South32

Appin Mine

Area 9 Longwall 903 End of Panel surface water and groundwater monitoring review

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EXECUTIVE SUMMARY

South32 Illawarra Metallurgical Coal operates Appin Colliery extracting hard coking coal used for steel production. Appin Colliery is an underground mine located near the township of Douglas Park in the Southern Coalfield of New South Wales. Appin Area 9 (AA9) consists of four approved longwalls (Longwalls 901 to 904), all located to the north of, and offset from, the Nepean River. Longwall 903 commenced on 1 November 2019 and was completed on 7 April 2021.

Potential impacts to watercourses and aquifers are monitored and managed through the AA9 Water Management Plan (WMP) (BHPBilliton, 2014). This report presents results of the surface water and groundwater monitoring program following the end of Longwall 903 (End of Panel Report), including an assessment of data against performance criteria in the Trigger Action Response Plan (TARP).

Groundwater assessment

Groundwater levels are monitored at seven bores within and surrounding AA9 as part of a much wider groundwater monitoring network covering the Appin, West Cliff and Dendrobium mining areas. During extraction of Longwall 903, a decline in groundwater pressure occurred in the Hawkesbury Sandstone at monitoring bore S1941, located 280 m away. The observed groundwater pressure reductions are within the predicted range for the upper two sensors at 65 m and 125 m depth but exceeded the Level 1 TARP trigger for the sensor at 201.6 m depth. Groundwater pressures in the sensor at 201.6 m recovered above the Level 1 TARP trigger after 93 days. No significant change in groundwater chemistry is noted for the reporting period.

Groundwater inflow to the mine is calculated from the daily mine water balance. The 20-day moving average mine inflow fluctuated between approximately 1.2 and 0 ML/day during the extraction of Longwall 903, below the TARP Level 1 trigger of 2.7 ML/day.

Surface water assessment

Monthly monitoring by South32 indicates a decline in pool water levels at site NR0 of 0.49 m from the baseline range during the reporting periods for Longwalls 901, 902 and 903. Water levels at site NR110 located 3.5 km further upstream show a decline of 0.25 m from the baseline range over the same period. Additional monitoring at NR0 and NR110 is recommended. Monitoring of Nepean River gauging weirs at Maldon and Menangle and the Cataract River at Broughtons Pass showed that there were zero no-flow days recorded during the period January 2018 to May 2021, including the periods of LW902 and LW903 extraction.

The Longwall 903 reporting period was characterised by widely variable water quality in the Nepean River. During the reporting period, Level 1 and 2 TARPs were triggered for EC at NR0 and SW3, as well as at the upstream control site, and therefore the exceedances are not attributed to mining activities. Level 1 TARP was triggered for total iron at NR0 and SW3 and for total manganese at SW3 and NR2. Deviations from the baseline of a similar magnitude were observed for these parameters at the upstream control site and there is no underlying adverse trend in concentrations. The exceedances are not attributed to mining activities.

One additional gas release zone was identified in the Nepean River during the monitoring period for Longwall 903. All 32 gas release zones identified during mining in Area 9 have had estimated emission rates of <3000 L/min and triggered a TARP Level 1 response under the AA9 WMP.

1. INTRODUCTION

South32 Illawarra Coal operates the Appin Colliery, extracting hard coking coal used for steel production. Appin Colliery is an underground mine located near the township of Douglas Park in the Southern Coalfield of New South Wales (Figure 1).

AA9 consists of four approved longwalls (Longwalls 901 to 904), all located to the north of, and offset from, the Nepean River (Figure 2). Longwall 901 commenced on 19 January 2016 and was completed on 8 September 2017. Longwall 902 commenced on 12 May 2018 and was completed on 3 April 2019. Longwall 903 commenced on 1 November 2019 and was completed on 7 April 2021. Longwall 903 has a width of 305 m, a length of 2297 m and a cutting height of between 2.8 and 2.9 m (full seam extraction).

Potential impacts to watercourses and aquifers are monitored and managed through the AA9 WMP (BHPBilliton, 2014), developed in accordance with the Bulli Seam Operations (BSO) Approval Condition 5 (h), Schedule 3. This report presents results of the surface water and groundwater monitoring program following the end of Longwall 903 (End of Panel Report), including an assessment of data against management criteria defined in the AA9 WMP.

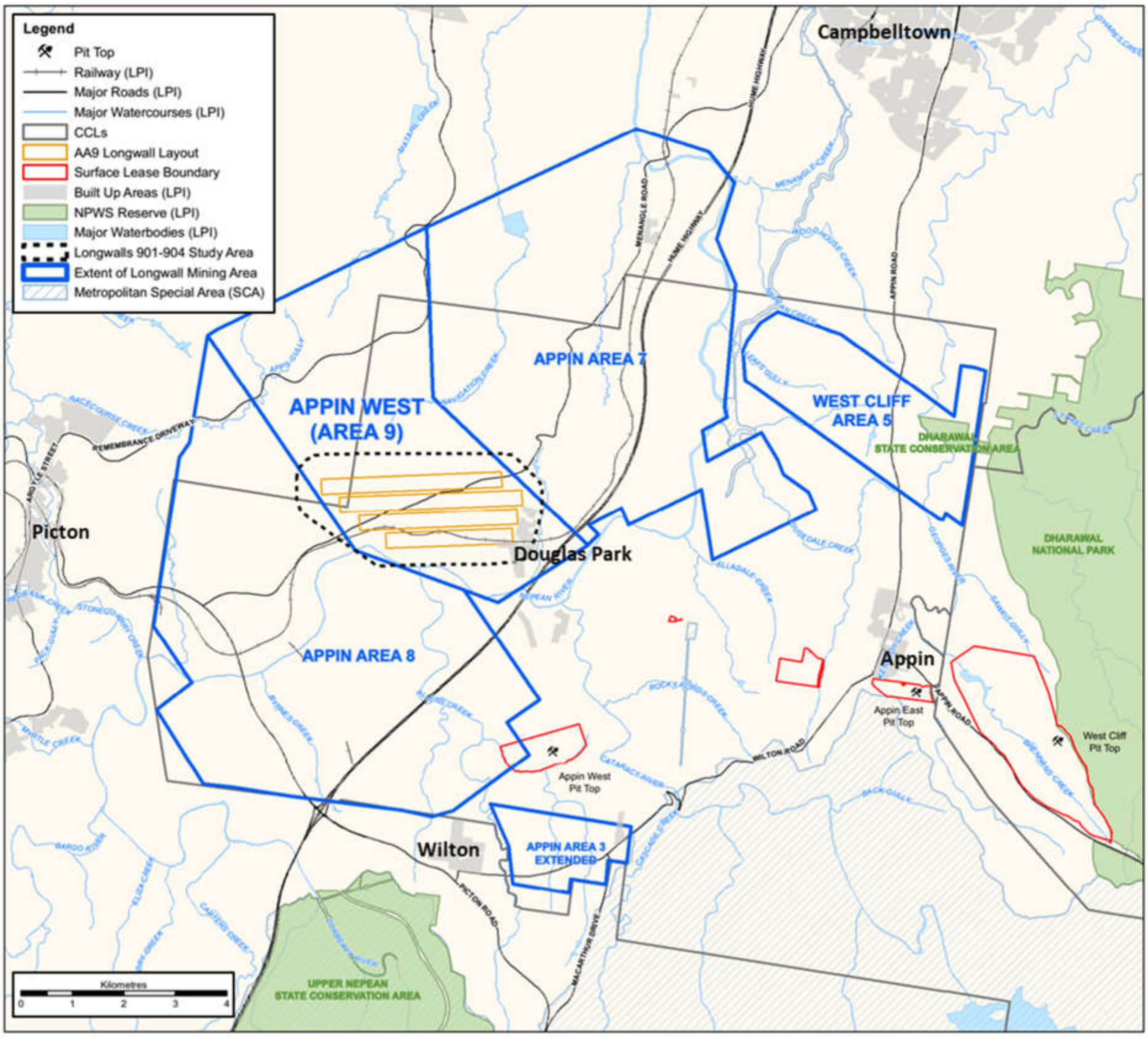
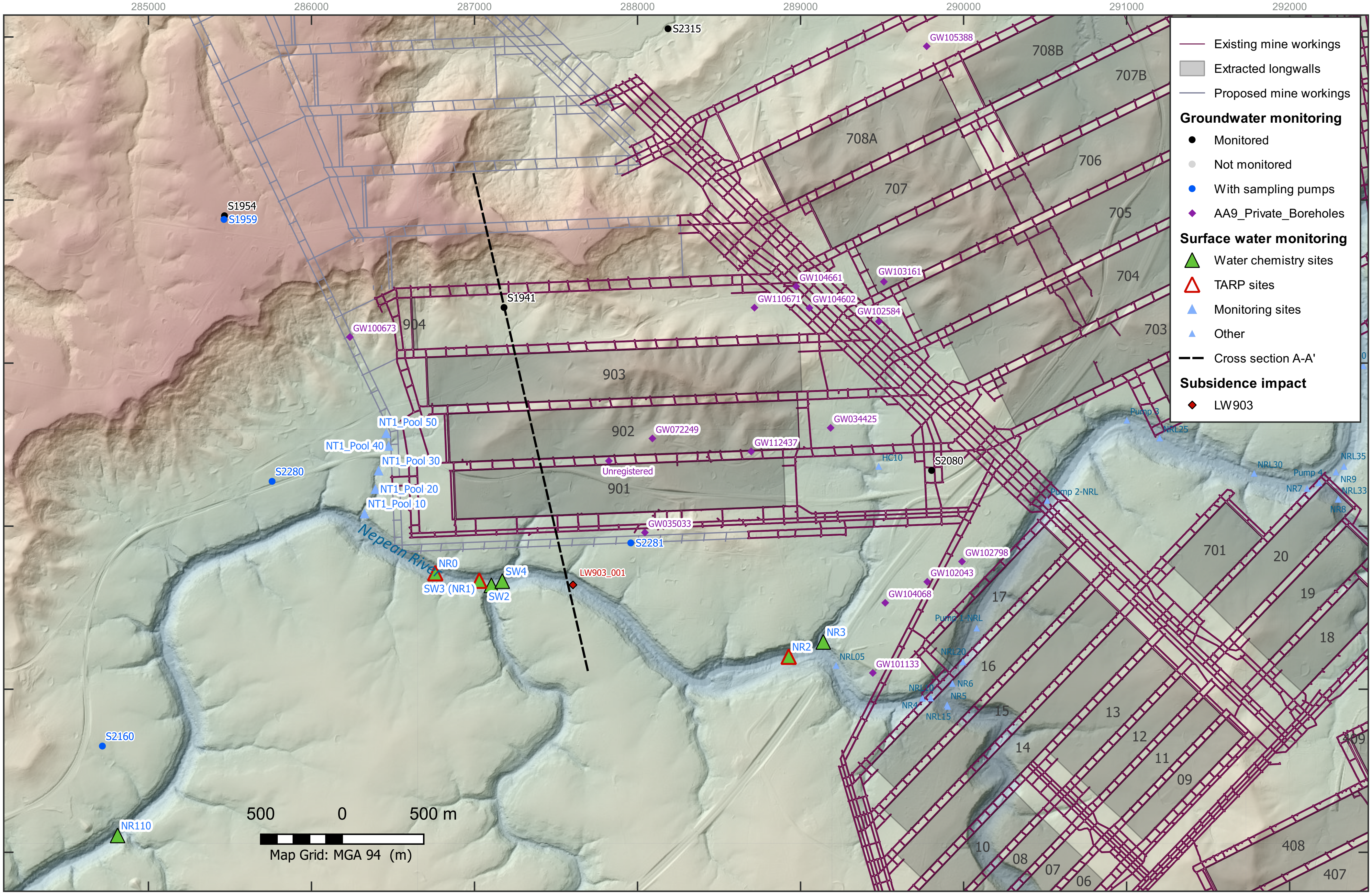


Figure 1. Location of Appin Colliery Area 9



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Appin Area 9 EOP Surface water and groundwater monitoring

Monitoring site locations

Figure 2

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1.1 Hydrogeology

Appin Colliery is located within the Southern Coalfield which is one of the five major coalfields that lie within the Sydney Geological Basin. The Basin is a Permo-Triassic sedimentary rock sequence, underlain by undifferentiated sediments of Carboniferous and Devonian age (Figure 3). The Bulli and Wongawilli Coal Seams are the primary target seams in the top part of the Illawarra Coal Measures. The Coal Measures are overlain by Triassic sandstones, siltstones and claystones of the Narrabeen Group, the Hawkesbury Sandstone and the Wianamatta Group. The Hawkesbury Sandstone is the dominant outcropping formation adjacent to, and underlying, the Nepean River Gorge. Wianamatta Group shales and claystone-dominated units underlie elevated areas including the Razorback Range. The geology and hydrogeology of the area is illustrated in a north-south cross section in Figure 4.

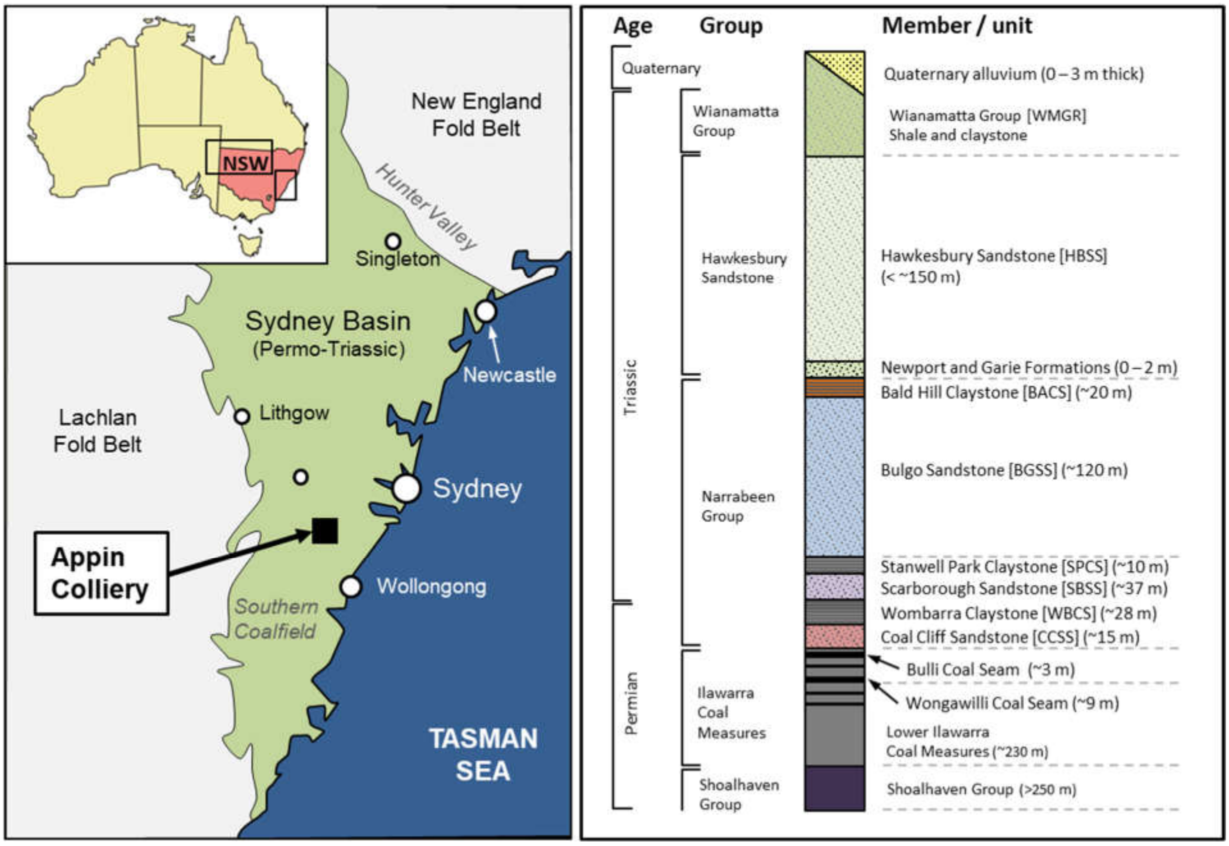

Figure 3. Stratigraphy of the Southern Sydney Basin

Three main groundwater systems are recognised:

1. Perched groundwater systems associated with fractures and bedding planes within the shallow sandstone and shale units of the Wianamatta Group and Hawkesbury Sandstone. These may be ephemeral and/or disconnected from the deeper groundwater systems;
2. Shallow groundwater systems: layered water-bearing zones within the saturated Hawkesbury Sandstone. The highest yielding groundwater bores are typically associated with coarse sandstone units and/or fractured sandstone; and
3. Deeper groundwater systems within the Narrabeen Group and the Illawarra Coal Measures. These units typically are of much lower permeability than the Hawkesbury Sandstone and produce low bore yields and poorer water quality.

