



REPORT

Metropolitan Coal Surface Water Review 1 January to 30 June 2019

Prepared for: Metropolitan Coal Pty Ltd

38a Nash Street
Rosalie QLD 4064
p (07) 3367 2388

PO Box 1575
Carindale QLD 4152
www.hecons.com
ABN 11 247 282 058

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1.0 INTRODUCTION AND BACKGROUND

Metropolitan Coal is wholly owned by Peabody Energy Australia Pty Ltd (Peabody) and is located adjacent to the township of Helensburgh and approximately 30 kilometres (km) north of Wollongong in New South Wales (NSW). The Metropolitan Coal Project (the Project) comprises the continuation, upgrade and extension of underground coal mining operations and surface facilities at Metropolitan Coal. The current underground mining longwall layout is shown on Figure 1.

This report documents a review undertaken by Hydro Engineering & Consulting Pty Ltd (HEC) of the environmental performance of the Project in relation to surface water (water resources and watercourses) in the Metropolitan Coal underground mining area and surrounds for the reporting period (1 January to 30 June 2019), consistent with the Metropolitan Coal Longwalls 301-303 Water Management Plan¹ and Metropolitan Coal Catchment Monitoring Program.

2.0 CATCHMENT MONITORING AND SURFACE WATER MODELLING

2.1 BACKGROUND

The Metropolitan Coal Catchment Monitoring Program and Longwalls 301-303 Water Management Plan include a program to monitor and assess impacts on surface water resources and watercourses. The meteorological sites, surface water quantity sites (i.e. streamflow gauging stations and pool water level monitoring) and surface water quality sites at which baseline data is available for the Metropolitan Coal underground mining area are shown on Figure 1 to Figure 3, respectively.

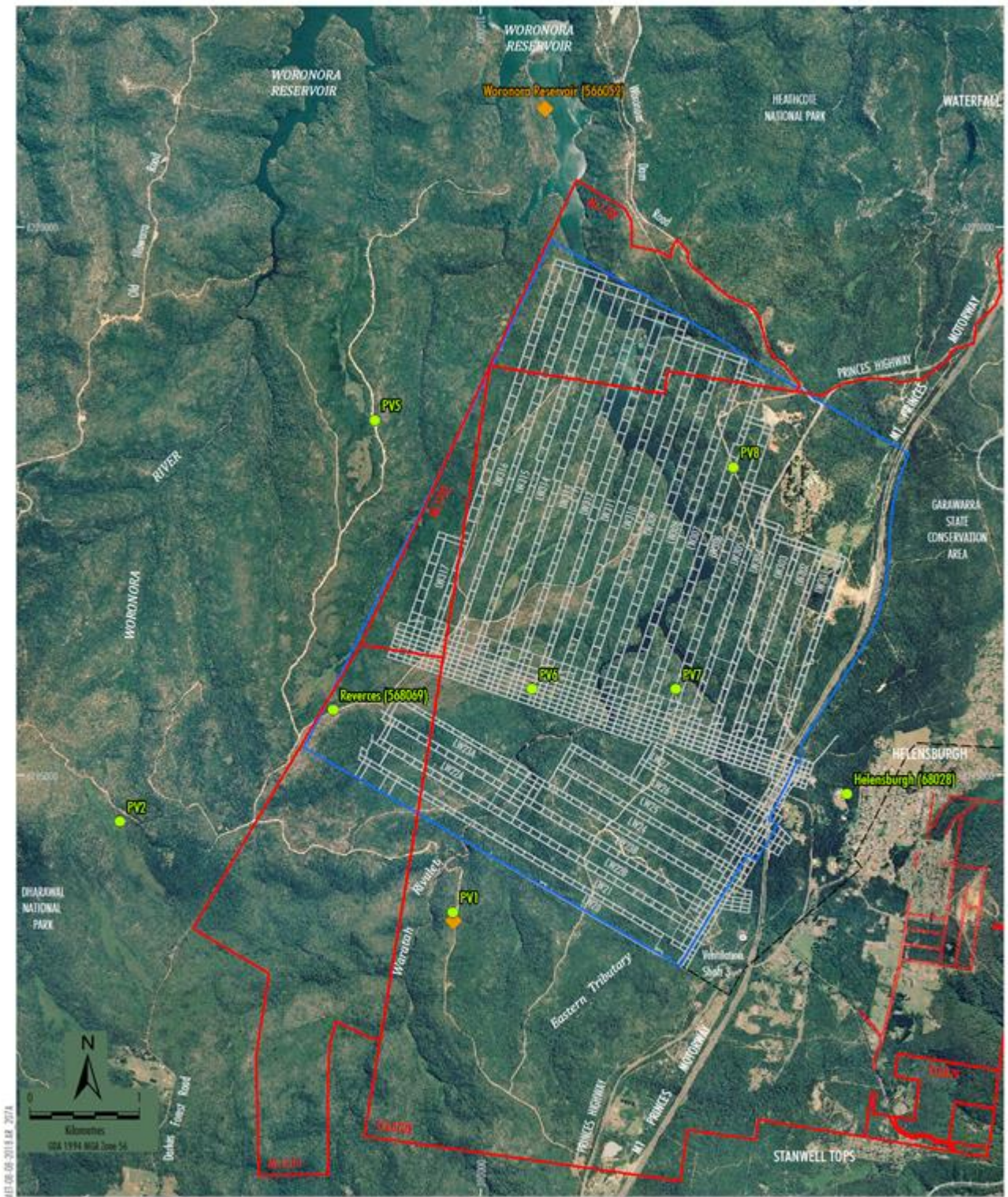
The Metropolitan Coal Catchment Monitoring Program also includes a program for the development, calibration and verification of catchment flow models.

2.2 STREAMFLOW

Surface water flow monitoring is conducted at the following sites:

- the existing Water NSW gauging station on the Waratah Rivulet, close to the inundation limits of the Woronora Reservoir (GS 2132102);
- the existing Water NSW gauging station on the Woronora River, close to the inundation limits of the Woronora Reservoir (GS 2132101) (control site);
- the existing Water NSW gauging station on O'Hares Creek at Wedderburn (GS 213200) (control site);
- the existing Metropolitan Coal gauging station on the Eastern Tributary (GS 300078) close to the inundation limits of the Woronora Reservoir; and
- the existing Metropolitan Coal gauging station on Honeysuckle Creek (GS 300077) (control site).

¹ The Metropolitan Coal Longwalls 301-303 Water Management Plan includes post-mining monitoring and management of water resources and watercourses for Longwalls 20-27.



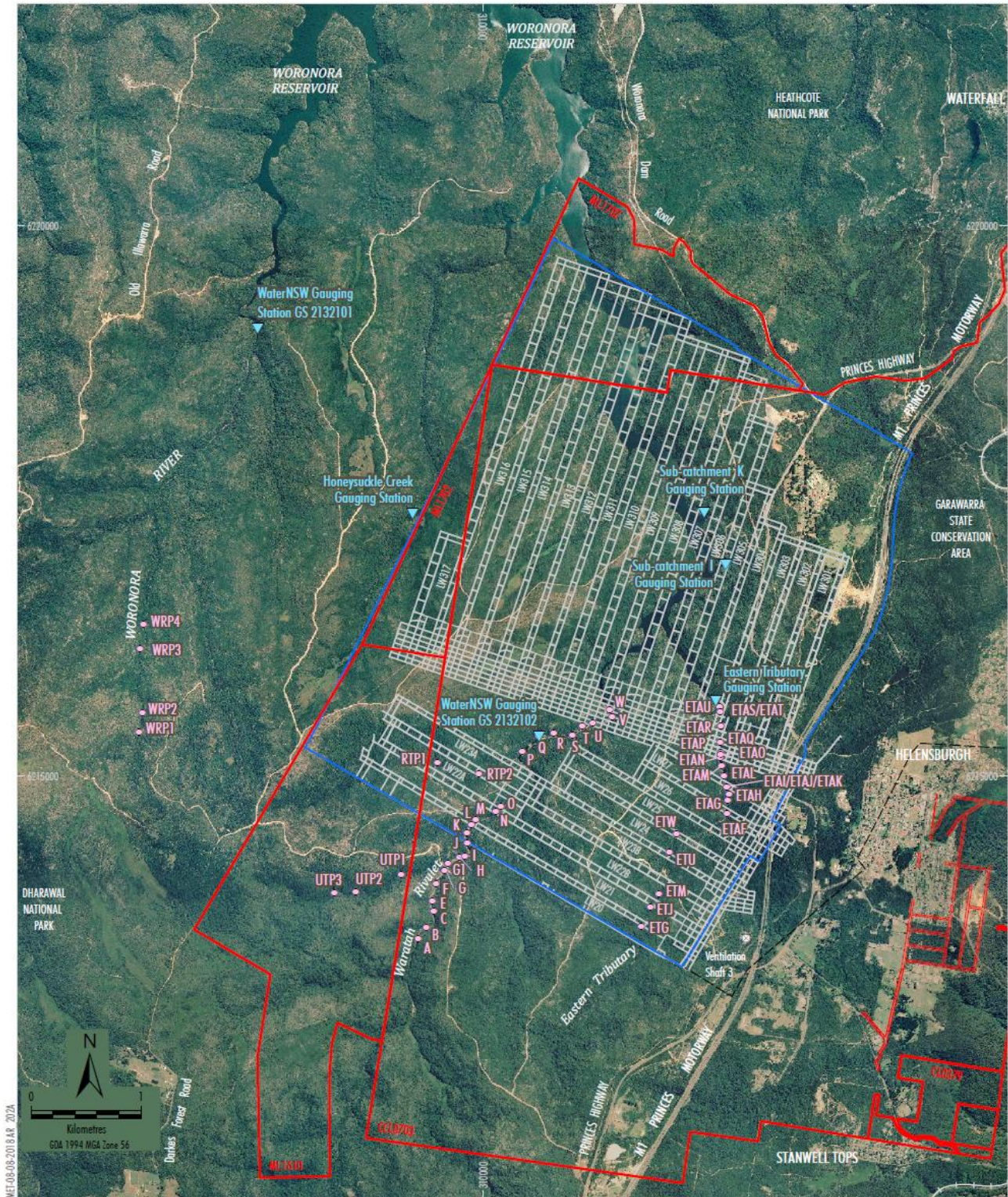
- LEGEND**
- Mining Lease Boundary
 - Railway
 - Project Underground Mining Area
Longwalls 20-27 and 301-317
 - Existing Underground Access Drive (Main Drift)
 - ◆ Evaporimeter
 - Pluviometer

Notes: 1. The Bureau of Meteorology pluviometer at Dorcas Forest (68024) is not shown. It is located approximately 3.75 km south of the Metropolitan Coal pluviometer (PV2).
 2. The Bureau of Meteorology pluviometer at Lucas Heights (66078) is not shown. It is located approximately 12.5 km north of the Metropolitan Coal pluviometer (PV8).

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2019); MSEC (2019)

Peabody
 METROPOLITAN COAL
 Meteorological Sites

Figure 1 Meteorological Sites

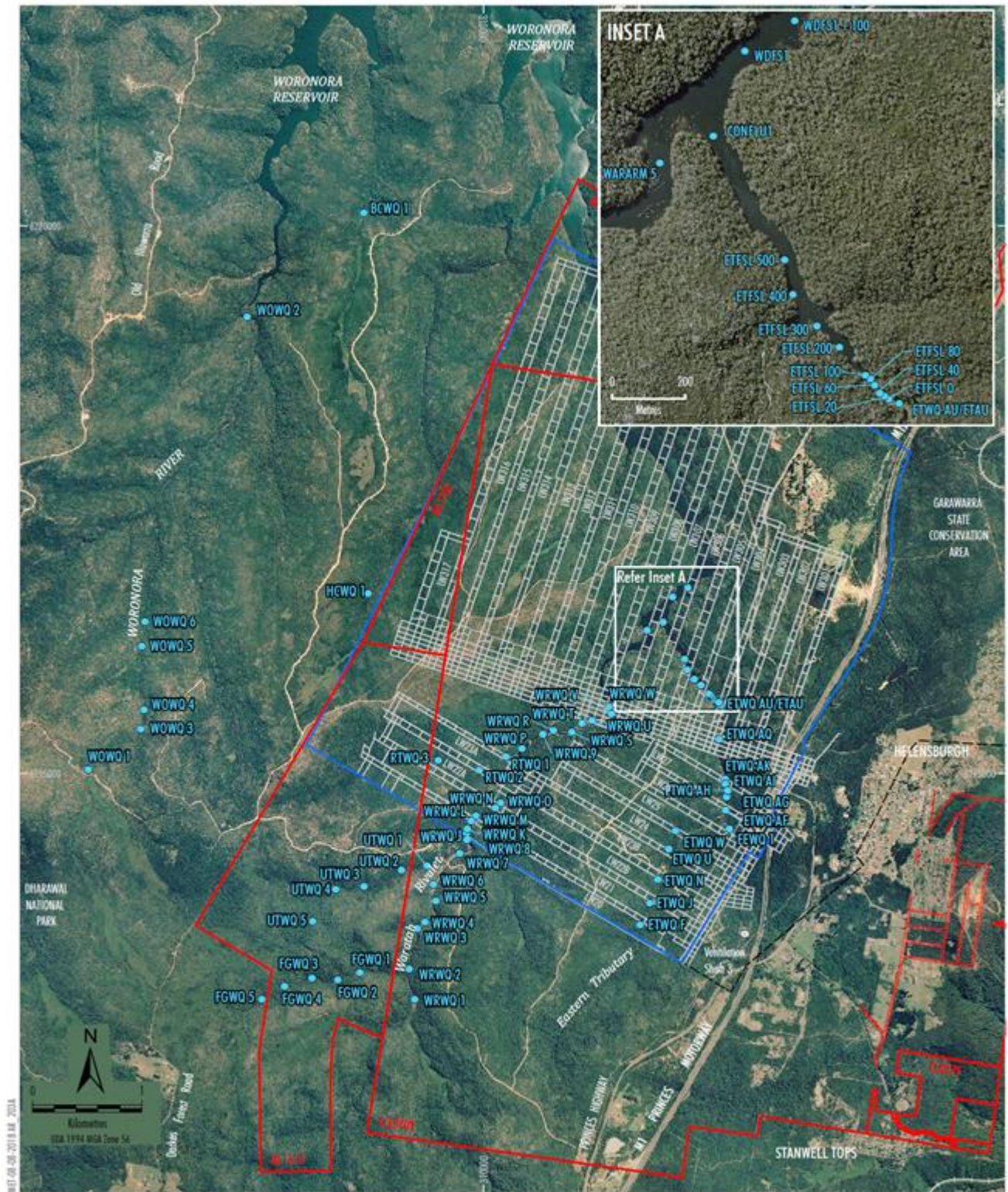


- LEGEND
- Mining Lease Boundary
 - Railway
 - Project Underground Mining Area
Longwalls 20-27 and 301-317
 - Existing Underground Access Drive (Main Drift)
 - ▼ Gauging Station
 - Pool Water Level Site

Source: Land and Property Information (2015); Date of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2019); MSEC (2019)

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Surface Water Quantity Sites

Figure 2 Surface Water Quantity Sites



MIS-08-28-2018 AM 2018

- LEGEND**
- Mining Lease Boundary
 - Railway
 - Project Underground Mining Area
Longwalls 20-27 and 301-317
 - Existing Underground Access Drive (Main Drift)
 - Surface Water Quality Site

Source: Land and Property Information (2015); Data of Aerial Photography 1998; Department of Industry (2015); Metropolitan Coal (2019); MSEC (2019)

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Surface Water Quality Sites

Figure 3 Surface Water Quality Sites

Flow records from the Waratah Rivulet (GS 2132102), Woronora River (GS 2132101) and O'Hares Creek at Wedderburn (GS 213200) gauging stations were regenerated using amended rating relationships developed by Gilbert & Associates (2015a) on behalf of Metropolitan Coal (as described in HEC, 2016).

Numerical catchment models for the Waratah Rivulet, Woronora River and O'Hares Creek catchments have been developed based on the nationally recognised Australian Water Balance Model (AWBM) (Boughton, 2004). The AWBM is a catchment-scale water balance model that estimates streamflow from rainfall and evaporation. Revised and re-calibrated catchment models (Gilbert & Associates, 2015b) have been used to assess potential subsidence impacts on the quantity of water resources reaching the Woronora Reservoir (as described in HEC, 2016).

2.3 POOL WATER LEVELS

Water levels in a number of pools on the Waratah Rivulet (Pools A, B, C, E, F, G, G1, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V and W), Eastern Tributary (Pools ETG, ETJ, ETM, ETU, ETW, ETAF, ETAG, ETAH, ETAI, ETAQ, ETAT and ETAU), Tributary B/Reference Tributary (Pools RTP1 and RTP2) and Woronora River (Pools WRP1, WRP2, WRP3 and WRP4) have been either manually monitored on a daily basis or monitored using a continuous water level sensor and logger. Recorded pool water level hydrographs are provided as a series of charts in Appendix A.

Pool water levels are controlled by different forms of natural controls with different hydraulic characteristics. Conceptually, these can be grouped into the following three types:

1. An 'effectively impermeable' rock bar control with limited continuous jointing and fracturing resulting in negligible flow either through or under the rock-bar;
2. A 'permeable' rock bar control where the presence of fractures and open joints in the rock-bar permits significant flow through or under the rock-bar; and
3. A boulder field which constricts downstream flow but where a significant flow occurs through the interstices between the boulder rock elements (i.e. braided flow).

A description of the water level behaviour for each pool during the 1 January to 30 June 2019 review period is provided in Table 1. In summary, all pools on Waratah Rivulet remained above the cease to flow level or historical minimum except for Pool A and Pool N. Pool A fell below the cease to flow level from February until mid-March 2019, while Pool N fell below the cease to flow level for a short period in March 2019. The reduction in water level at these pools is consistent with a reduction in water level also observed at control pools WRP1, WRP2, WRP3 and WRP4 on the Woronora River during the same periods (refer Chart A41 to Chart A44, Appendix A). Visual inspections undertaken by Metropolitan Coal indicated that WRP2 ceased to flow from the beginning of February to mid-March and again for a short period at the beginning of June 2019. The visual inspections also identified that WRP1, WRP3 and WRP4 ceased to flow from the beginning of February to mid-March and from the middle of April to the beginning of June.

Water levels in Pools ETG, ETJ, ETM, ETU, ETW, ETAF, ETAG, ETAH, ETAI and ETAQ on the Eastern Tributary were regularly below the cease to flow levels or historically low water levels during the review period. Pool water levels responded to rainfall events during the review period before returning to below the cease to flow levels or sensor levels. Pool ETAT and Pool ETAU did not fall below their cease to flow levels during the review period.

Pool RTP1 on Tributary B was dry during the review period, consistent with natural behaviour. Pool RTP2 was typically below the cease to flow level, however water levels rose for short durations following rainfall events.

Table 1 Summary of Pool Water Level Monitoring Results

Pool	Natural Control Characteristics	Recorded Water Level During 1 Jan to 30 June 2019	Comments
<i>Monitored Pools on Waratah Rivulet</i>			
A	Effectively impermeable rock bar. (Pool A impacted by previous mine subsidence and subject to previous stream remediation activities)	The water level of Pool A fell below the cease to flow level from February until mid-March 2019. Visual inspections undertaken by Metropolitan Coal indicated that control pools WRP1, WRP2, WRP3 and WRP4 in Woronora River also stopped flowing during this period. Following a rainfall event in mid-March, the water level rose above the cease to flow level and Pool A continued to flow for the remainder of the review period (Chart A1 [manual observations] and Chart A2 [logger data] in Appendix A).	Metropolitan Coal's visual inspections indicate that Pool A ceased to flow from the beginning of February until the middle of March 2019.
B	Effectively impermeable rock bar. (Pool B impacted by previous mine subsidence)	Water level records for Pool B were consistent with natural behaviour and indicate that the pool continued to flow for the duration of the review period (Chart A3 in Appendix A [manual observations]).	Metropolitan Coal's visual inspections indicate that Pool B was overflowing the rock bar on all inspection occasions.
C	Effectively impermeable rock bar. (Pool C impacted by previous mine subsidence)	Pool C water levels were consistent with natural behaviour and indicate that the pool continued to flow for the duration of the review period (Chart A4 in Appendix A [manual observations]).	Metropolitan Coal's visual inspections indicate that Pool C was overflowing the rock bar on all inspection occasions.
E	Effectively impermeable rock bar. (Pool E impacted by previous mine subsidence)	Water level records for Pool E were consistent with natural behaviour and indicate that the pool continued to flow for the duration of the review period (Chart A5 in Appendix A [manual observations]).	Metropolitan Coal's visual inspections indicate that Pool E was overflowing the rock bar on all inspection occasions.
F	Effectively impermeable rock bar. (Pool F impacted by previous mine subsidence and subject to previous stream remediation activities)	Water level records for Pool F were consistent with natural behaviour and indicate that the pool continued to flow for the duration of the review period (Chart A6 [manual observations] and Chart A7 [logger data] in Appendix A).	Metropolitan Coal's visual inspections indicate that Pool F was overflowing the rock bar on all inspection occasions.

Table 1 (Continued) Summary of Pool Water Level Monitoring Results

Pool	Natural Control Characteristics	Recorded Water Level During 1 Jan to 30 June 2019	Comments
G	Effectively impermeable rock bar. (Pool G impacted by previous mine subsidence and subject to previous stream remediation activities)	Water level records for Pool G were consistent with natural behaviour and indicate that the pool continued to flow for the duration of the review period (Chart A8 in Appendix A [manual observations]).	Metropolitan Coal's visual inspections indicate that Pool G was overflowing the rock bar on all inspection occasions.
G1	Effectively impermeable rock bar. (Pool G1 impacted by previous mine subsidence)	Water level records for Pool G1 were consistent with natural behaviour and indicate that the pool continued to flow for the duration of the review period (Chart A9 in Appendix A [manual observations]).	Metropolitan Coal's visual inspections indicate that Pool G1 was overflowing the rock bar on all inspection occasions.
H	Effectively impermeable rock bar.	Water level records for Pool H were consistent with natural behaviour and indicate that the pool continued to flow for the duration of the review period (Chart A10 in Appendix A [manual observations]).	Metropolitan Coal's visual inspections indicate that Pool H was overflowing the rock bar on all inspection occasions.
I	Effectively impermeable rock bar.	Water level records for Pool I were consistent with natural behaviour and indicate that the pool continued to flow for the duration of the review period (Chart A11 in Appendix A [manual observations]).	Metropolitan Coal's visual inspections indicate Pool I was overflowing the rock bar on all inspection occasions.
J	Effectively impermeable rock bar.	Pool water levels (stage levels from GS 300017) indicate that the pool continued to flow for the duration of the review period and were consistent with natural behaviour (Chart A12 in Appendix A [stage levels from the Metropolitan Coal gauging station]).	Metropolitan Coal's visual inspections indicate Pool J was overflowing the rock bar on all inspection occasions.
K	Effectively impermeable rock bar.	Pool K water levels were consistent with natural behaviour and indicate that the pool continued to flow for the duration of the review period (Chart A13 in Appendix A [logger data]).	Metropolitan Coal's visual inspections indicate Pool K was overflowing the rock bar on all inspection occasions.

Table 1 (Continued) Summary of Pool Water Level Monitoring Results

Pool	Natural Control Characteristics	Recorded Water Level During 1 Jan to 30 June 2019	Comments
L	Effectively impermeable rock bar.	Water level records for Pool L were consistent with natural behaviour and indicate that the pool continued to flow for the duration of the review period (Chart A14 in Appendix A [logger data]).	Metropolitan Coal's visual inspections indicate Pool L was overflowing the rock bar on all inspection occasions.
M	Effectively impermeable rock bar.	Pool M water levels were consistent with natural behaviour and indicate that the pool continued to flow for the duration of the review period (Chart A15 in Appendix A [logger data]).	Metropolitan Coal's visual inspections indicate Pool M was overflowing the rock bar on all inspection occasions.
N	Effectively impermeable rock bar. (Pool N impacted by mine subsidence; first ceased to overflow the rock bar in September 2012)	Water level records for Pool N indicate that the pool ceased to flow for a short period in March 2019. For the remainder of the review period, the pool water level was consistent with natural behaviour (Chart A16 in Appendix A [logger data]).	Metropolitan Coal's visual inspections indicate that Pool M ceased to flow from 8 to 14 March 2019. The pool was observed to be flowing on all other inspection occasions.
O	Boulder field.	Pool O water levels were consistent with natural behaviour for the duration of the review period (Chart A17 in Appendix A [logger data]).	Metropolitan Coal's visual inspections support the analysis of pool water level data.
P	Permeable rock bar.	Recorded pool water levels were near historically low recorded water levels for the duration of the monitoring period. Consistent with natural behaviour, the water level rose in March 2019 in response to a rainfall event, before returning to near the historical minimum for the remainder of the review period (Chart A18 in Appendix A [logger data]).	Metropolitan Coal's visual inspections indicate Pool P water levels appeared consistent with natural behaviour on all inspection occasions.

Table 1 (Continued) Summary of Pool Water Level Monitoring Results

Pool	Natural Control Characteristics	Recorded Water Level During 1 Jan to 30 June 2019	Comments
Q	Effectively impermeable rock bar.	Stage levels from the Water NSW gauging station (GS 2132102) indicate that Pool Q water levels were consistent with natural behaviour and continued to overflow the rock bar for the duration of the monitoring period (Chart A19 in Appendix A [stage levels from the Water NSW gauging station]).	Metropolitan Coal's visual inspections indicate Pool Q was overflowing the rock bar on all inspection occasions.
R	Effectively impermeable rock bar.	Recorded pool water levels were above the cease to flow level and consistent with natural behaviour for the duration of the monitored period ¹ (Chart A20 in Appendix A [logger data]).	Metropolitan Coal's visual inspections indicate Pool R was overflowing on all inspection occasions.
S	Effectively impermeable rock bar.	Recorded pool water levels were at or above the cease to flow level and consistent with natural behaviour for the duration of the review period (Chart A21 in Appendix A [logger data]).	Metropolitan Coal's visual inspections indicate Pool S was overflowing the rock bar on all inspection occasions.
T	Permeable rock bar.	Consistent with natural behaviour, the water level of Pool T rose in March 2019 in response to a rainfall event before returning to near the historical minimum for the remainder of the review period (Chart A22 in Appendix A [logger data]).	Metropolitan Coal's visual inspections indicate Pool T was overflowing on all inspection occasions.
U	Boulder field.	Recorded pool levels were at or above the previously recorded minimum water level and consistent with natural behaviour for the duration of the monitored period ² (Chart A23 in Appendix A [logger data]).	Metropolitan Coal's visual inspections indicate Pool U water levels were consistent with natural behaviour on all inspection occasions.

¹ The sensor malfunctioned on 14 February 2019 and was replaced on 24 April 2019. As such, no data was recorded during this period.

² The sensor malfunctioned on 6 June 2019 and was replaced in July 2019. As such, no data was recorded during this period.

Table 1 (Continued) Summary of Pool Water Level Monitoring Results

Pool	Natural Control Characteristics	Recorded Water Level During 1 Jan to 30 June 2019	Comments
V	Permeable rock bar.	Consistent with natural behaviour, the water level of Pool V rose in March 2019 in response to a rainfall event before returning to near the historical minimum for the remainder of the review period (Chart A24 in Appendix A [logger data]).	Metropolitan Coal's visual inspections indicate Pool V water levels were consistent with natural behaviour on all inspection occasions.
W	Boulder field.	Consistent with natural behaviour, the water level of Pool W rose in March 2019 in response to a rainfall event before returning to near the historical minimum for the remainder of the review period (Chart A25 in Appendix A [logger data]).	Metropolitan Coal's visual inspections indicate Pool W water levels were consistent with natural behaviour on all inspection occasions.
<i>Monitored Pools on Eastern Tributary</i>			
ETG	Effectively impermeable rock bar. (Pool ETG impacted by previous mine subsidence)	Recorded pool water levels were at or slightly below the cease to flow level for the majority of the review period except for a short duration in March 2019 in which the water level rose above the cease to flow level following a rainfall event (Chart A26 in Appendix A [logger data]).	Metropolitan Coal's visual inspections support the analysis of pool water level data.
ETJ	Effectively impermeable rock bar. (Pool ETJ impacted by previous mine subsidence)	Pool water levels fell below the sensor level from February to mid-March 2019. The pool water level rose in mid-March 2019 in response to a rainfall event and remained above the sensor level until early May 2019. From May to July 2019, the water level was below the sensor level (Chart A27 in Appendix A [logger data]).	Metropolitan Coal's visual inspections support the analysis of pool water level data.

Table 1 (Continued) Summary of Pool Water Level Monitoring Results

Pool	Natural Control Characteristics	Recorded Water Level During 1 Jan to 30 June 2019	Comments
ETM	Permeable rock bar. (Pool ETM impacted by previous mine subsidence)	Pool water levels fell below the sensor level from mid-January until mid-March 2019. The pool water level rose in mid-March 2019 in response to a rainfall event and remained above the sensor level until mid-April 2019. From mid-April to July 2019, the water level was below the sensor level (Chart A28 in Appendix A [logger data]).	Metropolitan Coal's visual inspections support the analysis of pool water level data.
ETU	Boulder field. (Pool ETU impacted by previous mine subsidence)	Pool water levels fell below the sensor level during the first half of March 2019. For the remainder of the review period, the water level was above the sensor level and consistent with natural behaviour (Chart A29 in Appendix A [logger data]).	Metropolitan Coal's visual inspections support the analysis of pool water level data.
ETW	Effectively impermeable rock bar. (Pool ETW impacted by previous mine subsidence)	Pool water levels fell below the sensor level during the first half of March 2019 and for a short period at the beginning of June 2019. For the remainder of the review period, the water level was above the sensor level and consistent with natural behaviour (Chart A30 in Appendix A [logger data]).	Metropolitan Coal's visual inspections support the analysis of pool water level data.
ETAF	Permeable rock bar before boulder field. (Pool ETAF impacted by previous mine subsidence)	Pool water levels fell below the sensor level in mid-February until mid-March 2019. The water level rose in response to rainfall events from mid-March to early April 2019 before receding slowly and falling being the sensor level for most of May 2019. Water levels rose again in June 2019 in response to rainfall events (Chart A31 in Appendix A [logger data]).	Metropolitan Coal's visual inspections support the analysis of pool water level data.

Table 1 (Continued) Summary of Pool Water Level Monitoring Results

Pool	Natural Control Characteristics	Recorded Water Level During 1 Jan to 30 June 2019	Comments
ETAG	Boulder field. (Pool ETAG impacted by previous mine subsidence)	Pool water levels were below the sensor level except following rainfall events in the first half of January, from mid-March to mid-April and for a short period at the beginning of June 2019 (Chart A32 in Appendix A [logger data]).	Metropolitan Coal's visual inspections support the analysis of pool water level data.
ETAH	Permeable rock bar. (Pool ETAH impacted by previous mine subsidence).	Pool water levels were below the sensor level for the majority of the review period except following rainfall events in mid-March to early April 2019 and in June 2019 (Chart A33 in Appendix A [logger data]).	Metropolitan Coal's visual inspections support the analysis of pool water level data.
ETAI	Effectively impermeable rock bar. (Pool ETAI impacted by previous mine subsidence).	Pool water levels were below the sensor level for the majority of the review period except following rainfall events in mid-March and in June 2019 (Chart A34 in Appendix A [logger data]).	Metropolitan Coal's visual inspections support the analysis of pool water level data.
ETAQ	Effectively impermeable rock bar. (Pool ETAQ impacted by previous mine subsidence).	Pool water levels were at or above the cease to flow level for the majority of the review period except in the first half of March, and at the beginning and end of June 2019 (Chart A35 in Appendix A [logger data]).	Metropolitan Coal's visual inspections support the analysis of pool water level data.
ETAT	Effectively impermeable rock bar.	Pool ETAT did not cease overflowing the rock bar for the duration of the review period and water levels were consistent with natural behaviour (Chart A36 in Appendix A [logger data]).	Metropolitan Coal's visual inspections support the analysis of pool water level data.
ETAU	Pool ETAU flows through Eastern Tributary gauging station, then over a rock bar and waterfall.	Pool ETAU water levels were consistent with natural behaviour (Chart A37 in Appendix A and Chart A38 in Appendix A [logger data]).	Metropolitan Coal's visual inspections indicate Pool ETAU was overflowing on all inspection occasions.

Table 1 (Continued) Summary of Pool Water Level Monitoring Results

Pool	Natural Control Characteristics	Recorded Water Level During 1 Jan to 30 June 2019	Comments
<i>Monitored Pools on Reference Tributary/Tributary B</i>			
RTP1	Effectively impermeable rock bar. (Pool RTP1 previously impacted by mine subsidence).	Records indicate that Pool RTP1 is typically dry with overflow events limited to significant wet periods. Pool RTP1 was not flowing for the duration of the monitoring period (Chart A39 in Appendix A [logger data]). Metropolitan Coal is not able to access the catchment during significant rain events and has been unable to reduce the recorded data to an equivalent water level because the pool has been invariably dry when the water level logger has been downloaded.	Metropolitan Coal's visual inspections are consistent with pool water level records.
RTP2	Effectively impermeable rock bar.	Records indicate that the water level of Pool RTP2 on Tributary B regularly falls to low levels except during and following rainfall events. The pool water level was below the rock bar for the majority of the review period but rose in response to rainfall events in mid-March and June 2019 (Chart A40 in Appendix A [logger data]).	Metropolitan Coal's visual inspections support the analysis of pool water level data.

2.4 STREAM WATER QUALITY

Surface water quality monitoring and sampling has been conducted at the following sites – refer Figure 3:

- sites WRWQ 2, WRWQ 6, WRWQ 8, WRWQ 9, WRWQ M, WRWQ N, WRWQ P, WRWQ R, WRWQ T and WRWQ W on the Waratah Rivulet;
- site RTWQ 1 on Tributary B;
- site UTWQ 1 on Tributary D;
- sites ETWQ F, ETWQ J, ETWQ N, ETWQ U, ETWQ W, ETWQ AF, ETWQ AH, ETWQ AQ and ETWQ AU on the Eastern Tributary;
- site FEWQ 1 on the Far Eastern Tributary;
- site HCWQ 1 on Honeysuckle Creek;
- site BCWQ 1 on Bee Creek; and
- control sites WOWQ 1 and WOWQ 2 on the Woronora River.

Water quality parameters recorded include electrical conductivity (EC), pH, redox potential (Eh), dissolved oxygen (DO), turbidity, calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), chloride (Cl), sulphate (SO₄), bicarbonate (HCO₃), total nitrogen (N_{tot}), total phosphorus (P_{tot}), nitrate (NO₃), barium (Ba), strontium (Sr), manganese (Mn), iron (Fe), zinc (Zn), cobalt (Co) and aluminium (Al). Samples collected for metal analysis have been field filtered. Unfiltered water quality samples were also collected at a select number of sites on the Waratah Rivulet, Eastern Tributary and Woronora River and analysed for total iron.

Monitoring results for the sites listed above are shown on a series of plots in Appendix B.

2.4.1 Waratah Rivulet

Water quality patterns at monitoring sites over the 1 January to 30 June 2019 review period have generally been consistent with historical water quality data. Upstream sites on Waratah Rivulet (sites WRWQ 2 and WRWQ 6) show slightly acidic to near neutral pH values, with higher (slightly alkaline) values being recorded at middle and lower reach sites (e.g. at sites WRWQ 8, WRWQ T and WRWQ W).

Electrical conductivity values were generally elevated in comparison with pre-2018 values though were consistent with 2018 values. There were no historically high electrical conductivity values recorded during the review period.

Dissolved iron concentrations were typically below 0.5 mg/L during the review period with the exception of WRWQ M which recorded a concentration 0.57 mg/L in June 2019. Dissolved aluminium concentrations were either low or below the detection limit. A slightly increasing trend in dissolved manganese concentrations has been recorded for WRWQ 2, WRWQ 6, WRWQ 8, WRWQ M and WRWQ N since 2016, however no historically high concentrations were recorded during the review period. Dissolved manganese concentrations at other sites were generally low and consistent with historical values.

2.4.2 Woronora River

The sampling sites WOWQ 1 and WOWQ 2 show slightly acidic conditions, with the pH levels recorded during the review period consistent with historical values. The electrical conductivity values recorded at WOWQ 2 have increased in variability since 2016 and have tended to be more elevated, with a high electrical conductivity value of 453 $\mu\text{S}/\text{cm}$ recorded in February 2019.

Dissolved iron concentrations were generally low and similar to values recorded in Waratah Rivulet, with the exception of WOWQ 2 which recorded a dissolved iron concentration of 1.37 mg/L in March 2019. This concentration is less than the historically high dissolved iron concentration of 1.5 mg/L recorded at WOWQ 2 in March 2011. Dissolved aluminium and manganese concentrations recorded at WOWQ 2 were low (less than 0.05 mg/L and 0.1 mg/L respectively). Slightly elevated dissolved aluminium concentrations were recorded at WOWQ 1 though the concentrations were consistent with historical values. A historically high dissolved manganese concentration of 0.26 mg/L was recorded at WOWQ 1 in January 2019. Field notes reported that there was no flowing water at the time of sampling which may have contributed to the elevated concentration of dissolved manganese.

2.4.3 Eastern Tributary

Results for the Eastern Tributary show slightly acidic conditions, with the pH values recorded during the review period consistent with historical values except for ETWQ AH. Variable pH levels were recorded at ETWQ AH though the lowest historically recorded value was not exceeded during the review period.

The electrical conductivity values recorded for the majority of Eastern Tributary sites have tended to be more elevated and variable relative to pre-2016 values. While the electrical conductivity values recorded at ETWQ AU during the review period were consistent with pre-2016 values, the remainder of sites continued to show elevated electrical conductivity levels. However, the highest historically recorded values were not exceeded during the review period.

Variable dissolved aluminium concentrations were recorded at all sites during the review period. The highest dissolved aluminium concentration was recorded at ETWQ AH (0.31 mg/L), though this concentration was significantly less than the highest concentration recorded historically at ETWQ AH of 19.4 mg/L.

Elevated concentrations of dissolved iron have been recorded in the Eastern Tributary since mid-2016, with similar concentrations reported for the review period. ETWQ AQ in particular recorded elevated dissolved iron concentrations ranging from 1.1 to 8.2 mg/L, though the highest historically recorded values were not exceeded during the review period.

Elevated concentrations of dissolved manganese have been recorded in the Eastern Tributary since mid-2016. The highest concentration recorded during the review period was at site ETWQ AQ (1.3 mg/L) though the dissolved manganese concentrations recorded at all other sites were less than 1 mg/L over the review period.

2.4.4 Bee Creek, Honeysuckle Creek, Far Eastern Creek and Tributaries B and D

During the monitoring period, the pH levels recorded at Bee Creek (BCWQ 1) and Honeysuckle Creek (HCWQ 1) indicated slightly acidic conditions, while pH levels in Far Eastern Tributary (FEWQ 1), Tributary B/Reference Tributary (RTWQ 1) and Tributary D/Un-named Tributary (UTWQ 1) were near neutral. The pH levels recorded during the monitoring period were consistent with historical values. The electrical conductivity values at all sites have tended to be more elevated and variable relative to pre-2013 values, with this trend continuing throughout the review period.

Dissolved iron and manganese concentrations were low at all sites during the reporting period and consistent with historical values. Dissolved aluminium concentrations at FEWQ 1, RTWQ 1 and UTWQ 1 were less than 0.2 mg/L during the reporting period, however, spikes of dissolved aluminium persisted at BCWQ 1 and HCWQ 1 over the review period.

2.5 WORONORA RESERVOIR WATER QUALITY

Metropolitan Coal has sourced water quality data for the Woronora Reservoir (at sampling location DW01), Nepean Reservoir (at sampling location DNE2 or DNE1) and Cataract Reservoir (at sampling location DCA1) from WaterNSW in accordance with a data exchange agreement. Results in relation to total iron, aluminium and manganese at levels from 0 m to 9 m below the reservoir surface for Woronora Reservoir are presented in Chart 1 to Chart 3 below.

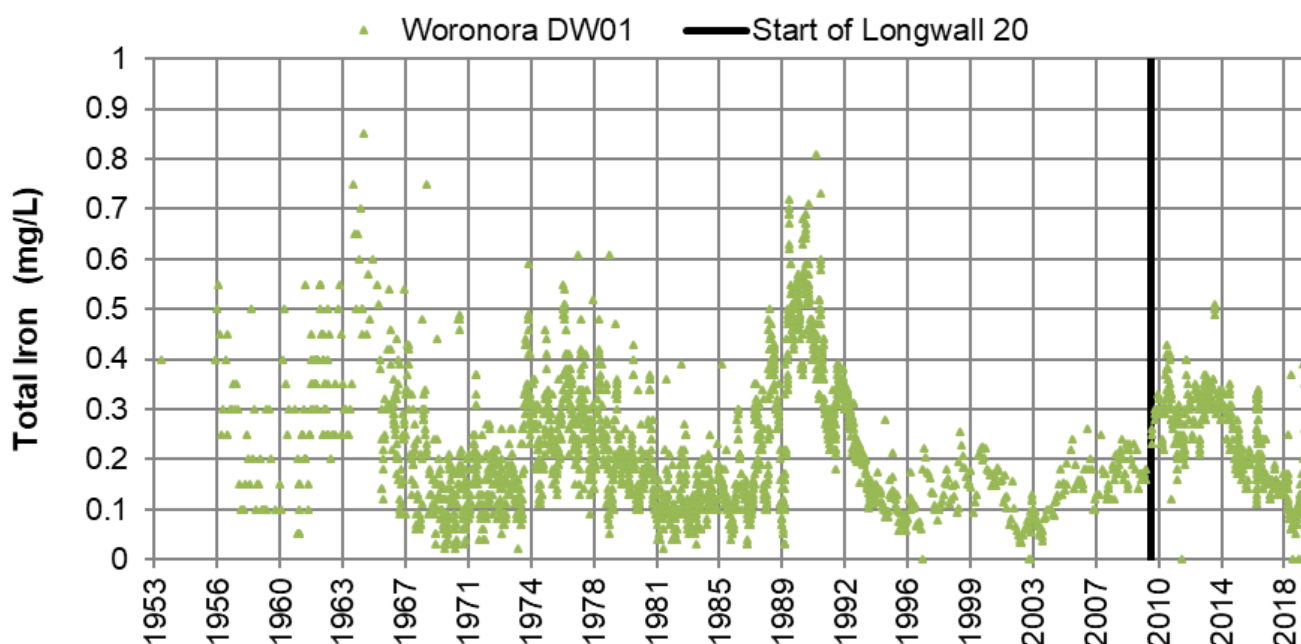


Chart 1 Total Iron Concentration Woronora Reservoir

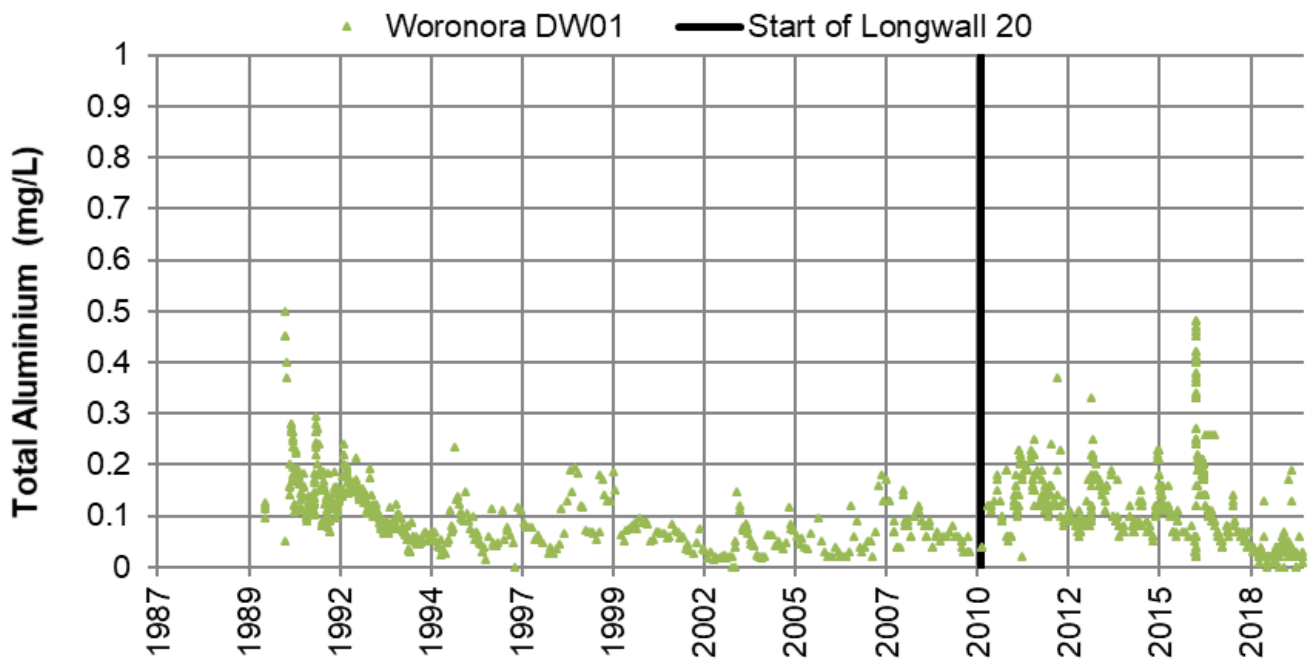


Chart 2 Total Aluminium Concentration Woronora Reservoir

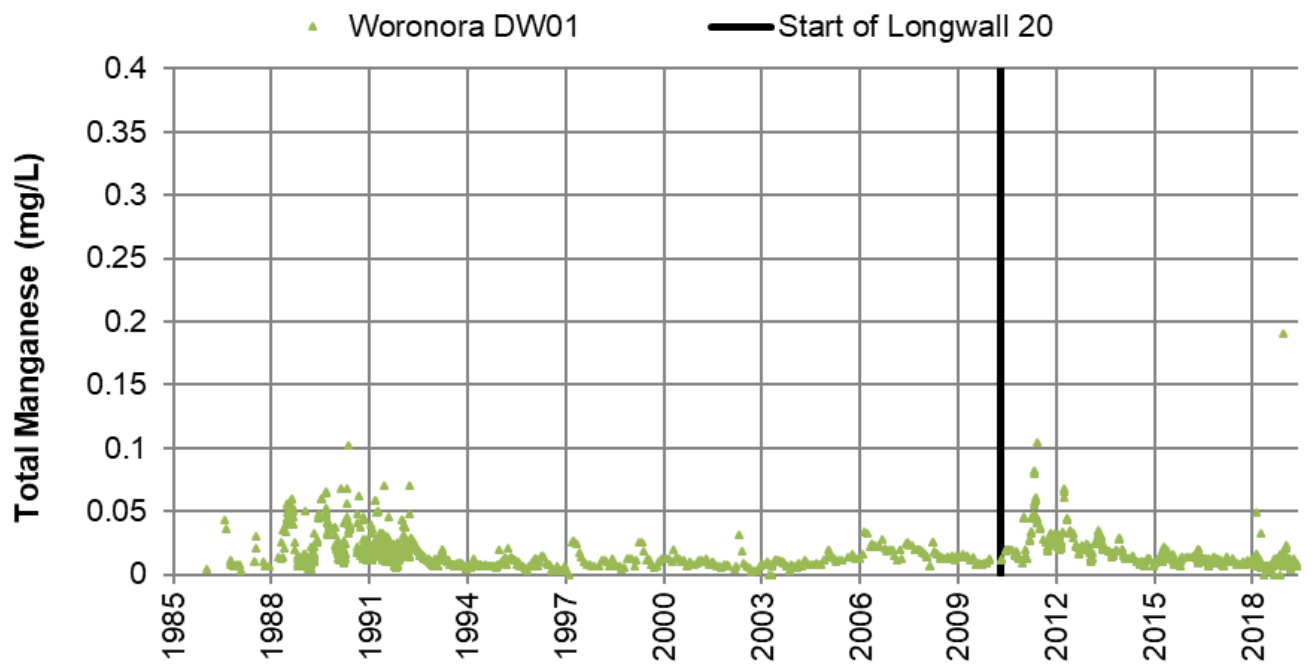


Chart 3 Total Manganese Concentration Woronora Reservoir

3.0 ASSESSMENT AGAINST SURFACE WATER SUBSIDENCE IMPACT PERFORMANCE INDICATORS AND MEASURES

The performance indicators and subsidence impact performance measures described below have been developed to address the predictions of subsidence impacts and environmental consequences on water resources and watercourses included in the Project Environmental Assessment (Helensburgh Coal, 2008), Preferred Project Report (PPR) (Helensburgh Coal, 2009) and Metropolitan Coal Extraction Plans.

