

8 April 2021

Paul Slough  
Quarry Manager  
Hanson Construction Materials Pty Ltd  
Sydney NSW 2000

**Re: Annual Independent Groundwater Audit - 2020**

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Dear Paul,

This letter documents the 2020 independent audit of groundwater impacts from the Calga Sand Quarry (the project).

The audit has been completed by Rachel Truscott and Samuel Cook of EMM Consulting Pty Limited (EMM). Rachel is an environmental scientist with over four years' experience. Samuel is an associate hydrogeologist with over 15 years' experience, Samuel also completed the 2019 independent audit for the project.

EMM have had no other involvement with the project or any reason to believe they should be precluded from performing an independent audit.

## 1 Introduction

### 1.1 Background

The project is contained within Lot 2 of Deposited Plan 229889 on the Central Coast of New South Wales. Hanson Construction Materials Pty Ltd (Hanson) is the project owner and operator. Operations comprise of extraction, processing, handling, storage, and transportation of extracted material.

The project is classified as State significant under section 76A(7) of the *Environmental Planning and Assessment Act 1979*. Project approval (DA 94-4-2004) was granted on 28 October 2005. The approval was amended in 2012 and again in 2017.

The project is approved to extract 400,000 tonnes of product per annum until 1 July 2030. Over the reporting period approximately 163,534 tonnes of material was extracted. Operations involved ripping and pushing up friable sandstone. All sand extracted was washed to produce a range of concrete sand products.

## 1.2 Development consent

Schedule 3, Condition 17 of DA 94-4-2004 (3) requires Hanson to complete an annual independent groundwater audit for inclusion in the Annual Environmental Management Review (AEMR). This document details the review for the 2020 calendar year (reporting period).

Schedule 3, Condition 17 of DA 94-4-2004 (3)

Each year from the date of this consent, or as otherwise directed by the Director-General, the Applicant shall undertake an independent audit of the groundwater impacts of the development to determine compliance with the groundwater impact assessment criteria, to the satisfaction of the Director-General. The audit shall be conducted by a suitably qualified and independent hydrogeologist whose appointment has been approved by the Director-General.

The referenced groundwater impact assessment criteria are detailed in the *Water Management Plan* (WMP) (RW Corkery, 2020) and the *Quarry Closure Groundwater Management Plan* (Dundon, Consulting 2019). In addition, the development consent requires a *Groundwater Contingency Strategy* (Martens and Associates, 2020) which has been considered in this review.

## 1.3 Scope

This independent audit of groundwater impacts includes:

- review of relevant project approval documentation, which define the consent conditions against which compliance was audited;
- review of the:
  - monitoring reports for the reporting period, provided by Carbon Based Environmental Pty Ltd;
  - previous annual independent groundwater audits for the project;
  - independent environmental compliance audits for the project; and
- assessment of monitoring data over the reporting period and historical trends.

## 2 Groundwater monitoring

### 2.1 Network

The objective of the groundwater monitoring program is to assess changes in groundwater level and quality over time. This facilitates the early detection of potential impacts from project operations. The monitoring network is summarised in Table 2.1 and presented spatially in Figure 2.1.

The groundwater monitoring network comprises of 24 active monitoring locations, including:

- ten monitoring bores surrounding the existing quarry operations (denoted by a CQ prefix);
- seven monitoring bores surrounding a formerly proposed southern extension (denoted by a MW prefix); and
- seven landholder (private) bores located within a 500 m radius of the project (denoted by a CP prefix).

Monitoring bore CP7 and MW7 were defined by Dundon Consulting (2019) as control bores. The WMP has since endorsed the removal of CP7 from the monitoring network.

**Table 2.1**      **Calga Quarry Monitoring Network**

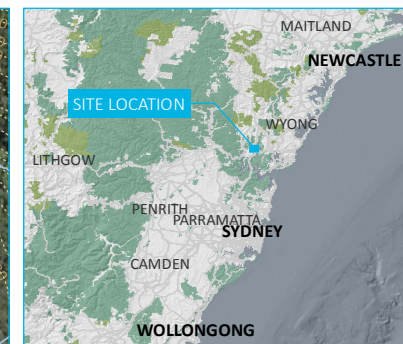
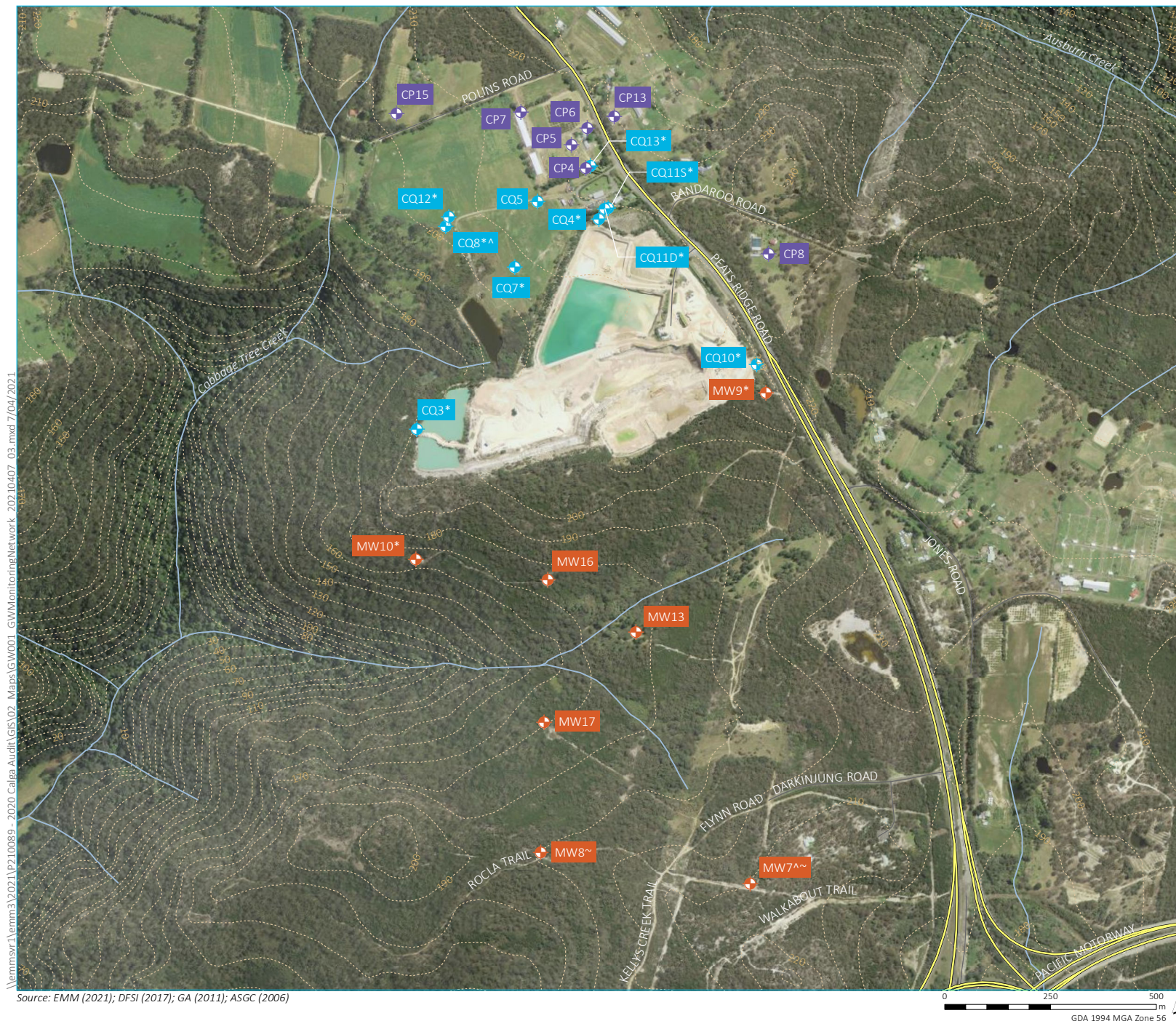
Bore ID	Registered number	Easting	Northing	RL-TOC (m AHD)	RL-GL (m AHD)	Bore depth (m)
<b>Monitoring bores - existing quarry</b>						
CQ3*	GW104245	333718.4	6301299.8	181.023	180.437	21.8
CQ4*	GW104246	334147.85	6301797.3	215.508	214.821	20
CQ5	NA	334003.3	6301838.4	213.527	212.697	23.7
CQ7*	NA	333950	6301683	205.153	204.303	29.7
CQ8*	NA	333786.4	6301778.8	201.764	200.904	26.6
CQ10*	GW202214	334520.7	6301453.3	223.98	223.13	57
CQ11S*	GW202191	334170.5	6301822.7	217.122	216.34	38
CQ11D*	GW202192	334162.6	6301820.7	217.076	216.3	65
CQ12*	GW202193	333794.2	6301802.3	202.633	202.61	15
CQ13*	GW202215	334128.1	6301923.3	219.118	218.3	65
<b>Monitoring bores - southern extension</b>						
MW7^	NA	334506	6300226	210.79	209.92	30
MW8^	NA	334011	6300298	191.905	191.03	30
MW9*	GW201800	334543	6301387	224.435	223.56	27
MW10*	GW201801	333716	6300992	164.005	163.14	30
MW13	GW201802	334236	6300819	178.42	178.42	45
MW16	NA	334027	6300943	173.67	173.67	NA
MW17	NA	334018.59	6300607.74	172.345	171.5	NA

**Table 2.1**      **Calga Quarry Monitoring Network**

Bore ID	Registered number	Easting	Northing	RL-TOC (m AHD)	RL-GL (m AHD)	Bore depth (m)
<b>Landholder (private) bores</b>						
CP4	GW066908	334118	6301917.3	218.271	218	44
CP5	GW067408	334083	6301972.1	216.318	215.92	76
CP6	GW101316	334120.7	6302011.4	218.02	217.27	92
CP7	GW037925	333964.3	6302049.2	210.901	210.54	76.2
CP8	GW066907	334549.9	6301715	223.581	223.33	NA
CP13	NA	334183.9	6302039.1	218.76	218.38	NA
CP15	NA	333670.15	6302046.4	~203	NA	NA

- Notes:
1. NA = data not available at the time of audit      RL = reference level      TOC = top of casing      GL = ground level      m = meters      AHD = Australian Height Datum
  2. Table only includes monitoring and production bores active over the 2020 reporting period. Decommissioned and historic bores have been excluded.
  3. \* Denotes bores that require automated water level logging (via dedicated pressure transducers).
  4. ^Additional water level logger installed
  5. Monitoring Network Information has been obtained from Table 4 of the Calga Sand Quarry Site Water Management Plan (RW Corkery, 2020)





#### KEY

- ◆ Monitoring bores - existing quarry
- ◆ Monitoring bores - southern extension
- ◆ Landholder (private) bores
- Major road
- Minor road
- Watercourse/drainage line
- 10 m contour

#### INSET KEY

- Main road
- NPWS reserve
- State forest

\* Contains automated water level logger as per WMP  
 ^ Automated water level logger stopped working in February 2020 due to water damage  
 ~ Contains additional automated water level logger

### Active groundwater monitoring network

Calga Sand Quarry Extension  
 Annual independent groundwater audit - 2020  
 Figure 2.1



## 2.2 Program notes

### 2.2.1 Reporting period

During the reporting period, groundwater monitoring was undertaken by Carbon Based Environmental Pty Ltd.

Landholder bore CP4 was reported as blocked or damaged between 3 February and 8 October 2020, monitoring data was not available at this bore over this period.

Data loggers installed in CQ8 and MW7 were removed in June 2020. These loggers stopped working in February 2020 due to water damage. No continuous water level data is available at these bores after this time.

### 2.2.2 Historical

Hanson (2017) recommended monitoring discontinue at MW10, MW13, MW16 and MW17 due to heavy erosion on the track and restricted access. Monitoring at these sites recommenced in 2018 after access was reinstated and occurred during the reporting period.

Monitoring at landholder (private) bore CP4 ceased in February 2017 (Hanson 2017). Monitoring at CP4 recommenced in 2018 and occurred during the reporting period.

Landholder (private) bores CP13 and CP15 were added to the network following their identification in a 2016 bore survey. These bores do not have baseline data or water quality trigger values. Water quality is therefore compared against the Australian and New Zealand Governments (ANZG), 2018. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018) 95% species protection freshwater guideline (which supersedes the previously used ANZECC (2000) guideline), and historical water quality within these wells.

The WMP removes MW7, MW8, MW16 and MW17 from the monitoring network:

‘these bores no longer provide useful information as they were previously installed for groundwater investigations concerning the proposed Southern Extension, that is not proceeding at this time’.

The WMP was finalised in September 2020, therefore, monitoring was conducted at these wells over the reporting period and are included in this audit.

## 2.3 Monitoring

### 2.3.1 Groundwater level

Monitoring of groundwater level is required across the monitoring network. This comprises of quarterly manual measurements (dips) at all bores and continuous data collected via automated data loggers (6-hourly logging frequency) at the 11 bores listed in Table 2.1. In addition, loggers have been installed in monitoring wells MW7 and MW8.

Over the reporting period:

- the groundwater level was manually monitored at least four times at all 24 bores on a quarterly basis; and
- continuous data was collected at all required monitoring bores, with the exception of CQ8, which stopped collecting data in February 2020 due to water damage to data logger.

Hydrographs plotting the temporal groundwater level at all bores are presented in Appendix A.

### 2.3.2 Groundwater quality

The WMP lists the following requirements to monitor groundwater quality:

- quarterly groundwater monitoring for the field measurement of groundwater pH and electrical conductivity (EC) across the entire monitoring network; and
- laboratory analysis of groundwater samples for major cations, anions and total metals<sup>1</sup> across the entire monitoring network on an annual basis.

Over the reporting period, water quality monitoring was conducted in general compliance with the requirements of the WMP.

#### i Field recorded groundwater quality (pH and EC)

Field readings of pH and EC were recorded on a quarterly basis, four or more readings were collected at each monitoring well except CP4. Only two readings were available at CP4 (refer Section 2.2).

A summary of pH and EC results is provided in Table 2.2 and graphically in Appendix B.

**Table 2.2 Calga Quarry 2020 water quality summary**

Bore	Sample count (2020)	pH (pH units)			Electrical conductivity (µS/cm)		
		min	max	mean	min	max	mean
Monitoring bores - existing quarry							
CQ3	6	6.0	6.3	6.2	100.2	175	131.0
CQ4	6	4.5	5.5	4.9	118.1	168	140.3
CQ5	6	4.1	7.2	5.1	189.1	279	219.1
CQ7	6	4.4	6.2	5.1	104.8	209	143.8
CQ8	6	4.2	6.7	4.7	114.6	176.1	136.6
CQ10	6	4.4	5.4	4.8	121.4	201.3	150.7
CQ11S	6	5.2	5.8	5.5	130.3	191.4	156.6
CQ11D	6	5.0	5.5	5.2	126.1	176.3	149.5
CQ12	5	4.0	6.2	4.5	130.7	168.5	152.0
CQ13	6	4.1	4.7	4.3	136.6	182.4	163.5
Monitoring bores - southern extension							
MW7	6	5.4	6.3	5.8	19.3	112.2	50.4
MW8	6	4.5	6.6	5.2	51.5	154	80.6
MW9	6	4.5	4.7	4.6	76.4	110.9	91.3
MW10	5	4.4	6.2	4.8	100.7	142.8	120.3
MW13	5	4.3	6.2	4.8	93.0	180.7	120.0
MW16	5	4.2	5.9	4.7	105.6	148.2	123.6
MW17	5	4.9	6.9	5.8	111.4	149.5	123.0

<sup>1</sup> Ambiguity exists with the WMP quoting dissolved metals as the monitoring requirement and total metals as the assessment criteria. It is recommended the program continues to monitor total metals for assessment consistency.

**Table 2.2 Calga Quarry 2020 water quality summary**

Bore	Sample count (2020)	pH (pH units)			Electrical conductivity (µS/cm)		
		min	max	mean	min	max	mean
Landholder (private) bores							
CP4	2*	4.3	4.6	4.4	192.8	336	264.4
CP5	6	5.6	6.3	5.8	102.5	156.8	124.0
CP6	6	4.1	5.0	4.5	125.9	178.1	149.0
CP7	6	5.1	6.6	5.9	105.0	187.2	148.6
CP8	6	4.2	5.0	4.5	95.4	150.4	120.1
CP13	6	4.3	5.1	4.6	130.4	199.8	156.9
CP15	6	4.0	5.1	4.5	107.3	181.7	143.5

Notes: µS/cm = micro siemens per centimetre

\*sampled only twice due to blocked / damaged bore

## ii Groundwater quality from laboratory analysis

Groundwater samples were collected biannually (April and October 2020) except at CP4 which was sampled once (refer Section 2.2). Collected samples were analysed for:

- pH, electrical conductivity (EC), alkalinity, fluoride, nitrate and nitrite;
- major ions (sulphate, chloride, calcium, magnesium, sodium, potassium, total anions and total cations); and
- total metals (aluminium, arsenic, cadmium, chromium, copper, nickel, lead, zinc, manganese, selenium, boron, iron and mercury).

Results from both April and October sampling events have been tabulated in Appendix C and compared against criteria listed in Table 3.1.



## 3 Impact audit

### 3.1 Criteria

The approved site water management plan (RW Corkery, 2020) provides impact assessment criteria for groundwater, summarised in Table 3.1.

**Table 3.1 Groundwater impact assessment criteria**

Assessment site	Assessment criteria
<b>2020 Assessment Criteria<sup>1</sup></b>	
Entire network	Declining trend attributable to sand extraction activities
CQ10 & CQ11	Groundwater level decline attributable to sand extraction impacts exceeds 1.0m
Off-site monitoring bore	Drawdown in excess of 1.0 m as a result of quarrying activity
Landholder (private) bore <sup>4</sup>	Reported loss of yield >10% due to declining groundwater levels 20% increase in EC or TDS based on the last five years of data
Monitoring network	ANZG (2018) 95% species protection guideline values for freshwater ecosystems <sup>3</sup> 95 <sup>th</sup> percentile of records recorded between 2012 and 2017

Notes: 1. RW Corkery 2020, *Calga Sand Quarry; Site Water Management Plan*  
2. EC = electrical conductivity; TDS = total dissolved solids  
3. ANZG = Australian and New Zealand Governments  
4. Landholder (private) bores are limited to those within 500m of the project

### 3.2 Groundwater level

Over the reporting period the groundwater level was stable with minor fluctuations consistent with rainfall trends (Appendix A).

Rainfall over the reporting period was consistent with the long-term average from January to June and above average from June to December 2020. Rainfall trends are displayed by plotting the cumulative deviation from the monthly mean<sup>2</sup>. The resulting plot trends upwards during 'wetter periods' and downwards during 'drier periods' enabling a visual comparison with groundwater level trends.

An analysis of the groundwater level noted:

- the dominant trend is an increase early in the reporting period (February and March 2020) with the elevated level maintained throughout the remainder of the reporting period observed at CQ4, CQ5, CQ7, CQ8, CQ11S, CQ11D, CQ12, CQ13, MW8, CP5, CP6, CP7, CP13, CP15;
- a sustained increasing trend was observed at MW7, MW9, MW10;
- a relatively constant level was observed at CQ10, CP8, MW13, MW16 and MW17; and
- a slight declining trend was observed at CQ3.

The groundwater level at those monitoring bores with drawdown assessment criteria (CQ10 and CQ11) did not decline.

The reported water level at CP4 is not considered reliable with the bore reported as blocked (refer Section 2.2).

Over the reporting period there was no observed declining water level trends or reported loss of yield >10% at landholder (private) bores. The slight declining trend at CQ3 should continue to be monitored and assessed against site operations.

