_MW9
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BOREHOLE LOG

MARROOTA



Name of Hole: MW9

Date Commenced: 19/12/2016

Project Number: 2801

Date Completed: 19/12/2016

Client: Hodgson Quarry Products and Plant

Surface RL: 225.577 m

Project: Drilling Operations/ Groundwater Study

Collar Height: 0.52m

Location: Off Roberts Road, Marroota, NSW

Coordinates: 313916 6295355

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
------------	----------------	-----------	-------------------	-----------	-------------	-------------	------------------------

Hammer Bit	185						
		41					
	184						
		42					
	183						
		43					
	182						
		44					
	181						
		45					
180							
	46						
179							
	47						
178							
	48						
177							
	49						
176							
	50						
175							

Sandstone- light brown

Water injected @49m

175 — Hole Terminated in Hawkesbury Sandstone

174 — 51

174 — 52

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By GT (12/01/2017)	Version: 2801_HMA_DO_LOG_MW9
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BOREHOLE LOG

MARROOTA

Name of Hole: MW10

Date Commenced: 12/12/2016

Project Number: 2801

Date Completed: 14/12/2016

Client: Hodgson Quarry Products and Plant

Surface RL: 217.124m

Project: Drilling Operations/ Groundwater Study

Collar Height: 0.49m

Location: Off Roberts Road, Maroota, NSW

Coordinates: 314122 6295186

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores



Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information	
Auger	217	0				Silty Clay - Orange to grey	Topsoil 0-0.2m	
	216	1				Clay- red to cream, no sand		
Blade Bit	215	2				Clay- red, no sand	Some Silt	
	214	3				Clay- cream to red, no sand	Some Silt	
	213	4						
	212	5				Clay- red to orange, no sand		
	211	6						
	210	7				Clay- pink to cream, no sand		
	209	8						
	208	9				Clay- pink to purple, no sand	Some Silt	
	207	10						
	206	11				Sand- light orange, fine grained, subrounded to rounded grains	Some Clay	
	Hammer Bit	205	12				Sand- dark orange, fine to very coarse, grained, subrounded/subangular to rounded grains	Not hammering @ 18m
		204	13					
		203	14					
		202	15					
		201	16					
		200	17					
		199	18					
		198	19					
197		20						

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration. Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By: GT (12/01/2017)	Date: 2801_HMA_DO_LOG_MW10_V2
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BOREHOLE LOG

MARootA

Name of Hole: MW10

Date Commenced: 12/12/2016

Project Number: 2801

Date Completed: 14/12/2016

Client: Hodgson Quarry Products and Plant

Surface RL: 217.124m

Project: Drilling Operations/ Groundwater Study

Collar Height: 0.49m

Location: Off Roberts Road, Maroota, NSW

Coordinates: 314122 6295186

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores



Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	196	21				Pebbly Sand- orange to red, coarse to very coarse, subrounded to rounded grains	Not hammering
	195	22				Sand- cream to light orange, fine to medium grained, subrounded/subangular to rounded grains	Not hammering
	194	23					
	193	24				Sand- orange, fine to coarse grained, subrounded/subangular to rounded	Not hammering
	192	25					
	191	26				Pebbly Sand- pink to orange, fine to very coarse grained, subangular to rounded grains	Not hammering, minor clay bands
	190	27					
	189	28				Pebbly Sand- pink to cream, coarse to very coarse, subrounded to rounded grains	Not hammering, minor clay bands
	188	29					
	187	30				Pebbly Sand- Pink to light brown, coarse to very coarse grained, subrounded to rounded grains	Hammering
	186	31					
	185	32				Pebbly Sand- pink to red, coarse to very coarse grained, subangular/subrounded to rounded grains	Water seepage
	184	33					
	183	34				Pebbly Sand- pink to red, coarse to very coarse grained, subangular/subrounded to rounded grains	Water seepage
	182	35					
	181	36				Pebbly Sand- pink to red, coarse to very coarse grained, subangular/subrounded to rounded grains	Water seepage
180	37						
179	38				Pebbly Sand- pink to red, coarse to very coarse grained, subangular/subrounded to rounded grains	Water seepage	
178	39						
177	40				Pebbly Sand- pink to red, coarse to very coarse grained, subangular/subrounded to rounded grains	Water seepage	

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By: GT (12/01/2017)	Date: 2801_HMA_DO_LOG_MW10_V2
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BOREHOLE LOG

MARROOTA

Name of Hole: MW10

Date Commenced: 12/12/2016

Project Number: 2801

Date Completed: 14/12/2016

Client: Hodgson Quarry Products and Plant

Surface RL: 217.124m

Project: Drilling Operations/ Groundwater Study

Collar Height: 0.49m

Location: Off Roberts Road, Marroota, NSW

Coordinates: 314122 6295186

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores



Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
------------	----------------	-----------	-------------------	-----------	-------------	-------------	------------------------

Hammer Bit	176	41				Pebbly Sand- brown, coarse to very coarse grained, subrounded to rounded grains	
	175	42					
	174	43					
	173	44					
	172	45					
	171	46				Pebbly Sand- red, coarse to very coarse grained, subangular/subrounded to rounded grains	
	170	47					
	169	48				Pebbly Sand- pink to orange, some very coarse to coarse grains, subrounded to rounded	
	168	49					
	167	50				Hole Terminated in Hawkesbury Sandstone as determined by drill penetration rates and colour change in drill water. No sample retained	
	166	51					
	165	52					

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By: GT (12/01/2017)	Date: 2801_HMA_DO_LOG_MW10_V2
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BOREHOLE LOG

MARROOTA

Name of Hole: MW11

Date Commenced: 20/12/2016

Project Number: 2801

Date Completed: 21/12/2016

Client: Hodgson Quarry Products

Surface RL: 192.349m

Project: Drilling Operations/ Groundwater Study Coordinates: 314176 6295788

Location: Off Roberts Road, Marroota, NSW

Collar Height: 0.7m

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores



Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Blade Bit	192	0				Sand- light brown to grey, fine to very coarse grained,	
	191	1				Sand- brown to orange, fine to very coarse grained, subrounded to rounded grains	
	190	2				Sand- orange, fine to very coarse grained, subrounded to rounded grains	
	189	3				Sand- orange, fine to very coarse grained, subrounded to rounded grains	
	188	4				Sand- orange, fine to very coarse grained, subrounded to rounded grains	
Hammer Bit	187	5				Pebbly Sand- orange to brown, fine to very coarse, rounded to subrounded	
	186	6				Pebbly Sand- orange to brown, fine to very coarse, rounded to subrounded	
	185	7				Pebbly Sand- orange to brown, fine to very coarse, rounded to subrounded	
	184	8				Pebbly Sand- red, coarse to very coarse grained, subrounded to rounded grains	
	183	9				Pebbly Sand- red, coarse to very coarse grained, subrounded to rounded grains	
	182	10				Pebbly Sand- orange, coarse to very coarse grained, subrounded to rounded grains	
	181	11				Pebbly Sand- orange, coarse to very coarse grained, subrounded to rounded grains	
	180	12				Sand- red, coarse to very coarse grained, subrounded to rounded grains	
	179	13				Sand- red, coarse to very coarse grained, subrounded to rounded grains	
	178	14				Sand- orange, coarse to very coarse grained, subrounded to rounded grains	
	177	15				Sand- orange, coarse to very coarse grained, subrounded to rounded grains	
	176	16				Sand- orange, coarse to very coarse grained, subrounded to rounded grains	
	175	17				Sand- orange, coarse to very coarse grained, subrounded to rounded grains	
	174	18				Sand- orange, coarse to very coarse grained, subrounded to rounded grains	
	173	19				Clay- White, some medium to fine grained sand	

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration. Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By: GT (12/01/2017)	Version: 2801_HMA_DO_LOG_MW11_V2
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BOREHOLE LOG