3.1 QUANTITY OF WATER RESOURCES REACHING THE WORONORA RESERVOIR

Performance Indicator:

Changes in the quantity of water entering Woronora Reservoir are not significantly different post-mining compared to pre-mining, that are not also occurring in the control catchment(s).

3.1.1 Assessment of Flow Reaching Woronora Reservoir from Waratah Rivulet at GS 2132102

Streamflow data has been analysed to assess whether a statistically significant reduction in the quantity of water entering Woronora Reservoir in the post-mine period relative to the pre-mine period has occurred, that has not also occurred in the control catchment(s).

Measured flows versus modelled flows in Waratah Rivulet have been analysed using a catchment model (a modified version of the AWBM), specifically:

- monitored flows have been filtered in order to assess low flows (i.e. flows of 1 mm/day or less²) by setting monitored flows that are greater than 1 mm/day to equal modelled flows;
- the filtered monitored flows on Waratah Rivulet have been integrated over successive 14 day periods to produce a smoothed set of data for comparison with the corresponding integrated flows (14 day totals) predicted by the modified AWBM for Waratah Rivulet; and
- the ratio of filtered monitored flows divided by the modified AWBM predicted flows has been calculated at 14 day intervals commencing at the beginning of the baseline period and advancing beyond the commencement of Longwall 20 secondary extraction - the median of the ratios has been analysed over a moving window of 1 year.

The results have been assessed against the Longwalls 301-303 Water Management Plan significance levels/triggers (below):

Significance Levels/Triggers	
Negligible Reduction to the Quantity of Water Resources Reaching the Woronora Reservoir	
Level 1	The median of the ratios does not fall below the 35 th percentile of the baseline data
Level 2	The median of the ratios falls below the 35 th percentile but does not fall below the 20 th percentile of the baseline data
Level 3	The median of the ratios falls below the 20 th percentile of the baseline data

Chart 4 shows a plot of the moving 12 month median of the ratio of 14 day sums of monitored flow at Waratah Rivulet (GS 2132102) and flows simulated with the modified AWBM to 30 June 2019.

² Equivalent to a daily flow of 20.5 ML/day at the Waratah Rivulet gauging station.

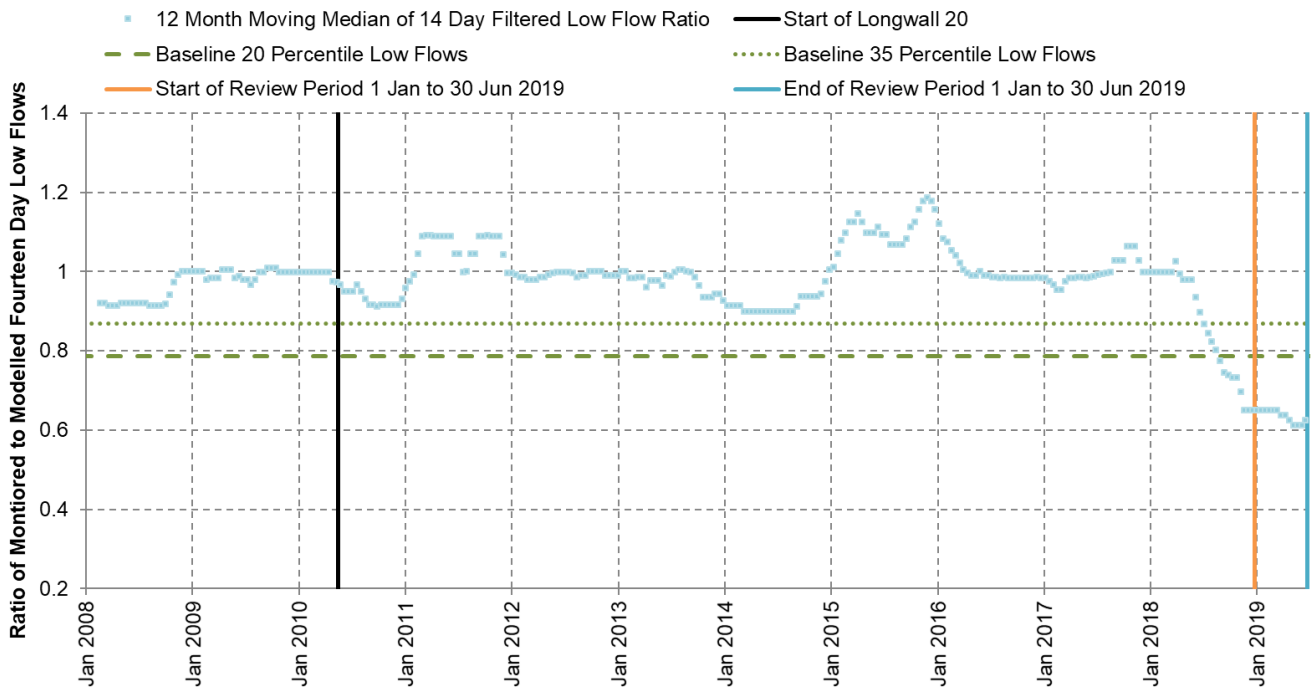


Chart 4 One Year Moving Median for the Ratios of the 14 Day Sums of Monitored and Modelled Flow Rates at Waratah Rivulet (GS 2132102)

The results shows that the moving 12 month median of the 14 day filtered low flow ratio fell below the 20th percentile of the baseline data during 2018 and remained below the 20th percentile of the baseline data during the review period. To assess if similar conditions have been observed at the control site in the region, a comparison of the 12 month median of the ratio of 14 day sums of monitored flow at a control site on O'Hares Creek at Wedderburn (GS 213200) and flows simulated via the modified AWBM have been assessed.

Chart 5 shows a plot of the moving 12 month median of the ratio of 14 day sums of monitored flow at O'Hares Creek at Wedderburn (GS 213200) and flows simulated with the modified AWBM to 30 June 2019.

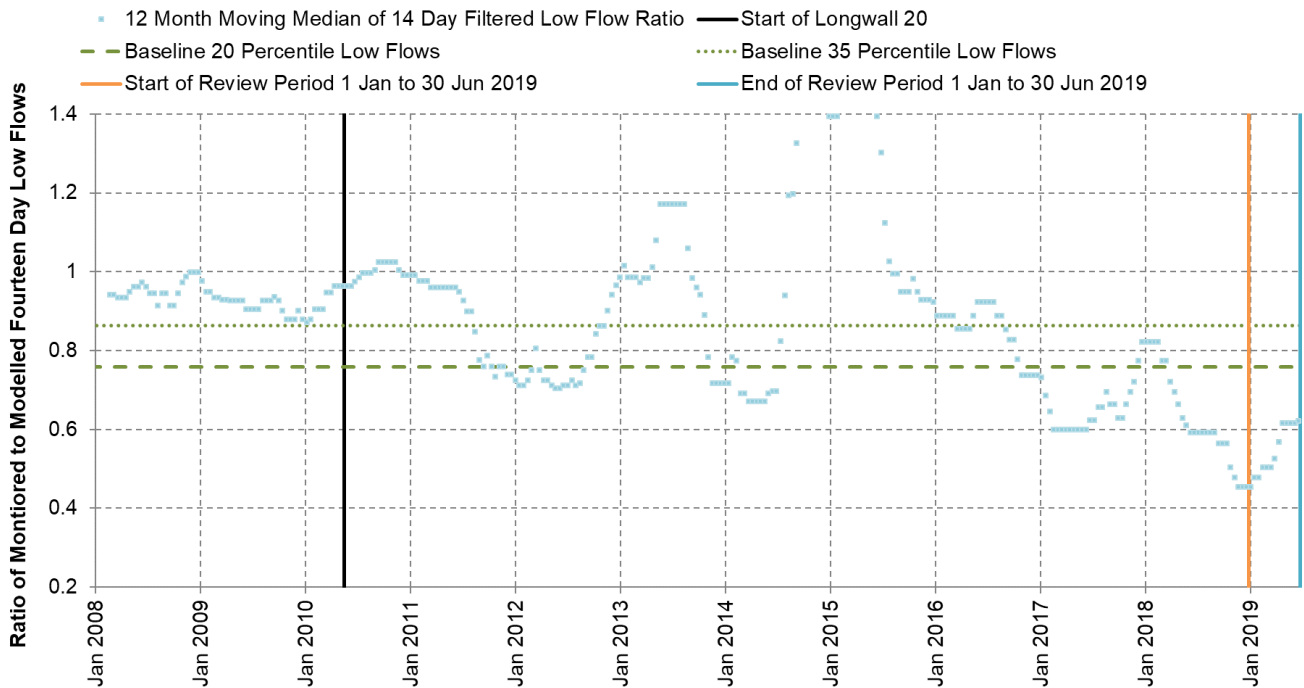


Chart 5 One Year Moving Median for the Ratios of the 14 Day Sums of Monitored and Modelled Flow Rates at O'Hares Creek at Wedderburn (GS 213200)

The results in Chart 5 show that the moving 12 month median of the 14 day filtered low flow ratio at O'Hares Creek at Wedderburn (GS 213200) also remained below the 20th percentile of the baseline data. This illustrates that similar flow conditions have occurred at both Waratah Rivulet and the control site (O'Hares Creek at Wedderburn). As such, while the Metropolitan Coal Longwalls 301-303 Water Management Plan Trigger Action Response Plan (TARP) has reached Level 3, it is considered that the performance indicator relating to the quantity of water entering Woronora Reservoir from Waratah Rivulet has not been exceeded and an assessment against the performance measure is not required.

A more detailed comparison of flows and rainfall data at O'Hares Creek and Waratah Rivulet for the previous reporting period concluded that the performance indicator had not been exceeded and that there was no evidence that the quantity of water reaching the Woronora Reservoir from the Waratah Rivulet catchment during this period had been reduced due to subsidence effects (HEC, 2019). The performance indicator will be considered to be exceeded if the median falls below the 20th percentile and the same is not occurring in the control catchment.

Additional rainfall data has been made available since the modified AWBM for O'Hares Creek at Wedderburn was previously calibrated. The additional dataset provides an improved representation of rainfall records for the O'Hares Creek catchment and, as such, the modified AWBM will be recalibrated using the expanded rainfall dataset. The modelled flow using the recalibrated catchment model will be used to assess the 12 month median of the 14 day filtered low flow ratio for O'Hares Creek at Wedderburn in the next review period.

3.1.2 Assessment of Flow Reaching Woronora Reservoir from Eastern Tributary at GS 300078

Flow data up to 30 June 2019 has been provided from gauging station 300078 – Eastern Tributary upstream of Woronora Reservoir. Flow data is available from station establishment on 23 September 2012. The available data is shown on Chart 6 below together with model predicted results.

Results show that flow has been continuous at the gauging station and that it has been generally consistent with or above model predictions. This indicates that flow reaching the Woronora Reservoir has not been reduced by mining.

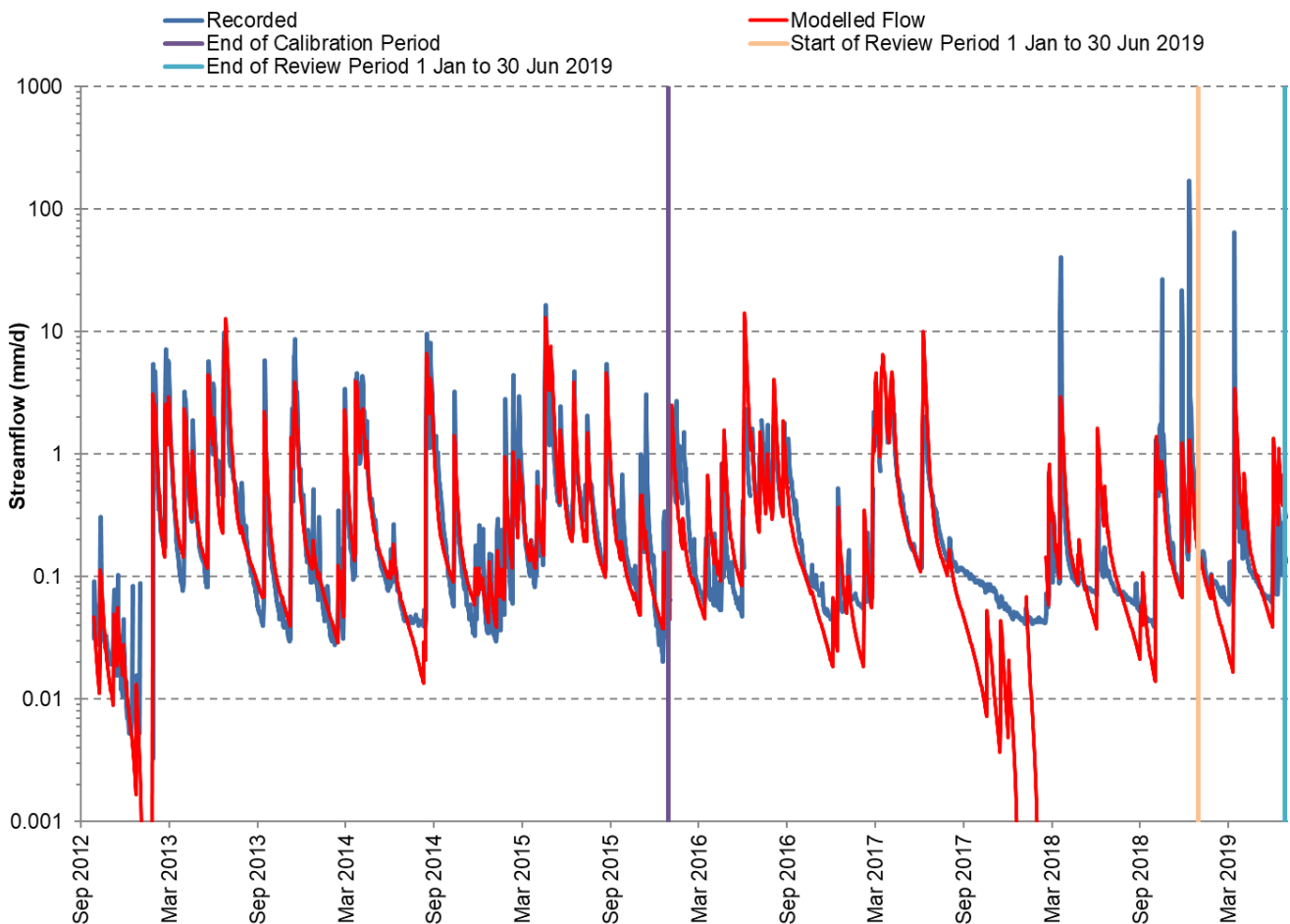


Chart 6 Monitored and Model Predicted Flows – Eastern Tributary Upstream of Woronora Reservoir

3.1.3 Analysis against Subsidence Impact Performance Measure

Subsidence Impact Performance Measure:

Negligible reduction to the quantity of water resources reaching the Woronora Reservoir.

The subsidence impact performance measure is considered to have been exceeded if analysis of the monitoring and modelling results confirms that the Project has resulted in a greater than negligible reduction in the quantity of water resources reaching the Woronora Reservoir.

The performance measure of negligible reduction to the quantity of water resources reaching the Woronora Reservoir has been met.

3.2 QUALITY OF WATER RESOURCES REACHING THE WORONORA RESERVOIR

Performance Indicator:

Changes in the quality of water entering Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations that are not also occurring at control site WOWQ2.

Water quality data has been analysed for key water quality parameters of relevance to water supply and the effects of subsidence, namely dissolved (field filtered) iron, manganese and aluminium at site WRWQ 9 on Waratah Rivulet, site ETWQ AU on Eastern Tributary and at control site WOWQ 2 on the Woronora River.

The results have been assessed against the Longwalls 301-303 Water Management Plan significance levels/triggers (below):

Significance Levels/Triggers	
Negligible Reduction to the Quality of Water Resources Reaching the Woronora Reservoir	
Level 1	Data analysis indicates no water quality parameter exceeds the adjusted baseline mean plus two standard deviations.
Level 2	Data analysis indicates any water quality parameter exceeds the adjusted baseline mean plus two standard deviations for one month.
Level 3	Data analysis indicates: <ul style="list-style-type: none"> • any water quality parameter exceeds the adjusted baseline mean plus two standard deviations for two consecutive months; or • over a three month period the water quality parameter exceeds the adjusted mean plus two standard deviations in the first month, the adjusted mean plus one standard deviation in the next month and the adjusted mean plus two standard deviations in the third month; or • the six month mean exceeds the adjusted baseline mean plus one standard deviation for two consecutive assessment periods (i.e. over two six monthly reports); and • there was not a similar exceedance of the trigger at the control site.

The performance indicator is exceeded if the results indicate a Level 3 significance level/trigger.

3.2.1 Assessment of Water Quality at Site WRWQ 9

Plots showing the concentrations of dissolved iron, dissolved aluminium and dissolved manganese recorded at sampling site WRWQ 9 in relation to the adjusted baseline mean plus one and two standard deviations are shown on Chart 7 to Chart 9 below.

Chart 10 to Chart 12 show the concentrations of dissolved iron, dissolved aluminium and dissolved manganese recorded at control site WOWQ 2 in comparison to the adjusted baseline mean plus one and two standard deviations.

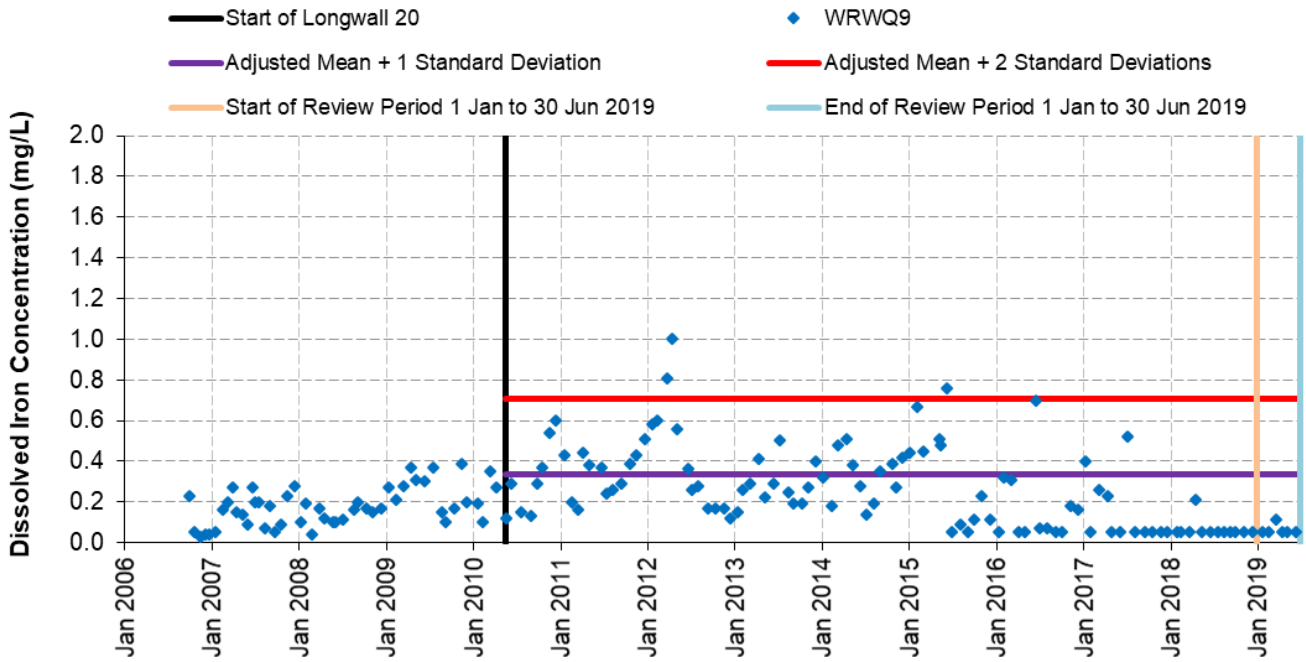


Chart 7 Dissolved Iron Concentrations in Waratah Rivulet at WRWQ9

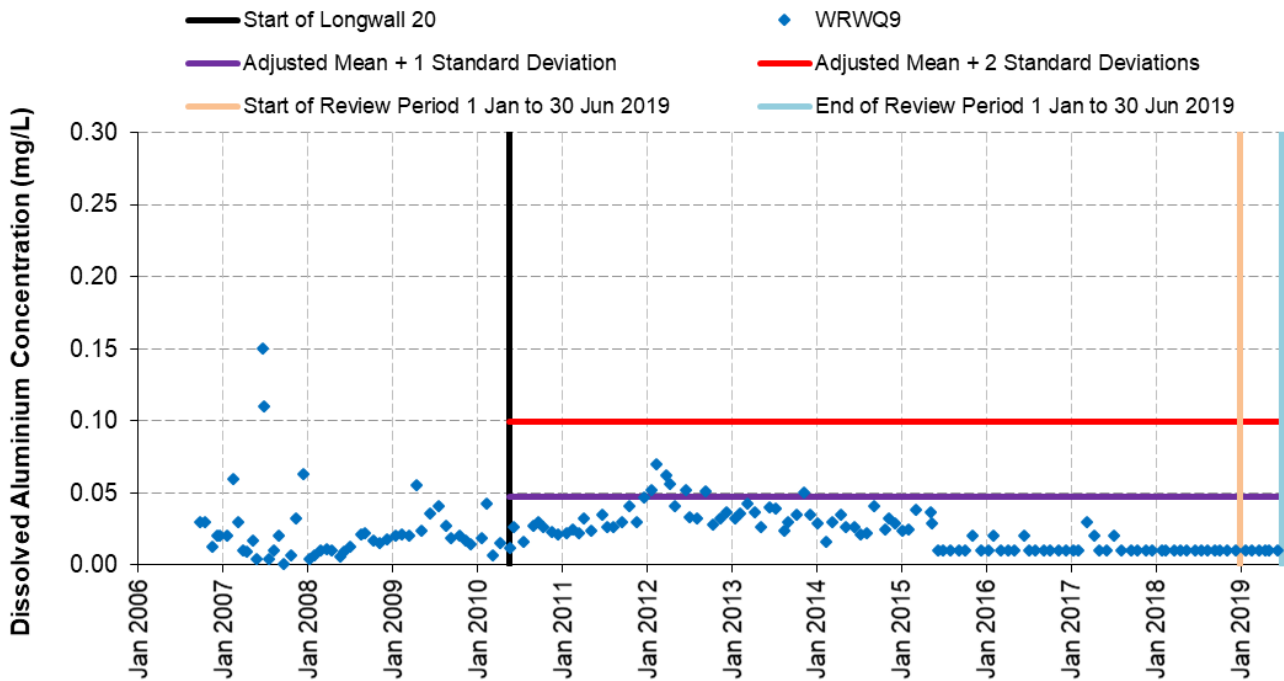


Chart 8 Dissolved Aluminium Concentrations in Waratah Rivulet at WRWQ9

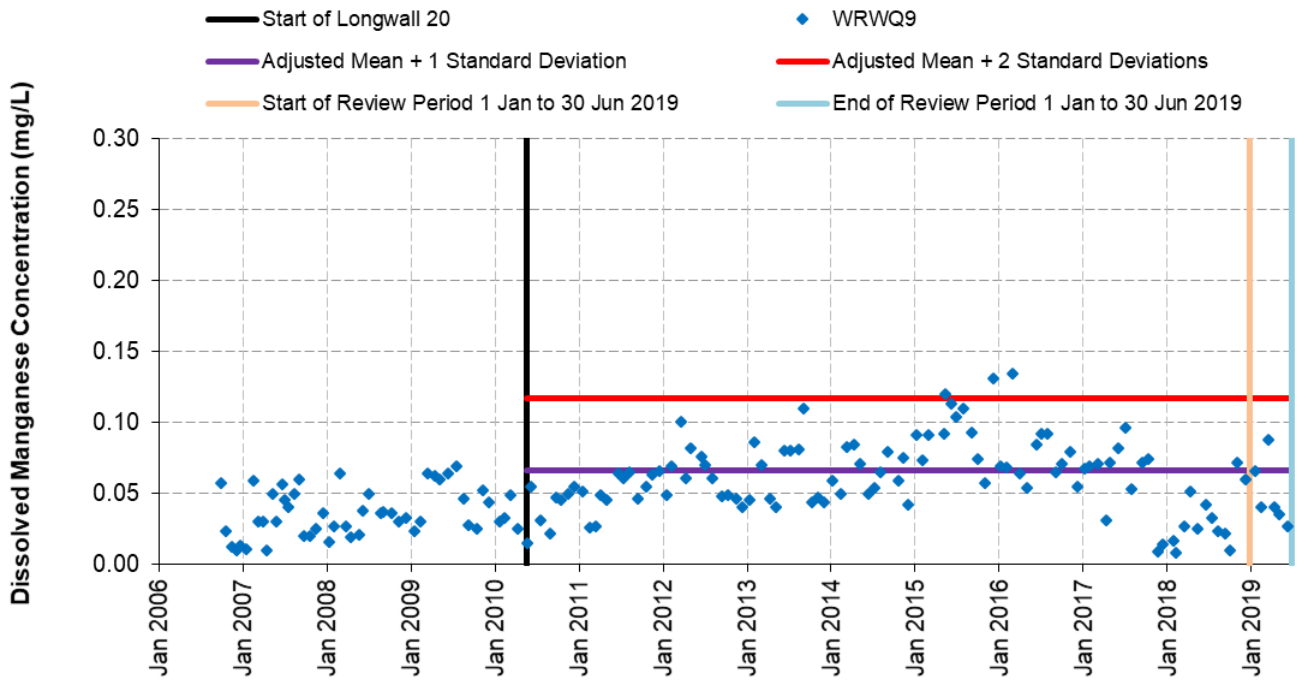


Chart 9 Dissolved Manganese Concentrations in Waratah Rivulet at WRWQ9



Chart 10 Dissolved Iron Concentrations in Woronora River at WOWQ2

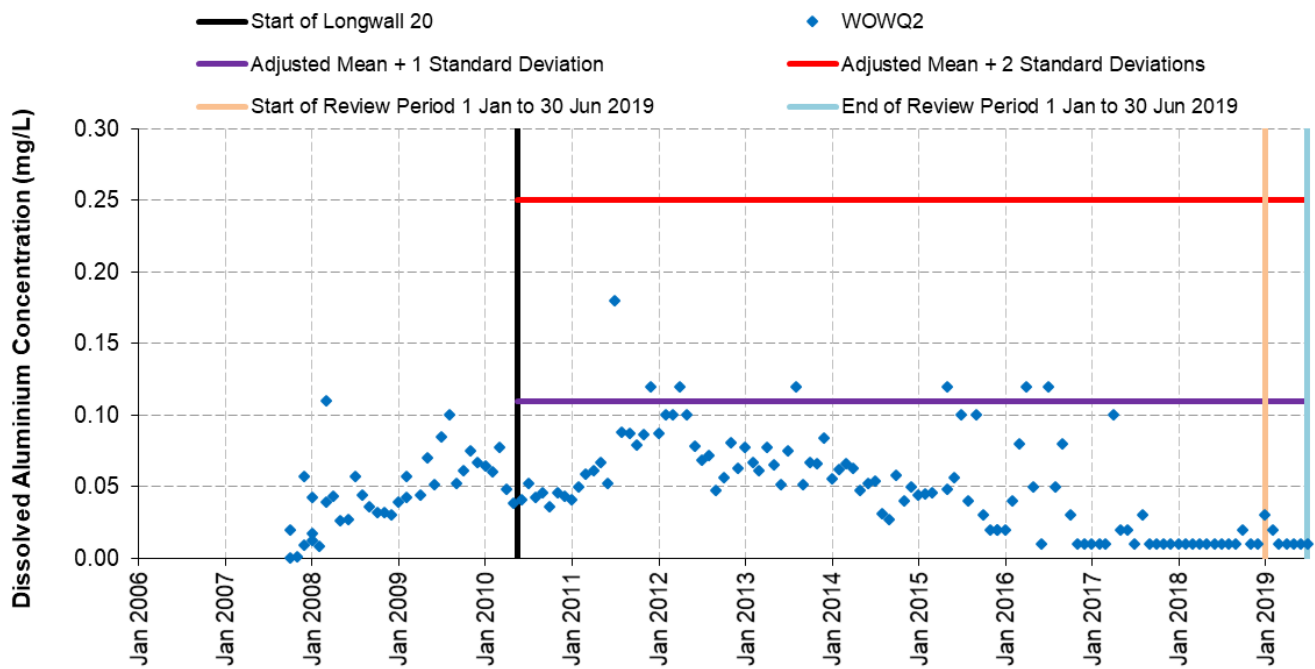


Chart 11 Dissolved Aluminium Concentrations in Woronora River at WOWQ2

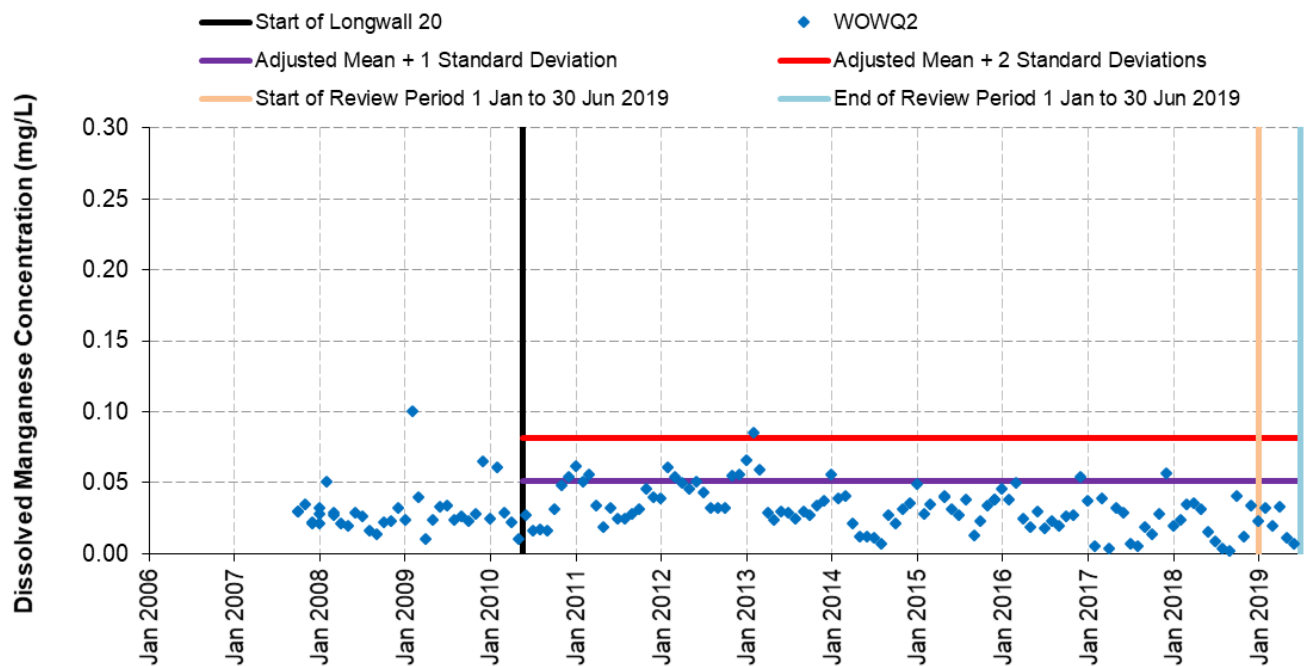


Chart 12 Dissolved Manganese Concentrations in Woronora River at WOWQ2

Chart 7 to Chart 9 indicate there were no exceedances of the adjusted baseline mean plus two standard deviations for dissolved iron, dissolved aluminium or dissolved manganese in Waratah Rivulet at site WRWQ 9 during the reporting period. There were also no exceedances of the adjusted baseline mean plus two standard deviations at control site WOWQ 2 on the Woronora River (Chart 10 to Chart 12).

Plots showing the six monthly mean concentrations for dissolved iron, dissolved aluminium and dissolved manganese recorded at site WRWQ 9 are shown on Chart 13 to Chart 15. For comparison, plots showing the six monthly mean concentrations for the same water quality parameters at control

site WOWQ 2 are shown on Chart 16 to Chart 18. Each plot shows the adjusted baseline mean plus one standard deviation value.

There were no exceedances of the adjusted baseline mean plus one standard deviation for two consecutive six month means for dissolved iron, dissolved aluminium or dissolved manganese in Waratah Rivulet at site WRWQ 9 (Chart 13 to Chart 15) or Woronora River at site WOWQ 2 (Chart 16 to Chart 18) during the reporting period. The above results equate to a Level 1 significance level.

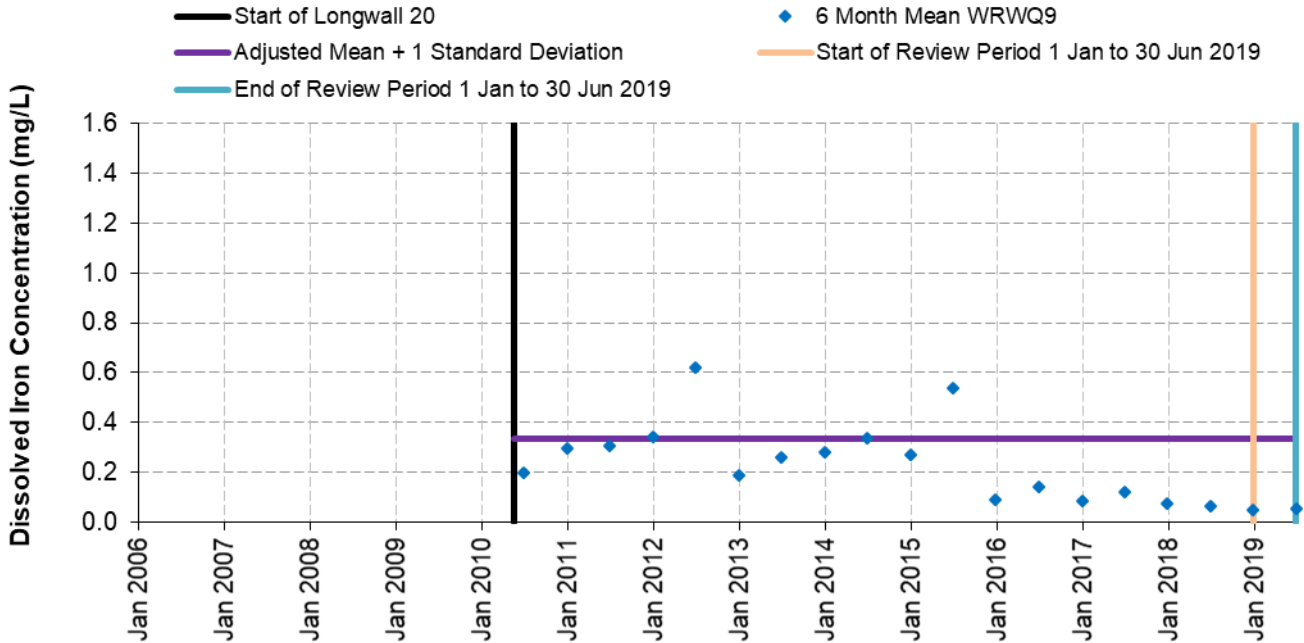


Chart 13 Six Monthly Means of Dissolved Iron Concentrations in Waratah Rivulet at WRWQ9

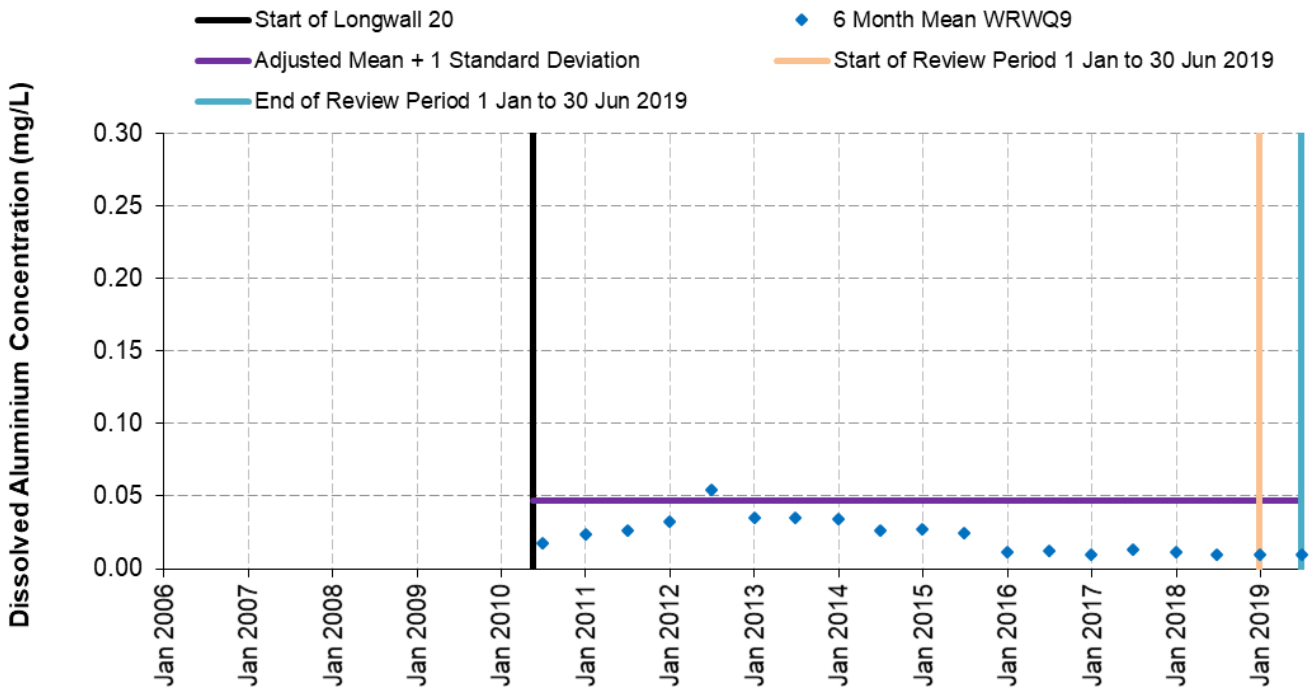


Chart 14 Six Monthly Means of Dissolved Aluminium Concentrations in Waratah Rivulet at WRWQ9

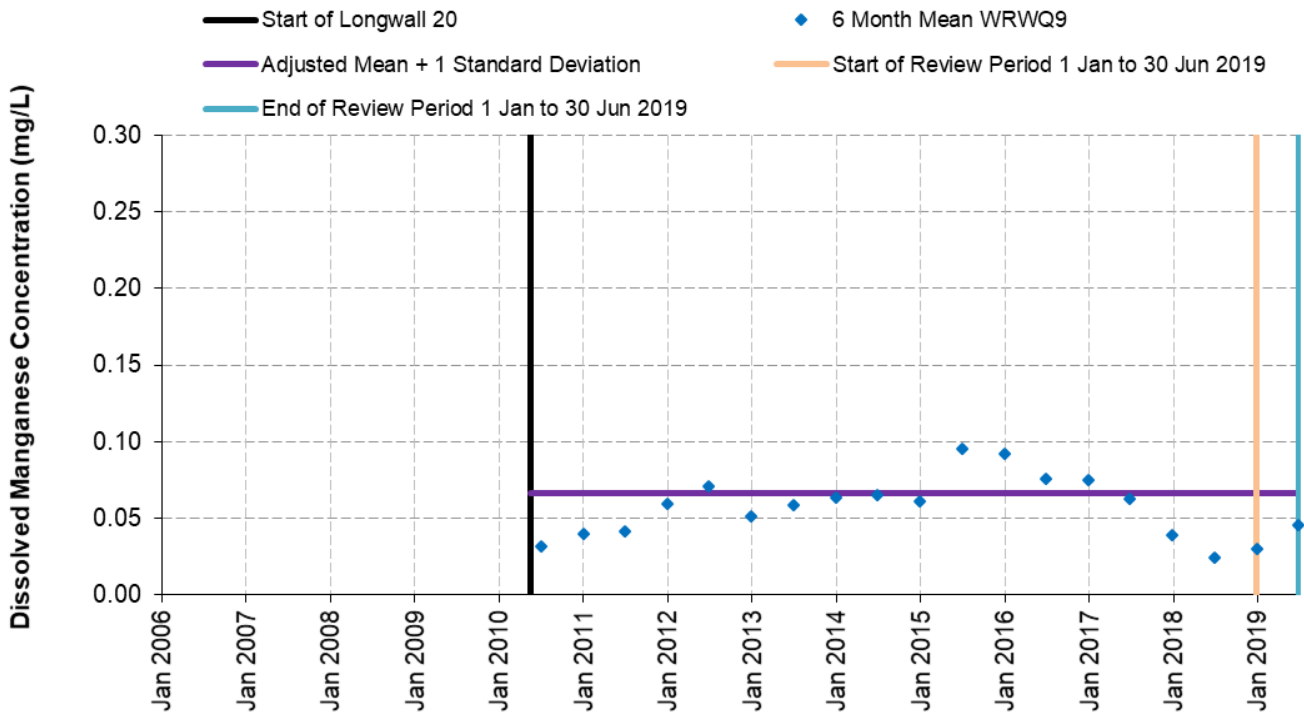


Chart 15 Six Monthly Means of Dissolved Manganese Concentrations in Waratah Rivulet at WRWQ9

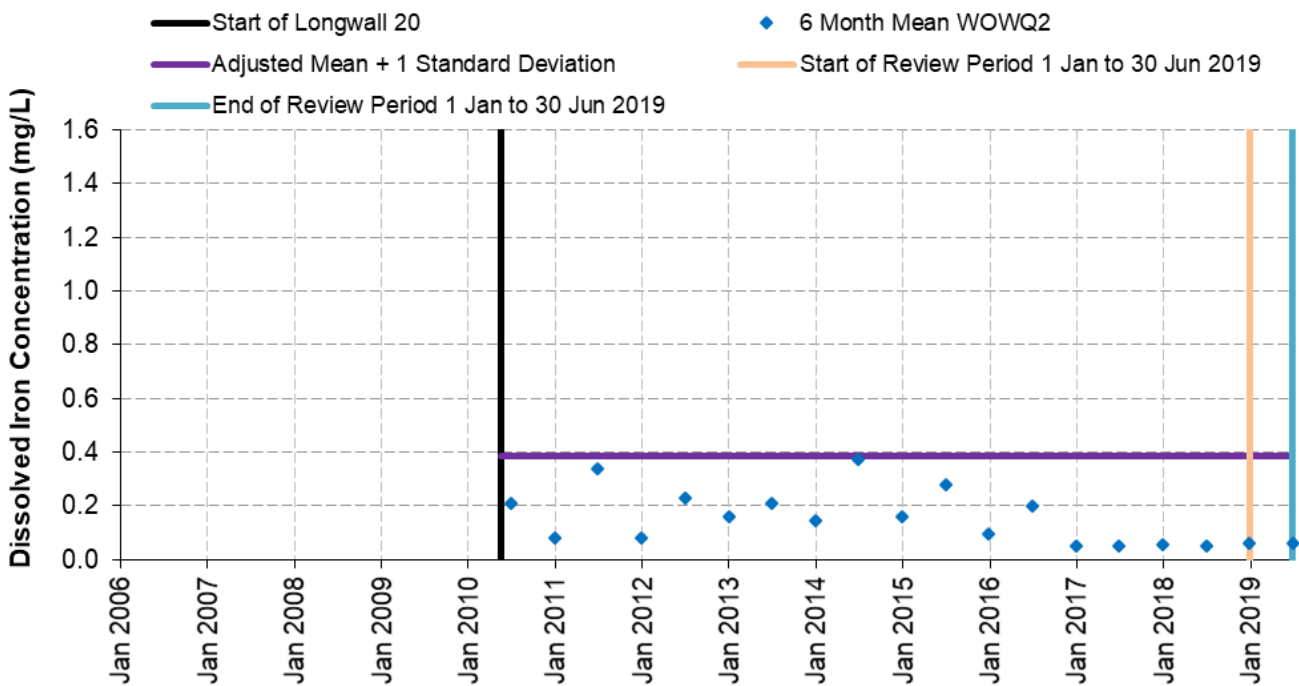


Chart 16 Six Monthly Means of Dissolved Iron Concentrations in Woronora River at WOWQ2

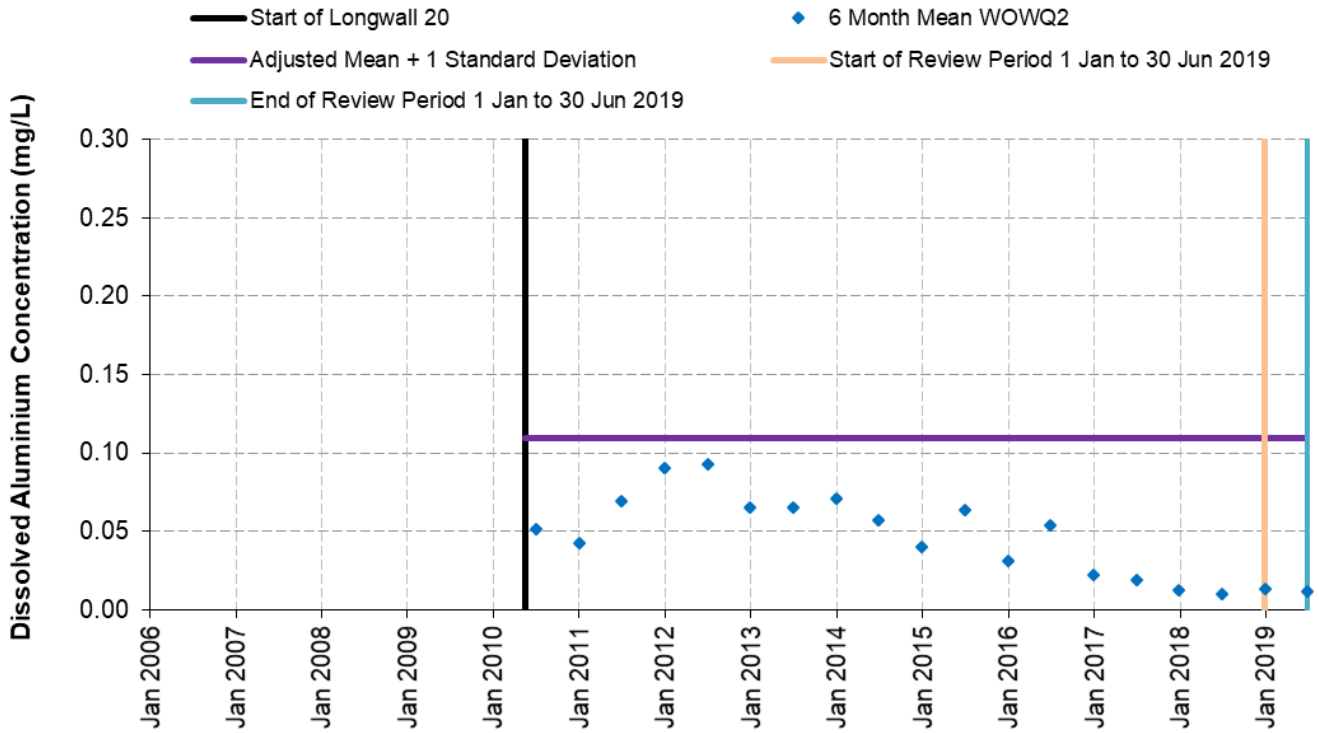


Chart 17 Six Monthly Means of Dissolved Aluminium Concentrations in Woronora River at WOWQ2

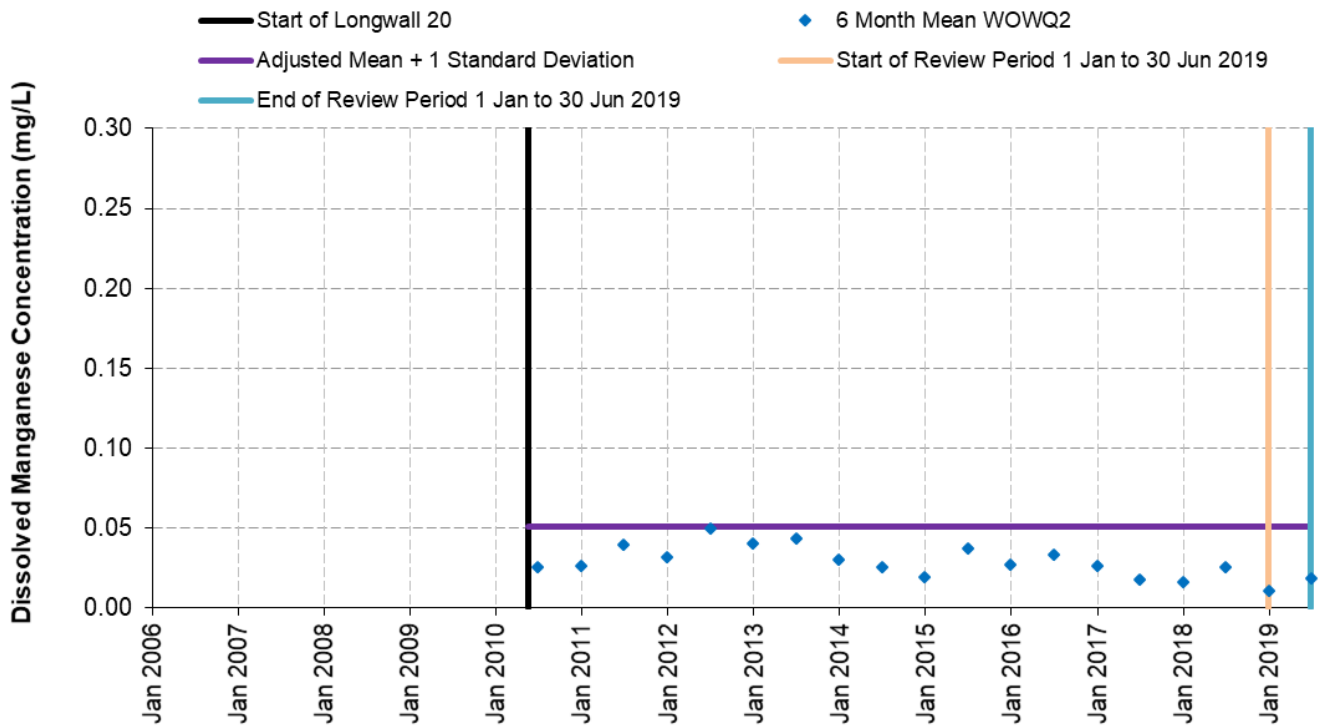


Chart 18 Six Monthly Means of Dissolved Manganese Concentrations in Woronora River at WOWQ2

3.2.2 Assessment of Water Quality at Site ETWQ AU

Plots showing the concentrations of dissolved iron, dissolved aluminium and dissolved manganese recorded at site ETWQ AU are shown on Chart 19 to Chart 21 in relation to the adjusted baseline mean plus one and two standard deviations calculated using data prior to potential subsidence effects from Longwall 20 on the Eastern Tributary.

