Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Groundwater Trend Analysis (2018-2022)

Low Lying Areas of Newcastle
Maryville, Wickham, Carrington and Islington

Prepared for
Newcastle City Council

Project 91247.01
December 2022

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	91247.01	Document No.	R.014.Rev0
Document title	Report on Groundwater Trend Analysis (2018-2022) Low Lying Areas of Newcastle		
Site address	Maryville, Wickham, Carrington and Islington		
Report prepared for	Newcastle City Council		
File name	91247.01.R.014.Rev0. TrendAnalysis.docx		

Document status and review

Status	Prepared by	Reviewed by	Date issued
Draft A	Jason Lambert	Will Wright	16 November 2022
Revision 0	Jason Lambert	Will Wright	8 December 2022

Distribution of copies

Status	Electronic	Paper	Issued to
Draft A	1	0	Anna Milner, Newcastle City Council
Revision 0	1	0	Anna Milner, Newcastle City Council

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		8 December 2022
Reviewer		8 December 2022

bsi ISO 9001 Quality Management Systems CERTIFIED
FS 604853

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Executive Summary

Douglas Partners Pty Ltd (DP) has been engaged by City of Newcastle (CN) to complete this Groundwater Trend Analysis as part of groundwater monitoring for low-lying areas of Newcastle. It is understood that CN will utilise the results of the monitoring and trend analysis to inform the timing for implementation of appropriate actions in response to groundwater level triggers with reference to CN's (2017) *Strategic Position for the Management of Low Lying Areas of Newcastle* (CN, 2017).

DP has undertaken groundwater level and salinity monitoring from May 2018 to August 2022 for seven monitoring wells located at four locations (Maryville, Wickham, Carrington and Islington) within the CN local government area. Monitoring wells have been installed at each of these four locations, generally in pairs (except for Islington), to target the upper portion of the unconfined aquifer (-B wells) and the lower portion of the unconfined aquifer (-A wells). Automatic dataloggers were installed in each well to monitor groundwater level and electrical conductivity (EC) changes with time, accompanied by field monitoring generally at three-monthly intervals. The location of monitoring wells are shown in Figure 1 (Section 2.1), and Drawings 1 to 5, Appendix A.

Due to the relatively short record of groundwater level data currently available, long-term trends are currently unable to be assessed and therefore this report presents a summary of data collected to date and comments on obvious emerging trends.

Key trends are summarised as follows:

- Tidal response:
  - Wells screened in the lower section of the aquifer (-A wells) typically demonstrate tidal influence as they are more directly connected to either Throsby Creek / Hunter River and they are semi confined by overlying less permeable layers, reducing storage and increasing the groundwater head response to tidal variations;
  - Wells screened in the upper section of the upper aquifer (-B wells) typically did not demonstrate obvious tidal influence. Storage for the upper aquifer is higher due to the available pore space above the water table and as such tidal head change dissipates quickly with distance from the river.
- Groundwater level:
  - Upper screened wells (-B wells) are typically highly responsive to rainfall events due to the proximity of the water table to surface rainfall recharge, little tidal influence due to limited connectivity with the creek, and high aquifer storage. The lower screened wells (-A wells) are generally responsive to short term tidal fluctuations due to better connectivity with the creek and lower storage. The degree of response to tidal events varies based on the presence of overlying semi-confining layers and the distance from the creek. Rainfall responses are evident in the lower screens although subdued due to the presence of lower permeability semi confining layers. Groundwater levels are generally higher in the shallow wells indicating a vertical hydraulic gradient driven by surface recharge which flows down into the deeper parts of the aquifer. Groundwater levels in the deeper part of the aquifer are higher than average tide levels indicating groundwater flows are occurring towards the river. There may be some short term reversals in flow direction due to high tide levels above groundwater levels, however, these would be highly transient and represent very low actual flow volumes, with overall flows towards the creek; and

- The data provides no obvious trends of changes in groundwater level, with the fluctuations observed occurring in response to short term factors. It can be expected that if average actual tide levels over time are to gradually increase in the future due to climate change that this would result in a gradual increase in average groundwater levels, although the impacts may be masked to an extent by shorter term influences. A longer period of monitoring than is currently available would be required to pick up such trends.

- Electrical Conductivity:
  - The shallow wells are more influenced by rainfall and EC typically decreases following rainfall (i.e. further dilution of fresh water sitting near the surface of the water table). Lower screened wells of higher salinity, sit below the fresh water (higher density) and show a lesser EC response to rainfall (i.e. EC in the well is more driven by the EC of surface water bodies). Fresh water is observed above brackish or saline water at Bore 2A, 2B and 3A. There is no obvious regional trend in EC across the wells for the monitoring period.
  - It should be noted, however that the EC trends are somewhat inconsistent, therefore further monitoring would be required to confirm trends.

It should be noted that groundwater levels are affected by factors such climatic conditions and soil permeability and will therefore vary with time.

Continued monitoring will allow for further assessment and comment on short-term and long-term trends in groundwater levels and EC in the low-lying study area. Continued monitoring and assessment should consider the comments provided in Section 5 of this report.

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1. Introduction

Douglas Partners Pty Ltd (DP) has been engaged by City of Newcastle (CN) to complete this Groundwater Trend Analysis as part of groundwater monitoring for low-lying areas of Newcastle. It is understood that CN will utilise the results of the monitoring and trend analysis to inform the timing for implementation of appropriate actions in response to groundwater level triggers with reference to CN's (2017) *Strategic Position for the Management of Low Lying Areas of Newcastle* (CN, 2017). The investigation was undertaken with reference to DP's proposal NCL190557.P.001.Rev1 dated 1 October 2019.

DP has undertaken groundwater level and salinity monitoring from May 2018 to August 2022 for seven monitoring wells located at four locations (Maryville, Wickham, Carrington and Islington) within the CN local government area. The monitoring locations are shown on Drawing 1 to 5 in Appendix A and the datalogger plots are shown in Appendix B.

Due to the relatively short record of groundwater level data currently available, long-term trends are currently unable to be assessed and therefore this report presents a summary of data collected to date and comments on obvious emerging trends.

This report must be read in conjunction with all appendices including the notes provided in Appendix A, and DP (2018) which present the relevant background information, and associated limitations.

2. Background

2.1 Strategic Position for the Management of Low Lying Areas of Newcastle (CN, 2017)

CN released a report detailing management of groundwater in low-lying areas known as *Strategic Position for the Management of Low Lying Areas of Newcastle* (CN, 2017). This report identifies risks to low lying areas due to climate change, particularly, permanent waterlogging in some areas due to sea level rise.

The report suggests CN adopts a strategic position in relation to sea level changes which includes monitoring water level in conjunction with other risk mitigating actions. Monitoring of water levels will provide data on how groundwater in low lying areas respond to tidal influence, wet and dry periods and assist to identify any long term trends, and inform timing of appropriate works by CN as shown in Table 1 below.

Table 1: Triggers and actions for low lying areas of Newcastle (CN, 2017)

Phase	Trigger	Actions
1	Adopt Strategic Position	• Monitor sea and groundwater levels • Investigate funding opportunities for future phases • Research climate change science and policy • Review planning controls and zoning maps • Collaborate with stakeholders • Ongoing community engagement
2	0.1m of sea level rise	• Installation of improved flood gates to all drainage outlets • Install high power pumps to assist with drainage from low lying pits • Planning and design of levee
3	0.2m of sea level rise	• Begin construction of levee • Detailed design of groundwater controls
4	0.3m of sea level rise	• Install levee to a height of 2.5m above mean sea level • Install groundwater controls
5	0.4m of sea level rise	• Complete construction of all flood and groundwater controls Operate and maintain controls • Investigate future planning options for when the horizon of the strategic position is reached
6	0.8m of sea level rise	• Implement additional management measures or planned retreat from the area

2.2 Geotechnical Investigation (DP, 2018)

DP conducted a geotechnical investigation in 2018 which included the drilling and installation of groundwater monitoring wells. The subsurface encountered generally comprised filling over predominantly sandy soils (silty sand, clayey sand and sand). Silty sand was encountered below the filling and above the sand at the Wickham, Islington and Carrington sites. Sandy clay was encountered below fill and above sand at the Maryville site.

Monitoring wells were installed at each site, generally in pairs (except for Islington), to target the upper portion of the unconfined aquifer (-B wells) and the lower portion of the unconfined aquifer (-A wells). Dataloggers were installed in each well to monitor groundwater level and electrical conductivity (EC). In summary the wells are identified as follows:

- **Wickham Park, Wickham** – Bores 1A and 1B (one logger each bore);
- **Hogue Park at William Street, Maryville** – Bores 2A and 2B (one logger each bore);
- **Islington Park, Islington** – Bore 3A (two loggers in one bore);
- **Connelly Park, Carrington** – Bores 5A and 5B (one logger each bore).

The location of monitoring wells are shown in Figure 1 below, and Drawings 1 to 5, Appendix A.

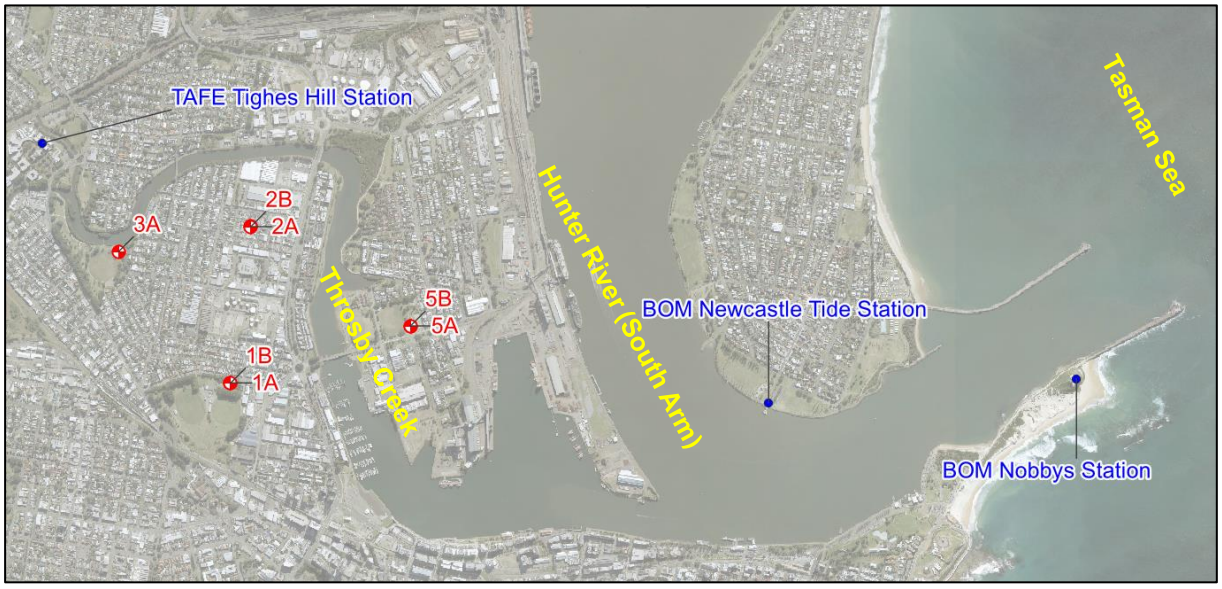


Figure 1: Monitoring Well Locations (shown in red) and Rainfall Stations (shown in blue)

2.3 Groundwater Monitoring

Since May 2018 to August 2022, DP have conducted groundwater monitoring of all seven monitoring well locations. Monitoring is conducted quarterly and comprised the following:

- Dip of water level;
- Download of loggers;
- Field parameter readings of pH and EC;
- EC calibration of loggers;
- Brief factual reporting.

The contents of this report generally draw from monitoring reports produced between May 2018 and August 2022. The full data set is shown on datalogger plots (Figure B1 to B8 in Appendix B) and EC profiling plots (Figures C.1 to C.4 in Appendix C).

3. Summary of Data

3.1 Climate Statistics and Rainfall Records

Table 2 summarises the rainfall data and tidal data reviewed for this report.

Table 2: Summary of Data Sources

Data Type	Source	Distance	Period	Comment
Rainfall	Nobbys Weather Station (061055) Supplied by Bureau of Meteorology (BOM)	Within 5 km	Full monitoring period (2018 to present)	Summarised in Table 3 and Figures B1 to B8 in Appendix B
Rainfall	TAFE Tighes Hill Station Supplied by CN	Within 2 km	Full monitoring period except for May 2019 to October 2019	Summarised in Table 3.
Tide	Newcastle predicted tide Supplied by BOM	Within 5 km	Full monitoring period (2018 to present)	Summarised in Table 3 and Figures B1 to B8 in Appendix B

The TAFE Tighes Hill weather station is in closest proximity to the test sites (i.e. within ~ 2 km), however, there are periods where rainfall is not recorded and thus the reliability of the station is low.

The Nobbys weather station is within 5 km of each of the test sites, the data from this weather station is mostly continuous. For this reason, the BOM Nobbys Station rainfall data has been presented against the groundwater level in plots (Figure B1 to B8, Appendix B). A summary of the rainfall data set from 2019 to 2022 is shown on Figure B.9 in Appendix B.

The Newcastle Predicted Tide is within 5 km of each of the test sites, the data is generated annually and represents expected predicted tides for Newcastle. In lieu of actual tide data, Newcastle predicted tide data has been presented against groundwater level in plots (Figure B1 to B8, Appendix B) and in tidal assessment plots (Figure B10 and B11, Appendix B).

Table 3 shows the published rainfall statistics for the Newcastle Nobbys and the TAFE weather station, and the monthly rainfall observations for the monitoring period May 2018 to August 2022, and indicates where rainfall is above or below the long term monthly mean rainfall for the corresponding month and indicates (in **bold** text) where rainfall for a given month is significantly higher (300% average monthly rainfall) or significantly lower (10% average monthly rainfall) than average monthly rainfall for a given month.