The private groundwater supply bores in the vicinity of AA9 are between 70 m to 240 m deep, with water obtained primarily from water-bearing horizons within the Hawkesbury Sandstone, and minor perched horizons within the Wianamatta Group shale (e.g. GW104602 at 29.9 m; GeoTerra, 2011). Groundwater in the New South Wales Office of Water (NoW) registered bores, where reported, is generally fresh to brackish with salinity (total dissolved solids; TDS) between 260 and 2500 mg/L. Most aquifer intersections over the Longwalls 901 to 904 Study Area lie at or below the elevation of the Nepean River.

The Nepean River is a ‘gaining’ system, where groundwater flows from the plateau under a regional hydraulic gradient to the river. These flows are predominantly horizontal and determined by a confined flow along discrete layers underlain by fine grained or relatively impermeable strata within the Hawkesbury Sandstone. Vibrating wire piezometers at monitoring bore S1941 show that groundwater pressures (potentiometric levels) are higher in the Narrabeen Group than in the Hawkesbury Sandstone and may be sub-artesian to artesian in some areas (the potentiometric level is near or above the ground surface). The lower groundwater pressures within the Hawkesbury Sandstone may be due to pumping from bores as well as discharges to the Nepean River gorge. These observations suggest that the Bald Hill Claystone is an effective confining unit in this area.

Recharge of the groundwater system occurs after rainfall infiltrates into the plateau soil, as well as the underlying Wianamatta Shale and/or Hawkesbury Sandstone. Most infiltrating water discharges from temporary seeps in the cliffs of the Nepean River gorge (“interflow”). The low permeability of the Bald Hill Claystone acts as an aquitard between the Hawkesbury Sandstone and the Bulgo Sandstone. It has been observed to maintain its low permeability after subsidence and inhibit the movement of water and gas.

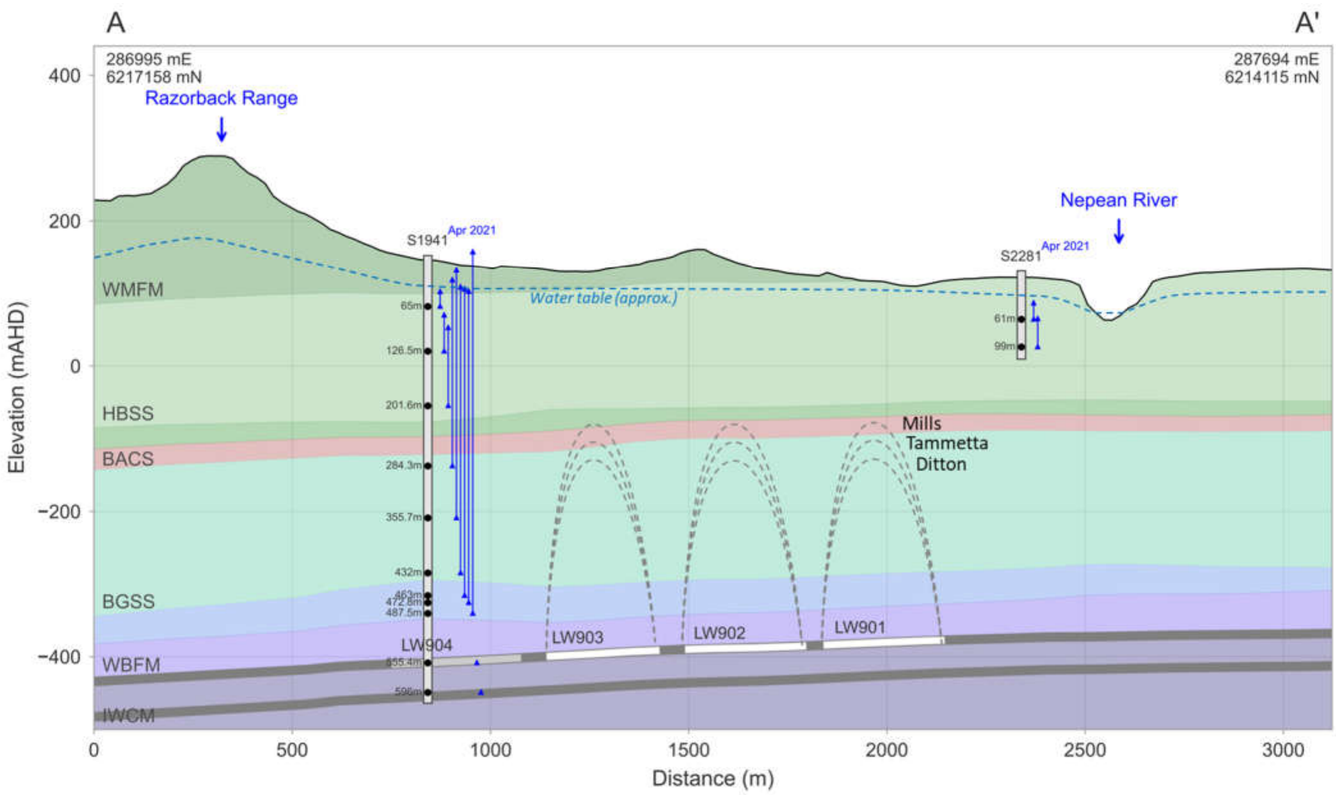

Figure 4. Hydrogeological cross section (N-S) through AA9

1.2 Surface water hydrology

Drainage lines within AA9 predominantly flow south to the Nepean River, which itself flows in an easterly direction. MSEC (2012) subdivided the Nepean River into two sections based on streambed morphology:

- Section 1 (upstream of Allens Creek) where flow is controlled by boulder fields, two rockbars and a small weir.
- Section 2 (downstream of Allens Creek) where the river is a flooded valley controlled by the Douglas Park Causeway.

Water flows in the Nepean River are derived from a number of sources, which include flows from catchment areas, licensed discharges (including Appin Colliery and Tahmoor Colliery) and runoff from agricultural and urban areas. Within the Study Area, river flow is predominantly controlled by the Maldon Weir (upstream) and the Douglas Park Weir (downstream). Water levels down river of the Study Area (i.e. down river of Douglas Park Causeway), are regulated by the Menangle Weir.

Water flows in the Nepean River:

- Vary greatly and are highly responsive to rain events due to the significant areas of catchment.
- Reach very high levels during sustained storm events, while minimum flow is rarely less than 1.5 ML/day (approx. 5 percentile flow).
- Cease on a small number of occasions, usually only when the rate of pumping out of the River exceeds the rate of inflow under low flow/drought conditions.

Median flow in the river section adjacent to the proposed longwalls is likely to be ~15% more than the median flow rate at Maldon Weir, which is 16.5 ML/day, and a little less than the median flow rate at Menangle Weir, which is 34.7 ML/day. Therefore median (50 percentile) flow rate adjacent to Longwall 901 is about 30 ML/day.

Baseline surface water monitoring for AA9 has been ongoing since October 2008 and provides a comprehensive baseline data set prior to extraction of Longwalls 901 to 904.

Tributaries to the Nepean River within the Longwalls 901 to 904 Study Area include:

- Nepean River Tributary 1 located directly above the proposed Longwalls 902 to 904.
- Harris Creek located east of the proposed longwalls and 400 m from Longwall 903 at its closest point. It is located just outside the Study Area, although Harris Creek has experienced valley related and far-field horizontal subsidence movements.

First and second order channels also flow to the Nepean River, and form smaller gullies along the cliffs of the gorge which generally discharge via elevated streams cascading down cliffs after sufficient rain. The majority of rainfall in the smaller catchments would infiltrate into these plateau soils and enter the groundwater system.

There are no areas considered flood prone and there are no upland swamps in the Study Area. A number of earth farm dams are located in the streams and are used as water sources on rural properties. All major streams have dams within their channels and catchment areas.

1.3 Potential mining effects

Extraction of coal using longwall methods commonly results in ground subsidence, deformation and fracturing of overlying strata and depressurisation of adjacent geological units (Peng and Chiang, 1984). The distribution of fracturing and its effects on aquifer characteristics has been well documented from numerous case studies (Booth, 1986; Forster and Enever, 1992; Guo et al., 2007; Mills, 2011; Tammetta, 2016; Tammetta, 2014; Tammetta, 2013).

While authors differ slightly in their terminology, there is general agreement on the overall sequence and pattern of fracturing that develops above a longwall. Immediately above a mined coal seam, the roof collapses into the void to form a caved zone that extends tens of metres above the seam. As the mining proceeds, a network of connected fractures extends above the caved zone to a height above the seam that is largely dictated by the width and mining height of the panel relative to the depth of cover (Mills, 2011; Ditton and Merrick, 2014; Tammetta, 2013). The development of fractures above (and below) the mined seam results in changes to aquifer properties; specifically, the permeability of the rock mass increases and groundwater pathways are potentially created between shallow and deeper groundwater systems. Subsidence and associated phenomena such as valley closure commonly result in increased surface cracking due to the unconfined nature of the surface rock. This type of surface cracking is typically limited to the top 10 to 20 m and may not be connected to the deeper fracture zones. Nevertheless, surface fracturing can affect shallow and perched groundwater systems and stream flow characteristics.

Calculations based on published geotechnical models indicate that the zone of connected fracturing above longwalls in AA9 is unlikely to extend above the base of the Bald Hill Claystone (Figure 4). A recent review commissioned by the Department of Planning and the Environment (DPE) of published methods for estimating the height of fracturing (PSM, 2017) concluded that the empirical approaches of Ditton and Merrick (2014) and Tammetta (2013) may not be accurate for all mining settings and such estimates should be considered indicative only. However, the observation of low water make at AA9 and strata gas movements is consistent with the extent of connective fracturing being limited to below the Bald Hill Claystone.

1.3.1 Ground subsidence

Ground subsidence and potential effects on natural and built surface features was assessed by MSEC (2012), prior to the commencement of mining at AA9. Contours of predicted subsidence after Longwall 903 are reproduced in Figure 5. Approximately 20 mm or less subsidence was expected at the Nepean River in response to Longwall 903 and approximately 800 to 1100 mm of subsidence is expected directly above the longwalls.

Actual changes in surface level due to the mining in Area 9 were measured using Airborne Laser Scan (ALS) / Light Detection and Ranging (LiDAR) surveys. The results, reported by MSEC (2021), show that observed subsidence due to the extraction of LW901 to LW903 is consistent with predictions.

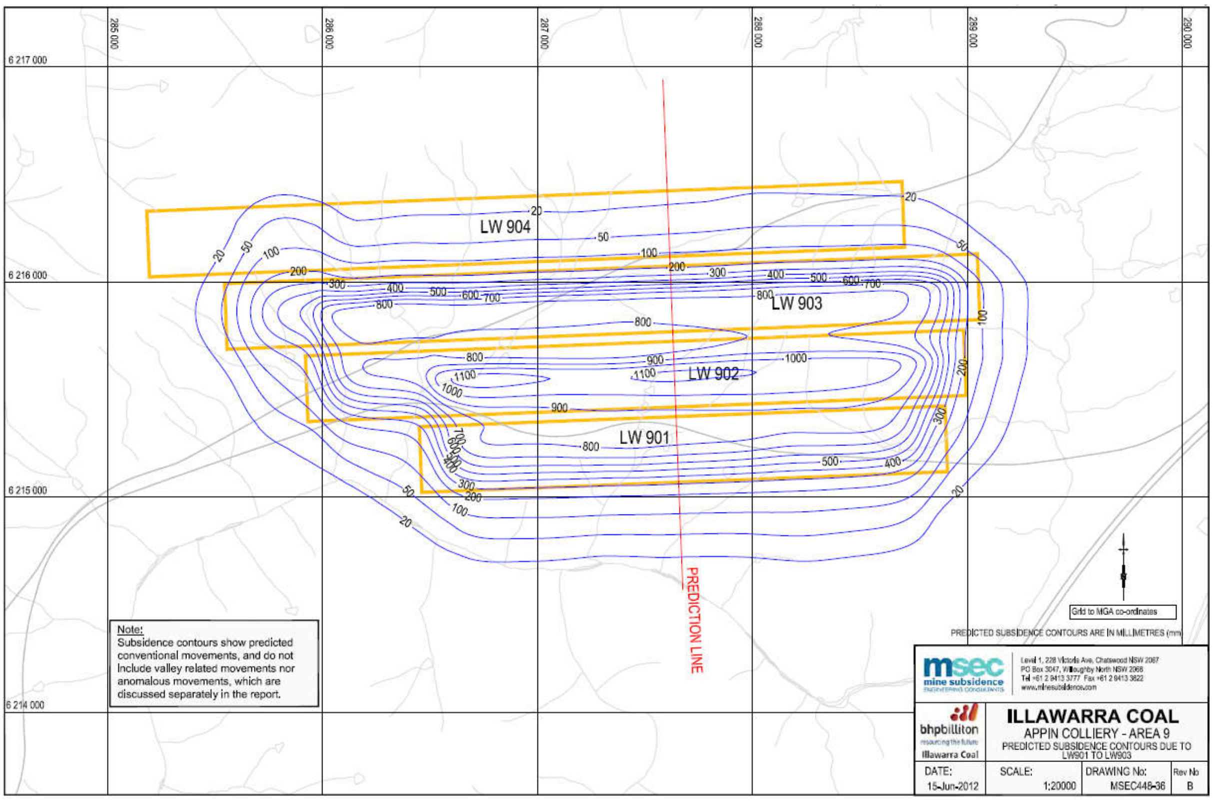

Figure 5. Contours of predicted subsidence due to Longwall 903 (in mm; MSEC 2012)

An End of Panel subsidence assessment was carried out following the completion of mining Longwall 903 (MSEC, 2021). The report assessed subsidence impacts to nearby natural drainage features including the Nepean River, and Harris Creek and the natural drainage lines directly above Longwall 903 that flow into the Nepean River. The impacts on natural drainage lines associated with the extraction of Longwall 903 recorded by the IMC Environmental Field Team were similar to or less than the MSEC assessments provided in Reports Nos. MSEC488, MSEC829 and MSEC1005

1.3.2 Surface water and groundwater effects

Ecoengineers (2012) and GeoTerra (2011) identified a number of possible water related environmental consequences that may occur due to the extraction of Longwalls 901 to 904. Those consequences are summarised in Table 1.