<sup>2</sup> Rainfall data sourced from the Bureau of Meteorology Mangrove Mountain Station (61375)

### 3.3 Groundwater quality

#### 3.3.1 Field measurements

Over the reporting period the field measurements of EC and pH (indicative of overall groundwater quality) were observed to generally be within the historical range.

Groundwater pH was recorded as slightly more neutral (increased pH) at CQ5, CQ7, CQ8, CQ10, CQ11S, CQ11D, CP5, CP7, CP8, MW7, MW8 and MW10. An exception to this trend was observed at CP4 where the groundwater was measured as slightly more acidic. Groundwater has historically been recorded as slightly acidic, a general increase in pH to more neutral conditions is not considered a groundwater impact attributable to quarry activities.

Electrical conductivity (EC) was recorded marginally outside historical baseline range in some measurements recorded in 2020. These marginal increases in conductivity did not trigger impact criteria and are considered a result of natural variation. Increases in EC is therefore not considered a groundwater impact.

The landholder (private) bore trigger value is a 20% increase in EC or total dissolved solids (TDS) based on the last five years of data (2016-2019) as documented in the WMP (RW Corkery 2020). This data is summarised in Table 3.2.

**Table 3.2 Water quality summary of last 5 years data (2016-2019)**

Landholder (private) bore	Electrical Conductivity (µS/cm)			
	Min	Max	Ave	Trigger
CP5	96	198	145	237.6
CP6	126	211	153	253.2
CP7	38	187	101	224.64
CP8	95	180	123	215.88

Notes: Data from Calga Quarry Site Water Management Plan (RW Corkery, 2020)

Electrical conductivity recorded at the landholder (private) bores over the reporting period were below the trigger values at all landholder (private) bores. This is consistent with the results of the 2019 independent audit.

#### 3.3.2 Laboratory analysis

Laboratory chemical analysis data was collected in April and October during the reporting period. This data is compared against ANZG (2018) 95% species protection guideline values for freshwater ecosystems and the 95<sup>th</sup> percentile of baseline records, as tabulated in Appendix C.

##### i Metals

Concentrations of metals exceeding 95% of baseline records were recorded at CQ5, CQ8, CQ10, CQ11S, CQ12, CQ13, MW7, MW9, MW10, MW13, CP5, CP6, CP7 and CP8. These exceedances were typically outside of baseline levels. Observed concentrations were marginally above previous historical maximums and, as such, not considered a groundwater impact.

Metals exceeding adopted ANZG guideline values in some groundwater samples included: aluminium, copper, chromium, zinc, cadmium, nickel and lead. Baseline historical results also exceeded ANZG guideline criteria suggesting pre operation groundwater quality contained elevated concentrations of metals. Based on comparisons with historical range and metal trends over time, these exceedances are not considered to indicate a groundwater impact associated with sand extraction activities.

## ii      **Nutrients**

Nutrient loads exceeding 95% of baseline records were recorded at CQ4, CQ7, CQ12, MW13, CP6 and CP8. Nutrient concentrations recorded in CQ4, CQ7 and CQ12 were historical maximums within these wells, exceeding the adopted ANZG nutrient criteria during some monitoring rounds. These concentrations are considered a slight elevation, as concentrations were recorded within the same order of magnitude as baseline results.

The WMP notes historical exceedances of nitrate are believed to be due to the agricultural activities of neighbouring properties. Given this context, these elevations in nutrient concentrations are not considered to constitute a groundwater impact.

In summary, the noted exceedances of groundwater quality trigger values are minor and attributed to natural variation. There is no observed trend in declining water quality attributable to sand extraction activities.

## 4 Conclusion

### 4.1 Summary

Based on a review of relevant documents and an assessment of site monitoring data the author concludes that Hanson has complied with most of the project consent conditions. Noted non-compliances are considered minor and include:

- continuous water level data was not provided over the whole reporting period for well CQ8; and
- quarterly water quality (pH and EC) data was not provided for blocked well CP4.

The observed data are typically consistent with climatic trends and baseline ranges. The assessment criteria (refer Table 3.1) were not triggered by monitoring data or analysis over the reporting period.

Given the groundwater levels, the project is considered unlikely to have resulted in a reduction of the pumping yield in privately-owned groundwater bores surrounding the quarry over the reporting period.

### 4.2 Recommendations

The following recommendations are provided as part of this audit:

- a barometric pressure logger to be installed at the project to provide a more accurate conversion of water level readings;
- TDS to be added to the analytical suite, to provide further information regarding salinity increases in landholder (private) bores; and
- monitoring network and analytical suite updated to reflect changes made in the WMP, specifically:
  - wells MW7, MW8, MW16 and MW17 are removed from the monitoring network; and
  - arsenic, boron, selenium and mercury are removed from the laboratory analytical suite.

### 4.3 Limitations

This independent audit was limited to a desktop review of reports and site monitoring data with no site visit completed.

Monitoring data and bore data has been validated via desktop review and relies on the accuracy and integrity of third-party data.

Yours sincerely



**Rachel Truscott**  
Environmental Scientist

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**Sam Cook**  
Associate Hydrogeologist

## 5 References

Aquas Pty Ltd 2018, Independent Environmental Audit: Calga Sand Quarry; DA 94-4-2004, prepared for Hanson Construction Materials Pty Ltd

Australian and New Zealand Governments (ANZG), 2018, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Available at [www.waterquality.gov.au/anz-guidelines](http://www.waterquality.gov.au/anz-guidelines)

Carbon Based Environmental Pty Limited, 2020, *Environmental Monitoring, Dust Deposition, Surface Water, Groundwater and Meteorological Data*, various dates.

Dundon Consulting Pty Limited (Dundon) 2018, *Calga Quarry – DA 94-4-2004 – Independent Environmental Audit*, prepared for Hanson Construction Materials Pty Ltd

Dundon Consulting Pty Limited (Dundon) 2019, *Calga Sand Quarry Closure and Post Closure Groundwater Management Plan*, prepared for Hanson Construction Materials Pty Ltd

EMM Consulting Pty Limited (EMM) 2020, *Annual Independent Groundwater Audit – 2019*

Hanson Construction Materials Pty Ltd, 2019, *Environmental Management Annual Review – Calga Quarry*

Martens and Associates Pty Limited 2020, *Groundwater Contingency Strategy, Calga Sand Quarry*, prepared for Hanson Construction Materials Pty Ltd

R.W. Corkery & Co. Pty. Limited (RW Corkery) 2020, *Site Water Management Plan for the Calga Sand Quarry*, prepared for Hanson Constructions Materials

Umwelt (Australia) Pty Limited 2015, *Calga Sand Quarry Independent Annual Compliance Audit*, prepared on behalf of Rocla Materials Pty Ltd

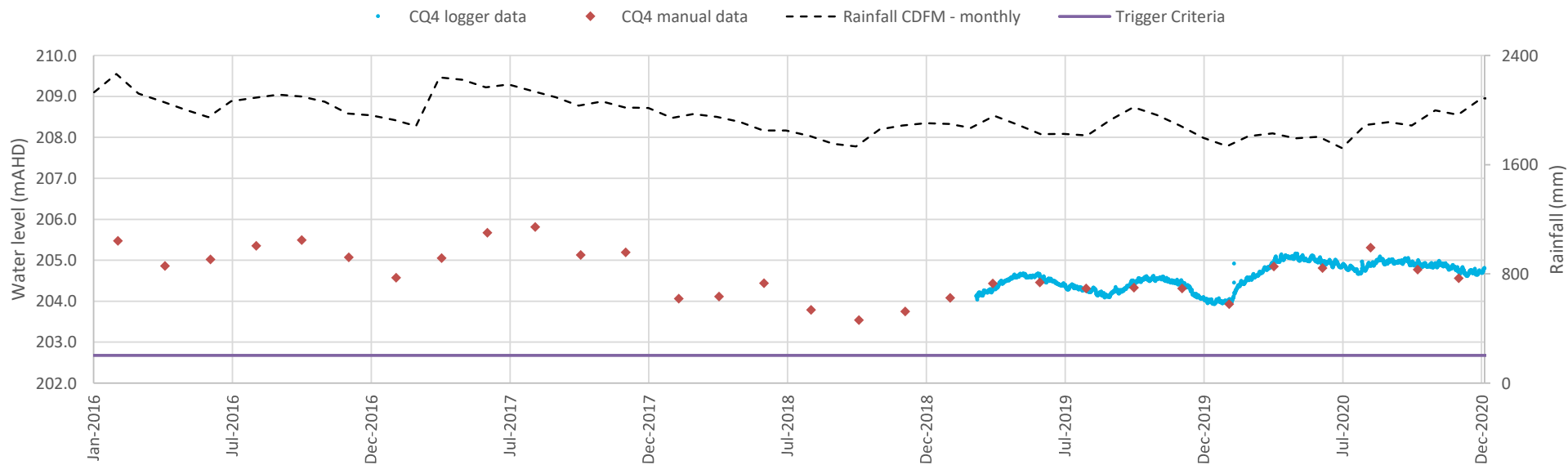
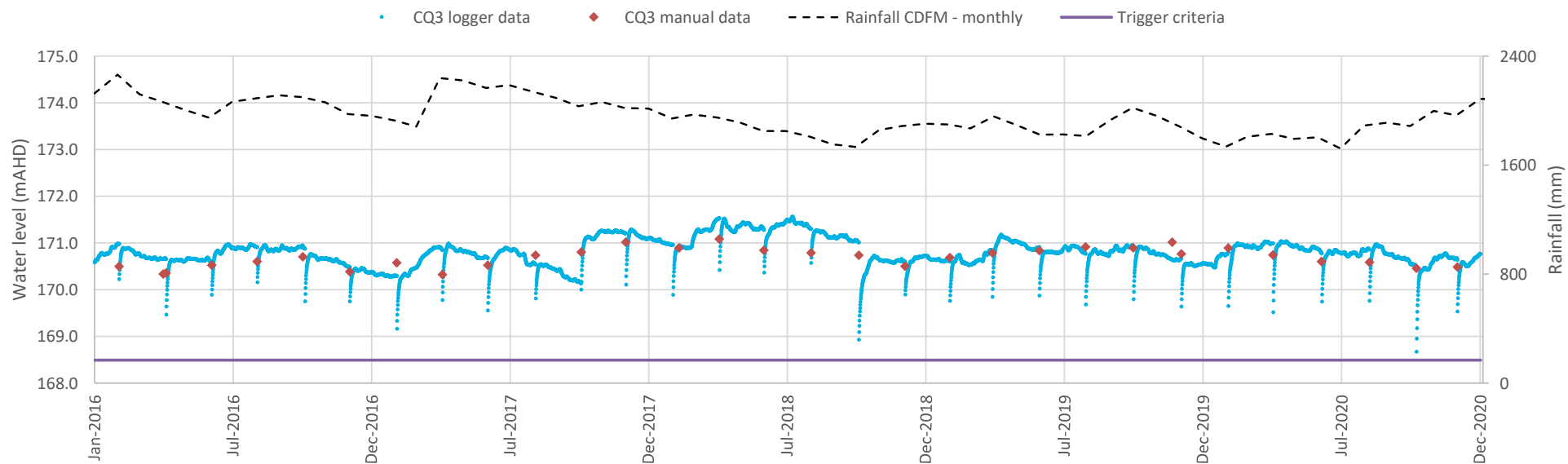


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Appendix A

# Hydrographs

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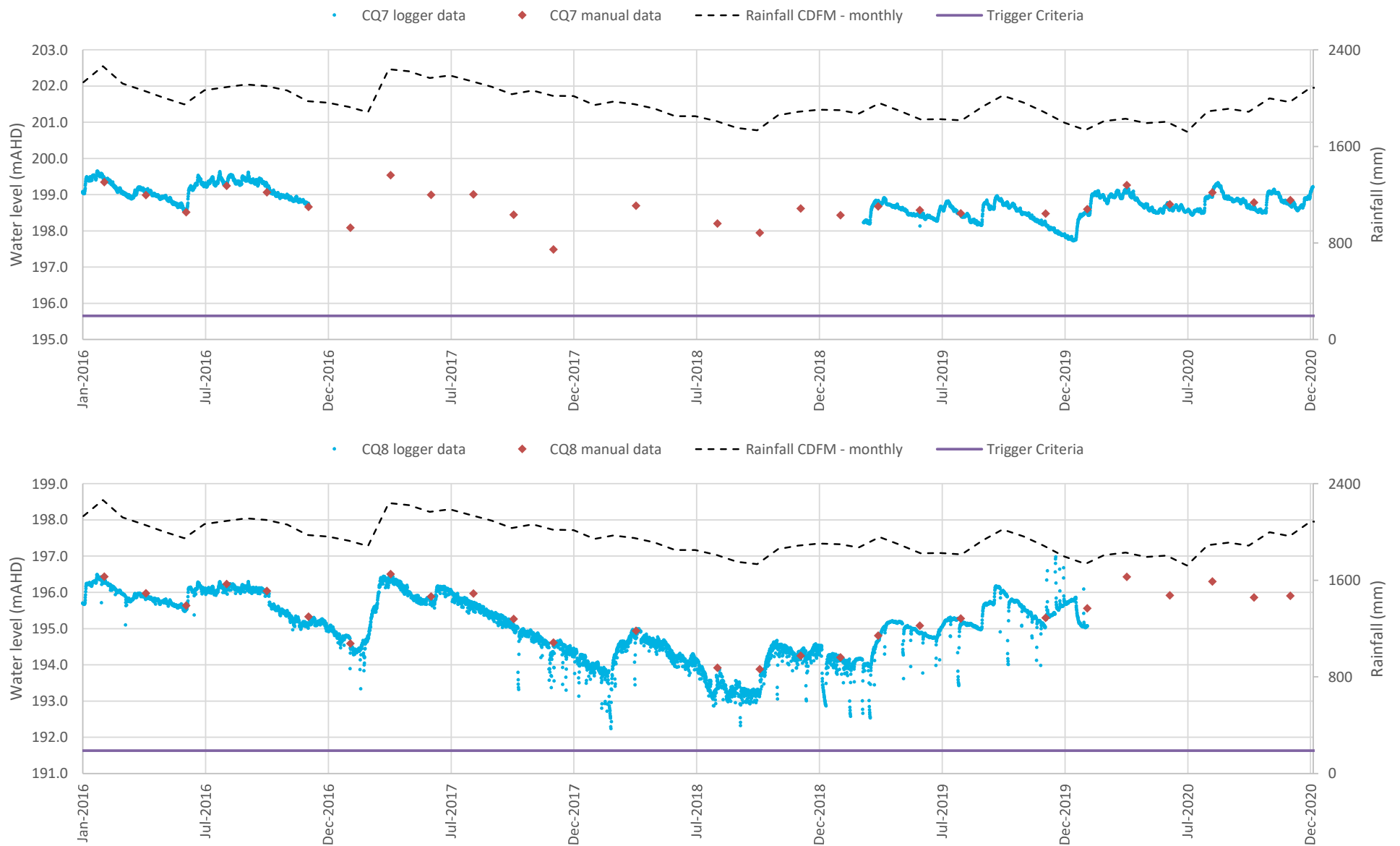


#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

Trigger criteria adopted as 5th percentile lowest historical record, as recorded in Table 7 of Site Water Management Plan ( RW Corkery 2020)



#### Notes

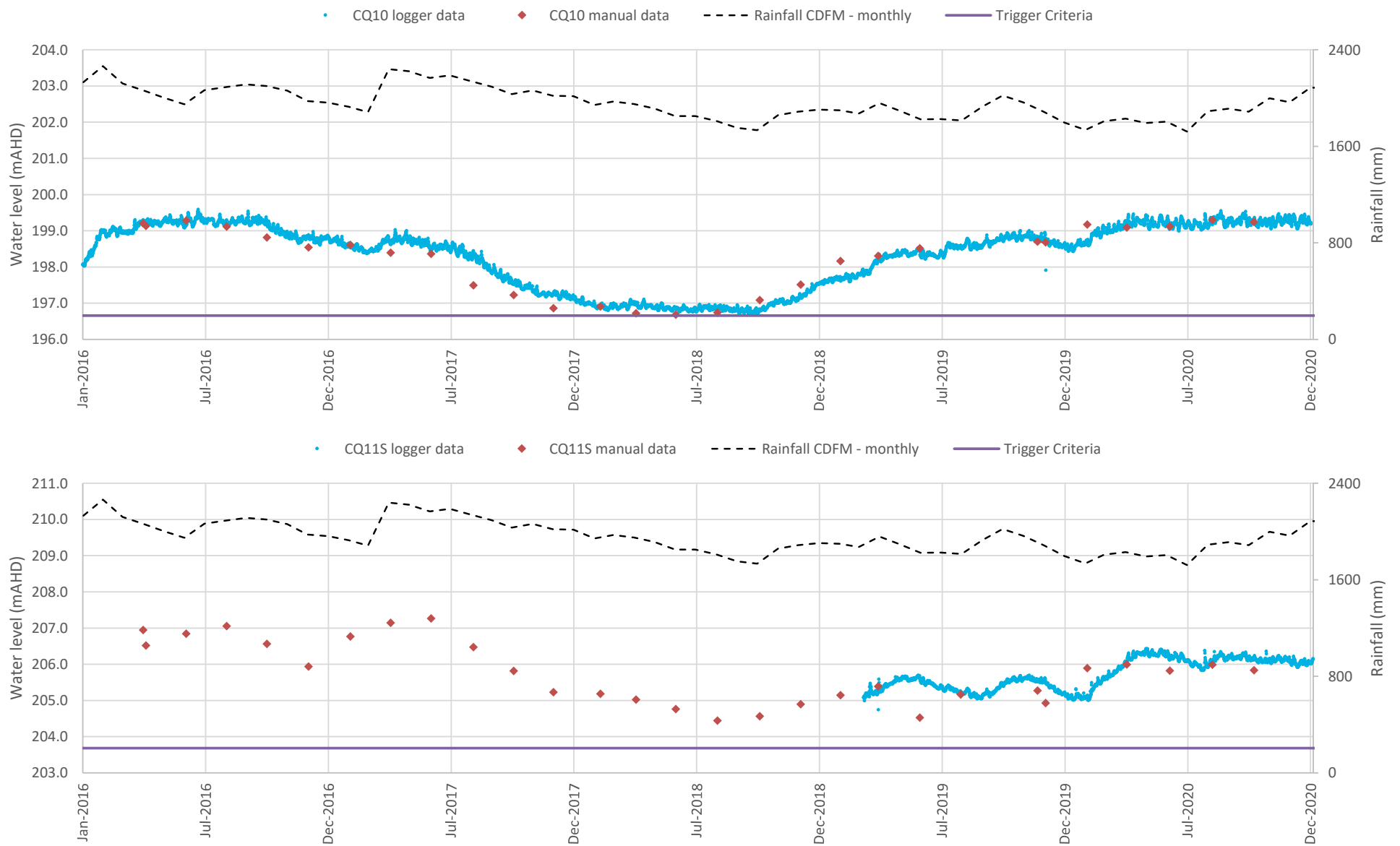
CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

CQ8's data logger stopped recording in February 2020 due to water damage

Trigger criteria adopted as 5th percentile lowest historical record, as recorded in Table 7 of Site Water Management Plan ( RW Corkery 2020)