Table 3: Summary of Monthly Rainfall Data (Nobbys and TAFE) vs BOM Averages

Month	BOM Nobbys Station						TAFE Station				
	Mean rainfall (mm) for 1862 to 2022	Recorded Rainfall (mm)					Recorded Rainfall (mm)				
		2018	2019	2020	2021	2022	2018	2019	2020	2021	2022
Jan	88	10	16	31	187	45	15	13	25	149	71
Feb	107	104	25	138	158	177	109	41	175	106	202
Mar	120	94	88	155	**459**	161	109	105	177	**401**	257
Apr	116	148	59	32	70	130	92	59	38	16	106
May	115	**10**	38	83	91	151	**8**	-	87	24	120
Jun	118	301	154	68	105	45	232	-	71	78	58
Jul	93	**6**	36	154	25	247	**2**	-	261	28	**289**
Aug	72	10	95	19	37	49	20	-	28	61	55
Sep	72	100	75	24	67	-	89	-	29	112	-
Oct	73	104	50	187	60	-	124	-	152	83	-
Nov	72	42	38	43	**233**	-	57	35	53	**254**	-
Dec	79	40	**5**	157	28	-	40	**1**	138	38	-
Annual	1118	968	680	1092	1520	-	897	-	1234	1289	-

Notes to table:

- indicates insuffiicent record or missing data

Red Text: Indicates significantly below average rainfall (10% mean monthly rainfall) for the corresponding month

Blue Text: Indicates significantly above average rainfall (300% mean monthly rainfall) for the correspodning month

The following comments are provided for the rainfall data in Table 3 and Figure B.9 in Appendix B:

- BOM Nobbys data:
  - 22 of the 56 months have recorded more rainfall than the reported statistical averages since monitoring commenced;
  - 2019 was the driest year, recording approximately 60% of the annual average total rainfall;
  - 2021 was the wettest full year, recording approximately 140% of the annual average total rainfall;
- TAFE Tighes Hill :
  - The data record is less reliable than the BOM Nobbys data;
  - The data generally agrees with BOM Nobbys data.

It is noted that the rainfall records are expected to provide an indication of the rainfall falling on the investigation sites, however, due to spatial variations in rainfall individual rainfall events may not be representative. Detailed review and assessment could include review of rainfall events and groundwater level responses to assess spatial variations.

3.2 Residual Rainfall Mass Balance (RRMB)

A residual rainfall mass balance (RRMB) was undertaken on the long term rainfall records provided by BOM Nobbys Weather station since 1862. A RRMB provides a cumulative plot of above or below average rainfall over the length of rainfall records. A slope upwards on the plot indicates above average rainfall whereas a slope downward indicates below average rainfall. RRMB plot is shown in Figure 2 below.

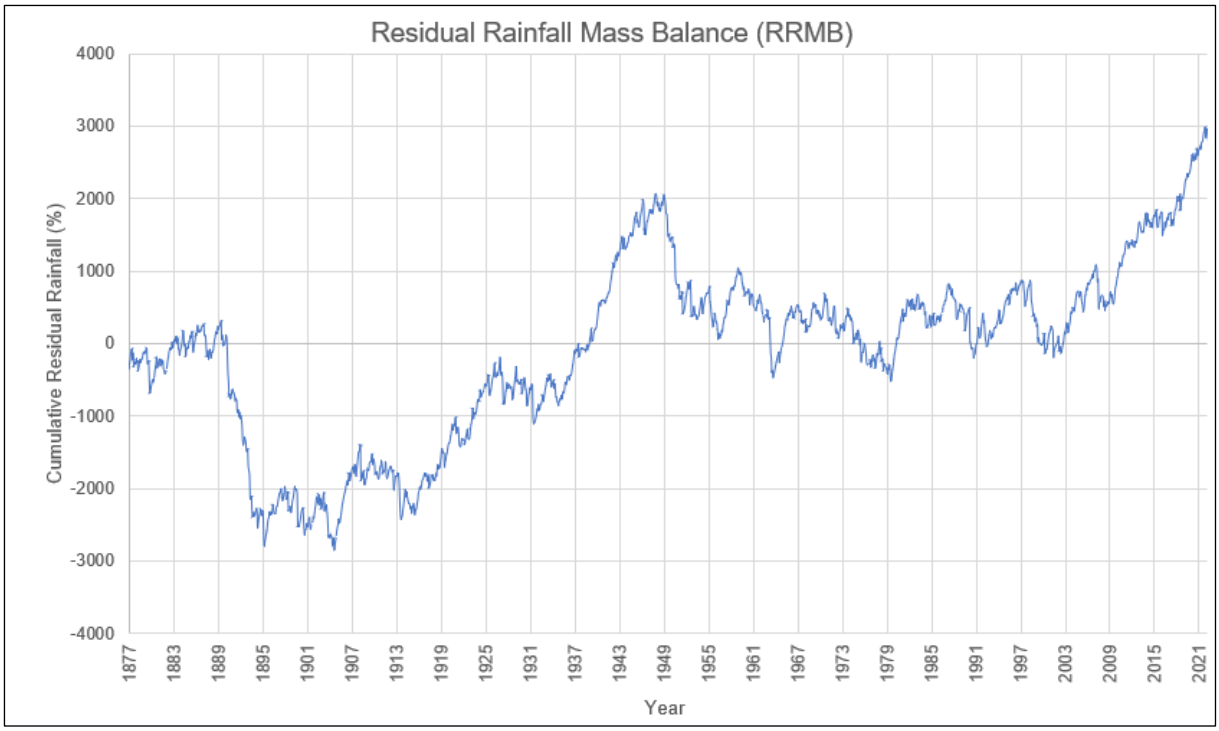


Figure 2: Residual Rainfall Mass Balance for Newcastle

The RRMB plot indicates a generally decreasing trend in rainfall from approximately 1950 to 1980, then from 1980 to 2022 the RRMB plot indicates a generally increasing trend in rainfall, with recent rainfall events in 2022 showing a steep increase on the RRMB plot.

Groundwater levels in unconfined aquifers often have similar trends to the RRMB trend line, however in this case the aquifer is highly constrained by boundary conditions (surface water bodies) and therefore water levels may be more related to shorter term rainfall events, river levels and tidal variations.

Lower bound water levels are likely constrained by the riven with groundwater levels unlikely to drop below average tide levels. Upper bound water levels are likely constrained by the relatively low surface levels as well as the river.

3.3 Groundwater Levels and Electrical Conductivity (EC)

Water level and EC trends are shown in Table 4 and
Table 5 respectively. It is noted that EC of marine waters are typically about 55 mS/cm, however, due to fresh water flows from the Hunter River and rainfall, groundwater encountered in wells are expected to have EC lower than 55 mS/cm.

Plots of groundwater level and EC versus rainfall (BOM Nobbys station) and predicted tides (BOM Newcastle) are shown on Figures B.1 to B.8, Appendix B. Tidal response is assessed by comparing groundwater level and tidal data, this assessment is best visualised over a single month period. Tidal assessment plots for June 2018 and January 2022 in Figure B.10 and Figure B.11 respectively, Appendix B.

It should be noted that groundwater levels are affected by factors such climatic conditions and soil permeability and will therefore vary with time.

Table 4: Summary of Water Levels and Trends – May 2018 to August 2022

Bore ID	Surface Level (AHD)	Logger ID	Well Position	Screened Strata	Observed Range of Groundwater				Average Groundwater		Tidal Observations
					Min Level	Max Level	Depth - From	Depth - To	Level	Depth	
					AHD	AHD	m bgl	m bgl	AHD	m bgl	
1A	1.35	1A	Lower	Sand	-0.48	1.02	1.83	0.33	0.07	1.28	Yes (minimal)
1B	1.32	1B	Upper	Fill (sand)	-0.17	1.55	1.49	**-0.23**	0.33	0.99	No
2A	1.29	2A	Lower	Sand	-0.10	0.90	1.39	0.39	0.28	1.01	Yes (minimal)
2B	1.28	2B	Upper	Fill (sand)	-0.04	1.10	1.32	0.18	0.24	1.04	No
3A	1.50	3A-U 3A-L	Upper	Silty sand; overlying sand	-0.98	0.98	2.48	0.52	0.08	1.42	Yes
5A	1.92	5A	Lower	Sand	-0.08	1.05	2.00	0.87	0.34	1.58	Yes
5B	1.92	5B	Upper	Fill (sand)	0.38	1.94	1.54	**-0.02**	0.77	1.15	No

Notes to table:

Bold text: indicates water level above ground level

Table 5: Summary of EC Concentrations and Trends – May 2018 to August 2022

Bore ID	Logger ID	Well Position in Aquifer	Screened Strata	Range of Logger EC (mS/cm)			Comments
				Min EC	Max EC	Average EC	
1A	1A	Lower	Sand	0.05	1.97	0.89	Typically fresh to brackish, similar in EC to 1B
1B	1B	Upper	Fill (sand)	0.00	2.60	0.92	Typically fresh to brackish, similar in EC to 1A
2A	2A	Lower (semi confined)	Sand	0.34	4.71	3.66	Typically brackish, higher EC than 2B
2B	2B	Upper	Fill (sand)	0.43	2.13	1.30	Typically fresh to brackish, lower EC than 2A
3A	3A-U	Upper	Silty sand; overlying sand	0.00	5.48	0.49	Typically fresh to brackish, lower EC than 3A-L
	3A-L			0.00	92.60	23.55	Typically fresh to saline, higher EC than 3A-U, typically lower EC following rainfall
5A	5A	Lower	Sand	0.00	1.55	0.48	Typically fresh to brackish, higher EC than 5B
5B	5B	Upper	Fill (sand)	0.00	0.81	0.48	Typically fresh, lower EC than 5A, typically lower EC following rainfall

Fresh	<1.43	mS/cm
Brackish	1.43-14.3	mS/cm
Saline	14.3-55.0	mS/cm
Marine	>55	mS/cm

Note: All loggers had a minimum EC near 0 mS/cm, this may be due to spikes of low EC due to rainfall diluting the water column in the well, datalogger download or similar.

3.4 EC Profiling

EC profiling refers to taking EC readings down the water column at a particular well location to understand the vertical profile of EC in the well. Typically EC profiling uses a calibrated EC datalogger, which is set to take readings and then lowered slowly through the water column.

The results of EC profiling are summarised in Table 6 and Figures C.1 to C.4, Appendix C.

Table 6: Summary EC Profiling (September 2021 and August 2022)

	Range of EC		Comments
Bore ID	September 2021	August 2022	
Bore 1A	Fresh	Fresh	Fresh water only.
Bore 1B	Fresh	Fresh	Fresh water only. Small amount of water in well and therefore short EC profile.
Bore 2A	Brackish	Fresh to brackish	Fresh becoming brackish with depth. Fresh not observed in September 2021 profile.
Bore 2B	Fresh to brackish	Fresh to brackish	Fresh becoming brackish with depth. Small amount of water in well and therefore short EC profile.
Bore 3A	Fresh to saline	Fresh to saline	Fresh becoming saline with depth.
Bore 5A	Fresh	Fresh	Fresh water only.
Bore 5B	Fresh	Fresh	Fresh water only. Small amount of water in well and therefore short EC profile.

4. Discussion

The key emerging trends are summarised as follows:

- **Tidal Response**
  - Wells screened in the lower section of the aquifer (-A wells) typically demonstrate tidal influence as they are more directly connected to either Throsby Creek / Hunter River and they are semi confined by overlying less permeable layers, reducing storage and increasing the groundwater head response to tidal variations;
  - Wells screened in the upper section of the upper aquifer (-B wells) typically did not demonstrate obvious tidal influence. Storage for the upper aquifer is higher due to the available pore space above the water table and as such tidal head change dissipates quickly with distance from the river.

- **Groundwater Level**
  - Bores 1A and 1B are separated vertically by a thin silty sand layer. Groundwater level responses observed at Bore 1A and 1B were similar in shape for the majority of the monitoring period, with levels slightly higher in Bore 1B indicating a downwards hydraulic gradient. Groundwater was observed to be responsive to rainfall in both wells the shallower well (Bore 1B). Groundwater levels were observed approximately 0.2 m above ground surface level after a large rainfall event in 2021, and it is expected that this would have been associated with surface water ponding occurring in the vicinity of the wells;
  - Bores 2A and 2B are separated vertically by a clay layer which leads to different rainfall responses. The upper well (Bore 2B) is more responsive to rainfall and also falls faster in drier periods, with no discernible tidal response. The rainfall response in the lower well (Bore 2A) is more subtle, with a slight response to tidal variations;
  - Bore 3A groundwater level was observed to be highly responsive to tidal variations in the nearby river (Throsby Creek). Response to rainfall can also be distinguished from the underlying tidal response following larger rainfall events. There was generally little difference between responses for the loggers in the upper and lower parts of the same screen, with minor differences in measured pressures possibly due to variations in water salinity and density across the water column.
  - Bores 5A and 5B are separated vertically by a silty sand layer, which leads to different rainfall responses. The upper well (Bore 5B) is more responsive to rainfall, with levels approaching the surface after several larger rainfall events. Bore 5B has no discernible tidal response. The rainfall response in the lower well (Bore 5A) is more subtle, with groundwater levels responding moderately to tidal variations;
  - In summary, upper screened wells (-B wells) are typically highly responsive to rainfall events due to the proximity of the water table to surface rainfall recharge, little tidal influence due to limited connectivity with the creek, and high aquifer storage. The lower screened wells (-A wells) are generally responsive to short term tidal fluctuations due to better connectivity with the creek and lower storage. The degree of response to tidal events varies based on the presence of overlying semi-confining layers and the distance from the creek. Rainfall responses are evident in the lower screens although subdued due to the presence of lower permeability semi confining layers. Groundwater levels are generally higher in the shallow wells indicating a vertical hydraulic gradient driven by surface recharge which flows down into the deeper parts of the aquifer. Groundwater levels in the deeper part of the aquifer are higher than average tide levels indicating groundwater flows are occurring towards the river. There may be some short term reversals in flow direction due to high tide levels above groundwater levels, however, these would be highly transient and represent very low actual flow volumes, with overall flows towards the creek; and
  - The data provides no obvious trends of changes in groundwater level, with the fluctuations observed occurring in response to short term factors. It can be expected that if average actual tide levels over time are to gradually increase in the future due to climate change that this would result in a gradual increase in average groundwater levels, although the impacts may be masked to an extent by shorter term influences. A longer period of monitoring than is currently available would be required to pick up such trends.

- **Electrical Conductivity (EC)**
  - EC observed at Bore 1A and Bore 1B was similar for majority of the monitoring period. After significant rainfall events EC in Bore 1B (upper) sometimes decreases whereas EC in Bore 1A (lower) remains relatively constant. This may be due to the rainfall diluting EC in the upper portion of the aquifer. EC profile of Bore 1A and 1B suggests water is fresh across the water column;
  - EC observed at Bore 2A (lower) was generally higher than EC at Bore 2B (upper) for majority of the monitoring period. After significant rainfall events EC in Bore 2A and 2B sometimes decreased. This may be due to the rainfall diluting EC in the upper portion of the aquifer. EC profile of Bore 2A and 2B suggests water is fresh at the top of the water column and becomes brackish with depth;
  - EC observed at Bore 3A-U was lower than EC at Bore 3A-L. After significant rainfall events EC in Bore 3A-U and 3A-L sometimes decreased. This may be due to the rainfall diluting EC in the upper portion of the aquifer. EC profile of Bore 3A suggests water is fresh at the top of the water column and becomes saline with depth;
  - EC observed at Bore 5A and Bore 5B was similar for majority of the monitoring period. After significant rainfall events EC in Bore 5B (upper) sometimes decreases whereas EC in Bore 5A (lower) remains relatively constant. This may be due to the rainfall diluting EC in the upper portion of the aquifer. EC profile of Bore 5A and 5B suggests water is fresh across the water column;
  - In summary, the shallow wells are more influenced by rainfall and EC typically decreases following rainfall (i.e. further dilution of fresh water sitting near the surface of the water table). Lower screened wells of higher salinity, sit below the fresh water (higher density) and show a lesser EC response to rainfall (i.e. EC in the well is more driven by the EC of surface water bodies). Fresh water is observed above brackish or saline water at Bore 2A, 2B and 3A. There is no obvious regional trend in EC across the wells for the monitoring period.
  - It should be noted, however that these trends are somewhat inconsistent, therefore further monitoring would be required to confirm this trend.