MARROOTA



Name of Hole: MW11

Date Commenced: 20/12/2016

Date Completed: 21/12/2016

Project Number: 2801

Surface RL: 192.349m

Client: Hodgson Quarry Products

Collar Height: 0.7m

Project: Drilling Operations/ Groundwater Study Coordinates: 314176 6295788

Location: Off Roberts Road, Marroota, NSW

Drilling Contractor: Ultra Drilling Waterbores

Logged by: MA

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
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Hammer Bit	172	21				Pebbly Sand- brown, coarse to very coarse subrounded/subangular to rounded grains	
	171	22				Clay- purple to pink	
	170	23					
	169	24				Pebbly Sand- pink to orange coarse to very coarse grained, subrounded to rounded grains	
	168	25				Pebbly Sand- light brown, coarse to very coarse grained, subrounded to rounded	
	167	26					
	166	27					
	165	28				Pebbly Sand- light brown, coarse to very coarse grained, subrounded to rounded	
	164	29				Sandstone-orange, coarse to very coarse grained, subrounded to rounded clasts	
	163	30				Hole terminated in Hawkesbury Sandstone	

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration. Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA

Checked By: GT (12/01/2017)

Version: 2801_HMA_DO_LOG_MW11_V2

BOREHOLE LOG

MARROOTA

Name of Hole: MW12

Date Commenced: 08/12/2016

Project Number: 2801

Date Completed: 08/12/2016

Client: Hodgson Quarry Products and Plant

Surface RL: 210.275m

Project: Drilling Operations/ Groundwater Study

Collar Height: 0.48m

Location: Off Roberts Road, Maroota, NSW

Coordinates: 313902 6295583

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores



Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Blade	210	0				Sand- orange to dark orange coarse to very coarse grained, subrounded to rounded grains	
	209	1				Sand- dark orange, fine to coarse grained, subrounded to rounded grains	Feruginised chips, some clay bands
	208	2				Sand- orange to red, fine to coarse grained, subrounded to rounded	Feruginised chips
	207	3				Sand- red to cream, fine to medium grained, subrounded to rounded grains	Feruginised chips
	206	4				Silty Sand- cream to light orange, fine to medium grained, subrounded to rounded grains	
	205	5				Sand- cream, fine to medium grained, rounded to subrounded grains	
	204	6					
	203	7					
	202	8					
	201	9					
	200	10					
199	11			Sand- cream to pink fine to medium grained, subrounded to rounded grains	Water seepage		
Hammer Bit	198	12		Sand- pink to light brown, fine grained, subrounded to rounded grains			
	197	13		Sand- cream to light brown, very coarse to coarse grained, subrounded to rounded grains			
	196	14					
	195	15					
	194	16		Sand- cream to light brown, coarse to very coarse, rounded to subrounded grains			
	193	17					
	192	18					
	191	19					
	190	20					

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

BOREHOLE LOG

MAROOKA



Name of Hole: MW12

Date Commenced: 08/12/2016

Project Number: 2801

Date Completed: 08/12/2016

Client: Hodgson Quarry Products and Plant

Surface RL: 210.275m

Project: Drilling Operations/ Groundwater Study

Collar Height: 0.48m

Location: Off Roberts Road, Marooka, NSW

Coordinates: 313902 6295583

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
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Hammer Bit	189	21				Sand- brown to light brown, fine to coarse, subrounded to rounded	Not Hammering
	188	22					
	187	23					
	186	24					
	185	25				Sandstone- grey to brown, fine to medium grained, subrounded to rounded grains	Shale laminations, hard
	184	26					

183 — 27

Hole Terminated in Hawkesbury Sandstone

182 — 28

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By: GT (12/01/2017)	Version: 2801_HMA_DO_LOG_MW12_V2
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BOREHOLE LOG

MARROOTA

Name of Hole: MW13

Date Commenced: 07/12/2016

Date Completed: 07/12/2016

Project Number: 2801

Surface RL: 225.497 m

Client: Hodgson Quarry Products and Plant

Collar Height: 0.46m

Project: Drilling Operations/ Groundwater Study Coordinates: 313915 6295358

Location: Off Roberts Road, Maroota, NSW

Drilling Contractor: Ultra Drilling Waterbores

Logged by: MA



Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	212	0				Silty Sand- orange to light orange, medium to coarse grained, round to subrounded grains	Some Feruginised chips
	211	1				Silty Sand- red to orange, medium to coarse grained, round to subrounded grains	
	210	2				Silty Sand- deep red to red, fine to medium grained, rounded to subrounded	
	209	3				Clayey Sand- red to light brown, fine to very coarse grained, rounded to subrounded grains	
	208	4				Clay- white, some fine grain sand	
	207	5				Clay- cream to pink	Some silt
	206	6					Some Feruginised chips
	205	7					
	204	8					
	203	9				Clay- purple to pink	
	202	10					
	201	11					
	200	12					
	199	13				Clay-pink to cream	
	198	14				Silty Clay- red to purple	
	197	15				Sand- orange, coarse to very coarse grained, rounded to subrounded grains	Sand @15.2
	196	16				Pebbly Sand- orange, coarse to very coarse, rounded to subrounded	
	195	17				Sand- white to light orange, medium grained, subrounded to rounded	
	194	18					
	193	19				Sand- white to light orange, coarse to very coarse, rounded to subrounded	
192	20						

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By	Version: 2801_HMA_DO_LOG_MW13_V2
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BOREHOLE LOG

MARROOTA



Name of Hole: MW13

Date Commenced: 07/12/2016

Project Number: 2801

Date Completed: 07/12/2016

Client: Hodgson Quarry Products and Plant

Surface RL: 225.497 m

Project: Drilling Operations/ Groundwater Study

Collar Height: 0.46m

Location: Off Roberts Road, Maroota, NSW

Coordinates: 313915 6295358

Logged by: MA

Drilling Contractor: Ultra Drilling Waterbores

Drill Type	Elevation (RL)	Depth (m)	Piezometer Design	Photo Log	Graphic Log	Description	Additional Information
Hammer Bit	191	21				Pebbly Sand- red to light brown, fine to very coarse grained, rounded to subrounded grains	Some clay bands
	190	22				Pebbly Sand-light brown, fine to coarse grained, rounded to subrounded grains	
	189	23				Sand- light brown to pink, fine grained	
	188	24				Sand- white to cream, fine grained	Water seepage @ 25m
	187	25					
	186	26				Sand- orange to light orange, medium to coarse grained, round to subrounded grains	
	185	27					
	184	28					
	183	29				Sand- orange to light red, medium to coarse grained, rounded to subrounded/subangular	
	182	30					
	181	31				Sand- orange to light red, medium to coarse grained, rounded to subrounded/subangular	Increasing hardness
						Hawkesbury Sandstone- white to light orange, fine grained*	
					Hole terminated		
	180	32					
	179	33					
	178	34					
	177	35					
	176	36					
	175	37					
	174	38					

Other Information: GPS Coordinates sourced from handheld devices. Survey conducted post exploration.
 Stratum contacts determined by hardness, colour, sample recovery and lithological analysis.