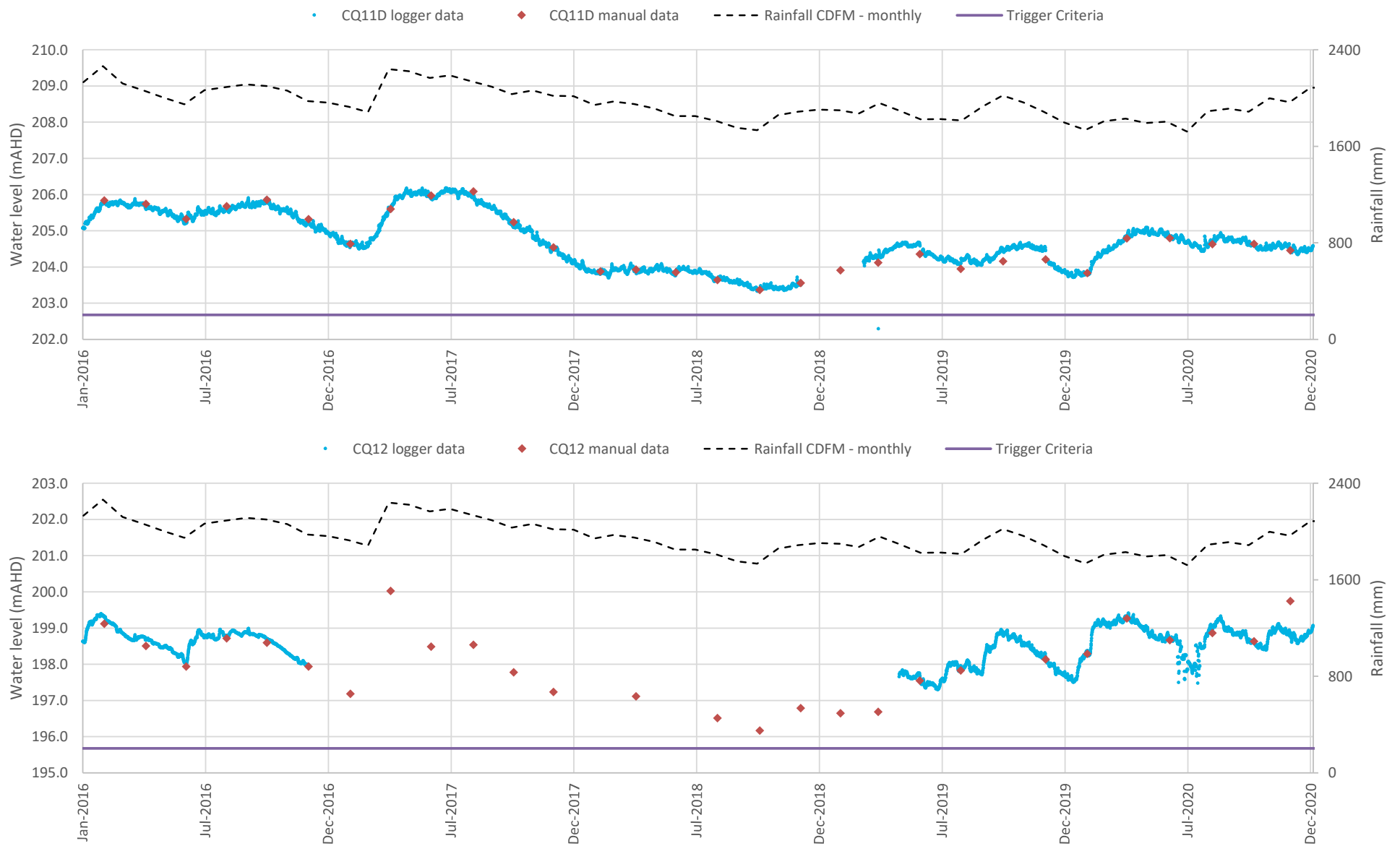


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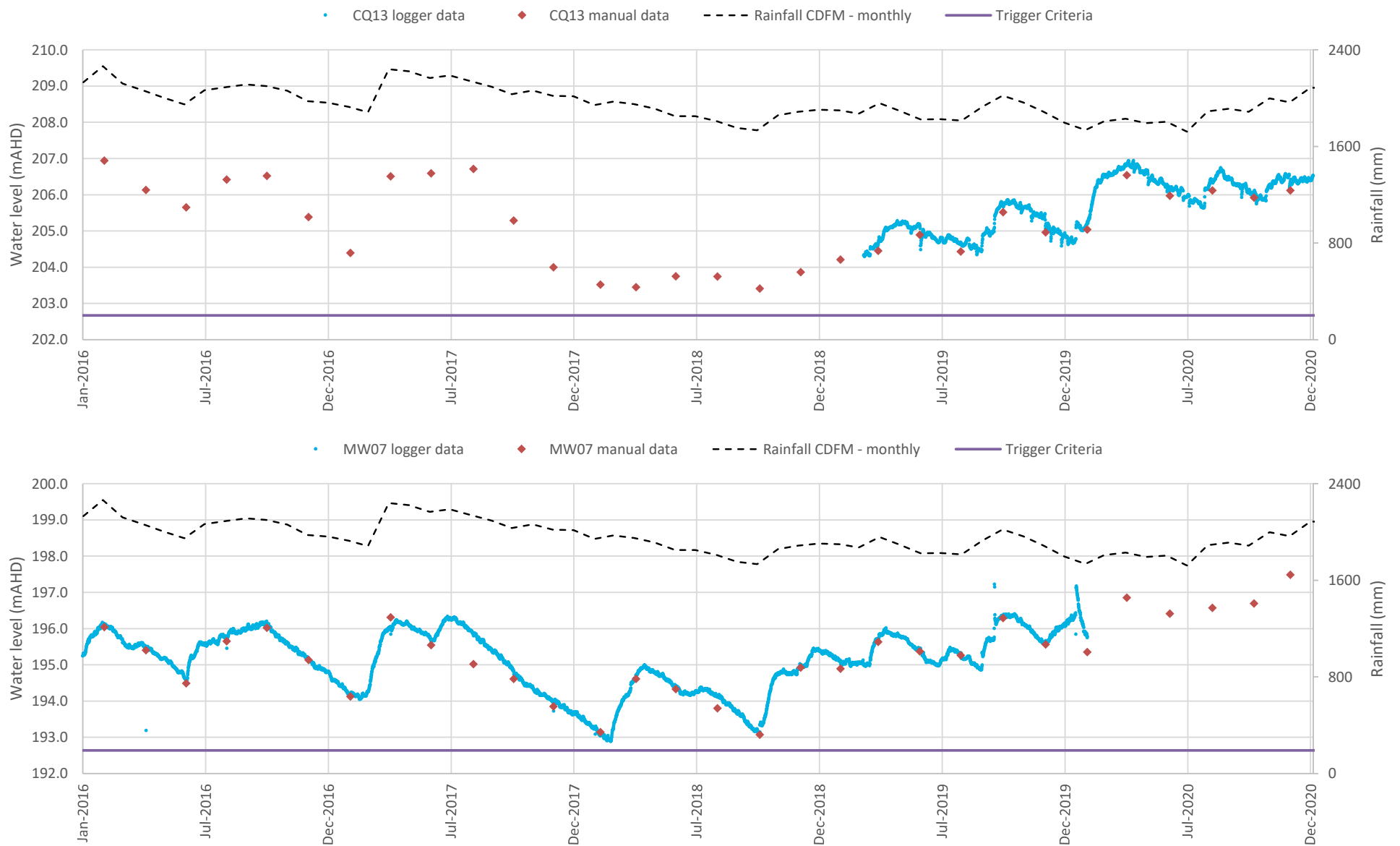
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**Hydrographs - CQ11D and CQ12**  
Hanson Construction Materials Pty Ltd  
Figure A4





#### Notes

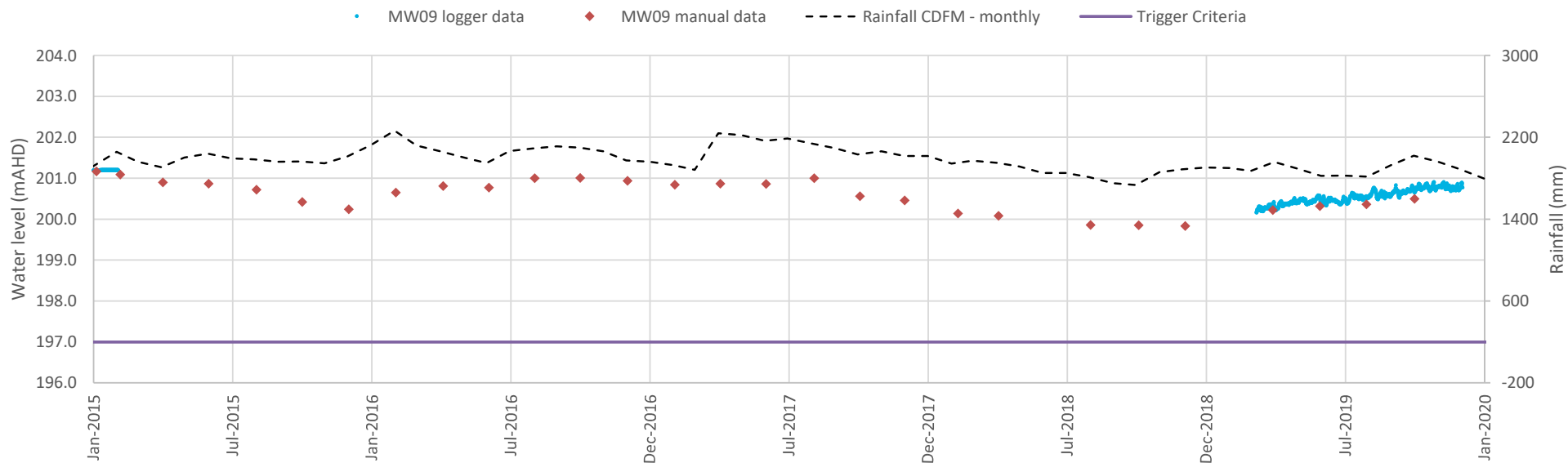
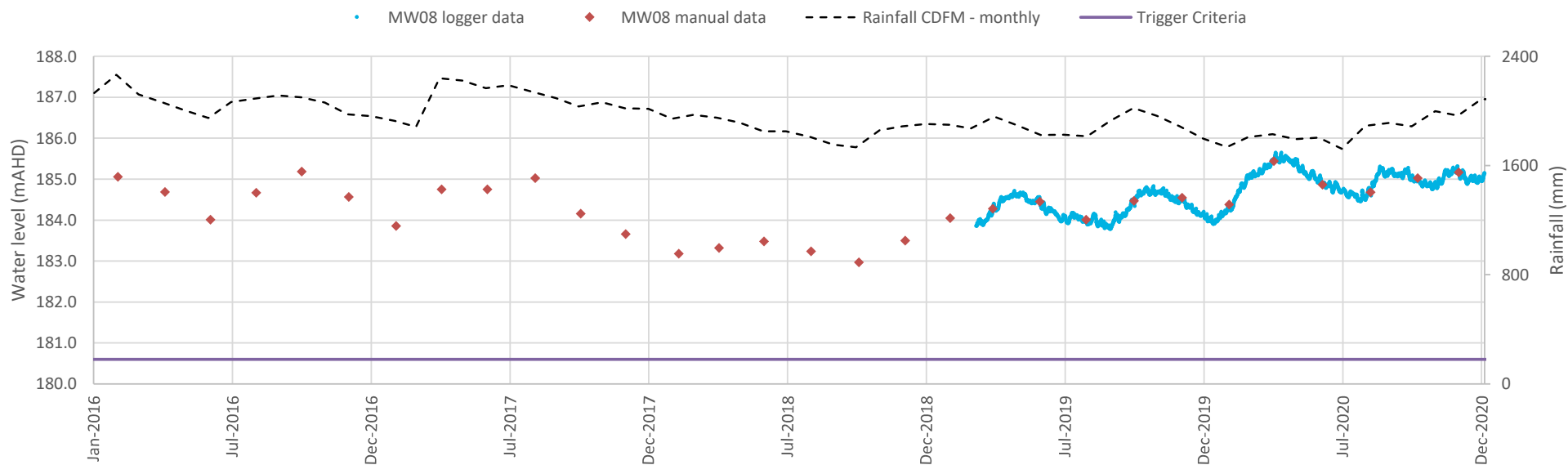
CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

MW07's data logger stopped recording in February 2020 due to water damage

Trigger criteria adopted as 5th percentile lowest historical record, as recorded in Table 7 of Site Water Management Plan ( RW Corkery 2020)



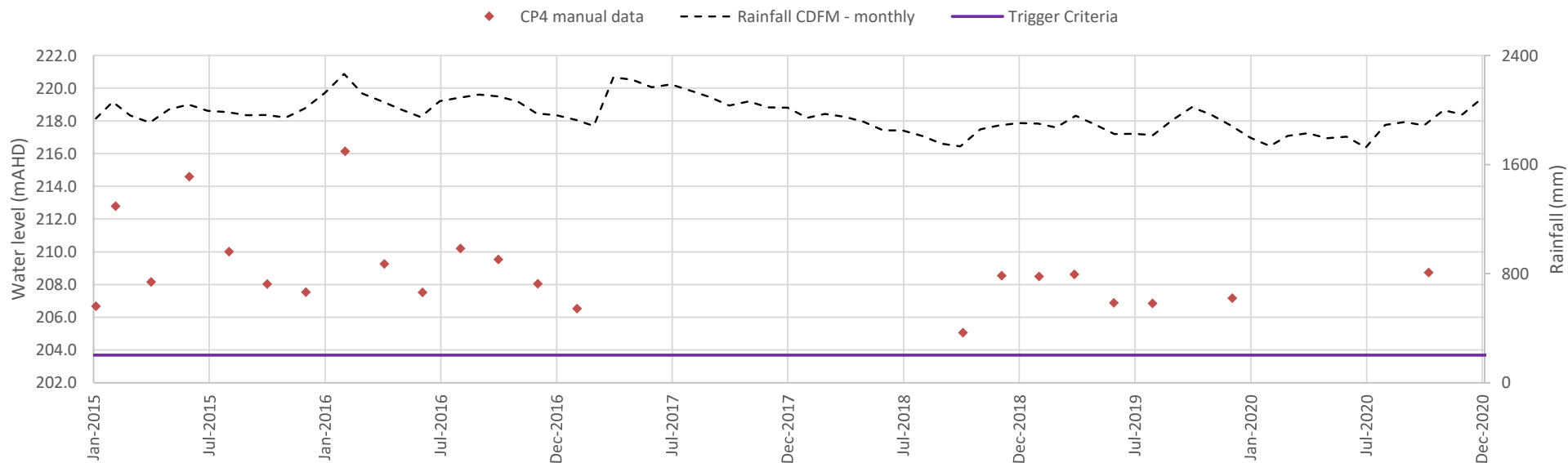
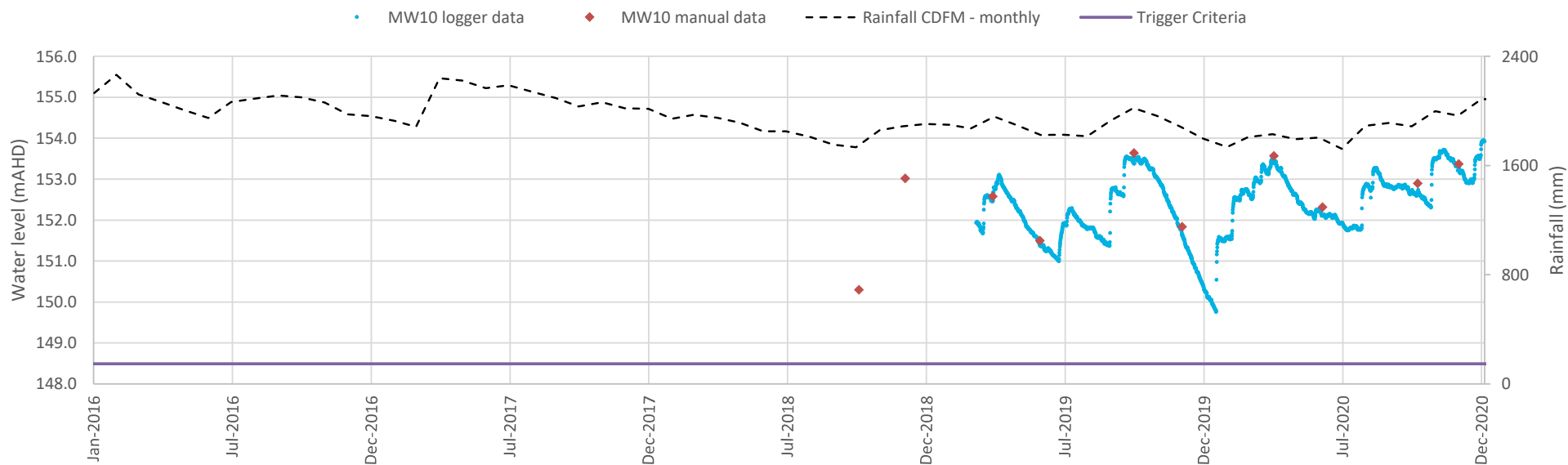


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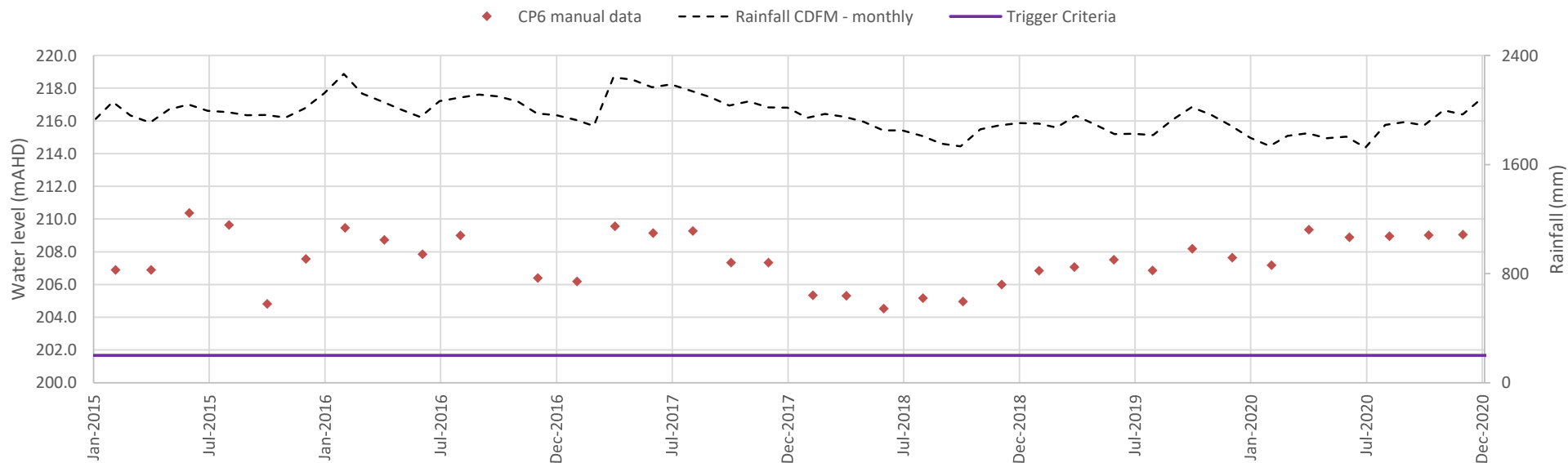
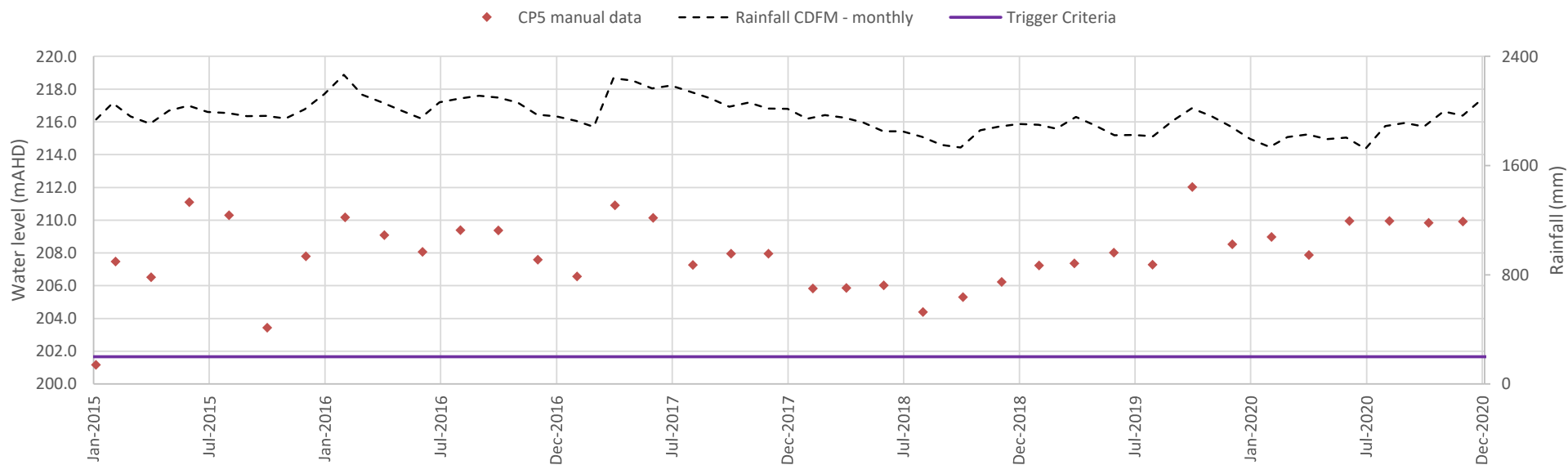