5. Conclusions

Continued monitoring will allow for further assessment and comment on short-term and long-term trends in groundwater levels and EC in the low-lying study area. It is understood that CN will utilise the results to inform the timing for implementation of appropriate actions in response to groundwater level triggers (CN, 2017).

The following could be considered as part of the continued monitoring program and assessment of the data set:

- EC profiling using a controlled, low gear reel to ensure minimal disturbance of the water column during profiling and capture the fresh water profile (where present);
- Sourcing of actual tide data, as opposed to predicted tide data, to monitor actual trends in sea level rise and advise triggers and actions as per Table 1 (CN, 2017). This could be undertaken prior to detailed studies;
- Installation of a project-specific weather station within the study area which may provide a more accurate correlation between measured rainfall and groundwater response.

6. References

CN. (2017). *Newcastle City Council, Strategic Position for the Management of Low Lying Areas of Newcastle, Wickham - Maryville - Carrington - Islington.* July 2017: Newcastle City Council.

DP. (2018). *Factual Report on Field Test Results, Groundwater Monitoring of Low-Lying Areas, Wickham, Maryville, Carrington and Islington.* Doc Ref 91247.00.R.002.Rev1: Douglas Partners Pty Ltd.

7. Limitations

Douglas Partners (DP) has prepared this report for this project at Maryville, Wickham, Carrington and Islington NSW with reference to DP's proposal NCL190557.P.001.Rev1 dated 1 October 2019 and acceptance received from Newcastle City Council. The work was carried out under agreed terms of the Hunter Councils Terms of Engagement for Consultants (Edition 5a). This report is provided for the exclusive use of Newcastle City Council for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the (geotechnical / environmental / groundwater) components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About This Report

Drawing 1 to 5 – Groundwater Monitoring Well Locations

Borehole Logs (Bores 1A, B to 3A, B and 5A, B) (DP, 2018)

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

0 10 20 30 40 m

Drawing adapted from Metromap Image 2022

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Newcastle City Council		
OFFICE:	Newcastle	DRAWN BY:	JCL
SCALE:	1:500 @ A3	DATE:	10.November.2022

TITLE: **Groundwater Monitoring Well Location**
Low Lying Lands Project
Wickham, Maryville, Islington and Carrington

N

PROJECT No:	91247.01
DRAWING No:	1
REVISION:	1

0 10 20 30 40 m

Drawing adapted from Metromap Image 2022

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Newcastle City Council		
OFFICE:	Newcastle	DRAWN BY: JCL	
SCALE:	1:500 @ A3	DATE: 10.November.2022	

TITLE: **Groundwater Monitoring Well Location**
Low Lying Lands Project
Wickham, Maryville, Islington and Carrington

N

PROJECT No:	91247.01
DRAWING No:	2
REVISION:	1

0 10 20 30 40 m

Drawing adapted from Metromap Image 2022

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT:	Newcastle City Council	TITLE:	**Groundwater Monitoring Well Location**
OFFICE:	Newcastle	DRAWN BY: JCL	**Low Lying Lands Project**
SCALE:	1:500 @ A3	DATE: 10.November.2022	**Wickham, Maryville, Islington and Carrington**

PROJECT No:	91247.01
DRAWING No:	3
REVISION:	1

0 10 20 30 40 m

Drawing adapted from Metromap Image 2022

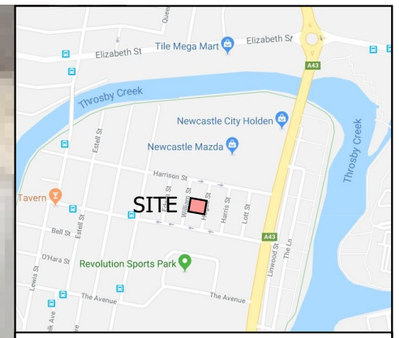
Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Newcastle City Council		
OFFICE: Newcastle	DRAWN BY: JCL	
SCALE: 1:500 @ A3	DATE: 10.November.2022	

TITLE: **Groundwater Monitoring Well Location**
Low Lying Lands Project
Wickham, Maryville, Islington and Carrington

N

PROJECT No:	91247.01
DRAWING No:	4
REVISION:	1



Locality Map

0 10 20 30 40 50 m

Drawing adapted from Nearmap aerial image dated 7 April 2018

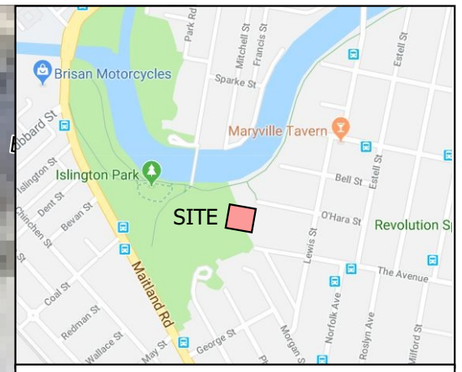
Legend

Groundwater Well Location

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Newcastle City Council		TITLE:	**Test Location Plan - Bores 2A and 2B**
OFFICE: Newcastle	DRAWN BY: JAW		**Low-Lying Lands Project**
SCALE: 1:500 @ A3	DATE: 06.November.2020		**William Street, Maryville**

PROPOSAL:	91247.00
DRAWING No:	2
REVISION:	0



Locality Map

0 10 20 30 40 50 m

Drawing adapted from Nearmap aerial image dated 7 April 2018

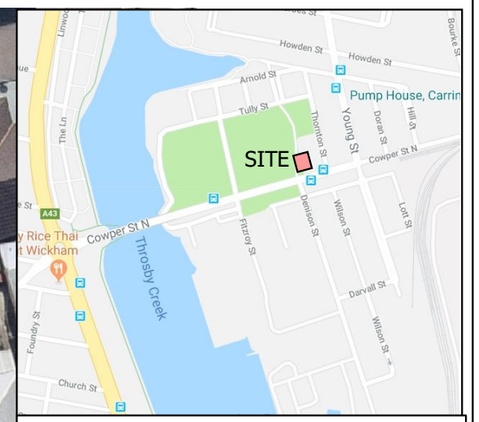
Legend

Groundwater Well Location

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Newcastle City Council		TITLE:	**Test Location Plan - Bore 3A**
OFFICE: Newcastle	DRAWN BY: JAW		**Low-Lying Lands Project**
SCALE: 1:500 @ A3	DATE: 06.November.2020		**Islington Park, Islington**

PROPOSAL:	91247.00
DRAWING No:	3
REVISION:	0



Locality Map

0 10 20 30 40 50 m

Drawing adapted from Nearmap aerial image dated 7 April 2018

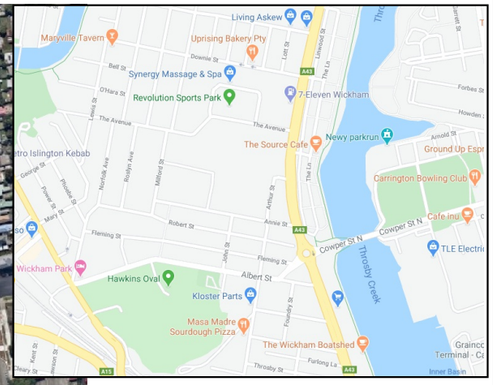
Legend

Groundwater Well Location

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Newcastle City Council		TITLE:	**Test Location Plan - Bores 5A and 5B**
OFFICE: Newcastle	DRAWN BY: CTB		**Low-Lying Lands Project**
SCALE: 1:500 @ A3	DATE: 06.November.2020		**Cowper Street, Carrington**

PROPOSAL:	91247.00
DRAWING No:	4
REVISION:	0



Site Location

0 100 200 300 400 m

Drawing adapted from Nearmap Image dated 07.04.2018.

Legend

Approximate Groundwater Well Location

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Newcastle City Council		TITLE:	**Groundwater Monitoring Well Location**
OFFICE: Newcastle	DRAWN BY: PLH		**Low Lying Lands Project**
SCALE: 1:5000 @ A3	DATE: 06.November.2020		**Wickham, Maryville, Islington and Carrington**

N

PROJECT No:	91247.01
DRAWING No:	5
REVISION:	0

BOREHOLE LOG

CLIENT: Newcastle City Council
PROJECT: Groundwater Monitoring Program
LOCATION: Albert Street, Wickham

SURFACE LEVEL: 1.35 AHD
EASTING: 383593.8
NORTHING: 6357075.1
DIP/AZIMUTH: 90°/--

BORE No: 1A
PROJECT No: 91247.00
DATE: 16/3/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - Generally comprising brown, fine to medium grained gravelly sand filling, gravel fine to medium sized subrounded with some shells, moist							Stick up 60mm below ground level From 0m to 0.2m, concrete From 0.2m to 0.5m, bentonite From 0.5m to 0.9m, backfill From 0 to 2m, 50mm diameter blank PVC From 0.9m to 1.8m, bentonite
	1.4	SILTY SAND - Very loose to loose, brown fine to coarse grained silty sand, some clay, saturated		D	1.5 2.0			16-03-18	
	2.2	SAND - Medium dense to dense, grey fine to medium grained sand, trace fine shells, saturated		S	2.5 2.95		2,4,5 N = 9		
				S	4.3 4.75		2,3,2 N = 5		From 1.8m to 6.5m, specialised sand From 2m to 6.5m, 50mm diameter machine slotted PVC End Cap
	6.5	Bore discontinued at 6.5m, limit of investigation							

RIG: Hanjin **DRILLER:** Total Drilling **LOGGED:** Parkinson **CASING:** HFA

TYPE OF BORING: Hollow flight auger to 6.5m

WATER OBSERVATIONS: Free groundwater observed at 1.3m, whilst drilling. Groundwater measured at 1.2m depth on 8.5.18.

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Newcastle City Council
PROJECT: Groundwater Monitoring Program
LOCATION: Albert Street, Wickham

SURFACE LEVEL: 1.32 AHD
EASTING: 383593.6
NORTHING: 6357074.1
DIP/AZIMUTH: 90°/--

BORE No: 1B
PROJECT No: 91247.00
DATE: 16/3/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - Generally comprising brown, fine to medium grained gravelly sand filling, gravel fine to medium sized subrounded with some shells, moist		D	0.5 1.0				Stick up 40mm below ground level From 0m to 0.2m, concrete From 0 to 0.4m, 50mm diameter blank PVC From 0.2m to 0.4m, bentonite From 0.4m to 1.5m, 50mm daimeter machine slotted PVC From 0.4m to 1.5m, specialised sand End cap
	1.4	SILTY SAND - Very loose to loose, brown fine to coarse grained silty sand, some clay, saturated							
	1.6	Bore discontinued at 1.6m, limit of investigation							

RIG: Hanjin **DRILLER:** Parkinson **LOGGED:** Parkinson **CASING:** HFA

TYPE OF BORING: Hollow flight auger to 1.5m

WATER OBSERVATIONS: No free groundwater whilst drilling

REMARKS: Approximately 1m south of 1A

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Newcastle City Council
PROJECT: Groundwater Monitoring Program
LOCATION: William Street, Maryville

SURFACE LEVEL: 1.29 AHD
EASTING: 383690.4
NORTHING: 6357821.7
DIP/AZIMUTH: 90°/--

BORE No: 2A
PROJECT No: 91247.00
DATE: 13/3/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - Generally comprising grey black gravelly sand filling, gravel comprising medium to coarse sized subangular and subrounded coal, trace glass, moist							Stick up 0.1m below ground level From 0m to 0.2m, concrete From 0.2m to 1.1m, bentonite
	1.2	SANDY CLAY - Soft grey, fine to medium grained sandy clay, saturated						08-05-18 13-03-18	From 0 to 3.5m, 50mm diameter blank PVC From 1.1m to 2.5m, backfill
				S	2.5 2.95		0,0,0 N = 0		From 2.5m to 3.3m, bentonite
	3.7	SAND - Loose grey fine to coarse grained sandy trace fine shells, saturated							From 3.3m to 5.5m, specialised sand From 3.5m to 5.5m, 50mm daimeter machine slotted PVC
				S	4.5 4.95		1,1,1 N = 2		
	5.5	Bore discontinued at 5.5m, limit of investigation							End Cap

RIG: Hanjin **DRILLER:** Total Drilling **LOGGED:** Parkinson **CASING:** HFA

TYPE OF BORING: Hollow flight auger to 5.5m

WATER OBSERVATIONS: Free groundwater observed at 1.6m whilst drilling. Groundwater measured at 0.96m depth on 8.5.18.

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Newcastle City Council
PROJECT: Groundwater Monitoring Program
LOCATION: William Street, Maryville

SURFACE LEVEL: 1.28 AHD
EASTING: 383690.2
NORTHING: 6357820.9
DIP/AZIMUTH: 90°/--

BORE No: 2B
PROJECT No: 91247.00
DATE: 12/3/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - Generally comprising grey black gravelly sand filling, gravel comprising medium to coarse sized subangular and subrounded coal, moist		D	0.0				Stick up 50mm below ground level From 0m to 0.1m, concrete From 0 to 0.3m, 50mm diameter blank PVC From 0.1m to 0.3m, bentonite From 0.3m to 1.45m, 50mm daimeter machine slotted PVC
	1.2	SANDY CLAY - Grey sandy clay / clayey sand, M>Wp		D	1.0 1.2				
	1.5	Bore discontinued at 1.5m, limit of investigation			1.5				From 0.3m to 1.45m, specialised sand End cap

RIG: Hanjin **DRILLER:** Total Drilling **LOGGED:** Parkinson **CASING:** HFA

TYPE OF BORING: Hollow flight auger to 1.5m

WATER OBSERVATIONS: No free groundwater whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Newcastle City Council
PROJECT: Groundwater Monitoring Program
LOCATION: Throsby Creek, Islington

SURFACE LEVEL: 1.50 AHD
EASTING: 383058.1
NORTHING: 635702.3
DIP/AZIMUTH: 90°/--

BORE No: 3A
PROJECT No: 91247.00
DATE: 12/3/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		SANDY CLAY - Brown mottled orange grey sandy clay, M<Wp		D	0.1				Stick up 50mm below ground level From 0m to 0.15m, concrete From 0 to 0.45m, 50mm diameter blank PVC From 0.15m to 0.45m, bentonite
	0.5	SILTY SAND - Loose grey brown fine to coarse grained silty sand, trace fine organics, trace clay, moist to wet			0.5				
				S	1.0		0,0,0 N = 0		
		From 1.3m, saturated			1.45			30-12-99	
	1.8	SAND - Medium dense, grey brown, fine to coarse grained sand, saturated			2.0				
				S D	2.5		1,1,3 N = 4		
					2.95				From 0.45m to 5.85m, 50mm daimeter machine slotted PVC From 0.45m to 5.85m, specialised sand
					3.5				
		From 4m, medium dense to dense		S	4.0		2,3,5 N = 8		
					4.45				
		From 5.5m, dense grey		S	5.5		6,8,8 N = 16		End cap
	6.0	Bore discontinued at 6.0m, limit of investigation			5.95				

RIG: Hanjin **DRILLER:** Total Drilling **LOGGED:** Parkinson **CASING:** HFA

TYPE OF BORING: Hollow flight auger (8 inch / 200mm) to 6.0m

WATER OBSERVATIONS: Free groundwater observed at 1.3m, whilst drilling. Groundwater measured at 1.39m depth on 7.5.18.