Logged By: MA	Checked By	Version: 2801_HMA_DO_LOG_MW13_V2
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WOODWARD - CLYDE



PROJECT : Dr.Martin EIS, Process Water Supply
 LOCATION: Roberts Road, Maroota, NSW.
 SUPERVISOR: Fabio Carosone

JOB NO.: A8602019.2
 DATE STARTED: 28.6.1999
 DATE COMPLETED: 6.7.1999

INSTALLED BY: Intertech Drilling Services
 RIG: Intertech 750
 DATUM m.above concrete/ground
 EASTING:

METHOD: air/mud
 TOTAL DEPTH : 126 m
 SWL: 14.8m b.g.
 NORTHING:

DIAMETER: 158 mm
 R.L. GROUND: m
 R.L.DATUM: m
 R.L. SWL : m

WELL NUMBER: PT84PB1

Lithological Log	Remarks	Depth (m)	Bore Construction
			158 mm Steel Casing
			Concrete pad
0-1.5 SAND: brown, medium to coarse, subangular quartz grains. Some minor layers of red fine sand and gravel.	blade bit ↓		
1.5-3 GRAVEL: white, coarse, pebbly, some minor sand, subang. qtz grains		5	
3-8 SAND: white-cream, med/coarse, subang. to subrd. Sorted qtz grains some purple bands, soft, becoming coarse, brown. Some clay.		10	Backfill
4.8-7 CLAY: light grey, some sand, dry becoming light brown and gold in colour at base. Some red-brown sand at 6-6.2 m.		15	200mm dia.hole
7-9 GRAVEL: white and red, rd,crse qtz pebbles and some sand. @7.5m. light red/pink, and some purple and grey clay.		20	Steel casing, 158mm ID 168 mm OD Welded joints
9-11.3 SAND: dark red/purple, med./coarse, sorted, subrd. qtz grains @10 m finer and darker, minor clay @10.5m lighter, pink and some purple clay @11m darker with dark red pebbles(2-3mm), some stiff purple clay		25	
11.3-11.5 FERRICRETE: dark red, hard		30	28.5 base of 200 mm hole 28.85 Base of casing
11.5-17.3 CLAY: grey mottled purple and brown, moist, plastic @12m grey brown		35	
17.3-18 CLAY: red-brown, high sand content		40	158 mm hole D.H. Hammer
18-20 CLAY: grey-red and orange, moist, plastic, with some brown red sand		45	
20-23.5 CLAY: grey, light grey, plastic	50	open hole	
23.5-24 CLAY: light brown, yellow and mottled purple. Some grit at 24m	55		
24-24.2 FERRICRETE: dark brown/red, hard	60		
24.2-26.1 CLAY: as @ 23.5-24	65		
26.1-34 SANDSTONE: grey, fine/med qtz grains, weathered, clayey @27 m white grey, @27.5m harder	70		
34-37 FERRICRETE: dark brown/red, hard	75		
34.1-41 SANDSTONE: grey white, fine to med., subang./subrd, sorted qtz grains	80		
41-42 CLAY: light grey and purple			
42-46 SANDSTONE: as @ 34.1-41			
46-48 FERRICRETE: brown, in several thinner bands			
48-51 SANDSTONE: as above			
51-58 SANDSTONE: brown, and orange, fine grained, med hard @53m grey white @56m yellow brown, iron-rich bands, fine/med.			
58-58.5 SILTSTONE: grey/black, harder than above, fine grained			
58.5-59.5 SANDSTONE: grey, medium grained			
59.5-62.5 SILTSTONE: dark grey, shaley, fine grained, hard			
62.5-66 SANDSTONE: orange, fine to medium grains			
66-68 SANDSTONE: grey, white, fine to medium			
68-74 SANDSTONE: yellow, iron-rich, medium			
74-78 SANDSTONE: yellow, iron-rich, white and brown			
78-84 SANDSTONE: dark grey, hard @79.5m light orange/brown			

Prepared by: FC
 Checked by: ..

WOODWARD - CLYDE



PROJECT : Dr.Martin EIS, Process Water Supply
 LOCATION: Roberts Road, Maroota, NSW
 SUPERVISOR: Fabio Carosone

JOB NO.: A8602019.2
 DATE STARTED: 28.6.1999
 DATE COMPLETED: 6.7.1999

INSTALLED BY: Intertech Drilling Services
 RIG: Intertech 750
 DATUM m.above concrete/ground
 EASTING:

METHOD: air/mud
 TOTAL DEPTH: 126.1 m
 SWL: m b.d.
 NORTHING:

DIAMETER: 158 mm
 R.L. GROUND: m
 R.L.DATUM: m
 R.L. SWL : m

WELL NUMBER: PT84PB1

Lithological Log	Remarks	Depth (m)	Bore Construction
<p>34-102 SANDSTONE: grey, hard/medium hard @86m iron-rich bands @90m some grey clay @96m minor iron rich bands</p> <p>102-126.1 SANDSTONE: grey and brown, med. grains, coarser than above finer. @104m milky white gravel pebbles (2 mm)</p> <p>@112m some coarse qtz pebbles @115m some coarse qtz pebbles</p> <p>126.1 Bottom of the hole</p>		<p>85</p> <p>90</p> <p>95</p> <p>100</p> <p>105</p> <p>110</p> <p>115</p> <p>120</p> <p>125</p> <p>130</p> <p>135</p> <p>140</p> <p>145</p> <p>150</p> <p>155</p> <p>160</p>	<p>open hole</p> <p>← 158 mm hole D.H.Hammer</p> <p>126.1 Bottom of the hole</p>



PROJECT : Dr.Martin EIS, Process Water Supply
 LOCATION: Roberts Road, Maroota, NSW
 SUPERVISOR: Fabio Carosone

JOB NO.: A8602019.2
 DATE STARTED: 6.7.1999
 DATE COMPLETED: 9.7.1999

INSTALLED BY: Intertech Drilling Services
 RIG: Intertech 750
 DATUM m.above concrete/ground
 EASTING:

METHOD: air
 TOTAL DEPTH : 156.5m
 SWL: 50.9m b.g.
 NORTHING:
 DIAMETER: 158 mm
 R.L. GROUND: m
 R.L.DATUM: m
 R.L. SWL : m

WELL NUMBER: PT84PB2

Lithological Log	Remarks	Depth (m)	Bore Construction
			158 mm Steel Casing
			Concrete pad
0-0.5 TOPSOIL: sandy loam, red brown			
0.5-1.5 CLAY: red, sandy, some ferricrete			
1.5-2 CLAY: grey/white, stiff		5	200mm dia.hole
	blade bit		Steel casing, 158mm ID
2.3-2.7 SAND: red, weakly cemented, hard band	↓	10	168 mm OD
2.7-4 CLAY: white/grey, stiff			welded joints
4-4.1 SAND: red/orange, fine to medium, sorted qtz grains. Some clay			10.4 base of 200mm casing
4.1-5 CLAY: grey/white, stiff, dry			
5-5.5 SAND: as above with thin iron cemented bands	D.H.Hammer	15	
5.5-9 CLAY: grey/white	↓	20	
5.5-9 SAND: orange, med/fine, sorted, subrnd qtz grains			
9-10.2 CLAY: yellow/orange, stiff, with thin layers of gravel @ 10.2m hard		25	Backfill
10.2-15.5 SANDSTONE: grey/white, clayey, fine grained, soft			
15.5-18 SANDSTONE: yellow/brown, firm, some orange clay @ 17m some ferricrete bands		30	
18-25 SANDSTONE: grey with coarse qtz pebbles and iron cement @ 19.5m ferricrete, 5 cm layers			
25-31 SANDSTONE: much as above, with very coarse qtz gravel pebbles with iron stains and cement. Weakly cemented, soft		35	
31-32 CLAY: grey, soft, plastic			
32-36.5 CLAY: dark red and yellow matrix, gravelly		40	158 mm hole
36.5-41.5 some grey clay and ferricrete, poor sample, unconsolidated, soft			D.H.Hammer
		45	
SANDSTONE: grey/dark grey, harder and ferricrete bands @ 42m red purple colour			
43-45 CLAY: grey and purple, stiff @ 43.5m ferricrete bands		50	125 mm PVC casing
45-49.5 CLAY: red/orange @ 48.5m ferricrete bands			spigot/socket glued
49.5-54 SANDSTONE: grey, fine grained, some light yellow colour @ 53.5m ferricrete bands		55	53 shade cloth seal
54-60.5 SANDSTONE: grey and yellow, medium, sorted, subrnd qtz grains. gravelly bands, minor ferricrete bands		60	59.5 base of PVC casing
60.5-63.5 SILTSTONE: grey/dark grey, sublaminar and hard			
63.5-66 SANDSTONE: yellow/grey, harder		65	
66-66.5 SANDSTONE: red, with ferricrete bands, medium grained			
66.5-70 SANDSTONE: grey/yellow, as above		70	
70-75.5 SILTSTONE: grey/dark grey, laminar			
		75	158 mm hole
			D.H.Hammer
75.5-78.5 SANDSTONE: grey/white, medium grained			
78.5-83 SILTSTONE: grey/dark grey, as above		80	