Table 1. Summary of potential water-related mining impacts

Consequence	Description	Impact / Likelihood
Gas emissions in the Nepean River and other areas	Based on observations at (AA7) it is likely that “minor” gas emissions will appear in the Nepean River as a consequence of mining Longwalls 901 to 904. Potential effects may include Dissolved Oxygen “sags”, and visible iron precipitates (localised iron staining).	Impact: Negligible Likelihood: Likely (Ecoengineers, 2012)
Groundwater outflows and ferruginous springs	The appearance of ferruginous springs due to mining has been noted in some Bulli Seam mining areas especially along margins of outcropping Wianamatta Shale. Ferruginous springs have not been detected in relation to	Impact: Negligible Likelihood: Low (Ecoengineers, 2012)

Consequence	Description	Impact / Likelihood
	mining of Longwalls 701 and 702, either in the walls of the Nepean River gorge or along adjacent tributaries.	
Sub-bed flow diversions and un-natural pool drainage	Section 1 of the Nepean River is characterised by boulder fields, which are less susceptible to fracturing than rockbars. Two rockbars have been identified in the Study Area: Rockbar NR-A9-RB01 is located 370 m from the nearest longwall. Rockbar NR-A9RB02 is submerged at times of high flow, and therefore does not restrict the surface water at these times.	Impact: Negligible Likelihood: Low (Ecoengineers, 2012) Nepean River Tributary 1: Likely impact
Impacts to streams and farm dams	Many farm dams have been mined under and monitored, with only a small number of dams exhibiting impacts (becoming dry) following mining. It is predicted that the impact on farm dams from mining Longwalls 901 to 904 will be similar.	Impact: Minor Likelihood: Likely (Ecoengineers, 2012)
Reduced groundwater yield	Six NoW registered bores within or near the proposed Longwalls 901 to 904 may be affected by subsidence, where the bores predominantly obtain water from the Hawkesbury Sandstone, rather than the overlying Wianamatta Group shale and sandstones. Groundwater levels in the Hawkesbury Sandstone are predicted to reduce by up to 10 m (WMP, p.14)	Impact: Negligible Likelihood: Likely (GeoTerra, 2011)
Groundwater quality impacts	It is likely that some [minor and localised] water quality changes will occur but there is a relatively low level of groundwater resource use in the area. Monitoring of potentially affected bores within AA9 is conducted in consultation with the owners.	Impact: Negligible Likelihood: Likely (GeoTerra, 2011)
Gas emissions	There is potential for strata gas emissions into private bores. Any such emissions are likely to diminish over time. Any bores with gas releases are decommissioned during the mining period.	Impact: Negligible Likelihood: Likely (GeoTerra, 2011)

1.4 Water management framework

Groundwater monitoring and reporting is carried out according to the AA9 WMP (BHPBilliton, 2014). The objectives of the WMP are to identify at risk surface water and groundwater features and characteristics within the Longwalls 901 to 904 Study Area and to manage the potential impacts and/or environmental consequences of the proposed workings on watercourses and aquifers, with specific focus on the Nepean River and its tributaries.

1.4.1 Trigger Action Response Plan (TARP)

Effects of mining on surface water and groundwater are managed through ongoing monitoring and regular reporting against agreed performance measures. The Water Management Plan (BHPBilliton, 2014) includes a Trigger Action Response Plan (TARP) which outlines specific performance measures and management actions to be taken in the event of a trigger event. The water related performance levels are listed in Table 2. Water chemistry TARP trigger levels calculated from baseline data (prior to the start of mining on 19/1/2016) are presented in Table 3.

Table 2. TARP Performance Criteria for AA9

Type / Location	Parameter	Level 1	Level 2	Level 3
Surface water quality				
Nepean River: ▪ NR0 ▪ SW3 ▪ NR2 If and where gas plumes above 3000 L/min are detected ** Compared with baseline monitoring prior to mining*	pH	Reduction* > 1SD < 2SD for two consecutive months	Reduction > 2SD for two consecutive months	As for level 2, for 6 consecutive months
	DO	Reduction > 1SD < 2SD for two consecutive months	Reduction > 2SD for two consecutive months	
	EC, Total Fe, Total Mn	N/A	Increase > 2SD for 2 consecutive months	
	Gas plumes	Plume <3000 L/min	Plume >3000 L/min	
	Cloudiness, iron staining	More than negligible		
Groundwater inflow to the mine	Inflow from the goaf (Over 20-day average)	Increase of between 2.7 and 3.0 ML/day	Increase of between 3.0 and 3.4 ML/day	Abnormal increase greater than 3.4 ML/day
Groundwater levels				
Private bores South32 Piezometers: ▪ S1913 (EAW5) ▪ S1936 (EAW7) ▪ S1941 (EAW9) ▪ S1954 (EAW18) ▪ S2080 (EAW58) ▪ S2280 (Harris Ck 7) ▪ S2281 (Harris Ck 6)	Reduction below predicted standing water level or pressure head in the Hawkesbury Sandstone.	5.0 to 7.5 m over a minimum two-month period.	7.5 to 10.0 m over a minimum two-month period.	>10 m over a minimum two-month period.

In relation to surface water flows, BSO Approval Condition 1, Schedule 3 stipulates that there should be *negligible diversion of flows or changes in the natural drainage behaviour of pools* in the Nepean River. In relation to other watercourses, there should be *no greater subsidence impact or environmental consequences than predicted in the Environmental Assessment and PPR.* The term “negligible” is defined within the Project Approval as “small and unimportant, such as not to be worth considering”.

Table 3. Baseline water chemistry TARP trigger levels

Parameter		NR110 (Reference)	NR0	SW3	NR2
Baseline samples (n):		33	254	21	389
EC	**Mean**	240	388	242	422
	Mean +1SD	320	586	328	652
	Mean +2SD	401	783	414	883
pH	**Mean**	7.9	7.8	7.9	8.0
	Mean -1SD	7.5	7.3	7.6	7.5
	Mean -2SD	7.1	6.8	7.4	7.0
DO	**Mean**	86.5	91.8	88.0	88.2
	Mean -1SD	69.7	78.7	74.6	70.1
	Mean -2SD	53.0	65.5	61.2	51.9
Fe (Total)	**Mean**	0.33	0.28	0.32	0.34
	Mean +1SD	0.46	0.50	0.45	0.74
	Mean +2SD	0.60	0.72	0.59	1.14
Mn (Total)	**Mean**	0.024	0.032	0.020	0.033
	Mean +1SD	0.038	0.057	0.029	0.058
	Mean +2SD	0.052	0.083	0.039	0.083

2. MONITORING NETWORK

2.1 Groundwater monitoring

Groundwater levels are monitored using multi-level vibrating wire piezometers (VWP) which are grouted into boreholes. There are seven groundwater monitoring sites relevant to AA9 operations and specified in the TARP, shown in Figure 2, and listed in Table 4.

Table 4. Groundwater monitoring sites in AA9

Bore ID	Alternate name	Total depth	Number of piezometers	Formations monitored	Date installed
S1913	EAW5	612.1	10	HBSS, BGSS, SBSS, BUSM	2008
S1936	EAW2	611.0	10	HBSS, BGSS, SBSS, BUSM	2008
S1941	EAW9	605.2	11	HBSS, BGSS, SBSS, BUSM	2008
S1954	EAW18	797.2	13	WMGR, HBSS, BUSM	2008
S2080	EAW58	524.2	10	HBSS, BGSS, SBSS, CCSS	2010
S2280	Harris Creek 7	110.0	2	HBSS	2014
S2281	Harris Creek 6	110.0	2	HBSS	2014

Deep groundwater responses to mining are assessed primarily through the use of time-series hydrographs for multi-level piezometer sites (VWPs). Noisy data are filtered and removed where practical. Hydrographs are presented in Appendix 1 and discussed in Section 3.1.

Hydrographs are plotted in terms of ***potentiometric head*** (mAHD). Potentiometric head can be thought of as the theoretical level to which water would rise in a bore that is open to an aquifer at a given elevation and is calculated by adding the measured pore pressure (at the VWP, expressed in m of water) to the elevation of the sensor (in m AHD). The potentiometric head in a confined aquifer system can be (and often is) different to the water table elevation at the same location.

Hydrographs presented in this assessment include the ground elevation at the bore site and the elevation of the Nepean River adjacent to Longwall 901. Note also that individual hydrograph traces are presented as dotted lines at times when the ***pressure head*** is below a threshold of 2 m. The pressure head is the absolute pore pressure at the sensor expressed in m of water. When the pressure head is below that threshold it is an indication that the rock matrix is approaching complete desaturation at the location of the sensor. This condition is not always apparent from plots of total piezometric head alone. Hydrographs of pressure head are also presented in Appendix 1.

2.1.1 Mine inflow

Groundwater inflow to AA9 is calculated from the daily mine water balance by accounting for water pumped in and out of the mine area.

2.2 Surface water monitoring

Surface water levels and chemistry are monitored at the sites shown in Figure 2 and listed in Table 5.

Table 5. Surface water monitoring sites

Site	Watercourse	MGA_mE	MGA_mN	Field Observations	Chemistry (Lab)	Flow
NR0	Nepean River	286759	6214712	Y	Y	
SW3 (NR1)	Nepean River	287029	6214666	Y	Y	
NR2	Nepean River	288927	6214200	Y	Y	
NR3	Harris Creek	289139	6214290	Y	Y	
SW2	Allens Creek	287103	6214637	Y	Y	
SW4	Nepean River	287170	6214663	Y		
NR110	Nepean River	284812	6213103	Y	Y	
NT1_Pool 10	Nepean Trib. 1	286324	6215077	Y	Y	
NT1_Pool 20	Nepean Trib. 1	286391	6215227	Y		
NT1_Pool 30	Nepean Trib. 1	286411	6215341	Y		
NT1_Pool 40	Nepean Trib. 1	286472	6215492	Y		
NT1_Pool 50	Nepean Trib. 1	286458	6215569	Y		
Maldon Weir	Nepean River	281633	6212737			Y*
Menangle Weir	Nepean River	291843	6222415			Y*
Broughtons Pass weir	Cataract River	292076	6210296			Y*

Note* Weirs operated by WaterNSW : Water level and flow at 15-minute frequency

2.2.1 Weather observations

Rainfall and solar exposure data have been collected at Douglas Park (Bureau of meteorology site 068200) since 1974 (with some gaps). Monthly rainfall, cumulative rainfall residual and solar radiation since the start of 2013 are plotted in Figure 6. Daily temperatures range between 10 to 46 °C in January and between -3.7 and 27 °C in July (at Campbelltown). Evapotranspiration also varies seasonally in line with temperature and solar radiation, peaking during the summer months.

Average annual rainfall since 1974 is 745 mm (2.03 mm/day). Rain can fall year-round with slightly higher monthly average rainfall in late summer months (February-March). It is common for a substantial proportion of the annual rainfall to be delivered in one or two large rainfall events, during which significant surface water runoff and groundwater recharge is generated. This was the case during the reporting period with heavy rainfall events in February 2020 and March 2021.

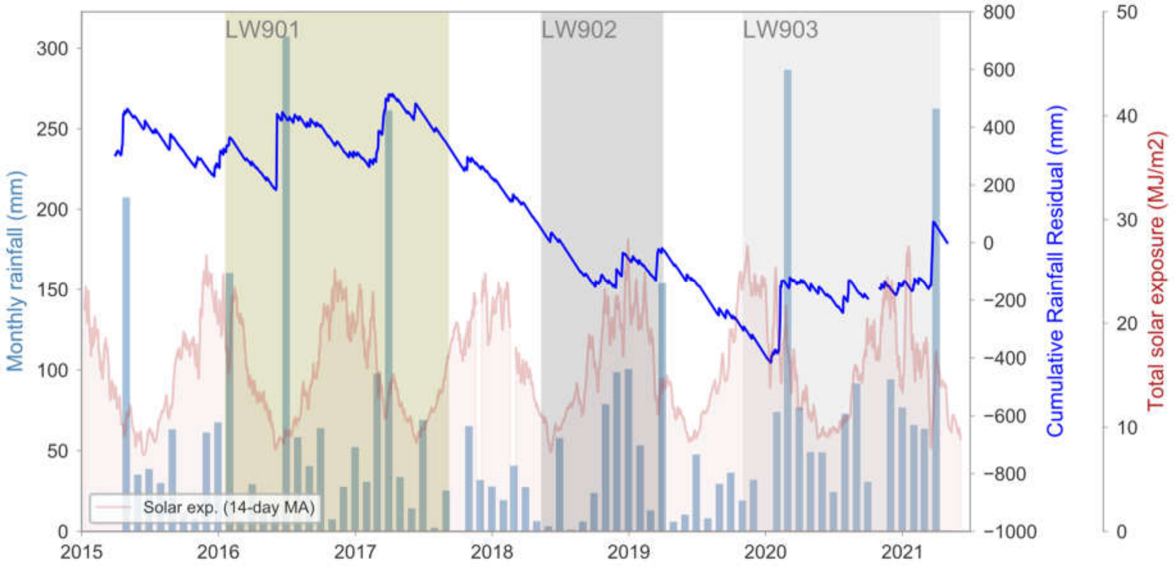

Figure 6. Rainfall and solar exposure at Douglas Park

3. GROUNDWATER ASSESSMENT

3.1 Groundwater levels

Groundwater bore hydrographs are presented in Figures 7, 8, 9 and 10 and Appendix 1. Observations in relation to temporal trends in groundwater pressures are listed in Table 6.

The Level 1 TARP was triggered at monitoring bore S1941 for the Hawkesbury Sandstone sensor at 201.6 m depth. A decline in groundwater pressure between 5.0 and 7.5 m more than predicted in the WMP for a period of more than 2 months was recorded for this sensor. The following actions were initiated in response to the Level 1 trigger, in accordance with the WMP:

- Continue monitoring program
- Submit an Impact Report to OEH, DoPI, DPI and other relevant resource managers
- Report in the End of Panel Report
- Summarise actions and monitoring in the AEMR.

Groundwater pressures at the sensor have since recovered.

Table 6. Groundwater level observations

Bore	Observations	TARP Level
S1913 (EAW5)	S1913 is located 2.6 km north of Longwall 903. It has three sensors in the Hawkesbury Sandstone at 65 m, 137 m and 194 m depth. During Longwall 903, groundwater pressures at the upper two Hawkesbury Sandstone sensors remained relatively stable, and pressures at the 194 m sensor showed a declining trend. Pressures at the upper two Hawkesbury Sandstone sensors were above the level of the Nepean River during Longwall 903. Pressures at the 194 m sensor have been below the level of the Nepean River since prior to the commencement of mining in AA9. Pressures at the 194 m sensor have declined by 14.3 m since the commencement of mining in AA9, more than the predicted maximum reduction of 10 m.	Not triggered
S1936 (EAW7)	S1936 is located 3 km north east of Longwall 903 and above Longwall 706 in AA7. All sensors apart from the shallowest Hawkesbury Sandstone sensor (65 m) failed in 2014 due to subsidence in AA7. The 65 m sensor shows a slight declining trend during longwalls 901, 902 and 903 which is unlikely to be associated with mining in AA9.	Not triggered
S1941 (EAW9)	S1941 is located 280 m north of Longwall 903 (and above planned Longwall 904). It has three sensors in the Hawkesbury Sandstone at 65 m, 126.5 m and 201.6 m depth. Groundwater pressures at all three sensors have shown a similar trend, with a decline in groundwater pressure following the start of mining at Longwalls 901, 902 and 903, followed by a period of groundwater pressure recovery. Groundwater pressures at the sensors at 65 m and 126.5 m have declined by less than 5 m and the heads remain above the level of the Nepean River. Groundwater pressures at the sensor at 201.6 m have been below the level of the Nepean River since prior to the commencement of mining in AA9 and declined by 6.7 m overall. During Longwall 903, a maximum decline in pressure from pre-mining levels of 17.2 m was recorded at the 201.6 m sensor, followed by a period of recovery. The Level 1 trigger in Annex C – Water Management Plan is reached when there is 5.0 – 7.5 m reduction in the Hawkesbury Sandstone greater than predicted standing water level or	TARP Level 1 triggered