Chart 22 to Chart 24 show the concentrations of dissolved iron, dissolved aluminium and dissolved manganese recorded at control site WOWQ 2 in comparison to the adjusted baseline mean plus one and two standard deviations calculated using data collected prior to potential subsidence effects from Longwall 20 on the Eastern Tributary.

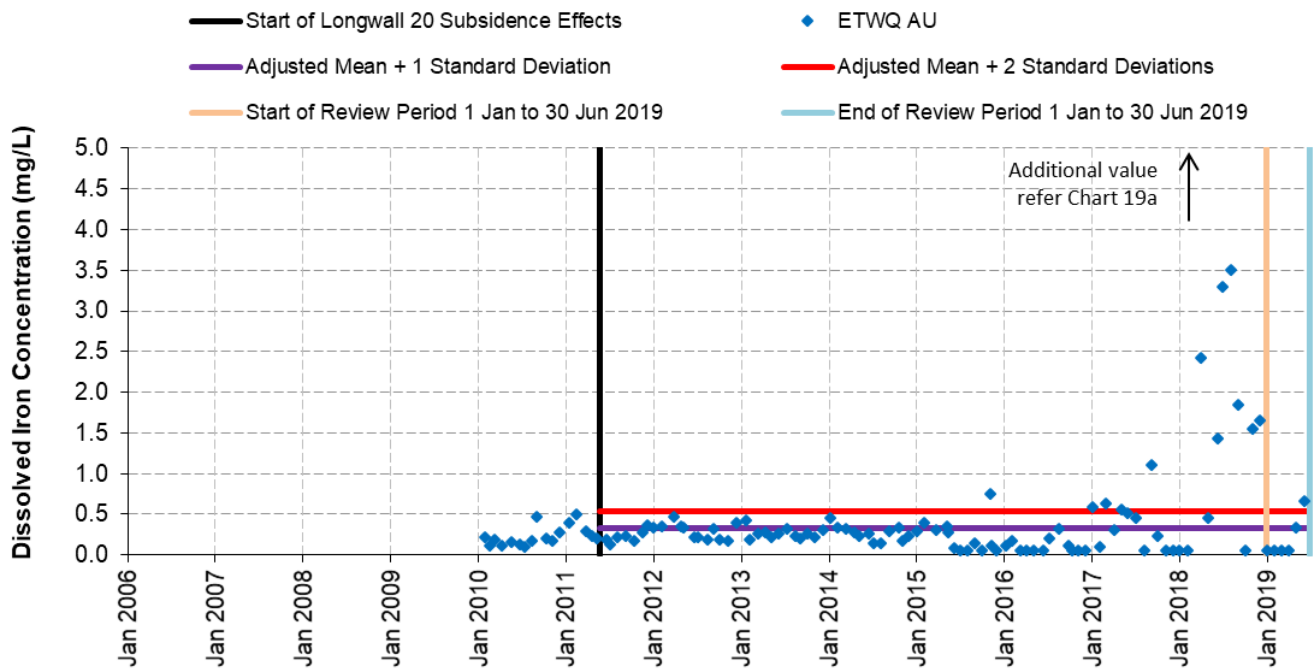


Chart 19 Dissolved Iron Concentrations in Eastern Tributary at ETWQ AU

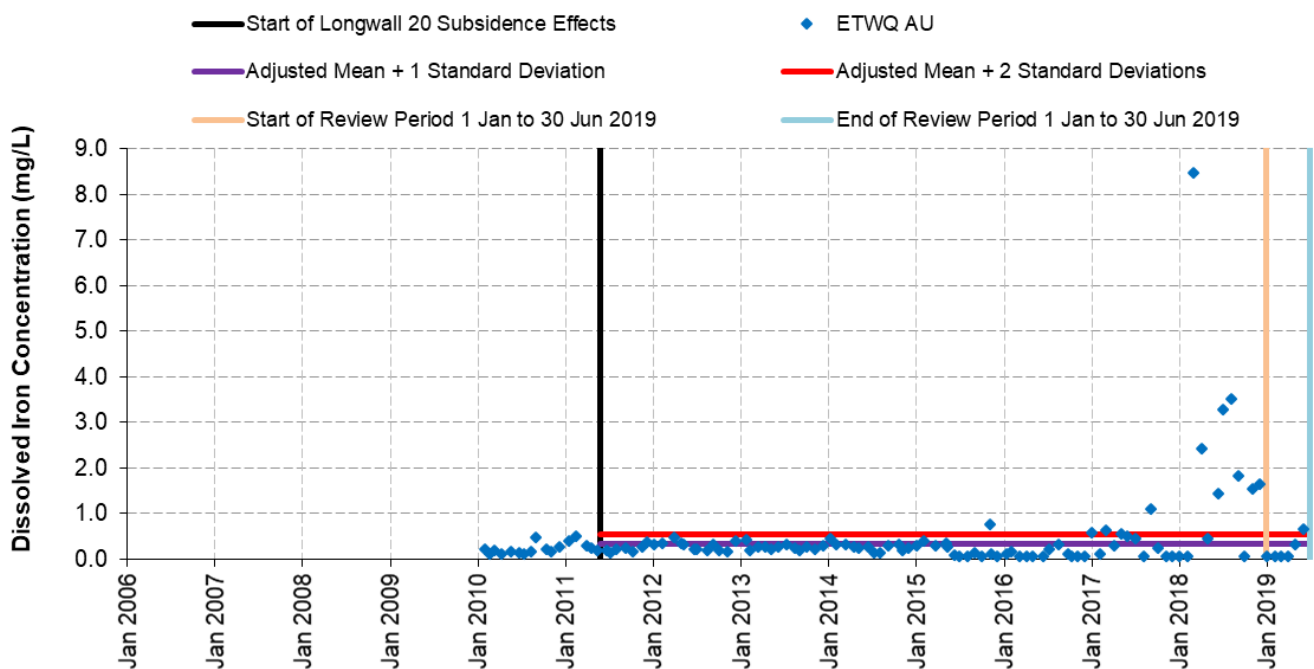


Chart 19a Dissolved Iron Concentrations in Eastern Tributary at ETWQ AU

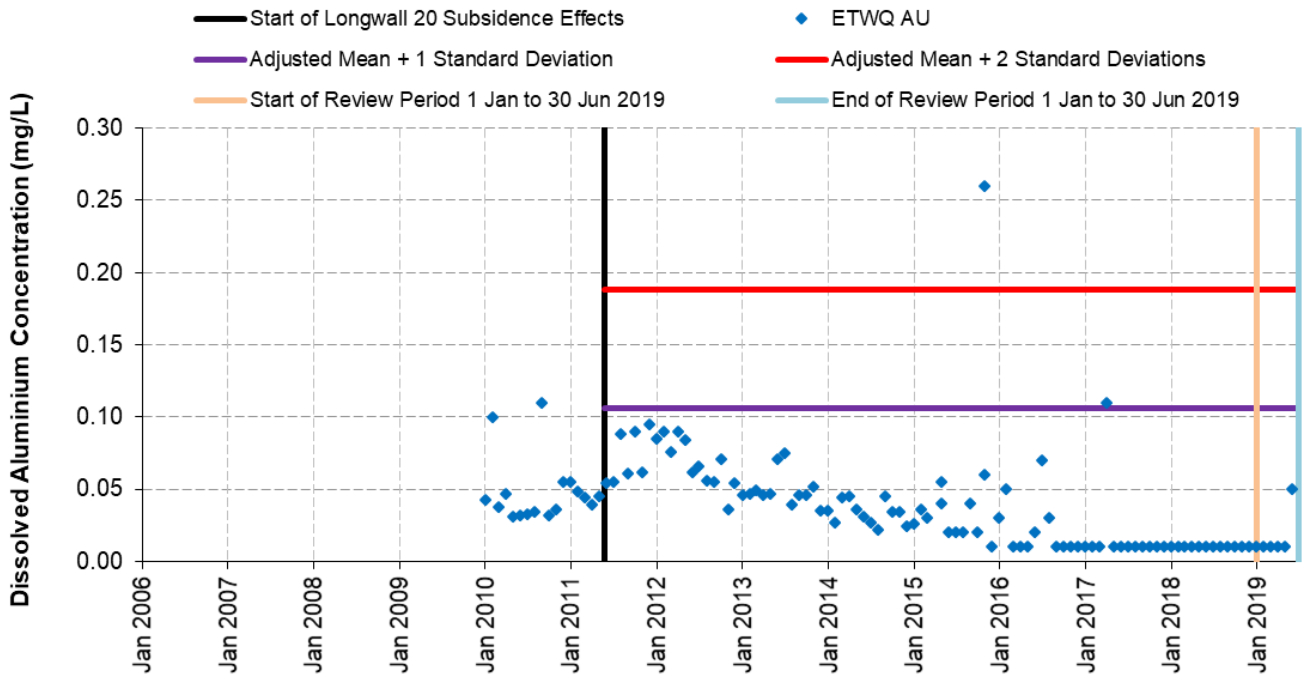


Chart 20 Dissolved Aluminium Concentrations in Eastern Tributary at ETWQ AU

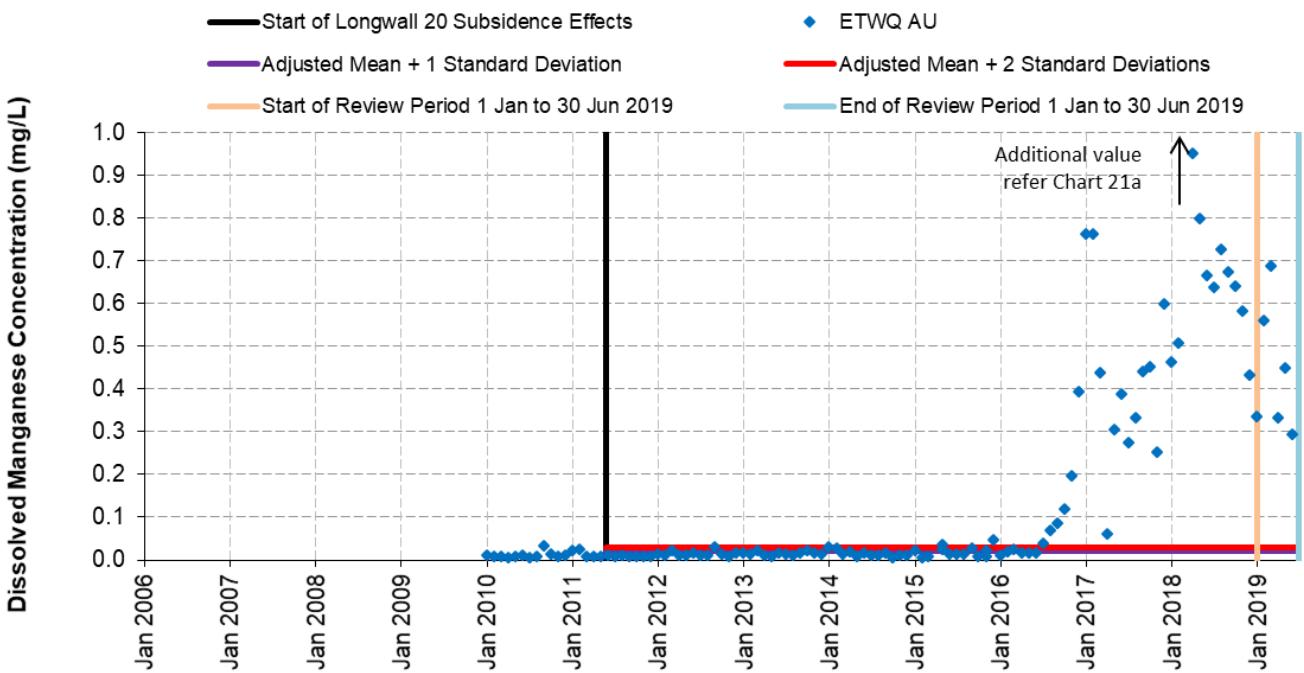


Chart 21 Dissolved Manganese Concentrations in Eastern Tributary at ETWQ AU

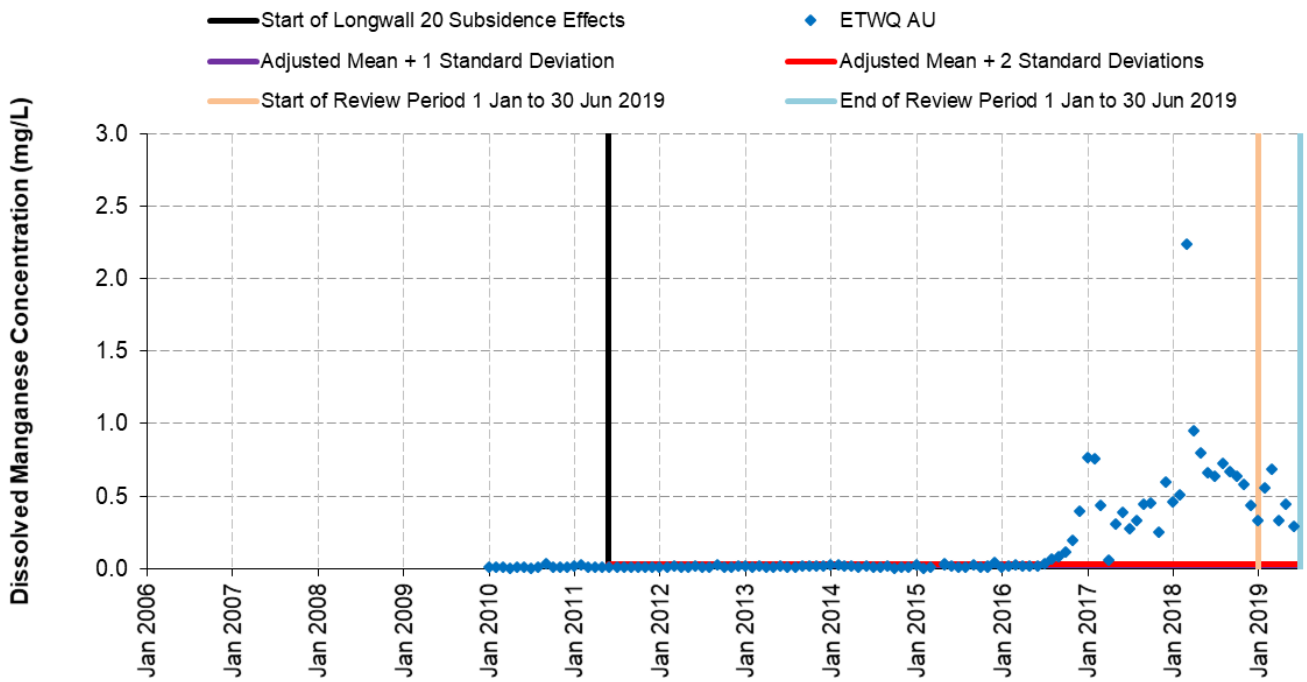


Chart 21a Dissolved Manganese Concentrations in Eastern Tributary at ETWQ AU

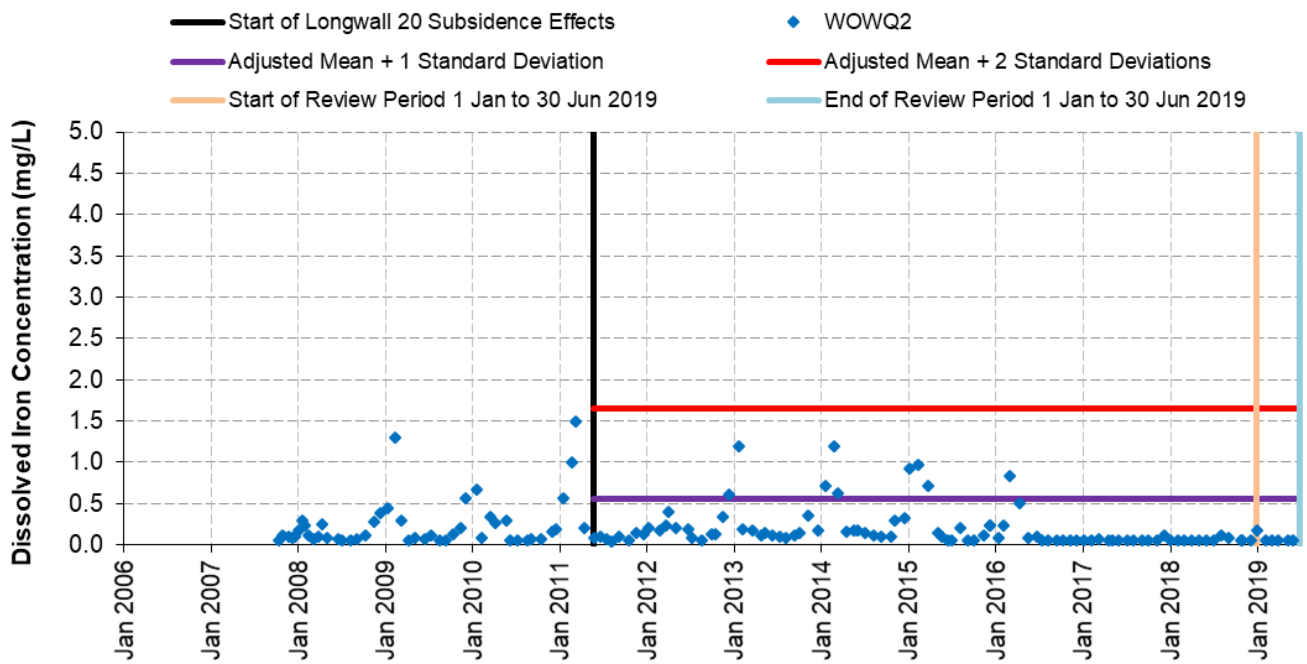


Chart 22 Dissolved Iron Concentrations in Woronora River at WOWQ2

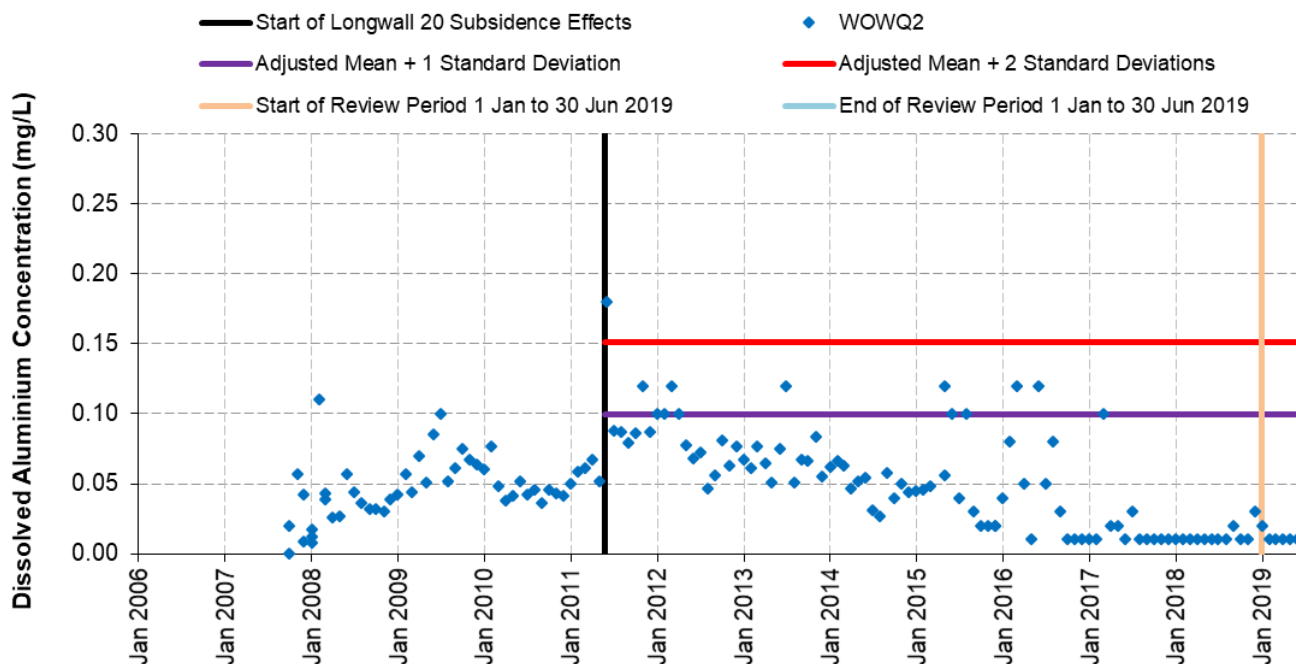


Chart 23 Dissolved Aluminium Concentrations in Woronora River at WOWQ2

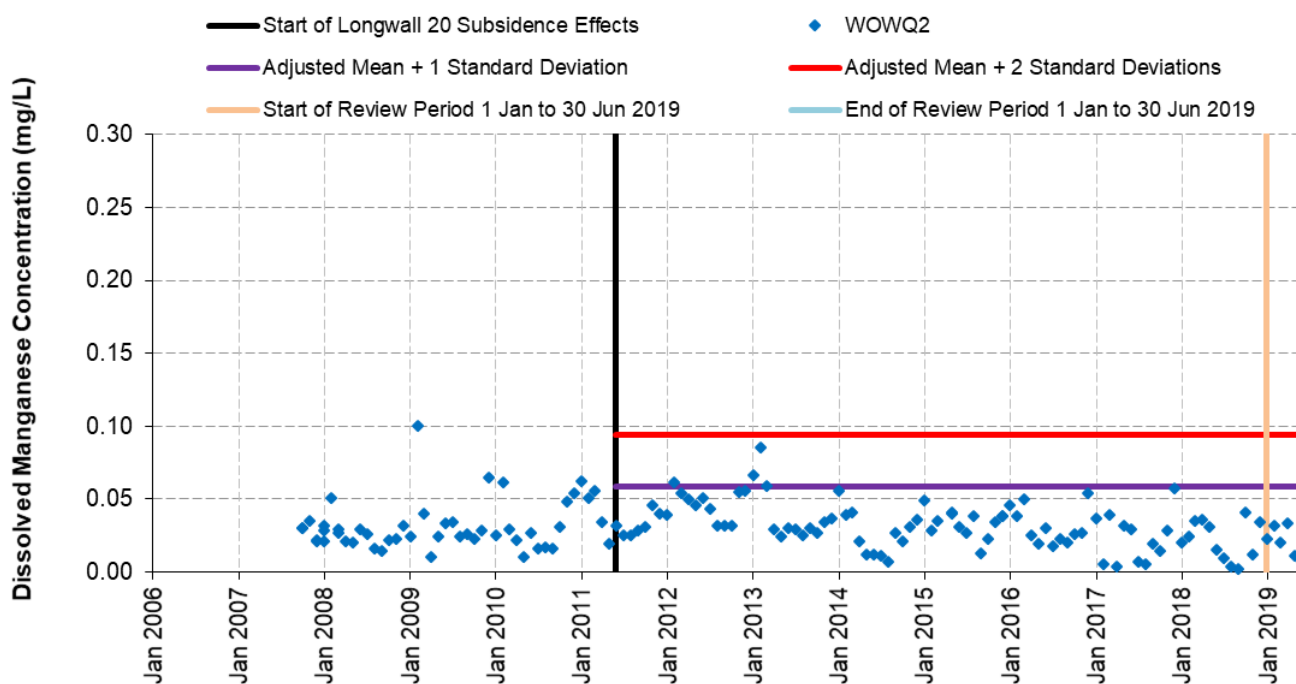


Chart 24 Dissolved Manganese Concentrations in Woronora River at WOWQ2

Charts 19/19a indicate there was an exceedance of the adjusted baseline mean plus two standard deviations for dissolved iron at sampling site ETWQ AU for one month (June 2019). As there was not a similar exceedance of this trigger at the control site WOWQ 2 on the Woronora River (Chart 22), the results equate to a Level 2 significance level in June 2019.

Chart 20 indicates there were no exceedances of the adjusted baseline mean plus two standard deviations for dissolved aluminium at sampling site ETWQ AU during the reporting period. The results for dissolved aluminium equate to a Level 1 significance level. There were also no exceedances of the adjusted baseline mean plus two standard deviations for dissolved aluminium at control site WOWQ 2 on the Woronora River (Chart 23).

The dissolved manganese concentrations continued to exceed the adjusted baseline mean plus two standard deviations at site ETWQ AU from January to June 2019 (Charts 21/21a). Dissolved manganese concentrations exceeded the adjusted mean plus two standard deviations in the first month, the adjusted mean plus one standard deviation in the next month and the adjusted mean plus two standard deviations in the third month throughout the reporting period. As there was not a similar exceedance of these triggers at the control site WOWQ 2 on the Woronora River (Chart 24), the results for dissolved manganese equate to a Level 3 significance level throughout the reporting period.

Plots showing the six monthly mean concentrations for dissolved iron, dissolved aluminium and dissolved manganese recorded at site ETWQ AU are shown on Chart 25 to Chart 27. For comparison, plots showing the six monthly mean concentrations for the same water quality parameters at control site WOWQ2 are shown on Chart 28 to Chart 30. Each plot shows the adjusted baseline mean plus one standard deviation value.

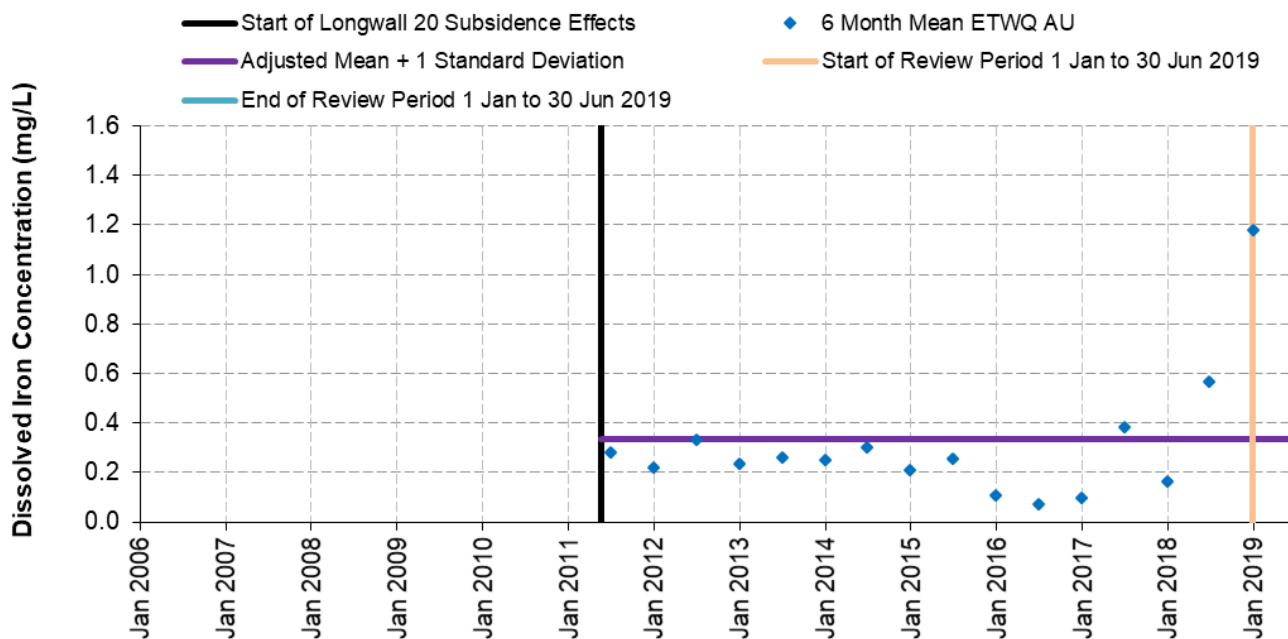


Chart 25 Six Month Means of Dissolved Iron Concentrations in Eastern Tributary at ETWQ AU

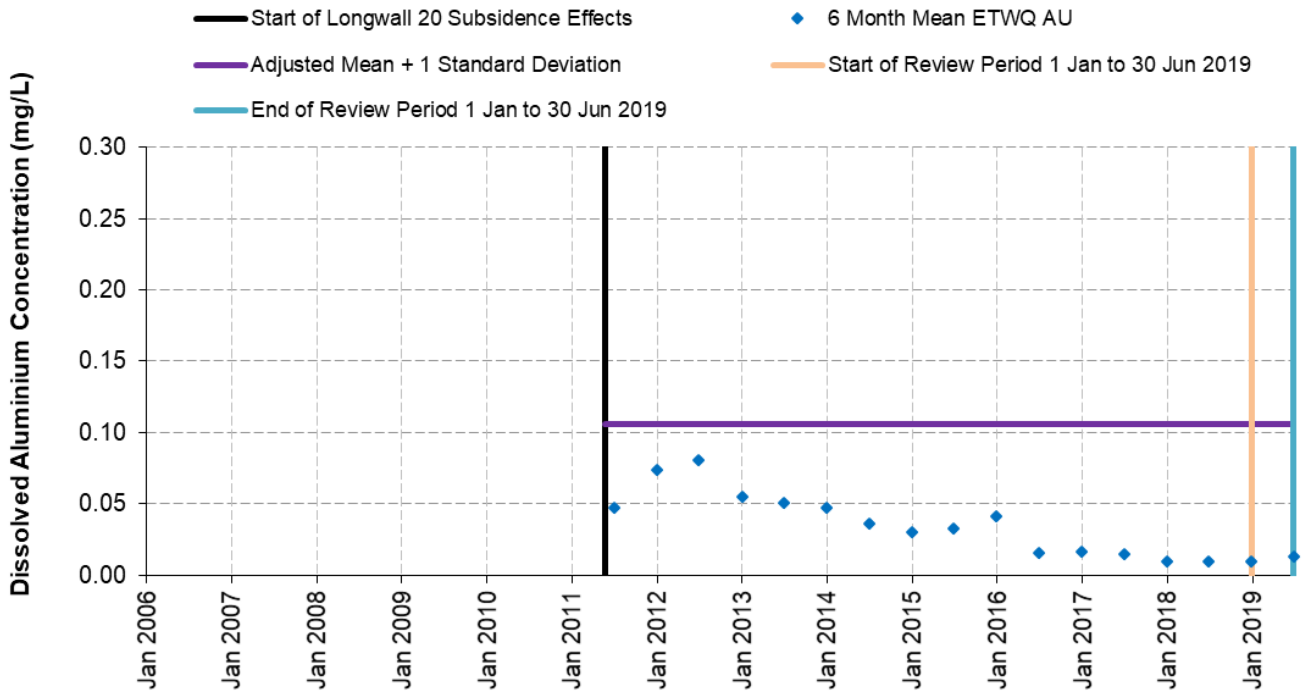


Chart 26 Six Month Means of Dissolved Aluminium Concentrations in Eastern Tributary at ETWQ AU

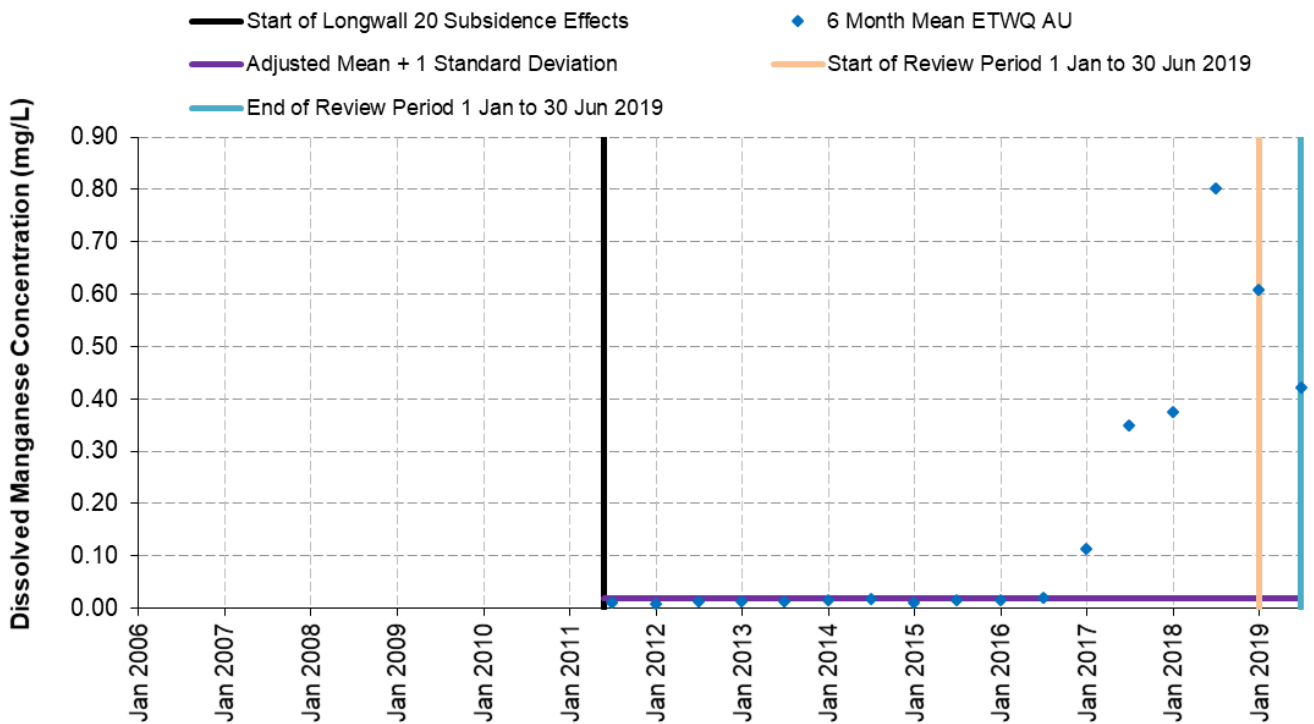


Chart 27 Six Month Means of Dissolved Manganese Concentrations in Eastern Tributary at ETWQ AU

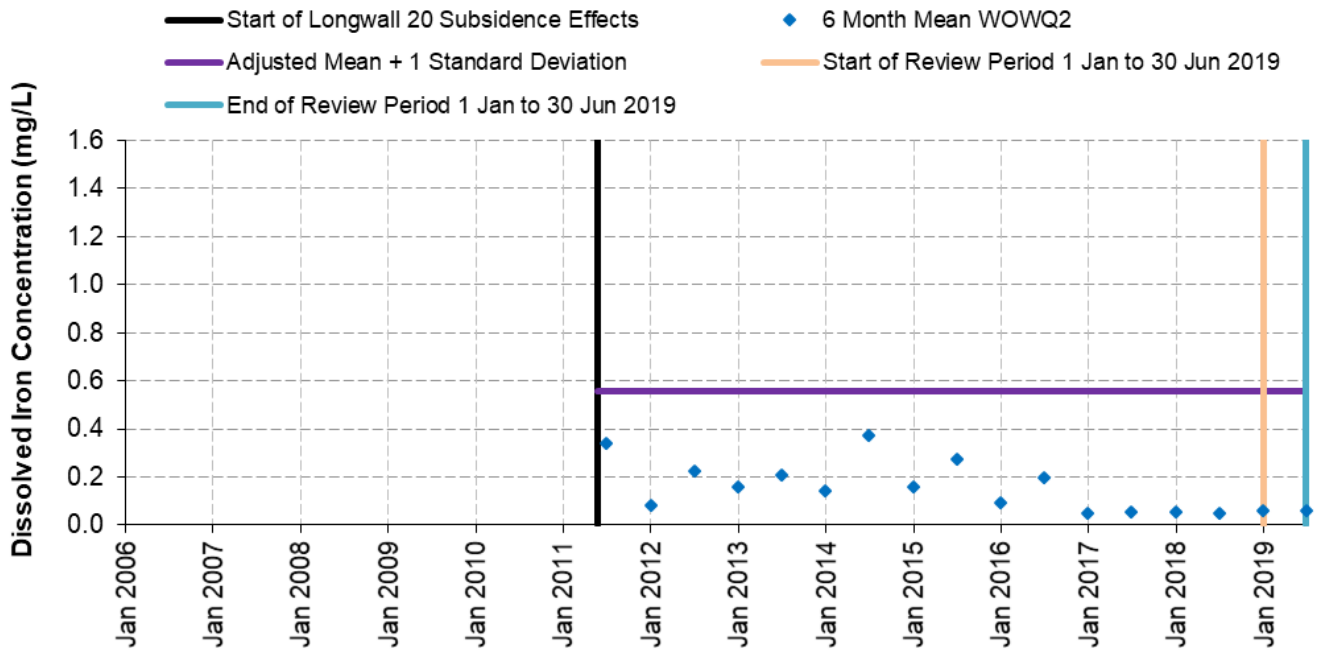


Chart 28 Six Month Means of Dissolved Iron Concentrations in Woronora River at WOWQ2

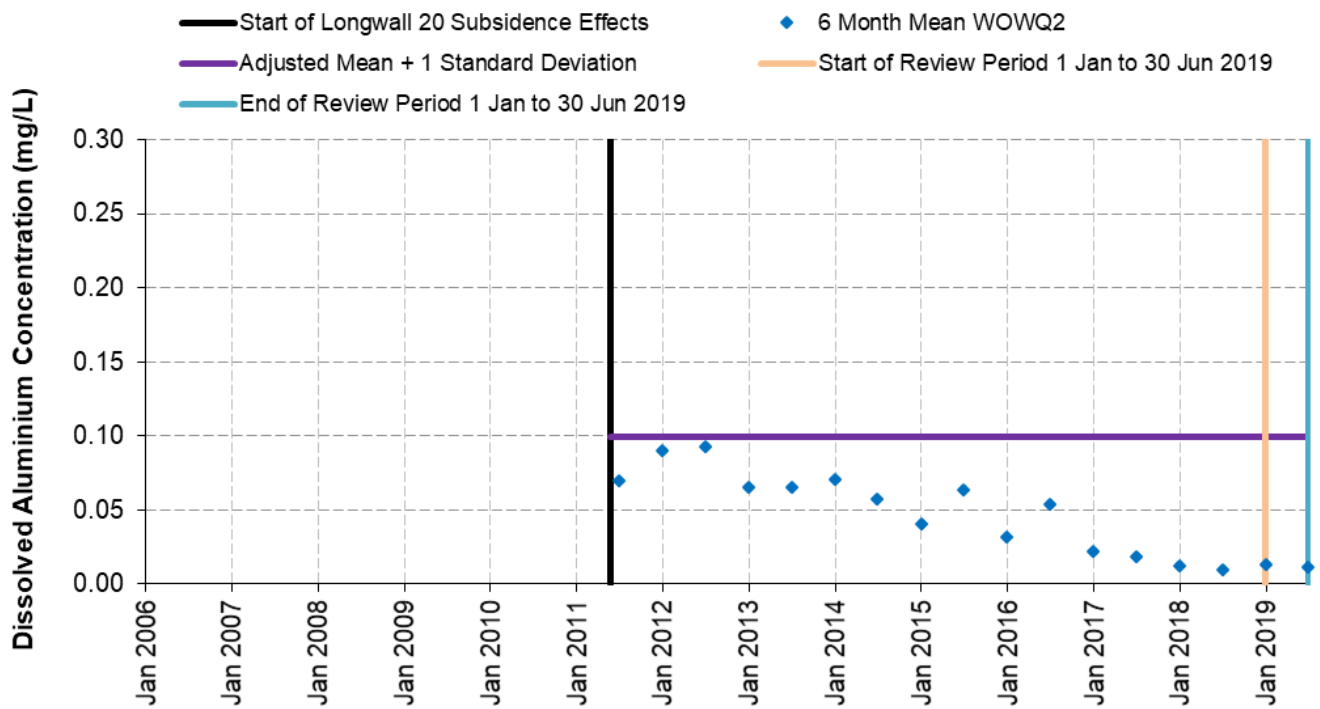


Chart 29 Six Month Means of Dissolved Aluminium Concentrations in Woronora River at WOWQ2

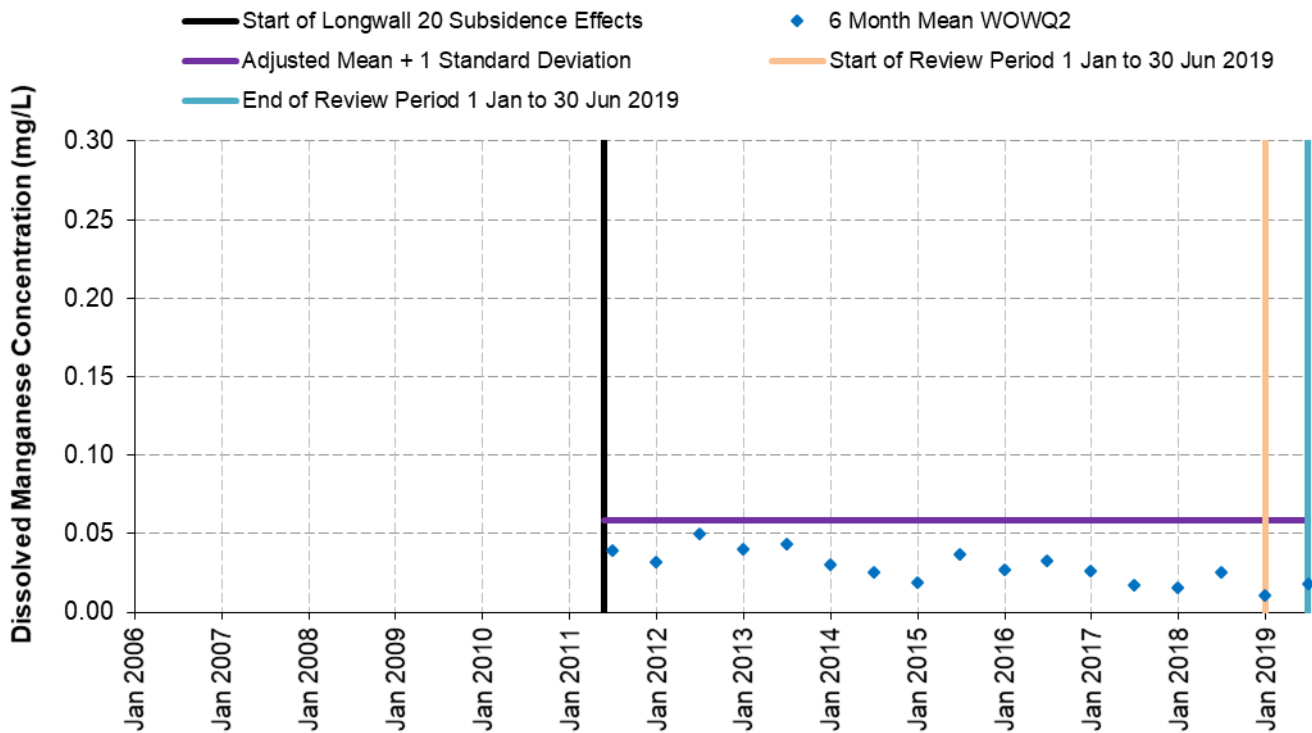


Chart 30 Six Month Means of Dissolved Manganese Concentrations in Woronora River at WOWQ2

There were no exceedances of the adjusted baseline mean plus one standard deviation for two consecutive six month means for dissolved iron or dissolved aluminium in Eastern Tributary at site ETWQ AU (Chart 25 and Chart 26). There continued to be an exceedance of the adjusted baseline mean plus one standard deviation for two consecutive six month means for dissolved manganese in Eastern Tributary at site ETWQ AU for the reporting period (Chart 27). There were no similar exceedances on the Woronora River at control site WOWQ2 (Chart 28 to Chart 30), accordingly the results for dissolved manganese equate to a Level 3 significance level. It is worth noting that the six month mean for dissolved manganese indicates a steady decline from the peak concentration recorded in mid-2018.

3.2.3 Analysis against Subsidence Impact Performance Measure – Eastern Tributary

Subsidence Impact Performance Measure:

Negligible reduction to the quality of water resources reaching the Woronora Reservoir.

The exceedances of the performance indicator in relation to dissolved manganese (from January to June 2019) has triggered assessments of whether the subsidence impact performance measure for water quality reaching the Woronora Reservoir has been exceeded (i.e. whether the Project has resulted in a greater than negligible reduction in the quality of water resources reaching the Woronora Reservoir). These assessments have or will be undertaken by an environmental water quality expert: Professor Barry Noller from The University of Queensland.

3.3 FLOW DIVERSION AND NATURAL DRAINAGE BEHAVIOUR OF DOWNSTREAM POOLS

3.3.1 Waratah Rivulet Downstream of Maingate of Longwall 23

Performance Indicators:

No change to the natural drainage behaviour of Pools P, Q, R, S, T, U, V and W.

Analysis of water level data for Pools P, T, U, V and W indicates the water level is at or above the pool's previous minimum.

Analysis of water level data for Pools Q, R and S indicates the water levels are above that required to maintain water over the downstream rock-bar.

The results are assessed against the Longwalls 301-303 Water Management Plan significance levels/triggers (below):

Negligible Environmental Consequences on Waratah Rivulet: No Diversion of Flows, No Change in the Natural Drainage Behaviour		
Performance Indicator	Significance Levels/Triggers	
<i>No change to the natural drainage behaviour of Pools P, Q, R, S, T, U, V and W.</i>	Level 1	No mine-induced surface cracking or impacts to natural drainage behaviour observed
	Level 2	Mine-induced surface cracking observed. No impacts to natural drainage behaviour observed.
	Level 3	There appear to be impacts to natural drainage behaviour such that: <ul style="list-style-type: none"> - a pool does not continue to flow over, through and/or below the rock bars (where relevant); or - surface flow is not evident along the length of Pools P or T prior to flowing through/below the rock bars; - surface flow is not evident along the length of Pools Q, R or S prior to flowing over the rock bars; - surface flow is not evident along the length of Pool V prior to flowing over/through/below the rock bar; and - surface flow is not evident along the length of Pools U or W prior to flowing through the downstream boulder field.
<i>Analysis of water level data for Pools P, T, U, V and W indicates the water level is at or above the pool's previous minimum.</i>	Level 1	The water level in Pools P, T, U, V or W has not been below the pool's previous minimum.
	Level 2	The water level in Pools P, T, U, V or W has been below the pool's previous minimum, however, is considered to be due to an error type.
	Level 3	The water level in Pools P, T, U, V or W has been below the pool's previous minimum and does not appear to be due to an error type; and the same is not occurring in control pool(s).
<i>Analysis of water level data for Pools Q, R and S indicates the water levels are above that required to maintain water over the downstream rock bar.</i>	Level 1	The water level in Pools Q, R or S has been above that required to maintain water over the downstream rock bar.
	Level 2	The water level in Pools Q, R or S has been below that required to maintain water over the downstream rock bar, however, appears to be due to an error type.
	Level 3	The water level in Pools Q, R or S has been below that required to maintain water over the downstream rock bar and does not appear to be due to an error type and the same is not occurring in control pool(s).