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Newcastle City Council
PROJECT: Groundwater Monitoring Program
LOCATION: Cowper Street, Carrington

SURFACE LEVEL: 1.92 AHD
EASTING: 384453.9
NORTHING: 6357347.5
DIP/AZIMUTH: 90°/--

BORE No: 5A
PROJECT No: 91247.00
DATE: 16/3/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - Generally comprising brown fine to coarse grained sand, with some fine to coarse sized subrounded gravel and shells, moist							Stick up 120mm below ground level From 0m to 0.2m, concrete From 0.2m to 0.5m, bentonite From 0.5m to 1.4m, backfill From 0 to 2.5m, 50mm diameter blank PVC From 1.4m to 2m, bentonite
	1.7	SILTY SAND - Loose brown silty sand, some clay, saturated						▼	
	2.3	SAND - Loose grey fine to coarse grained sand, trace fine shell fragments, saturated		S	2.5 2.95		0,0,0 N = 0		From 2m to 5.5m, specialised sand From 2.5m to 5.5m, 50mm diameter machine slotted PVC
				U	4.3 4.75		1,1,4 N = 5		End Cap
	5.5	Bore discontinued at 5.5m, limit of investigation							

RIG: Hanjin **DRILLER:** Total Drilling **LOGGED:** Parkinson **CASING:** HFA

TYPE OF BORING: Hollow flight auger to 5.5m

WATER OBSERVATIONS: Free groundwater observed at 1.8m, whilst drilling

REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Newcastle City Council
PROJECT: Groundwater Monitoring Program
LOCATION: Cowper Street, Carrington

SURFACE LEVEL: 1.92 AHD
EASTING: 384454.1
NORTHING: 6357346.4
DIP/AZIMUTH: 90°/--

BORE No: 5B
PROJECT No: 91247.00
DATE: 16/3/2018
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
		FILLING - Generally comprising brown fine to coarse grained sand, with some fine to coarse sized subrounded gravel and shells, moist		D	1.0 1.5			▼	Stick up 120mm below ground level From 0m to 0.2m, concrete From 0 to 0.5m, 50mm diameter blank PVC From 0.2m to 0.5m, bentonite From 0.5m to 1.7m, specialised sand From 0.5m to 1.7m, 50mm diameter machine slotted PVC End Cap
	1.7	Bore discontinued at 1.7m, limit of investigation							

RIG: Hanjin **DRILLER:** Total Drilling **LOGGED:** Parkinson **CASING:** HFA

TYPE OF BORING: Hollow flight auger to 1.7m

WATER OBSERVATIONS: Free groundwater observed at 1.4m, whilst drilling. Groundwater measured at 1.48m depth on 8.5.18.

REMARKS: Approximately 1m south of 5A

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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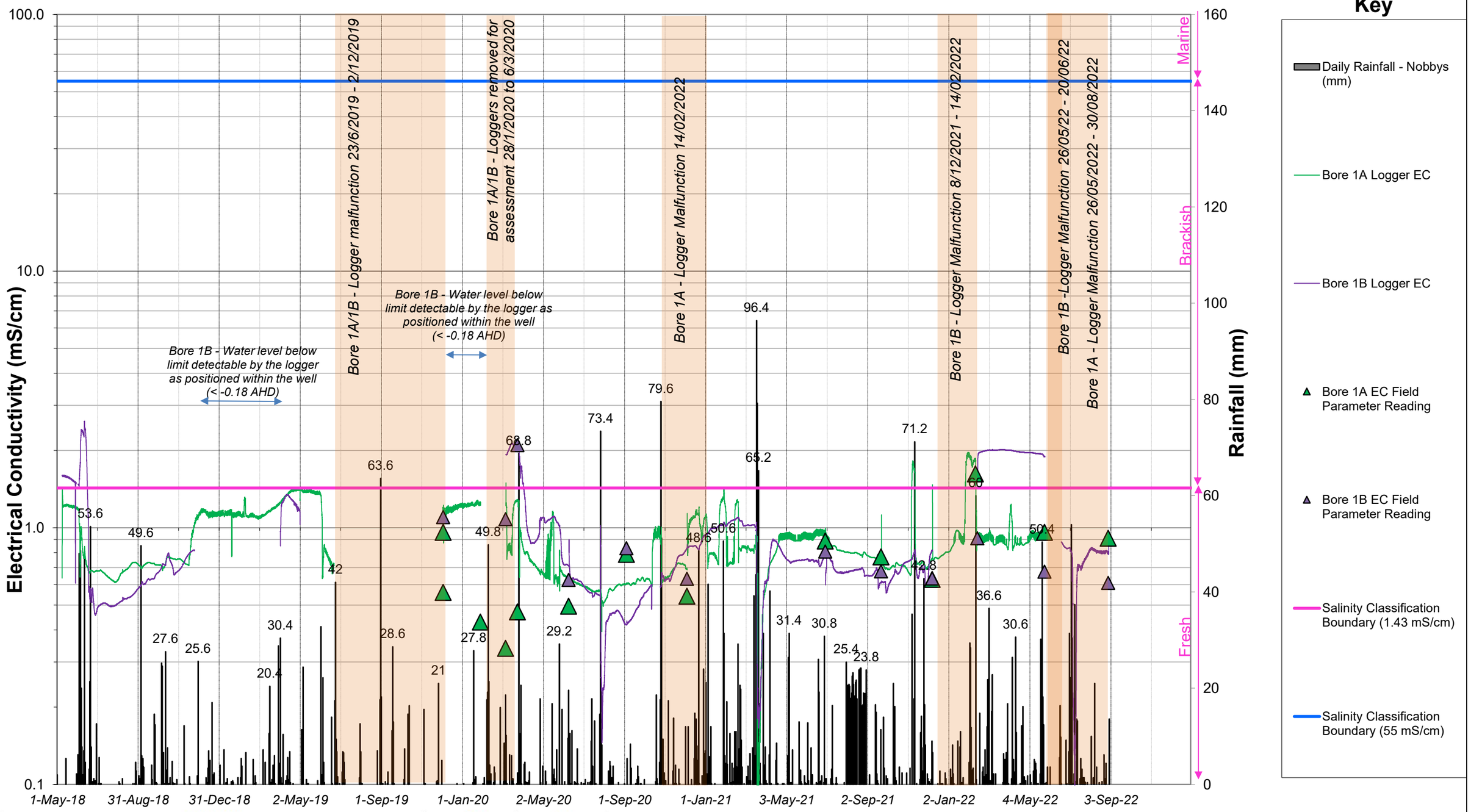
Appendix B

Figures B.1 to B.8 – Datalogger Plots (Groundwater Level and EC)

Figure B.9 – Hydrograph of Rainfall Data 2018-2022
(BOM Nobbys and TAFE Tighes Hill)

Figure B.10 and B.11 – Tidal Assessment

Groundwater Electrical Conductivity Data (Wells 1A & 1B)



Well ID	1A	1B
Well Position	Lower	Upper
Screen Interval (AHD)	-0.57 to -5.27	0.82 to -0.28
Appoximate Logger Position (AHD)	-3.3	0.5
Approximate Distance from Nearest Surface Water Body (m)	450 m East (Throsby Creek)	

91247.01 Figure B.1

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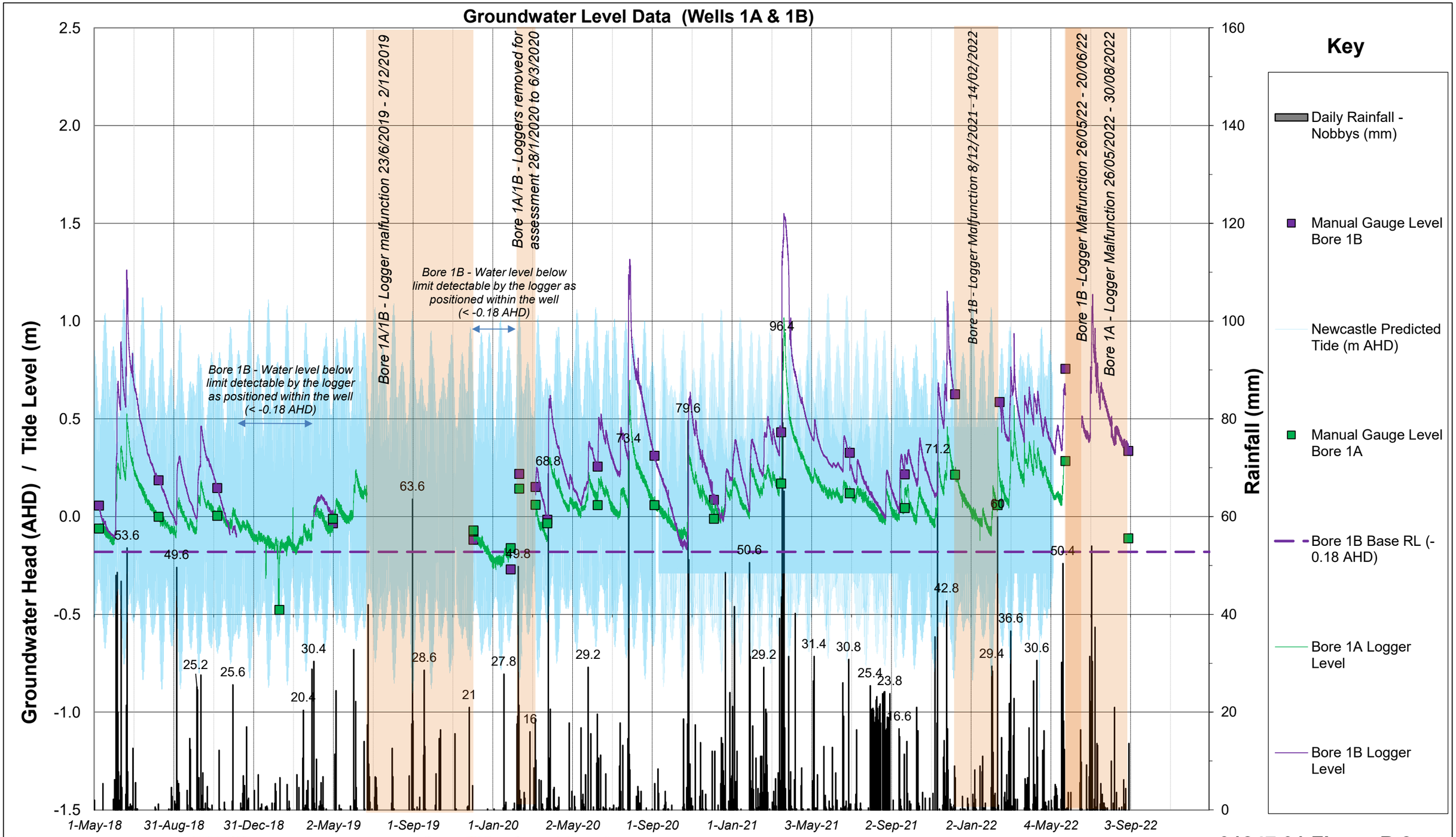

Well ID	1A	1B
Well Position	Lower	Upper
Screen Interval (AHD)	-0.57 to -5.27	0.82 to -0.28
Appoximate Logger Position (AHD)	-3.3	0.5
Approximate Distance from Nearest Surface Water Body (m)	450 m East (Throsby Creek)	

91247.01 Figure B.2

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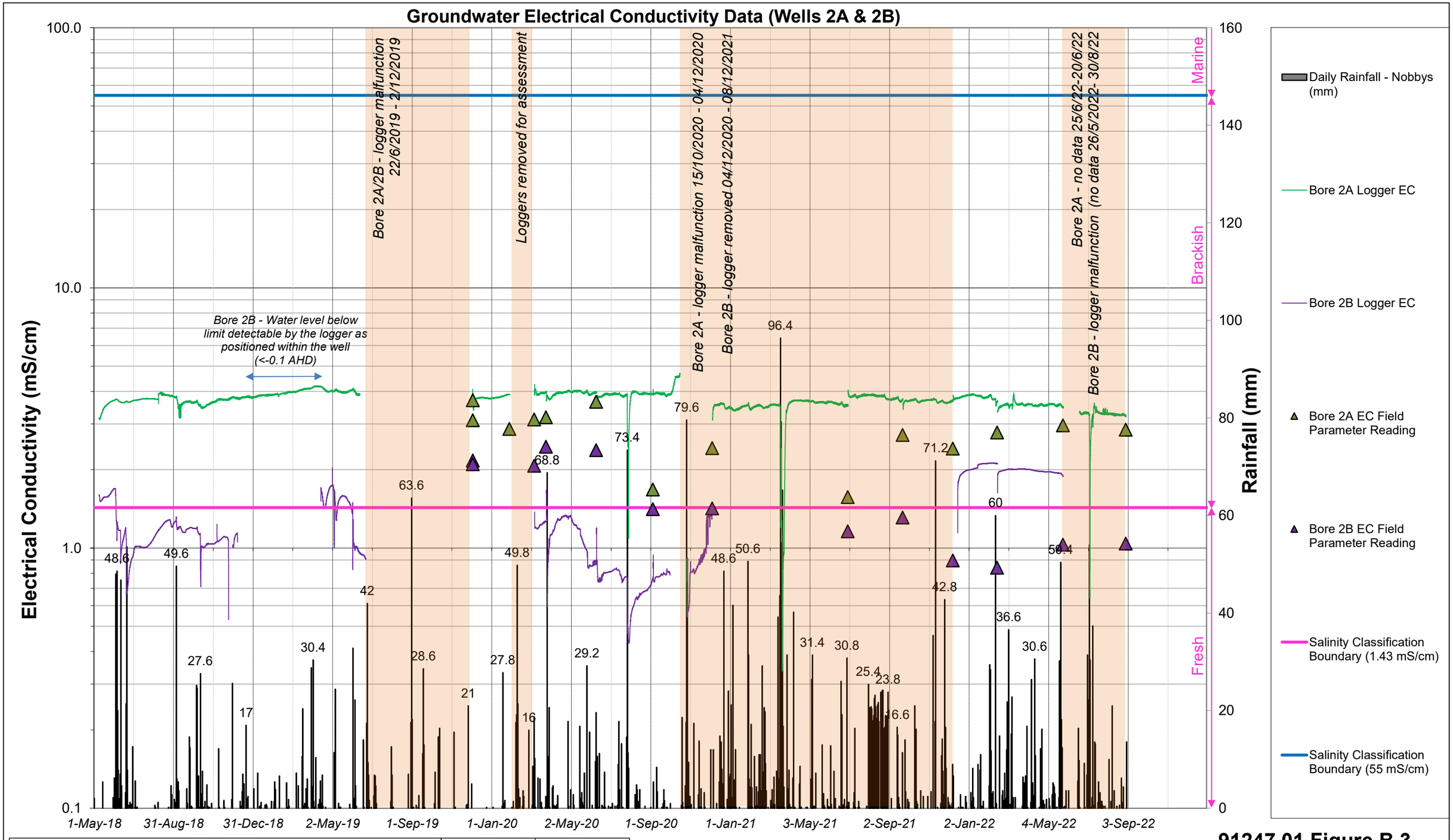