#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

Trigger criteria adopted as 5th percentile lowest historical record, as recorded in Table 7 of Site Water Management Plan ( RW Corkery 2020)



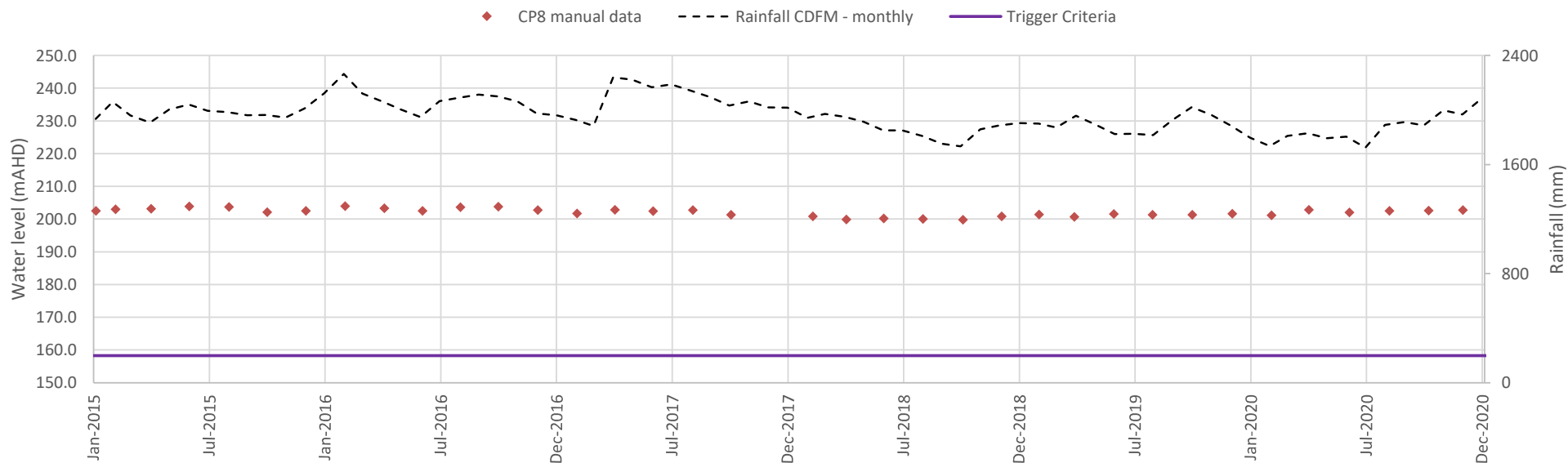
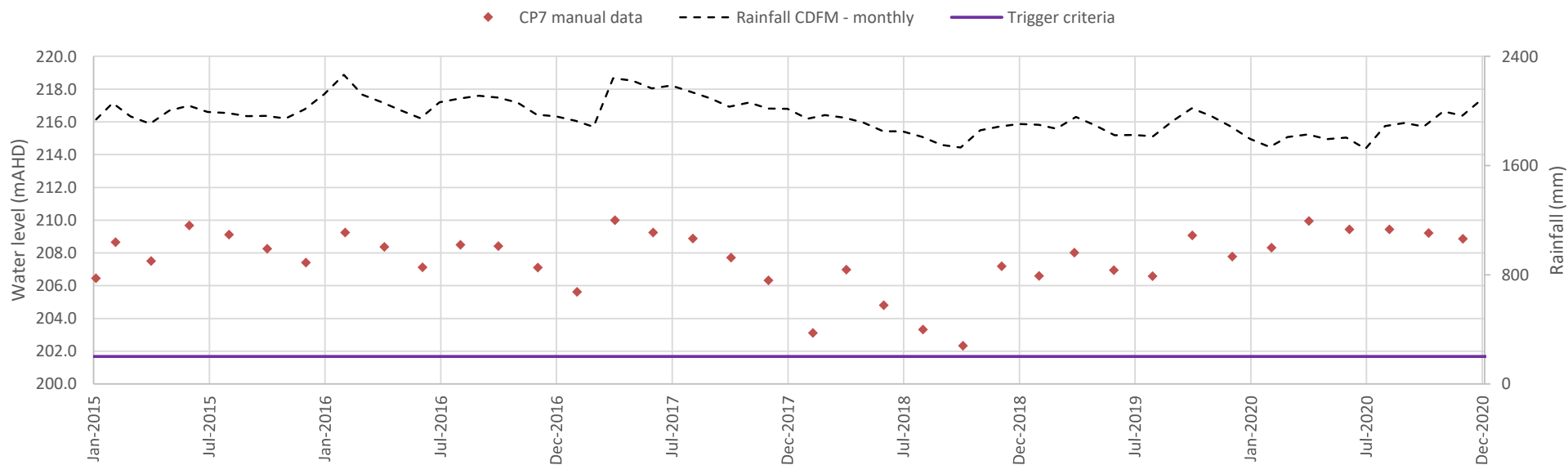
#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

Trigger criteria adopted as 5th percentile lowest historical record, as recorded in Table 7 of Site Water Management Plan ( RW Corkery 2020)

**Hydrographs - CP5 and CP6**  
Hanson Construction Materials Pty Ltd  
Figure A8



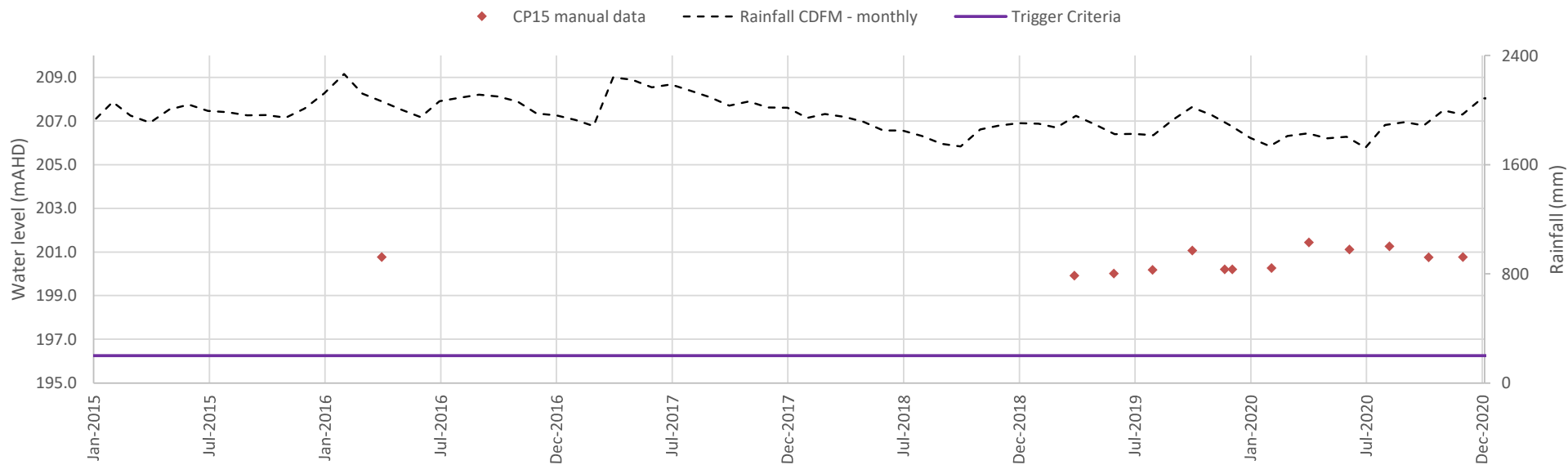
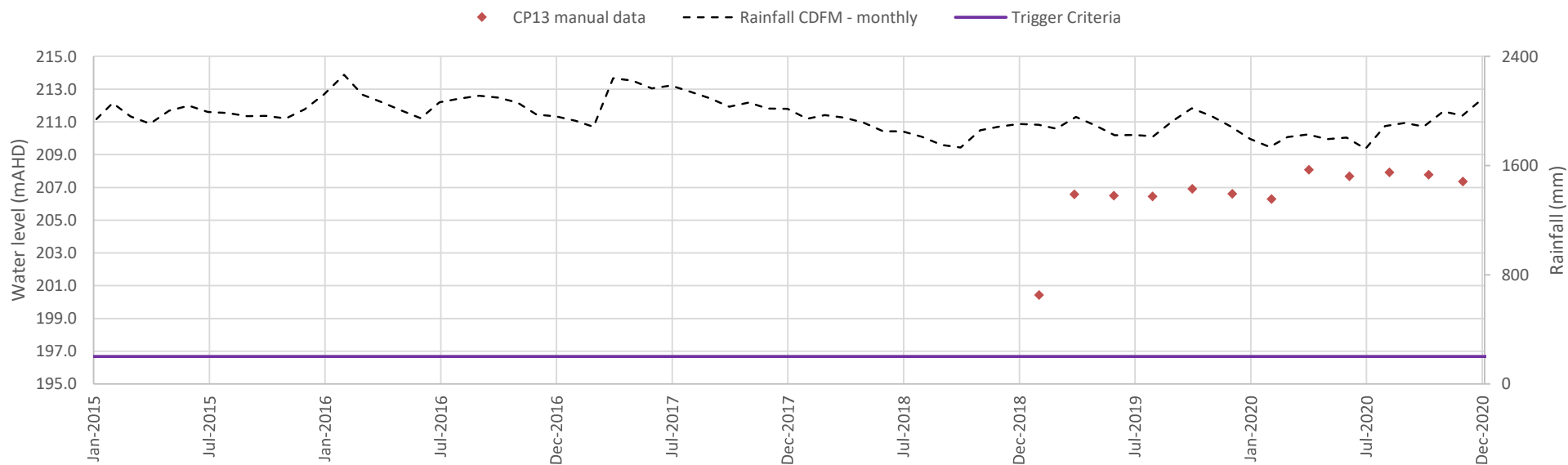
#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

Trigger criteria adopted as 5th percentile lowest historical record, as recorded in Table 7 of Site Water Management Plan ( RW Corkery 2020)



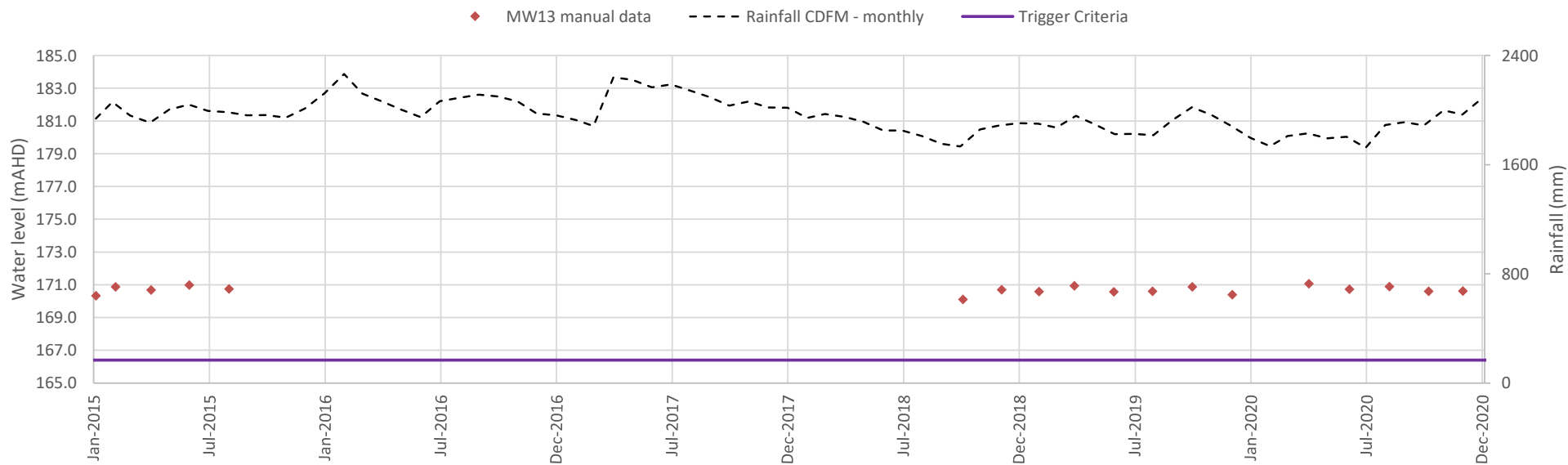
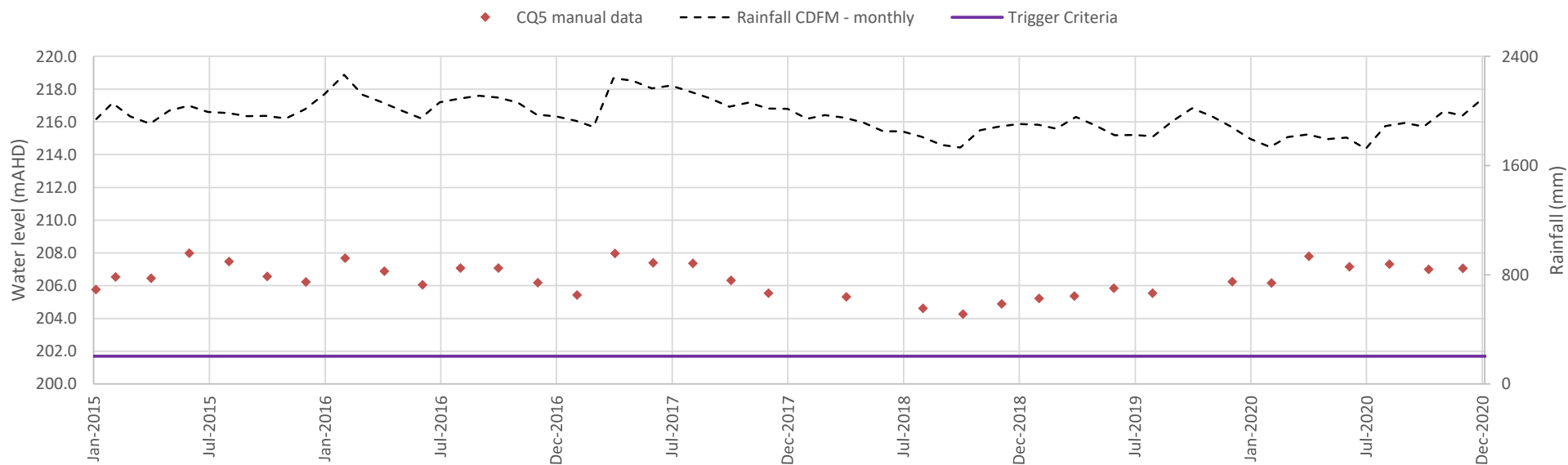


#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

Trigger criteria adopted as 5th percentile lowest historical record, as recorded in Table 7 of Site Water Management Plan ( RW Corkery 2020)

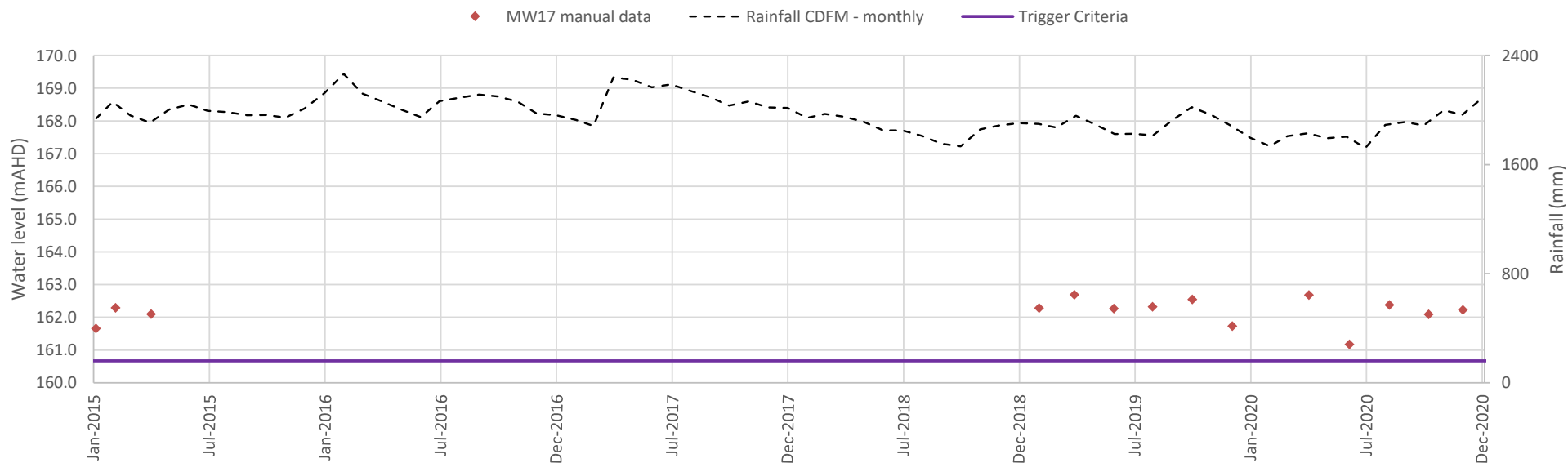
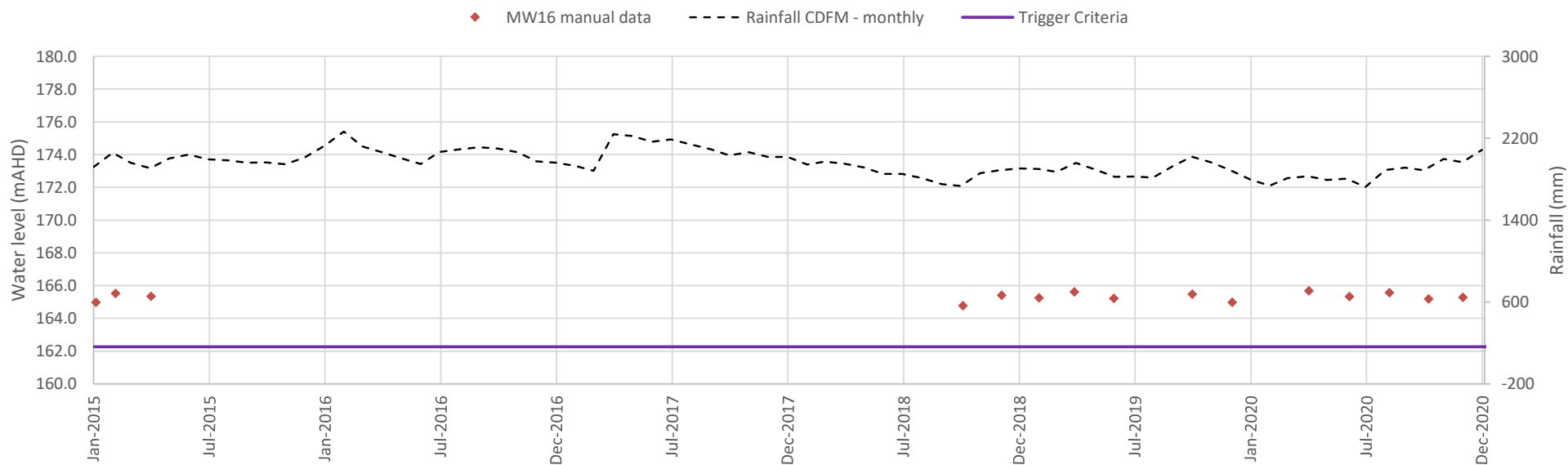