Metropolitan Coal's visual inspections of Pools P, Q, R, S, T, U, V and W downstream of the maingate of Longwall 23 indicate no mine-induced surface cracking and no observed changes to the natural drainage behaviour of the pools (Metropolitan Coal, pers. comm). The visual inspection results equate to a Level 1 significance level.

The recorded water levels in Pools P, T, U, V and W have remained at or above the pools' previously recorded minimums. The recorded water levels in Pools Q, R and S have remained above that required to maintain water over the downstream rock bar. The results equate to a Level 1 significance level for all pools.

3.3.2 Analysis against Subsidence Impact Performance Measure – Waratah Rivulet Downstream of Maingate of Longwall 23

Subsidence Impact Performance Measure:

Negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining and minimal gas releases) on the Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P).

Assessment against Performance Measure

The performance measure, *negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools)*, has been met.

3.3.3 Eastern Tributary Downstream of Maingate 26

Pools ETAG to ETAU on the Eastern Tributary are situated between the full supply level of the Woronora Reservoir and the maingate of Longwall 26. Pools ETAG and ETAH are situated above Longwall 27, Pools ETAI, ETAJ and ETAK are situated above the maingate of Longwall 27 and Pools ETAL to ETAU are situated downstream of the maingate of Longwall 27.

As reported in the Metropolitan Coal 2017 Annual Review, the natural drainage behaviour of Pools ETAG, ETAH, ETAI, ETAJ, ETAK, ETAL, ETAM, ETAN, ETAO, ETAQ and ETAR has been impacted by mine subsidence (Metropolitan Coal, 2018). The observed impacts to the Eastern Tributary pools in December 2016/January 2017 resulted in the exceedance of the negligible environmental consequences performance measure for the Eastern Tributary in relation to diversion of flows and drainage behaviour.

Performance indicators have been developed for the Longwalls 301-303 Water Management Plan for Pools ETAS, ETAT and ETAU and the results for the reporting period are assessed below.

Performance Indicators:

No change to the natural drainage behaviour of Pools ETAS, ETAT and ETAU.

Analysis of water level data for Pool ETAU indicates the water levels are above that required to maintain water over the downstream rock bar.

The results are assessed against the Longwalls 301-303 Water Management Plan significance levels/triggers (below):

Negligible Environmental Consequences on Eastern Tributary: No Diversion of Flows, No Change in the Natural Drainage Behaviour		
Performance Indicator	Significance Levels/Triggers	
<i>No change to the natural drainage behaviour of Pools ETAS, ETAT and ETAU.</i>	Level 1	No mine-induced surface cracking at Pool ETAS or Pool ETAT; no increase in previous cracking at Pool ETAU. No impacts to natural drainage behaviour observed.
	Level 2	Mine-induced surface cracking observed at Pool ETAS or Pool ETAT, or increase observed in previous cracking at Pool ETAU. No impacts to natural drainage behaviour observed.
	Level 3	There appear to be impacts to natural drainage behaviour such that there is not continual surface flow along the length of Pools ETAS, ETAT or ETAU.
<i>Analysis of water level data for Pool ETAU indicates the water levels are above that required to maintain water over the downstream rock bar.</i>	Level 1	The water level in Pool ETAU have been above that required to maintain water over the downstream rock bar.
	Level 2	The water level in Pool ETAU has been below that required to maintain water over the downstream rock bar, however, appears to be due to an error type.
	Level 3	The water level in Pool ETAU has been below that required to maintain water over the downstream rock bar and does not appear to be due to an error type.

Metropolitan Coal’s visual inspections of Pools ETAS, ETAT and ETAU (and associated rock bars) indicate no mine-induced surface cracking has been observed at Pools ETAS and ETAT during the reporting period, and no increase in the occurrence of cracking has been observed at Pool ETAU. There have been no observed changes to the natural drainage behaviour of Pools ETAS, ETAT or ETAU during the reporting period (Metropolitan Coal, pers. comm.). The visual inspection results equate to a Level 1 significance level for Pools ETAS, ETAT and ETAU.

The recorded water level hydrograph for Pool ETAU indicates the water level in Pool ETAU has been above that required to maintain water over the downstream rock bar. The water level results equate to a Level 1 significance level for Pool ETAU.

3.3.4 Analysis against Subsidence Impact Performance Measure – Eastern Tributary Downstream of Maingate 26

Subsidence Impact Performance Measure:

Negligible environmental consequences over at least 70% of the stream length (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining and minimal gas releases) on the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26.

Assessment against Performance Measure

The above performance measure for no diversion of flows or change in the natural drainage behaviour of pools has been exceeded during previous reporting periods and has been reported to the Department of Planning and Environment (now Department of Planning, Industry and Environment) and other relevant agencies. The natural drainage behaviour of Pool ETAS, Pool ETAT and Pool ETAU has not been impacted by mine subsidence.

3.4 SUMMARY OF ASSESSMENT AGAINST SUBSIDENCE IMPACT PERFORMANCE INDICATORS AND PERFORMANCE MEASURES

The subsidence impact performance indicators and performance measures in Table 2 were developed to address the predictions of subsidence impacts and environmental consequences on surface water included in the Project Environmental Assessment, PPR and Metropolitan Coal Water Management Plans. Assessments against the subsidence impact performance indicators and performance measures have been conducted for the reporting period (1 January to 30 June 2019) in Table 2.

Table 2 Summary of Surface Water Environmental Performance Assessment

Performance Measure	Performance Indicator	Monitoring Site(s) being Assessed	Parameters	Significance Level/Trigger		Comment	Subsidence Impact Performance Indicator Exceeded?	Subsidence Impact Performance Measure Exceeded?
Negligible reduction to the quantity of water resources reaching the Woronora Reservoir	<i>Changes in the quantity of water entering Woronora Reservoir are not significantly different post-mining compared to pre-mining, that are not also occurring in the control catchment(s).</i>	WaterNSW gauging station on Waratah Rivulet (GS 2132102)	Surface water flow.	Level 3	The median of the ratios falls below the 20 th percentile of the baseline data.	Surface water flow was at Level 3 throughout the reporting period, though the same was also occurring in the control catchment.	No ³	No
Negligible reduction to the quality of water resources reaching the Woronora Reservoir	<i>Changes in the quality of water entering Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations that are not also occurring at control site WOWQ2.</i>	Site WRWQ9 on the Waratah Rivulet.	Iron (Fe). Manganese (Mn). Aluminium (Al). [Field filtered]	Level 1	Data analysis indicates no water quality parameter exceeds the adjusted baseline mean plus two standard deviations.	Dissolved iron, aluminium and manganese were at Level 1 throughout the reporting period.	No	No
		Site ETWQ AU on the Eastern Tributary.		Level 1	Data analysis indicates no water quality parameter exceeds the adjusted baseline mean plus two standard deviations.	Dissolved aluminium was at Level 1 throughout the reporting period. Dissolved iron was at Level 1 in January to May 2019.	No	No

³ A detailed assessment of this performance indicator was undertaken for the previous six monthly period and concluded that it had not been exceeded (HEC, 2019). The performance indicator will be considered to be exceeded if the median falls below the 20th percentile and the same is not occurring in the control catchment.

Table 2 (Cont) Summary of Surface Water Environmental Performance Assessment

Performance Measure	Performance Indicator	Monitoring Site(s) being Assessed	Parameters	Significance Level/Trigger		Comment	Subsidence Impact Performance Indicator Exceeded?	Subsidence Impact Performance Measure Exceeded?
Negligible reduction to the quality of water resources reaching the Woronora Reservoir	<i>Changes in the quality of water entering Woronora Reservoir are not significantly different post-mining compared to pre-mining concentrations that are not also occurring at control site WOWQ2.</i>	Site ETWQ AU on the Eastern Tributary.	Iron (Fe). Manganese (Mn). Aluminium (Al). [Field filtered]	Level 2	Data analysis indicates any water quality parameter exceeds the adjusted baseline mean plus two standard deviations for one month.	Dissolved iron was at Level 2 in June 2019.	No	No
				Level 3	Data analysis indicates: <ul style="list-style-type: none"> any water quality parameter exceeds the adjusted baseline mean plus two standard deviations for two consecutive months; or over a three month period the water quality parameter exceeds the adjusted mean plus two standard deviations in the first month, the adjusted mean plus one standard deviation in the next month and the adjusted mean plus two standard deviations in the third month; or the six month mean exceeds the adjusted baseline mean plus one standard deviation for two consecutive assessment periods (i.e. over two six monthly reports); and there was not a similar exceedance of the trigger at the control site. 	Dissolved manganese was at Level 3 throughout the reporting period.	Yes	Assessment to be conducted by Associate Professor Barry Noller.

Table 2 (Cont) Summary of Surface Water Environmental Performance Assessment

Performance Measure	Performance Indicator	Monitoring Site(s) being Assessed	Parameters	Significance Level/Trigger		Comment	Subsidence Impact Performance Indicator Exceeded?	Subsidence Impact Performance Measure Exceeded?
Negligible environmental consequences (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases) on the Waratah Rivulet between the full supply level of the Woronora Reservoir and the maingate of Longwall 23 (upstream of Pool P).	<i>No change to the natural drainage behaviour of Pools P, Q, R, S, T, U, V and W.</i>	Pools P to W on Waratah Rivulet.	Streambed cracking and drainage behaviour.	Level 1	No mine-induced surface cracking or impacts to natural drainage behaviour observed.	-	No	No
	<i>Analysis of water level data for Pools P, T, U, V and W indicates the water level is at or above the pool's previous minimum.</i>	Pools P, T, U, V and W on Waratah Rivulet.	Pool water level.	Level 1	The water level in Pools P, T, U, V or W has not been below the pool's previous minimum.	-	No	No
	<i>Analysis of water level data for Pools Q, R and S indicates the water levels are above that required to maintain water over the downstream rock bar.</i>	Pools Q, R and S on the Waratah Rivulet.	Pool water level.	Level 1	The water level in Pools Q, R or S has been above that required to maintain water over the downstream rock bar.	-	No	No
Negligible environmental consequences over at least 70% of the stream length (that is, no diversion of flows, no change in the natural drainage behaviour of pools, minimal iron staining, and minimal gas releases) on the Eastern Tributary between the full supply level of the Woronora Reservoir and the maingate of Longwall 26⁶	<i>No change to the natural drainage behaviour of Pools ETAS, ETAT and ETAU.</i>	Pools ETAS, ETAT and ETAU on the Eastern Tributary.	Stream cracking and drainage behaviour.	Level 1	No mine-induced surface cracking at Pool ETAS or Pool ETAT; no increase in previous cracking at Pool ETAU. No impacts to natural drainage behaviour observed.	-	No	Refer Note 1
	<i>Analysis of water level data for Pool ETAU indicates the water levels are above that required to maintain water over the downstream rock bar.</i>	Pool ETAU on the Eastern Tributary.	Pool water level.	Level 1	The water level in Pool ETAU has been above that required to maintain water over the downstream rock bar.	-	No	Refer Note 1

¹ The no diversion of flows, no change in natural drainage behaviour component of this performance measure was exceeded during the mining of Longwalls 23-27, triggering contingency measures for the impacted pools. This TARP monitors pools not impacted during the mining of Longwalls 23-27. The minimal iron staining component of this performance measure was exceeded during the mining of Longwalls 23-27, triggering contingency measures for the impacted pools. The nature and extent of iron staining on the Eastern Tributary will continue to be monitored during the mining of Longwalls 301-303.

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- Gilbert & Associates (2015b). "AWBM Model Calibration - Waratah Rivulet, Woronora River and O'Hares Creek". Report prepared for Metropolitan Coal.
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- Hydro Engineering & Consulting (2019). "Assessment of Performance Indicator for the Quantity of Water Resources Reaching the Woronora Reservoir from the Waratah Rivulet Catchment". Letter report prepared for Metropolitan Coal.

APPENDICES

Appendix A Monitored Pool Water Level Hydrographs Pools on Waratah Rivulet

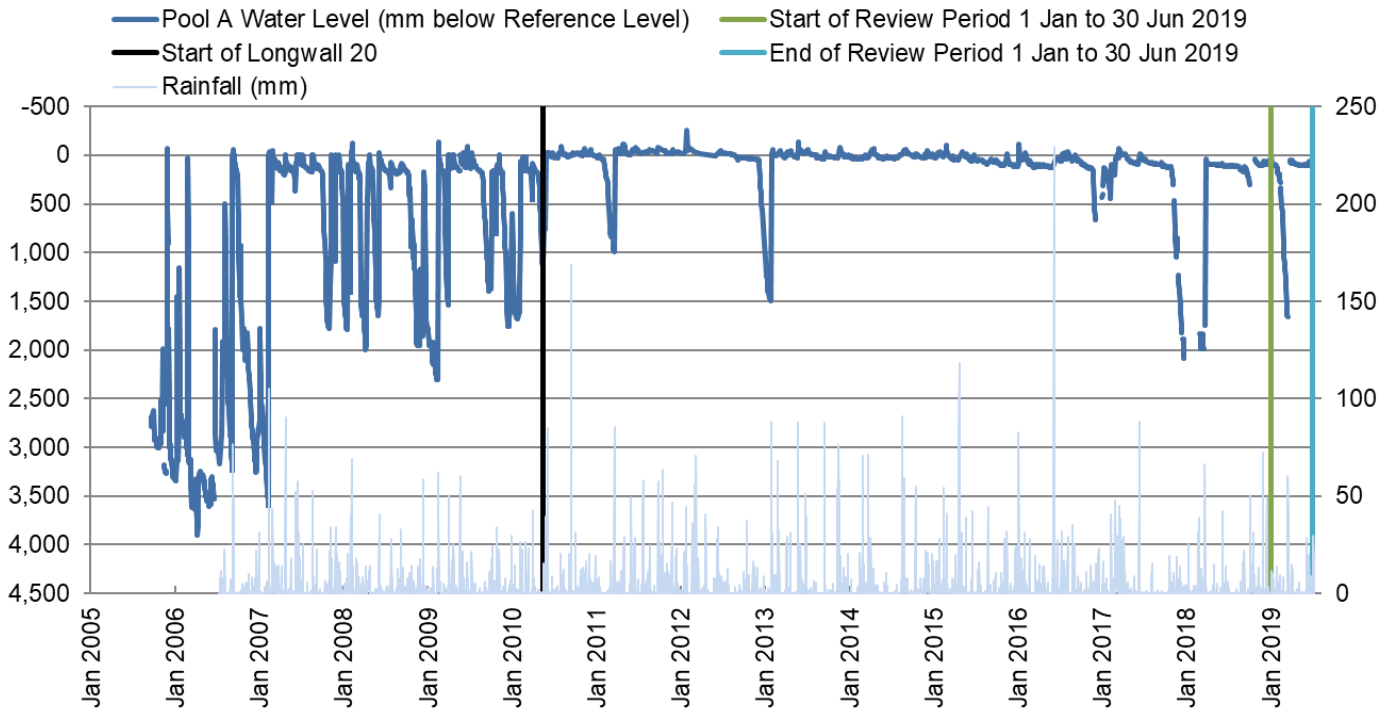


Chart A1 Pool A Waratah Rivulet (Manual Observations)

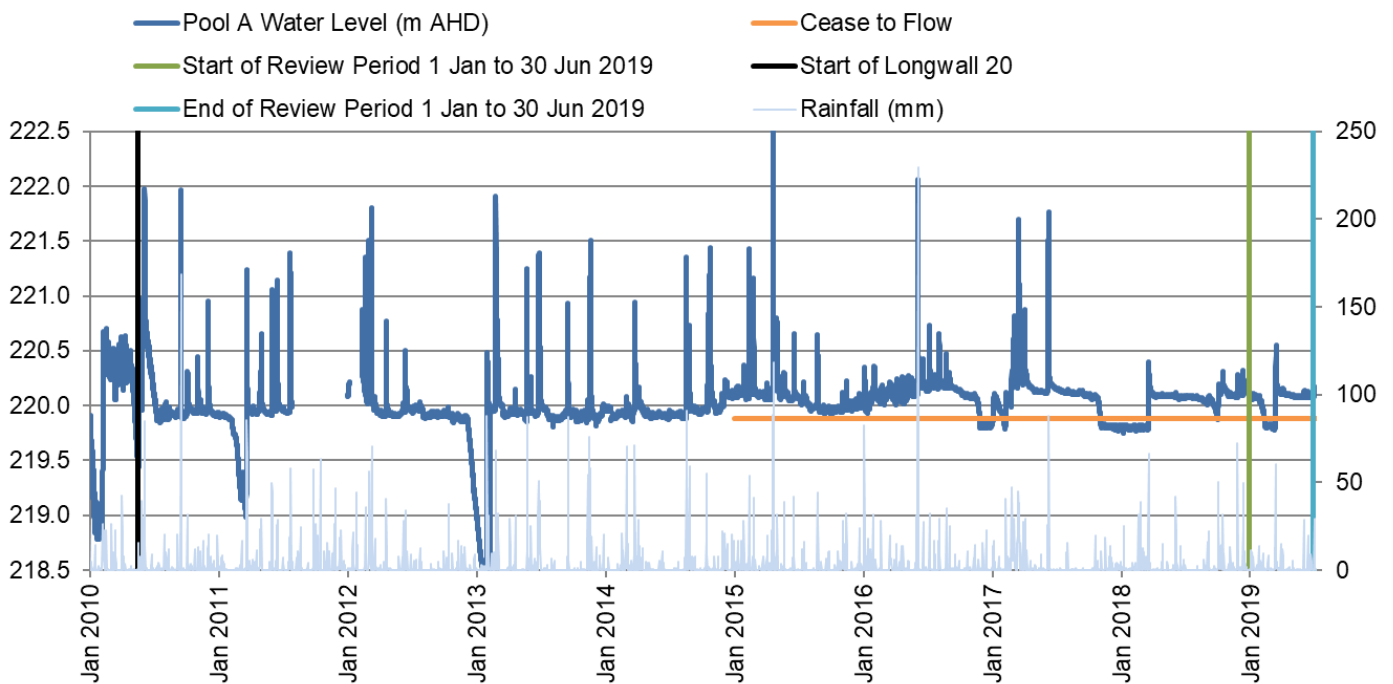


Chart A2 Pool A Waratah Rivulet⁴

⁴ Pool A cease to flow level was revised from 219.829 m AHD to 219.883 m AHD based on advice from Metropolitan Coal.

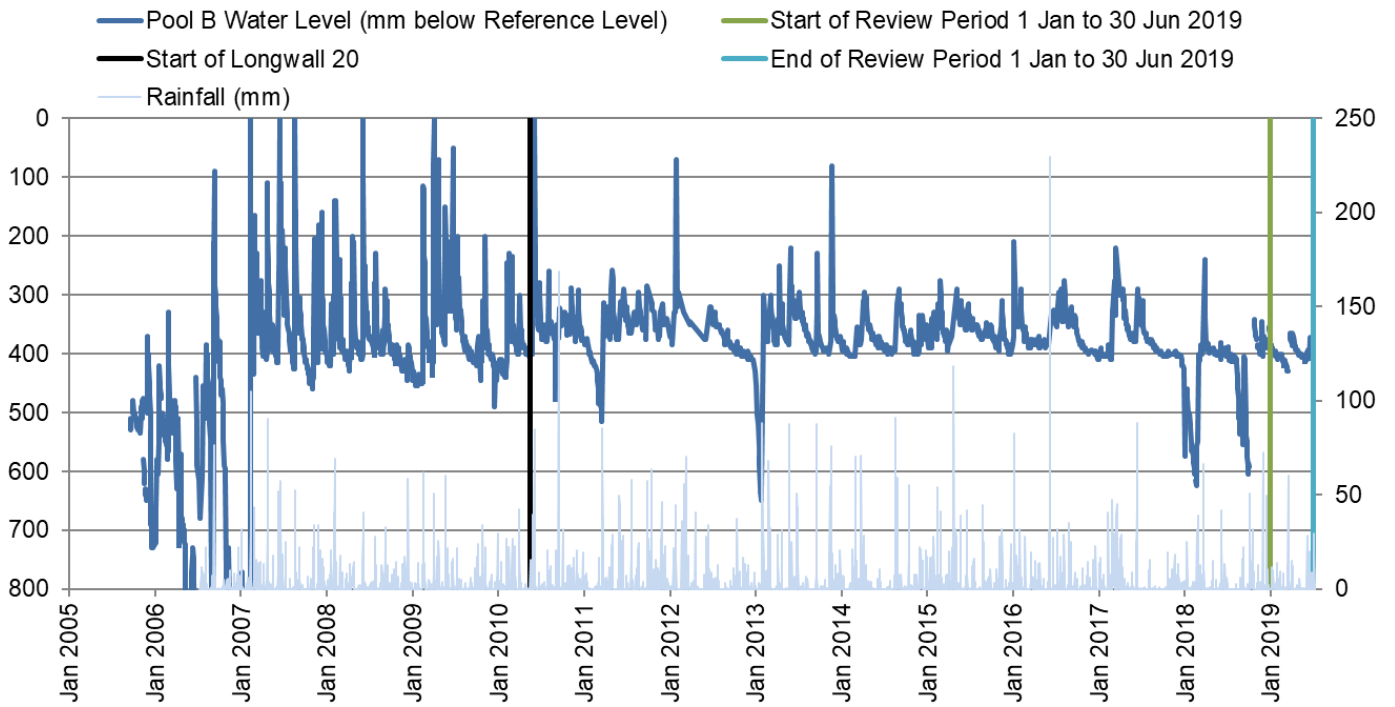


Chart A3 Pool B Waratah Rivulet (Manual Observations)⁵

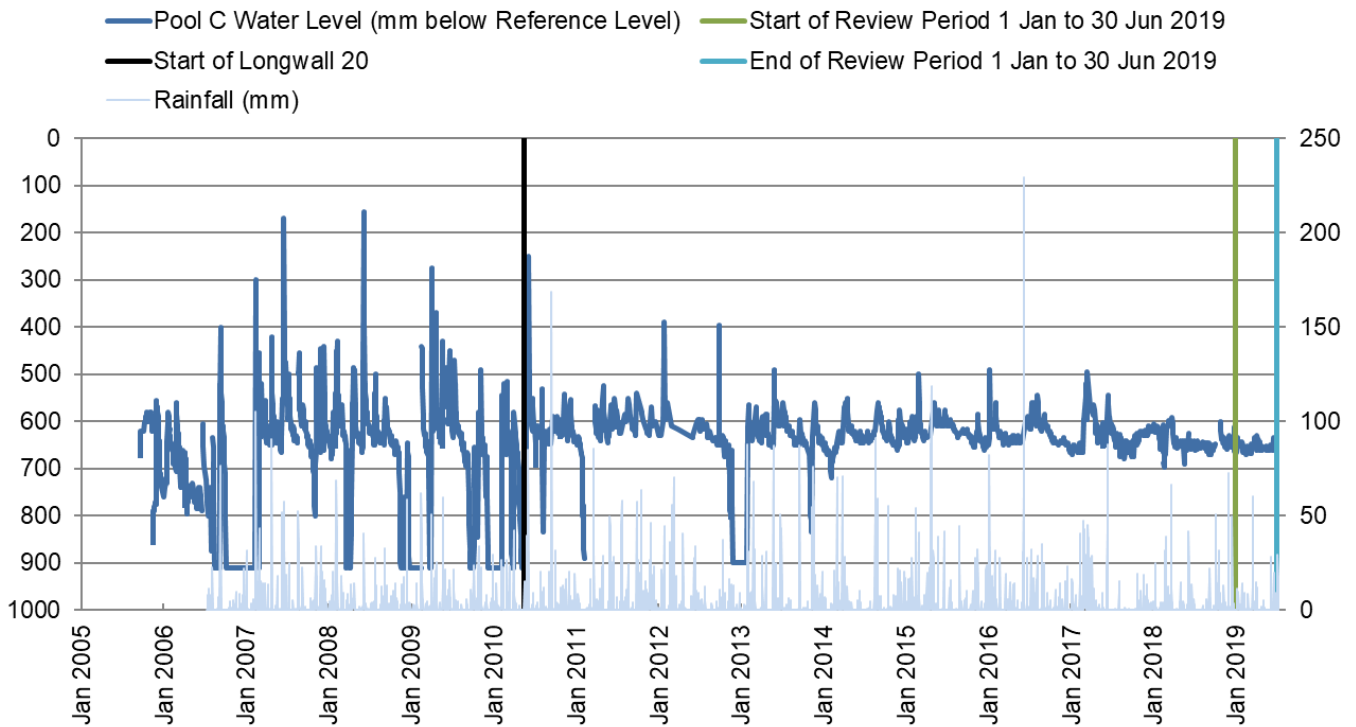


Chart A4 Pool C Waratah Rivulet (Manual Observations)

⁵ Cease to Flow level has been removed from the chart for this review period as the manual observations indicate that the Cease to Flow level previously shown was incorrect.

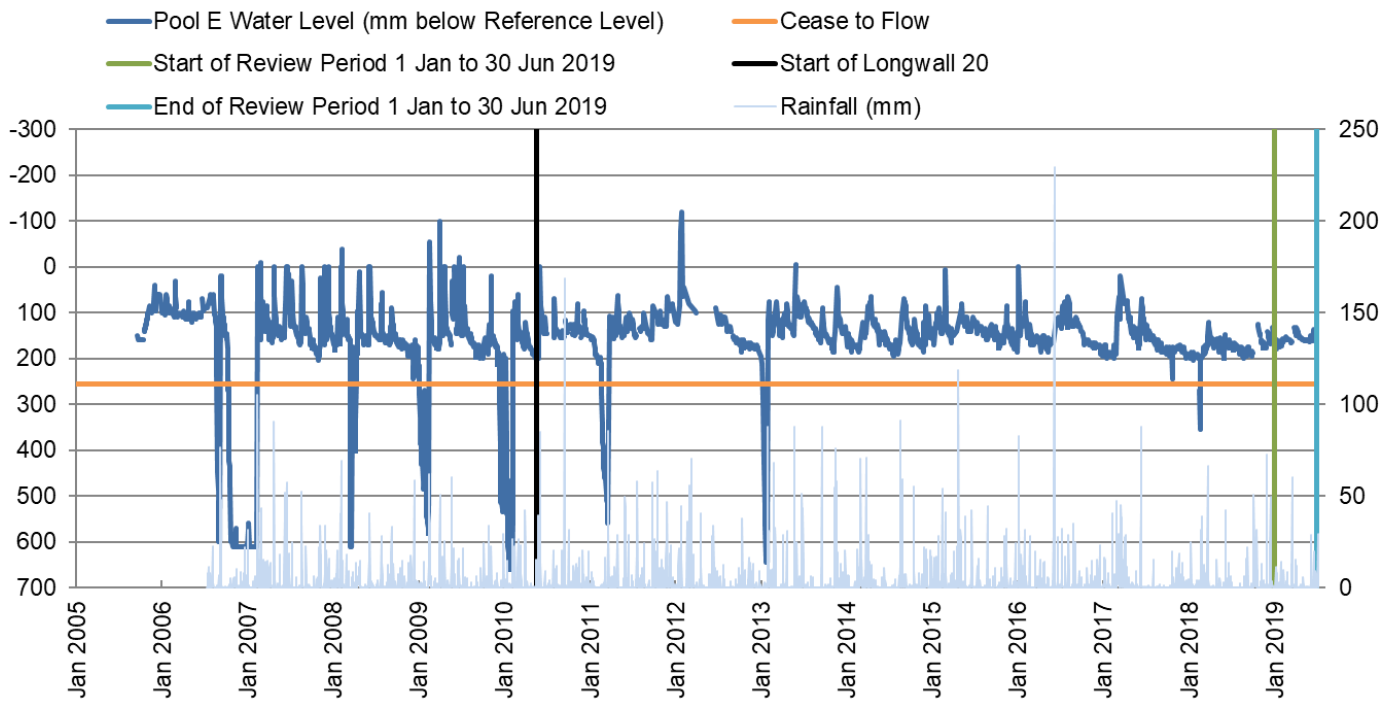


Chart A5 Pool E Waratah Rivulet (Manual Observations)

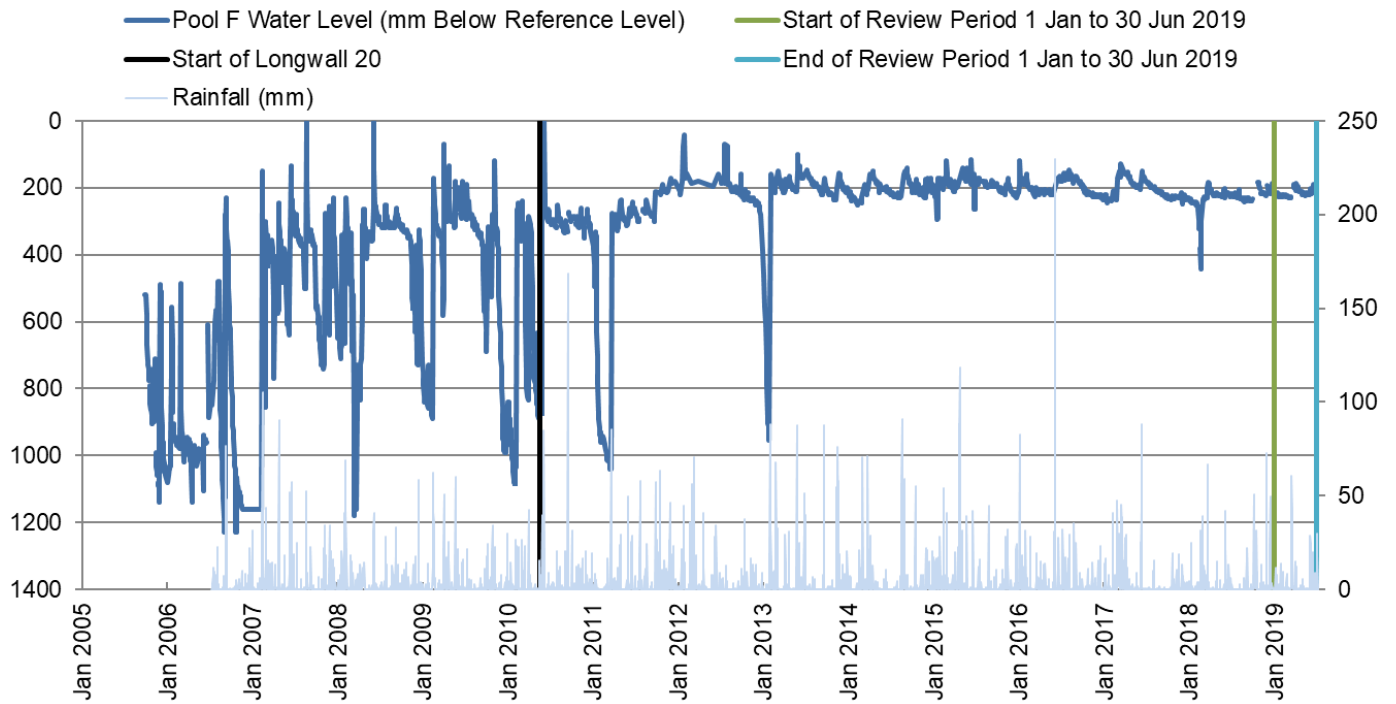


Chart A6 Pool F Waratah Rivulet (Manual Observations)

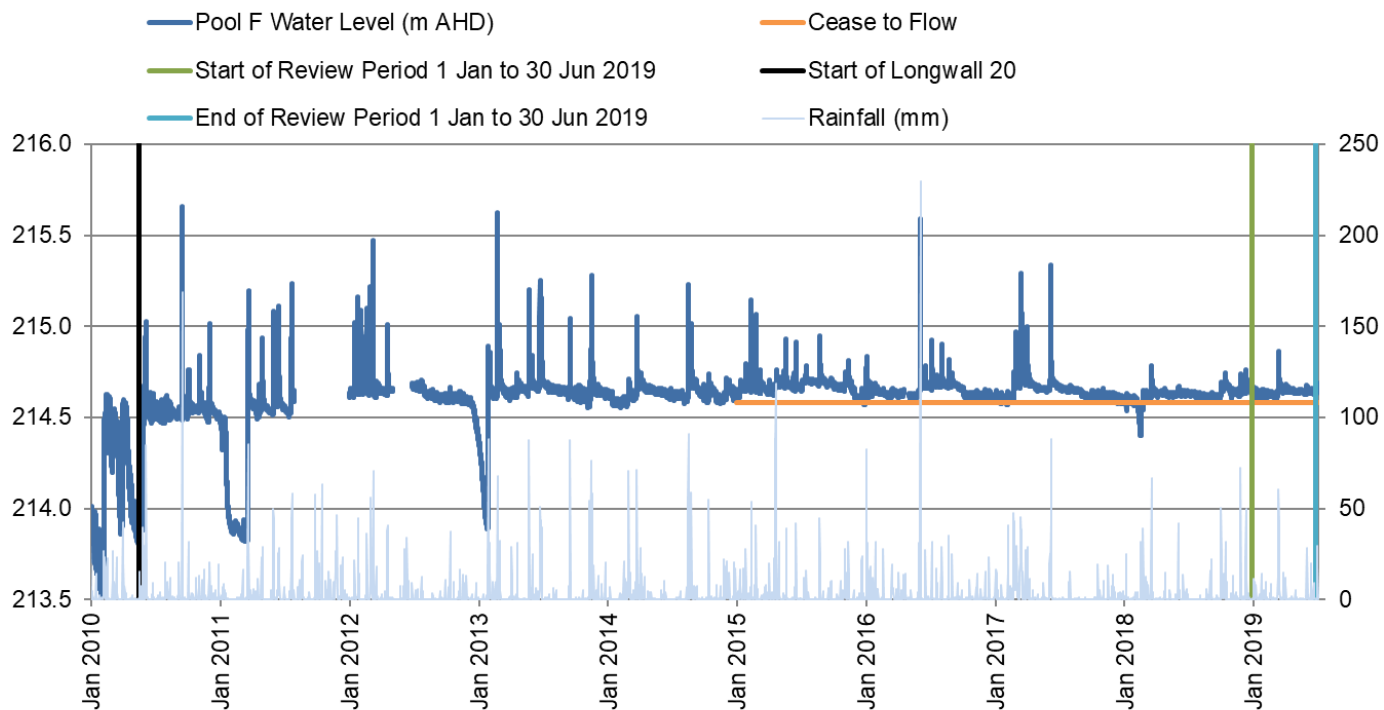


Chart A7 Pool F Waratah Rivulet

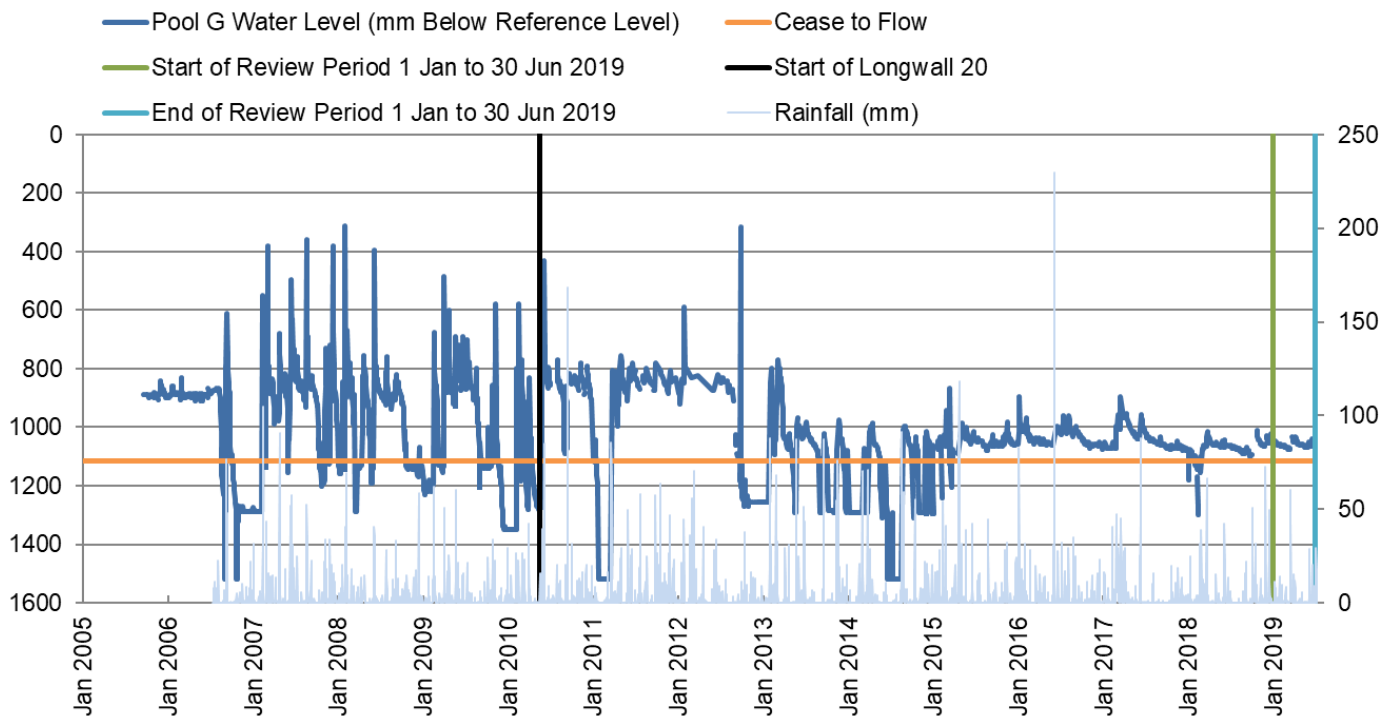


Chart A8 Pool G Waratah Rivulet (Manual Observations)

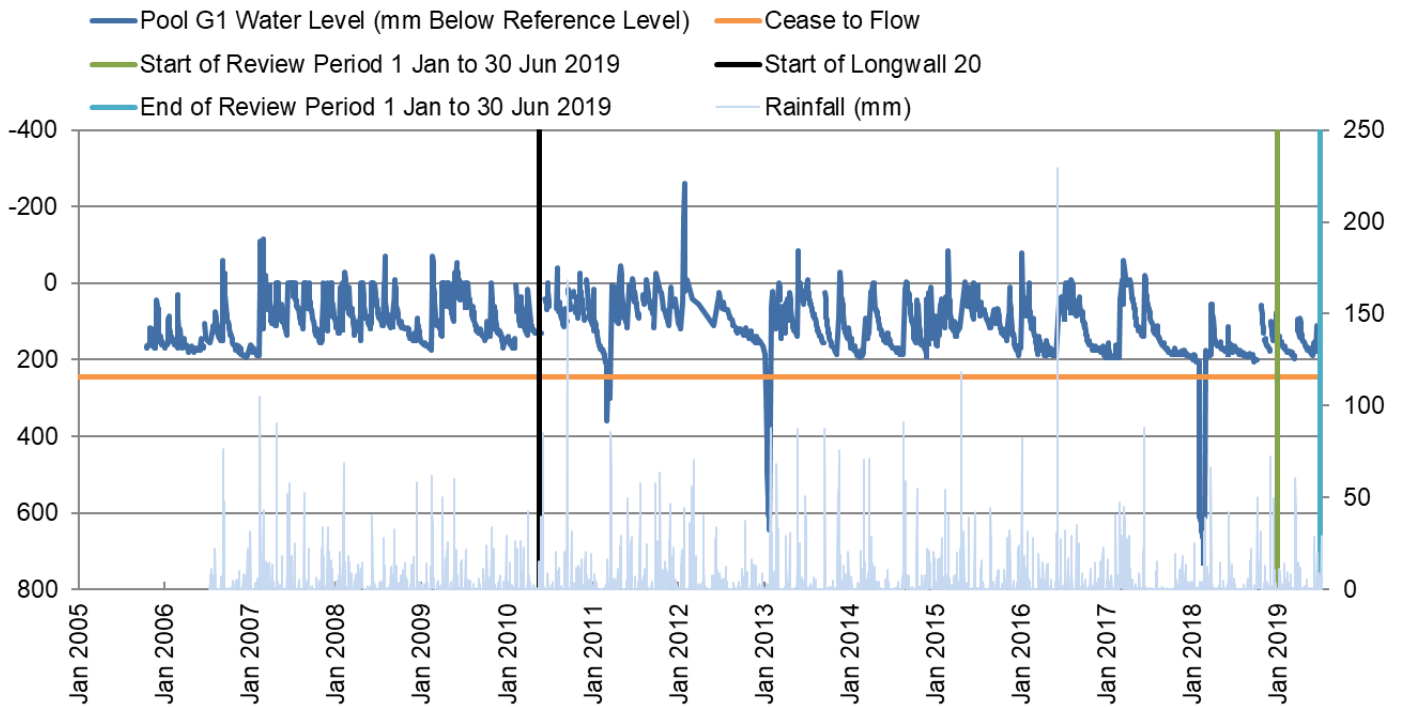


Chart A9 Pool G1 Waratah Rivulet (Manual Observations)

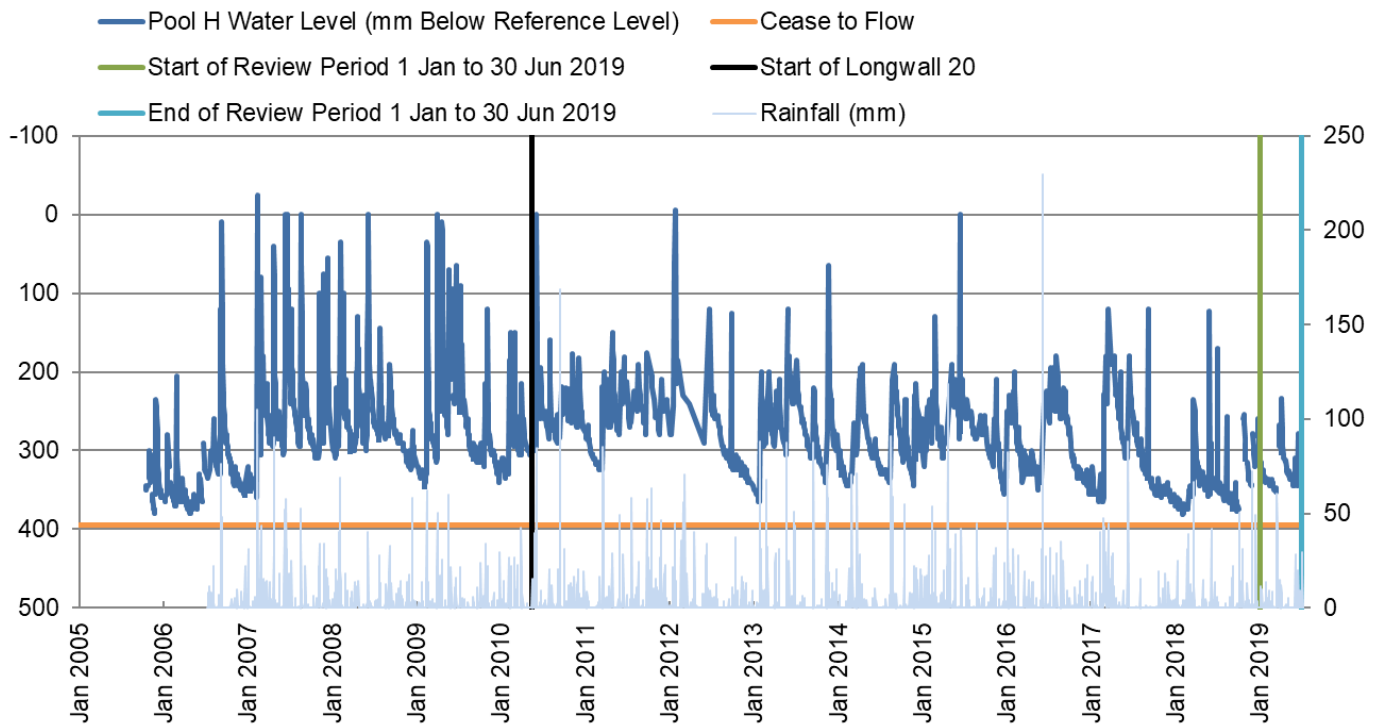


Chart A10 Pool H Waratah Rivulet (Manual Observations)

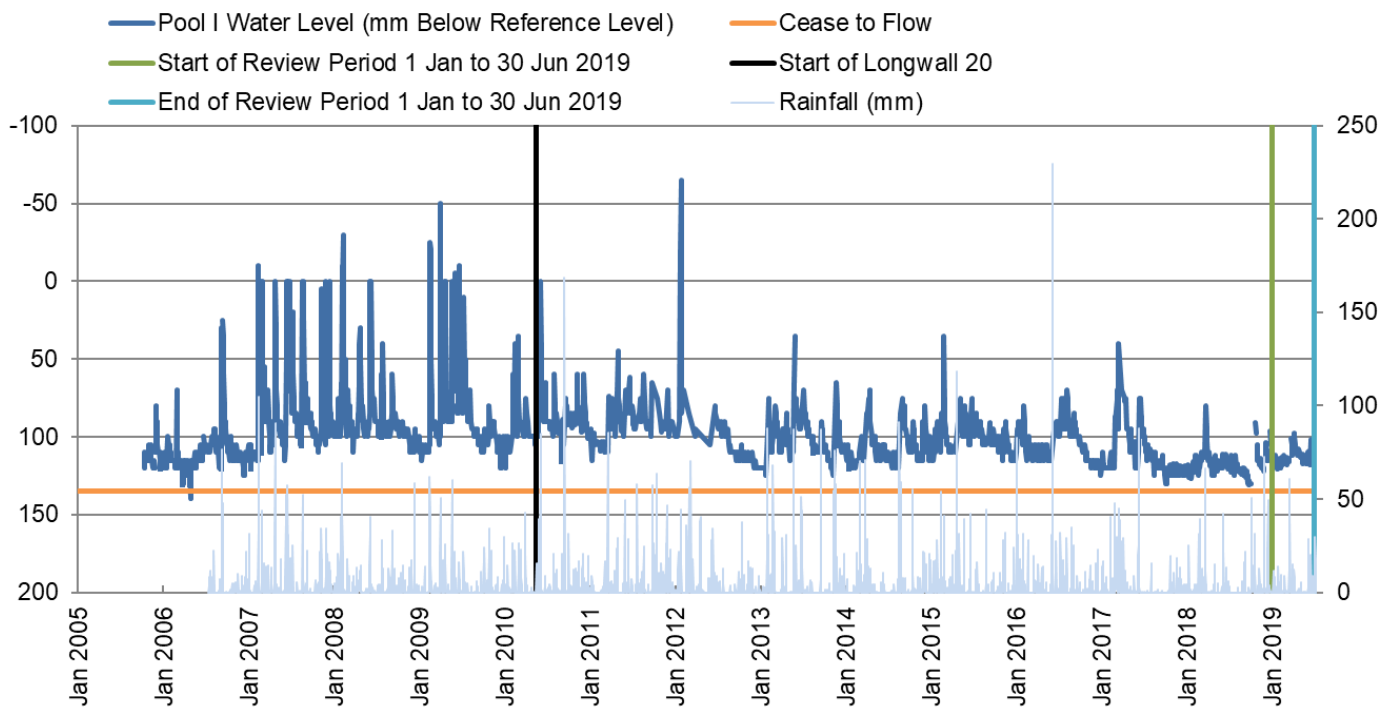


Chart A11 Pool I Waratah Rivulet (Manual Observations)