Bore	Observations	TARP Level
	pressure (outside of pumping influences in private bores) over a minimum 2 month period. Section 4.2 of the Water Management Plan predicts up to 10 m reduction in HBSS, therefore the level 1 trigger condition is a 15 - 17.5 m reduction for 2 months. Prior to mining in Appin Area 9, pressure in the piezometer at 201.6 m was stabilising at RL of 59.16 m. On 19 June 2020, water pressure RL in borehole S1941 dropped to 44.15 m, i.e. more than 15 m below the baseline, and on 17 August 2020 (2 months later) the recorded pressure RL was 41,97 m, meeting the level 1 trigger conditions.	
S1954 (EAW 18)	S1954 is located 1.5 km north west of Longwall 903, on the far side of the Razorback range from AA9. S1954 has seven sensors within the Wianamatta Group shales and five sensors within the Hawkesbury Sandstone. Loggers were inoperative from early 2014 to mid-2017 with monitoring re-commencing at the end of mining at Longwall 901. Groundwater pressures at the Wianamatta Group shale and Hawkesbury Sandstone sensors declined by less than 3.6 m following mining at longwalls 902 and 903,. Piezometric levels in all sensors remained above the elevation of the Nepean River following mining at Longwall 901 and throughout mining at longwalls 902 and 903.	Not triggered
S2080 (EAW58)	S2080 is located 930 m south east of Longwall 903. It has three sensors in the Hawkesbury Sandstone at 65 m, 95 m and 170 m depth. Groundwater pressures in the uppermost Hawkesbury Sandstone sensor (65 m) declined by approximately 8 m during mining at longwalls 901, 902 and 903 but remain approximately 20 m above the elevation of the Nepean River. Groundwater pressures at the other two Hawkesbury Sandstone sensors were relatively stable during longwalls 901 and 902 and then declined during Longwall 903, although it is noted the logger failed at the start of December 2020 prior to the completion of Longwall 903 in April 2021. Groundwater pressures at these sensors were below the level of the Nepean River prior to and throughout mining at longwalls 901, 902 and 903.	Not triggered
S2280 (Harris Ck 7)	S2280 is located 1 km south west of Longwall 903 and has two sensors within the Hawkesbury Sandstone (60 m and 99 m depth). Groundwater pressure at both sensors was relatively stable during mining at longwalls 901, 902 and 903, and piezometric head in both sensors remains above the elevation of the Nepean River.	Not triggered
S2281 (Harris Ck 6)	S2281 is located 880 m south of Longwall 903, between Longwall 901 and the Nepean River. It has two sensors within the Hawkesbury Sandstone at 61 m and 99 m depth. Groundwater pressures at both sensors responded to the passage of Longwall 901, initially increasing (due to strata compression) as the longwall approached and then declining in August 2016 as the longwall moved away before stabilising in March 2017. A similar more subdued response was observed during the passage of Longwall 902. During Longwall 903, pressures at the upper sensor remained stable and pressures at the 99 m sensor showed an increasing trend. Overall the pressure in S2281_61 remained approximately 25 m above the elevation of the Nepean River and the piezometric head in S2281_99 recovered to a level approximately 5 m above the Nepean River.	Not triggered

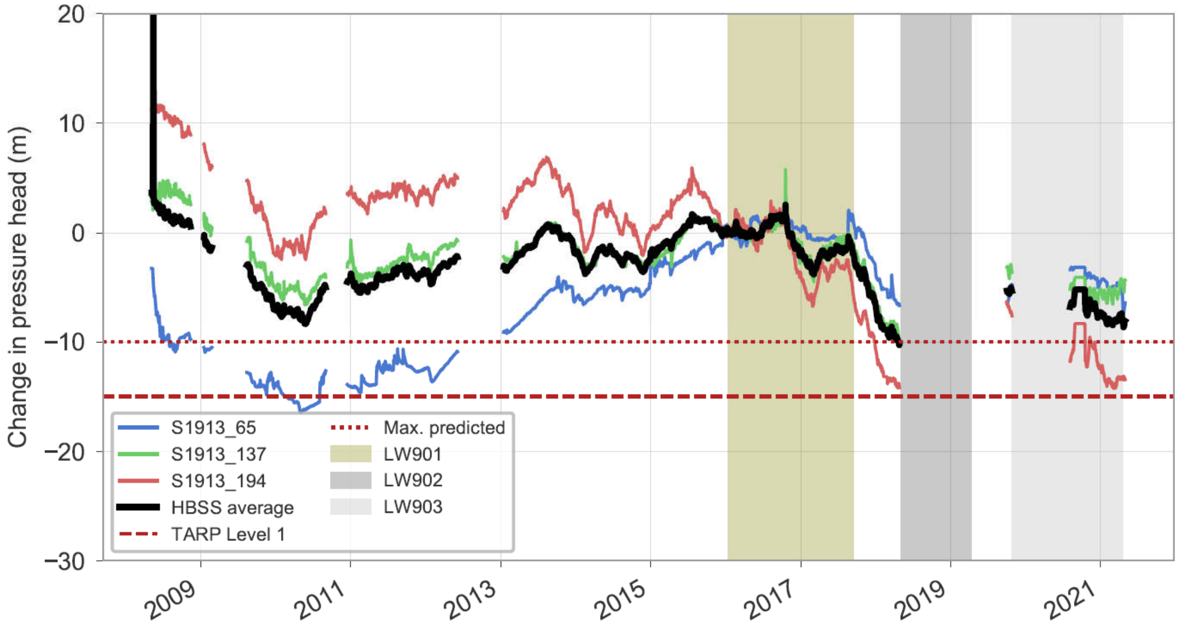

Figure 7. Pressure head change hydrograph for S1913

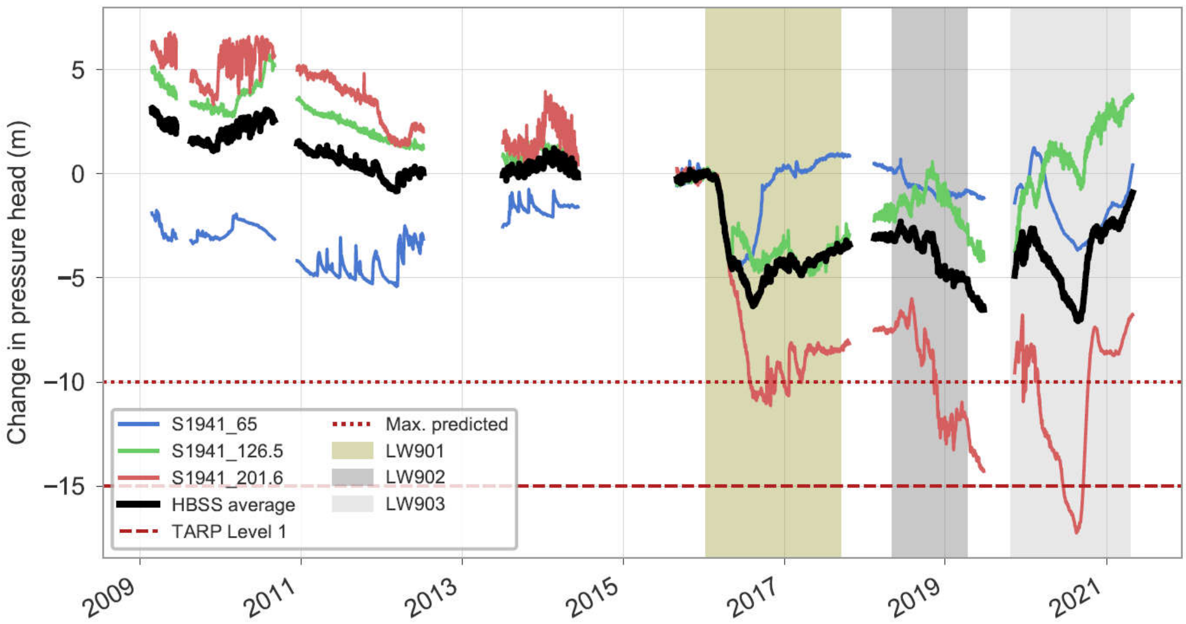

Figure 8. Pressure head change hydrograph for S1941

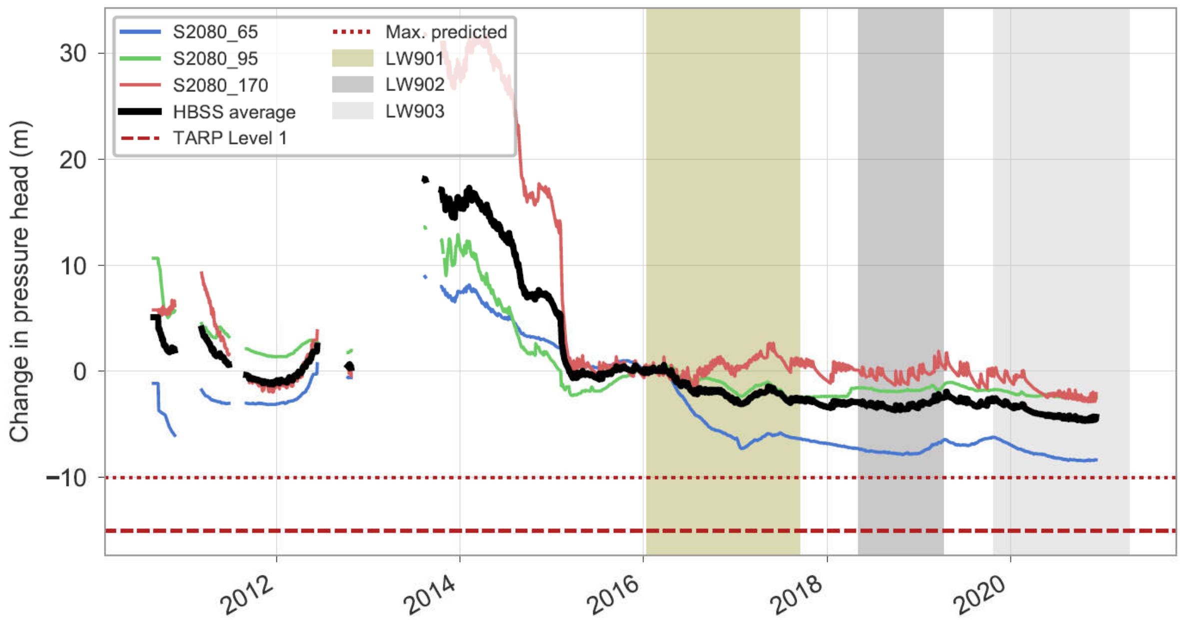

Figure 9. Pressure head change hydrograph for S2080

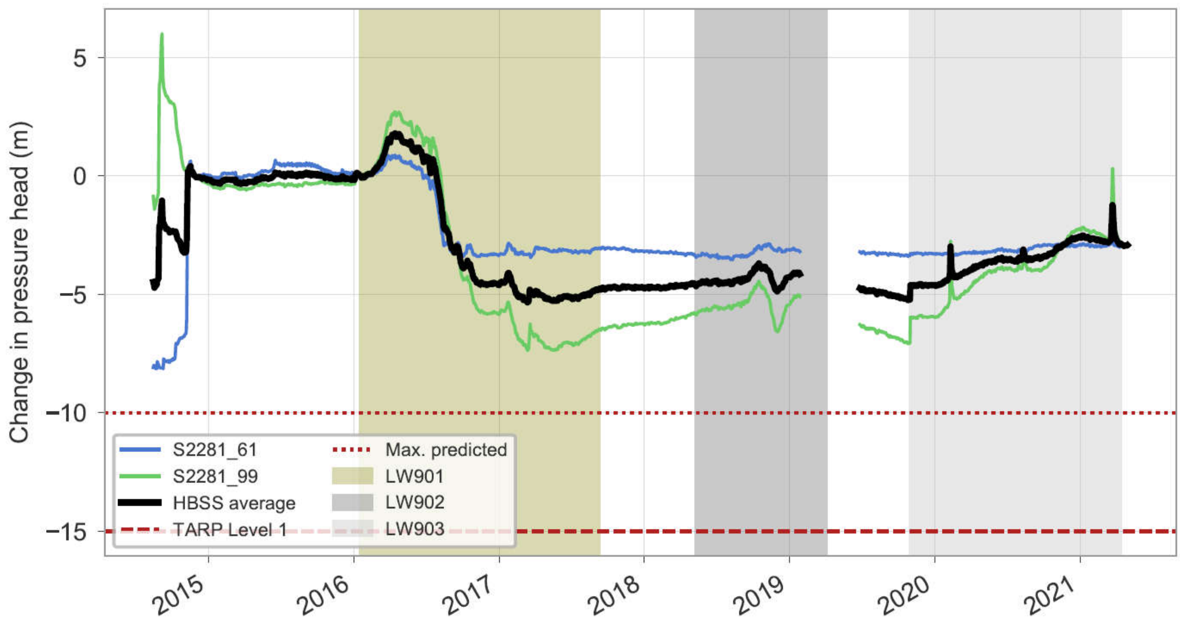

Figure 10. Pressure head change hydrograph for S2281

3.2 Groundwater chemistry

Groundwater samples are collected from four monitoring bores in the vicinity of AA9. Two bores (S1954, S2080) are sampled at multiple depths. Key groundwater quality parameters are summarised in Table 7 and water chemistry time-series plots are in Appendix 2. Groundwater in the Hawkesbury Sandstone is typically brackish (EC ~ 1400 to 6100 µS/cm; TDS ~ 840 to 3660 mg/L) and near neutral in pH. In contrast, the Nepean River has water of low salinity (fresh; EC typically 140 to 460 µS/cm; TDS 85 to 280 mg/L).

Time-series plots of key water quality parameters (Appendix 2) show no significant change in water quality as a result of mining at longwalls 901, 902 and 903. Groundwater quality samples were not collected at S1954 during or following the completion of mining at Longwall 903.

Table 7. Summary of groundwater quality near AA9

Site / depth	Statistic	Field EC (µS/cm)	Field pH	Na/Cl (meq)
S1954_198m (Wianamatta Grp)	P5%	2715	8.12	1.27
	Median	2996	8.85	1.45
	P95%	3845	9.42	1.51
S1954_255m (Hawkesbury Sst)	P5%	2747	7.74	0.85
	Median	3050	7.85	0.93
	P95%	3280	8.66	0.99
S2080_158m (Hawkesbury Sst)	P5%	1090	6.85	1.1
	Median	1240	7.40	1.1
	P95%	1521	7.99	1.2
S2080_290m (Bulgo Sst)	P5%	3616	6.91	7.5
	Median	4775	7.03	10.6
	P95%	5807	7.18	13.7
S2280_60m (Hawkesbury Sst)	P5%	3228	6.75	0.62
	Median	3720	6.88	0.73
	P95%	4550	7.36	0.82
S2281_60m (Hawkesbury Sst)	P5%	2430	6.50	0.56
	Median	5960	6.60	0.73
	P95%	7196	7.29	0.82
Nepean River (NR0, SW3 / NR1, NR2)	P5%	140	7.00	1.00
	Median	295	7.9	1.62
	P95%	602	8.4	2.76

3.3 Private groundwater bores and dams

Pre and post-mining inspection of dams, boreholes and natural features above AA9 (set out in the Built Feature Management Plans) are conducted by the ICEFT with the consent of the relevant property/infrastructure owner and tenant. Significant changes or impacts are reported in the End of Panel Landscape Report (South32, 2017).

Post-mining inspections for Longwall 903 were undertaken in April 2021 at five properties: Lot 1 DP810978, Lot 15 DP803255, Lot 9 DP810978, Lot 3 DP1133989 and Lot 59-64 DP1321. Post mining inspections were unable to be undertaken at property Lot 22 DP203255 due to access issues. The inspections included recording key observations for private bores and dams and collection of in-situ water quality parameters and water samples for laboratory analysis. Key findings of the inspections are summarised below. Further details can be found in the relevant property reports.

Lot 1 DP810978

Bore GW110671 on Lot 1 DP810978 is located approximately 230 m north of Longwall 903, is 240 m deep and is mainly used to water a garden. At the time of the inspection, groundwater from the bore had a hydrogen sulfide odour which dissipated quickly. The bore was purged for ten minutes prior to sampling. Groundwater quality data indicate:

- Dissolved and total iron concentrations have increased since the pre-mining inspection in November 2017, with total iron increasing from <0.05 mg/L pre-mining to 0.33 mg/L following Longwall 903
- Dissolved manganese and zinc concentrations have also increased.

The groundwater quality data may indicative of potential impacts to bore GW110671 associated with Longwall 903. Ongoing monitoring is recommended.

The dam on the property was observed to be in good condition, with the dam level close to full and no signs of leaks or slumping.