Well ID	2A	2B
Well Position	Lower	Upper
Screen Interval (AHD)	-2.31 to -4.31	0.91 to -0.24
Appoximate Logger Position (AHD)	-3.3	0.5
Approximate Distance from Nearest Surface Water Body (m)	320 m North (Throsby Creek)	

91247.01 Figure B.3

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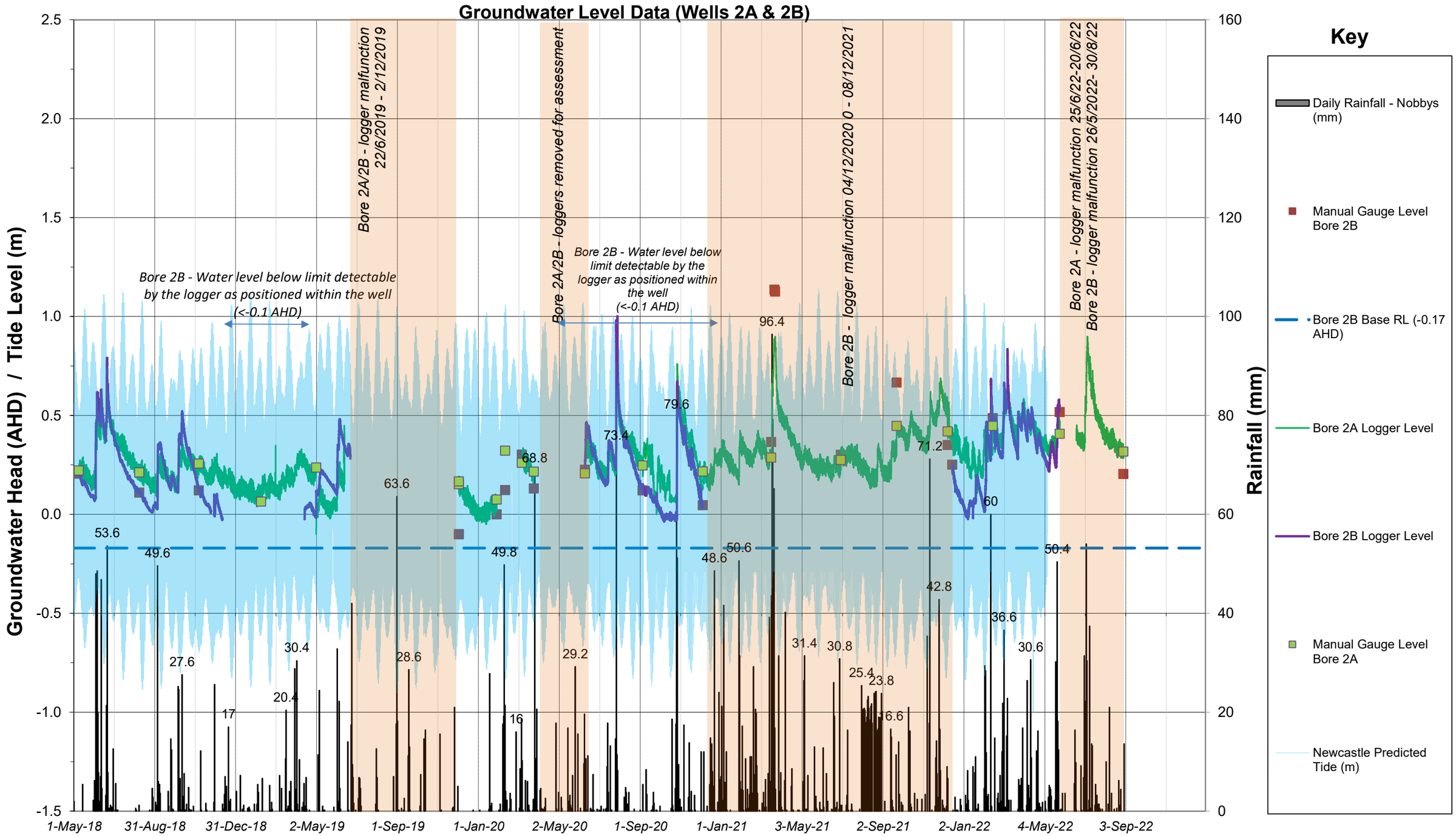

Well ID	2A	2B
Well Position	Lower	Upper
Screen Interval (AHD)	-2.31 to -4.31	0.91 to -0.24
Appoximate Logger Position (AHD)	-3.3	0.5
Approximate Distance from Nearest Surface Water Body (m)	320 m North (Throsby Creek)	

91247.01 Figure B.4

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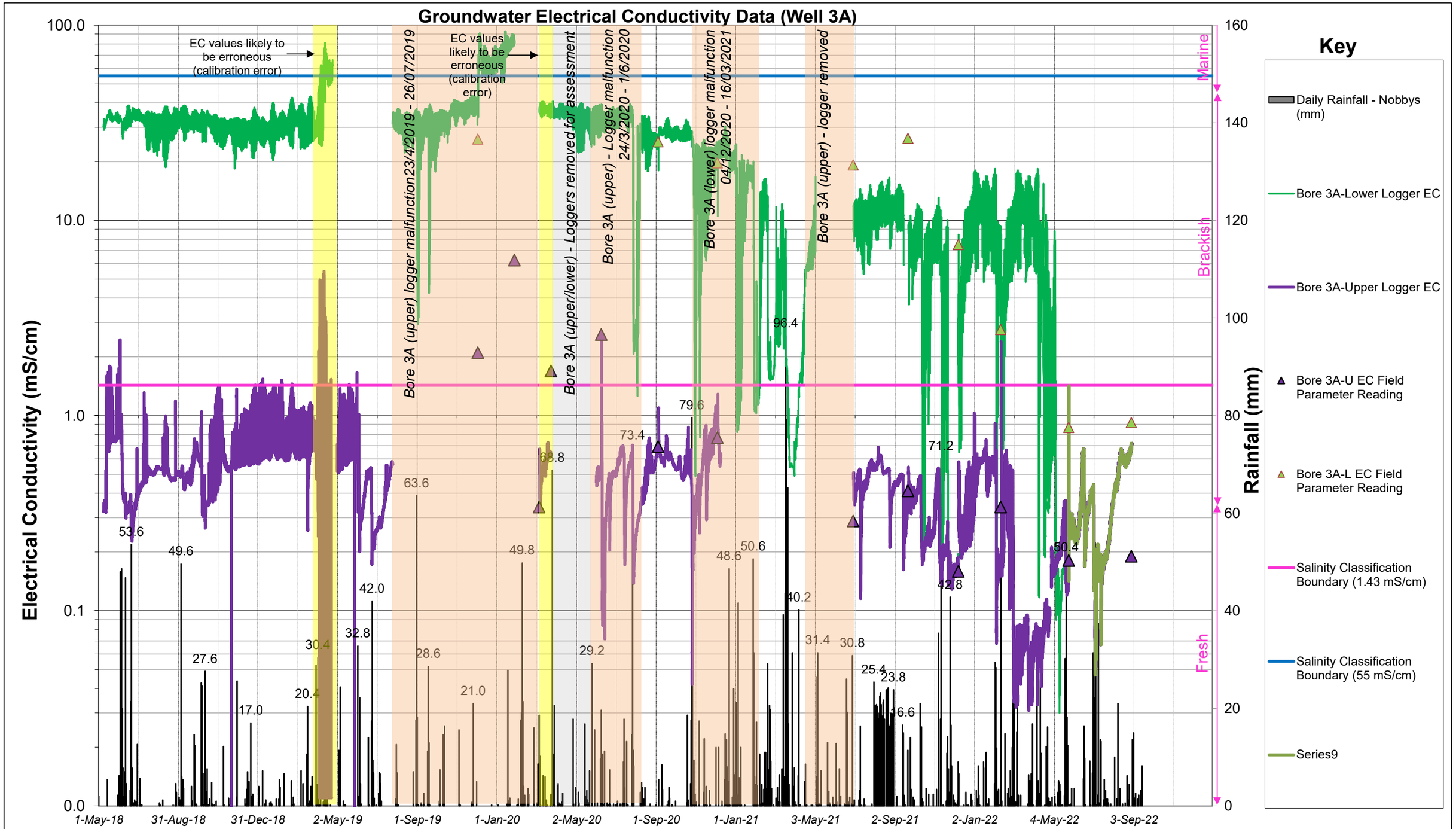

Well ID	3AL	3AU
Well Position	Lower	Upper
Screen Interval (AHD)	1.0 to -4.4	
Appoximate Logger Position (AHD)	-2.55	1.09
Approximate Distance from Nearest Surface Water Body (m)	30 m North (Throsby Creek)	

91247.01 Figure B.5

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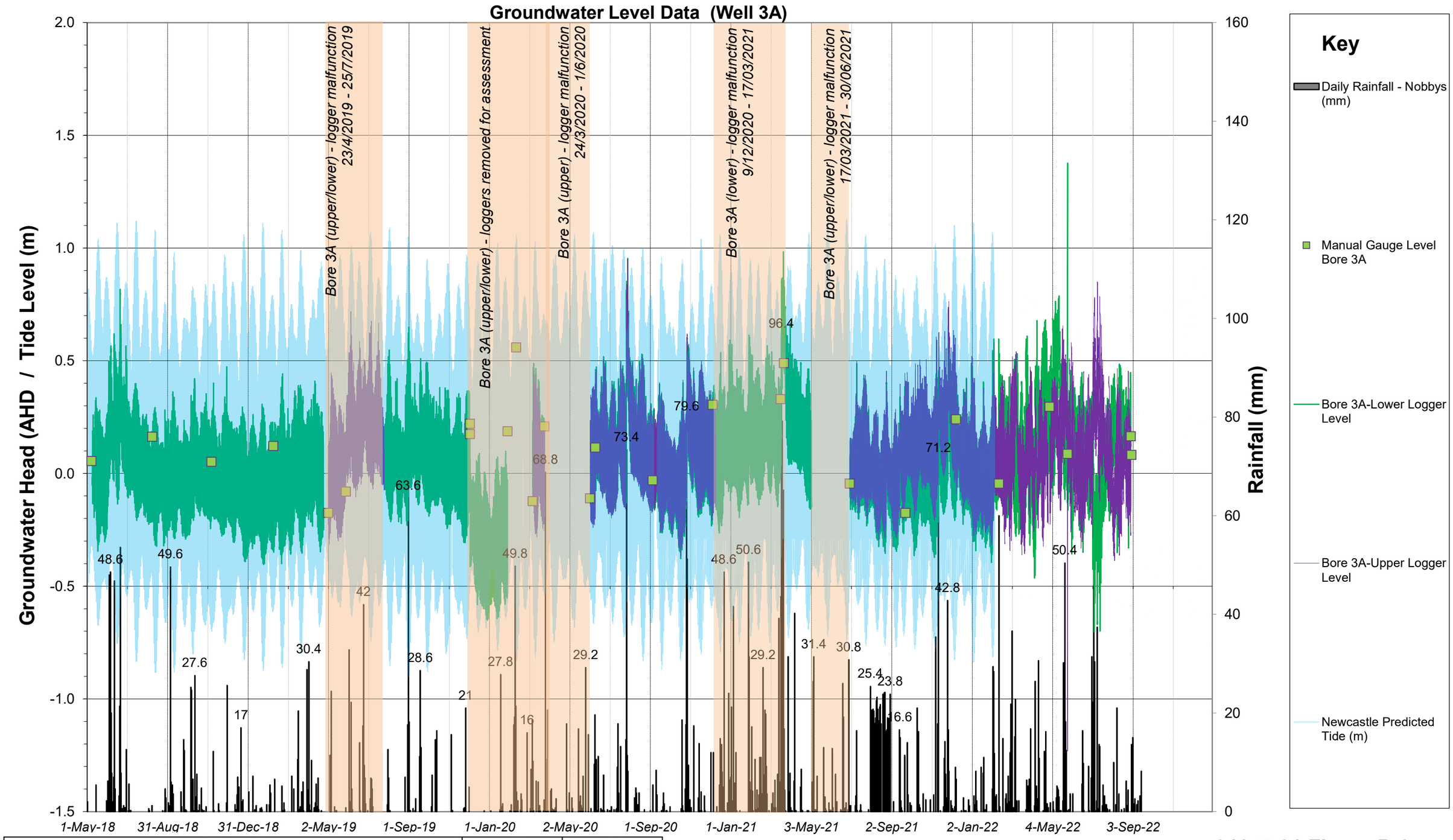

Well ID	3AL	3AU
Well Position	Lower	Upper
Screen Interval (AHD)	1.0 to -4.4	
Appoximate Logger Position (AHD)	-2.55	1.09
Approximate Distance from Nearest Surface Water Body (m)	30 m North (Throsby Creek)	