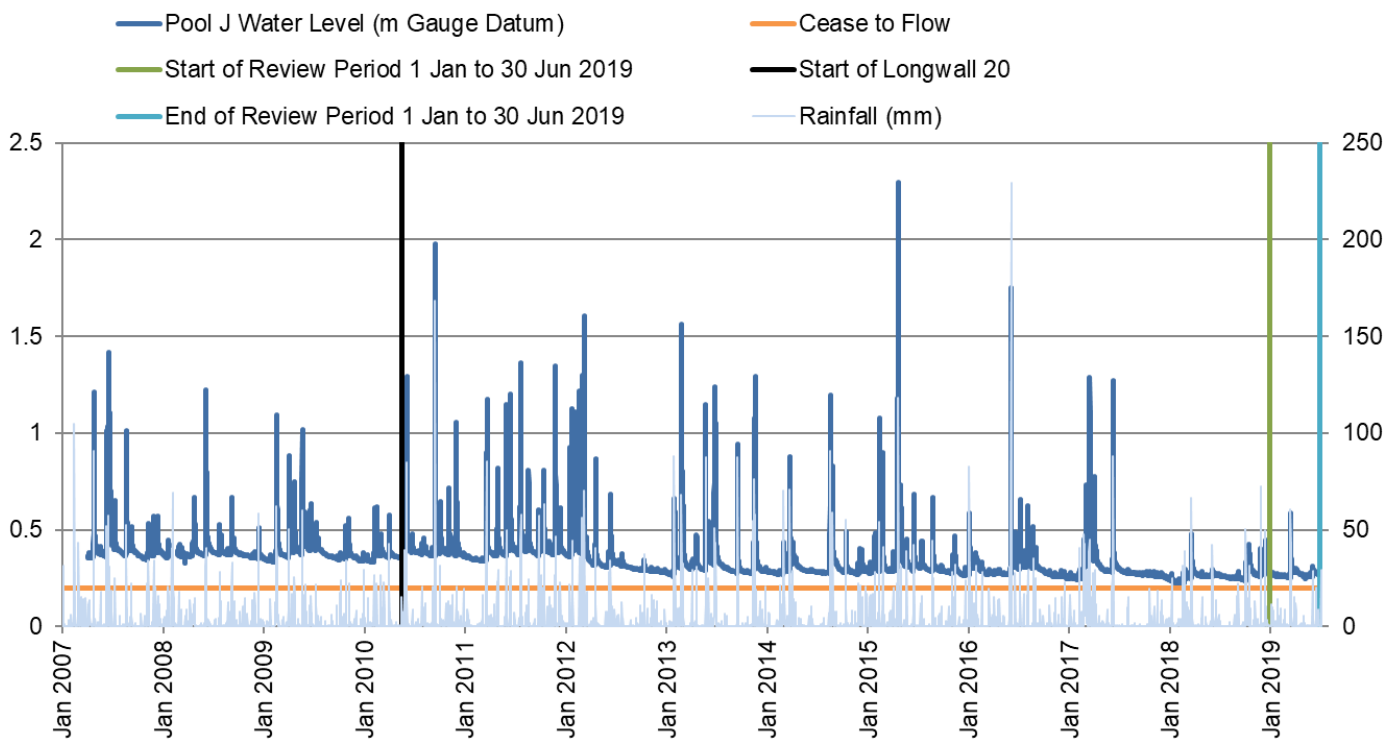


Chart A12 Pool J Waratah Rivulet

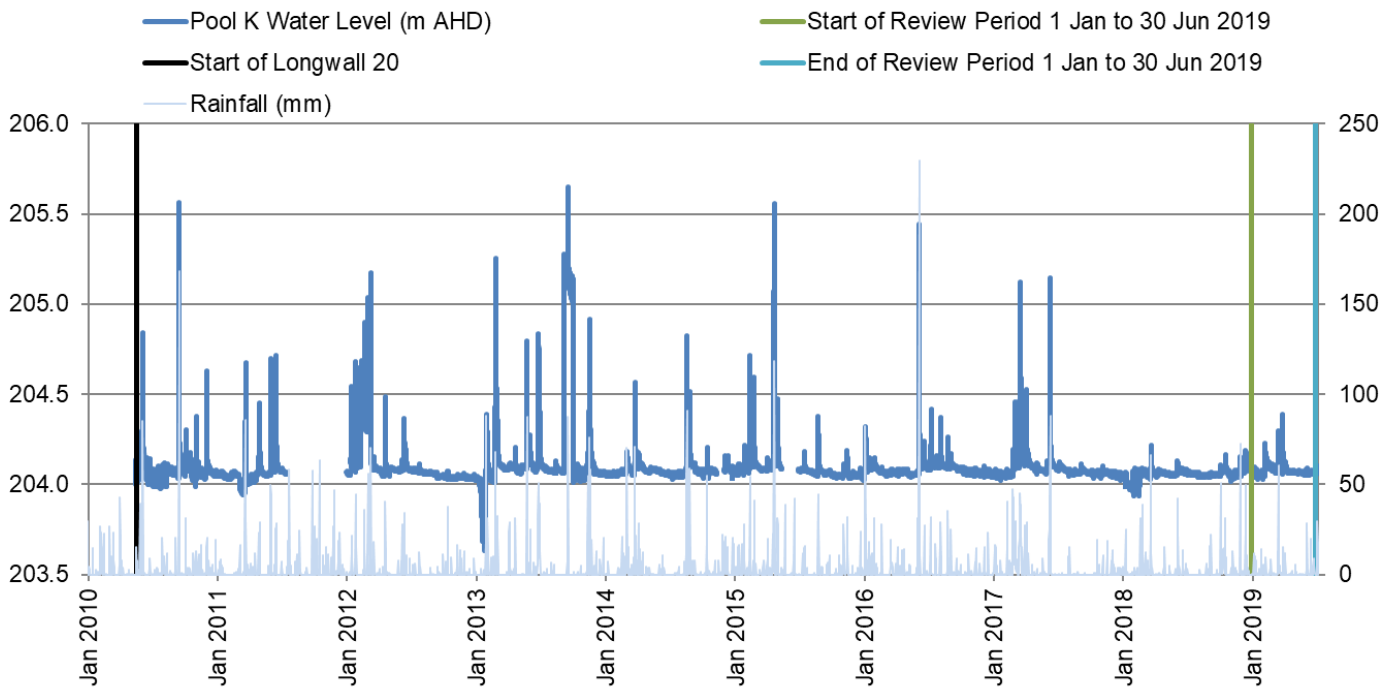


Chart A13 Pool K Waratah Rivulet

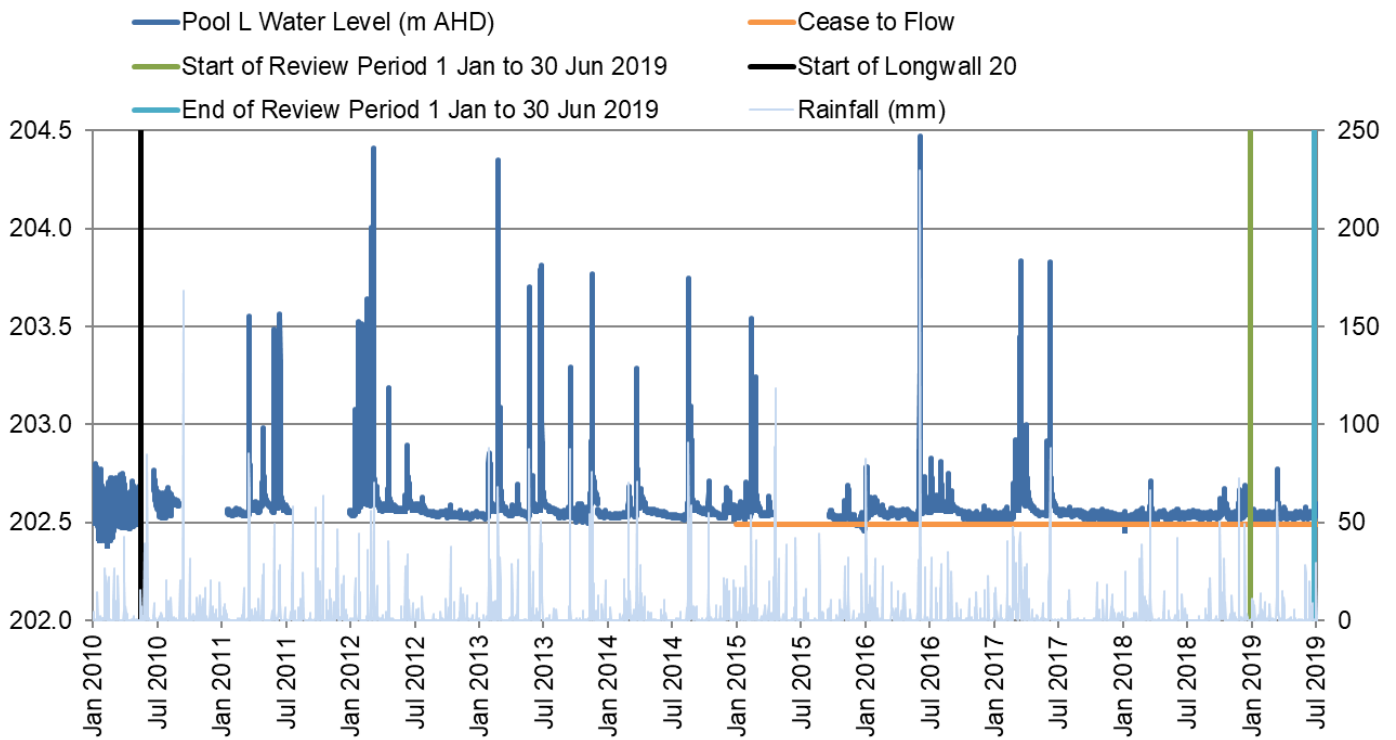


Chart A14 Pool L Waratah Rivulet

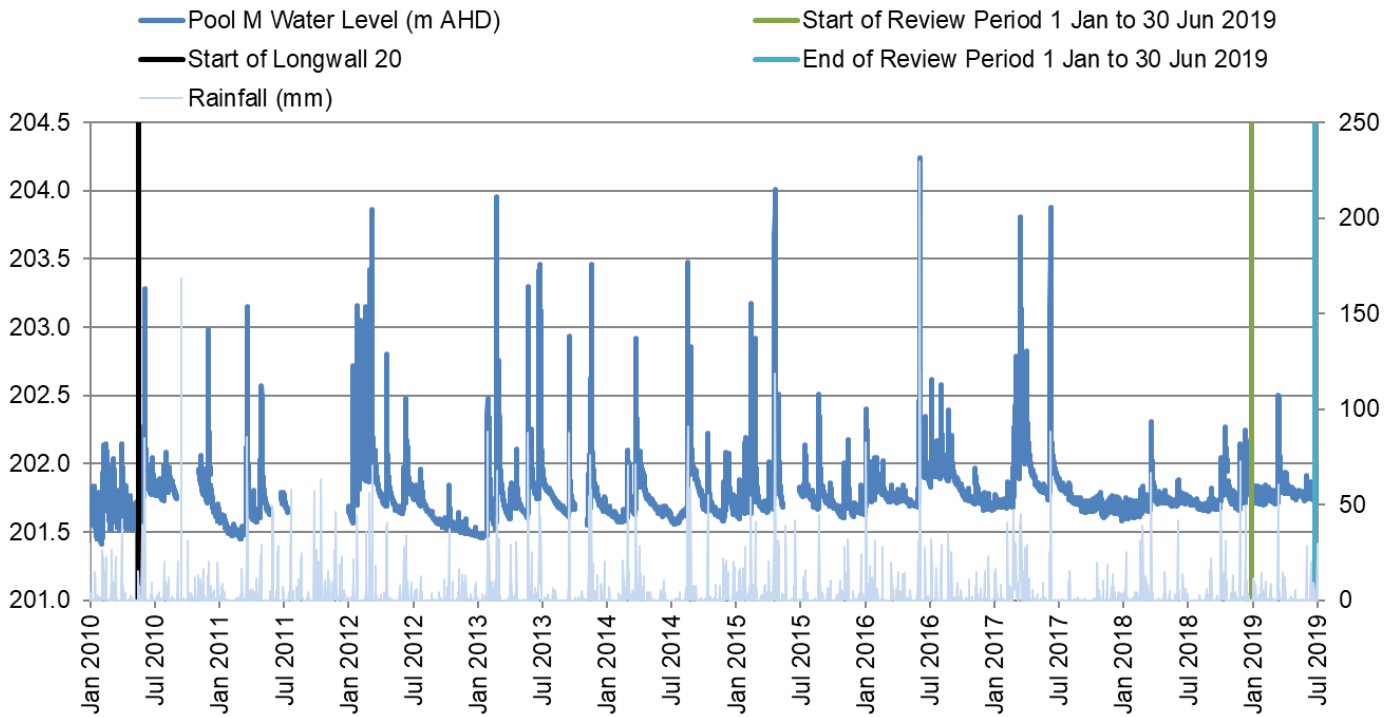


Chart A15 Pool M Waratah Rivulet

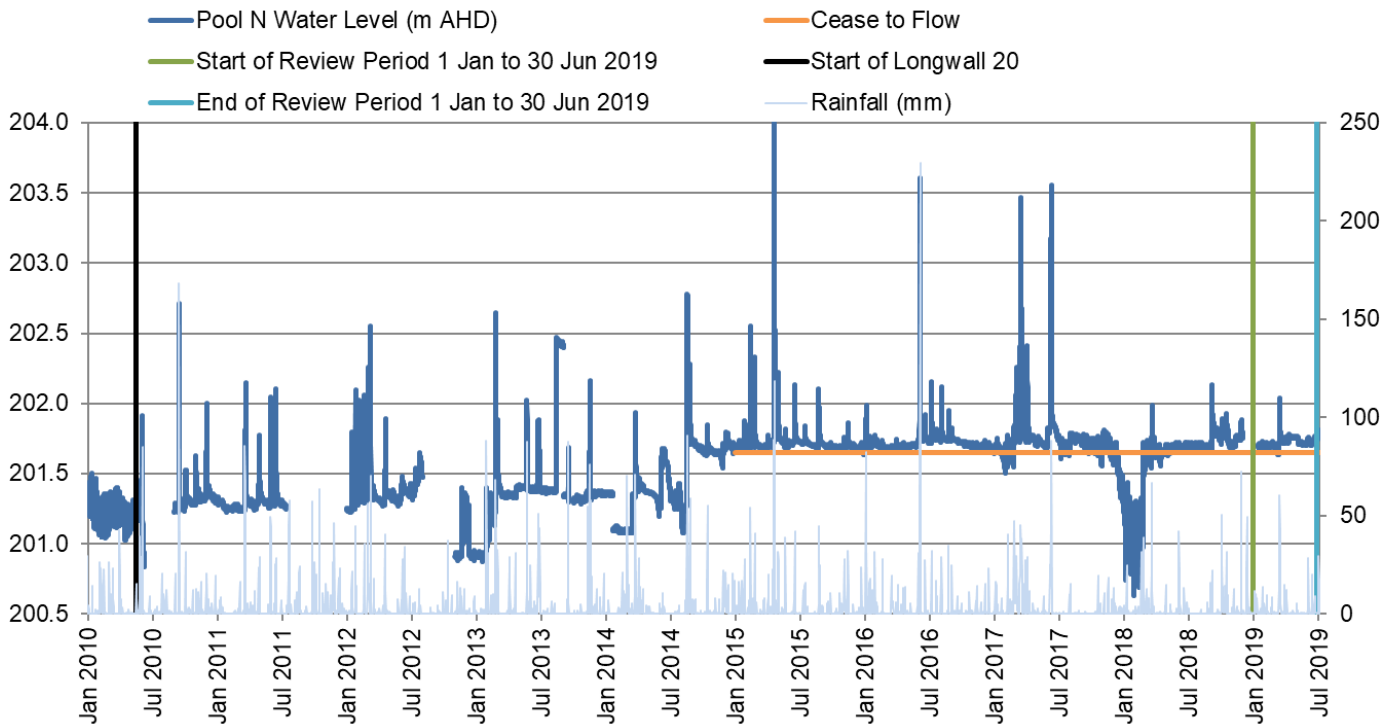


Chart A16 Pool N Waratah Rivulet⁶

⁶ Pool N water level sensor did not record any data during December 2018. Subsequently, the sensor was replaced in January 2019.

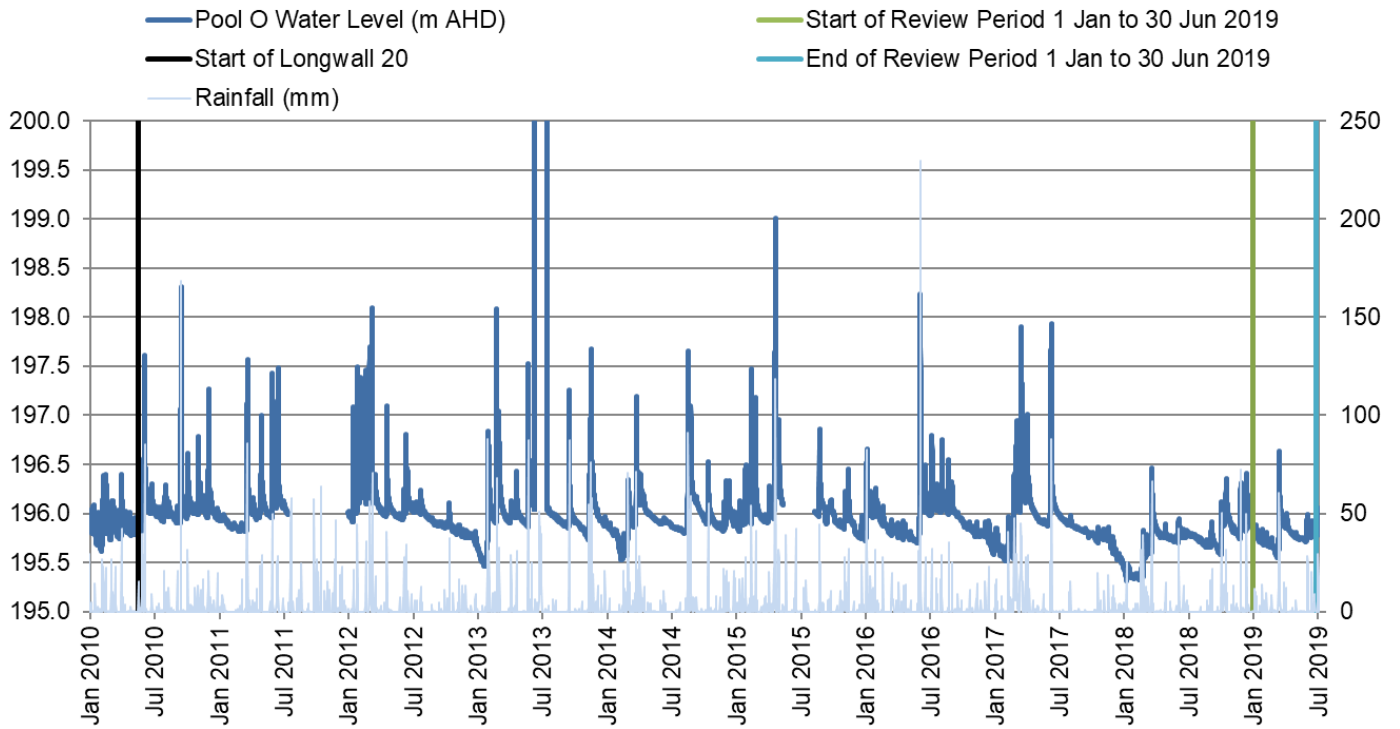


Chart A17 Pool O Waratah Rivulet

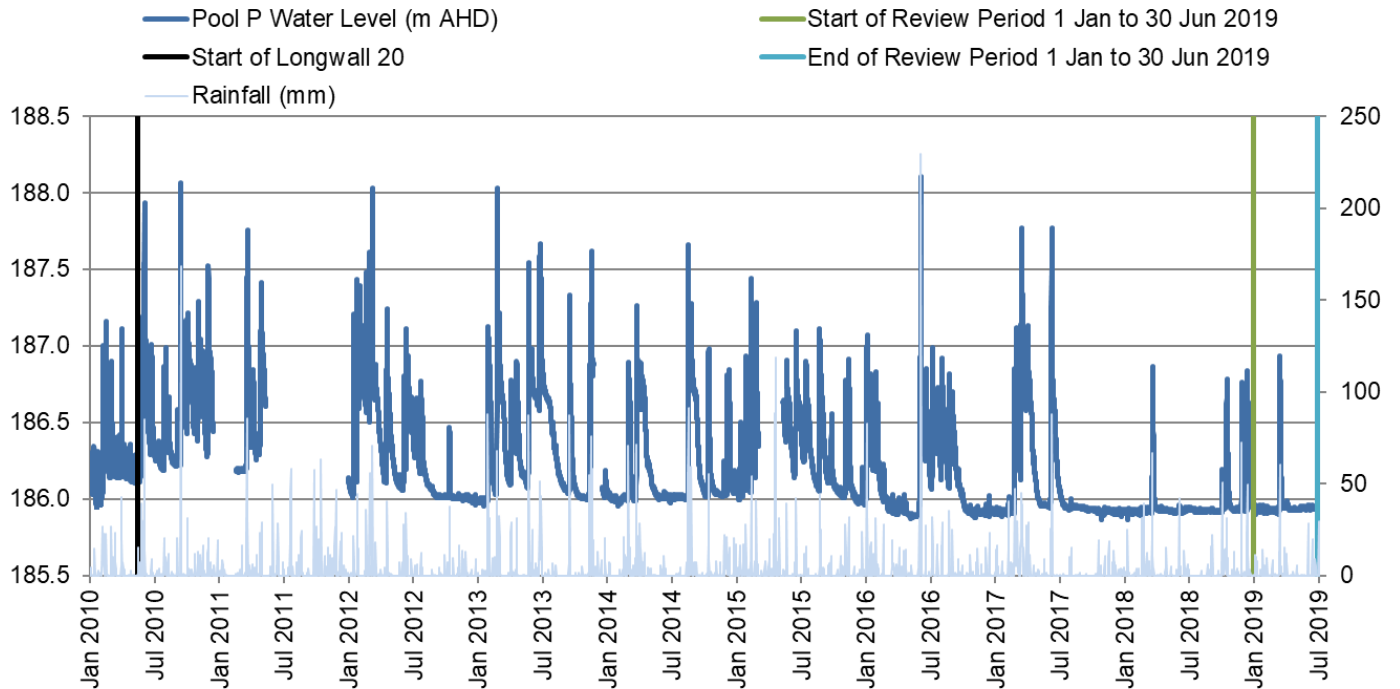


Chart A18 Pool P Waratah Rivulet

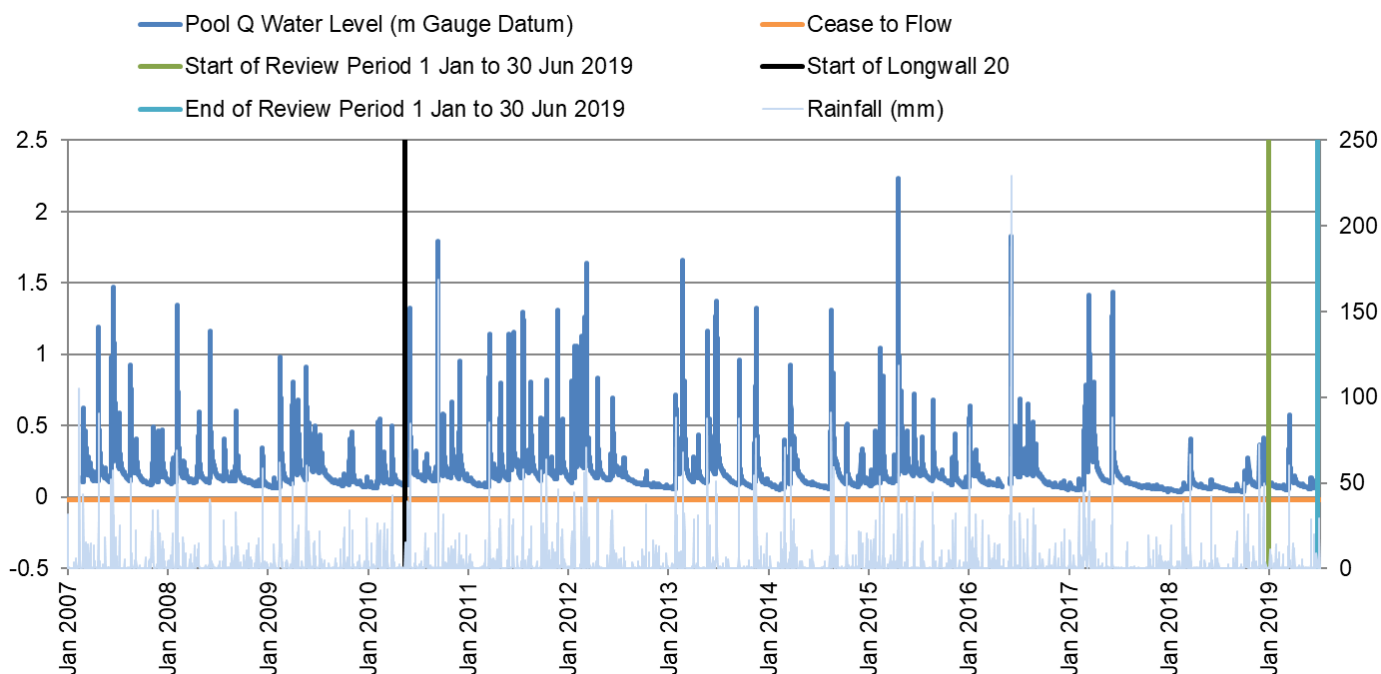


Chart A19 Pool Q Waratah Rivulet

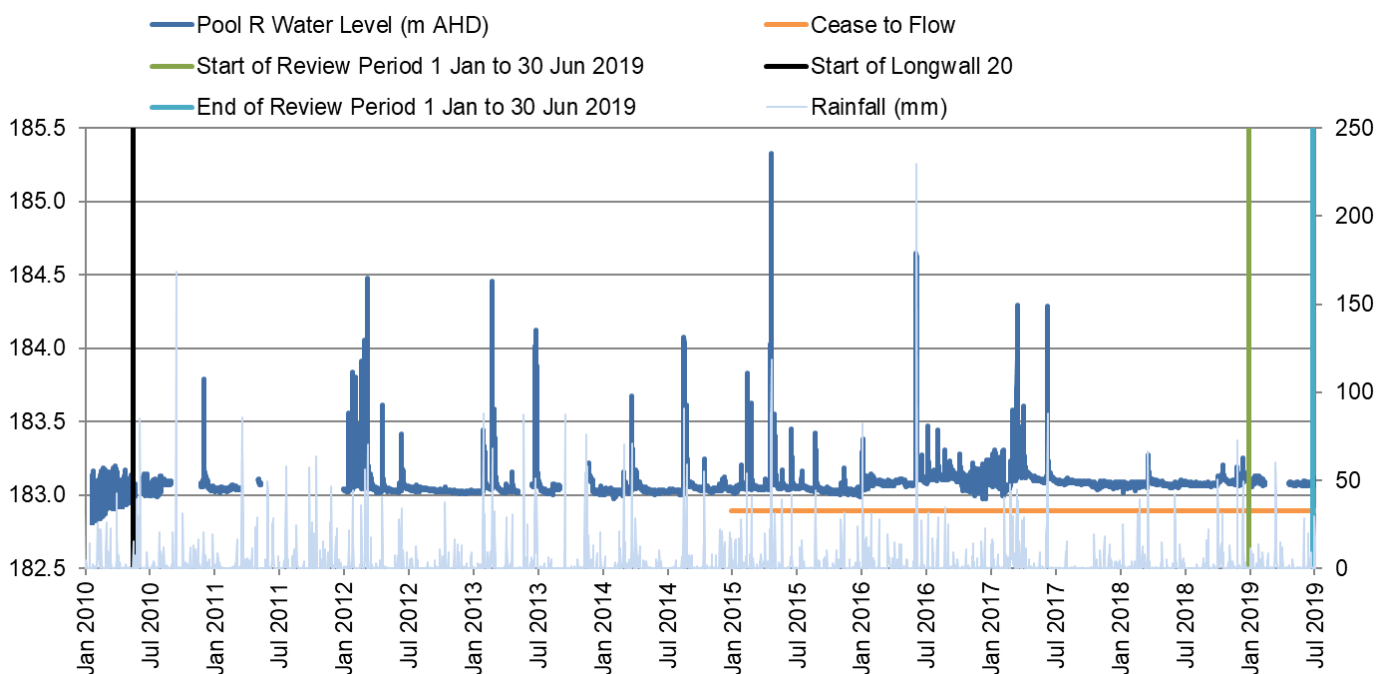


Chart A20 Pool R Waratah Rivulet⁷

⁷ The sensor malfunctioned on 14 February 2019 and was replaced on 24 April 2019. As such, no data was recorded during this period.

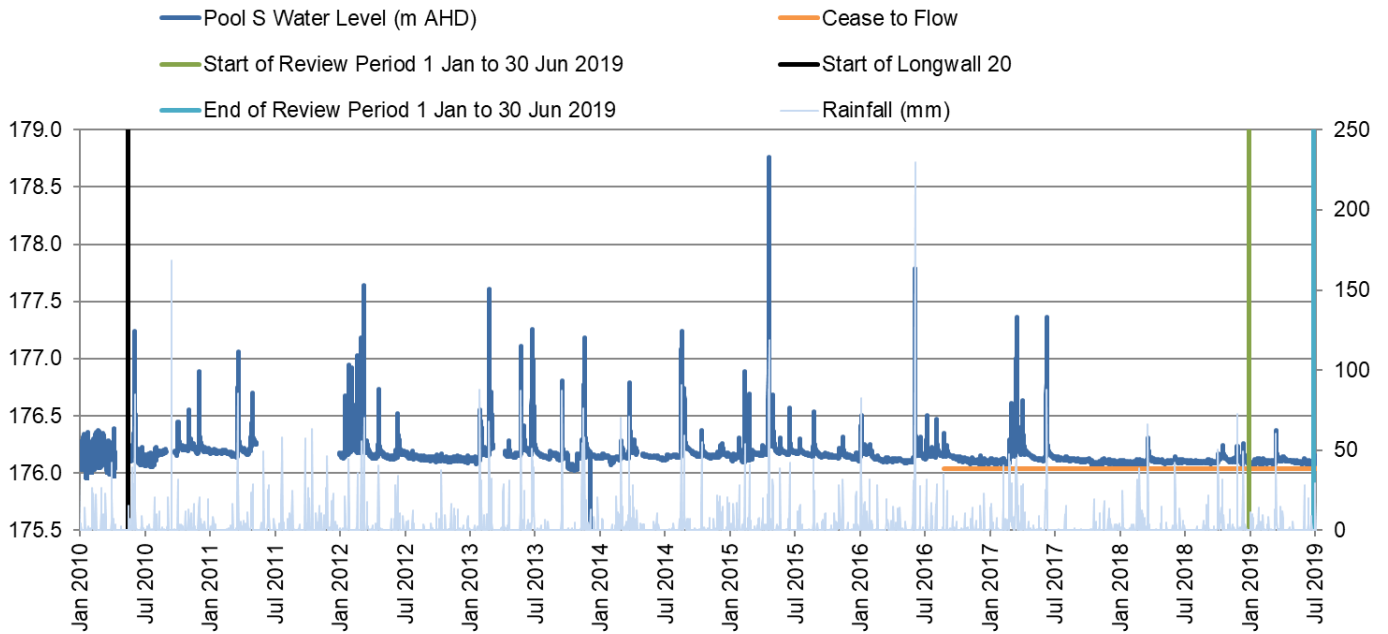


Chart A21 Pool S Waratah Rivulet

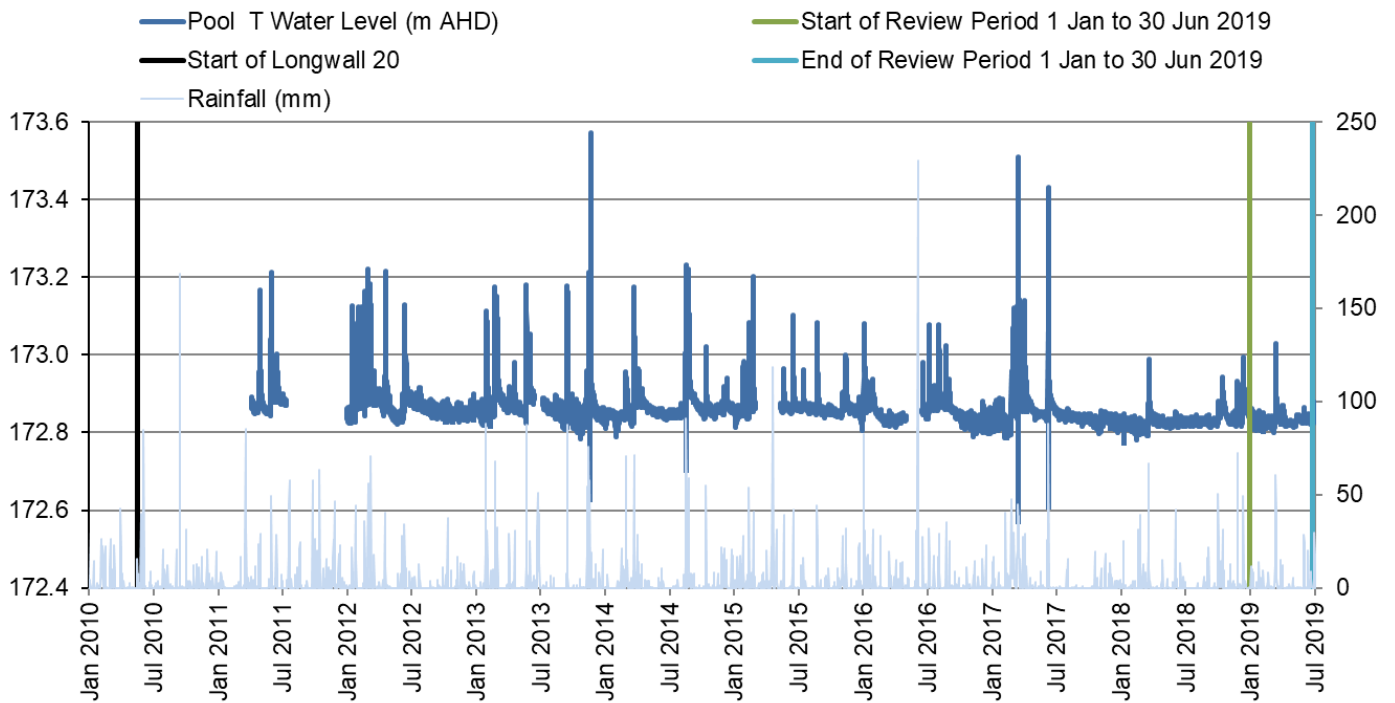


Chart A22 Pool T Waratah Rivulet⁸

⁸ The sudden drop in water level recorded on 18/3/2017 and 10/6/2017 are consistent with logger error.

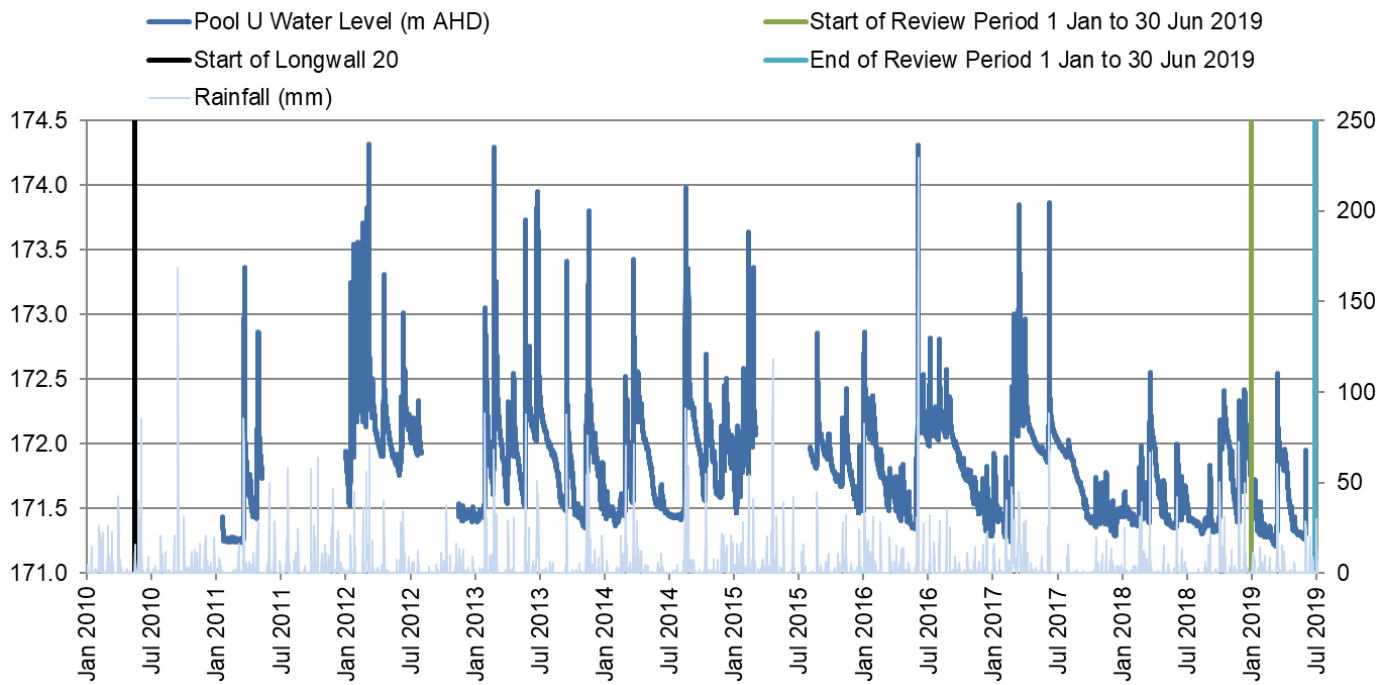


Chart A23 Pool U Waratah Rivulet⁹

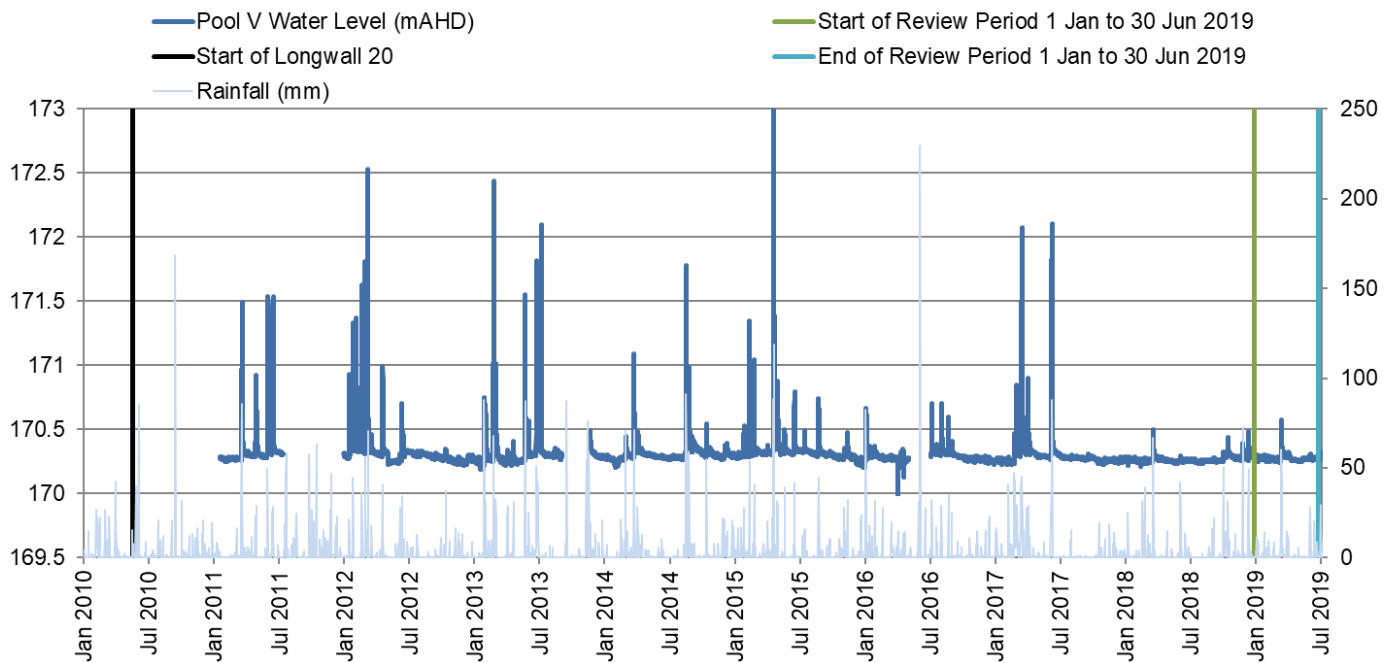


Chart A24 Pool V Waratah Rivulet

⁹ The sensor malfunctioned on 6 June 2019 and was replaced in July 2019. As such, no data was recorded during this period.