Lot 15 DP803255

Bore GW112437 on Lot 15 DP803255 is located approximately 380 m south of Longwall 903, is 156 m deep. The landholder advised that the bore water is used for land care and domestic purposes. At the post-LW903 inspection in April 2021, the groundwater level in the bore was 77.05 m below ground level (mbgl), compared with 70.71 mbgl in June 2019 at the post mining inspection for Longwall 902. However, note that the April 2021 measurement was taken after the pump was run for sampling and therefore reflects pumping drawdown in the bore and not a mining impact. Bore yield during the inspection remained steady at 2 L/s, matching the extraction rate observed in the pre-mining inspection. Groundwater quality data for the bore indicate:

- Dissolved and total iron concentrations have increased since the pre-mining inspection in November 2017, with total iron increasing from 0.43 mg/L pre-mining to 1.44 mg/L after Longwall 903.

The changes to groundwater quality may be indicative of potential mining impacts to bore GW112437 associated with Longwall 903. Ongoing monitoring is recommended.

Impacts to water quality in the dam on Lot 15 DP803255 were not observed, with no visible signs of iron staining or odour detected and water quality remaining relatively stable following the extraction of Longwall 903.

Lot 9 DP810978

Bore GW104602 on Lot 9 DP810978 is located 185 m northeast of Longwall 903, is approximately 231 m deep. The landholder advised that the bore water is used to water a garden, although the pump had been removed at the time of the inspection in May 2021. Groundwater from the bore had a hydrogen sulfide odour. Note that in the most recent sampling event, the bore was not able to be purged and the sample was collected using a bailer. Therefore, the results may not be directly comparable to previous samples collected from the bore after purging. Groundwater quality data indicate:

- Dissolved and total iron concentrations have increased since the pre-mining inspection in November 2017, with total iron increasing from 0.14 mg/L pre-mining to 0.54 mg/L following Longwall 903
- Dissolved manganese and zinc concentrations have also increased.

Given that the sampling method was different to that of baseline sampling, the observed minor changes in water quality may not be arbitrable to subsidence effects of Longwall 903.

Lot 3 DP1133989

Bore GW100673 on Lot 3 DP1133989 is located 840 m west of Longwall 903, is 146 m deep. The landholder advised that the bore water is used for livestock.

Groundwater quality remained relatively stable, except for dissolved and total iron concentrations which have increased since the pre-mining inspection in November 2017, with total iron increasing from 0.78 mg/L pre-mining to 1.44 mg/L following Longwall 903. There is no evidence for potential mining related impacts at this bore as of the end of LW903.

Lot 59-64 DP1321

There is an unregistered bore on Lot 59-64 DP1321, which is located approximately 380 m south of Longwall 903, 30 m south of Longwall 902 and 20 m north of Longwall 901. The water level in the bore was 11.6 mbgl following Longwall 901, 14.1 mbgl following Longwall 902 and 12.2 mbgl following Longwall 903. The bore was not equipped with a pump at the time of the inspection in May 2021.

Groundwater from the bore had a hydrogen sulfide odour and slight sheen but no signs of iron or salinity staining. The groundwater quality data indicate an improvement in groundwater quality since Longwall 902, with a reduction in salinity and the concentrations of dissolved and total iron and manganese and nutrients. Comprehensive pre-mining groundwater quality data is not available for the bore because it is unregistered. There is no evidence for potential mining related impacts at this bore as of the end of LW903.

Dam 1 is located approximately 250 m south of Longwall 903 and was previously undermined by Longwall 902. No gas bubbling, slumping or signs of damage to the dam were observed during the inspection. Water quality data indicate an improvement in the pH of dam water from 5.4 following Longwall 901 to 7.4 following Longwall 903, and a reduction in DO from 105% to 71.2%.

Dam 2 is located approximately 328 m south of Longwall 903 and was previously undermined by Longwall 902. No gas bubbling, slumping or signs of damage to the dam were observed during the inspection. Water quality data indicate an improvement in the pH of dam water from 9.0 following Longwall 901 to 7.0 following Longwall 903, and a reduction in DO from 83.9% to 67.1%.

3.4 Mine water balance

The daily mine water balance is monitored by South32. The balance tracks daily volumes of water pumped into the mine (supply), within the mine, and from the mine into storage and/or discharge. The rate of groundwater inflow to AA9 is determined by subtracting the estimated water supply volume (to AA9) from the total volume of water pumped to storage. Total mine inflow to AA9 is calculated from 31 July 2017.

The TARP level for mine inflow is based on the 20-day rolling average inflow to AA9, with level triggers listed in Table 2. A time-series of groundwater inflow to AA9 based on water balance calculations is shown in Figure 11, including the 20-day rolling mean and TARP trigger levels. No TARP was triggered during the reporting period.

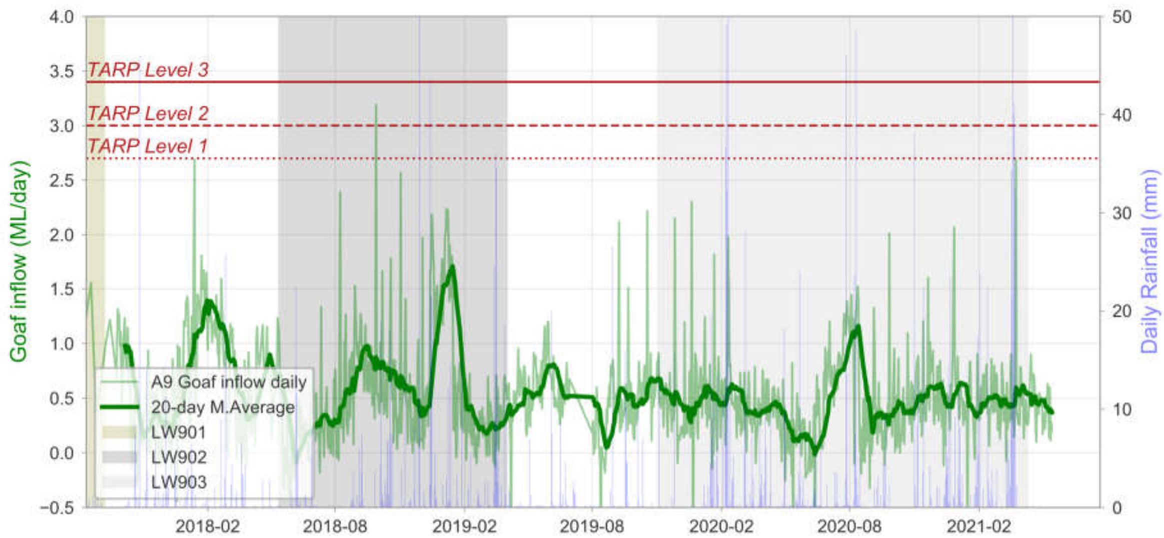

Figure 11. AA9 mine water balance

4. SURFACE WATER ASSESSMENT

Observations and laboratory analyses of surface water level and chemistry are presented as time-series plots (hydrographs) in Appendix 3.

4.1 Water level and flow

4.1.1 Nepean River flow

The Water Management Plan recommends that flow in the Nepean River is monitored by assessing dry weather recession characteristics for the Maldon, Menangle and Broughtons Pass weirs, based on daily flow records from those sites, as for the AA7 monitoring reviews.

The recorded flow rates at Menangle Weir (downstream of AA9) and Maldon Weir (upstream of AA9) are plotted in Figure 12. The Nepean River is a gaining system in the vicinity of AA9 and therefore the flowrate increases downstream due to baseflow contributions and inflow from minor catchments along the reach. The flow at Maldon Weir exceeded the flow in the downstream Menangle Weir during October 2019, prior to the commencement of mining at LW903, but subsequently remained less than or equal to the flow at Menangle Weir throughout mining at LW903.

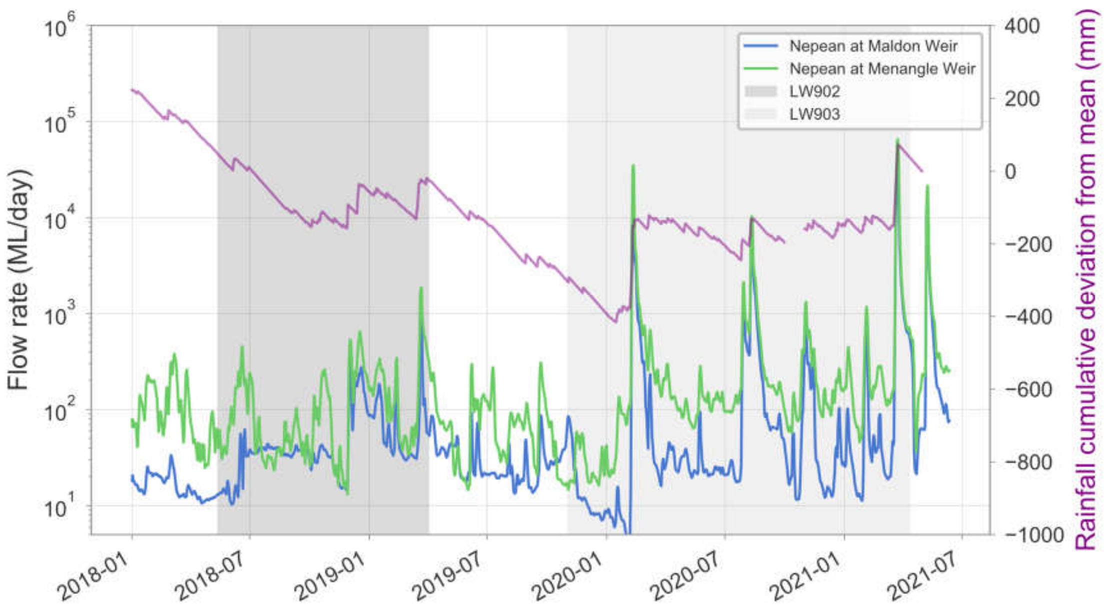

Figure 12. Nepean River flow rates at WaterNSW weirs

Flow duration curves for the Menangle and Maldon Weirs on the Nepean River and the Broughtons Pass Weir on the Cataract River are plotted in Figure 13. These indicate that during the period of January 2018 to May 2021, including the periods of LW902 and LW903 extraction, there were no no-flow days recorded at any of the monitoring sites.

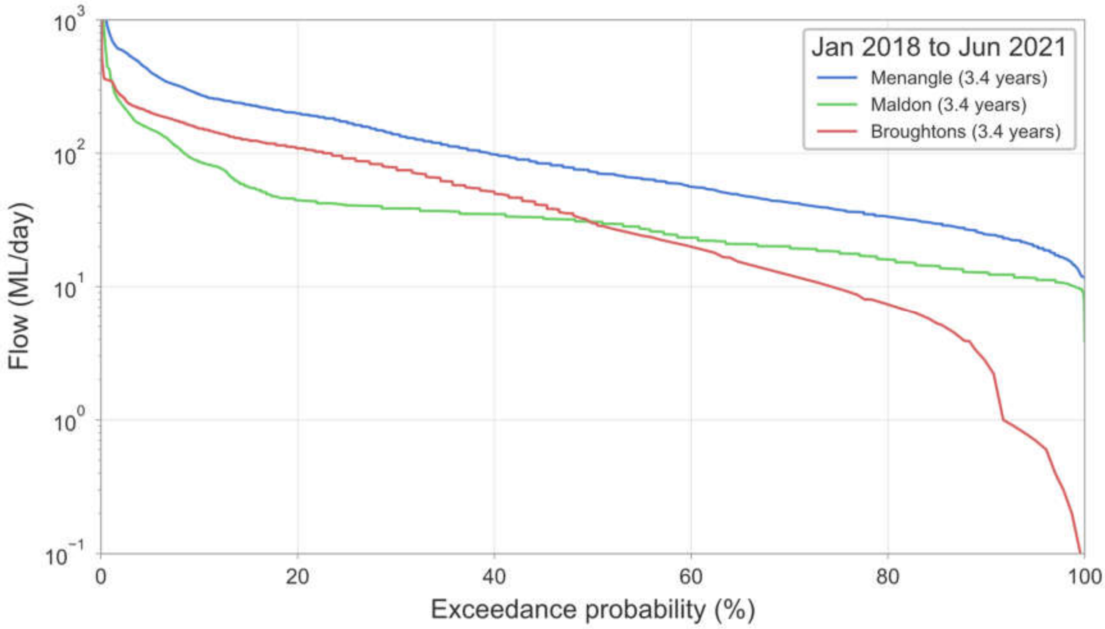

Figure 13. Flow duration curves for period Jan 2018 to May 2021

4.1.2 Pool water levels

Water levels are monitored at some pools during regular sampling events. Pool water levels are measured relative to a reference benchmark at the pool. Water levels are displayed as a time-series with other field observations in Appendix 3. The 5th to 95th percentile range for water levels measured during the pre-mining baseline period is also shown for reference.

Of the sites where water levels are measured, most show water levels during the reporting period that are within the baseline range. Nepean River monitoring site NR0 shows a decline in water level of 0.49 m relative to the baseline range during longwalls 901, 902 and 903, with the latest water level recorded within the baseline range after Longwall 903. Water levels at site NR110 located 3.5 km further upstream of longwalls 901, 902 and 903 show a maximum decline of 0.25 m below the baseline range over the same period, suggesting a cause other than mining at Appin Area 9. It is recommended that monitoring of water levels at NR0 and NR110 be continued to assess water levels in the Nepean River.

4.2 Water quality

Trigger Action Response Plan (TARP) levels for surface water quality parameters are listed in Table 3. Criteria for triggering TARP levels are based on both magnitude and duration, as well as comparison with upstream reference site. For example, a TARP Level 1 is triggered for pH at site NR0 if the pH at that location is lower than the baseline mean minus 1 standard deviation (at that location), for at least 2 consecutive months but less than 6 consecutive months. To facilitate comparison between sites with different sampling frequencies, each time-series is resampled to monthly, whereby a maximum value is considered where there is more than one sampling event per month. In addition to the three nominated TARP sites for the Nepean River, the WMP recommends comparison with site NR110, located more than 3.5 km upstream of longwall 901.

Time-series plots of key water quality parameters are presented in Appendix 3. Analysis of the hydrographs in relation to the TARP criteria is provided in tabular format in Appendix 4 and summarised in Table 8 below.

The reporting period for Longwall 903 is characterised by widely variable water quality in the Nepean River, with many parameters deviating by more than one or two standard deviations from the baseline mean on several occasions.

Level 1 and 2 TARPs were triggered for electrical conductivity (EC) at NR0 and SW3 during the reporting period. However, EC levels equating to a Level 2 TARP trigger were measured at the upstream control site for the same periods and therefore the exceedances are not attributed to mining activities.

Level 1 TARPs were triggered total iron (Fe) at NR0 and SW3 in April 2021. In both cases the TARP threshold exceedances are clear outliers related to preceding high rainfall events and there is no underlying adverse trend and therefore the exceedances are not attributed to mining activities.

Level 1 TARPs were triggered total manganese (Mn) at SW3 in December 2020 and at NR2 in February 2021. Levels equating to a Level 1 TARP trigger were measured at the upstream control site NR110 in December 2020. In both cases there is no underlying adverse trend and therefore the exceedances are not attributed to mining activities.

The TARP levels for total iron (Fe) have not been triggered. Ongoing monitoring at all sites is recommended to assess the trends in water chemistry as mining progresses.

Table 8. Summary of surface water TARP levels for reporting period

TARP Site	NR110 (Upstream control)	NR0 (Adjacent/ slightly upstream)	SW3 (Adjacent)	NR2 (Downstream)
EC	Level 2 TARP	Level 1 TARP	Level 2 TARP	No TARPs triggered
pH	No TARPs triggered	No TARPs triggered	No TARPs triggered	No TARPs triggered
DO	No TARPs triggered	No TARPs triggered	No TARPs triggered	No TARPs triggered
Fe (Total)	No TARPs triggered	Level 1 TARP	Level 1 TARP	No TARPs triggered
Mn (Total)	Level 1 TARP	No TARPs triggered	Level 1 TARP	Level 1 TARP
Clarity / staining	None noted	None noted	None noted	None noted
TARP Level	Upstream Control Site	TARPs technically triggered for EC and total Mn **suggesting downstream TARP triggers are not associated with mining**.		