Client:		Bore:	Elevation (GL):	Elevation (TOC):	Project No:	Stickup:
Hodgson Quarry and Plant Pty Ltd		PB2 (PT84PB2)	approx 216.5 mAHD	approx 217.2 mAHD	16-0318	0.70m
Location:		Drilling Contractor:	Date Started:	Date Finished:	Supervised By:	
Roberts Rd Maroota Quarry		Intertech Drilling	06-Jul-99	09-Jul-99	F Carosone	
		Hole depths: As shown				

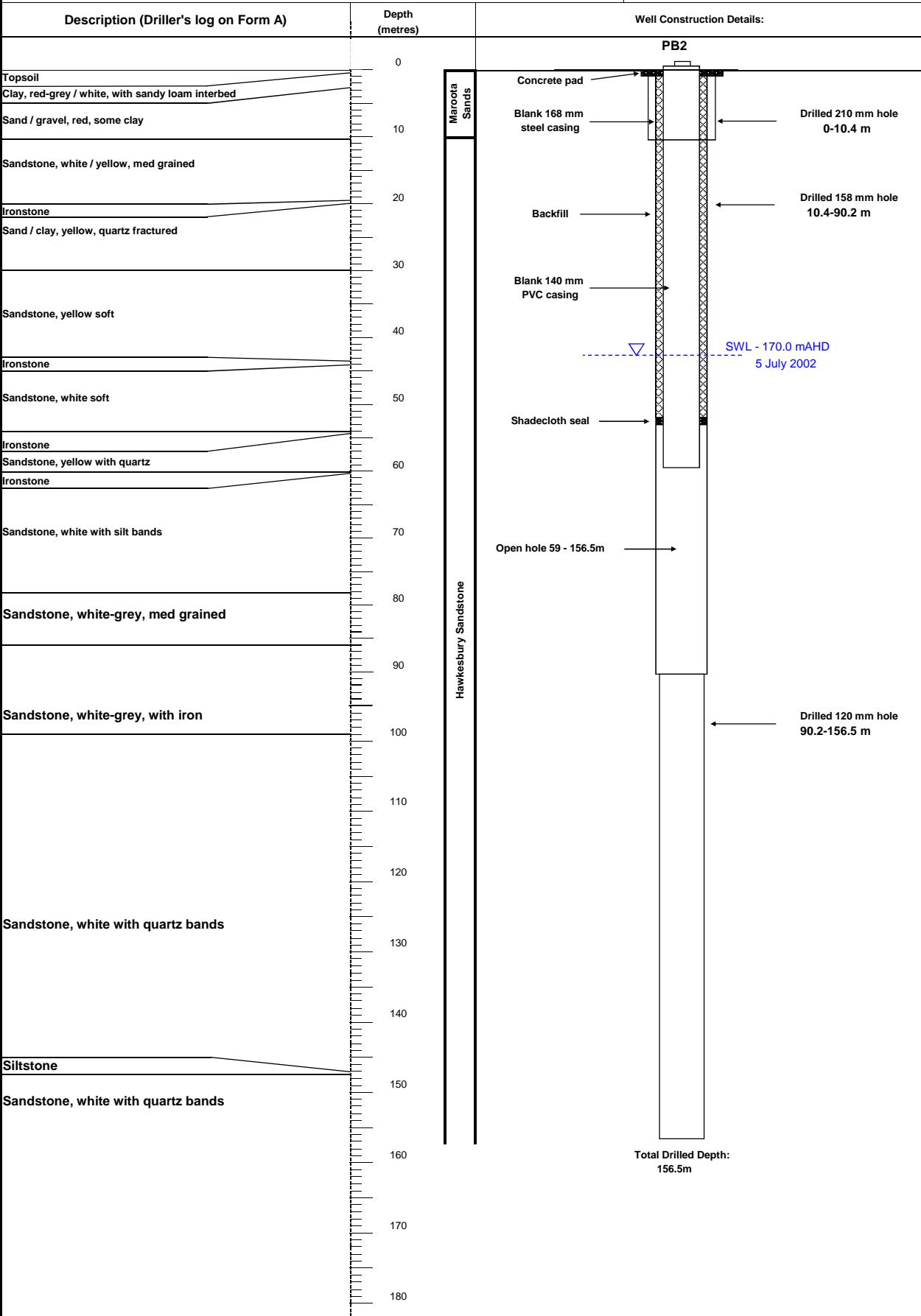


Figure xx: Bore Log - PT84PB2

APPENDIX B

BORE LOGS – DPI-WATER MONITORING BORES

NSW Office of Water

Work Summary

GW075003

Licence:

Licence Status:

Authorised Purpose
(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore

Work Status: Instrumented

Construct.Method: Rotary

Owner Type: NSW Office of Water

Commenced Date:

Completion Date: 01/07/1997

Final Depth: 109.00 m

Drilled Depth: 109.00 m

Contractor Name: JH ISELT PTY LTD

Driller: John Hans Iselt

Assistant Driller:

Property:

Standing Water Level

GWMA:

GW Zone:

(m):

Salinity Description: Fresh

Yield (L/s):

Site Details

Site Chosen By:

County: CUMBERLAND
Parish: MAROOTA
Cadastre: LT2 DP228308
Form A: CUMBERLAND
Licensed:

Region: 10 - Sydney South Coast
River Basin: 212 - HAWKESBURY RIVER
Area/District:

CMA Map: 9031-2S

Grid Zone:

Scale:

Elevation: 225.34 m (A.H.D.)

Elevation R.L. at W.L.M.Pt.

Source:

Northing: 6295298.400

Easting: 313869.800

Latitude: 33°27'56.2"S

Longitude: 150°59'49.5"E

GS Map: -

MGA Zone: 56

Coordinate PR.,ACC.MAP
Source:

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	3.00	200			Rotary Air
1		Hole	Hole	3.00	24.00	160			Rotary Air
1		Backfill	Backfill	0.00	24.00				
2		Hole	Hole	0.00	3.00	200			Rotary
2		Hole	Hole	3.00	109.00	160			Rotary
2		Backfill	Backfill	3.00	68.50				
2		Annulus	Waterworn/Rounded	70.00	86.00	160			Graded
2		Backfill	Backfill	86.00	109.00				
2	1	Casing	P.V.C.	-0.75	84.50	90	80		Seated on Bottom, Screwed and Glued
2	1	Opening	Screen	72.00	75.00	90		1	PVC Class 12, , A: 0.50mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
55.00	55.50	0.50	Unknown	50.00	60.00	0.05	60.00		
72.50	74.00	1.50	Unknown	45.00	80.00	0.45	80.00		
82.00	83.00	1.00	Unknown	47.80	109.00	0.25	109.00	01:00:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.20	0.20	Topsoil	Topsoil	
0.20	3.30	3.10	Sandy Clay	Clay	
3.30	6.40	3.10	Clay White	Clay	
6.40	14.60	8.20	Clay Red	Clay	
14.60	23.70	9.10	Sand Coarse	Sand	
23.70	55.00	31.30	Sandstone Yellow	Sandstone	
55.00	55.50	0.50	Sandstone Yellow WB	Sandstone	
55.50	70.00	14.50	Sandstone Yellow	Sandstone	
70.00	72.50	2.50	Mudstone Grey	Mudstone	
72.50	74.00	1.50	Sandstone Grey WB	Sandstone	
74.00	82.00	8.00	Sandstone Yellow	Sandstone	
82.00	83.00	1.00	Sandstone Yellow WB	Sandstone	
83.00	93.70	10.70	Sandstone Yellow	Sandstone	
93.70	95.50	1.80	Shale/Mudstone	Mudstone	
95.50	100.50	5.00	Sandstone Grey	Sandstone	
100.50	104.00	3.50	Mudstone Grey	Mudstone	
104.00	109.00	5.00	Sandstone Yellow	Sandstone	

Remarks

01/07/1997: Form A Remarks:

Rem: Backfilled from 109m to 86m, Bento Plug from 86m to 84.5m, Gravel pack from 84.5m to 70m, Bento Plug from 70m to 68.5m, Backfilled to 3m, Bento Plug from 3m to 1m.