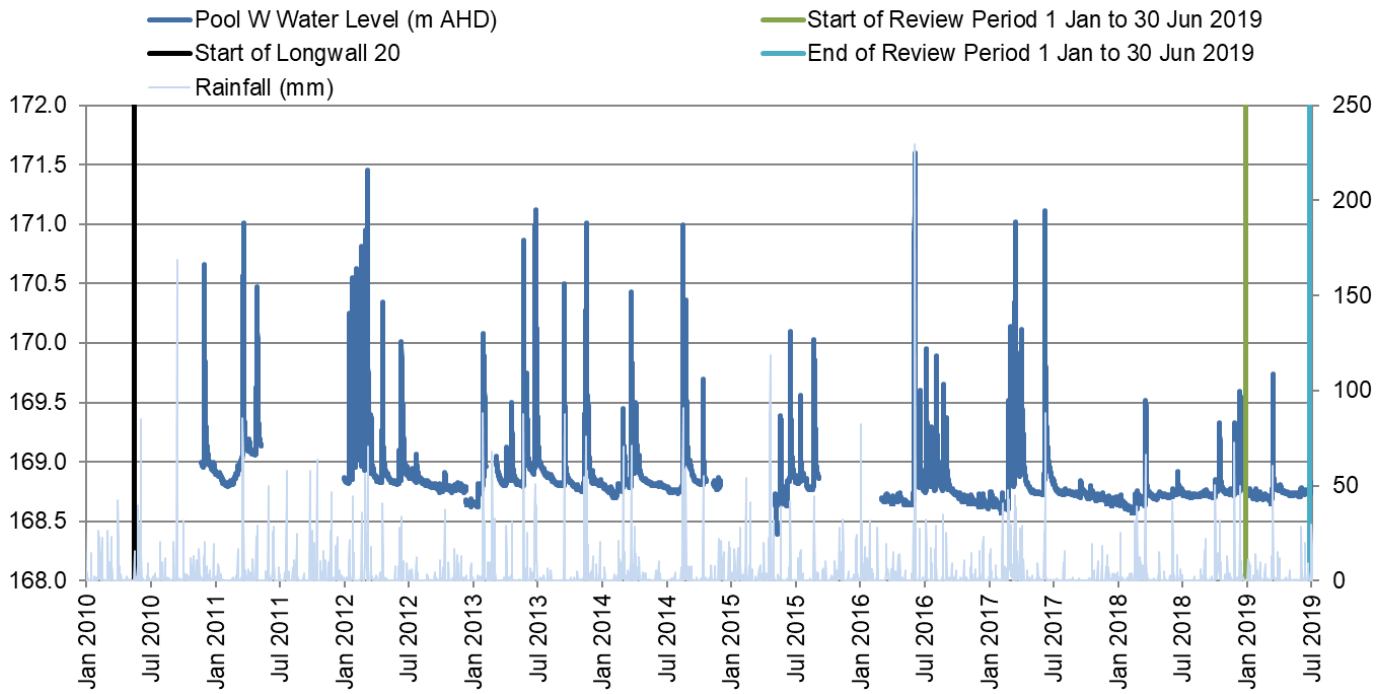


Chart A25 Pool W Waratah Rivulet

Pools on Eastern Tributary

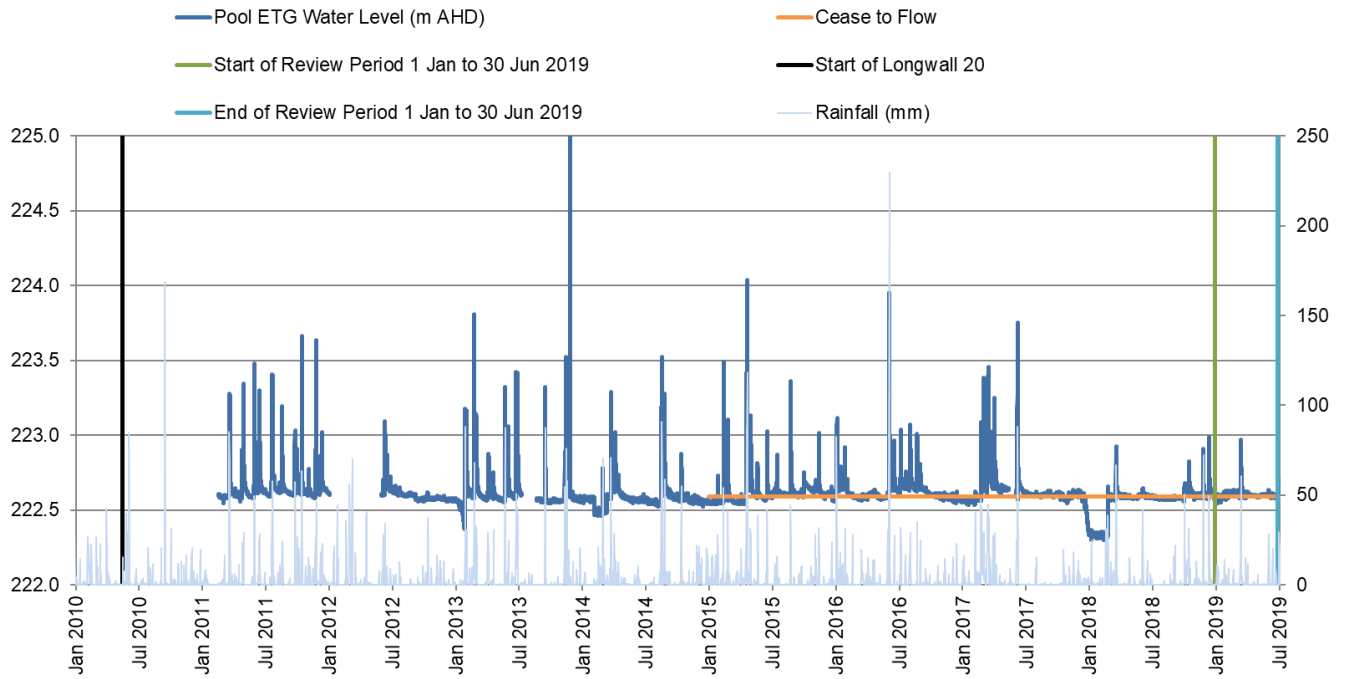


Chart A26 Pool ETG

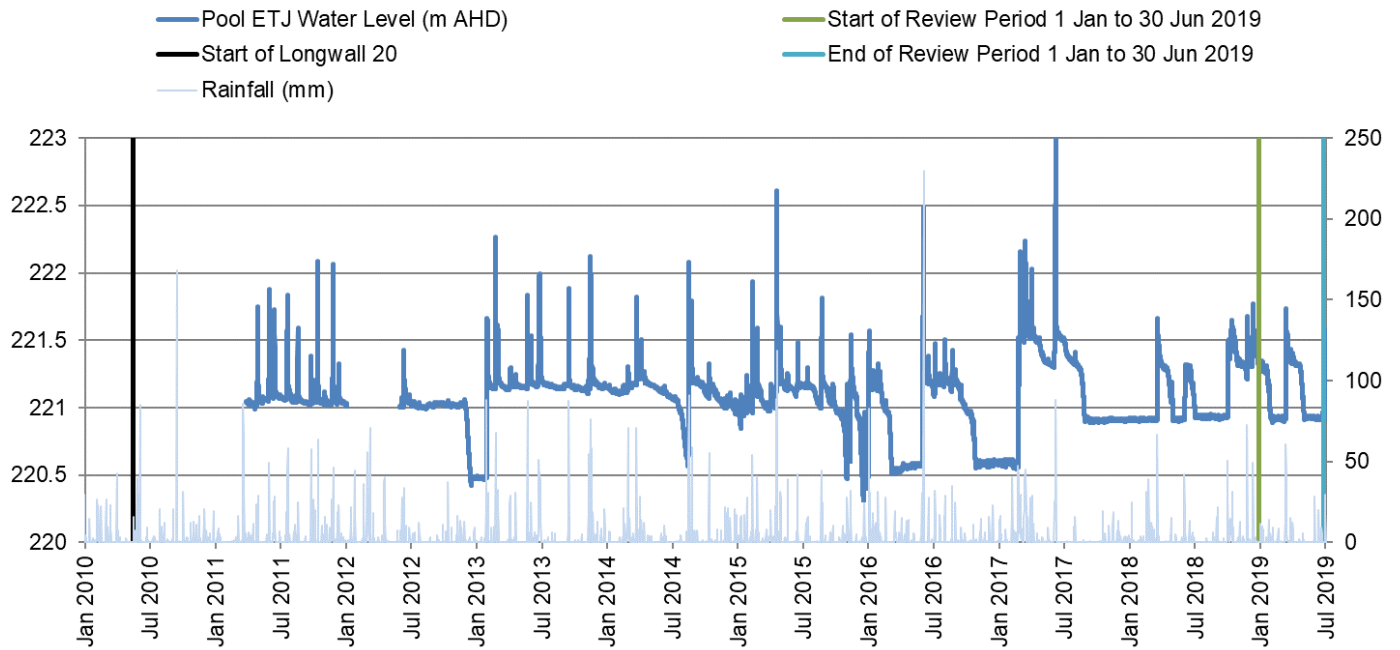


Chart A27 Pool ETJ

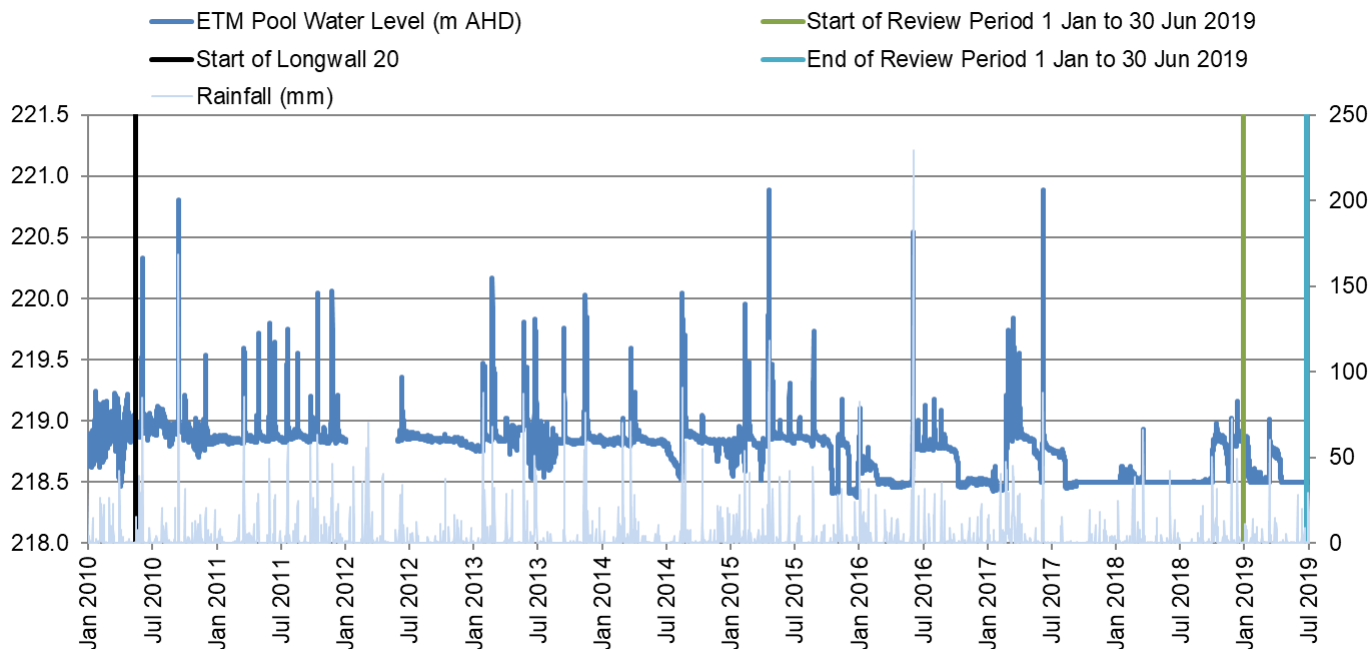


Chart A28 Pool ETM

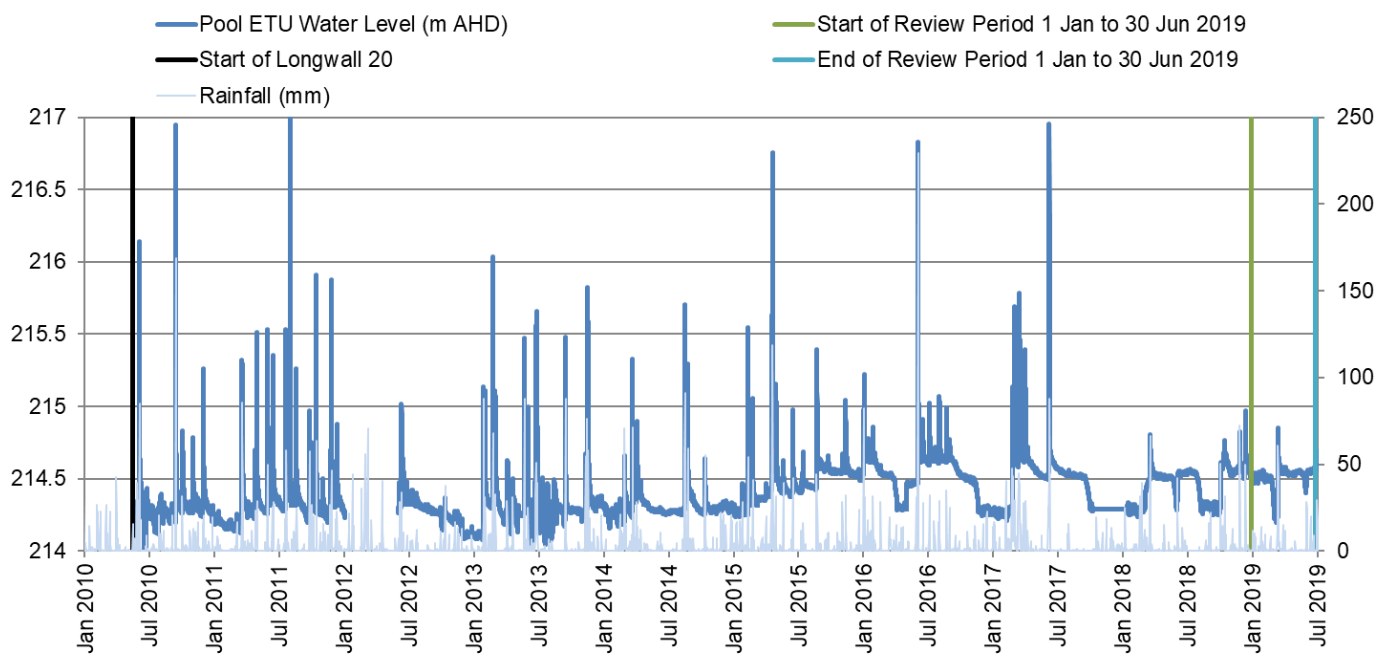


Chart A29 Pool ETU

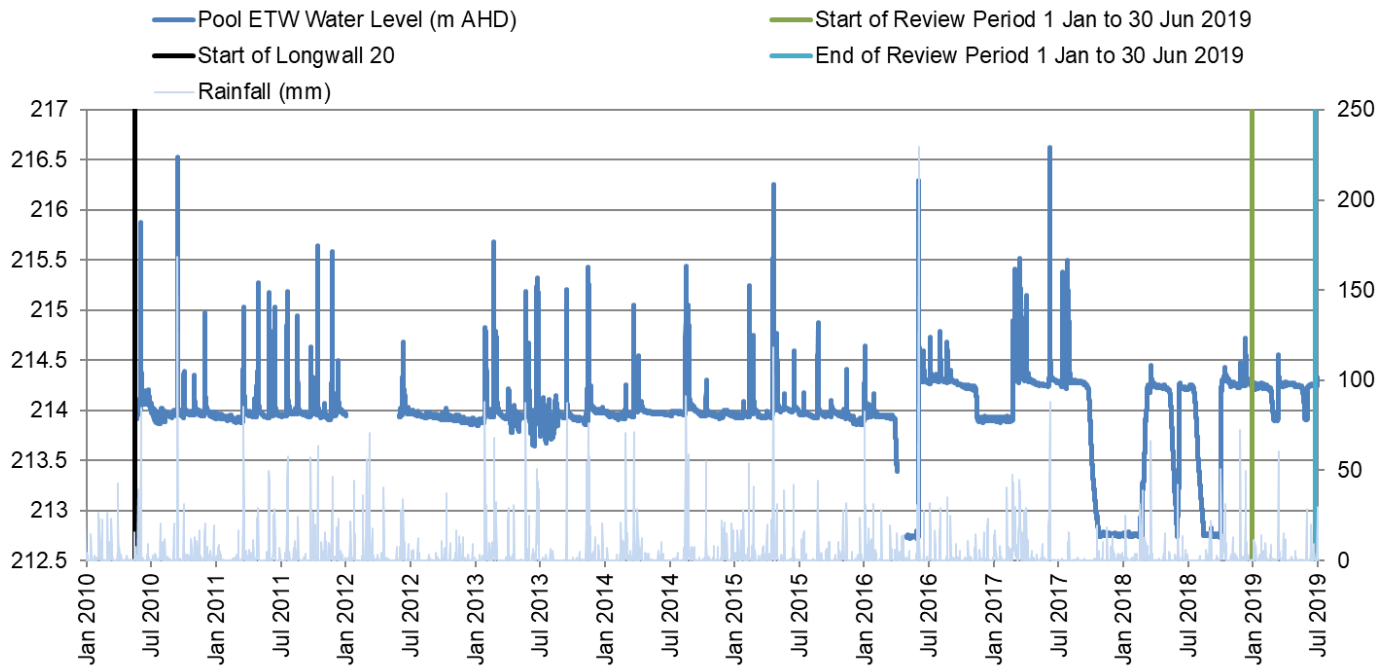


Chart A30 Pool ETW^{10,11}

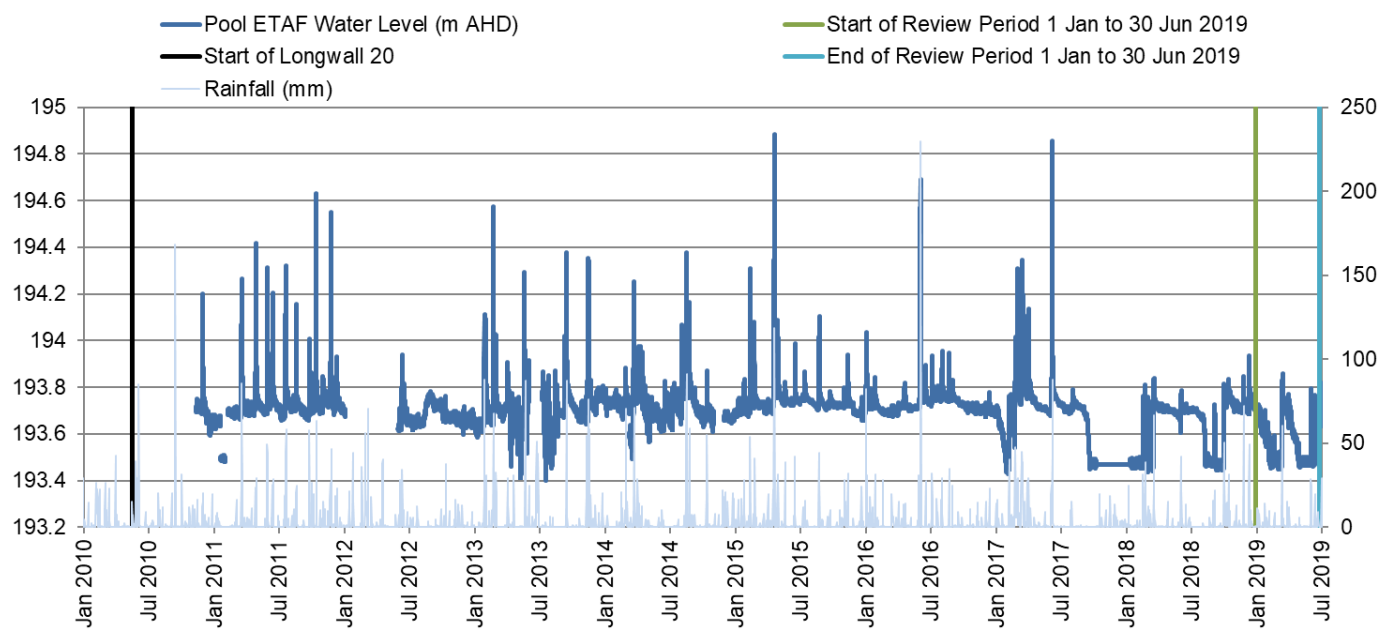


Chart A31 Pool ETAF

¹⁰ Note discrepancies in water levels caused by pool being dry and water level sensor being exposed at time of download.

¹¹ After heavy rainfalls in early June 2016, the diver stand at Pool ETW became clogged with sediment and the diver was unable to reach the bottom. On 14 July 2016, a new diver was installed at Pool ETW to replace the previous diver. In September 2017, the old diver was cleared of sediment and was able to be used again. The original diver extends deeper into the pool, allowing additional information to be obtained during periods when the pool water level is below the cease to flow level. Data shown after September 2017 is from the original diver.

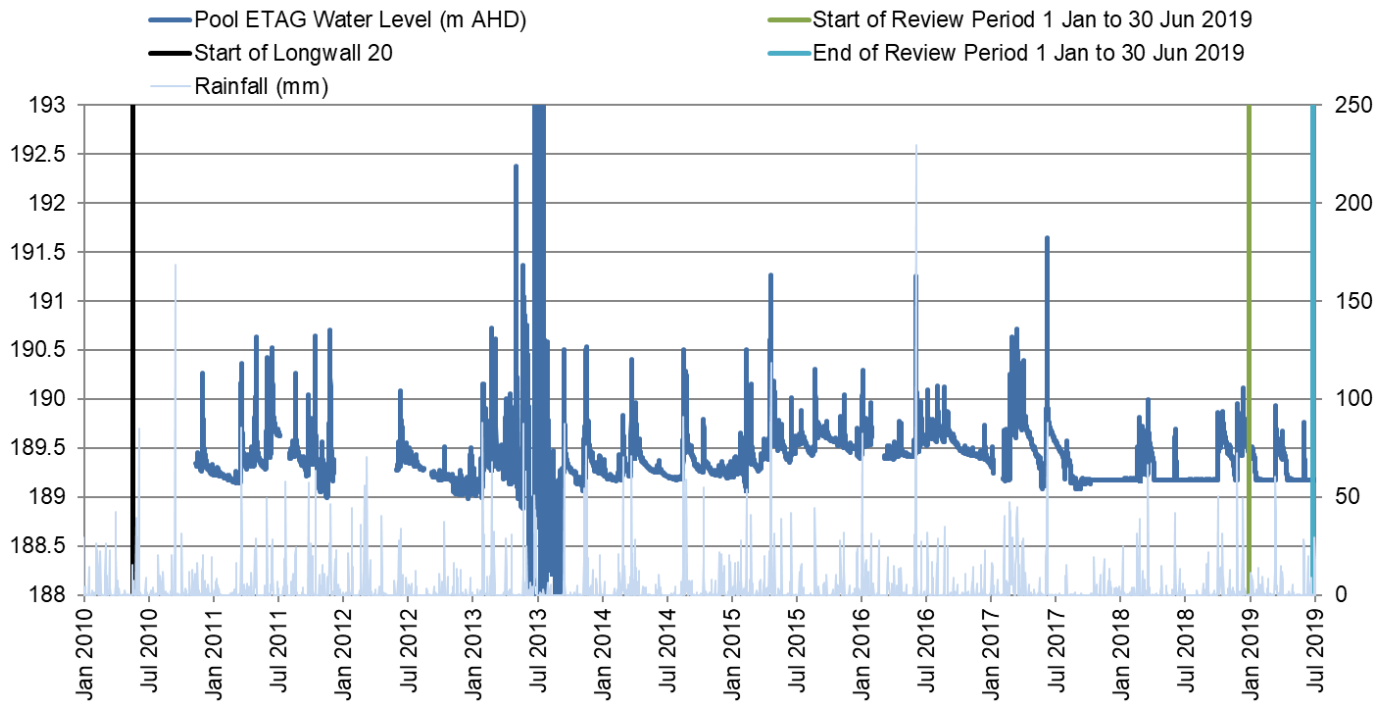


Chart A32 Pool ETAG

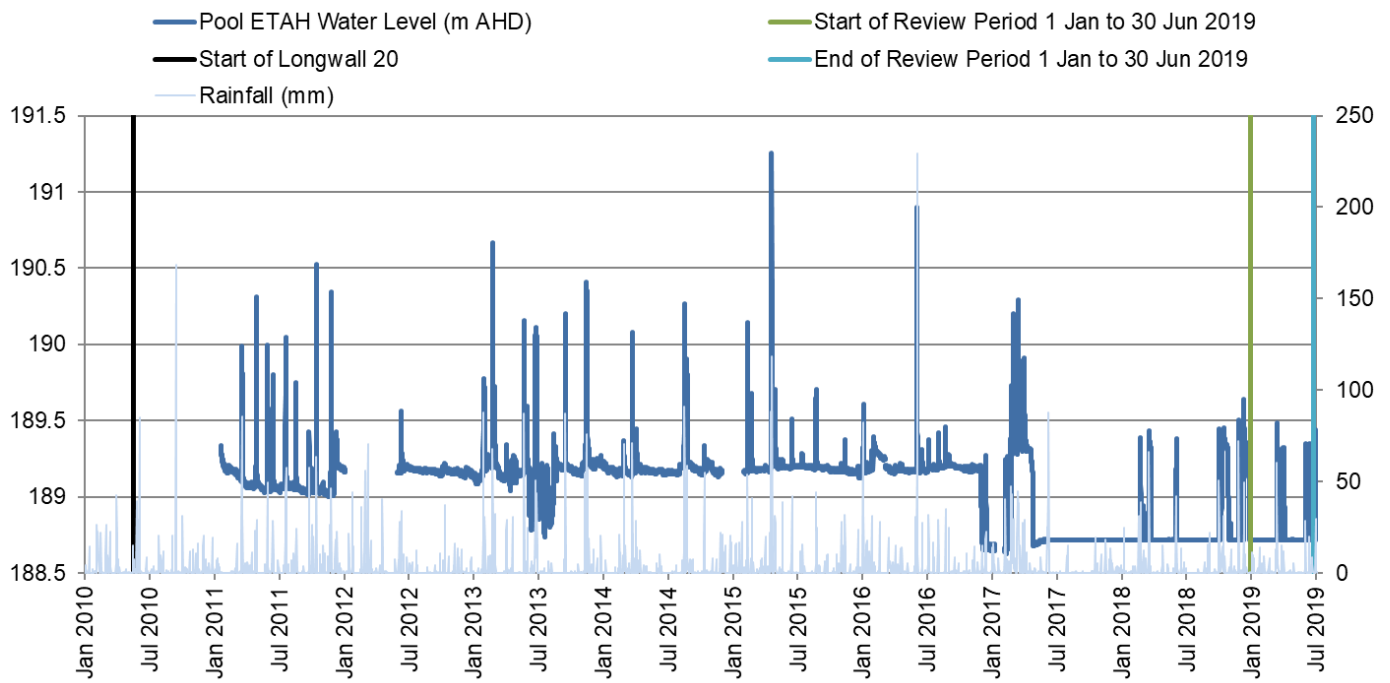


Chart A33 Pool ETAH

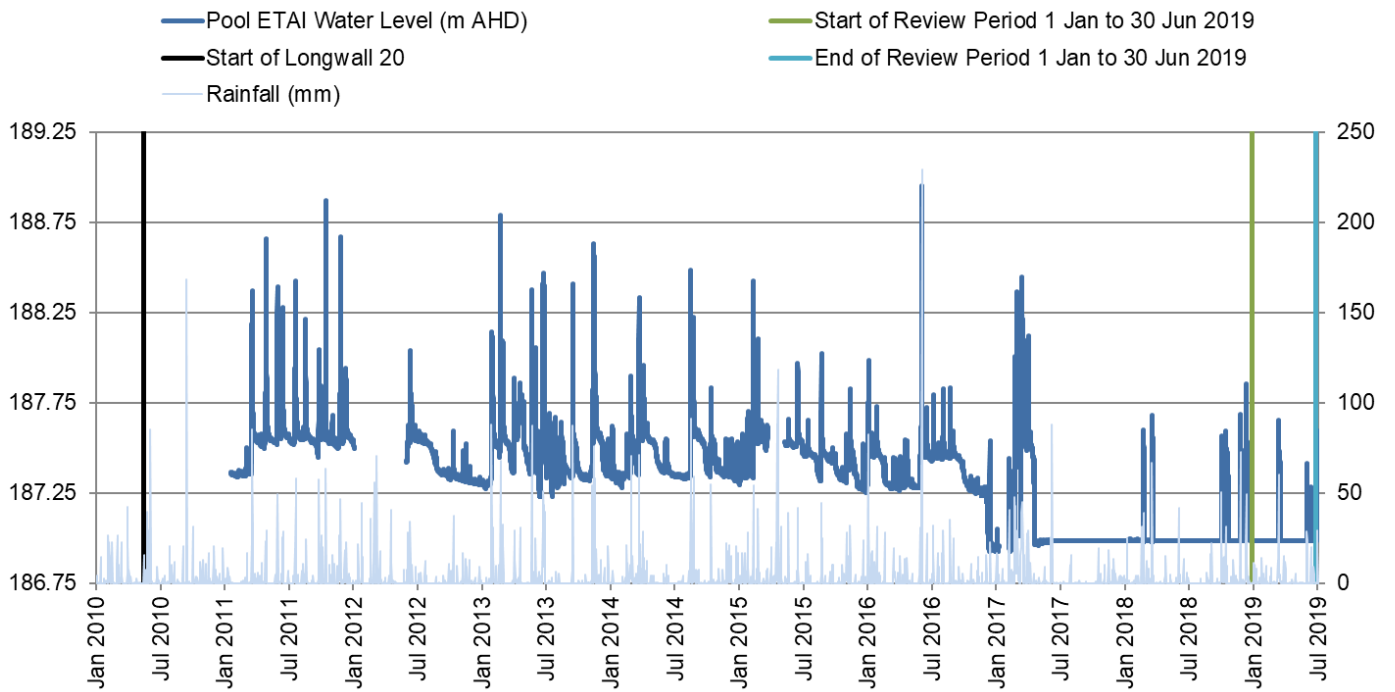


Chart A34 Pool ETAI

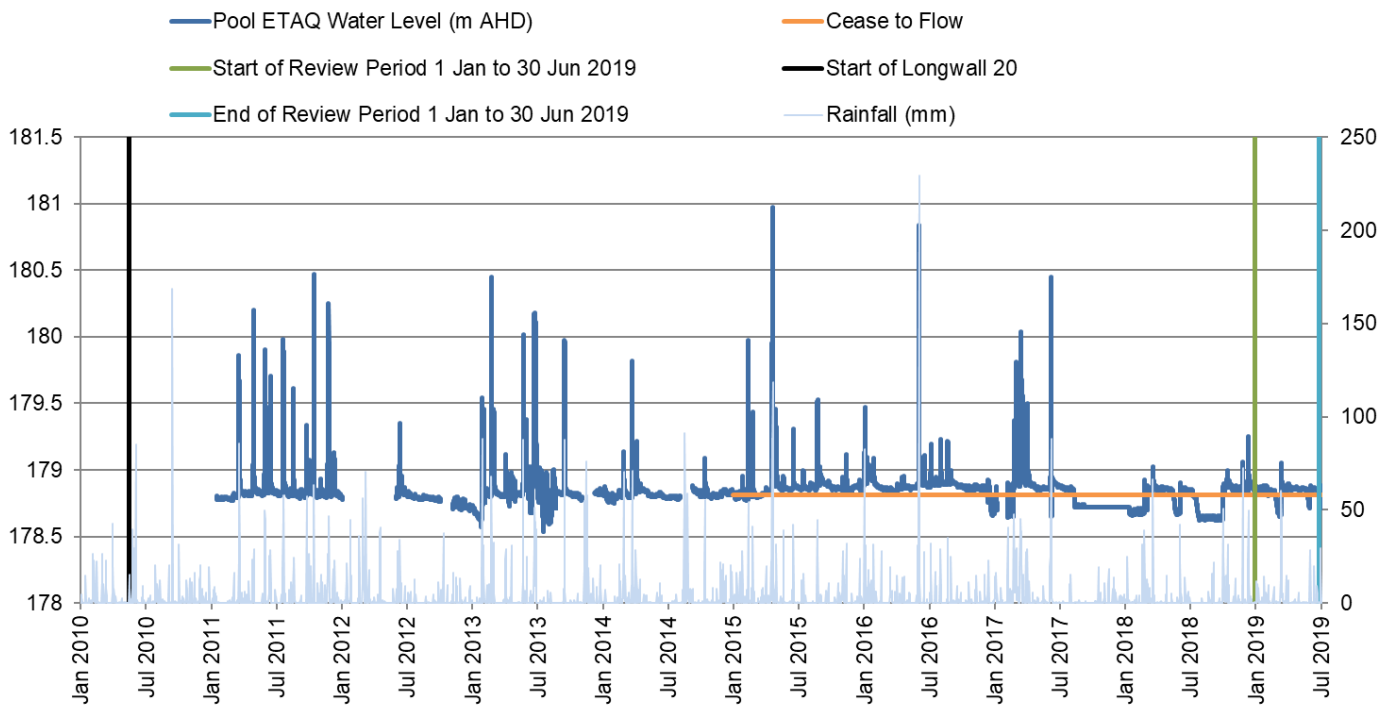


Chart A35 Pool ETAQ

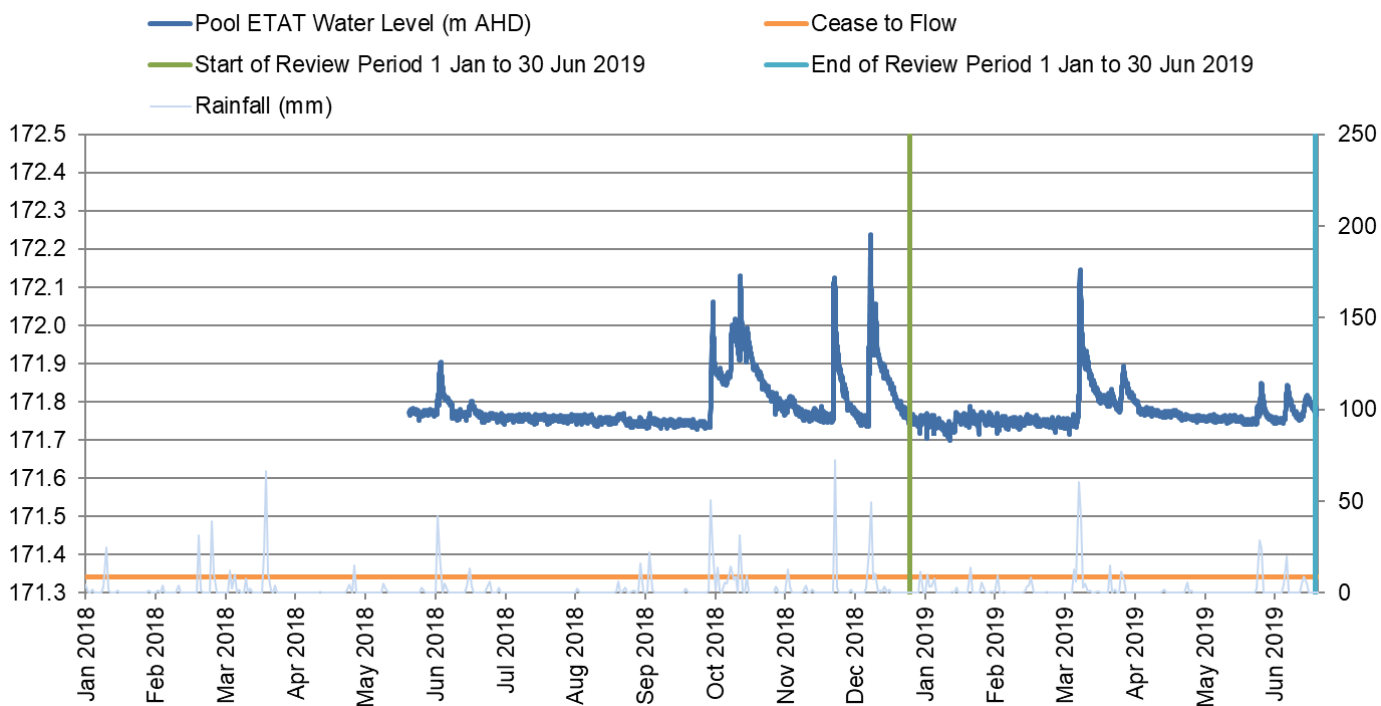


Chart A36 Pool ETAT

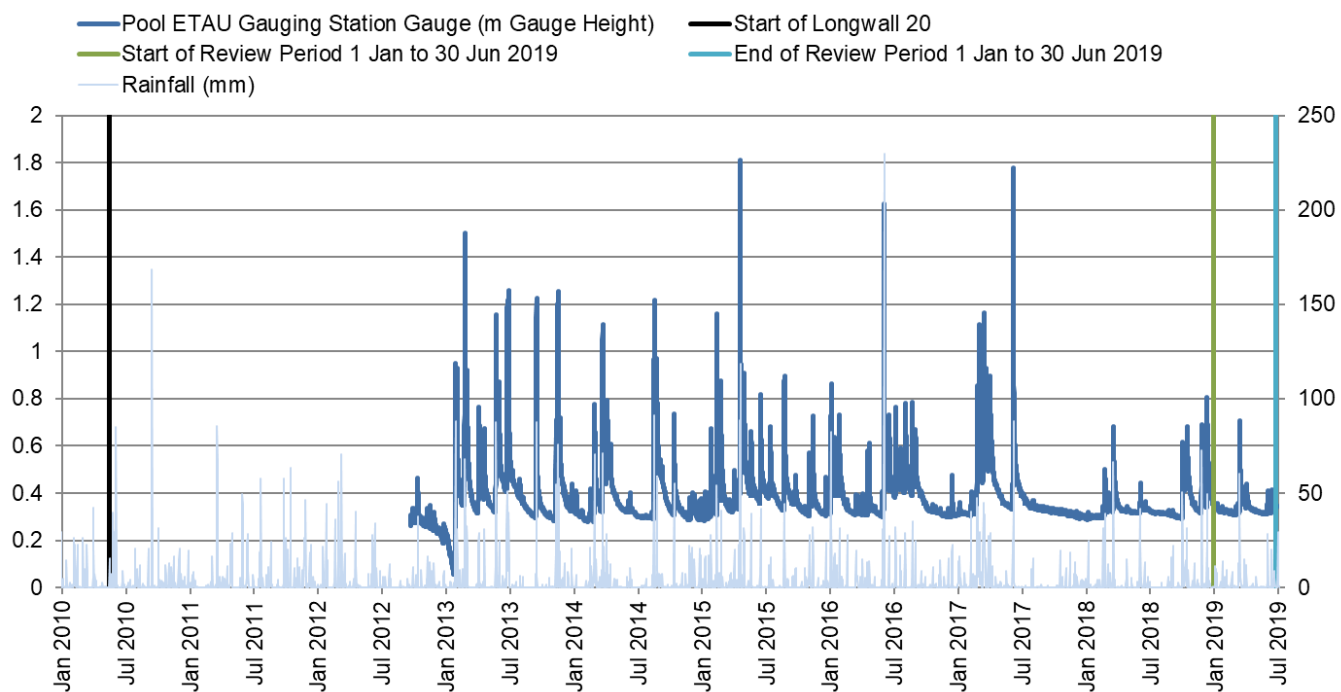


Chart A37 Pool ETAU (Stage data)

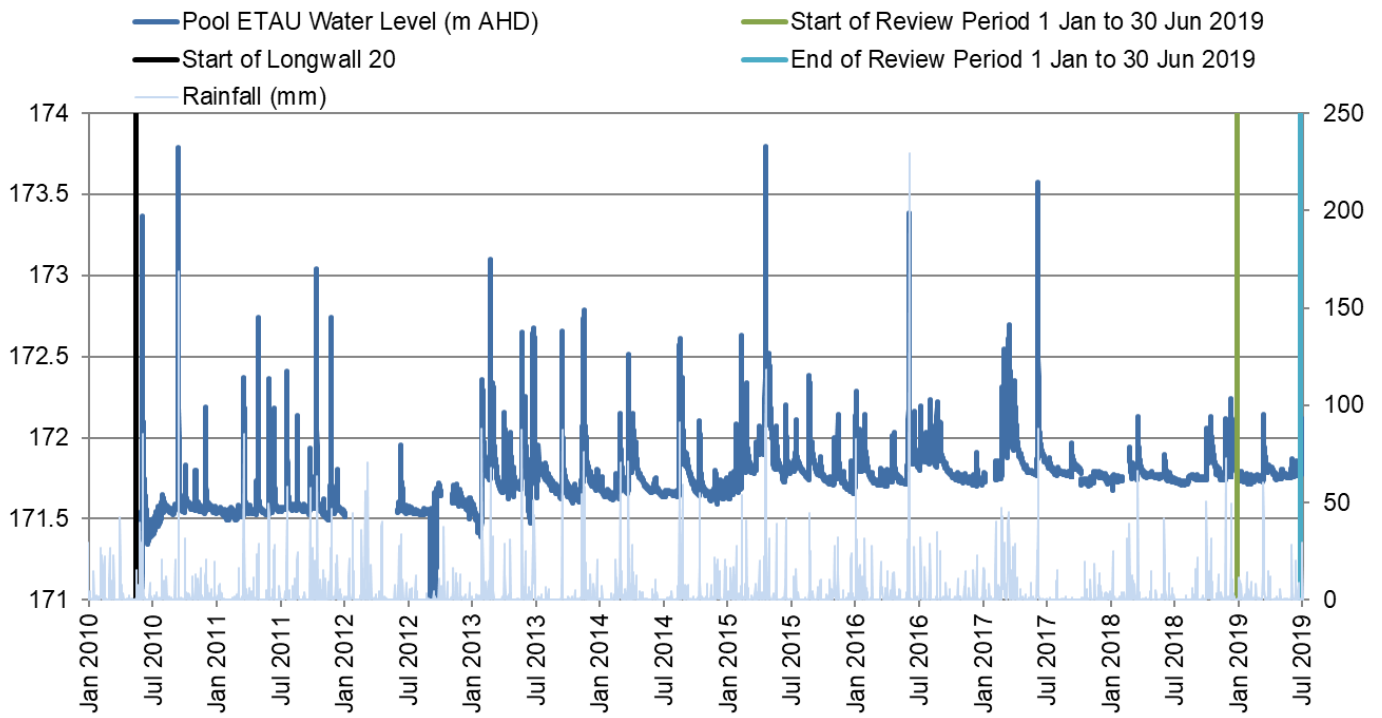


Chart A38 Pool ETAU

Pools on Tributary B/Reference Tributary

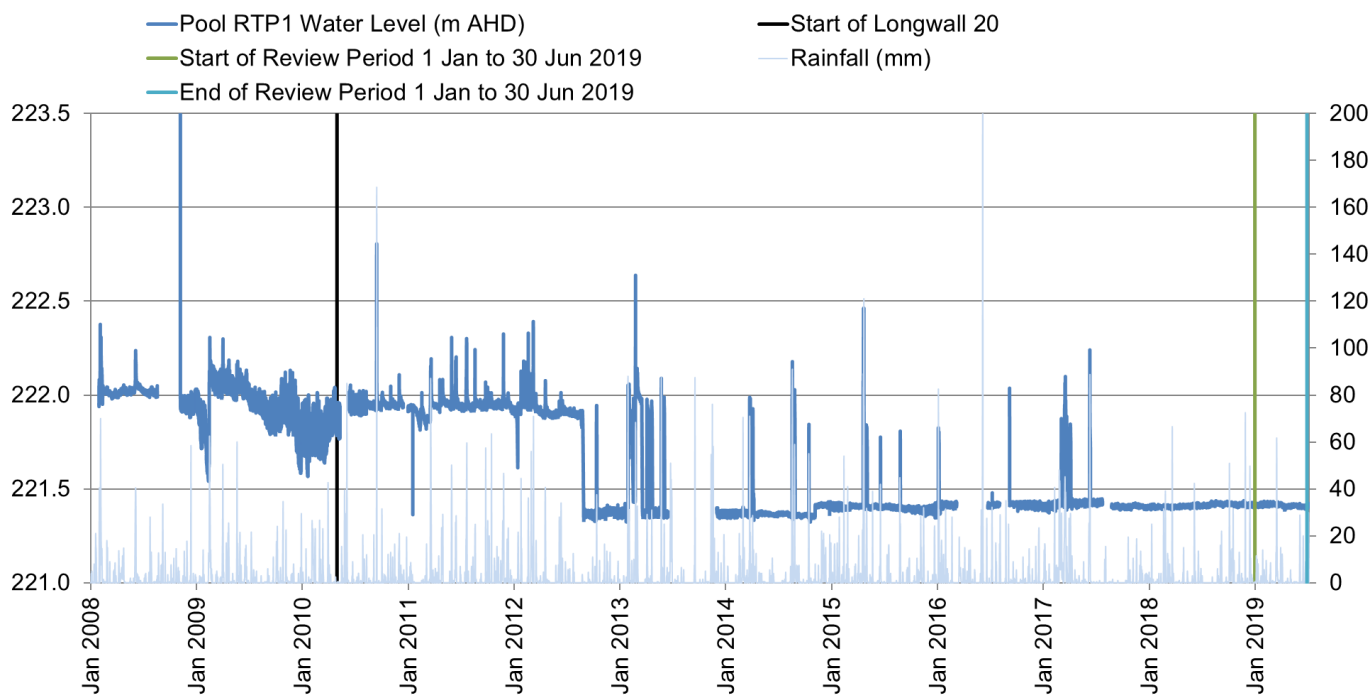


Chart A39 Pool RTP1¹²

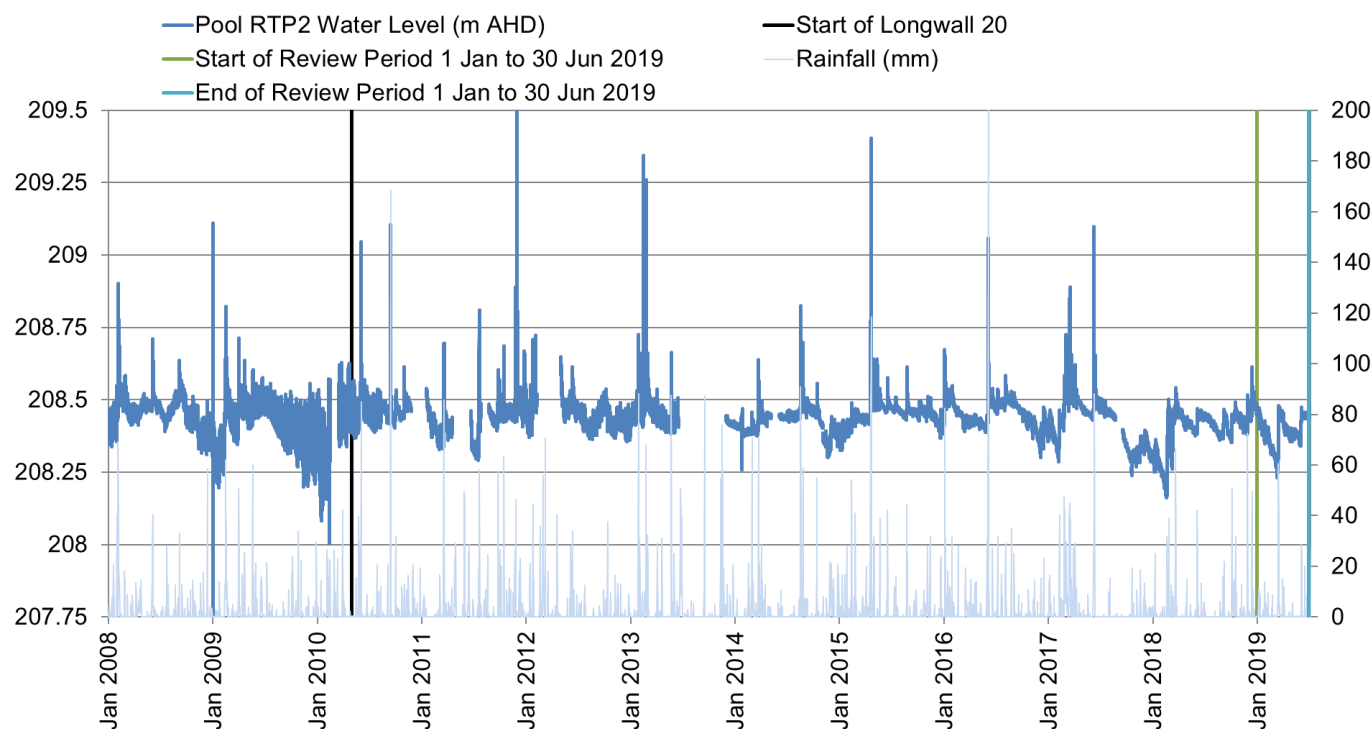


Chart A40 Pool RTP2

¹² Water levels have not been able to be reduced to AHD levels. The spikes are however indicative of water level rises associated with rainfall-runoff events and should be regarded as being indicative of relative pool water level changes.

Pools on Woronora River¹³

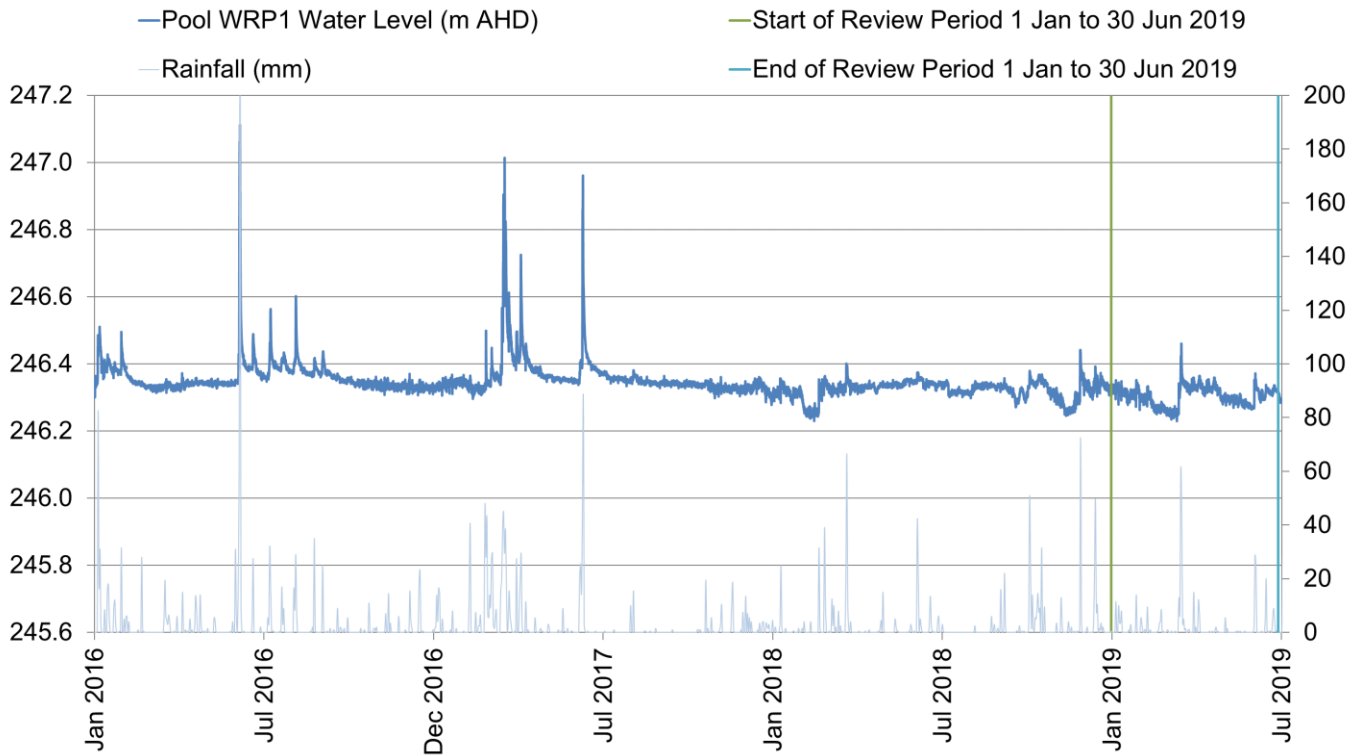


Chart A41 Pool WRP1

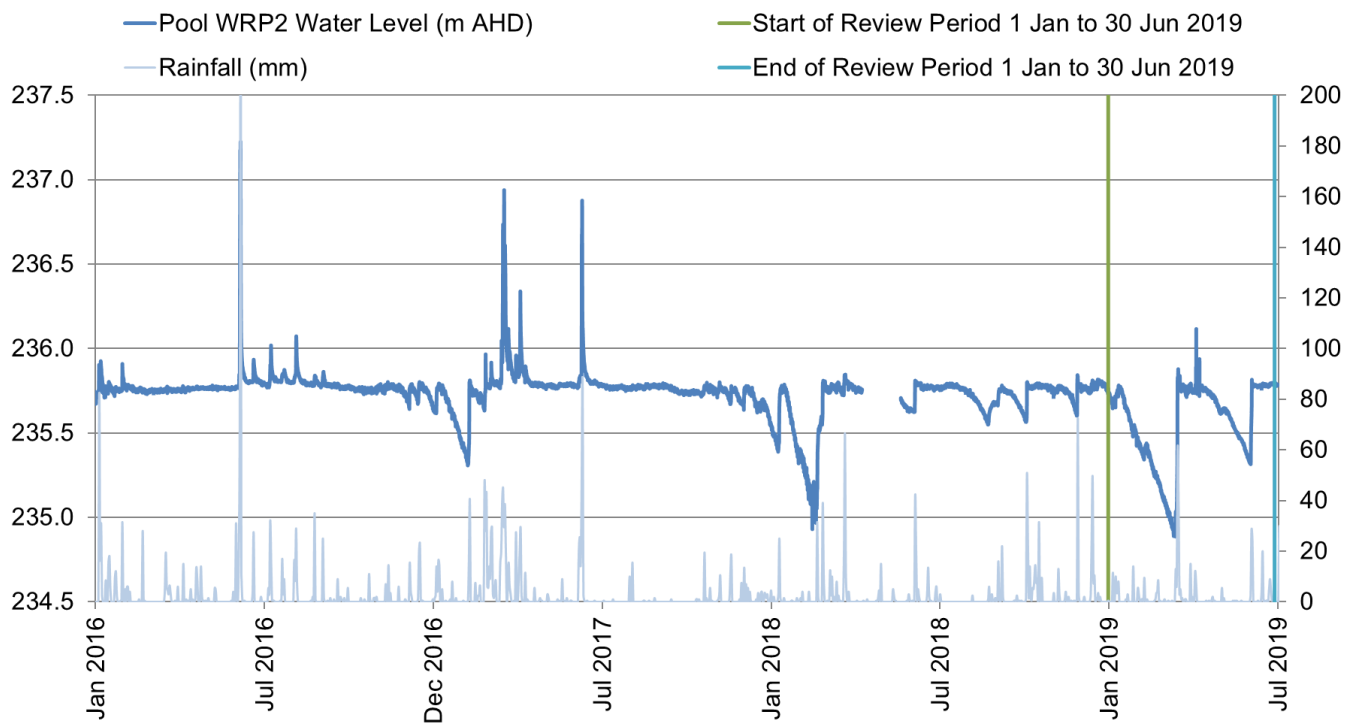


Chart A42 Pool WRP2

¹³ Pool water level data for the Woronora River pools prior to January 2016 is considered to be largely erroneous as a result of water level sensor issues and is not shown.