4.3 Gas emissions

Twenty-five gas release zones were identified in the Nepean River by the ICEFT during the monitoring period for Longwall 901 and six gas release zones were identified in the Nepean River during the monitoring period for Longwall 902. An additional gas zone, and an update to an existing gas zone, were identified in the Nepean River during the monitoring period for Longwall 903. A total of ten gas zones were active during the inspection on 21 April 2021.

All 32 occurrences had estimated emission rates of <3000 L/min, and are classified as TARP Level 1. Gas emissions are described in detail in the End of Panel Landscape Reports for Longwall 901 (South32, 2017), Longwall 902 (South32, 2019) and Longwall 903 (South32, 2021). The locations of the emissions are shown in Figure 2 in the End of Panel Landscape Report for Longwall 903 (South32, 2021).

The following actions were initiated in response to the Level 1 triggers, in accordance with the WMP:

• Continue monitoring program

• Submit an Impact Report to relevant stakeholders

• Report in the End of Panel Report

• Summarise actions and monitoring in the AEMR.

5. CONCLUSIONS

An assessment of groundwater and surface water monitoring data was carried out to assess the potential impacts from mining of Longwall 903 at Appin Colliery, in accordance with the WMP. The following conclusions are made:

Groundwater assessment

- A decline in groundwater pressure occurred in the Hawkesbury Sandstone at monitoring bore S1941, located 280 m from Longwall 903. The observed groundwater pressure reductions for the sensor at 201.6 m depth exceeded the Level 1 TARP trigger, however groundwater pressures recovered above the Level 1 TARP trigger after 93 days.

- No significant change in groundwater chemistry is noted for the reporting period.

- Changes to groundwater quality were identified in three bores on private properties; a WMP has been implemented in response to the potential impact. Ongoing monitoring of the bores is recommended.

- Groundwater inflow to the mine is calculated from the daily mine water balance. The 20-day moving average mine inflow fluctuated between ~1.2 and 0 ML/day following the extraction of Longwall 903, below the TARP Level 1 trigger of 2.7 ML/day.

Surface water assessment

- Monitoring of Nepean River gauging weirs at Maldon and Menangle and the Cataract

- River at Broughtons Pass showed that there were zero no-flow days recorded for the during the period January 2018 to May 2021, including the periods of LW902 and LW903 extraction.

- Monthly monitoring by South32 indicates a decline in pool water levels at site NR0 of 0.49 m from the baseline range. Water levels at the upstream control site NR110 show a decline of 0.25 m from the baseline range over the same period. Ongoing monitoring at NR0 and NR110 is recommended.

- The Longwall 903 reporting period was characterised by widely variable water quality in the Nepean River. During the reporting period, Level 1 and 2 TARPs were triggered for EC at NR0 and SW3, as well as at the upstream control site, and therefore the exceedances are not attributed to mining activities. Level 1 TARP was triggered for total iron at NR0 and SW3 and for total manganese at SW3 and NR2. However, deviations from the baseline of a similar magnitude were observed for these parameters at the upstream control site and there is no underlying adverse trend in concentrations. The exceedances are not attributed to mining activities.

- One additional gas release zone was identified in the Nepean River during the monitoring period for Longwall 903. All 32 gas release zones identified during mining in Area 9 have had estimated emission rates of <3000 L/min and have triggered a TARP Level 1 response under the WMP.

6. RECOMMENDATIONS

1. There are no recommendations for this reporting period.

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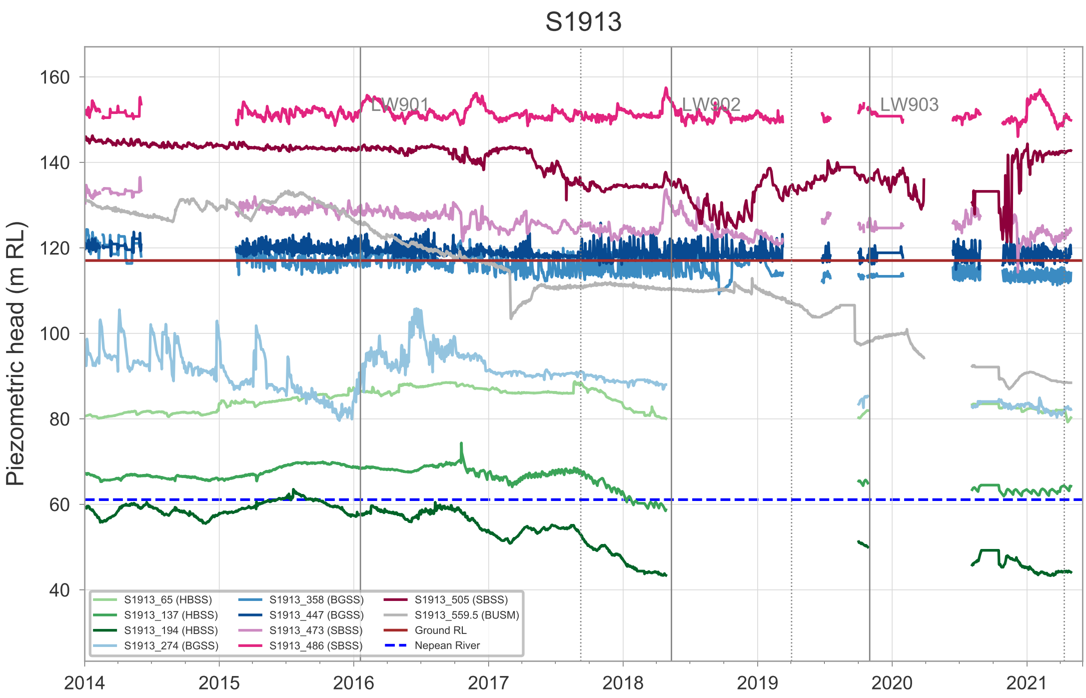
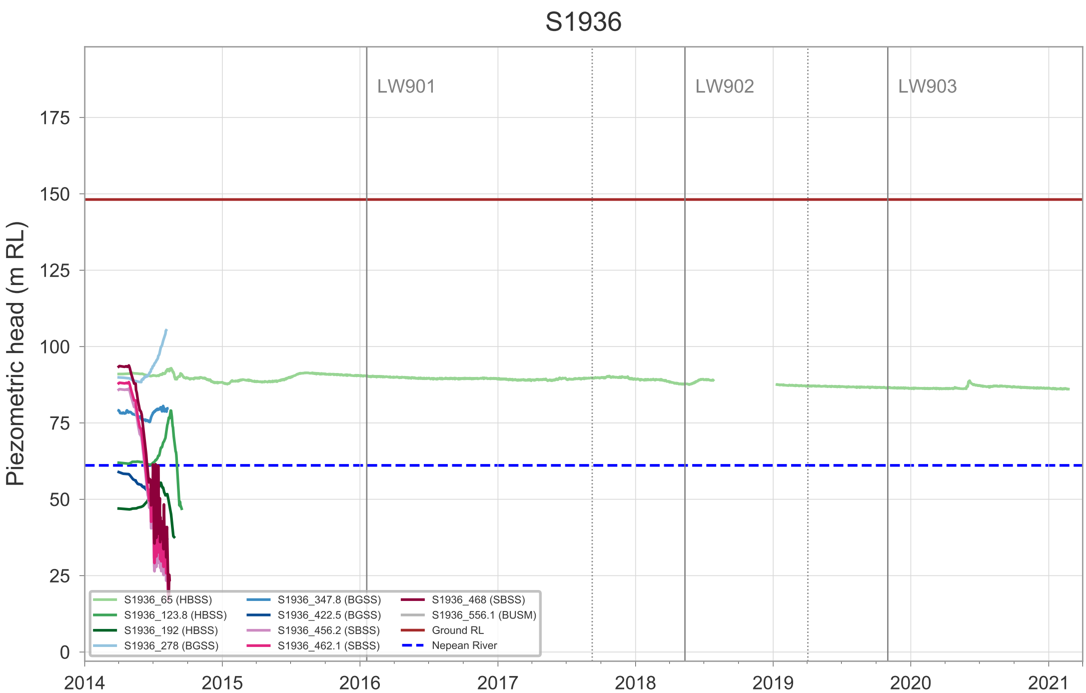
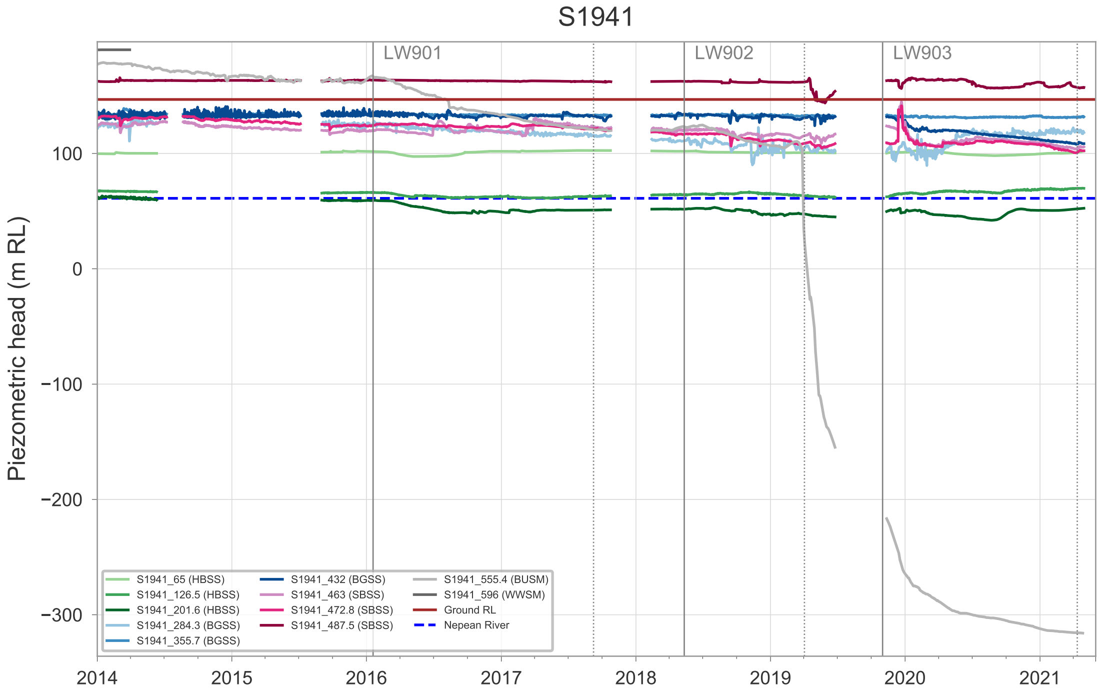
APPENDIX 1 – Groundwater bore hydrographs

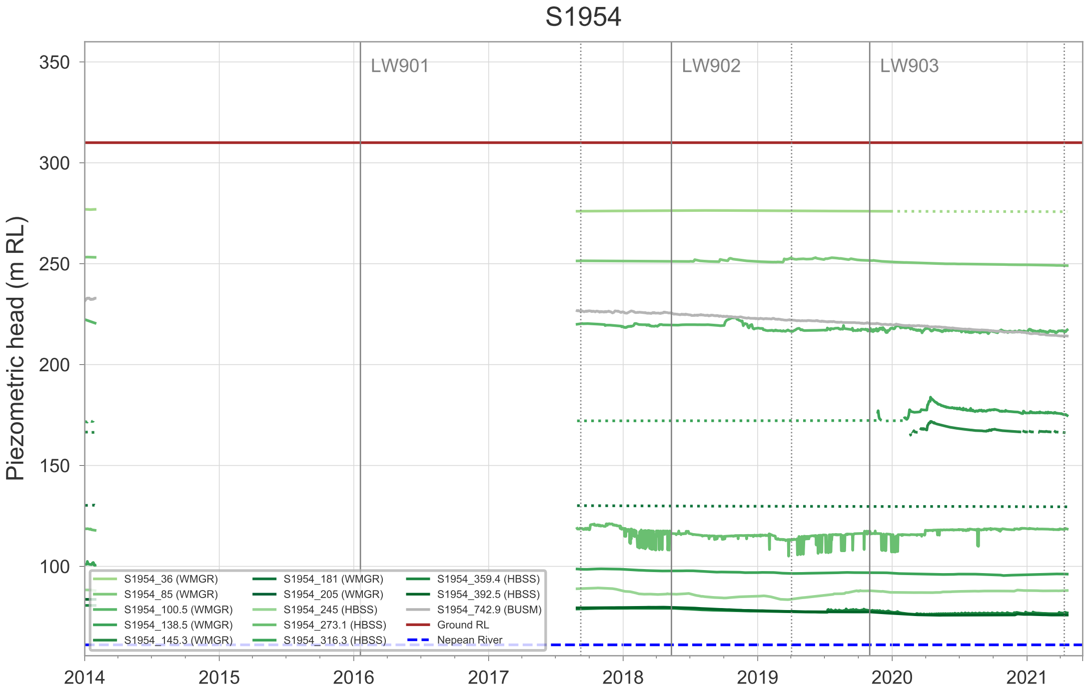


S1913
Piezometric head (m RL)
160
140
120
100
80
60
40
2014
2015
2016
2017
2018
2019
2020
2021
LW901
LW902
LW903
S1913_65 (HBSS)
S1913_137 (HBSS)
S1913_194 (HBSS)
S1913_274 (BGSS)
S1913_358 (BGSS)
S1913_447 (BGSS)
S1913_473 (SBSS)
S1913_486 (SBSS)
S1913_505 (SBSS)
S1913_559.5 (BUSM)
Ground RL
Nepean River

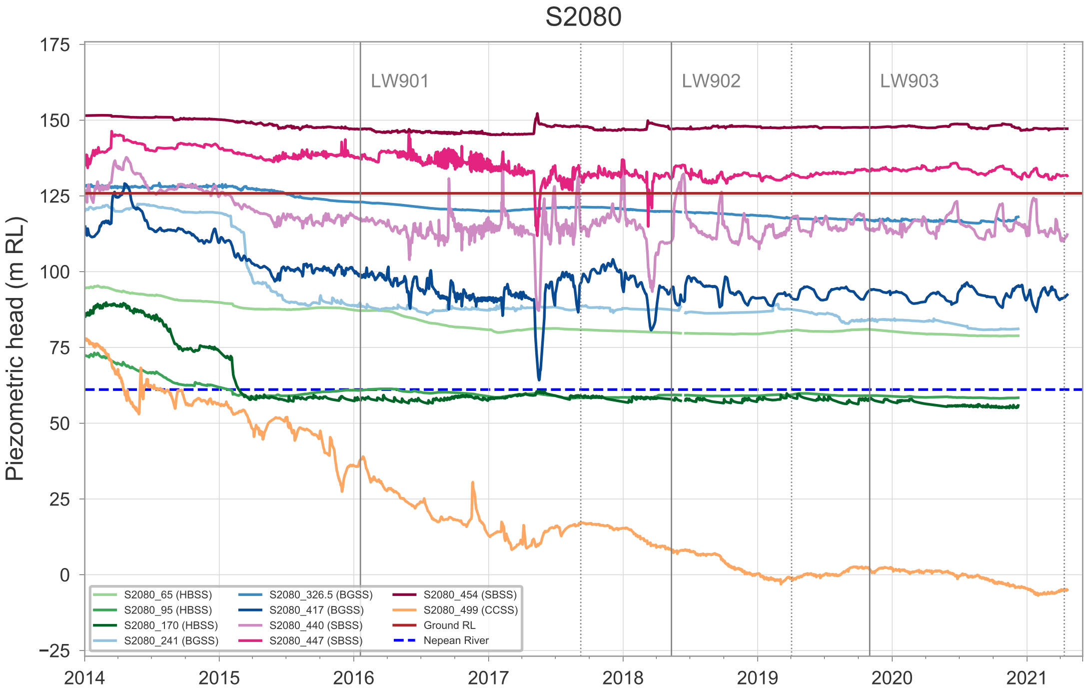

S1936
Piezometric head (m RL)
175
150
125
100
75
50
25
0
2014
2015
2016
2017
2018
2019
2020
2021
LW901
LW902
LW903
S1936_65 (HBSS)
S1936_123.8 (HBSS)
S1936_192 (HBSS)
S1936_278 (BGSS)
S1936_347.8 (BGSS)
S1936_422.5 (BGSS)
S1936_456.2 (SBSS)
S1936_462.1 (SBSS)
S1936_468 (SBSS)
S1936_556.1 (BUSM)
Ground RL
Nepean River