#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

Trigger criteria adopted as 5th percentile lowest historical record, as recorded in Table 7 of Site Water Management Plan ( RW Corkery 2020)



#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

Trigger criteria adopted as 5th percentile lowest historical record, as recorded in Table 7 of Site Water Management Plan ( RW Corkery 2020)

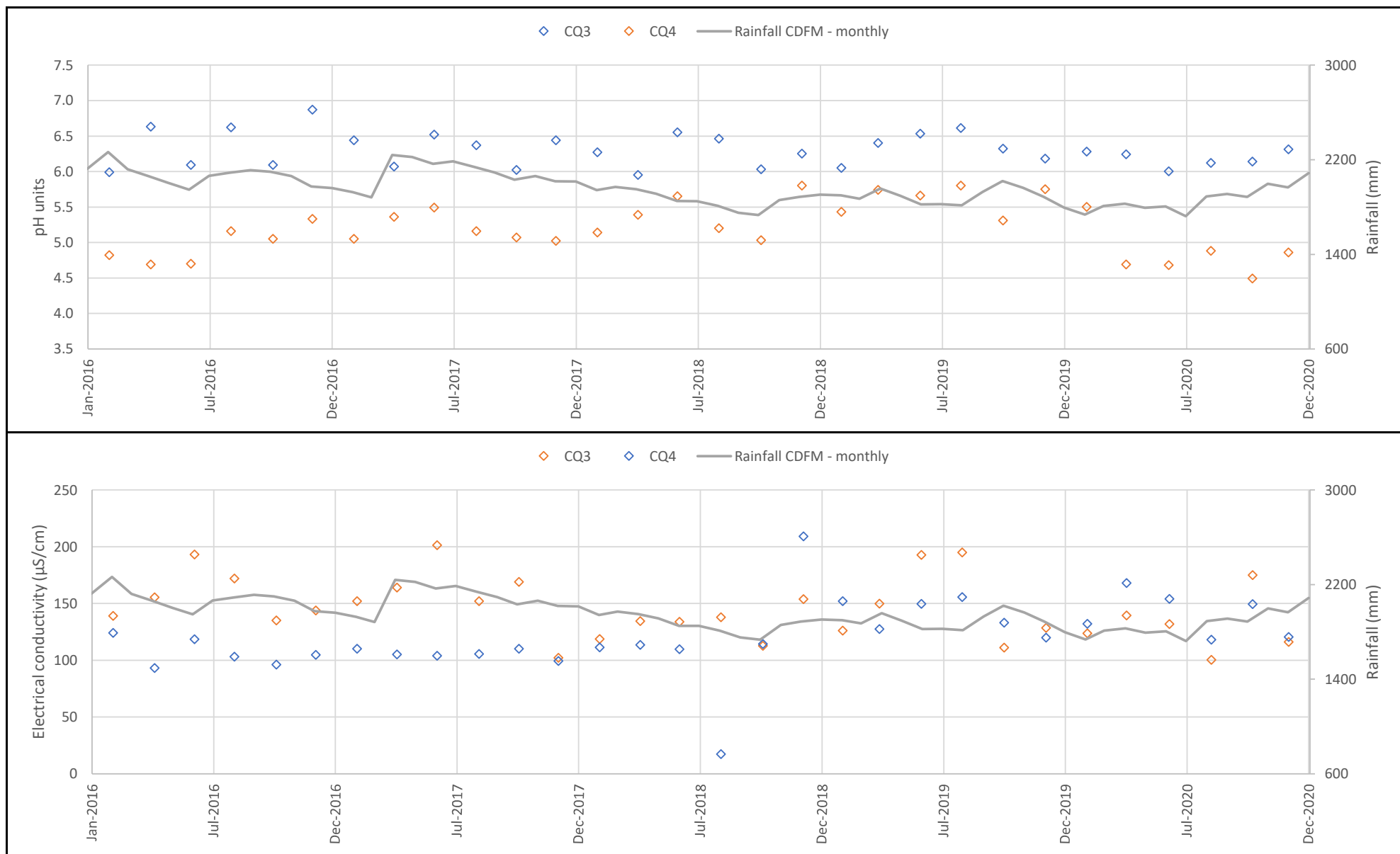
**Hydrograph - MW16 and MW17**  
Hanson Construction Materials Pty Ltd  
Figure A12

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Appendix B

# Field water quality

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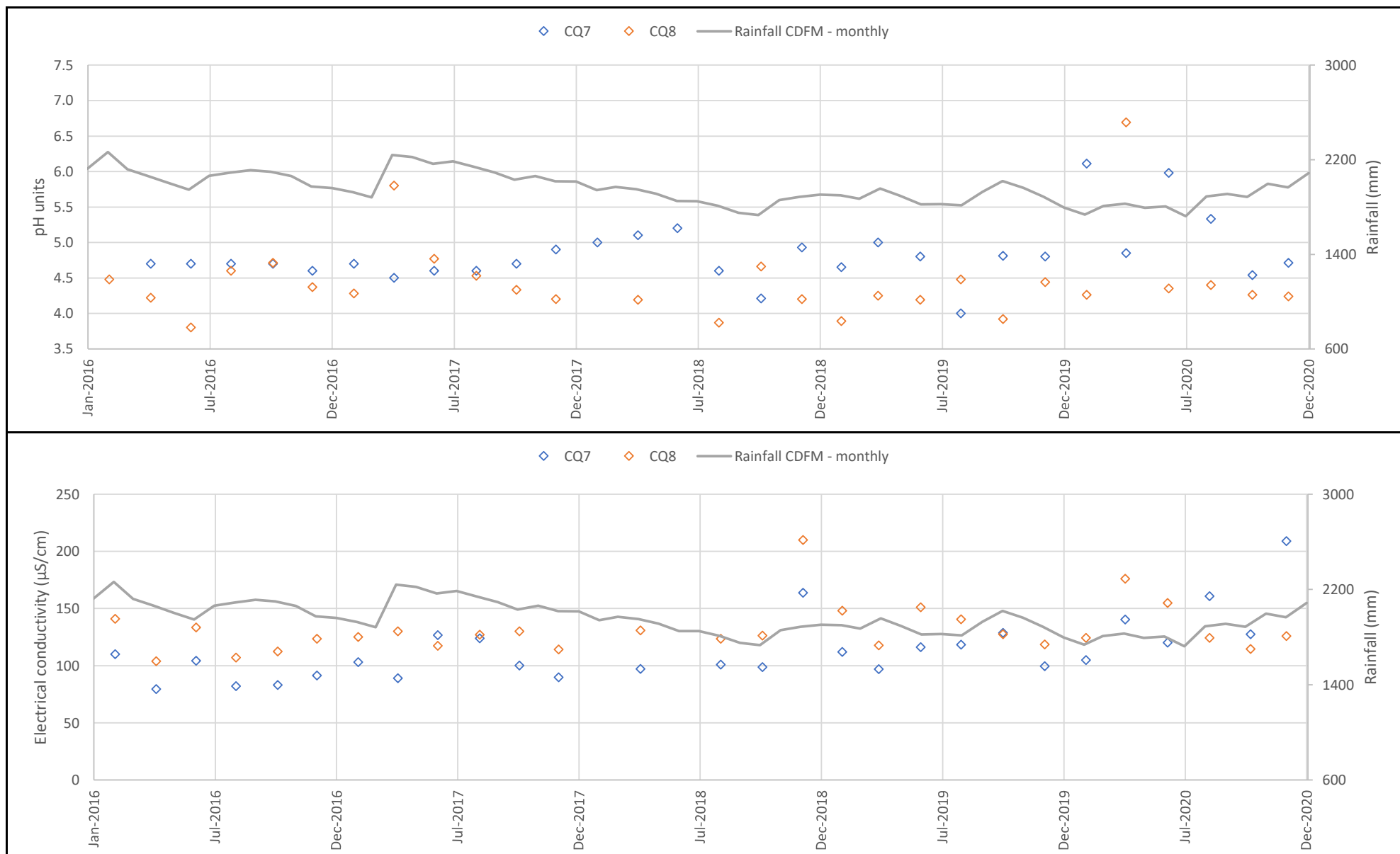
#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

**Water quality - CQ3 and CQ4**  
Hanson Construction Materials Pty Ltd  
Figure B1



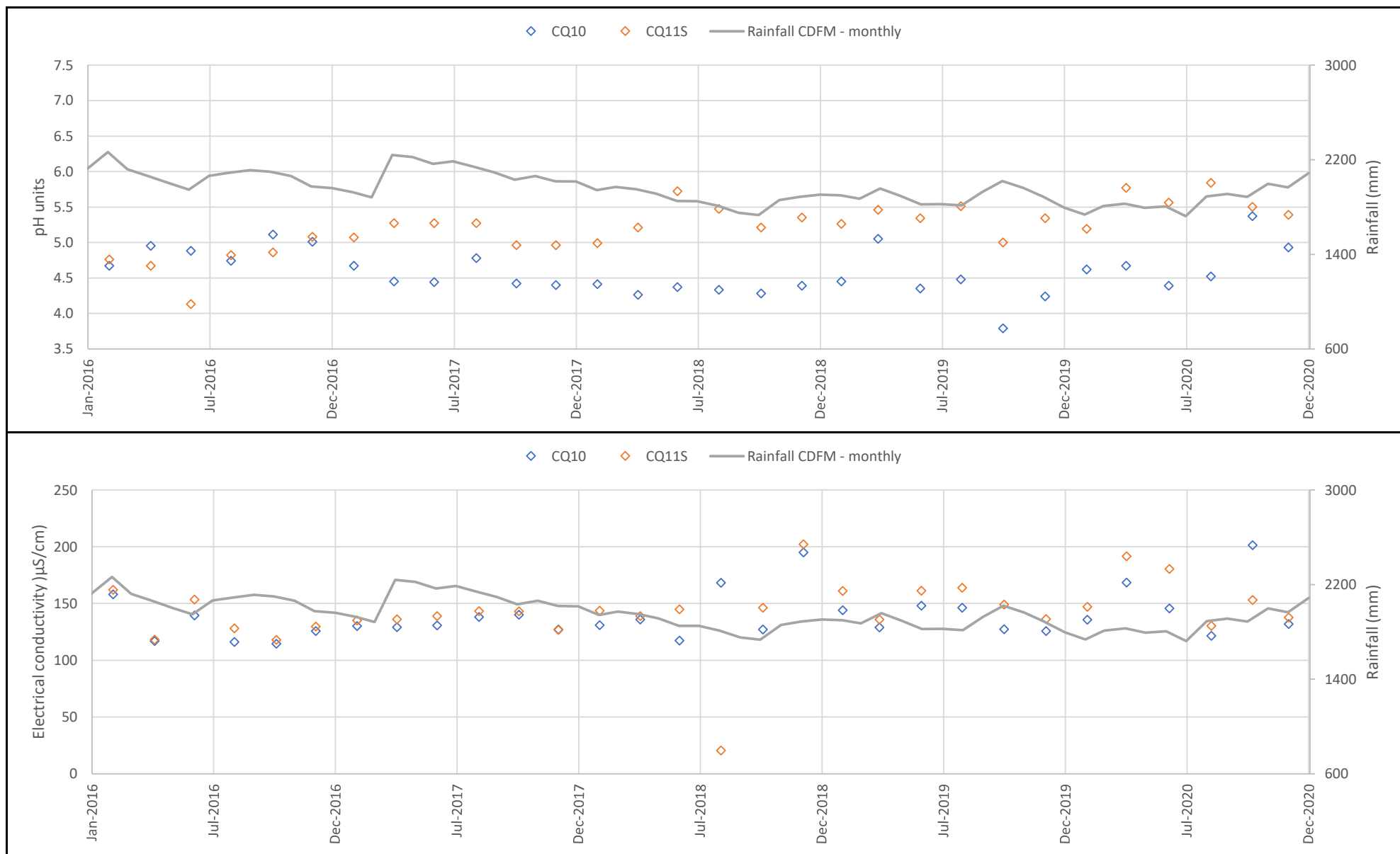


#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

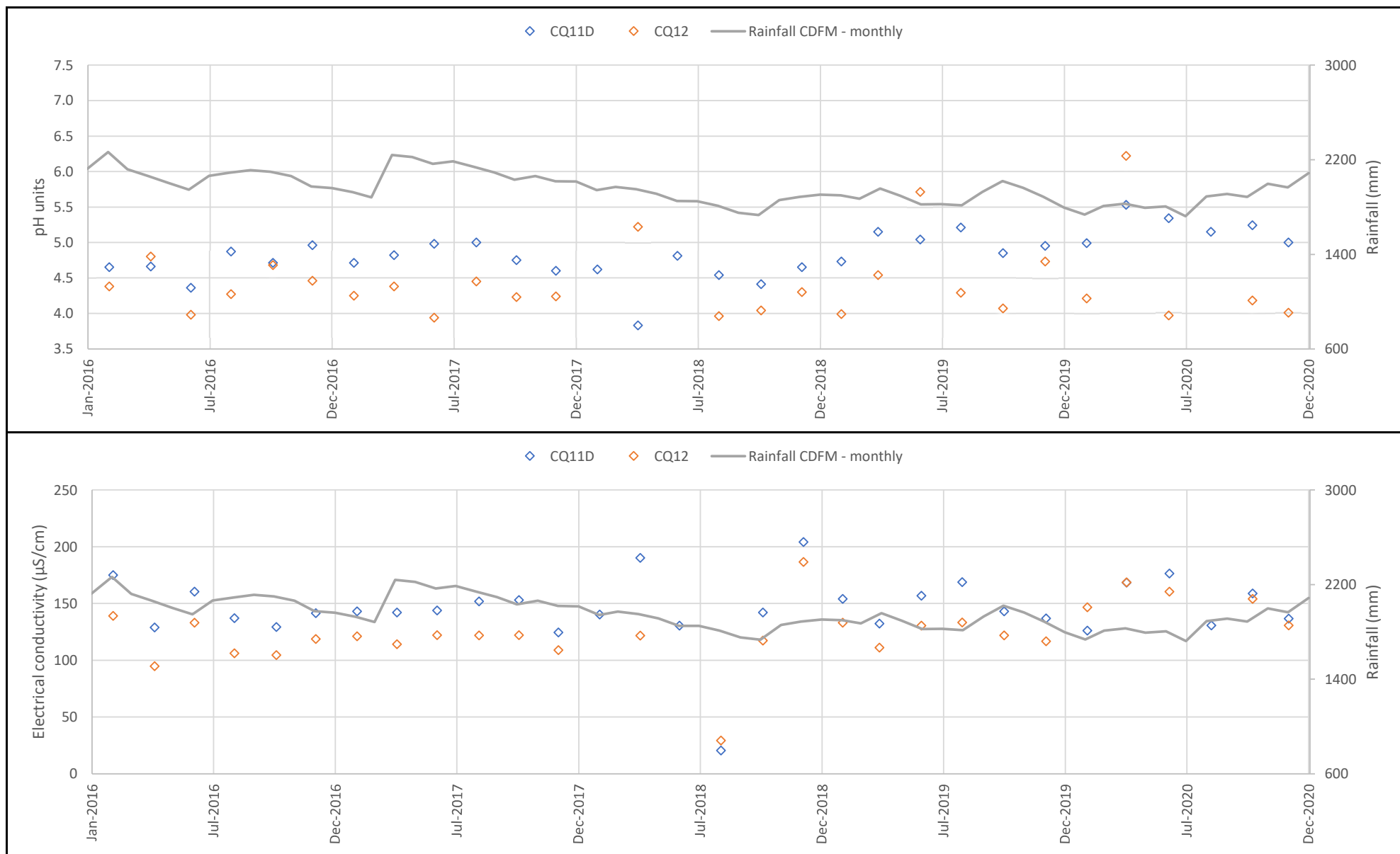
**Water quality - CQ7 and CQ8**  
Hanson Construction Materials Pty Ltd  
Figure B2