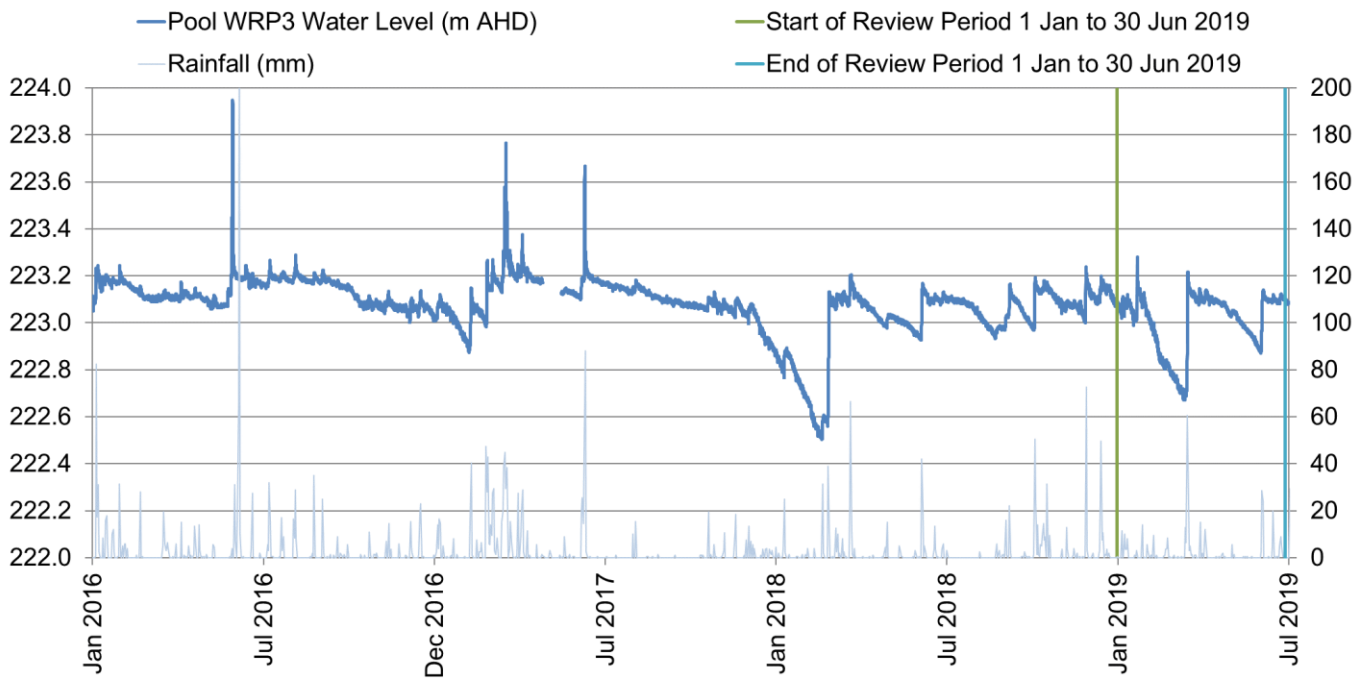


Chart A43 Pool WRP3

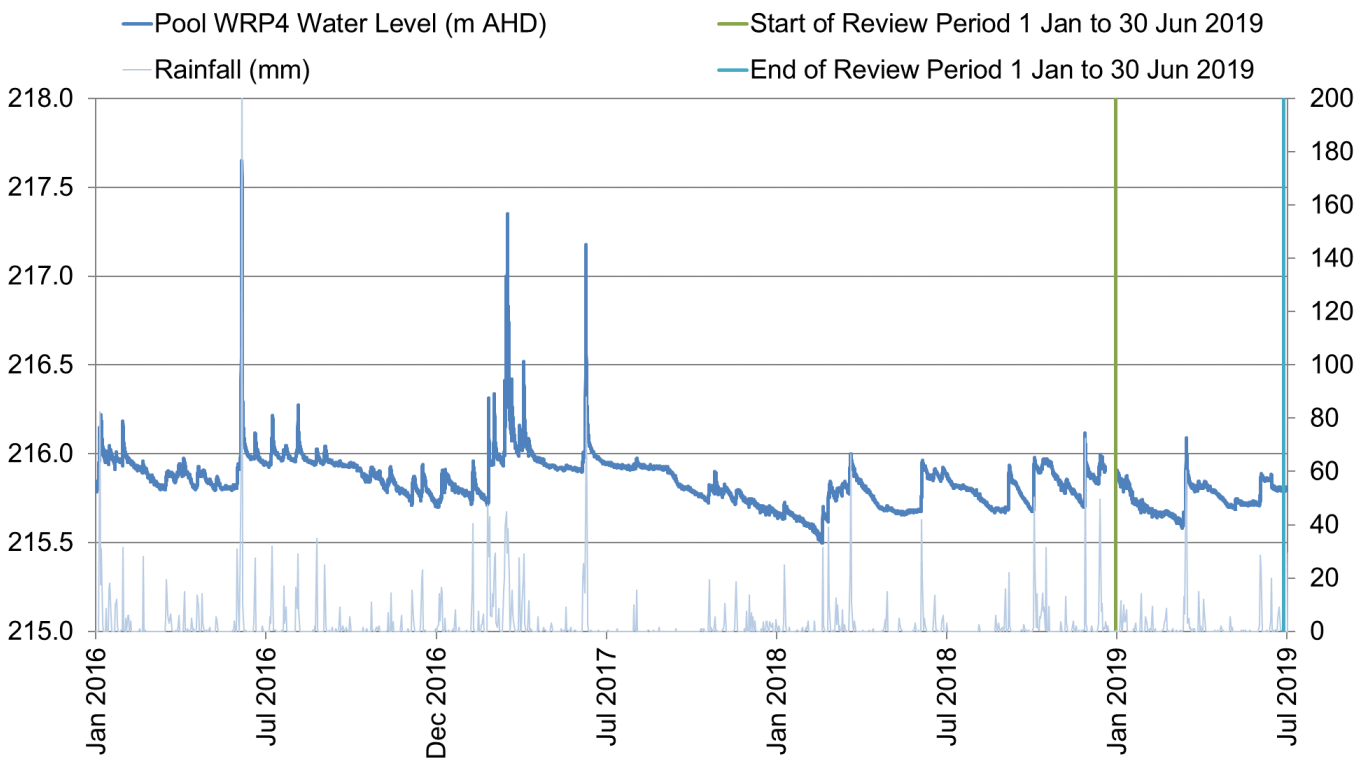


Chart A44 Pool WRP4¹⁴

¹⁴ Pool water level data for WRP4 was erroneous from 20/12/18 to 01/01/2019 and removed from the dataset. The erroneous data was a result of a logger positioning error.

Appendix B Surface Water Quality Monitoring Results for Select Sites – pH, Electrical Conductivity, Dissolved Iron, Dissolved Manganese and Dissolved Aluminium

Waratah Rivulet

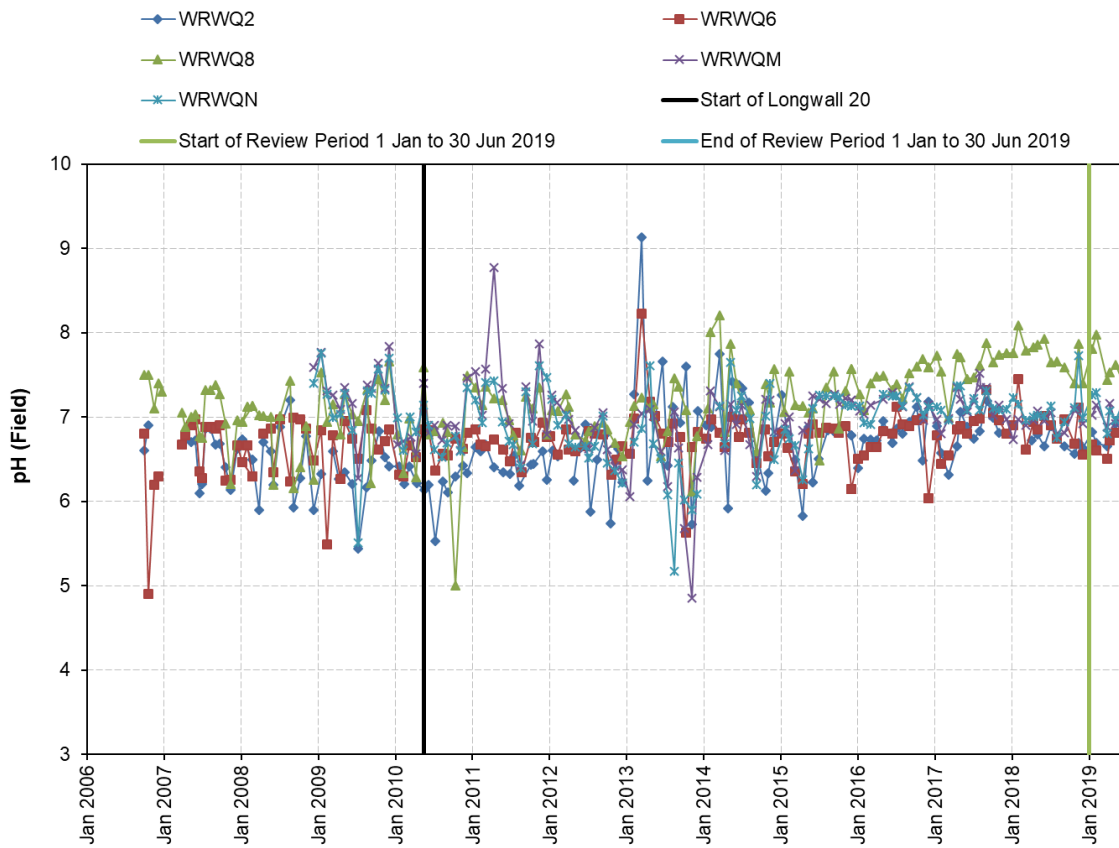


Chart B1 pH Levels Waratah Rivulet – Upper to Middle Reach Sites

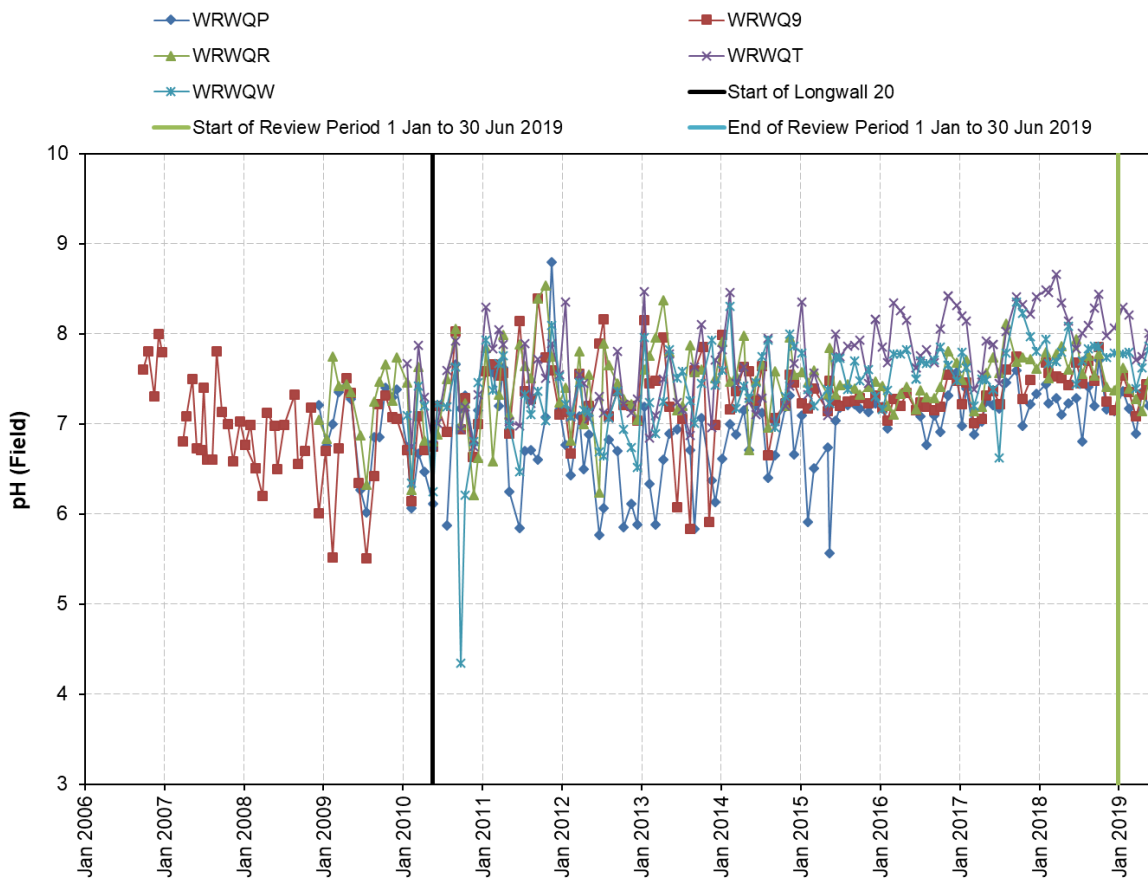


Chart B2 pH Levels Waratah Rivulet – Lower Reach Sites

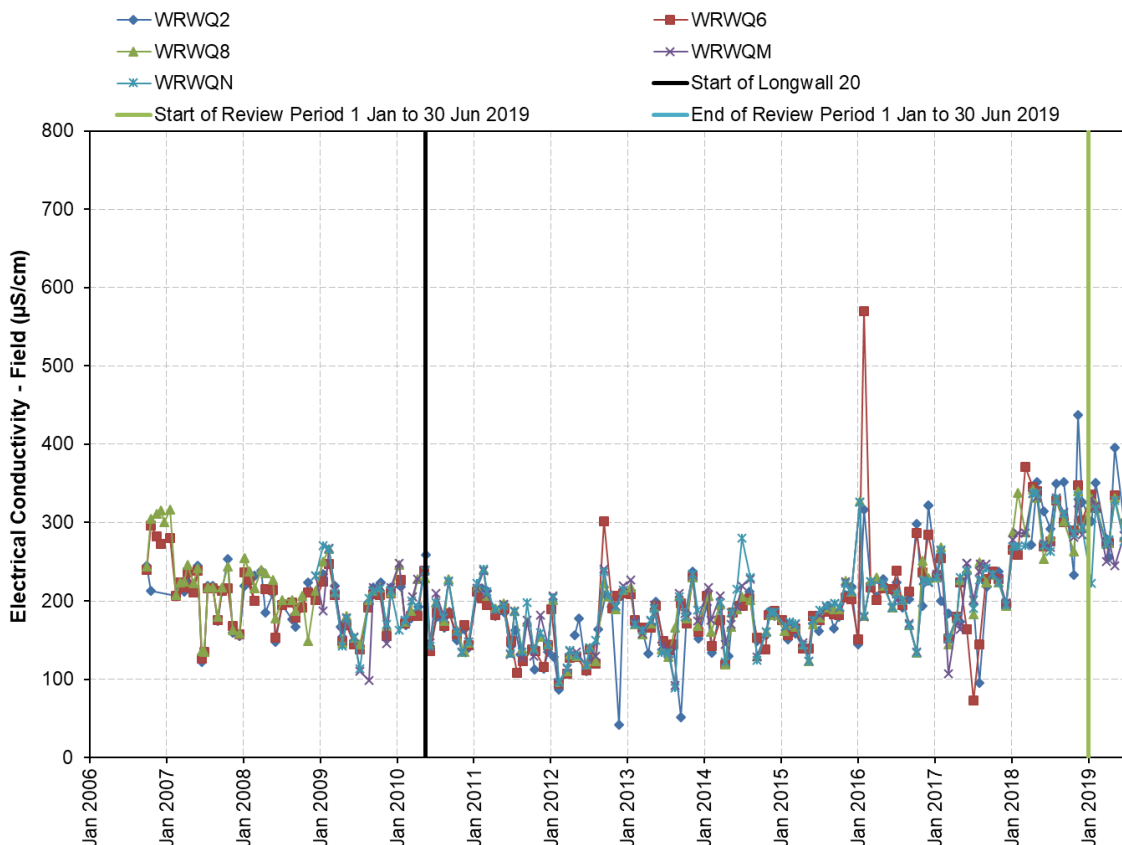


Chart B3 Electrical Conductivity (EC) Waratah Rivulet – Upper to Middle Reach Sites