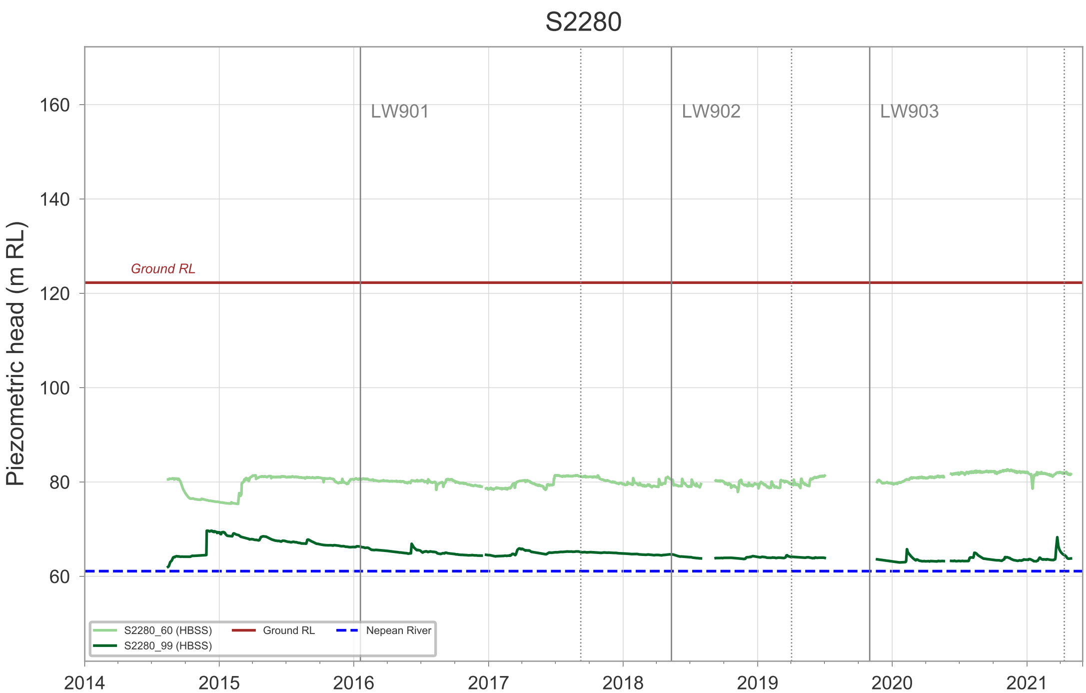
S1941
LW901
LW902
LW903
Piezometric head (m RL)
100
0
−100
−200
−300
2014
2015
2016
2017
2018
2019
2020
2021
S1941_65 (HBSS)
S1941_126.5 (HBSS)
S1941_201.6 (HBSS)
S1941_284.3 (BGSS)
S1941_355.7 (BGSS)
S1941_432 (BGSS)
S1941_463 (SBSS)
S1941_472.8 (SBSS)
S1941_487.5 (SBSS)
S1941_555.4 (BUSM)
S1941_596 (WWSM)
Ground RL
Nepean River



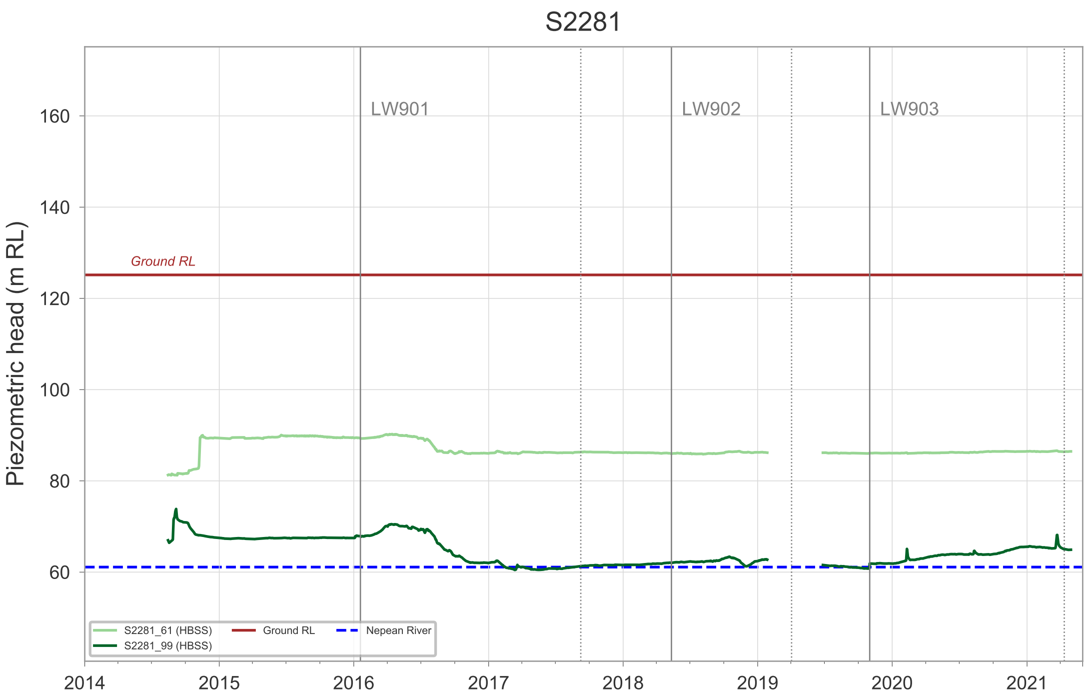
S1954
LW901
LW902
LW903
Piezometric head (m RL)
350
300
250
200
150
100
2014
2015
2016
2017
2018
2019
2020
2021
S1954_36 (WMGR)
S1954_85 (WMGR)
S1954_100.5 (WMGR)
S1954_138.5 (WMGR)
S1954_145.3 (WMGR)
S1954_181 (WMGR)
S1954_205 (WMGR)
S1954_245 (HBSS)
S1954_273.1 (HBSS)
S1954_316.3 (HBSS)
S1954_359.4 (HBSS)
S1954_392.5 (HBSS)
S1954_742.9 (BUSM)
Ground RL
Nepean River

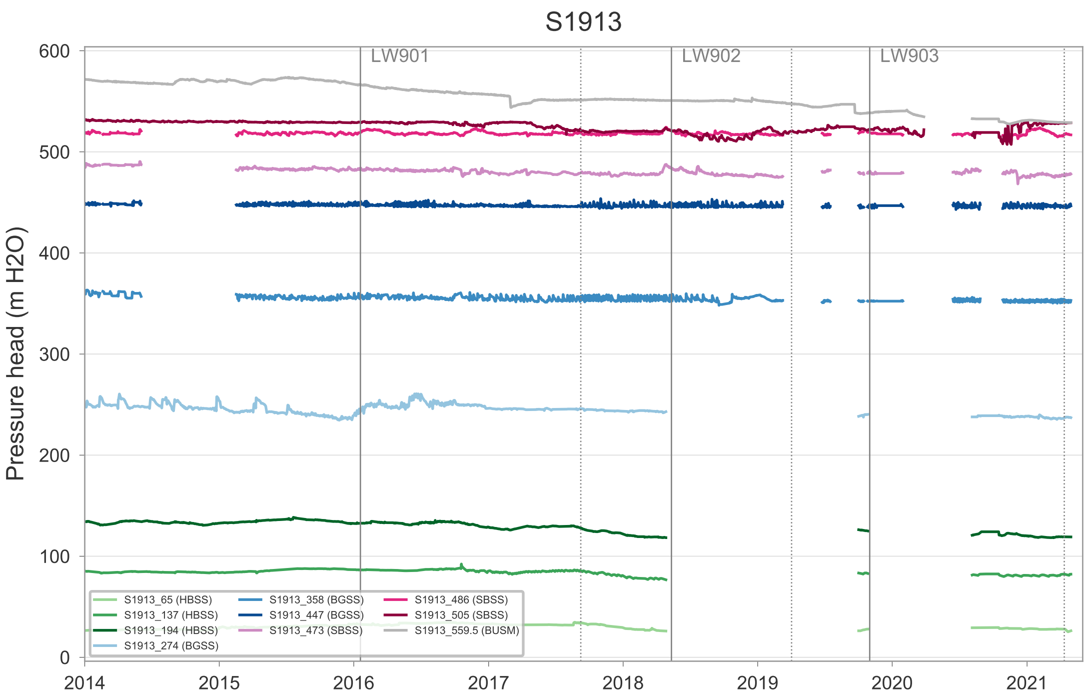


S2080
Piezometric head (m RL)
175
150
125
100
75
50
25
0
−25
2014
2015
2016
2017
2018
2019
2020
2021
LW901
LW902
LW903
S2080_65 (HBSS)
S2080_95 (HBSS)
S2080_170 (HBSS)
S2080_241 (BGSS)
S2080_326.5 (BGSS)
S2080_417 (BGSS)
S2080_440 (SBSS)
S2080_447 (SBSS)
S2080_454 (SBSS)
S2080_499 (CCSS)
Ground RL
Nepean River

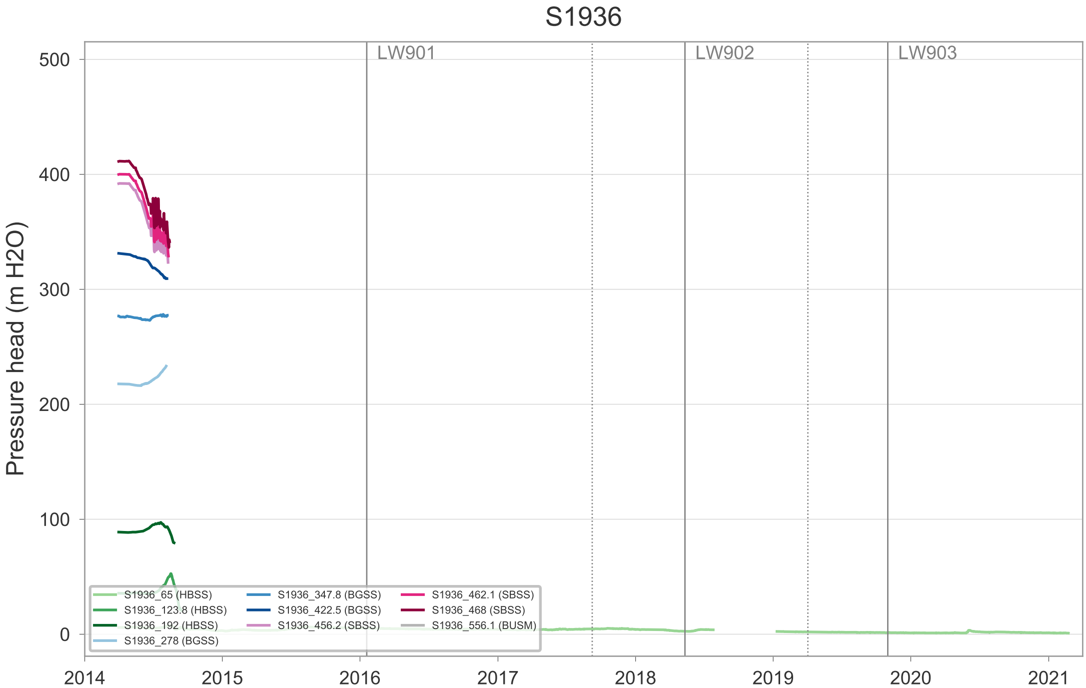


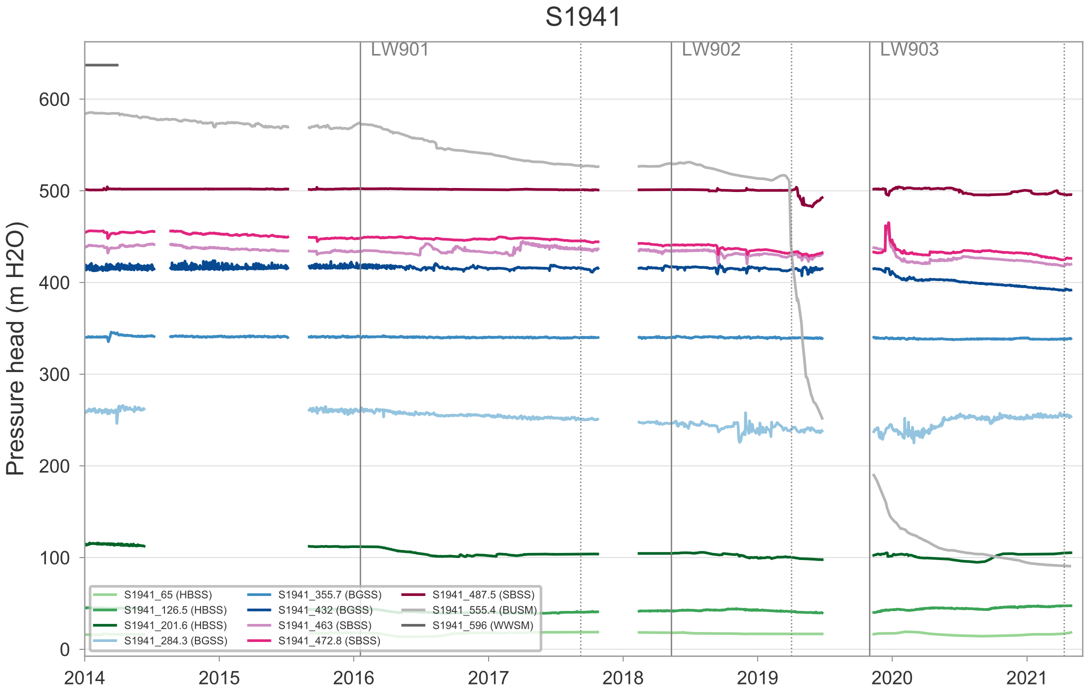
S2280
Piezometric head (m RL)
160
140
120
100
80
60
2014
2015
2016
2017
2018
2019
2020
2021
LW901
LW902
LW903
Ground RL
S2280_60 (HBSS)
S2280_99 (HBSS)
Ground RL
Nepean River


S2281
LW901
LW902
LW903
Ground RL
Piezometric head (m RL)
160
140
120
100
80
60
2014
2015
2016
2017
2018
2019
2020
2021
S2281_61 (HBSS)
S2281_99 (HBSS)
Ground RL
Nepean River