Hole 1 Abandoned due to loss of circulation through gravel layers.

01/08/1997: Hole 1 Abandoned due to loss of circulation through gravel layers.

11/02/1998: Drilled depth 109 m. Slotted depth 72 - 75 m.

11/02/1998: Top of PVC casing 226.339 metres AHD RL Ground = 225.459m

Top of PVC casing used as zero reference point.

11/02/1998: New equipment installed.

Dataflow model 392 datalogger in, s/n 42236

Dataflow 3 metre capacitance sensor in, s/n unknown.

26/02/1999: Sensor calibrated.

Calibrated slope -3005

Calibrated offset 10961.5

26/02/1999: Sensor o-ring set to 45.7 m. below PVC casing.

20/03/2001: Logging interval changed to 12 hours.

29/05/2002: Datalogger/sensor replaced.

Dataflow model 392 datalogger out, s/n 42236

Dataflow 3 metre capacitance sensor out, s/n unknown

Diver TD sensor/datalogger in, s/n 29122

29/05/2002: Sensor tip set to 48.14 m. below PVC casing.

29/05/2004: 0.1 m. data resolution from this point.

22/09/2004: Access too site restricted by dumping of quarry spoil 75004.jpg

22/09/2004: Data collection

07/05/2005: data collection

08/03/2006: Loggers removed for cal check

14/03/2006: Logger re installed post cal check

13/07/2006: Combo lock installed (7232)

13/07/2006: GW075003 - From Parramatta take Windsor Rd too BaulkHam Hills

Turn right into OLD Northern RD at Bull & Bush Hotel

Follow Old Northern Rd, through Castle Hill, Dural, Glenorie & Sth Maroota continue towards Maroota

At Roberts Rd go approx 20m further along Old Northern Rd and turn right into second gate near cottage.

Turn left and follow along fence line for approx 20m

Bore (yellow standpipe) is located near fence line.

Access to this site requires the completion of "Site Induction/sign in-out" from the Sand Mine operator located in Roberts Rd, Maroota.

HB Maroota Pty Ltd

C/- Ralph Betts

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GOSFORD NSW 2250

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13/07/2006: Access to this site requires the completion of "Site Induction" from Sand Mining company located in Roberts Rd, Maroota

27/11/2006: Conc pad too steel flange plate 0.585m Conc pad too PVC 8.885

27/11/2006: Download 02

19/10/2007: D/L #3; Dip SWL=49.49 (to PVC); EC=89; Temp=18.7

12/08/2008: Downloaded; Dip SWL=45.33m(to PVC); EC=97; Temp=18.7

12/08/2008: Sensor level set to 51.32m below PVC

22/01/2009: Downloaded; Dip SWL=45.06m(to PVC); EC=98; Temp=18.9

24/07/2009: Downloaded; Dip SWL=44.83m(to PVC); EC=99; Temp=18.7

24/01/2011: Site visited - Upon arrival Water Level = 46.84m EC = 99m/S Temp = 19.2 deg

Instrument changed OUT: Baro S/N A5792 IN: Diver S/N 29123. Actual depth of sensor measured = 51.27m

07/04/2011: Site visited - Upon arrival Water Level = 47.57m EC = 95u/S Temp = 18.7 deg

Instrument changed OUT: Baro S/N A5792 IN: Solinst S/N 63425.

01/06/2011: Site visited - Water level = 47.52m EC = 98U/m Temp = 18.6Deg

Instrument swapped - OUT = Baro S/N 63425 IN = Solinst S/N 63830

02/08/2011: Site visited - Upon arrival Water Level = 46.011m EC = 99u/S Temp = 18.9 deg

21/09/2011: Site visited - Upon arrival Water Level = 46.718m EC = 99u/S Temp = 18.9 deg

Logger Swapped as it gave a range of 0 - 4.096m? Tried to change the range to 0cm - 1000cm but failed to stick.

OUT: solinst logger S/N 63830

IN: Diver logger S/N D3891

29/11/2011: Site visited - Upon arrival Water Level = 46.880m EC = 102u/S Temp = 18.9 deg

24/01/2012: Site visited - Upon arrival Water Level = 42.525m EC = 102u/S Temp = 18.7 deg

02/05/2012: Site visited - Upon arrival Water Level = 44.090m EC = 107u/S Temp = 18.7 deg

26/06/2012: Site visited - Upon arrival Water Level = 45.784m EC = 168u/S Temp = 18.5 deg

14/08/2012: Site visited - Upon arrival Water Level = 45.132m EC = 162u/S Temp = 18.6 deg

26/09/2012: Primary Client changed from GWSE to GWA on 26/09/2012.

24/10/2012: Site visited - Upon arrival Water Level = 46.202m EC = 161u/S Temp = 18.5 deg LOGGEr FAILED to DOWNLOAD

Diver Baro logger removed S/No. = D3891

Troll logger installed S/No. = 320670

12/12/2012: Routine Site visit - Upon arrival Water Level = 45.823m EC = 117u/s Temp = 18.7 deg

14/03/2013: Routine Site visit - Upon arrival Water Level = 45.747m EC = 115u/s Temp = 18.9 deg

23/04/2013: Routine Site visit - Upon arrival Water Level = 46.023m EC = 115u/s Temp = 18.7 deg

06/08/2013: Routine Site visit - Upon arrival Water Level = 45.471m EC = 106u/s Temp = 18.7 deg

Last logger level = 46.081m, Last logged Temp = 17.9 deg

09/10/2013: Routine Site visit - Upon arrival Water Level = 46.266m EC = 95u/s Temp = 18.7 deg

Last logger level = 45.400m, Last logged Temp = 18.4 deg

20/03/2014: Routine Site visit: SWL = 47.585 m

EC = 92u/s Temp = 18.8 deg

Last logger level = 46.162m, Last logged Temp = 18.4 deg

15/05/2014: Routine Site visit: SWL = 47.448 m

EC = 93 u/s Temp = 18.7 deg

Last logger level = 47.608 m, Last logged Temp = 19.9 deg

27/05/2014: Routine Site visit: SWL = 47.405 m

EC = 98 u/s Temp = 18.9 deg

Last logger level = N/A m, Last logged Temp = N/A deg

Cable extended 6m to approx 51m

22/07/2014: Routine Site visit: SWL = 47.535 m

EC = 96 u/s Temp = 18.6 deg

Last logger level = 47.403 m, Last logged Temp = 18.4 deg

09/10/2014: Regular site visit: SWL = 47.490 m

Measured EC = 96 us/cm Measured Temp = 18.7 deg

Last logged level= 47.526 m Last logged temp = 18.4 deg.

Logger time 1 hour fast. Adjusted in editing.

04/02/2015: Regular site visit: SWL = 48.900 m

Measured EC = 125 us/cm Measured Temp = 18.7 deg

Last logged level= 47.940 m Last logged temp = 18.4 deg.

Logger time 1 hour behind. Adjusted in editing.

20/08/2015: Regular site visit: SWL = 46.970 m

Measured EC = 156 us/cm Measured Temp = 18.6 deg

***** End of GW075003 *****

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

NSW Office of Water

Work Summary

GW075004

Licence:

Licence Status:

Authorised Purpose
(s):

Intended Purpose(s): MONITORING BORE

Work Type: Bore

Work Status: Instrumented

Construct.Method: Rotary

Owner Type: NSW Office of Water

Commenced Date:

Completion Date: 07/07/1997

Final Depth: 60.00 m

Drilled Depth: 60.00 m

Contractor Name: JH ISELT PTY LTD

Driller: John Hans Iselt

Assistant Driller:

Property:

Standing Water Level
(m):

GWMA:

Salinity Description: Fresh

GW Zone:

Yield (L/s):

Site Details

Site Chosen By:

County: CUMBERLAND
Parish: MAROOTA
Cadastre: LT2 DP228308
Form A: CUMBERLAND
Licensed:

Region: 10 - Sydney South Coast
River Basin: 212 - HAWKESBURY RIVER
Area/District:

CMA Map: 9031-2S

Grid Zone:

Scale:

Elevation: 227.76 m (A.H.D.)