91247.01 Figure B.6

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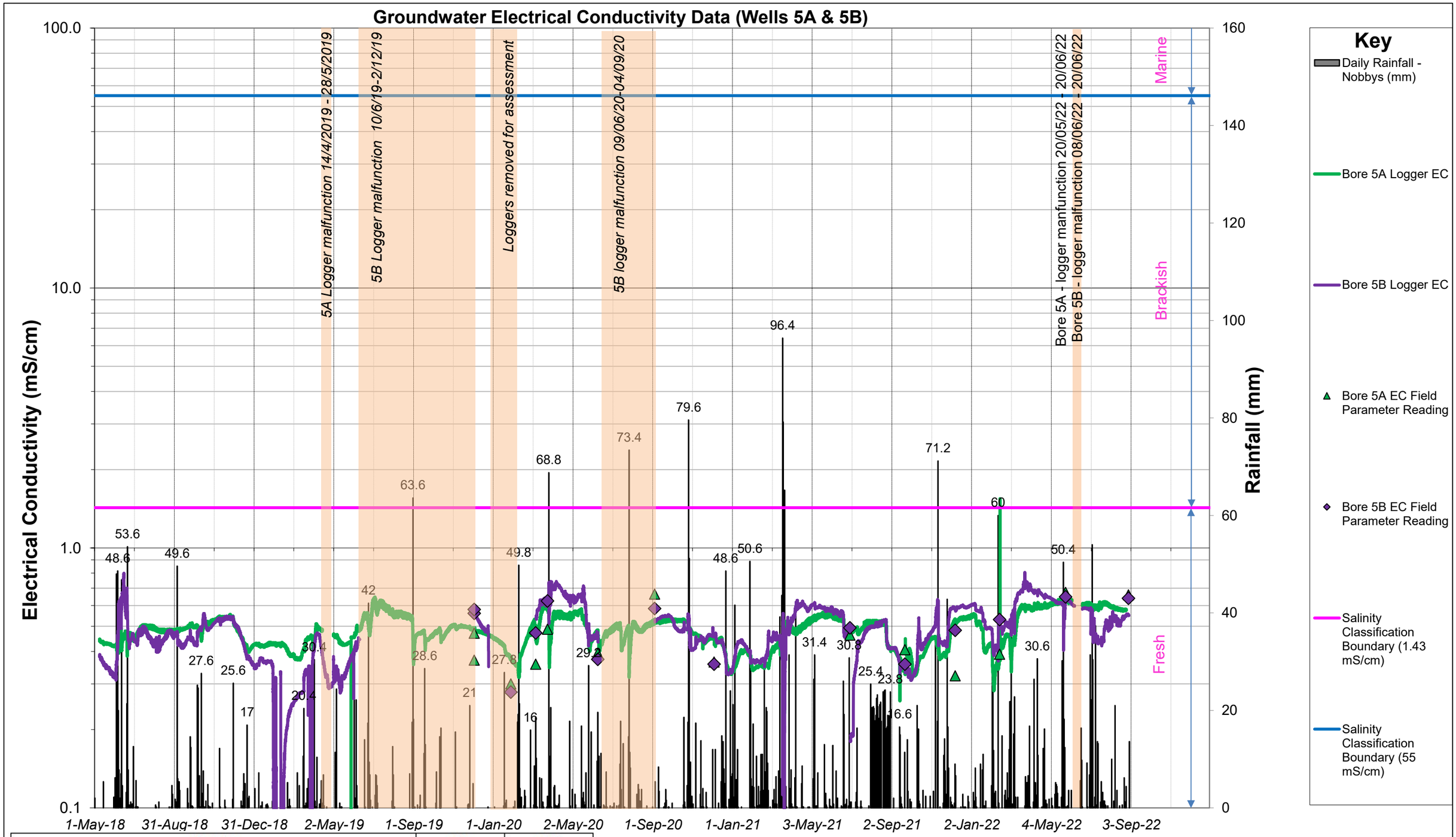

Well ID	5A	5B
Well Position	Lower	Upper
Screen Interval (AHD)	-0.70 to -3.70	1.30 to 0.09
Appoximate Logger Position (AHD)	-2.7	0.38
Approximate Distance from Nearest Surface Water Body (m)	300 m West (Throsby Creek)	

91247.01 Figure B.7

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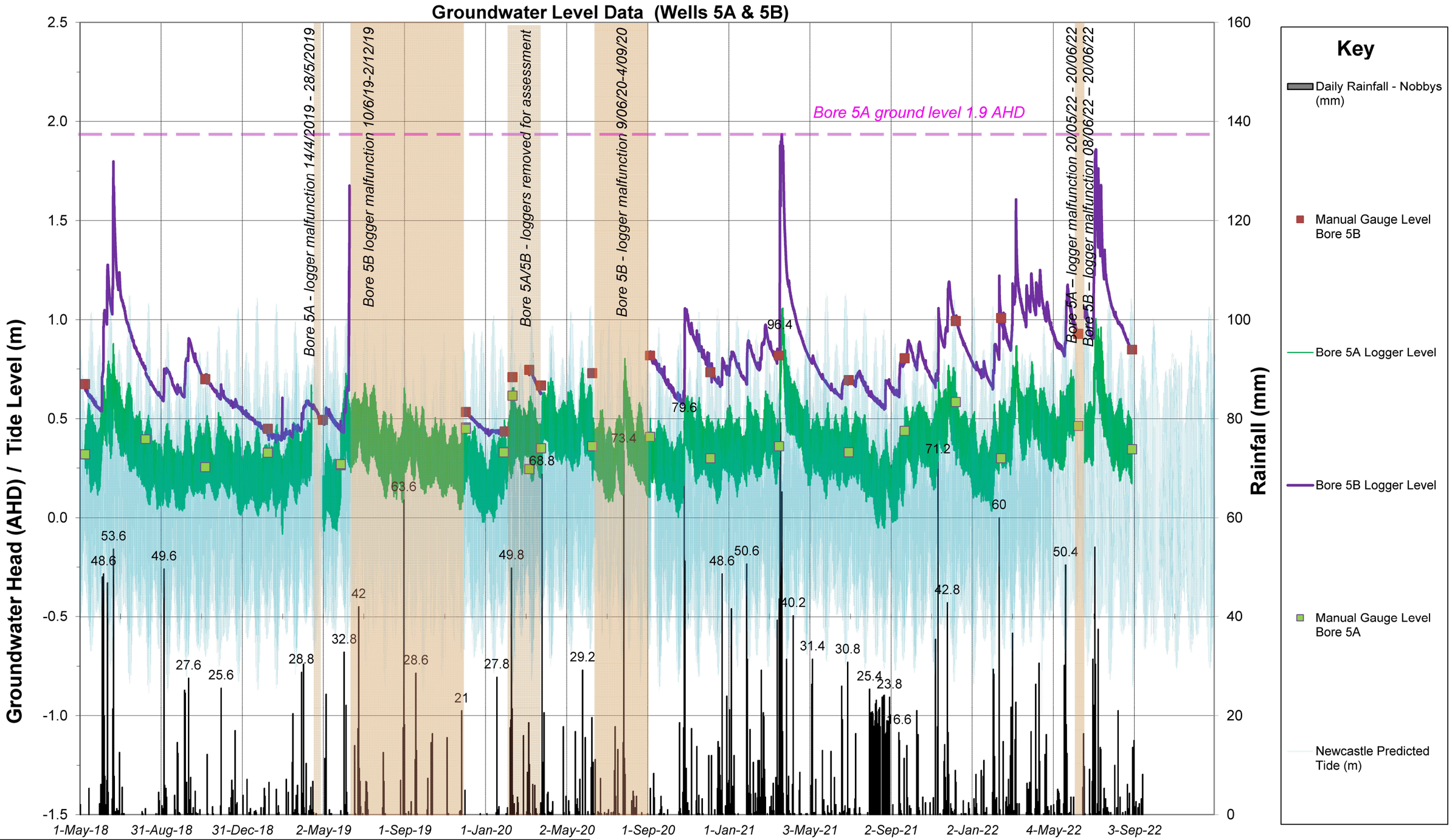

Well ID	5A	5B
Well Position	Lower	Upper
Screen Interval (AHD)	-0.70 to -3.70	1.30 to 0.09
Appoximate Logger Position (AHD)	-2.7	0.38
Approximate Distance from Nearest Surface Water Body (m)	300 m West (Throsby Creek)	

91247.01 Figure B.8

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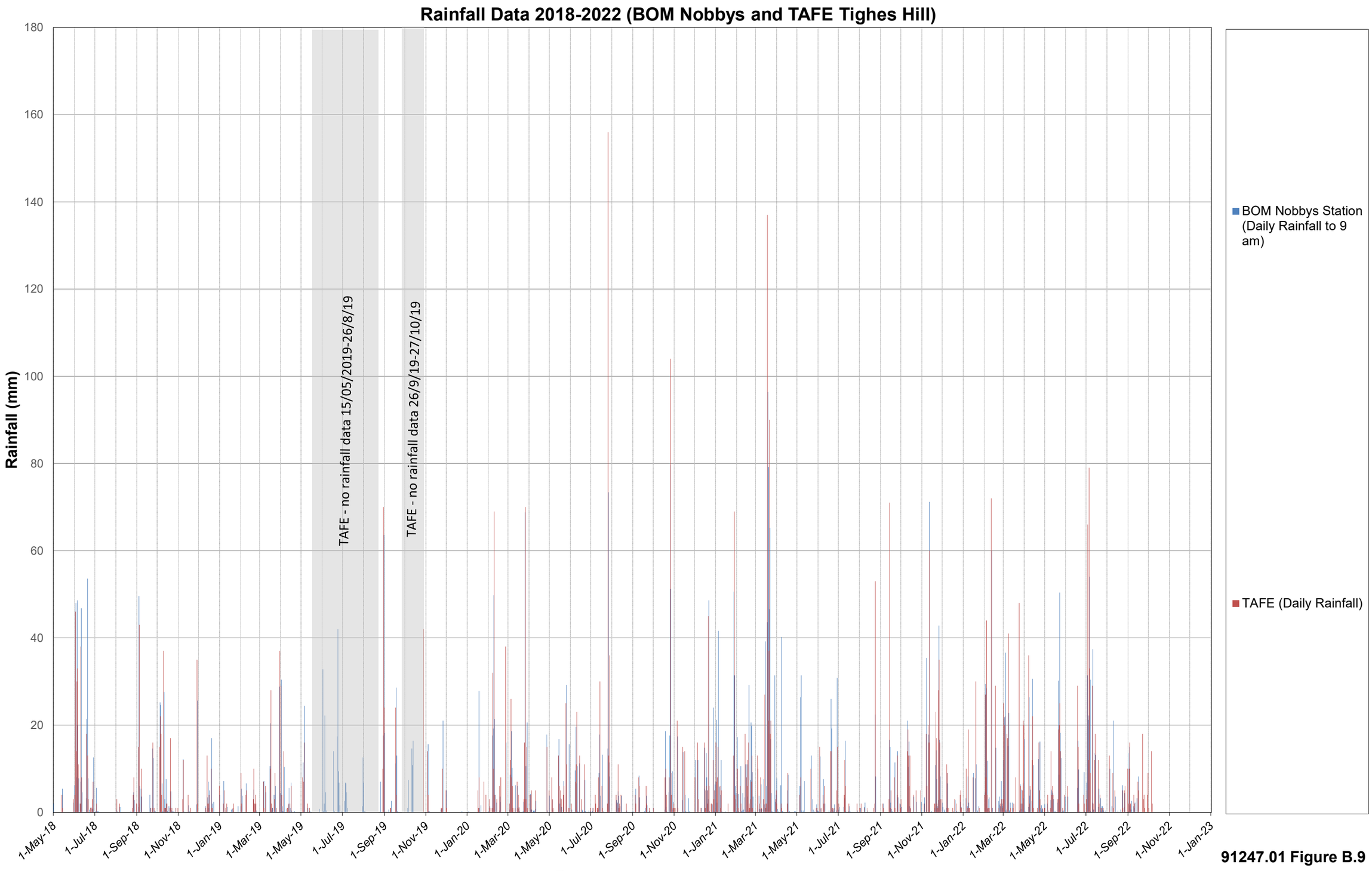

91247.01 Figure B.9

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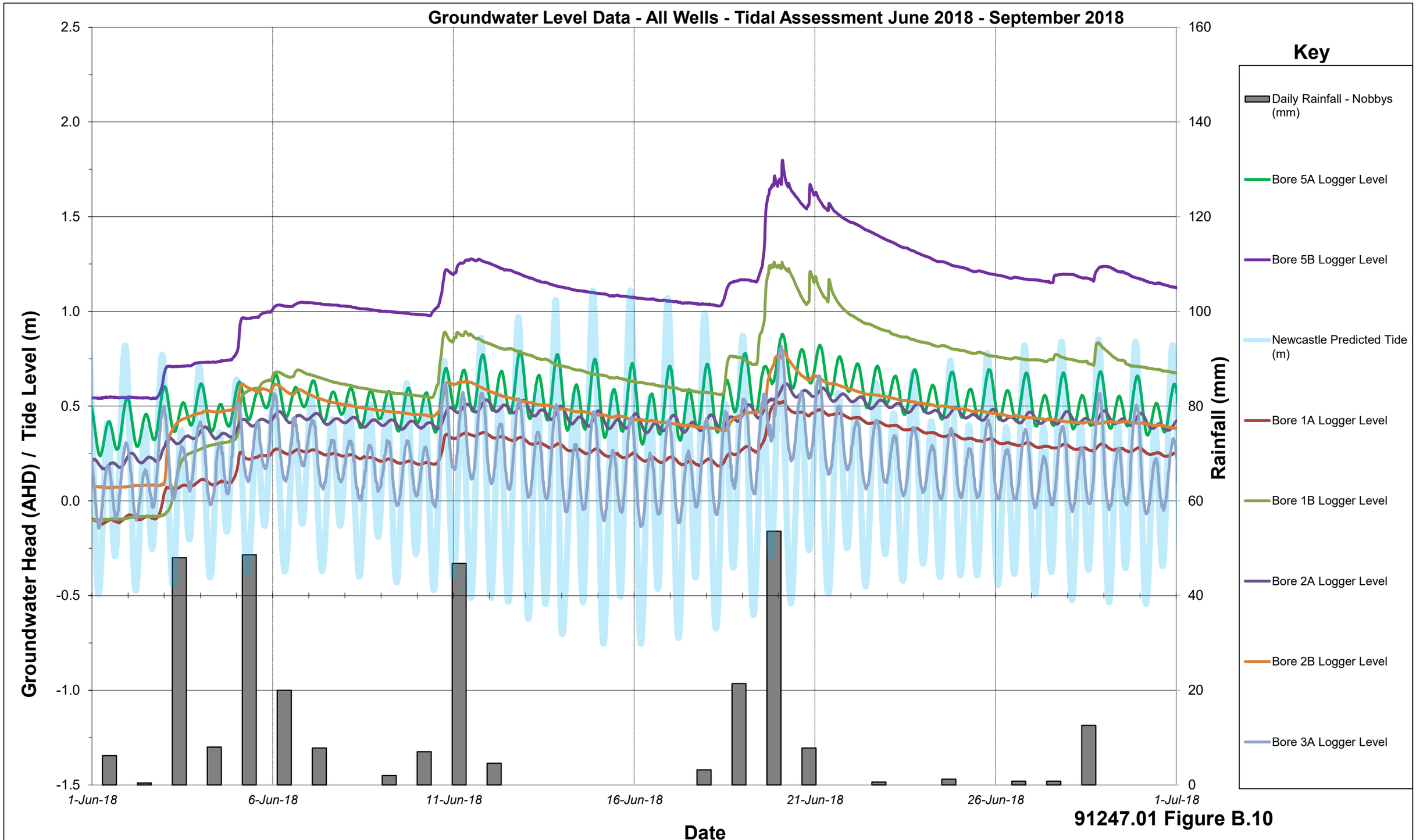