#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

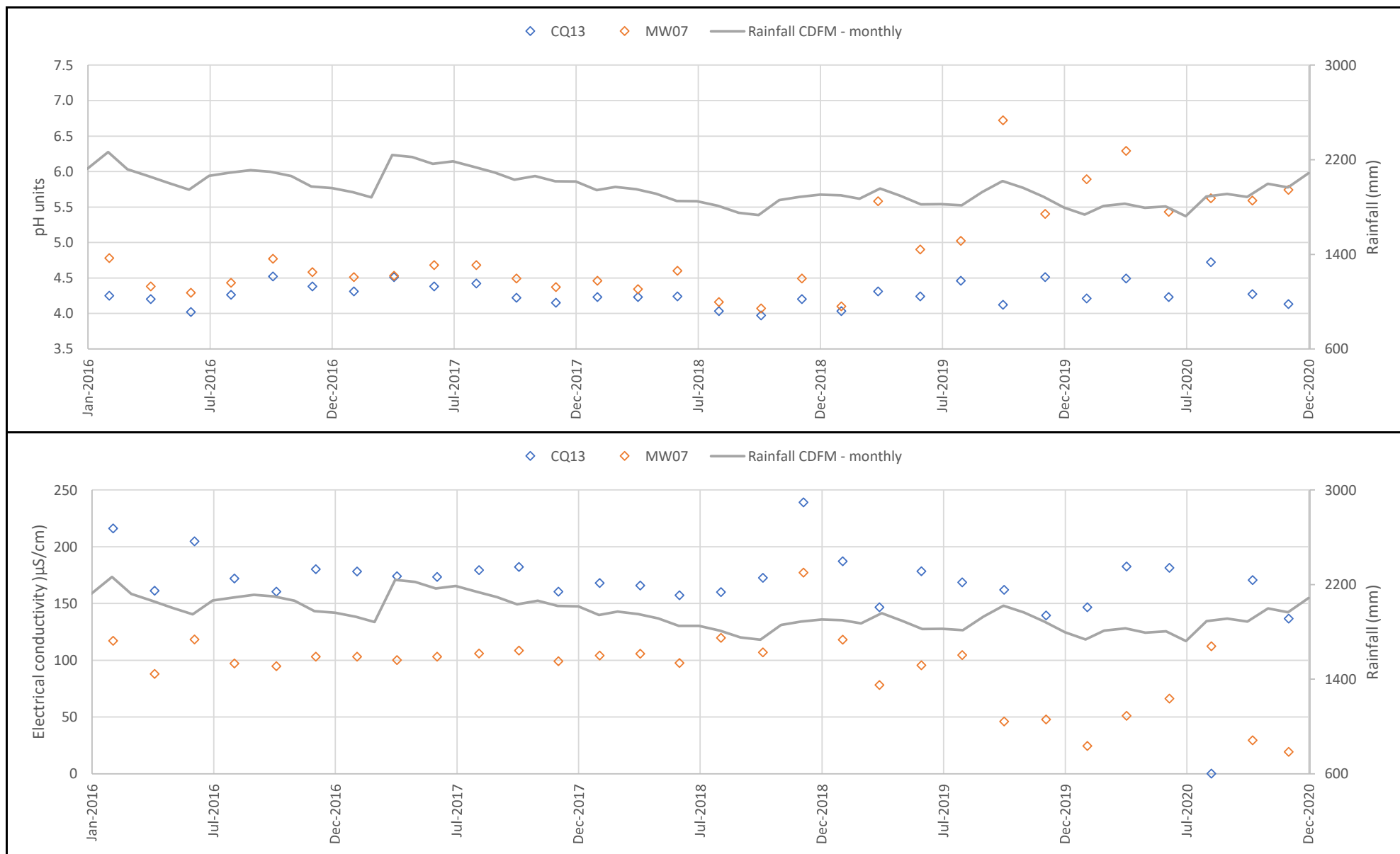


Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

**Water quality - CQ11D and CQ12**  
Hanson Construction Materials Pty Ltd  
Figure B4



#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

**Water quality - CQ13 and MW07**  
Hanson Construction Materials Pty Ltd  
Figure B5

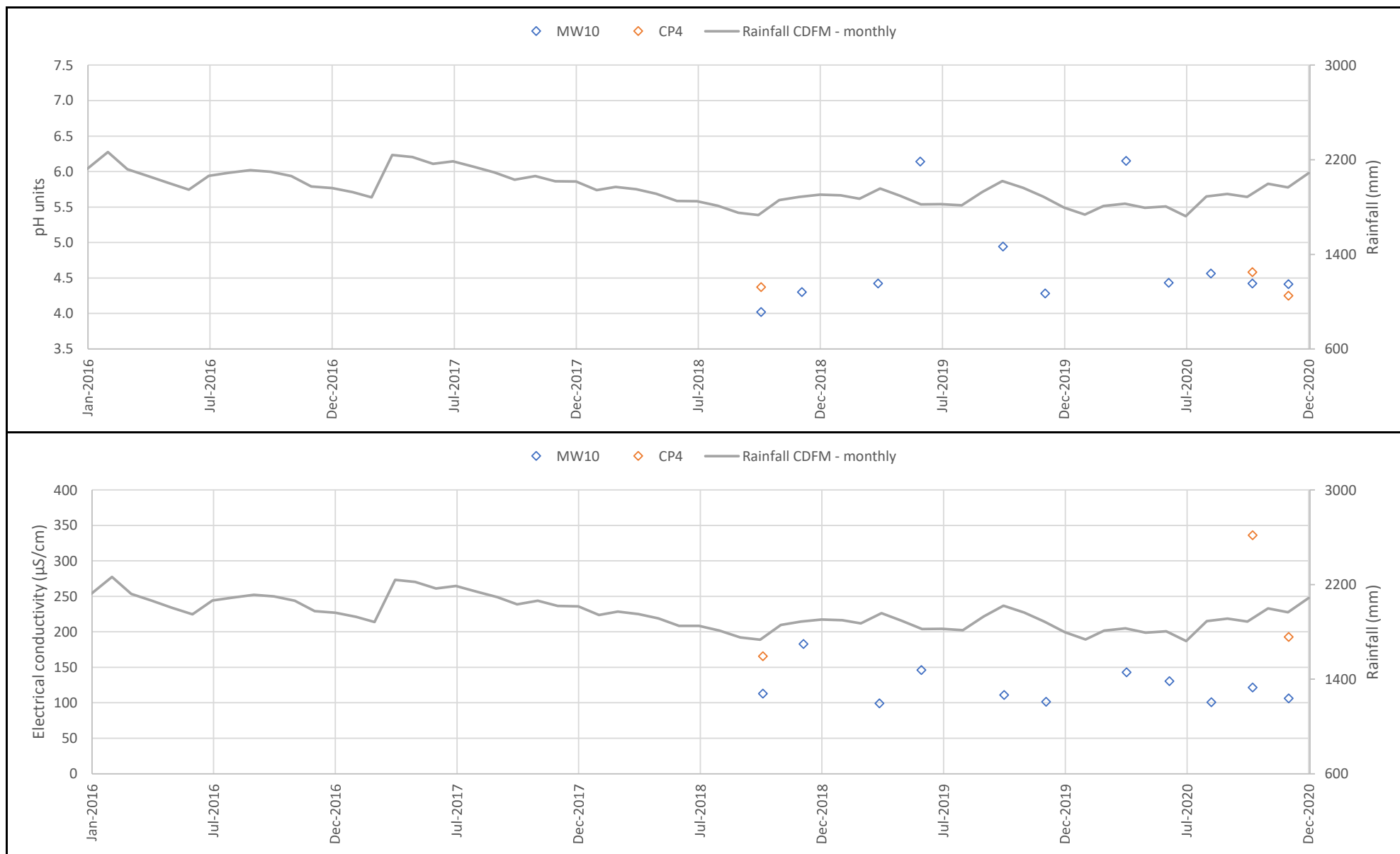


#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

**Water quality - MW08 and MW09**  
Hanson Construction Materials Pty Ltd  
Figure B6



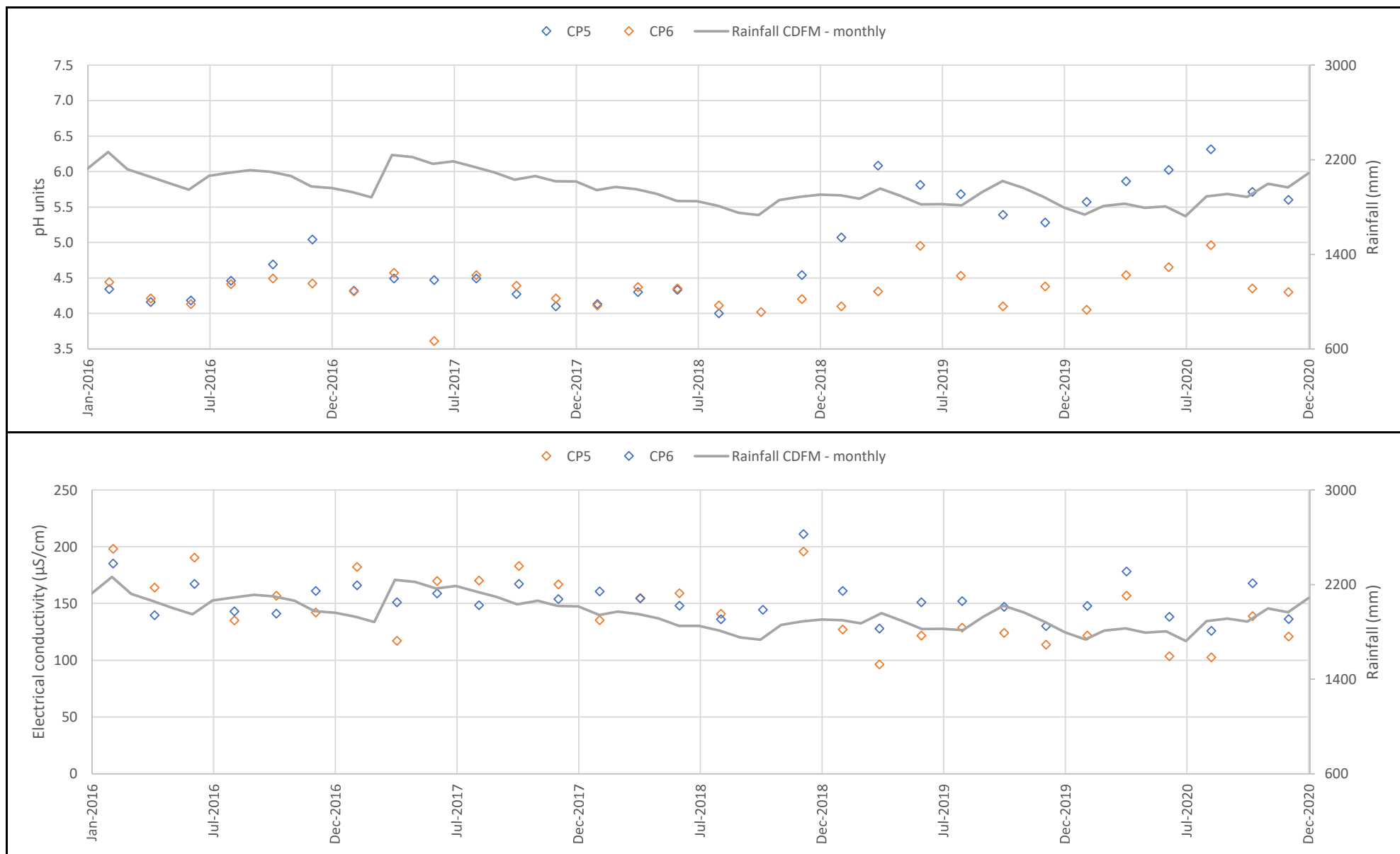
Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

CP4 measured only twice due to damage / blocked bore

**Water quality - MW10 and CP4**  
Hanson Construction Materials Pty Ltd  
Figure B7

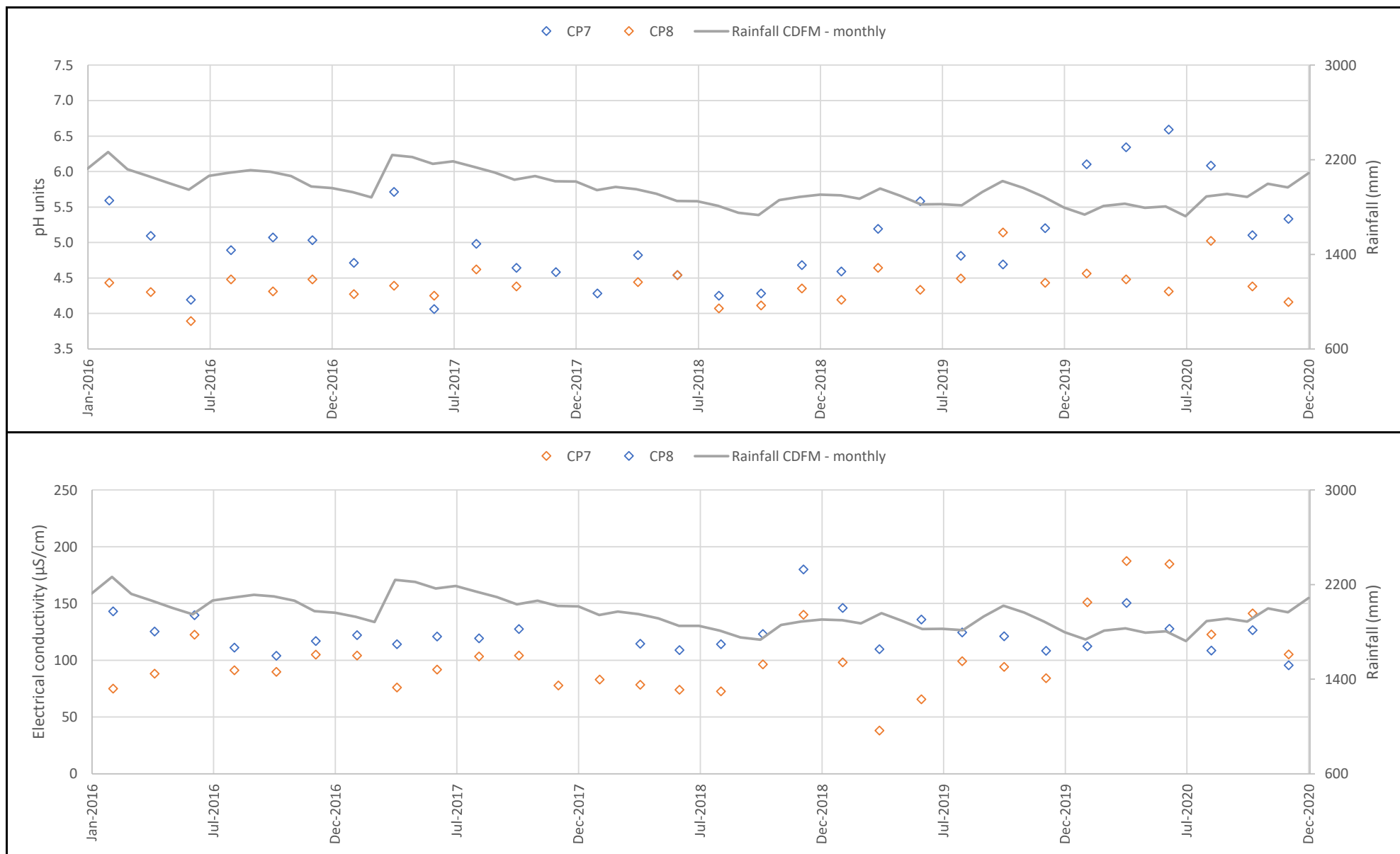


#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

**Water quality - CP5 and CP6**  
Hanson Construction Materials Pty Ltd  
Figure B8



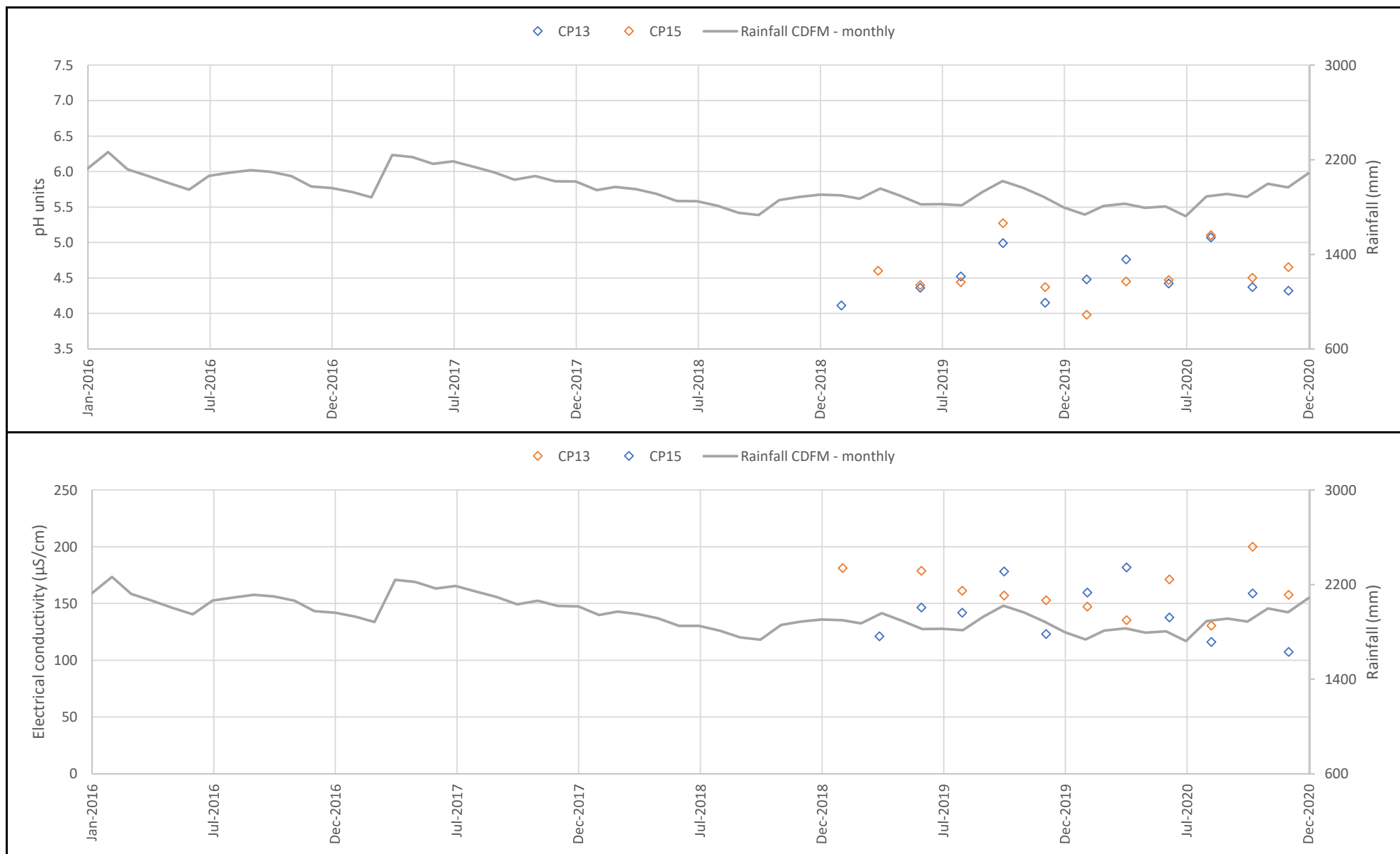
#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