Elevation R.L. at W.L.M.Pt.

Source:

Northing: 6295287.700

Easting: 313890.200

Latitude: 33°27'56.6"S

Longitude: 150°59'50.3"E

GS Map: -

MGA Zone: 56

Coordinate PR.,ACC.MAP
Source:

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	24.00	200			Rotary
1		Hole	Hole	24.00	60.00	160			Rotary
1		Backfill	Backfill	3.00	28.00				
1		Annulus	Waterworn/Rounded	30.00	60.00				Graded
1	1	Casing	P.V.C.	-0.75	60.00	90	80		Seated on Bottom, Screwed and Glued
1	1	Opening	Screen	54.00	57.00	90		1	PVC Class 12, , A: 0.50mm

Water Bearing Zones

			WBZ Type						

From (m)	To (m)	Thickness (m)		S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
53.00	54.00	1.00	Unknown	44.80	60.00	0.20	60.00	01:00:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.40	0.40	Topsoil	Topsoil	
0.40	7.50	7.10	Sand Coarse	Sand	
7.50	9.00	1.50	Clay Red/White	Clay	
9.00	15.50	6.50	Gravel Fine	Gravel	
15.50	19.70	4.20	Clay Red	Clay	
19.70	24.70	5.00	Gravel Fine	Gravel	
24.70	28.00	3.30	Sand Coarse	Sand	
28.00	32.50	4.50	Sandstone White	Sandstone	
32.50	37.90	5.40	Ironstone	Ironstone	
37.90	38.50	0.60	Clay Red/White	Clay	
38.50	53.00	14.50	Sandstone Yellow	Sandstone	
53.00	54.00	1.00	Sandstone Yellow WB	Sandstone	
54.00	60.00	6.00	Sandstone Yellow	Sandstone	

Remarks

07/07/1997: Form A Remarks:

Rem: Gravel pack from 30m to 60m, Bento plug from 30m to 28m, Backfill from 38m to 3m, Bento Plug from 3m to 1m

03/12/1997: Drilled depth 60 m. Slotted depth 54 - 57 m.

03/12/1997: Top of PVC casing = 227.764 metres AHD RL Ground = 226.894m

Top of PVC casing used as zero reference point.

04/02/1998: New equipment installed.

Dataflow model 392 datalogger in, s/n 42226

Dataflow 3 metre capacitance sensor in, s/n unknown

26/02/1999: Sensor calibrated.

Calibrated slope -2807

Calibrated offset 9654.299

26/02/1999: Sensor o-ring set to 43.11 m. below PVC casing.

03/05/2000: Logging interval set to 3 hours.

20/03/2001: Datalogger replaced.

Dataflow model 392 datalogger out, s/n 42226

Dataflow model 392 datalogger in, s/n 43231

20/03/2001: Logging interval changed to 12 hours.

29/05/2002: Datalogger/sensor replaced.

Dataflow model 392 datalogger out, s/n 43231

Dataflow 3 metre capacitance sensor out, s/n unknown

Diver TD sensor/datalogger in, s/n 29093

Diver Barometric sensor/datalogger in, 27720

29/05/2002: Sensort tip set to 46.13 m. below PVC casing.

29/05/2004: 0.1 m. data resolution from this point.

22/09/2004: data collection

07/05/2005: data collection

08/03/2006: Logger removed for cal check

14/03/2006: loggers re installed post cal check

13/07/2006: new set level for sensor 51.30m

13/07/2006: GW075004 - From Parramatta take Windsor Rd too BaulkHam Hills

Turn right into OLD Northern RD at Bull & Bush Hotel

Follow Old Northern Rd, through Castle Hill, Dural, Glenorie & Sth Maroota continue towards Maroota

At Roberts Rd go approx 20m further along Old Northern Rd and turn right into second gate near cottage.

Turn left and follow along fence line for approx 20m

Bore (yellow standpipe) is located near fence line.

Access to this site requires the completion of "Site Induction/sign in-out" from the Sand Mine operator located in Roberts Rd, Maroota.

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Mobile 0409-912536

Email hbresources@bigpond.com

13/07/2006: Access to this site requires the completion of "Site Induction" from Sand Mining company located in Roberts Rd, Maroota

13/07/2006: Combo lock installed (7232)

27/11/2006: cONC PAD TOO STEEL FLANGE PALTE 0.565m Conc Pad too PVC 0.855m

27/11/2006: Download 02

19/10/2007: D/L #3; Dip SWL=44.16 m (to pVC); EC=150; Temp =18.7

12/08/2008: Downloaded; Dip SWL=42.45m (to PVC); EC=166; Temp =18.7

22/01/2009: Downloaded; Dip SWL=42.10m (to PVC); EC=159; Temp =18.7
 24/07/2009: Downloaded; Dip SWL=42.23m (to PVC); EC=147; Temp =18.7
 24/01/2011: Site visited - Upon arrival Water Level = 42.65m EC = 152m/S Temp = 18.9 deg

Actual depth of sensor measured = 51.8m

07/04/2011: Site visited - Upon arrival Water Level = 42.94m EC = 140u/S Temp = 19.0 deg

Instrument changed OUT: Diver S/N 60246 IN: Solinst S/N 66752.

01/06/2011: Site visited - Water level = 42.90m EC = 142U/m Temp = 18.7Deg
 02/08/2011: Site visited - Upon arrival Water Level = 42.883m EC = 145u/S Temp = 18.7 deg
 20/09/2011: Site visited - Upon arrival Water Level = 42.418m EC = 141u/S Temp = 18.9 deg
 29/11/2011: Site visited - Upon arrival Water Level = 42.528m EC = 146u/S Temp = 19.1 deg
 24/01/2012: Site visited - Upon arrival Water Level = 42.437m EC = 143u/S Temp = 18.7 deg
 02/05/2012: Site visited - Upon arrival Water Level = 41.317m EC = 153u/S Temp = 18.7 deg
 26/06/2012: Logger lost - cable broken logger fell into bore. No logger replacement available.
 14/08/2012: Site visited - Upon arrival Water Level = 41.377m EC = 233u/S Temp = 18.7 deg

New logger installed - Solinst Serial No. = 1022337

26/09/2012: Primary Client changed from GWSE to GWA on 26/09/2012.

24/10/2012: Site visited - Upon arrival Water Level = 41.745m EC = 229u/S Temp = 18.7 deg