91247.01 Figure B.10

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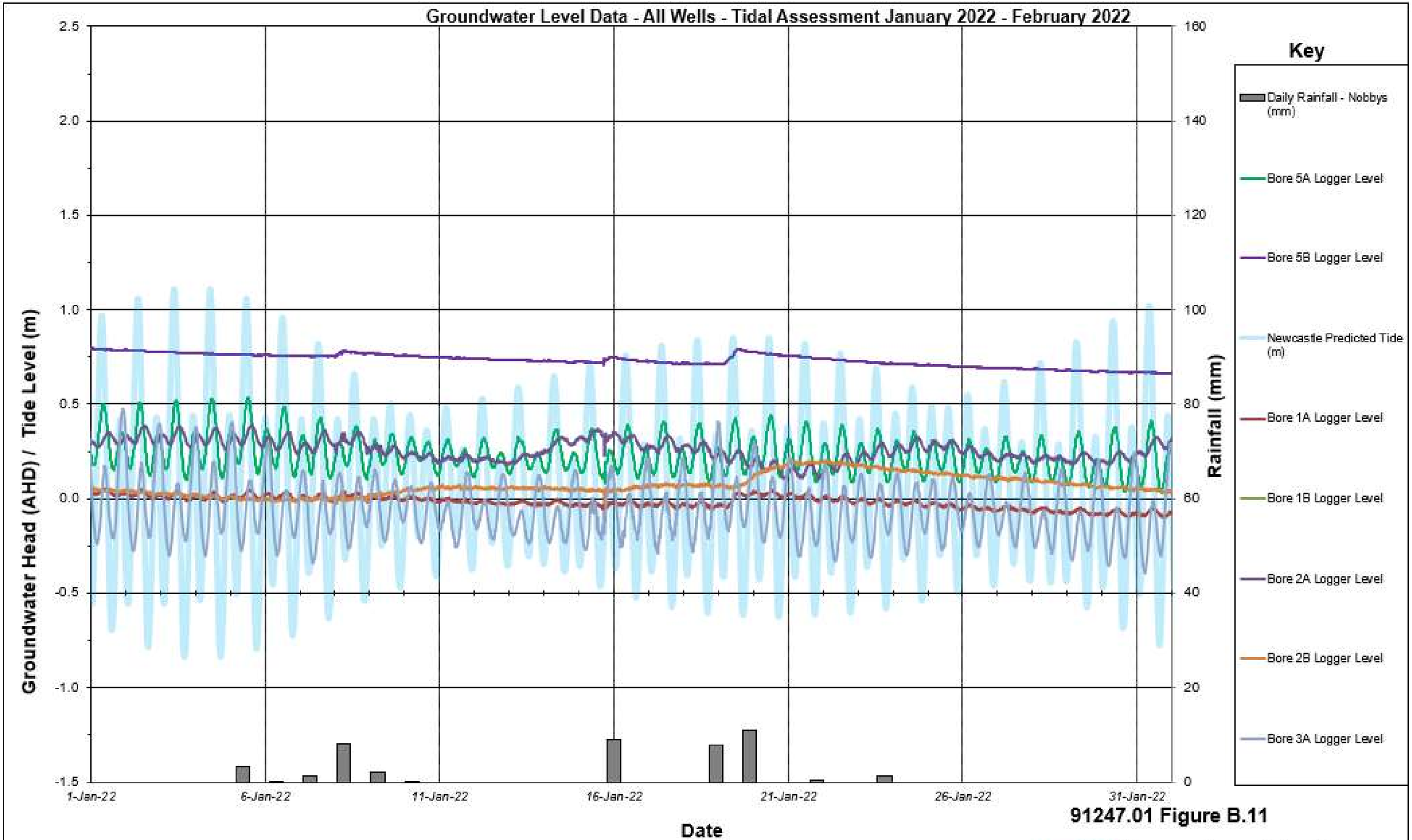

91247.01 Figure B.11

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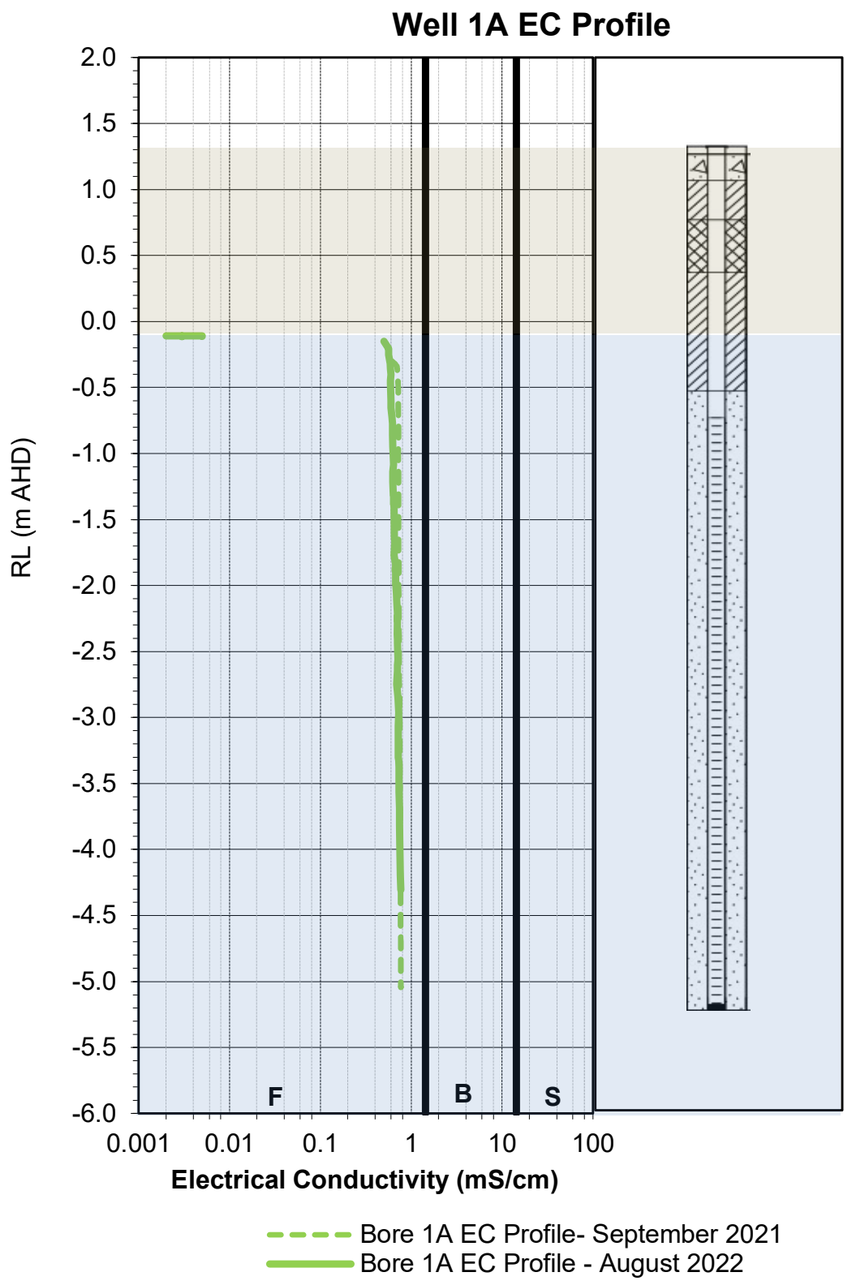
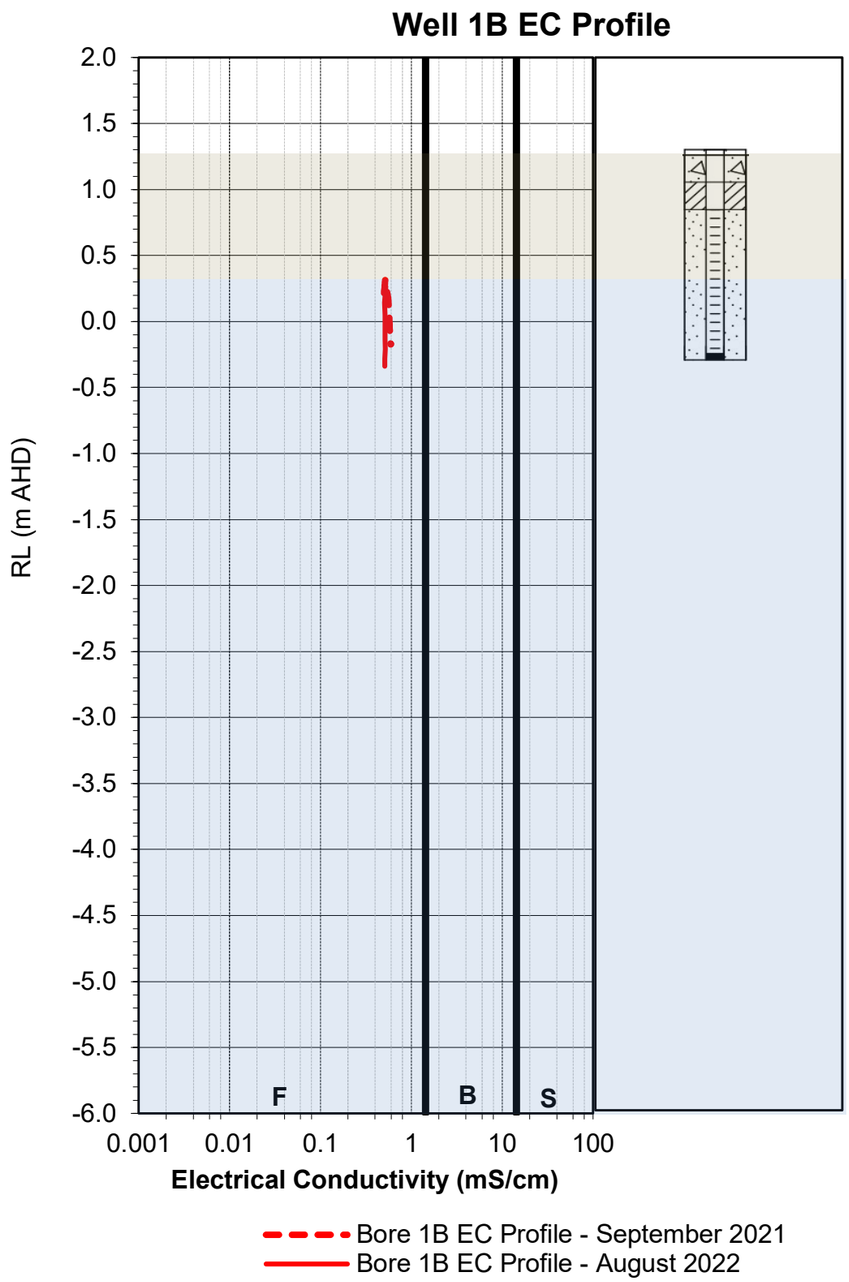
Appendix C

Figures C.1 to C.4 – EC Profiles





F = Fresh (0-1.43 mS/cm) B = Brackish (1.43-14.3) S = Saline (14.3-143 mS/cm)

91247.01 Figure C.1

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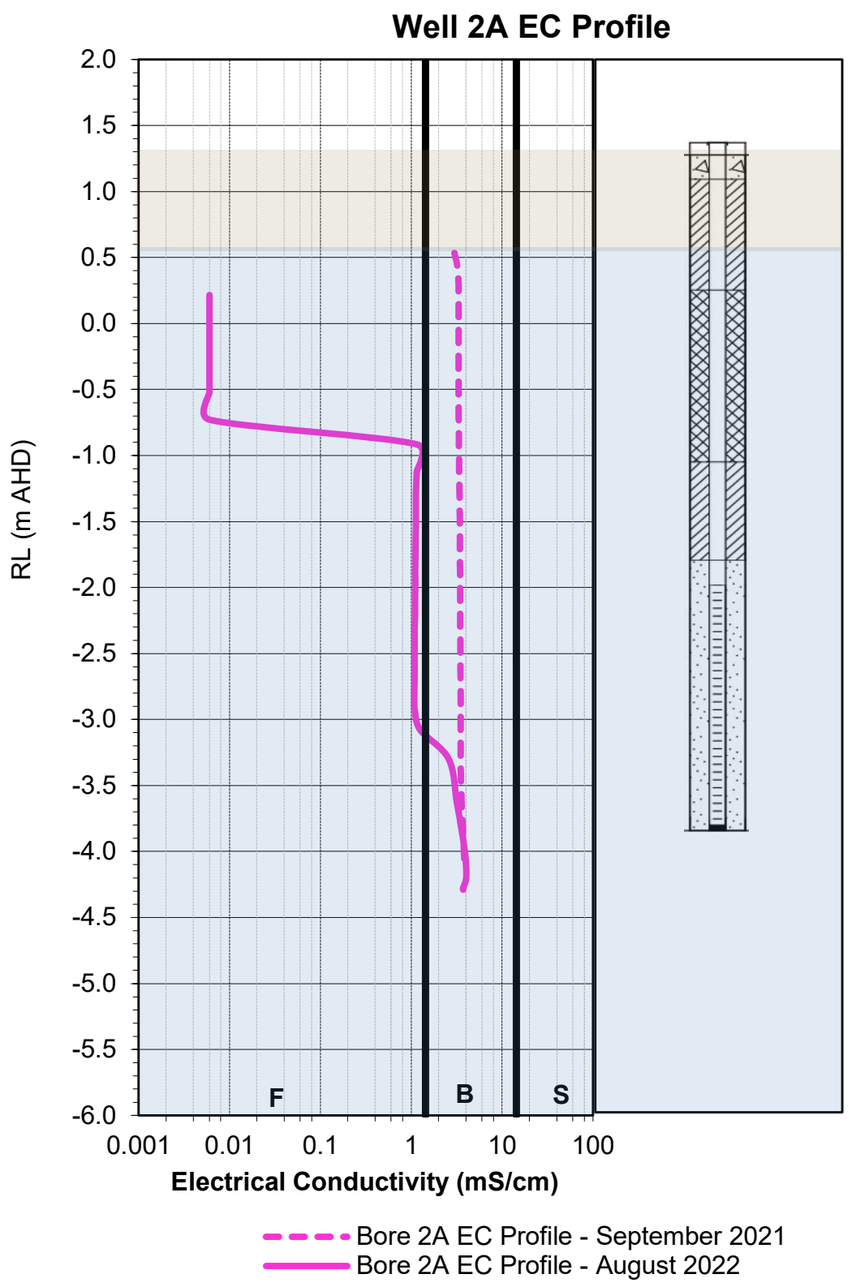