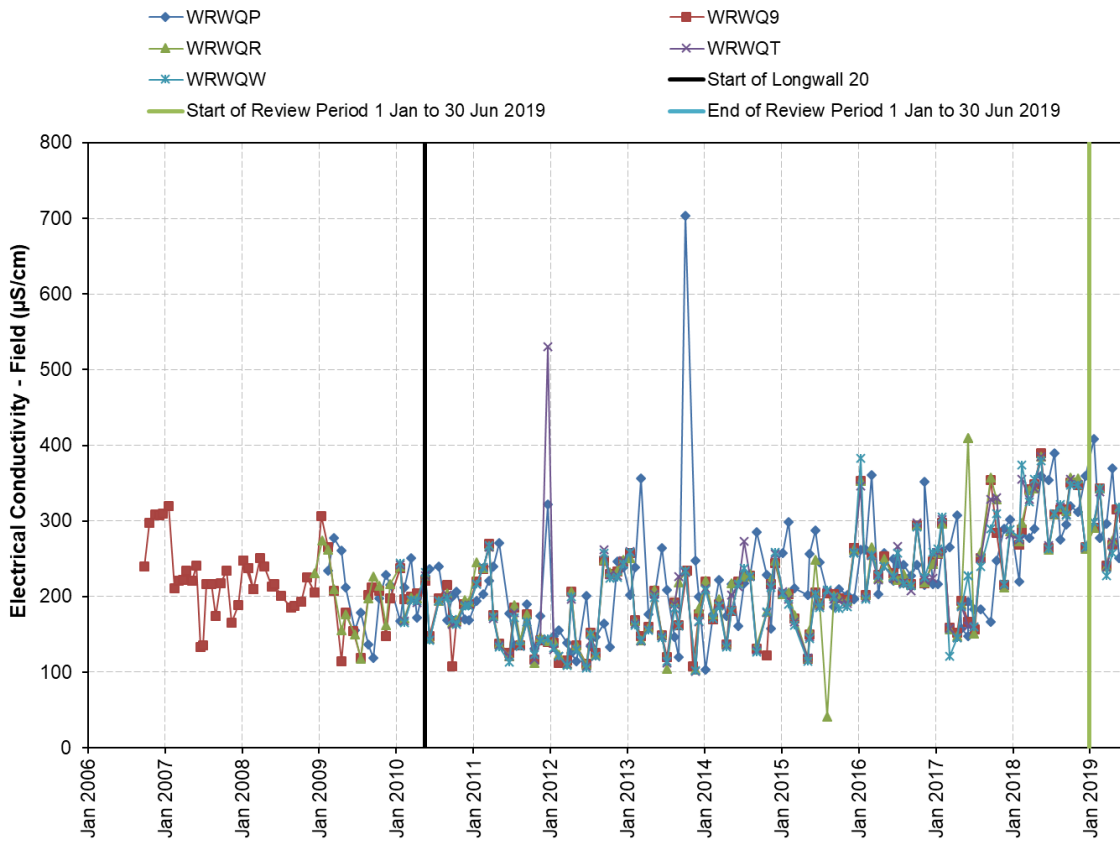


Chart B4 Electrical Conductivity (EC) Waratah Rivulet – Lower Reach Sites

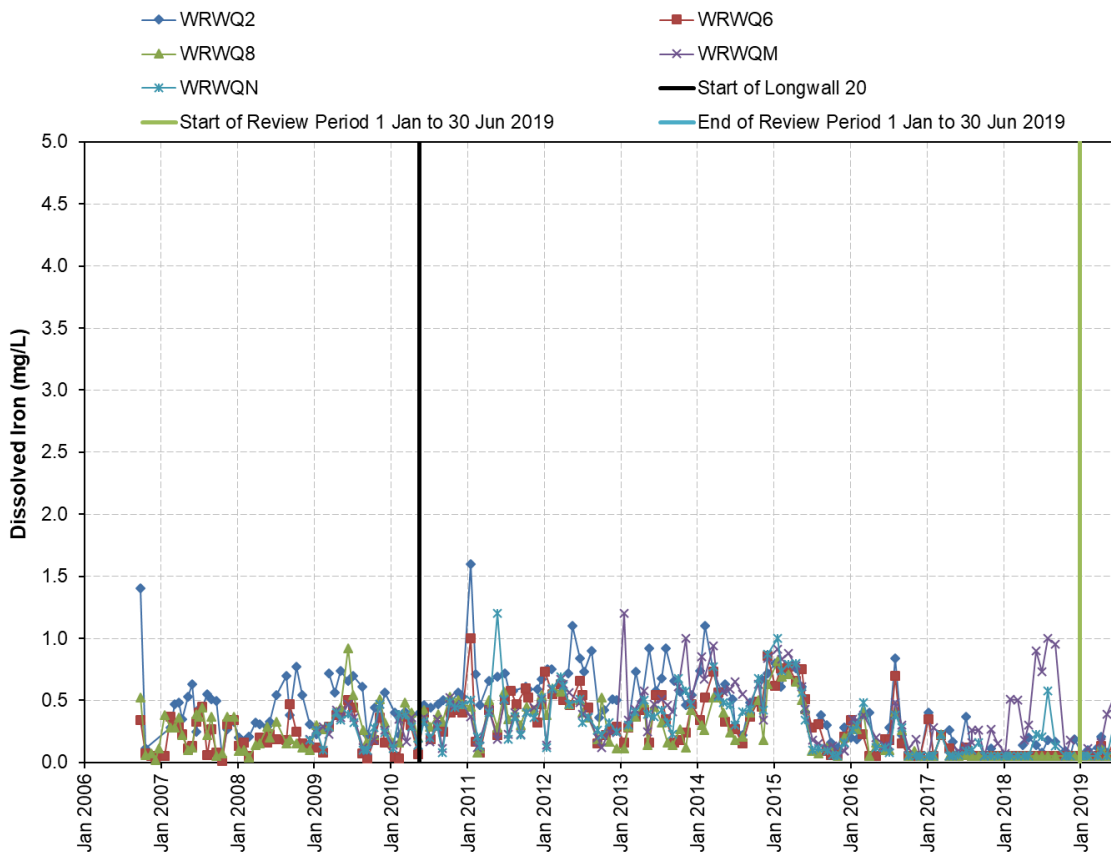


Chart B5 Dissolved Iron Waratah Rivulet – Upper and Middle Reach Sites

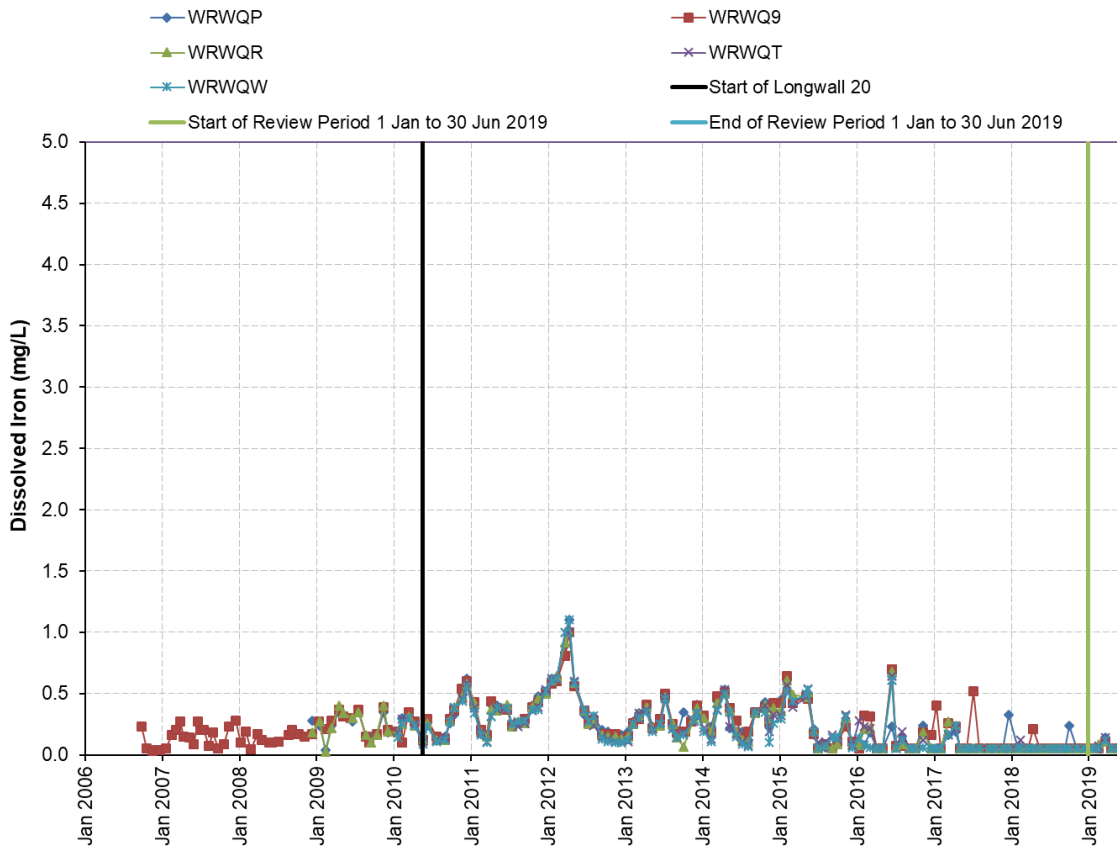


Chart B6 Dissolved Iron Waratah Rivulet – Lower Reach Sites

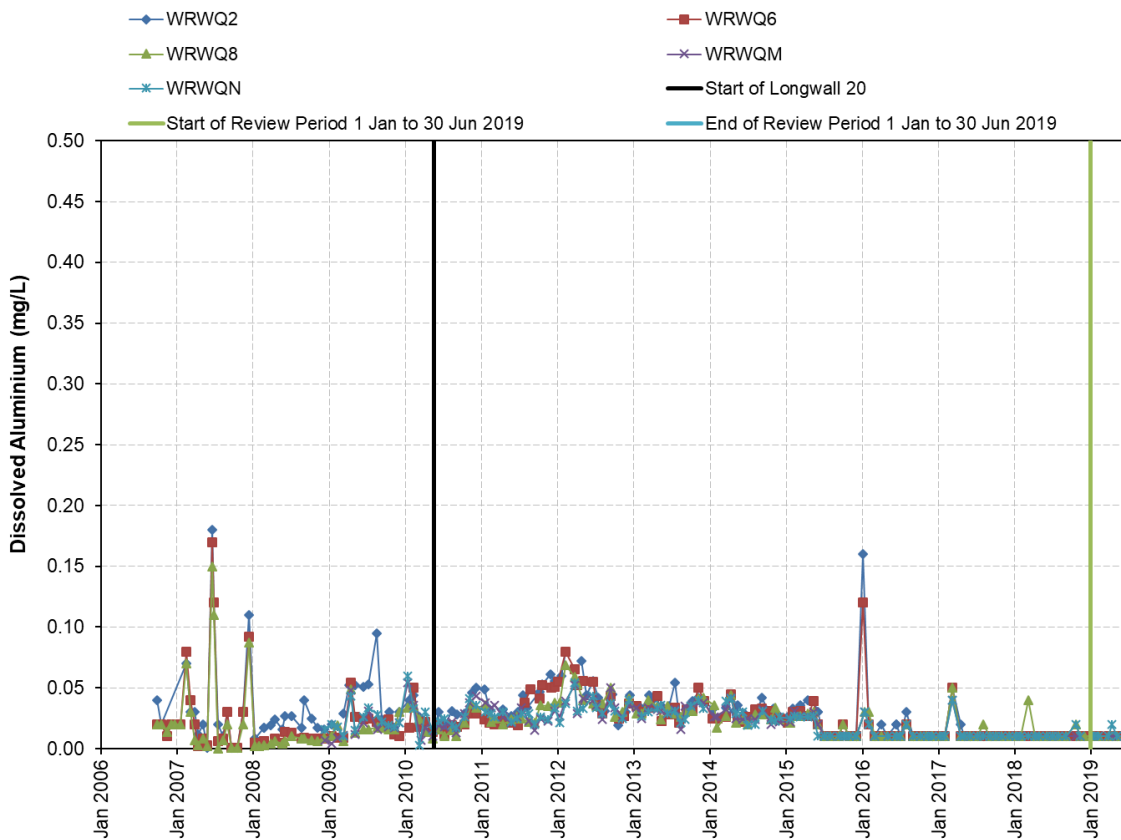


Chart B7 Dissolved Aluminium Waratah Rivulet – Upper to Middle Reach Sites

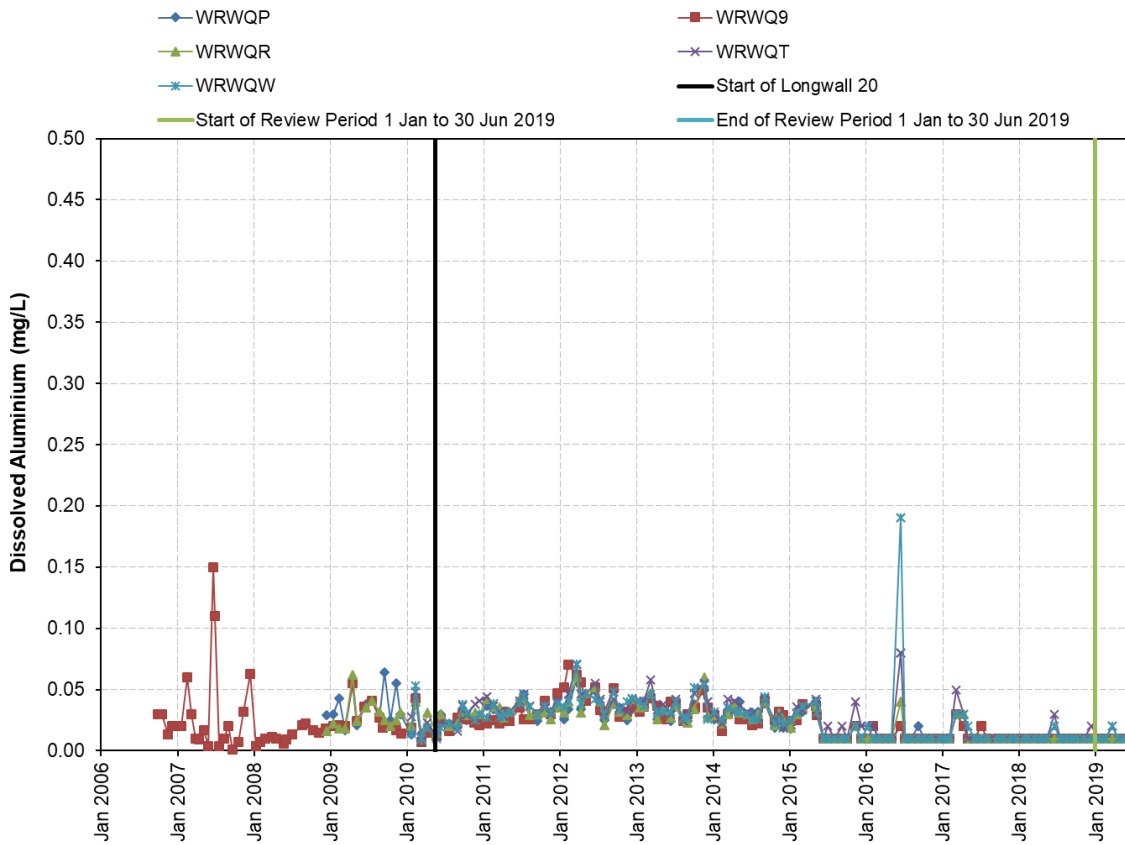


Chart B8 Dissolved Aluminium Waratah Rivulet – Lower Reach Sites

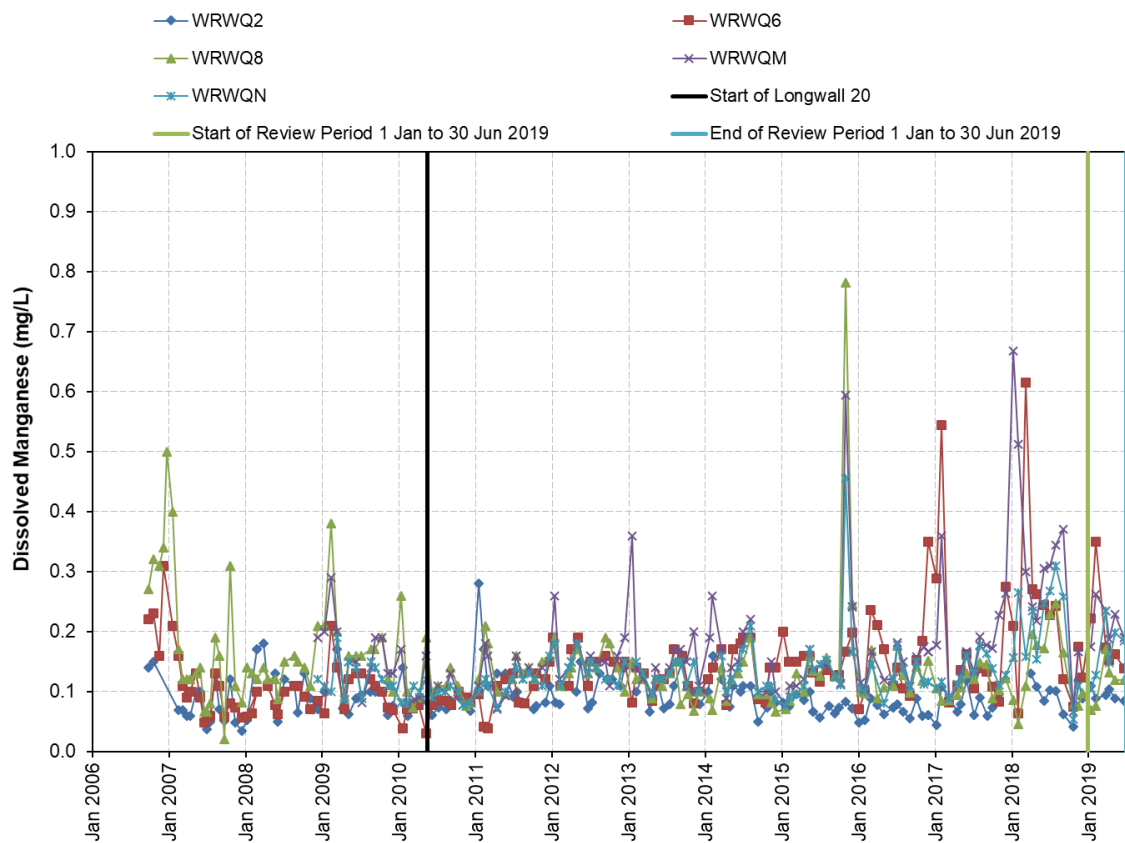


Chart B9 Dissolved Manganese Waratah Rivulet – Upper to Middle Reach Sites

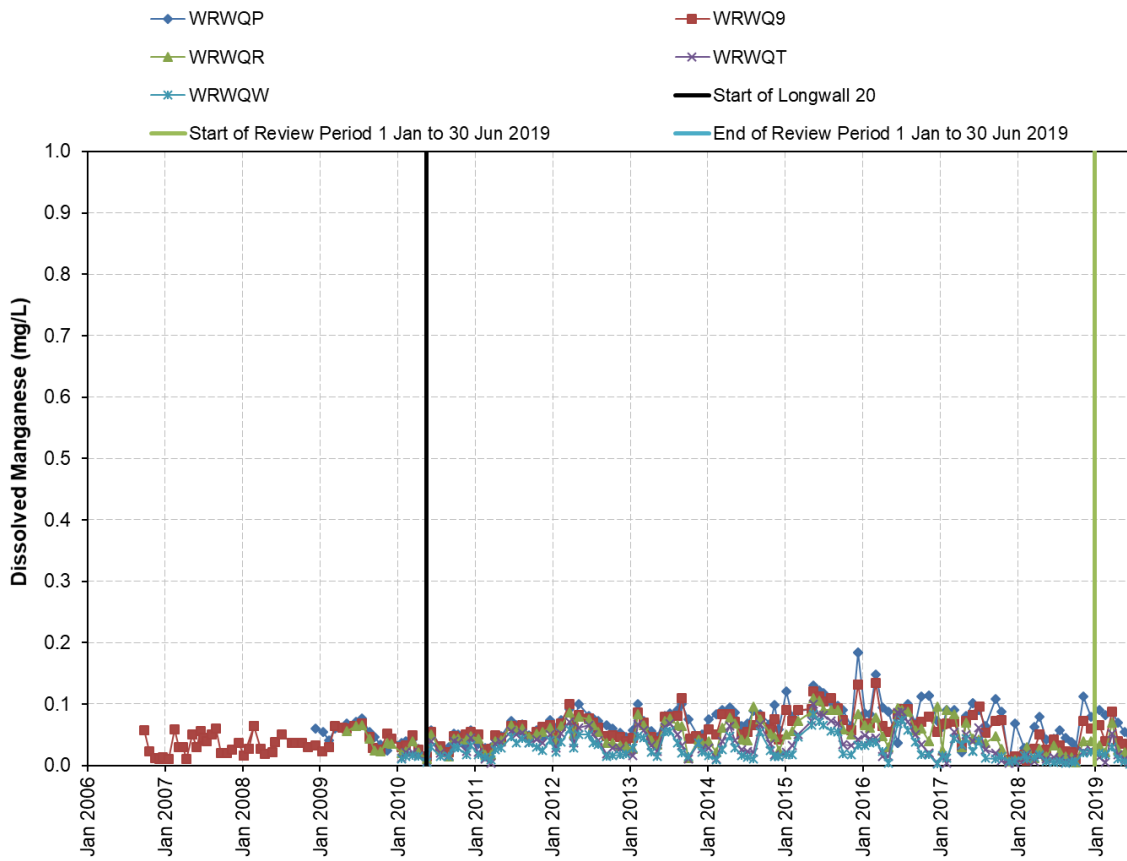


Chart B10 Dissolved Manganese Waratah Rivulet – Lower Reach Sites

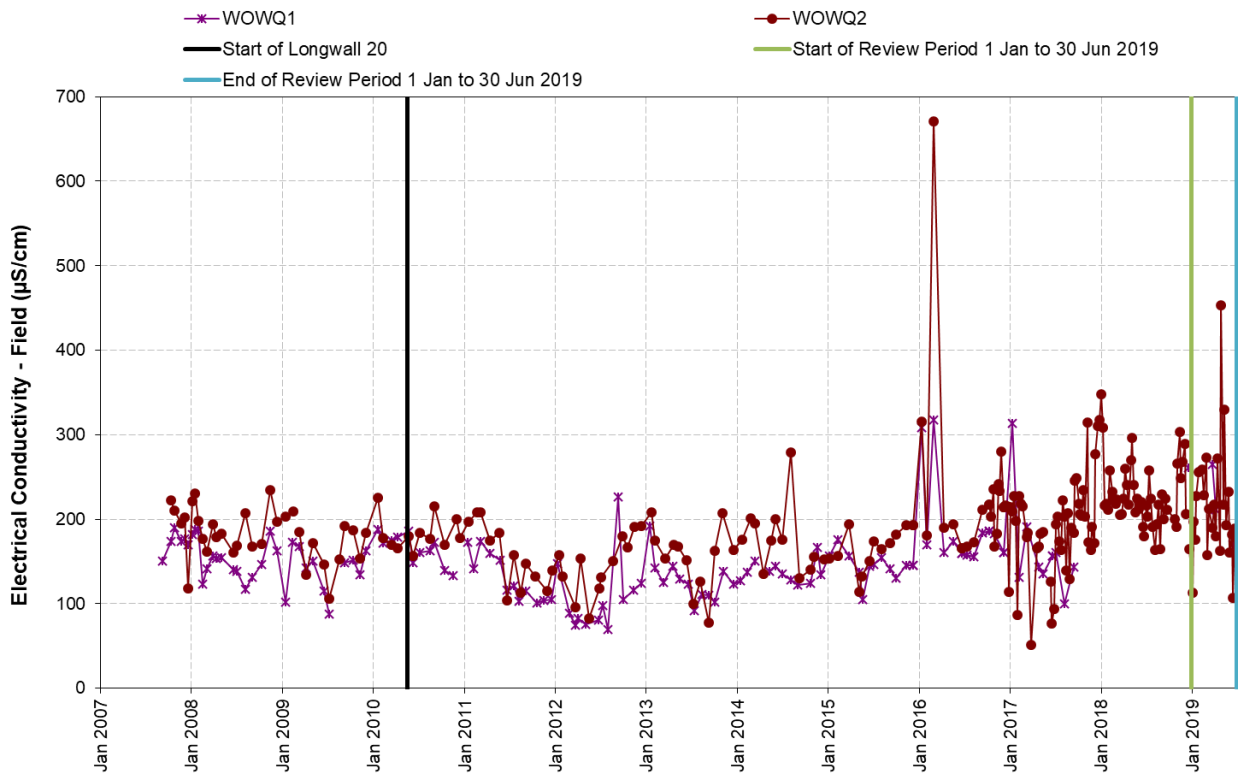


Chart B12a Electrical Conductivity (EC) Woronora River

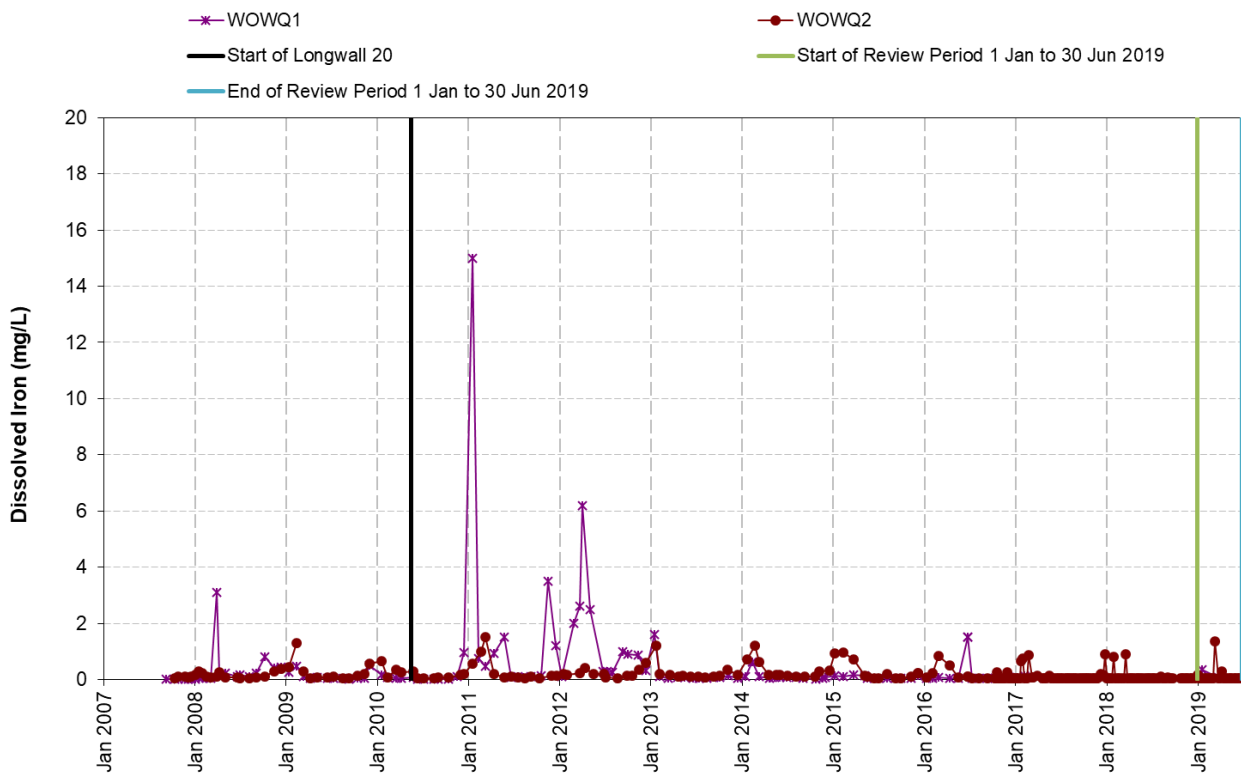


Chart B13 Dissolved Iron Woronora River

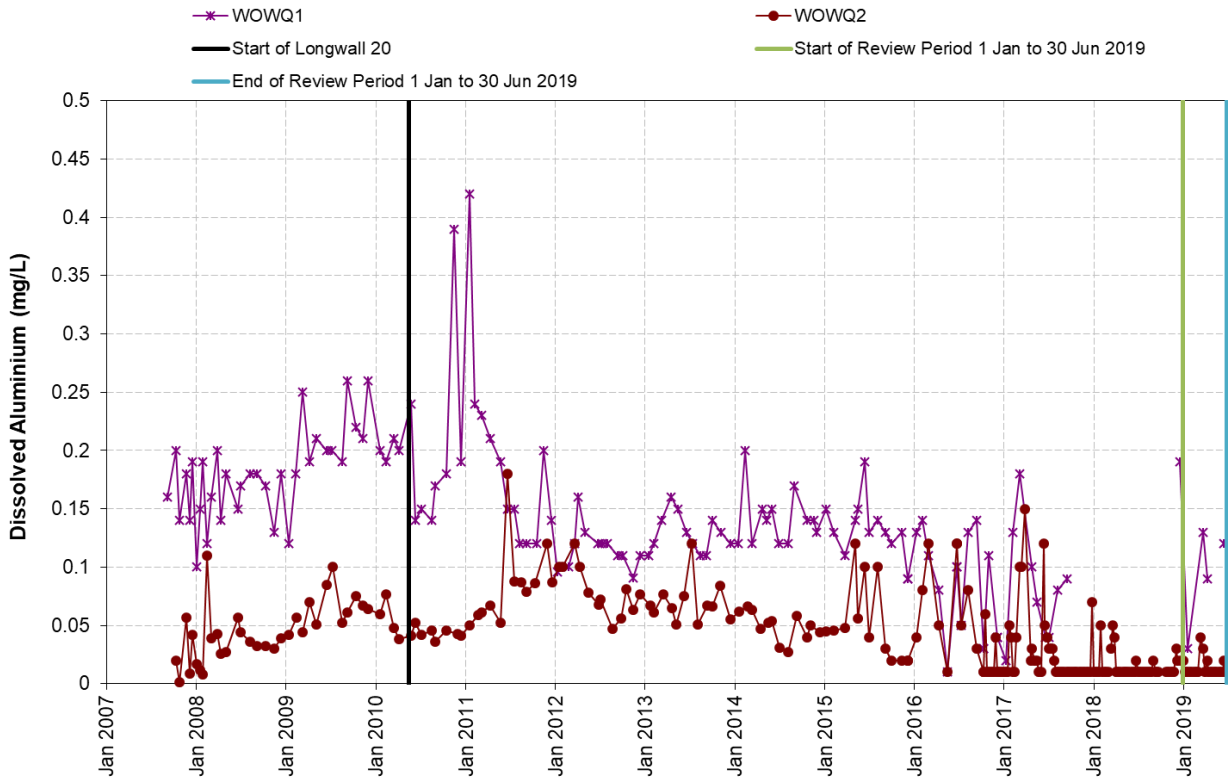


Chart B14 Dissolved Aluminium Woronora River

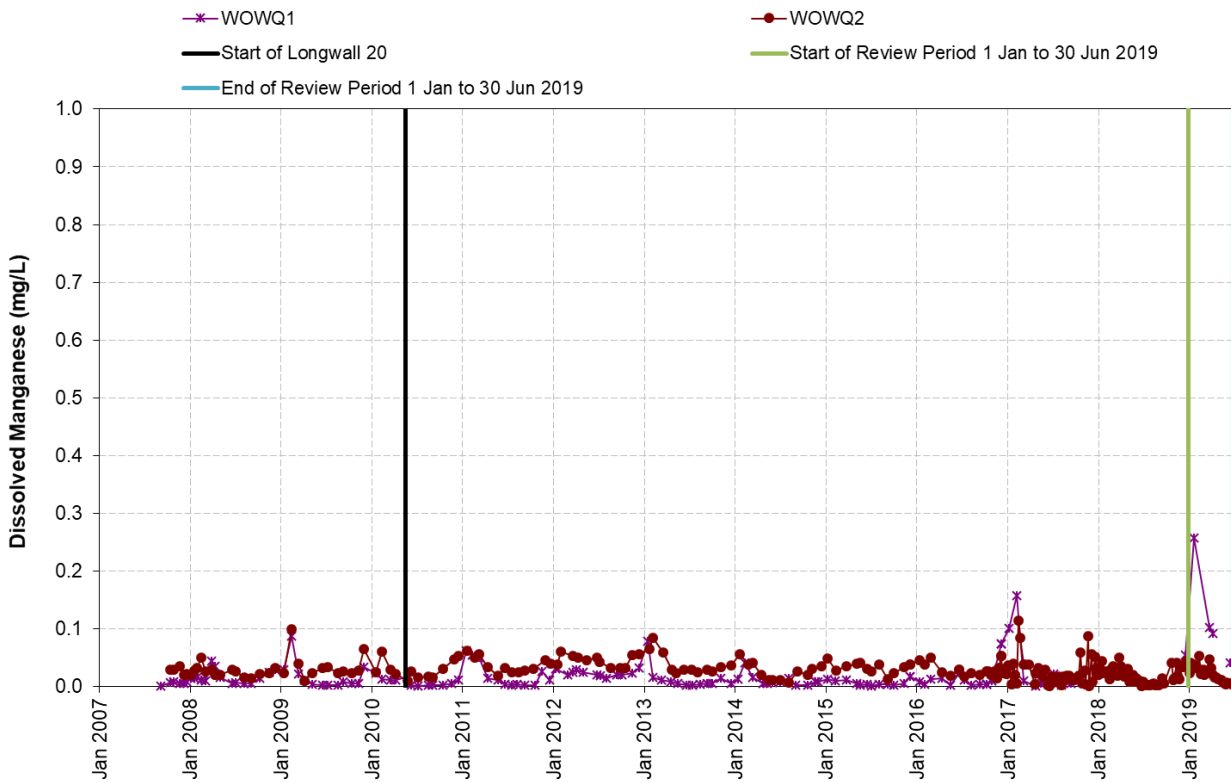


Chart B15 Dissolved Manganese Woronora River

Eastern Tributary

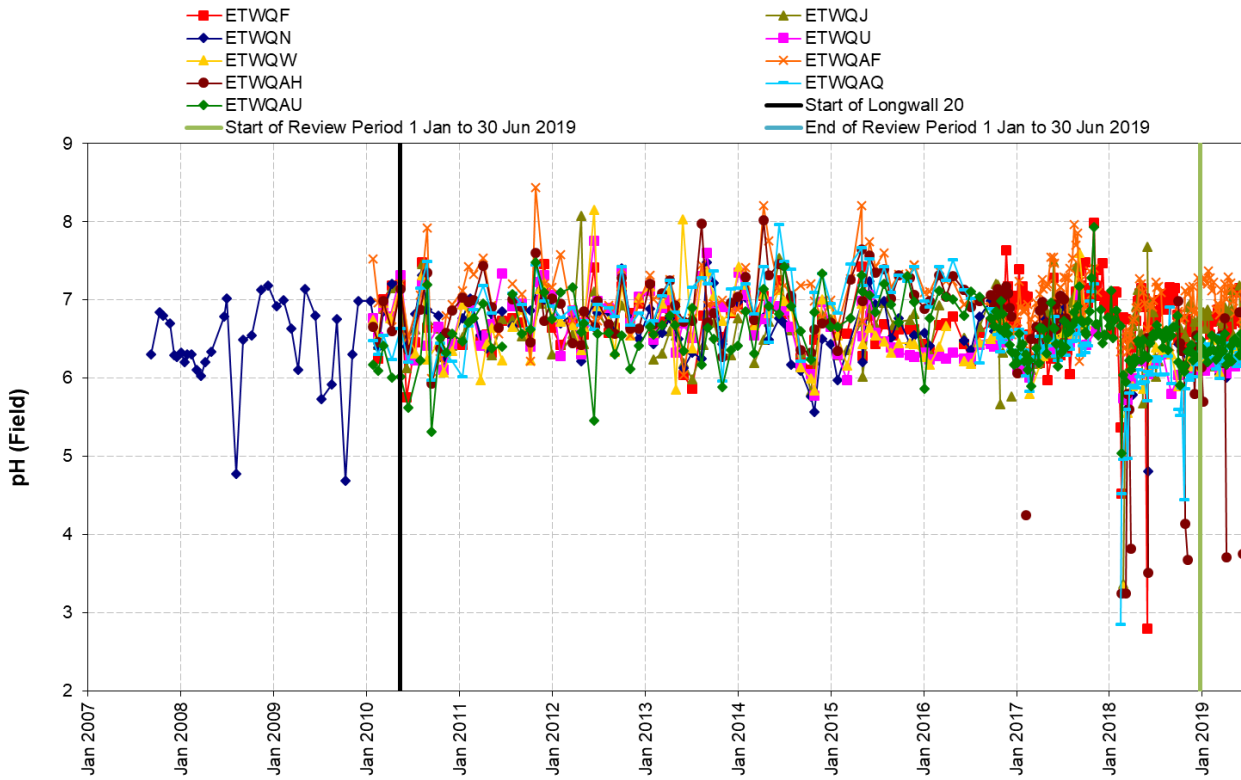


Chart B16 pH Levels Eastern Tributary

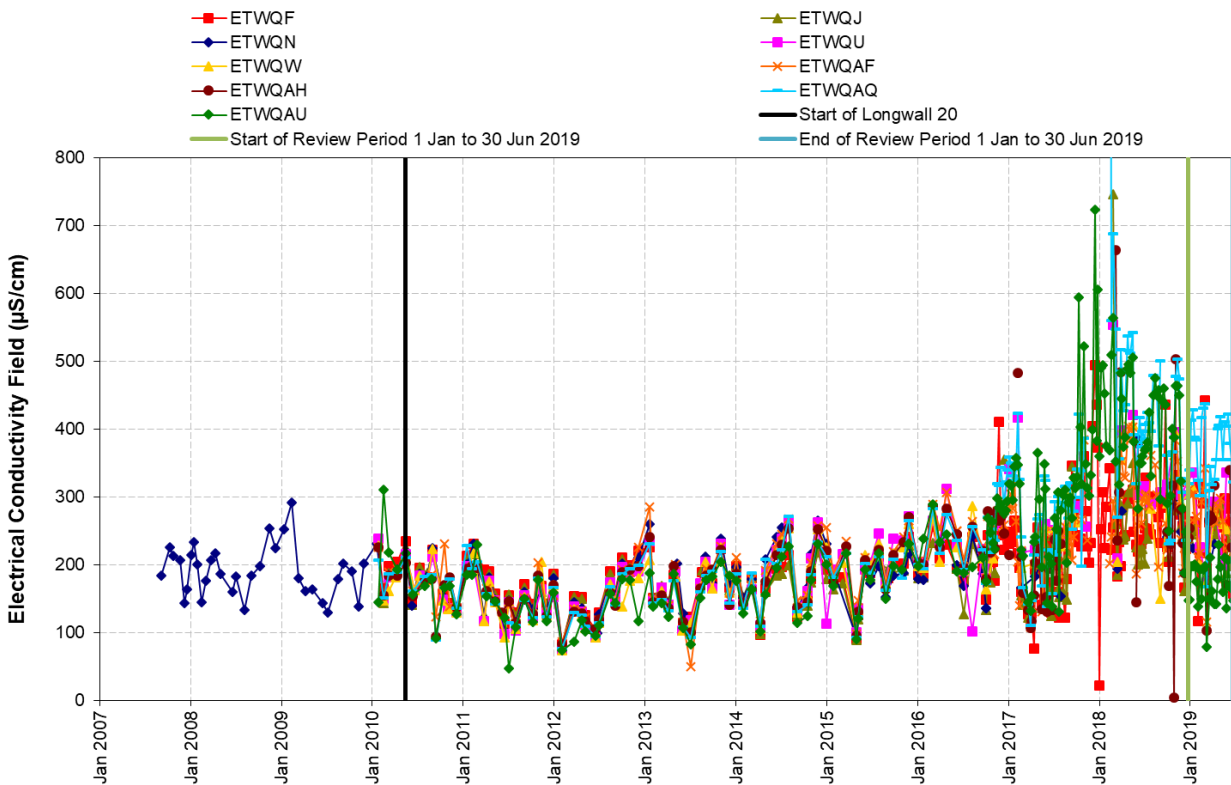


Chart B17 Electrical Conductivity (EC) Eastern Tributary

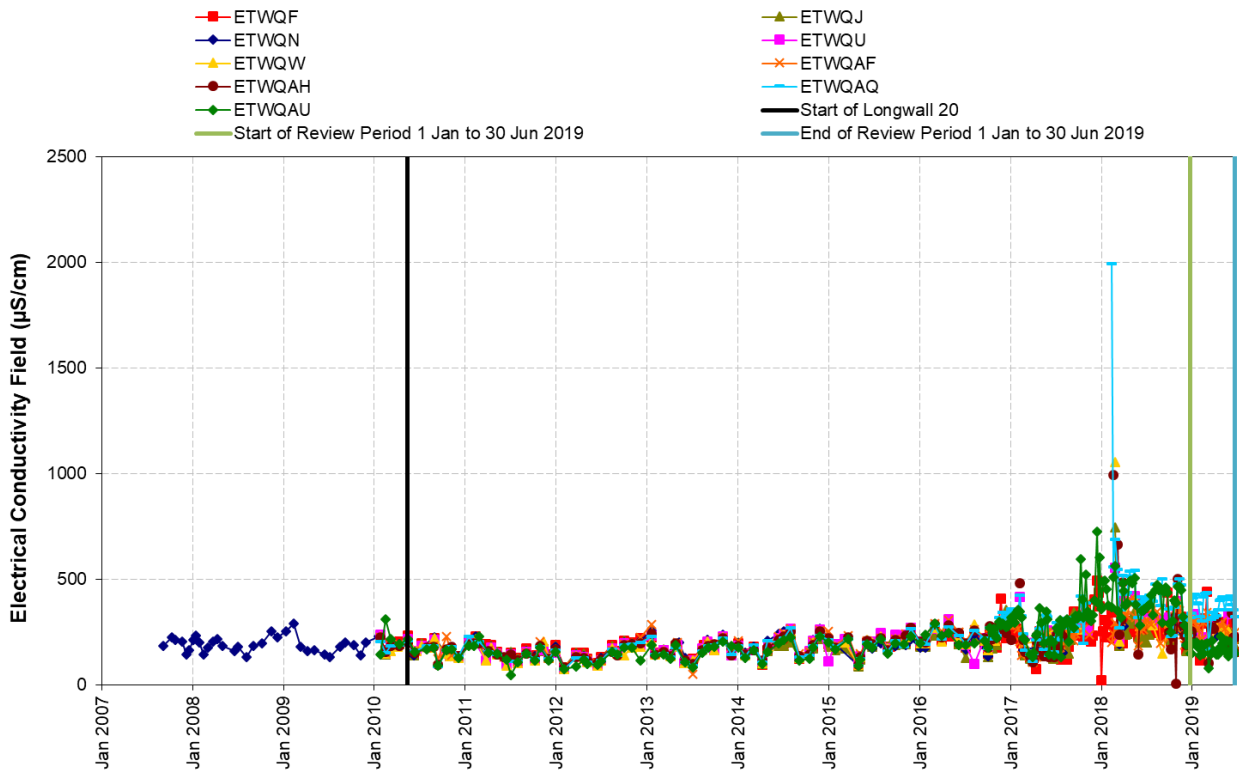


Chart B17a Electrical Conductivity (EC) Eastern Tributary

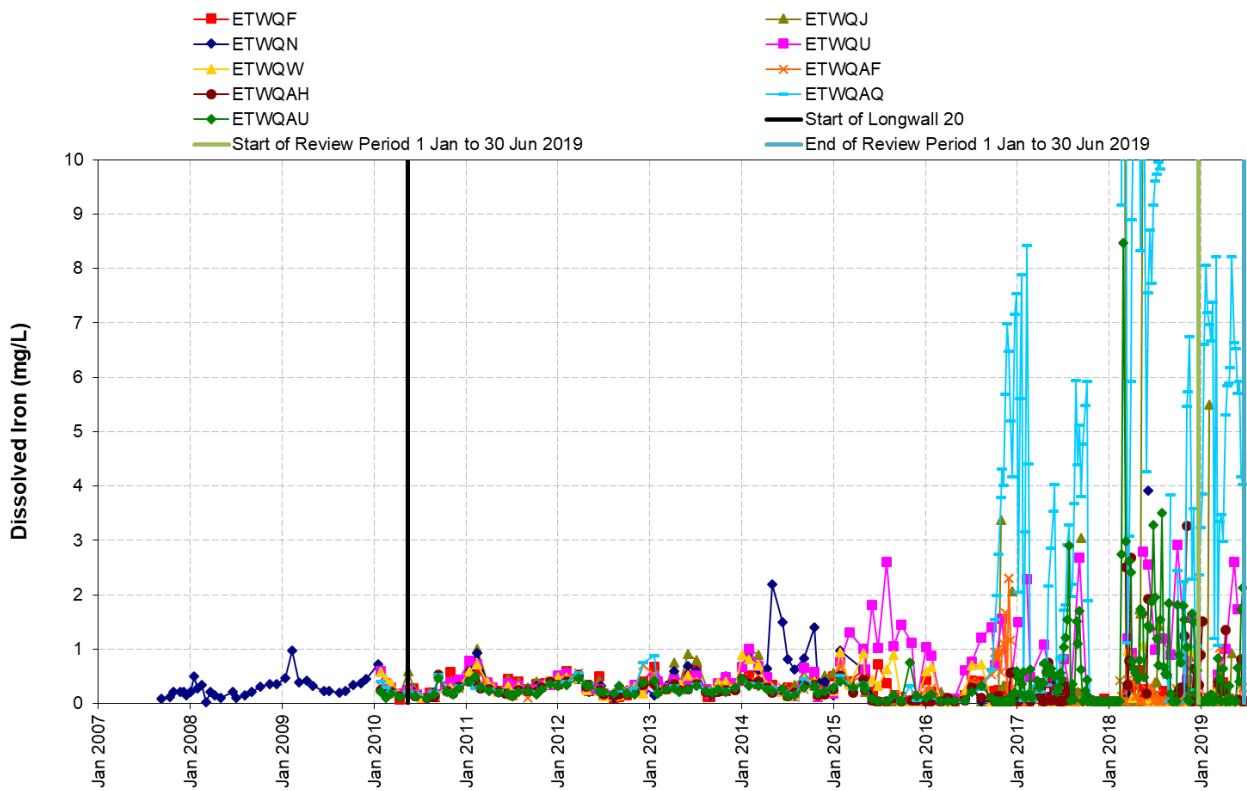


Chart B18 Dissolved Iron Eastern Tributary

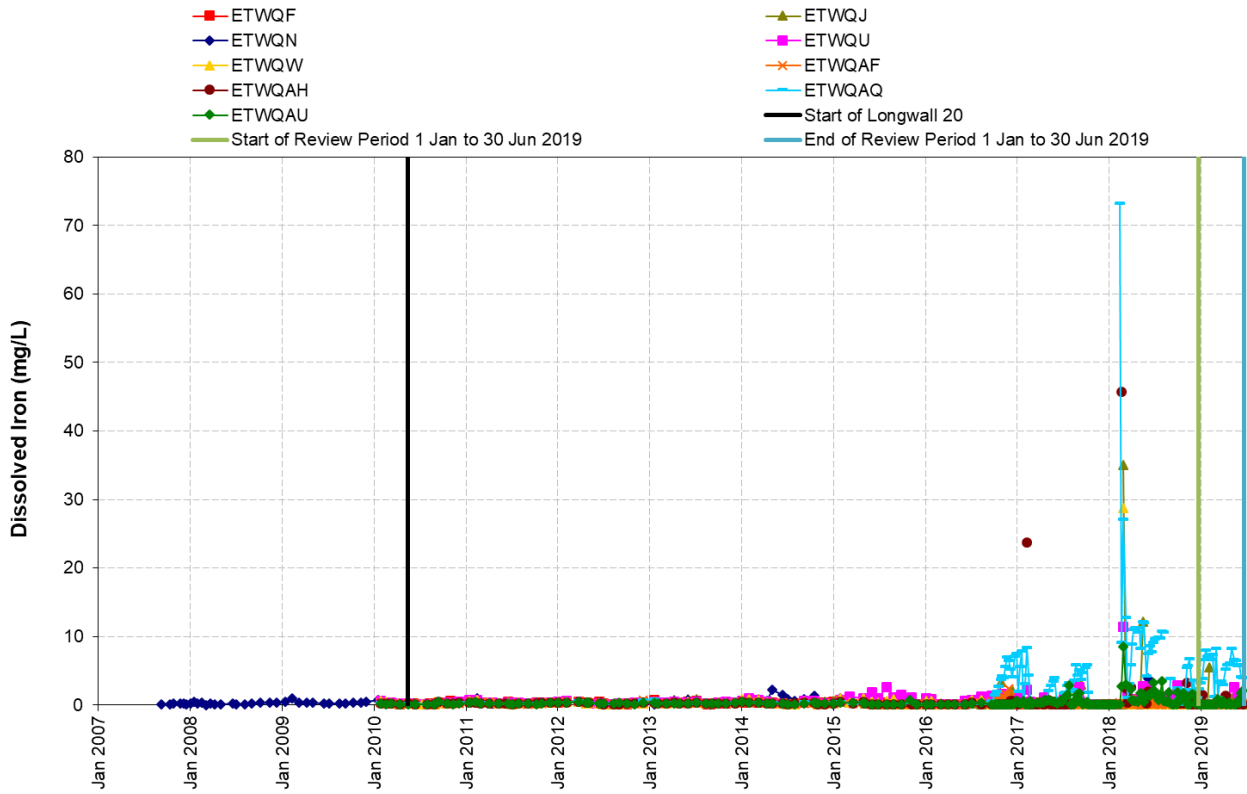


Chart B18a Dissolved Iron Eastern Tributary

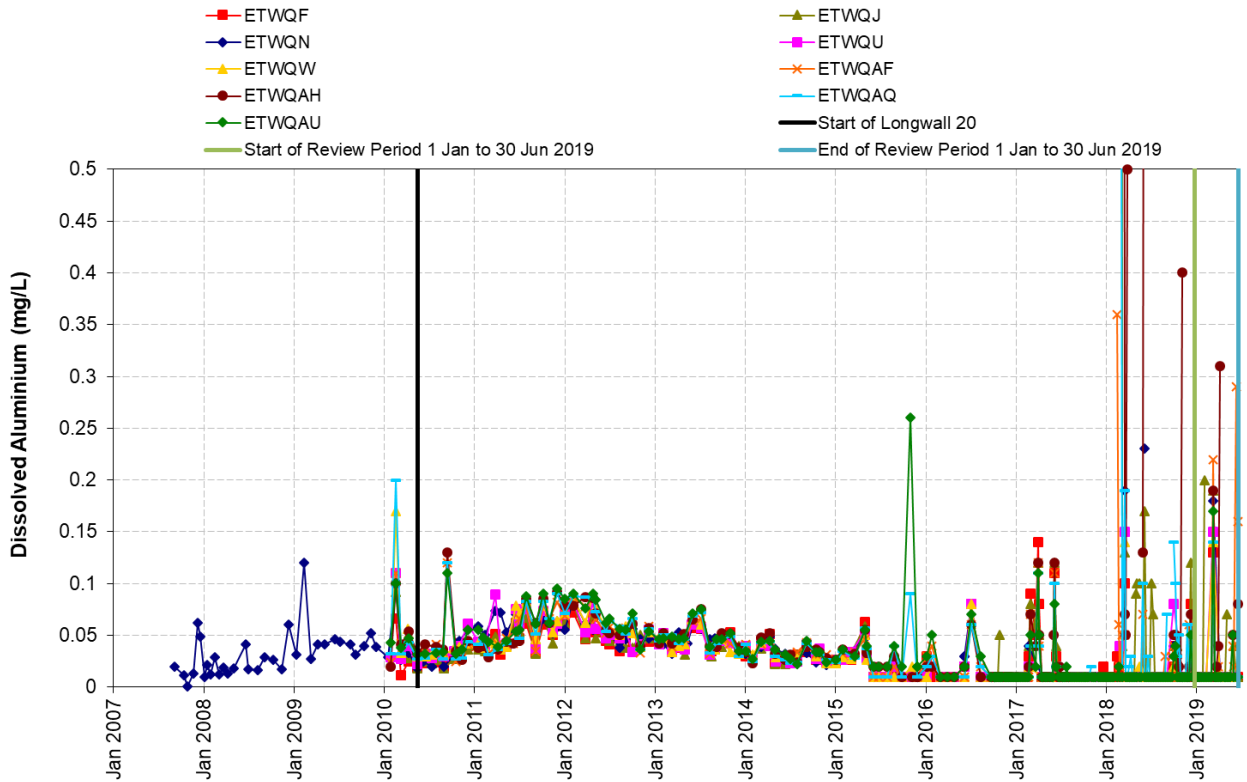


Chart B19 Dissolved Aluminium Eastern Tributary

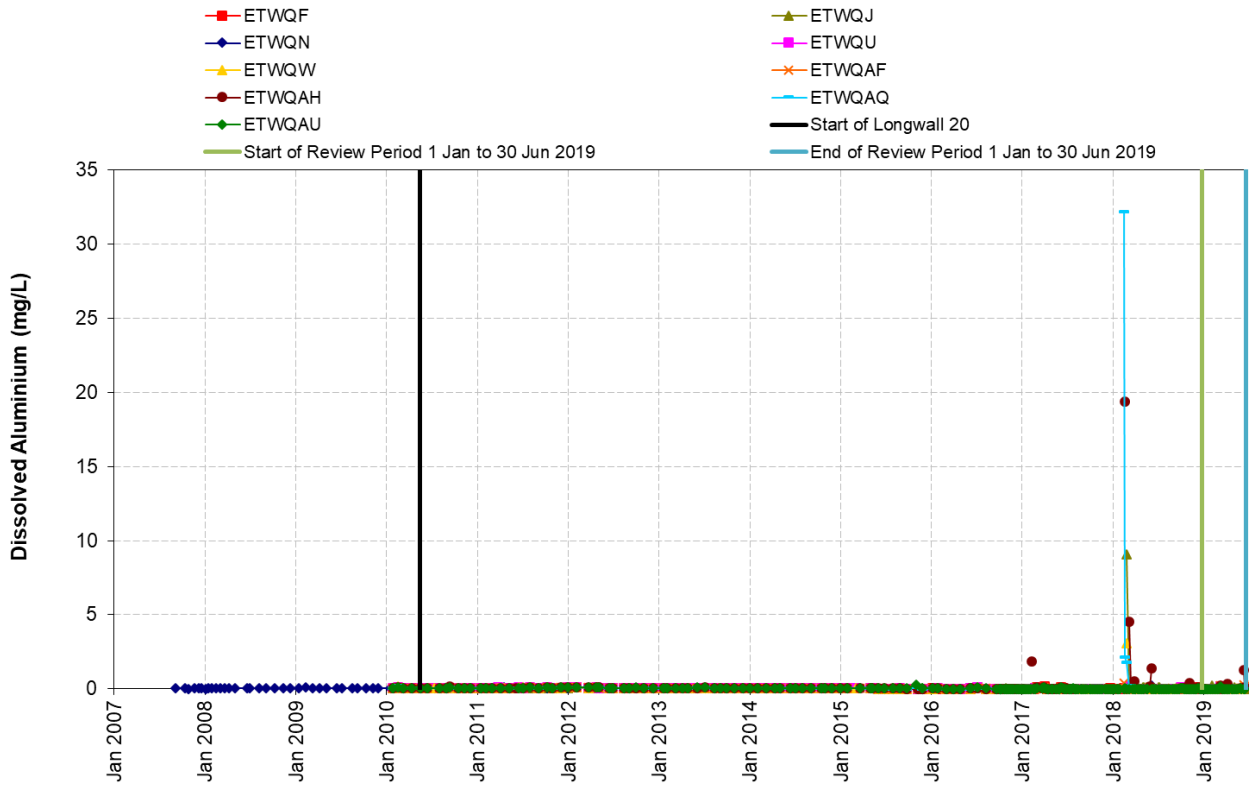


Chart B19a Dissolved Aluminium Eastern Tributary

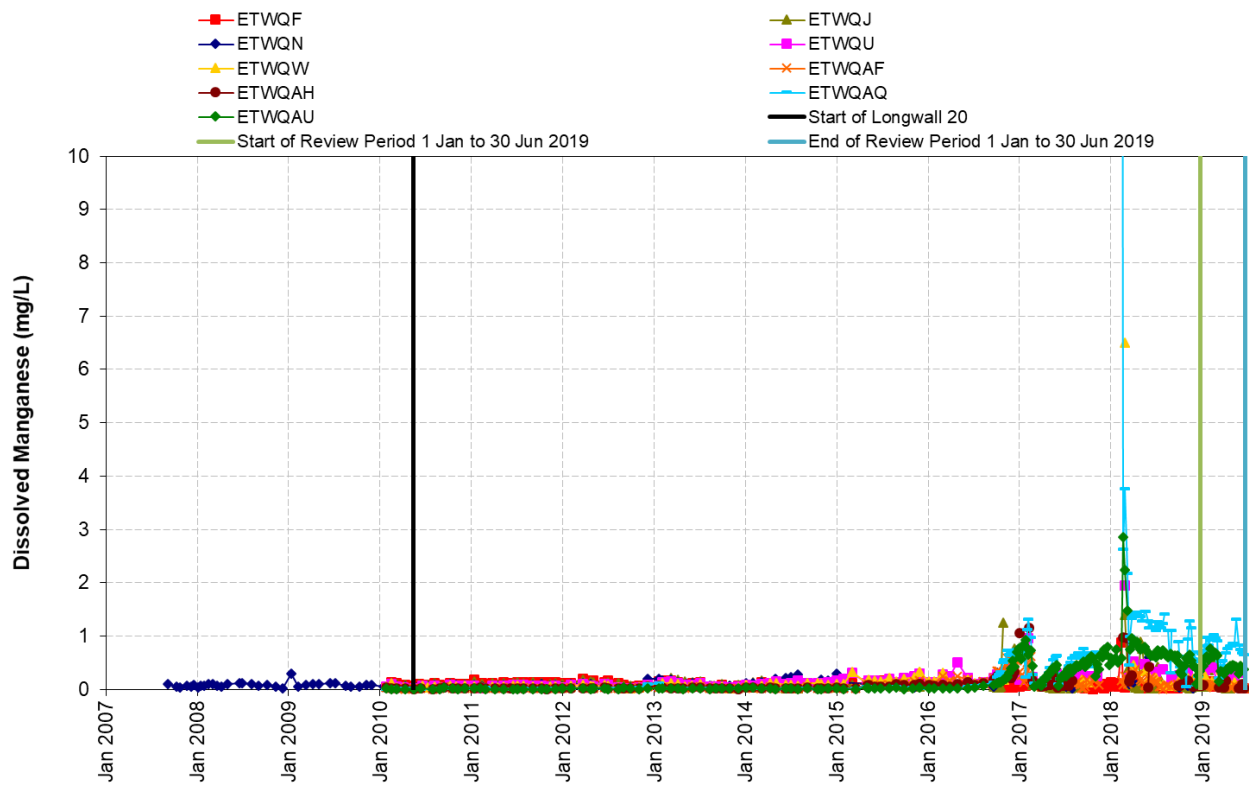


Chart B20 Dissolved Manganese Eastern Tributary

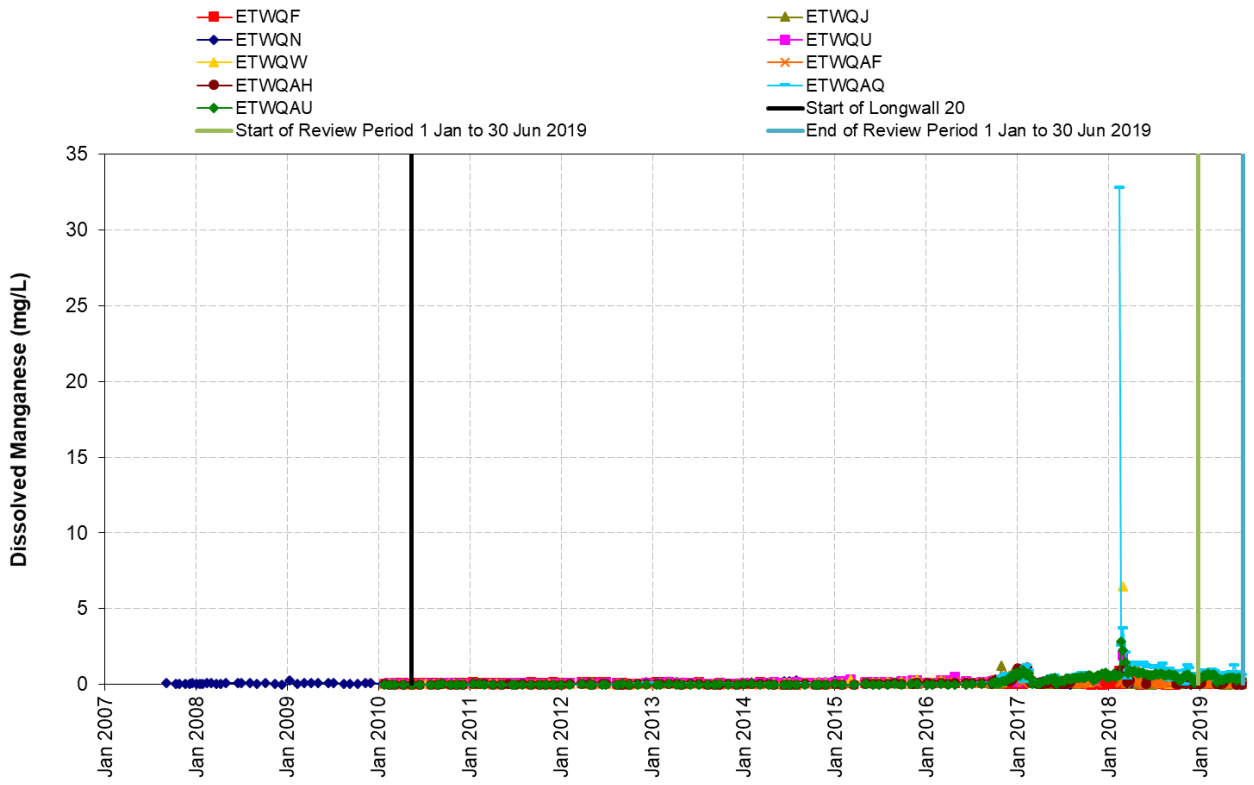


Chart B20a Dissolved Manganese Eastern Tributary

Tributary B, Tributary D, Far Eastern Tributary, Bee Creek and Honeysuckle Creek

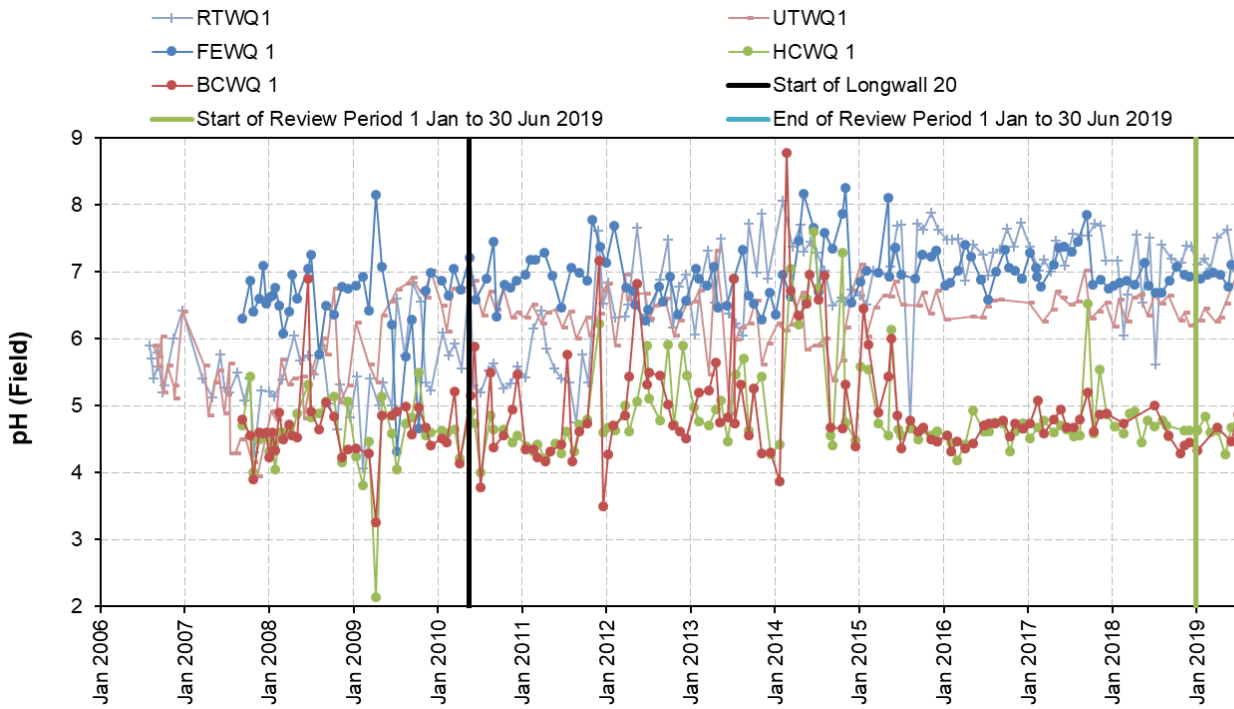


Chart B21 pH Levels Tributary B, Tributary D, Far Eastern Tributary, Bee Creek and Honeysuckle Creek

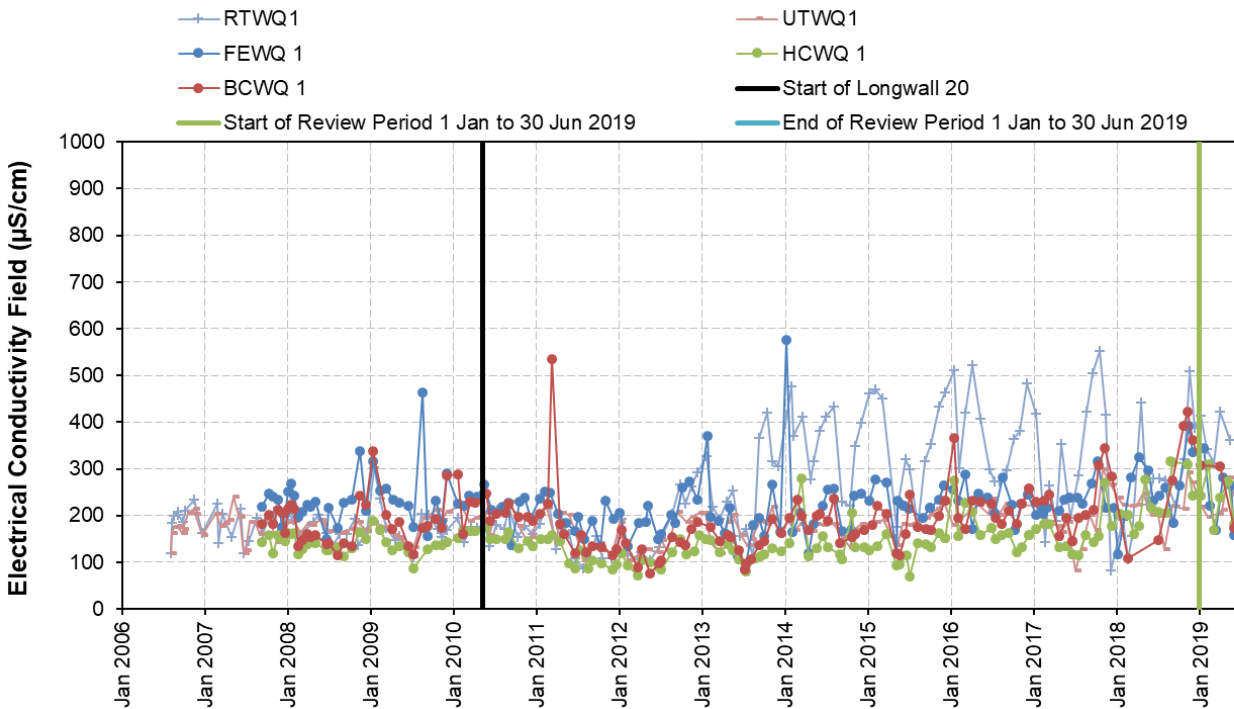


Chart B22 Electrical Conductivity (EC) Tributary B, Tributary D, Far Eastern Tributary, Bee Creek and Honeysuckle Creek

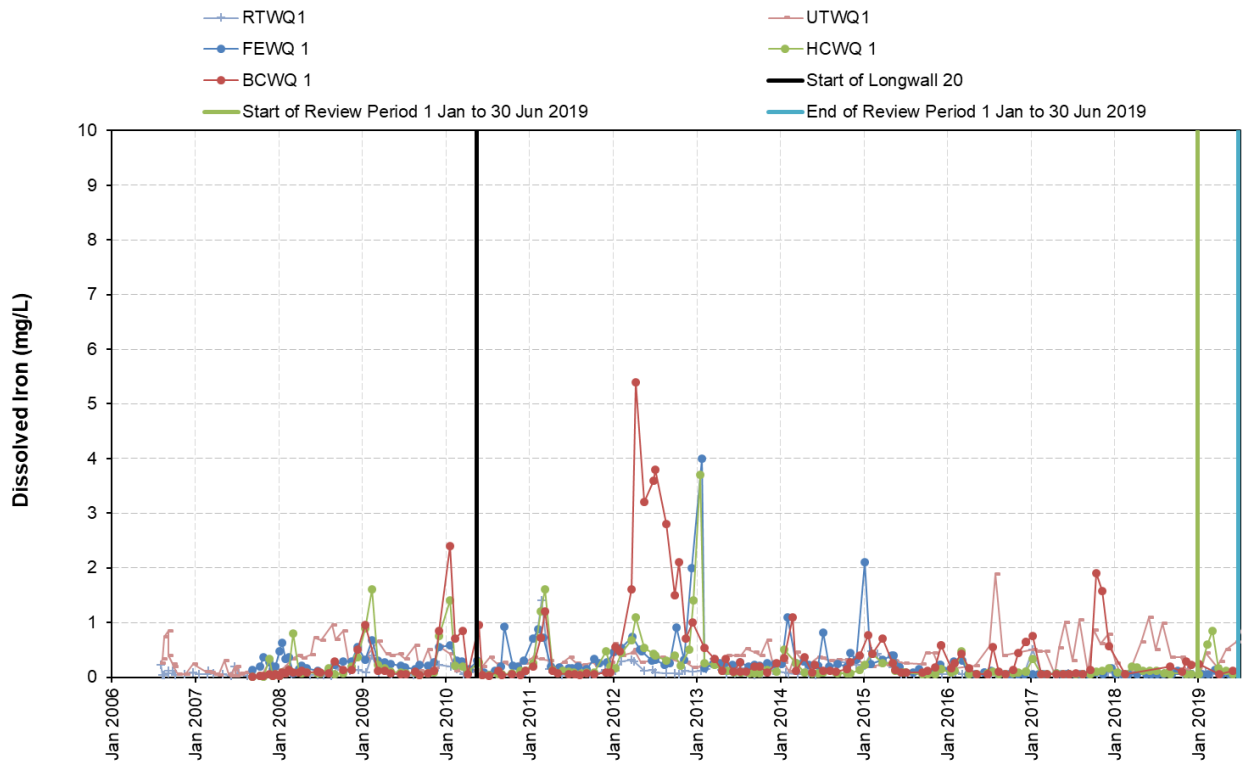


Chart B23 Dissolved Iron Tributary B, Tributary D, Far Eastern Tributary, Bee Creek and Honeysuckle Creek

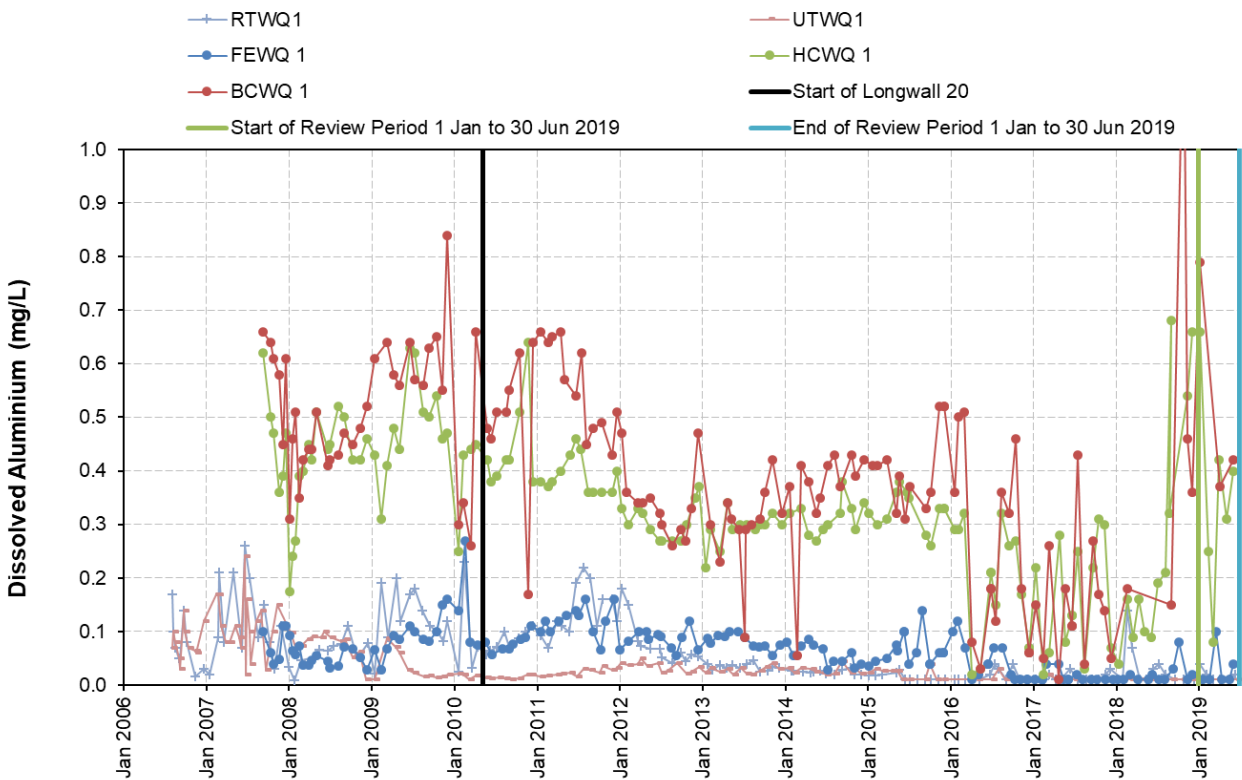


Chart B24 Dissolved Aluminium Tributary B, Tributary D, Far Eastern Tributary, Bee Creek and Honeysuckle Creek

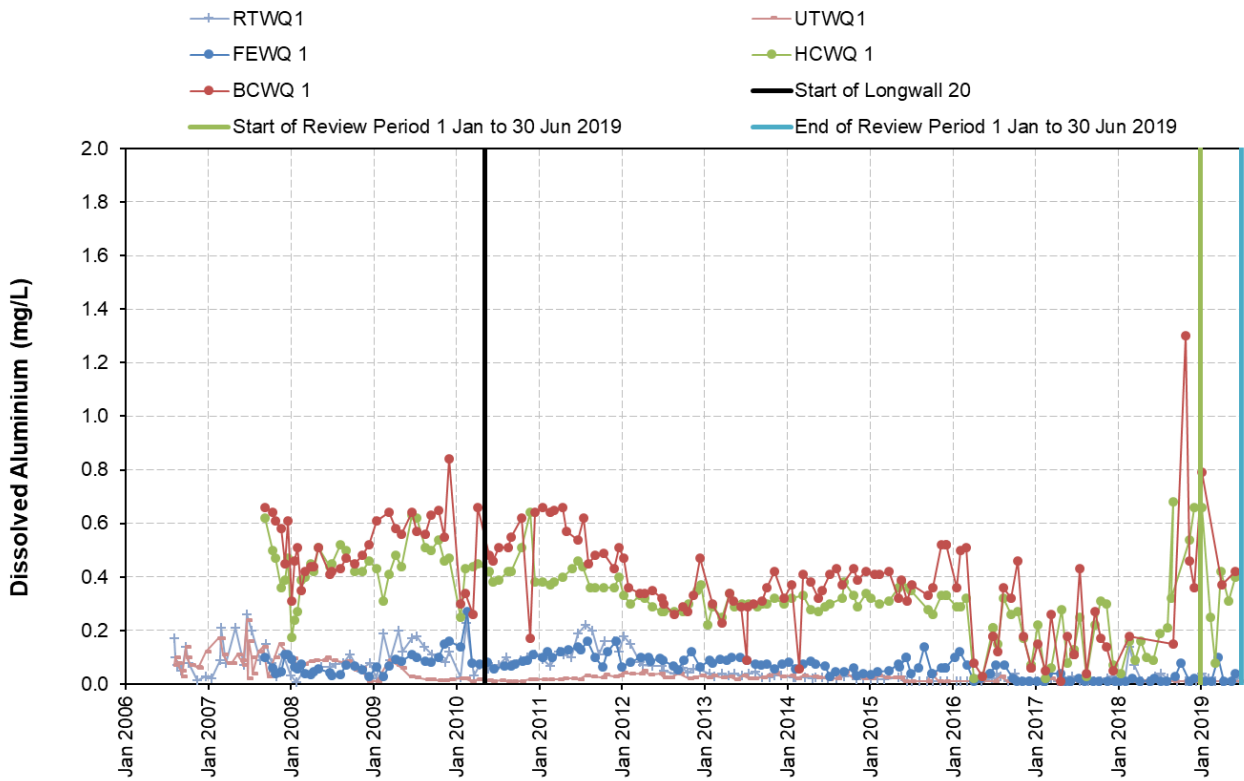


Chart B24a Dissolved Aluminium Tributary B, Tributary D, Far Eastern Tributary, Bee Creek and Honeysuckle Creek

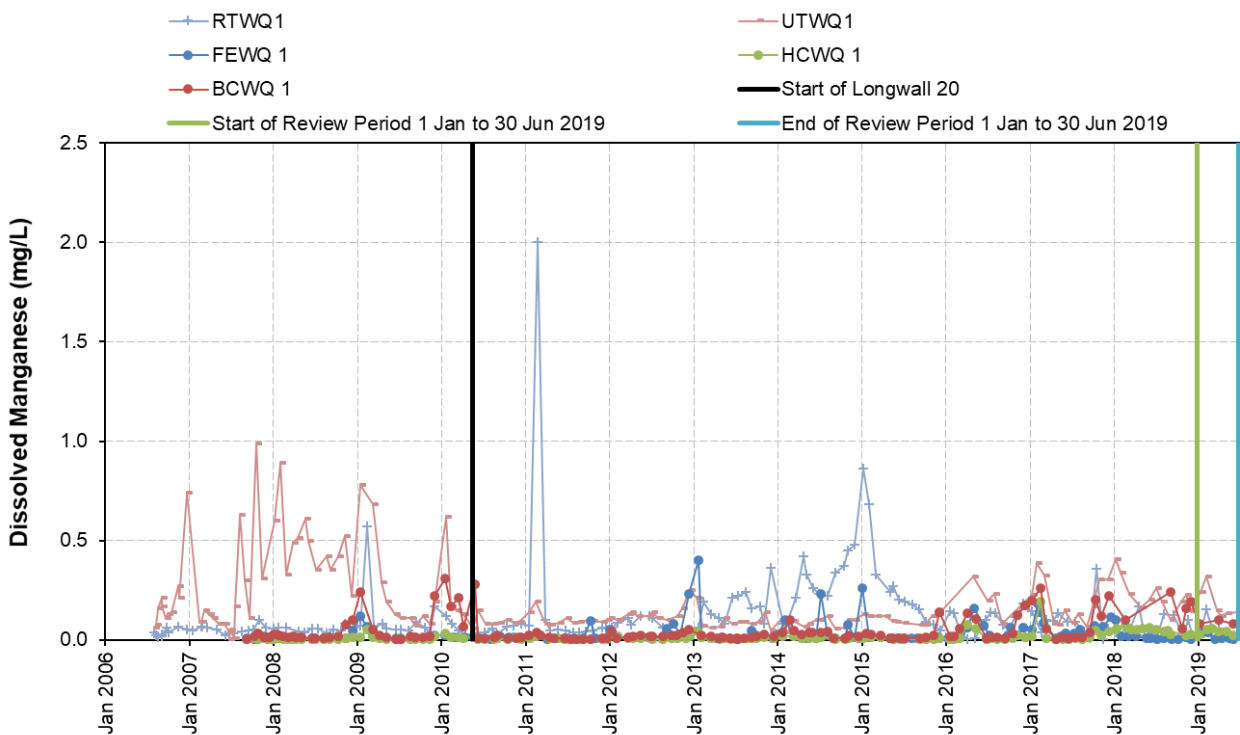


Chart B25 Dissolved Manganese Tributary B, Tributary D, Far Eastern Tributary, Bee Creek and Honeysuckle Creek