Solinst logger removed S/No. = 22337

Troll logger installed S/No. = 320538

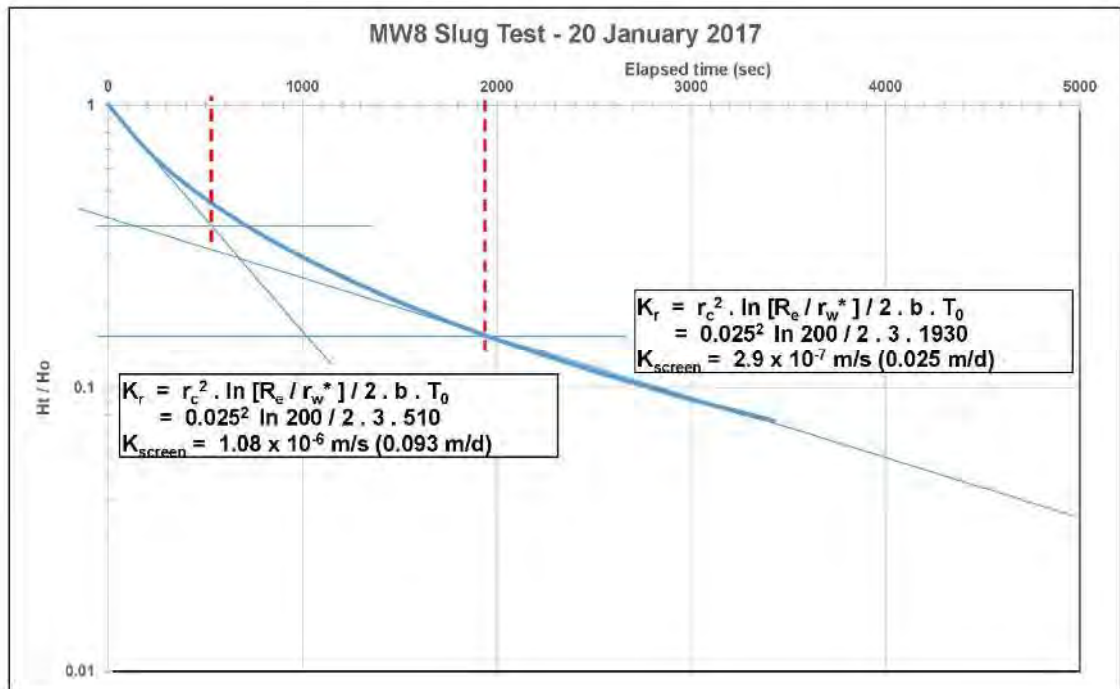
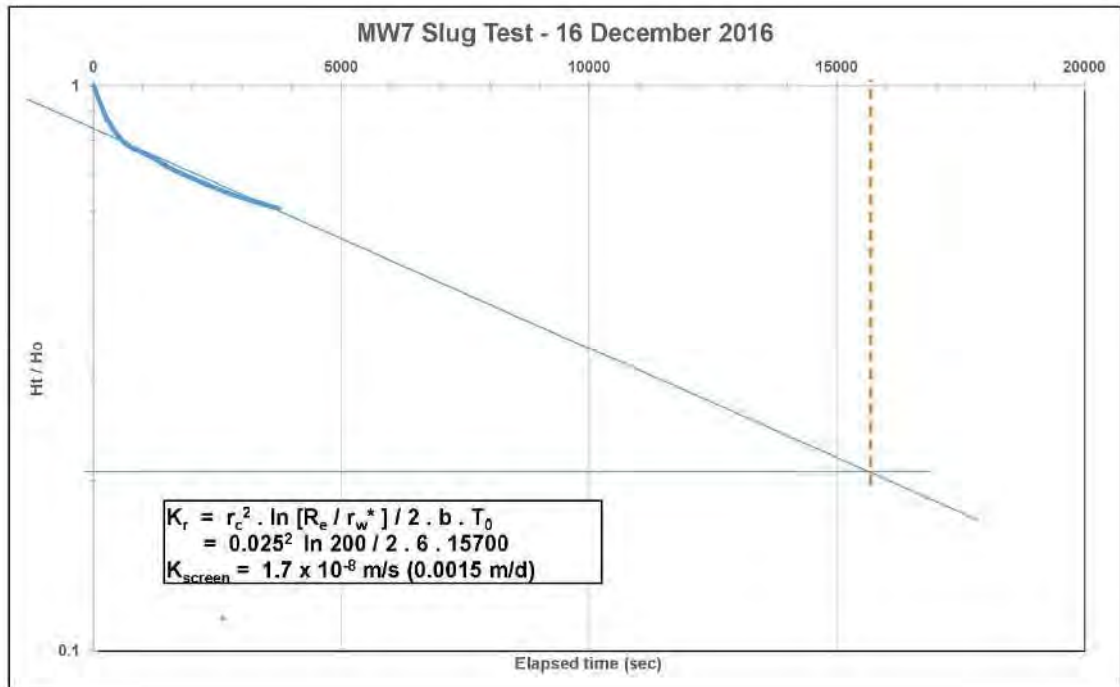
12/12/2012: Routine Site visit - Upon arrival Water Level = 42.003m EC = 162u/s Temp = 18.7 deg
 14/03/2013: Routine Site visit - Upon arrival Water Level = 41.959m EC = 162u/s Temp = 18.7 deg
 23/04/2013: Routine Site visit - Upon arrival Water Level = 41.988m EC = 155u/s Temp = 18.7 deg
 06/08/2013: Routine Site visit - Upon arrival Water Level = 42.195m EC = 140u/s Temp = 18.7 deg
 Last logger level = 41.996m, Last logged Temp = 18.4 deg
 09/10/2013: Routine Site visit - Upon arrival Water Level = 45.527m EC = 128u/s Temp = 18.7 deg
 Last logger level = 42.122m, Last logged Temp = 18.4 deg
 20/03/2014: Routine Site visit: SWL = 43.318 m
 EC = 126u/s Temp = 18.7 deg
 Last logger level = 42.424m, Last logged Temp = 18.4 deg
 15/05/2014: Routine Site visit: SWL = 42.737 m
 EC = 123 u/s Temp = 18.7 deg
 Last logger level = 43.292 m, Last logged Temp = 18.4 deg
 27/05/2014: Routine Site visit: SWL = 42.575 m
 EC = 132 u/s Temp = 18.8 deg
 Last logger level = N/A m, Last logged Temp = N/A deg
 Cable extended 4m to approx 46m
 22/07/2014: Routine Site visit: SWL = 42.535 m
 EC = 96 u/s Temp = 18.6 deg
 Last logger level = 42.446 m, Last logged Temp = 18.3 deg
 09/10/2014: Regular site visit: SWL = 42.345 m
 Measured EC = 133 us/cm Measured Temp = 18.7 deg
 Last logged level= 42.361 m Last logged temp = 18.4 deg.
 Logger time 1 hour fast. Adjusted in editing.
 04/02/2015: Regular site visit: SWL = 42.447 m
 Measured EC = 166 us/cm Measured Temp = 18.7 deg
 Last logged level= 42.498 m Last logged temp = 18.4 deg.
 Logger time 1 hour behind. Adjusted in editing.
 20/08/2015: Regular site visit: SWL = 41.845 m
 Measured EC = 192 us/cm Measured Temp = 18.6 deg