**Water quality - CP7 and CP8**  
Hanson Construction Materials Pty Ltd  
Figure B9



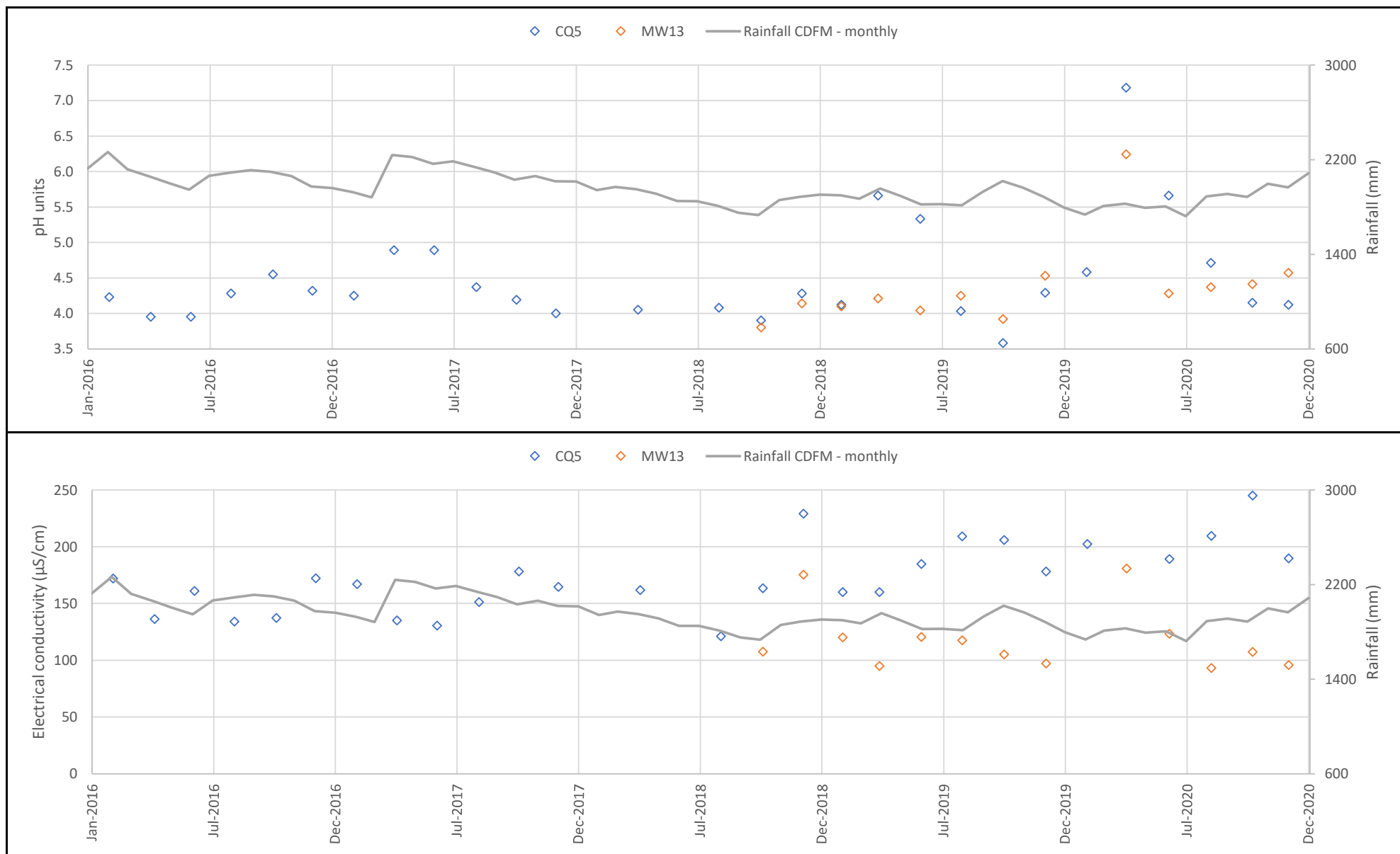


#### Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

**Water quality - CP13 and CP15**  
Hanson Construction Materials Pty Ltd  
Figure B10

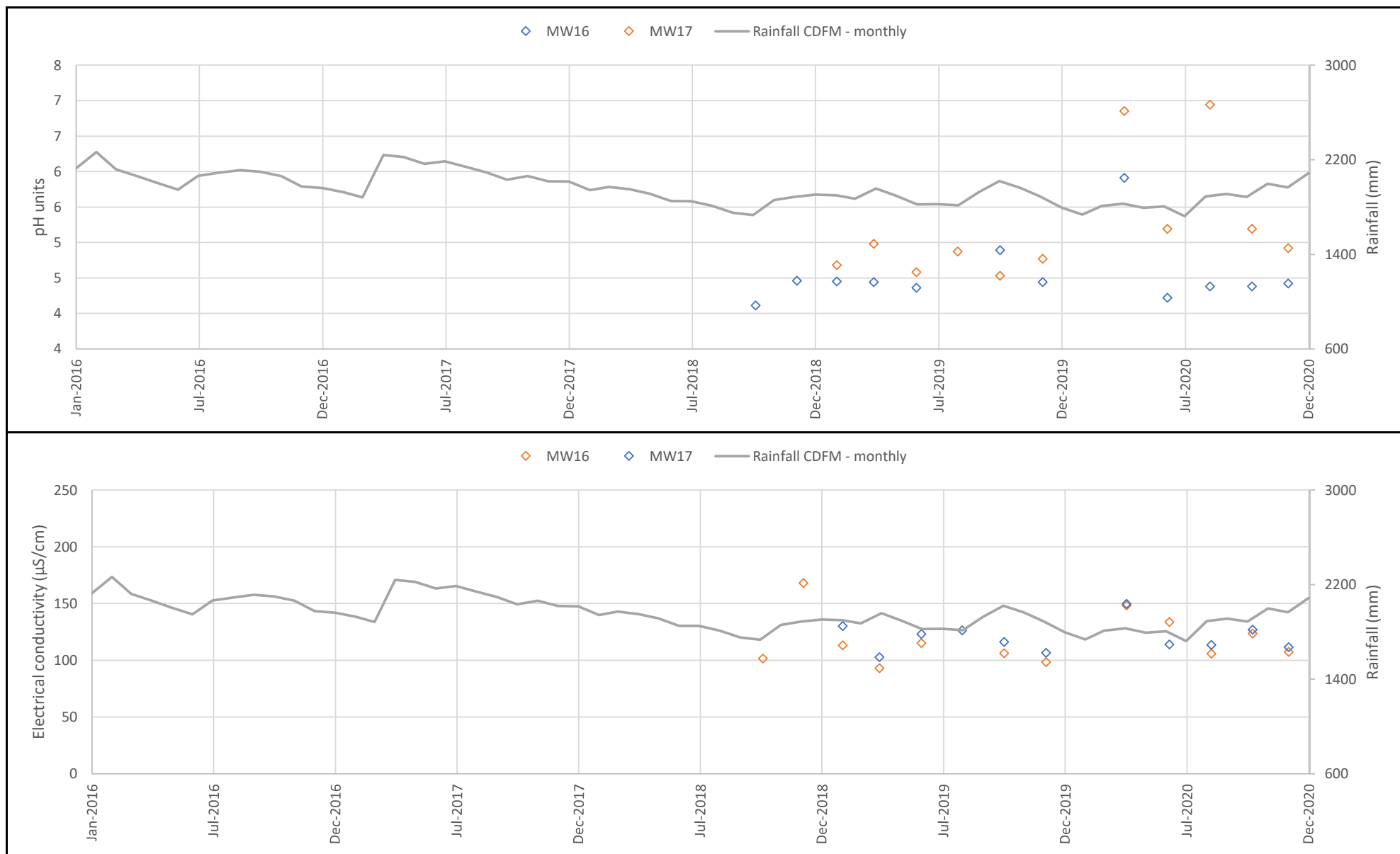


Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

**Water quality - CQ5 and MW13**  
Hanson Construction Materials Pty Ltd  
Figure B11



Notes

CDFM = Cumulative Deviation From Mean, calculated at monthly sample intervals;

Rainfall data accessed from Mangrove Mountain AWS, station 61375. (<http://www.bom.gov.au/climate/data/>)

**Hydrograph - MW16 and MW17**  
Hanson Construction Materials Pty Ltd  
Figure B12

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Appendix C

# Laboratory water quality

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# Calga Sand Quarry - Groundwater Trigger Levels

	Location Code																							
	CQ3	CQ4	CQ5	CQ7	CQ8	CQ10	CQ11S	CQ11D	CQ12	CQ13	MW7	MW8	MW9	MW10	MW13	MW16	MW17	CP4	CP5	CP6	CP7	CP8	CP13	CP15
Analyte																								
pH Value	<u>6.64</u>	<u>5.84</u>	<u>4.99</u>	<u>5.65</u>	<u>5.64</u>	<u>5.02</u>	<u>5.24</u>	<u>5.04</u>	<u>4.937</u>	<u>5.095</u>	<u>4.83</u>	<u>5.35</u>	<u>5.32</u>	<u>4.89</u>	<u>5.36</u>	-	-	<u>5.41</u>	<u>4.76</u>	<u>4.78</u>	<u>6</u>	<u>4.77</u>	-	-
Electrical Conductivity @ 25°C	<u>187</u>	<u>132.2</u>	<u>197</u>	<u>121</u>	<u>156</u>	<u>187</u>	<u>175</u>	<u>178</u>	<u>149</u>	<u>240</u>	<u>128</u>	<u>95</u>	<u>100.3</u>	<u>139.00</u>	<u>113</u>	-	-	<u>219</u>	<u>248</u>	<u>197</u>	<u>163</u>	<u>159.6</u>	-	-
Hydroxide Alkalinity as CaCO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate Alkalinity as CaCO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bicarbonate Alkalinity as CaCO3	<u>52</u>	<u>6</u>	-	<u>3</u>	<u>20</u>	<u>2</u>	<u>8</u>	<u>2</u>	<u>1</u>	-	-	<u>4</u>	-	-	<u>1</u>	-	-	<u>2</u>	-	-	-	<u>9</u>	-	-
Total Alkalinity as CaCO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sulphate as SO4 2-	<u>6</u>	<u>8</u>	<u>30</u>	<u>4</u>	<u>10</u>	<u>35</u>	<u>36</u>	<u>42</u>	<u>29.1</u>	<u>2</u>	<u>5</u>	<u>6.6</u>	<u>4</u>	<u>6.00</u>	<u>3</u>	-	-	<u>23</u>	<u>4</u>	<u>9</u>	<u>27</u>	<u>10</u>	-	-
Chloride	<u>29</u>	<u>27.1</u>	<u>31</u>	<u>28</u>	<u>25</u>	<u>30</u>	<u>26</u>	<u>25</u>	<u>23.1</u>	<u>40</u>	<u>33</u>	<u>23.7</u>	<u>27.1</u>	<u>35</u>	<u>29</u>	-	-	<u>39</u>	<u>25</u>	<u>30</u>	<u>16</u>	<u>35</u>	-	-
Calcium	<u>2</u>	-	<u>4</u>	<u>1</u>	-	<u>3</u>	-	-	-	-	-	-	-	-	-	-	-	<u>4</u>	<u>2</u>	-	<u>8</u>	-	-	-
Magnesium	<u>5</u>	<u>2</u>	<u>6</u>	<u>2</u>	<u>5</u>	<u>4</u>	<u>5</u>	<u>5</u>	<u>6</u>	<u>8</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	-	-	<u>6</u>	<u>16</u>	<u>8</u>	<u>5</u>	<u>3</u>	-	-
Sodium	<u>18</u>	<u>20.1</u>	<u>19</u>	<u>16</u>	<u>18</u>	<u>21</u>	<u>22</u>	<u>22</u>	<u>13</u>	<u>27</u>	<u>18</u>	<u>13</u>	<u>14</u>	<u>16</u>	<u>15</u>	-	-	<u>20</u>	<u>14</u>	<u>19</u>	<u>8</u>	<u>22</u>	-	-
Potassium	<u>2</u>	-	<u>3</u>	<u>1</u>	<u>1</u>	-	<u>4</u>	<u>2</u>	<u>1</u>	<u>2</u>	-	-	-	-	-	-	-	<u>4</u>	<u>3</u>	<u>1</u>	<u>11</u>	-	-	-
Aluminium	<u>0.22</u>	<u>0.46</u>	<u>2.27</u>	<u>1.41</u>	<u>0.582</u>	<u>2.359</u>	<u>1.02</u>	<u>1.63</u>	<u>1.1485</u>	<u>1.113</u>	<u>0.36</u>	<u>0.43</u>	<u>6.32</u>	<u>1.08</u>	<u>0.17</u>	-	-	<u>0.98</u>	<u>0.91</u>	<u>1.01</u>	<u>0.56</u>	<u>1.01</u>	-	-
Arsenic	<u>0.003</u>	-	<u>0.002</u>	-	-	<u>0.001</u>	-	<u>0.001</u>	-	-	-	-	<u>0.009</u>	-	-	-	-	-	-	-	-	-	-	-
Cadmium	<u>0.0006</u>	-	-	-	-	<u>0.0002</u>	-	<u>0.0002</u>	-	-	-	-	-	-	-	-	-	<u>0.0002</u>	<u>0.0002</u>	-	-	-	-	-
Chromium	<u>0.003</u>	<u>0.001</u>	<u>0.001</u>	<u>0.003</u>	<u>0.002</u>	<u>0.0155</u>	<u>0.001</u>	<u>0.004</u>	<u>0.001</u>	<u>0.002</u>	-	<u>0.001</u>	<u>0.0202</u>	-	-	-	-	<u>0.0048</u>	<u>0.002</u>	<u>0.007</u>	-	<u>0.002</u>	-	-
Copper	<u>0.01</u>	<u>0.007</u>	<u>0.014</u>	<u>0.0096</u>	<u>0.003</u>	<u>0.048</u>	<u>0.006</u>	<u>0.007</u>	<u>0.004</u>	<u>0.004</u>	<u>0.004</u>	<u>0.009</u>	<u>0.016</u>	<u>0.004</u>	<u>0.007</u>	-	-	<u>0.026</u>	<u>0.057</u>	<u>0.028</u>	<u>0.014</u>	<u>0.005</u>	-	-
Nickel	<u>0.016</u>	<u>0.004</u>	<u>0.004</u>	<u>0.001</u>	<u>0.003</u>	<u>0.005</u>	<u>0.002</u>	<u>0.003</u>	<u>0.001</u>	<u>0.001</u>	<u>0.001</u>	<u>0.002</u>	<u>0.003</u>	<u>0.002</u>	<u>0.003</u>	-	-	<u>0.008</u>	<u>0.007</u>	<u>0.001</u>	-	<u>0.003</u>	-	-
Lead	<u>0.0028</u>	<u>0.007</u>	<u>0.003</u>	<u>0.0055</u>	<u>0.003</u>	<u>0.011</u>	<u>0.009</u>	<u>0.098</u>	<u>0.005</u>	<u>0.008</u>	<u>0.002</u>	<u>0.002</u>	<u>0.012</u>	<u>0.003</u>	<u>0.002</u>	-	-	<u>0.02</u>	<u>0.009</u>	<u>0.005</u>	<u>0.002</u>	<u>0.0029</u>	-	-
Zinc	<u>0.097</u>	<u>0.102</u>	<u>0.136</u>	<u>0.088</u>	<u>0.06</u>	<u>0.17</u>	<u>0.1059</u>	<u>0.236</u>	<u>0.135</u>	<u>0.05</u>	<u>0.066</u>	<u>0.077</u>	<u>0.05</u>	<u>0.08</u>	<u>0.088</u>	-	-	<u>0.371</u>	<u>0.289</u>	<u>0.117</u>	<u>0.04</u>	<u>0.05</u>	-	-
Manganese	<u>1.8935</u>	<u>0.028</u>	<u>0.023</u>	<u>0.02065</u>	<u>0.006</u>	<u>0.039</u>	<u>0.017</u>	<u>0.022</u>	<u>0.006</u>	<u>0.006</u>	<u>0.011</u>	<u>0.011</u>	<u>0.013</u>	<u>0.01</u>	<u>0.04</u>	-	-	<u>0.02</u>	<u>0.009</u>	<u>0.005</u>	<u>0.002</u>	<u>0.0029</u>	-	-
Selenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	<u>18.6</u>	<u>0.396</u>	<u>0.778</u>	<u>0.96</u>	<u>0.11</u>	<u>0.72</u>	<u>0.35</u>	<u>0.45</u>	<u>0.16</u>	<u>0.32</u>	<u>0.14</u>	<u>0.36</u>	<u>7.63</u>	<u>0.06</u>	<u>0.13</u>	-	-	-	<u>0.09</u>	<u>5.67</u>	<u>0.19</u>	<u>7.63</u>	-	-
Mercury	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluoride	-	-	-	-	-	-	-	-	-	-	-	-	<u>0.2</u>	-	-	-	-	-	-	-	-	-	-	-
Nitrite as N	<u>0.05</u>	<u>0.08</u>	<u>0.06</u>	<u>0.02</u>	<u>0.02</u>	-	-	-	<u>0.01</u>	<u>0.02</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate as N	<u>0.555</u>	<u>2.85</u>	<u>3.34</u>	<u>2.14</u>	<u>7.208</u>	<u>0.99</u>	<u>0.35</u>	<u>0.282</u>	<u>1.08</u>	<u>12.11</u>	<u>0.55</u>	<u>0.81</u>	<u>0.34</u>	<u>0.37</u>	<u>0.67</u>	-	-	<u>20.17</u>	<u>10.21</u>	<u>5.22</u>	<u>2.27</u>	<u>0.34</u>	-	-
Nitrite + Nitrate as N	<u>0.59</u>	<u>2.85</u>	<u>3.34</u>	<u>2.15</u>	<u>7.208</u>	<u>0.99</u>	<u>0.35</u>	<u>0.282</u>	<u>1.08</u>	<u>12.11</u>	<u>0.55</u>	<u>0.81</u>	<u>0.34</u>	<u>0.37</u>	<u>0.67</u>	-	-	<u>20.17</u>	<u>10.21</u>	<u>5.22</u>	<u>2.27</u>	<u>0.34</u>	-	-
Total Anions	<u>1.9</u>	<u>0.93</u>	<u>1.38</u>	<u>0.82</u>	<u>1.22</u>	<u>1.53</u>	<u>1.43</u>	<u>1.5</u>	<u>1.19</u>	<u>1.95</u>	<u>1.01</u>	<u>0.77</u>	<u>0.82</u>	<u>1.08</u>	<u>0.87</u>	-	-	<u>2.07</u>	<u>1.64</u>	<u>1.01</u>	<u>1.11</u>	<u>0.82</u>	-	-
Total Cations	<u>1.51</u>	<u>1.04</u>	<u>1.36</u>	<u>0.9</u>	<u>1.19</u>	<u>1.37</u>	<u>1.37</u>	<u>1.424</u>	<u>1.04</u>	<u>1.87</u>	<u>0.9</u>	<u>0.67</u>	<u>0.69</u>	<u>0.86</u>	<u>0.8</u>	-	-	<u>2</u>	<u>1.45</u>	<u>1.35</u>	<u>1.18</u>	<u>0.69</u>	-	-

## Notes:

Trigger values based off 95th percentile calculated from 2012-2017 monitoring data, as presented in Draft Site Water Management Plan (RW Corkey, 2020)

'-' indicates no guideline provided

# April water quality results - Existing quarry

Analyte	Units	Location Code	CQ3	CQ4	CQ5	CQ7	CQ8	CQ10	CQ11S	CQ11D	CQ12	CQ13
		ANZG 2018 95% Freshwater guideline										
pH Value	pH Unit		6.1	4.58	<u>5.76</u>	4.54	4.28	4.43	5.62	<u>5.26</u>	4.8	4.3
Electrical Conductivity @ 25°C	µS/cm		126	<u>149</u>	<u>243</u>	120	154	148	175	165	147	170
Hydroxide Alkalinity as CaCO <sub>3</sub>	mg/L		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/L		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/L		21	<u>8</u>	48	3	<1	1	<u>20</u>	<u>11</u>	<u>3</u>	<1
Total Alkalinity as CaCO <sub>3</sub>	mg/L		21	8	48	3	<1	1	20	11	3	<1
Sulphate as SO <sub>4</sub> 2-	mg/L		4	8	21	<u>5</u>	<u>11</u>	16	19	24	27	<u>3</u>
Chloride	mg/L		24	24	30	24	21	27	26	25	17	31
Calcium	mg/L		2	<1	<u>5</u>	<1	<1	2	1	<1	<1	<1
Magnesium	mg/L		4	2	5	2	4	2	4	4	5	4
Sodium	mg/L		14	20	16	14	14	18	20	20	11	17
Potassium	mg/L		2	<1	<u>6</u>	1	<1	<1	3	2	<u>2</u>	2
Aluminium - Total	mg/L	0.0008	0.13	0.32	<u>2.33</u>	0.19	0.54	1.32	0.18	0.35	0.71	0.42
Arsenic - Total	mg/L	0.013*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium - Total	mg/L	0.0002	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium - Total	mg/L	0.001**	<0.001	<0.001	0.001	<0.001	<0.001	0.004	0.001	<0.001	<0.001	<0.001
Copper - Total	mg/L	0.0014	0.002	0.001	0.011	0.001	<u>0.011</u>	0.027	0.002	0.002	0.002	<0.001
Nickel - Total	mg/L	0.011	0.004	<0.001	0.001	<0.001	0.002	0.004	0.002	0.002	<0.001	<0.001
Lead - Total	mg/L	0.0034	0.001	<0.001	<u>0.004</u>	0.002	0.001	<u>0.015</u>	0.002	0.001	<0.001	<0.001
Zinc - Total	mg/L	0.08	0.048	0.028	<u>0.317</u>	0.027	<u>0.08</u>	<u>0.2</u>	0.056	0.106	<u>0.267</u>	0.006
Manganese - Total	mg/L	1.9	0.152	0.003	<u>0.052</u>	0.004	<u>0.007</u>	0.036	<u>0.019</u>	0.017	<u>0.008</u>	0.004
Selenium - Total	mg/L	0.011	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron - Total	mg/L	0.37	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron - Total	mg/L		1.02	<0.05	<u>1.00</u>	0.08	0.09	<u>1.13</u>	0.35	0.24	<0.05	<0.05
Mercury	mg/L	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluoride	mg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
Nitrite as N	mg/L		<0.01	<0.01	<0.01	<u>0.04</u>	<0.01	<0.01	<0.01	<0.01	<u>0.19</u>	<0.01
Nitrate as N	mg/L	2.4^^	0.31	<u>4.27</u>	<0.01	1.87	<u>4.63</u>	0.67	0.01	0.06	1	4.85
Nitrite + Nitrate as N	mg/L		0.31	<u>4.27</u>	<0.01	1.91	<u>4.63</u>	0.67	0.01	0.06	1.19	4.85
Total Anions	meq/L		-	-	-	-	-	-	-	-	-	-
Total Cations	meq/L		-	-	-	-	-	-	-	-	-	-