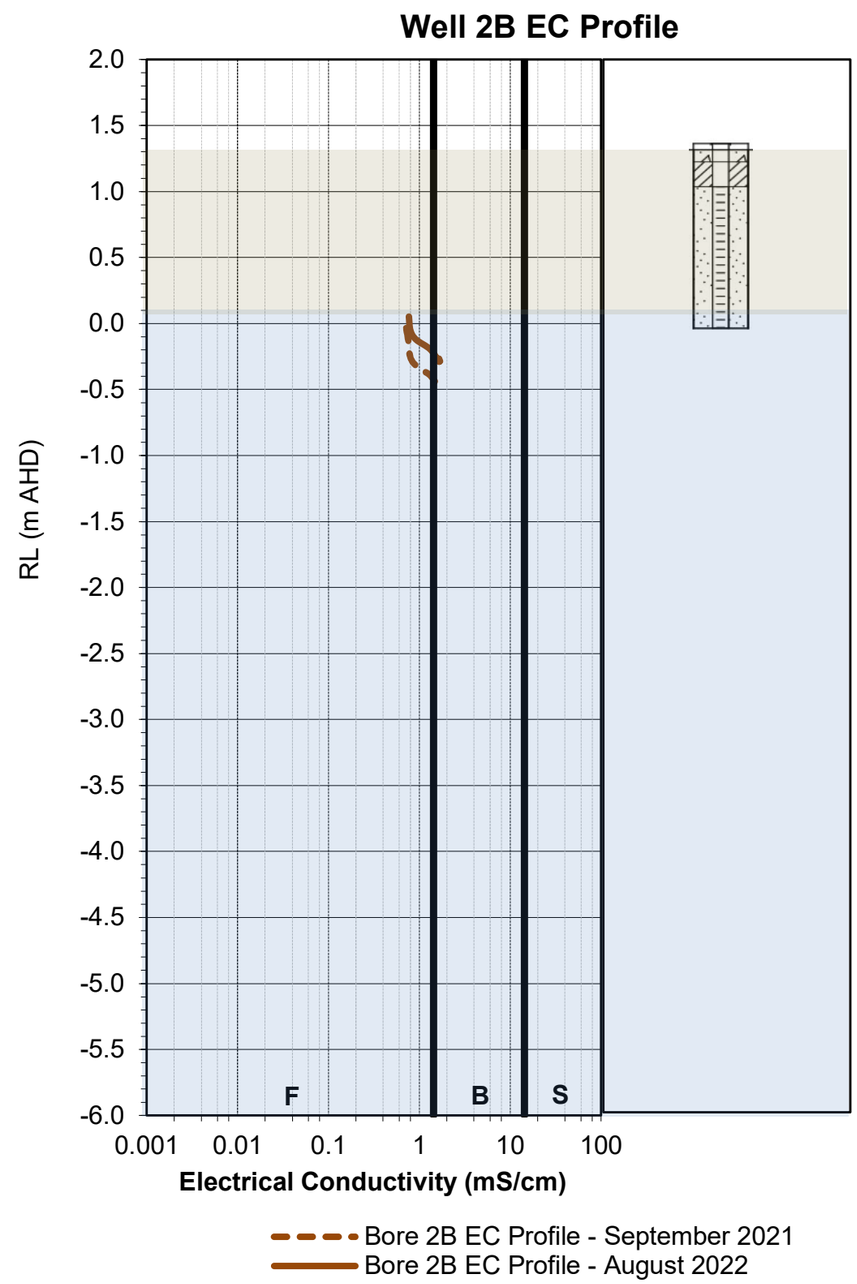

F = Fresh (0-1.43 mS/cm) B = Brackish (1.43-14.3) S = Saline (14.3-143 mS/cm)

91247.01 Figure C.2

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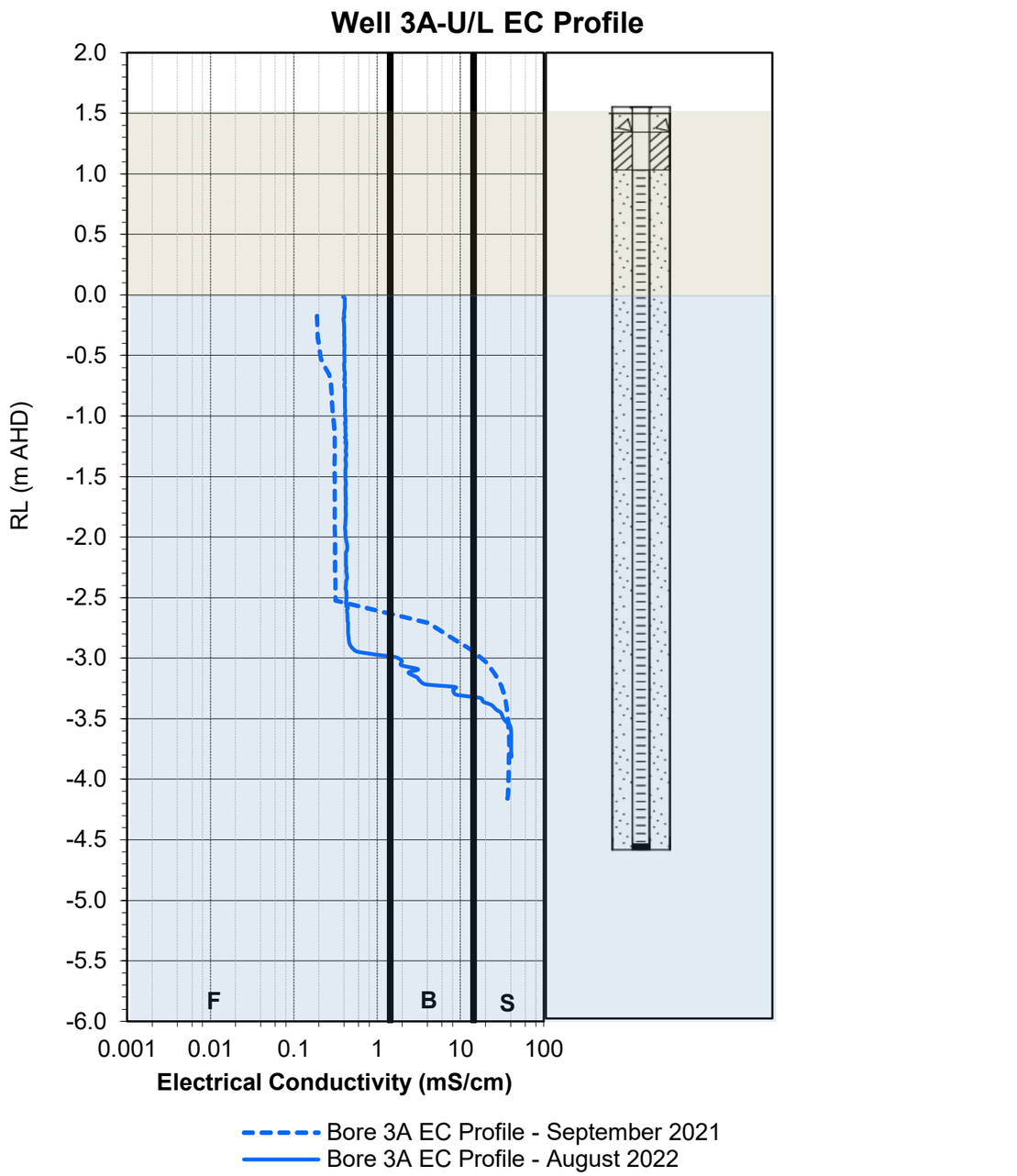

F = Fresh (0-1.43 mS/cm) B = Brackish (1.43-14.3) S = Saline (14.3-143 mS/cm)

91247.01 Figure C.3

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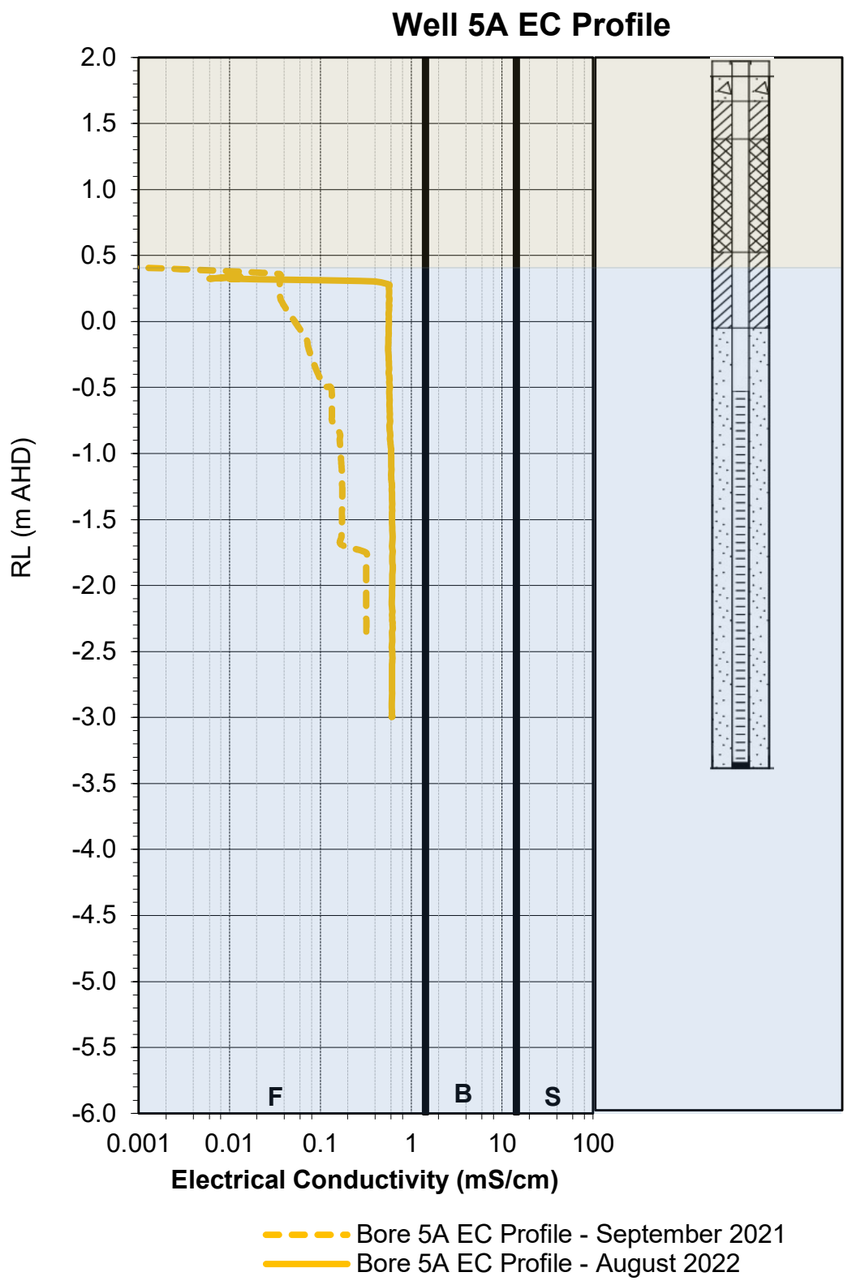

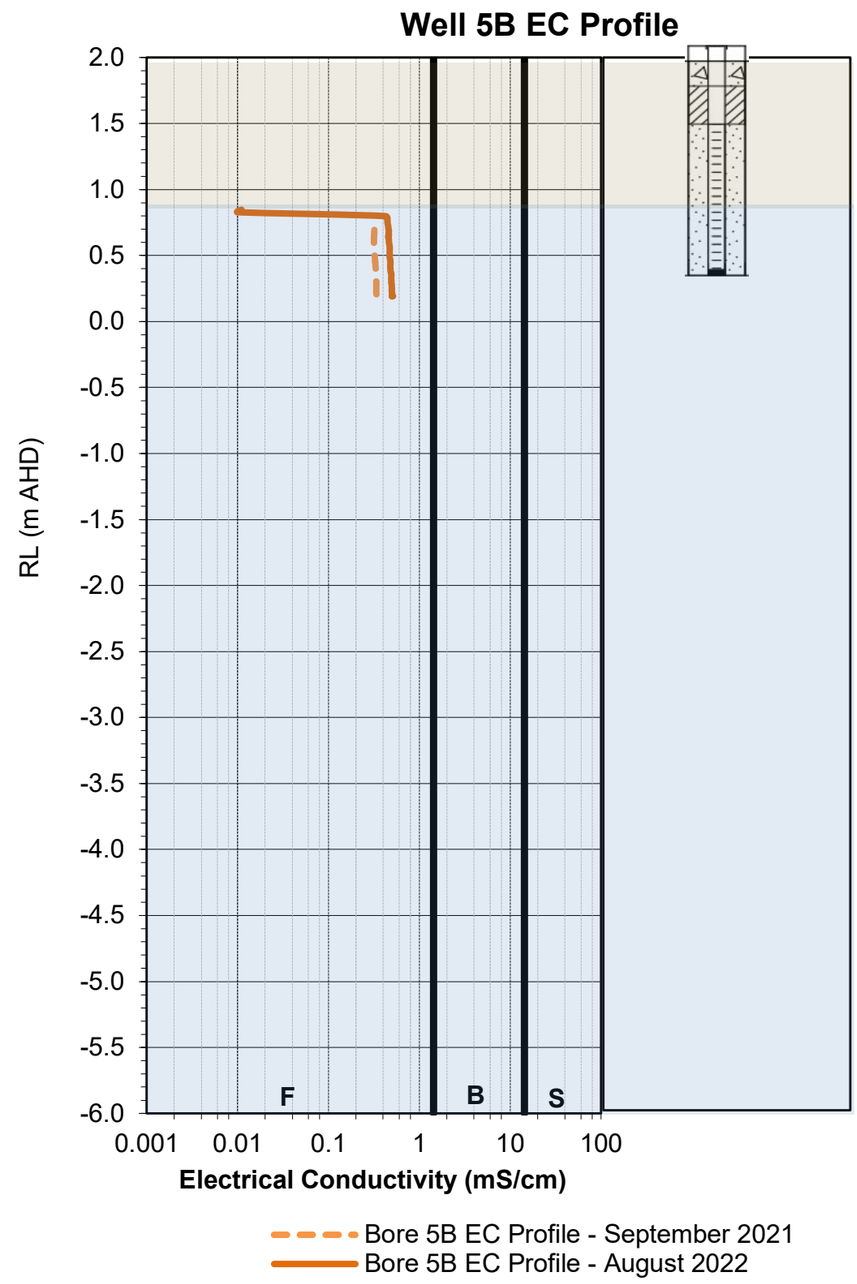

F = Fresh (0-1.43 mS/cm) B = Brackish (1.43-14.3) S = Saline (14.3-143 mS/cm)

91247.01 Figure C.4

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