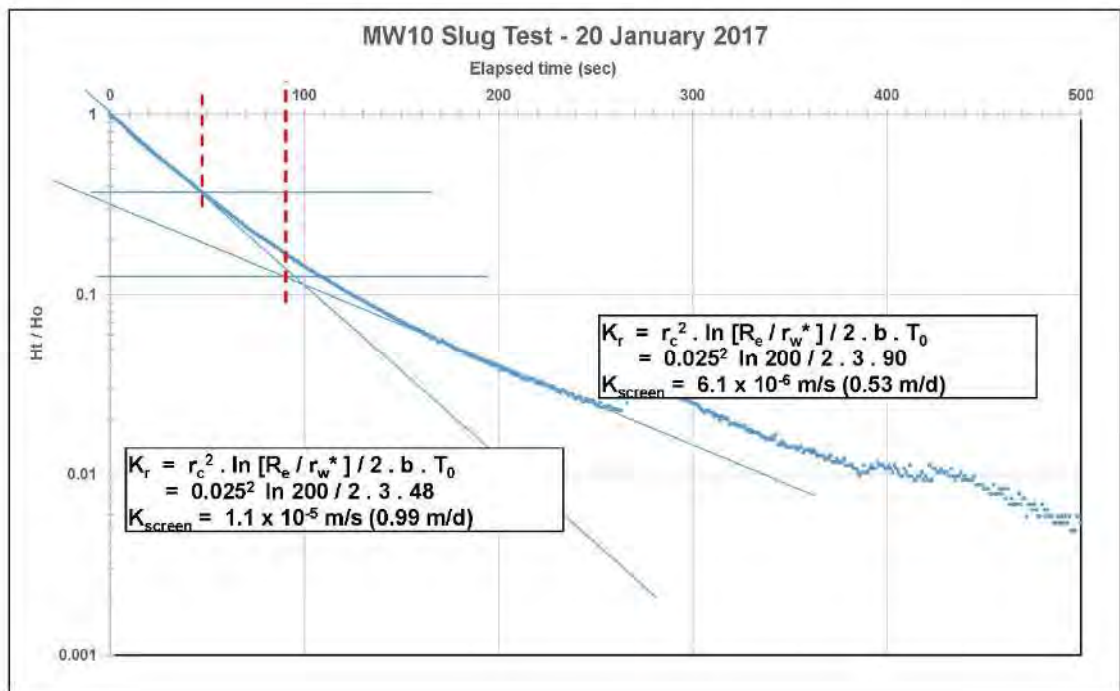
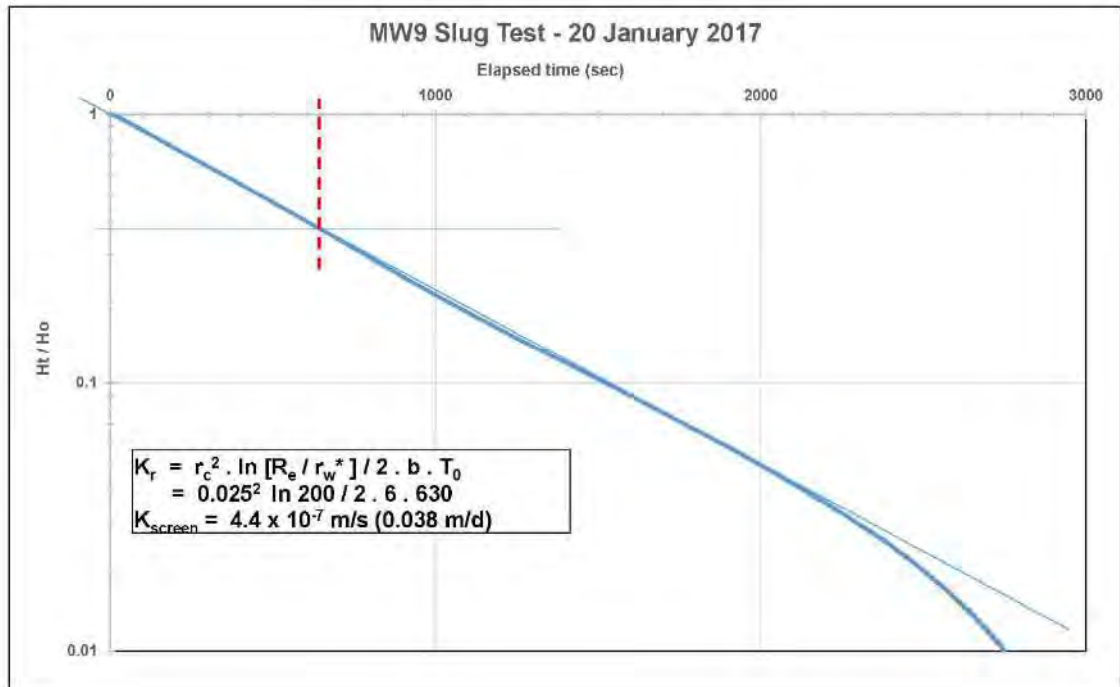
*** End of GW075004 ***

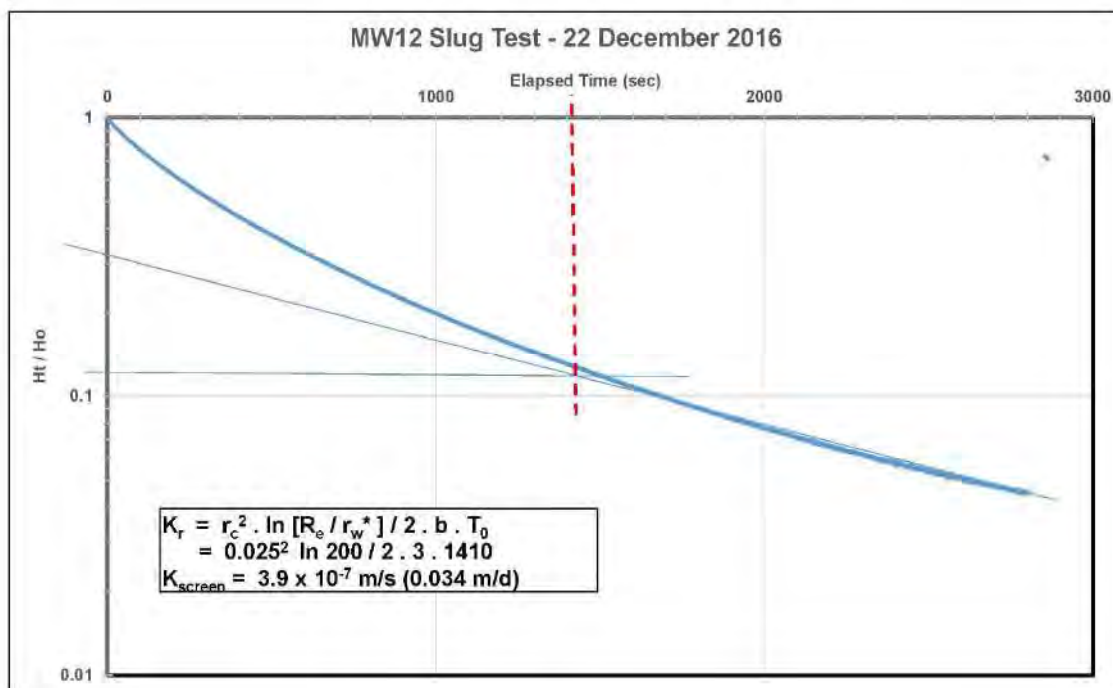
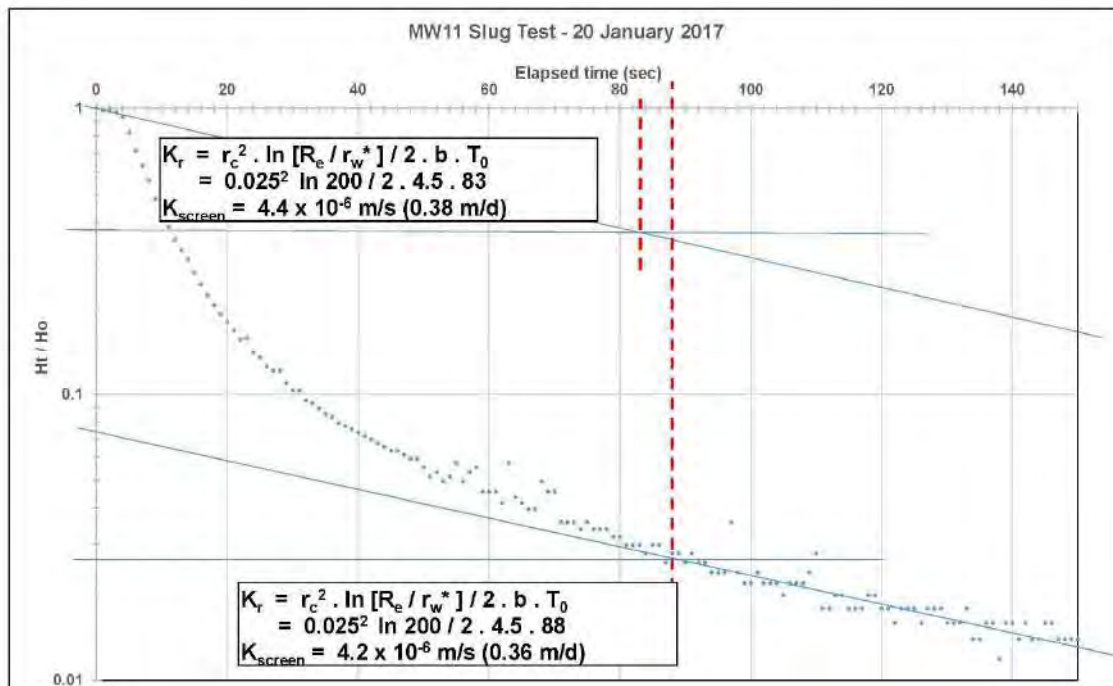
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APPENDIX C

HYDRAULIC TESTING RESULTS







MW 13 Slug Test - 16 December 2016