## Notes:

Results underlined and in italics represent exceedances of individual groundwater quality trigger values in the Draft Site Water Management Plan (Hanson 2018)

Shaded cells indicate exceedances of Australian and New Zealand Guidelines 2018 Freshwater 95% species protection

\* Guideline value for Arsenic (V) adopted as a conservative approach

\*\* Guideline value for Chromium (VI) adopted as a conservative approach

^^ Nitrate guideline adopted from NIWA 2013, *Updating nitrate toxicity effects on freshwater aquatic species*

Analyte	Units	Location Code	MW7	MW8	MW9	MW10	MW13	MW16^	MW17^
		ANZG 2018 95% Freshwater guideline							
pH Value	pH Unit		<u>6.11</u>	5.06	4.45	4.55	4.48	4.47	4.9
Electrical Conductivity @ 25°C	µS/cm		53	77	96	127	<u>131</u>	127	132
Hydroxide Alkalinity as CaCO <sub>3</sub>	mg/L		<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/L		<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/L		11	<1	<1	<1	<1	<1	<1
Total Alkalinity as CaCO <sub>3</sub>	mg/L		11	<1	<1	<1	<1	<1	<1
Sulphate as SO <sub>4</sub> 2-	mg/L		<5	4	4	6	<u>6</u>	3	3
Chloride	mg/L		8	18	23	30	28	31	34
Calcium	mg/L		3	<1	<1	<1	<1	<1	<1
Magnesium	mg/L		<1	1	1	2	2	2	2
Sodium	mg/L		5	10	13	14	15	16	16
Potassium	mg/L		1	<1	<1	<1	<1	<1	<1
Aluminium - Total	mg/L	0.0008	<u>0.09</u>	0.12	0.41	0.68	<u>0.19</u>	0.23	0.09
Arsenic - Total	mg/L	0.013*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium - Total	mg/L	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium - Total	mg/L	0.001**	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper - Total	mg/L	0.0014	0.003	0.001	<u>0.002</u>	0.002	0.004	0.002	0.002
Nickel - Total	mg/L	0.011	<u>0.002</u>	<0.001	0.001	<0.001	0.003	0.002	0.005
Lead - Total	mg/L	0.0034	<u>0.007</u>	<0.001	0.002	0.002	0.002	<0.001	0.004
Zinc - Total	mg/L	0.08	<u>0.495</u>	0.046	<u>0.061</u>	0.069	0.086	0.032	0.071
Manganese - Total	mg/L	1.9	<u>0.066</u>	0.007	0.013	<u>0.026</u>	<u>0.058</u>	0.019	0.174
Selenium - Total	mg/L	0.011	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron - Total	mg/L	0.37	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron - Total	mg/L		<u>1.96</u>	0.10	0.24	0.06	0.12	<0.05	0.1
Mercury	mg/L	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluoride	mg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite as N	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	2.4^^	0.07	0.01	0.16	0.18	<u>0.98</u>	0.5	0.25
Nitrite + Nitrate as N	mg/L		0.07	0.01	0.16	0.18	<u>0.98</u>	0.5	0.25
Total Anions	meq/L		-	-	-	-	-	-	-
Total Cations	meq/L		-	-	-	-	-	-	-

**Notes:**

Results underlined and in italics represent exceedances of individual groundwater quality trigger values in the Draft Site Water Management Plan (Hanson 2018)

^ No groundwater trigger values for MW16 and MW17

Shaded cells indicate exceedances of Australian and New Zealand Guidelines 2018 Freshwater 95% species protection

\* Guideline value for Arsenic (V) adopted as a conservative approach

\*\* Guideline value for Chromium (VI) adopted as a conservative approach

^^ Nitrate guideline adopted from NIWA 2013, *Updating nitrate toxicity effects on freshwater aquatic species*

		Location Code	CP4 ^^^	CP5	CP6	CP7	CP8	CP13^	CP15^
Analyte	Units	ANZG 2018 95% Freshwater guideline							
pH Value	pH Unit		-	<u>5.17</u>	4.34	<u>6.3</u>	4.46	4.71	4.35
Electrical Conductivity @ 25°C	µS/cm		-	140	158	163	129	120	157
Hydroxide Alkalinity as CaCO3	mg/L		-	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L		-	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	mg/L		-	2	<1	24	2	<1	<1
Total Alkalinity as CaCO3	mg/L		-	2	<1	24	2	<1	<1
Sulphate as SO4 2-	mg/L		-	<u>9</u>	<u>10</u>	<1	10	16	10
Chloride	mg/L		-	17	21	15	25	21	22
Calcium	mg/L		-	1	<1	6	<1	2	<1
Magnesium	mg/L		-	8	6	3	2	2	5
Sodium	mg/L		-	9	14	6	17	13	14
Potassium	mg/L		-	2	<1	<u>18</u>	<1	3	2
Aluminium - Total	mg/L	0.0008	-	0.39	0.23	<u>1.11</u>	0.68	0.5	0.54
Arsenic - Total	mg/L	0.013*	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium - Total	mg/L	0.0002	-	<0.0001	0.0004	<0.0001	<0.0001	<0.0001	0.0002
Chromium - Total	mg/L	0.001**	-	<u>0.006</u>	0.005	0.002	0.001	<0.001	<0.001
Copper - Total	mg/L	0.0014	-	0.022	0.007	<u>0.102</u>	0.003	0.002	0.156
Nickel - Total	mg/L	0.011	-	<u>0.046</u>	<u>0.016</u>	0.002	<0.001	0.001	0.009
Lead - Total	mg/L	0.0034	-	0.006	<u>0.024</u>	<u>0.017</u>	<u>0.003</u>	0.001	0.004
Zinc - Total	mg/L	0.08	-	0.155	<u>0.332</u>	<u>0.126</u>	0.029	0.019	0.385
Manganese - Total	mg/L	1.9	-	<u>0.023</u>	<u>0.111</u>	<u>0.326</u>	<u>0.008</u>	0.016	0.014
Selenium - Total	mg/L	0.011	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron - Total	mg/L	0.37	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron - Total	mg/L		-	<u>0.23</u>	1.91	<u>6.64</u>	0.25	0.22	0.12
Mercury	mg/L	0.0006	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluoride	mg/L		-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite as N	mg/L		-	<0.01	<0.01	0.02	<0.01	<0.01	<0.01
Nitrate as N	mg/L	2.4^^	-	<u>5.72</u>	<u>5.93</u>	0.17	<u>1.08</u>	0.27	5.14
Nitrite + Nitrate as N	mg/L		-	5.72	<u>5.93</u>	0.19	<u>1.08</u>	0.27	5.14
Total Anions	meq/L		-	-	-	-	-	-	-
Total Cations	meq/L		-	-	-	-	-	-	-

**Notes:**

Results underlined and in italics represent exceedances of individual groundwater quality trigger values in the Draft Site Water Management Plan (Hanson 2018)

^ No groundwater trigger values for CP13 and CP15

Shaded cells indicate exceedances of Australian and New Zealand Guidelines 2018 Freshwater 95% species protection

\* Guideline value for Arsenic (V) adopted as a conservative approach

\*\* Guideline value for Chromium (VI) adopted as a conservative approach

^^ Nitrate guideline adopted from NIWA 2013, *Updating nitrate toxicity effects on freshwater aquatic species*

^^^ CP4 could not be sampled during April sampling round



# October water quality results - Existing quarry

		Location Code	CQ3	CQ4	CQ5	CQ7	CQ8	CQ10	CQ11S	CQ11D	CQ12	CQ13
Chemical Name	Units	ANZG 2018 95% Freshwater guideline										
pH Value	pH Unit		6.21	4.62	4.29	4.46	4.38	4.95	<u>5.51</u>	<u>5.26</u>	4.24	4.44
Electrical Conductivity @ 25°C	µS/cm		174	<u>144</u>	<u>230</u>	<u>129</u>	146	184	<u>157</u>	158	<u>154</u>	167
Hydroxide Alkalinity as CaCO <sub>3</sub>	mg/L		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO <sub>3</sub>	mg/L		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO <sub>3</sub>	mg/L		28	<u>7</u>	<1	<1	<1	<u>7</u>	<u>15</u>	<u>11</u>	<1	<1
Total Alkalinity as CaCO <sub>3</sub>	mg/L		28	7	<1	<1	<1	7	15	11	<1	<1
Sulphate as SO <sub>4</sub> 2-	mg/L		<u>7</u>	7	20	<u>6</u>	<u>12</u>	19	15	21	23	<u>3</u>
Chloride	mg/L		<u>34</u>	23	27	25	21	<u>33</u>	26	24	16	30
Calcium	mg/L		<u>3</u>	<1	<u>5</u>	1	<1	<u>5</u>	1	<1	<1	<1
Magnesium	mg/L		5	2	6	<u>3</u>	5	4	4	4	6	5
Sodium	mg/L		<u>22</u>	<u>21</u>	16	15	15	<u>24</u>	21	20	12	17
Potassium	mg/L		2	<1	3	<1	<1	1	2	2	<1	2
Aluminium - Total	mg/L	0.0008	<u>0.39</u>	0.27	<u>2.37</u>	0.31	<u>0.66</u>	<u>2.7</u>	0.1	0.33	1.04	0.5
Arsenic - Total	mg/L	0.013*	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Cadmium - Total	mg/L	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium - Total	mg/L	0.001**	<0.001	<0.001	<u>0.002</u>	<0.001	<u>0.004</u>	0.006	<0.001	<0.001	<u>0.002</u>	0.002
Copper - Total	mg/L	0.0014	0.005	<0.001	0.003	<0.001	0.003	0.043	0.003	<0.001	<0.001	<0.001
Nickel - Total	mg/L	0.011	0.016	<0.001	<0.001	<0.001	0.002	0.008	<0.001	<0.001	<0.001	0.001
Lead - Total	mg/L	0.0034	<u>0.003</u>	<0.001	0.002	<0.001	<0.001	<u>0.018</u>	<0.001	<0.001	<0.001	0.001
Zinc - Total	mg/L	0.08	<u>0.113</u>	0.015	<u>0.164</u>	0.008	<u>0.098</u>	<u>0.291</u>	0.018	0.042	0.022	0.03
Manganese - Total	mg/L	1.9	1.28	0.002	0.016	0.003	<u>0.012</u>	<u>0.226</u>	0.013	0.019	0.002	0.004
Selenium - Total	mg/L	0.011	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron - Total	mg/L	0.37	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron - Total	mg/L		4.42	<0.05	<u>0.40</u>	0.07	<u>0.32</u>	<u>3.46</u>	0.31	0.38	0.08	0.08
Mercury	mg/L	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluoride	mg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite as N	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	2.4^^	0.19	<u>4.66</u>	<u>8.19</u>	<u>2.55</u>	4.78	0.65	0.02	0.03	<u>3.28</u>	5.1
Nitrite + Nitrate as N	mg/L		0.19	<u>4.66</u>	<u>8.19</u>	<u>2.55</u>	4.78	0.65	0.02	0.03	<u>3.28</u>	5.1
Total Anions	meq/L		1.66	0.93	<u>1.76</u>	<u>0.83</u>	0.84	1.47	1.34	1.33	0.93	1.2
Total Cations	meq/L		<u>1.57</u>	<u>1.08</u>	<u>1.52</u>	<u>0.95</u>	1.06	<u>1.65</u>	1.34	1.25	1.02	1.2

## Notes:

Results underlined and in italics represent exceedances of individual groundwater quality trigger values in the Draft Site Water Management Plan (Hanson 2018)

Shaded cells indicate exceedances of Australian and New Zealand Guidelines 2018 Freshwater 95% species protection

\* Guideline value for Arsenic (V) adopted as a conservative approach

\*\* Guideline value for Chromium (VI) adopted as a conservative approach

^^ Nitrate guideline adopted from NIWA 2013, *Updating nitrate toxicity effects on freshwater aquatic species, which supersedes ANZECC 2000 criteria*

		Location Code	MW7	MW8	MW9	MW10	MW13	MW16^	MW17^
Chemical Name	Units	ANZG 2018 95% Freshwater guideline							
pH Value	pH Unit		<u>5.76</u>	5.16	4.48	4.4	4.52	4.33	5.36
Electrical Conductivity @ 25°C	µS/cm		42	73	100	124	<u>114</u>	126	131
Hydroxide Alkalinity as CaCO3	mg/L		<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L		<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	mg/L		8	3	4	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L		8	3	4	<1	<1	<1	<1
Sulphate as SO4 2-	mg/L		<1	4	4	5	3	3	3
Chloride	mg/L		7	18	24	30	26	31	35
Calcium	mg/L		2	<1	<1	<1	<1	<1	1
Magnesium	mg/L		<1	1	<u>2</u>	2	2	2	3
Sodium	mg/L		5	10	14	15	15	17	19
Potassium	mg/L		<1	<1	<1	<1	<1	<1	<1
Aluminium - Total	mg/L	0.0008	<u>0.71</u>	0.14	0.44	<u>1.18</u>	0.12	0.24	0.1
Arsenic - Total	mg/L	0.013*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium - Total	mg/L	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium - Total	mg/L	0.001**	0.001	<0.001	<0.001	0.001	<0.001	0.002	<0.001
Copper - Total	mg/L	0.0014	0.001	<0.001	0.002	<u>0.052</u>	0.002	0.003	0.002
Nickel - Total	mg/L	0.011	<0.001	<0.001	0.001	<0.001	0.002	0.002	0.004
Lead - Total	mg/L	0.0034	<0.001	<0.001	<0.001	0.002	<0.001	0.001	0.002
Zinc - Total	mg/L	0.08	0.048	0.033	0.016	0.063	0.054	0.047	0.052
Manganese - Total	mg/L	1.9	0.006	0.008	0.013	<u>0.022</u>	0.034	0.018	0.178
Selenium - Total	mg/L	0.011	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron - Total	mg/L	0.37	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron - Total	mg/L		<u>0.48</u>	0.07	0.47	<u>0.73</u>	<0.05	0.15	0.13
Mercury	mg/L	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluoride	mg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite as N	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	2.4^^	0.2	0.02	0.17	0.19	0.67	0.44	0.19
Nitrite + Nitrate as N	mg/L		0.2	0.02	0.17	0.19	0.67	0.44	0.19
Total Anions	meq/L		0.36	0.65	<u>0.84</u>	0.95	0.8	0.94	1.05
Total Cations	meq/L		0.32	0.52	<u>0.77</u>	0.82	<u>0.82</u>	0.9	1.12

**Notes:**

Results underlined and in italics represent exceedances of individual groundwater quality trigger values in the Draft Site Water Management Plan (Hanson 2018)

^No groundwater trigger values for MW16 and MW17

Shaded cells indicate exceedances of Australian and New Zealand Guidelines 2018 Freshwater 95% species protection

\* Guideline value for Arsenic (V) adopted as a conservative approach

\*\* Guideline value for Chromium (VI) adopted as a conservative approach

^^ Nitrate guideline adopted from NIWA 2013, *Updating nitrate toxicity effects on freshwater aquatic species*

		Location Code	CP4	CP5	CP6	CP7	CP8	CP13^	CP15^
Analyte	Units	ANZG 2018 95% Freshwater guideline							
pH Value	pH Unit		4.6	<u>5.81</u>	4.41	5.89	4.4	4.38	4.5
Electrical Conductivity @ 25°C	µS/cm		<u>275</u>	137	157	142	123	196	161
Hydroxide Alkalinity as CaCO3	mg/L		<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L		<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	mg/L		<1	3	<1	3	<1	<1	<1
Total Alkalinity as CaCO3	mg/L		<1	3	<1	3	<1	<1	<1
Sulphate as SO4 2-	mg/L		20	<u>6</u>	<u>10</u>	26	10	11	8
Chloride	mg/L		32	17	22	13	24	43	21
Calcium	mg/L		<u>7</u>	1	<1	8	<1	1	<1
Magnesium	mg/L		<u>7</u>	8	6	4	2	3	6
Sodium	mg/L		<u>28</u>	10	15	8	17	26	15
Potassium	mg/L		3	2	1	7	<1	2	2
Aluminium - Total	mg/L	0.0008	0.97	0.02	0.43	<u>2.48</u>	0.45	0.54	0.82
Arsenic - Total	mg/L	0.013*	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cadmium - Total	mg/L	0.0002	0.0002	<u>0.0003</u>	<0.0001	<u>0.0003</u>	<0.0001	<0.0001	<0.0001
Chromium - Total	mg/L	0.001**	<0.001	0.002	0.004	0.003	<0.001	<0.001	<0.001
Copper - Total	mg/L	0.0014	0.001	0.056	0.008	<u>0.101</u>	0.001	<0.001	<0.001
Nickel - Total	mg/L	0.011	<0.001	<u>0.048</u>	<u>0.008</u>	0.002	<0.001	0.001	<0.001
Lead - Total	mg/L	0.0034	0.002	0.002	0.003	<u>0.022</u>	<0.001	<0.001	<0.001
Zinc - Total	mg/L	0.08	0.102	<u>0.994</u>	<u>0.142</u>	<u>0.291</u>	0.008	<0.005	<0.005
Manganese - Total	mg/L	1.9	0.005	<u>0.139</u>	<u>0.007</u>	<u>0.129</u>	<u>0.003</u>	0.013	0.008
Selenium - Total	mg/L	0.011	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron - Total	mg/L	0.37	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron - Total	mg/L		0.32	<u>0.33</u>	<0.05	<u>6.11</u>	0.18	0.08	1.07
Mercury	mg/L	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluoride	mg/L		0.4	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
Nitrite as N	mg/L		<0.01	<0.01	<0.01	0.14	<0.01	<0.01	<0.01
Nitrate as N	mg/L	2.4^^	14.3	6.26	<u>6.18</u>	2.22	<u>0.98</u>	1.08	7.14
Nitrite + Nitrate as N	mg/L		14.3	6.26	<u>6.18</u>	<u>2.36</u>	<u>0.98</u>	1.08	7.14
Total Anions	meq/L		<u>2.34</u>	1.11	<u>1.27</u>	<u>1.14</u>	<u>0.88</u>	1.44	1.27
Total Cations	meq/L		<u>2.22</u>	1.19	1.17	1.26	<u>0.9</u>	1.48	1.2

**Notes:**

Results underlined and in italics represent exceedances of individual groundwater quality trigger values in the Draft Site Water Management Plan (Hanson 2018)

^ No groundwater trigger values for CP13 and CP15

Shaded cells indicate exceedances of Australian and New Zealand Guidelines 2018 Freshwater 95% species protection

\* Guideline value for Arsenic (V) adopted as a conservative approach

\*\* Guideline value for Chromium (VI) adopted as a conservative approach

^^ Nitrate guideline adopted from NIWA 2013, *Updating nitrate toxicity effects on freshwater aquatic species*