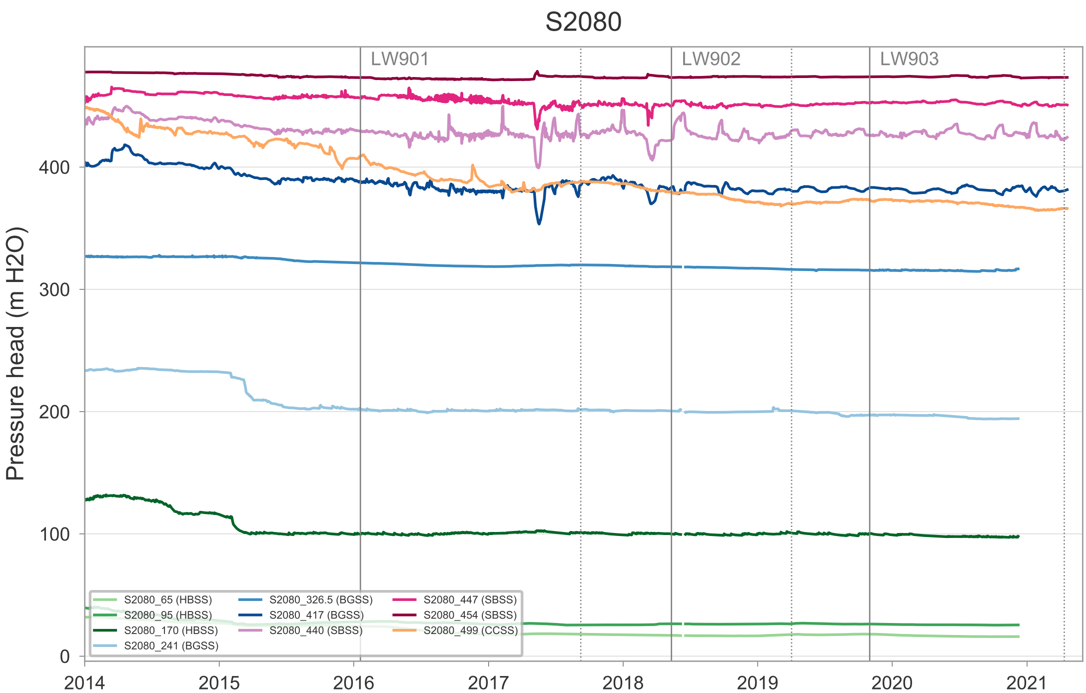


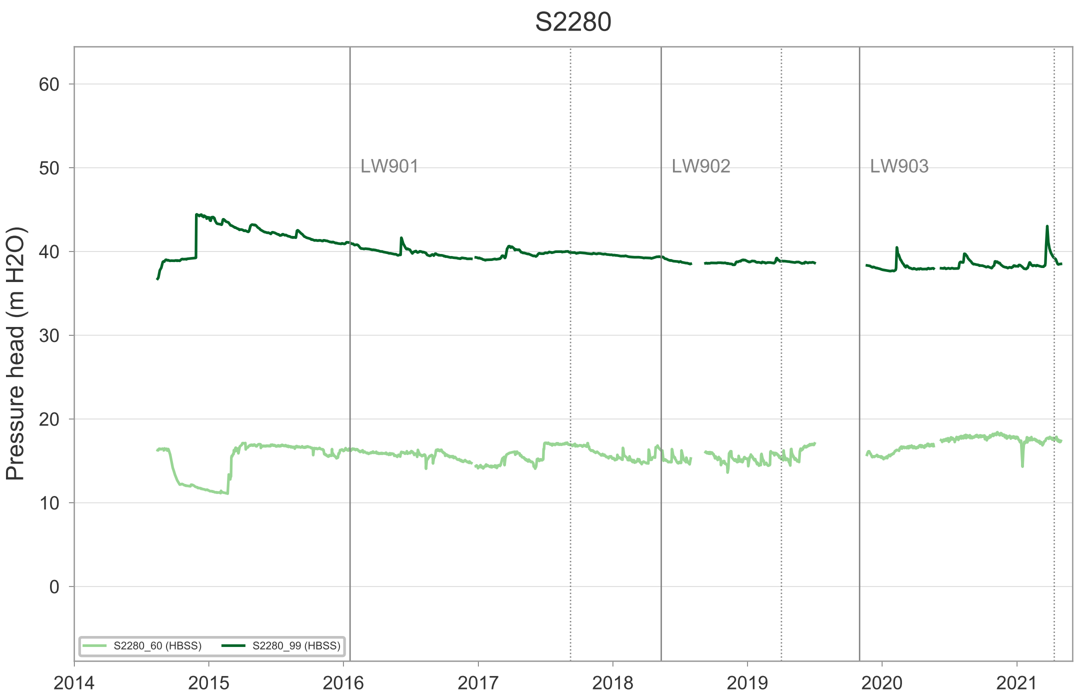
S1913
Pressure head (m H2O)
600
500
400
300
200
100
0
2014
2015
2016
2017
2018
2019
2020
2021
LW901
LW902
LW903
S1913_65 (HBSS)
S1913_137 (HBSS)
S1913_194 (HBSS)
S1913_274 (BGSS)
S1913_358 (BGSS)
S1913_447 (BGSS)
S1913_473 (SBSS)
S1913_486 (SBSS)
S1913_505 (SBSS)
S1913_559.5 (BUSM)

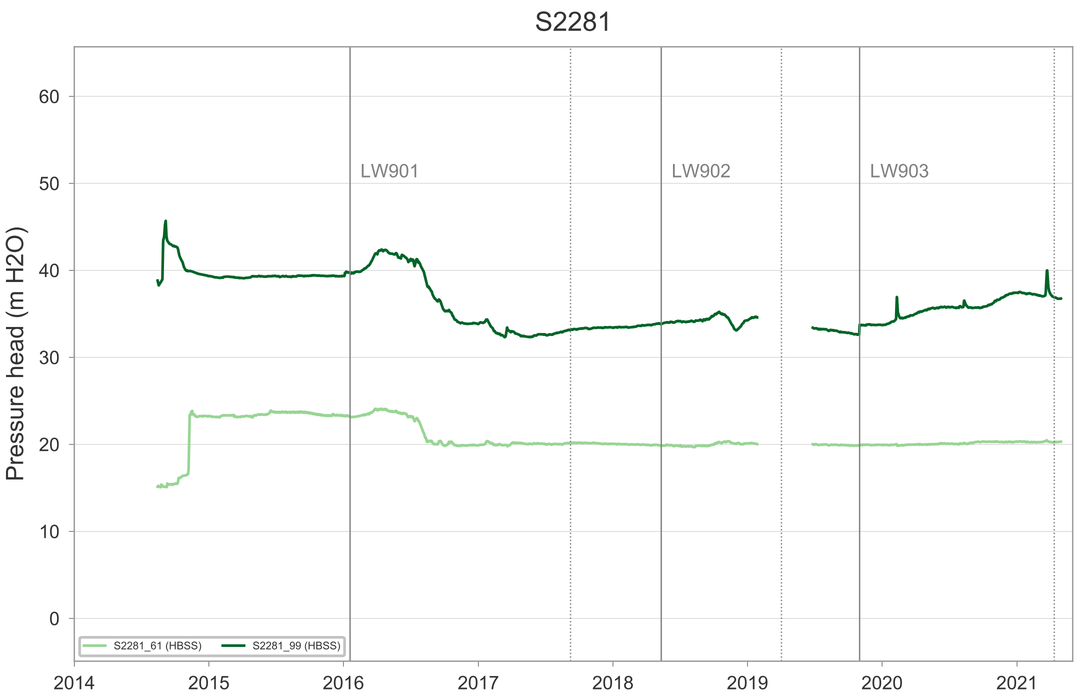

S1936
Pressure head (m H2O)
LW901
LW902
LW903
500
400
300
200
100
0
2014
2015
2016
2017
2018
2019
2020
2021
S1936_65 (HBSS)
S1936_123.8 (HBSS)
S1936_192 (HBSS)
S1936_278 (BGSS)
S1936_347.8 (BGSS)
S1936_422.5 (BGSS)
S1936_456.2 (SBSS)
S1936_462.1 (SBSS)
S1936_468 (SBSS)
S1936_556.1 (BUSM)



S1941
LW901
LW902
LW903
Pressure head (m H2O)
600
500
400
300
200
100
0
2014
2015
2016
2017
2018
2019
2020
2021
S1941_65 (HBSS)
S1941_126.5 (HBSS)
S1941_201.6 (HBSS)
S1941_284.3 (BGSS)
S1941_355.7 (BGSS)
S1941_432 (BGSS)
S1941_463 (SBSS)
S1941_472.8 (SBSS)
S1941_487.5 (SBSS)
S1941_555.4 (BUSM)
S1941_596 (WWSM)


S2080
LW901
LW902
LW903
Pressure head (m H2O)
400
300
200
100
0
2014
2015
2016
2017
2018
2019
2020
2021
S2080_65 (HBSS)
S2080_95 (HBSS)
S2080_170 (HBSS)
S2080_241 (BGSS)
S2080_326.5 (BGSS)
S2080_417 (BGSS)
S2080_440 (SBSS)
S2080_447 (SBSS)
S2080_454 (SBSS)
S2080_499 (CCSS)

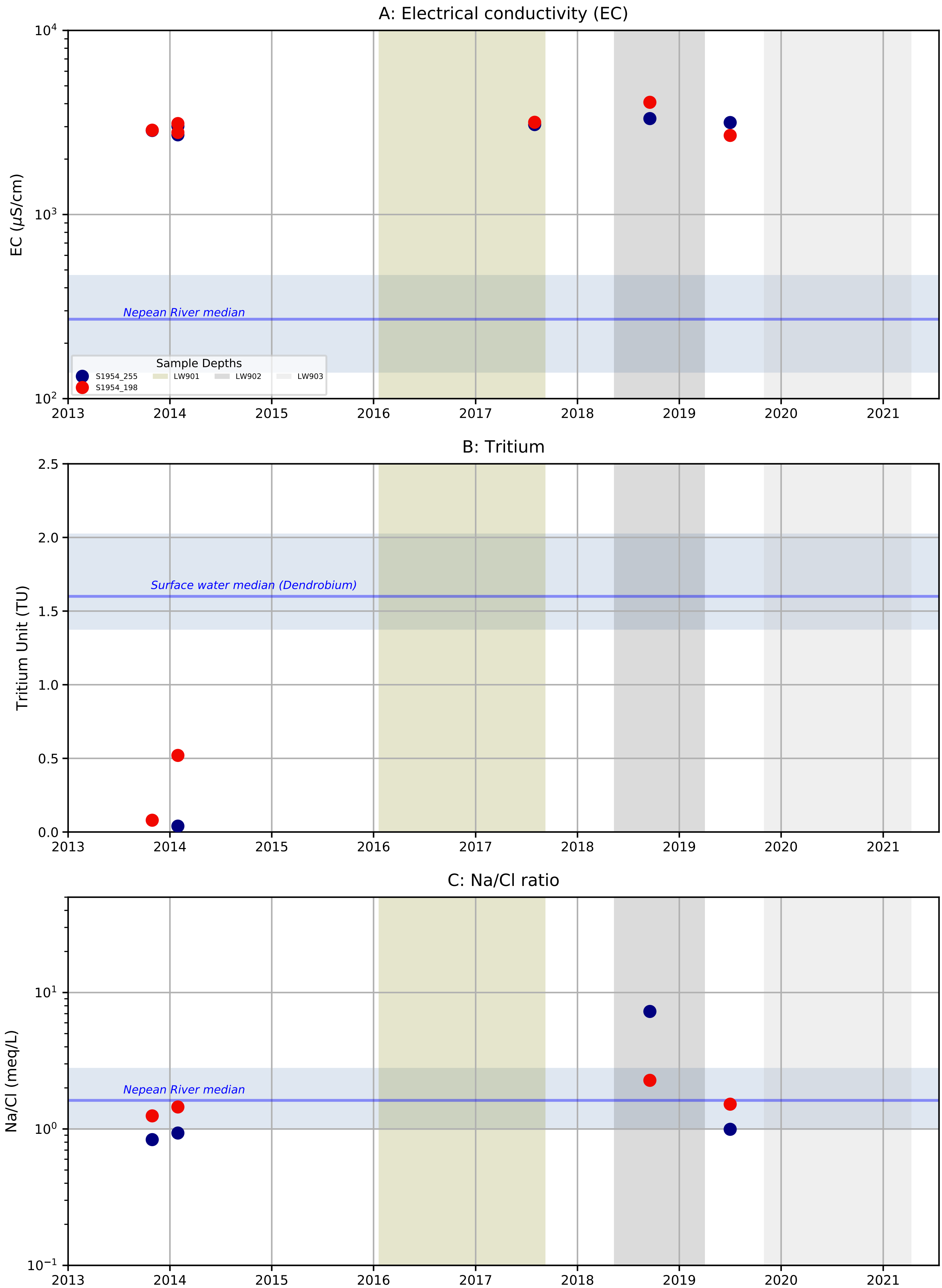

S2280
Pressure head (m H2O)
60
50
40
30
20
10
0
LW901
LW902
LW903
S2280_60 (HBSS)
S2280_99 (HBSS)
2014
2015
2016
2017
2018
2019
2020
2021



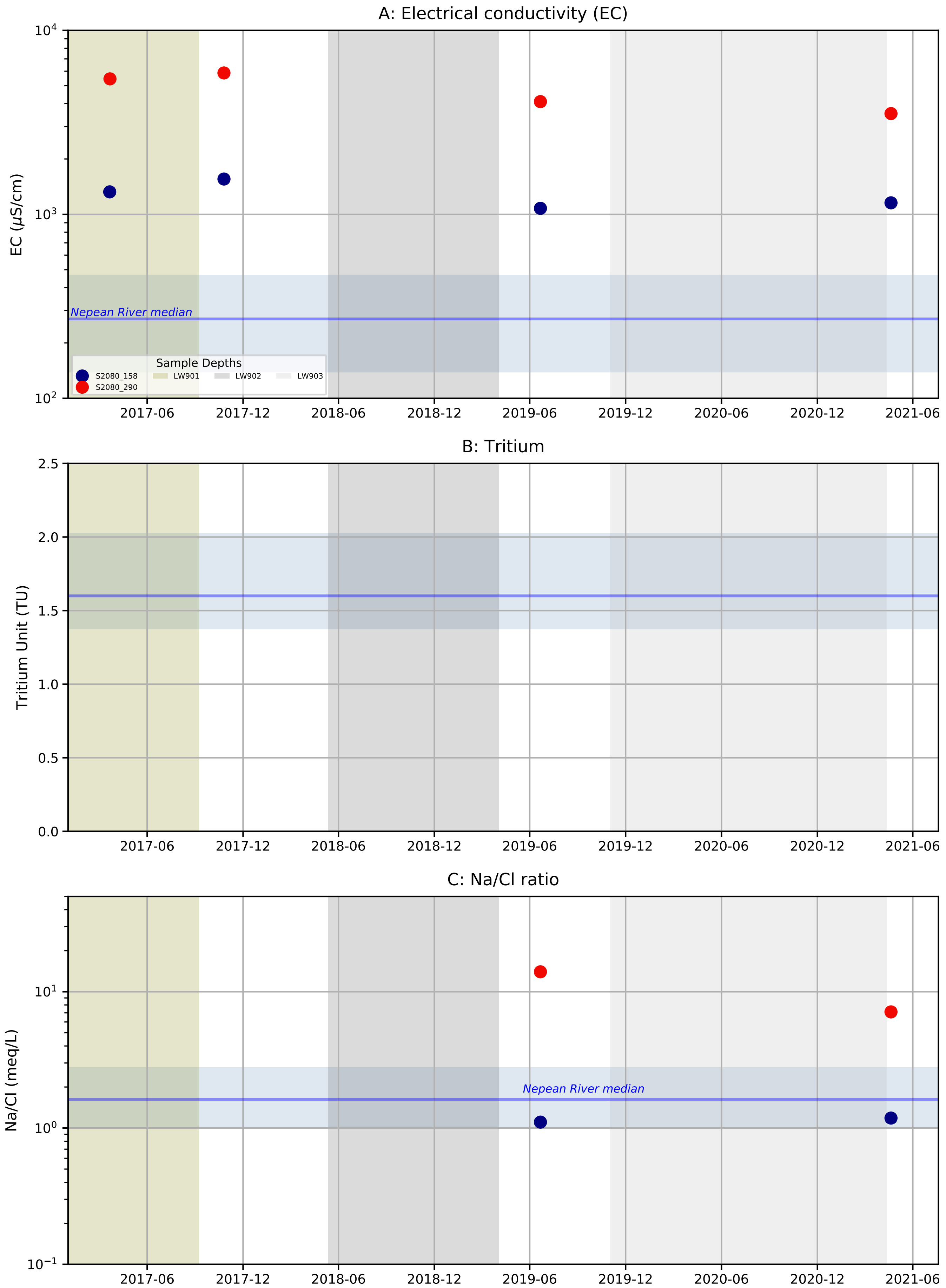
S2281
Pressure head (m H2O)
60
50
40
30
20
10
0
2014
2015
2016
2017
2018
2019
2020
2021
LW901
LW902
LW903
S2281_61 (HBSS)
S2281_99 (HBSS)

APPENDIX 2 – Groundwater chemistry time-series plots

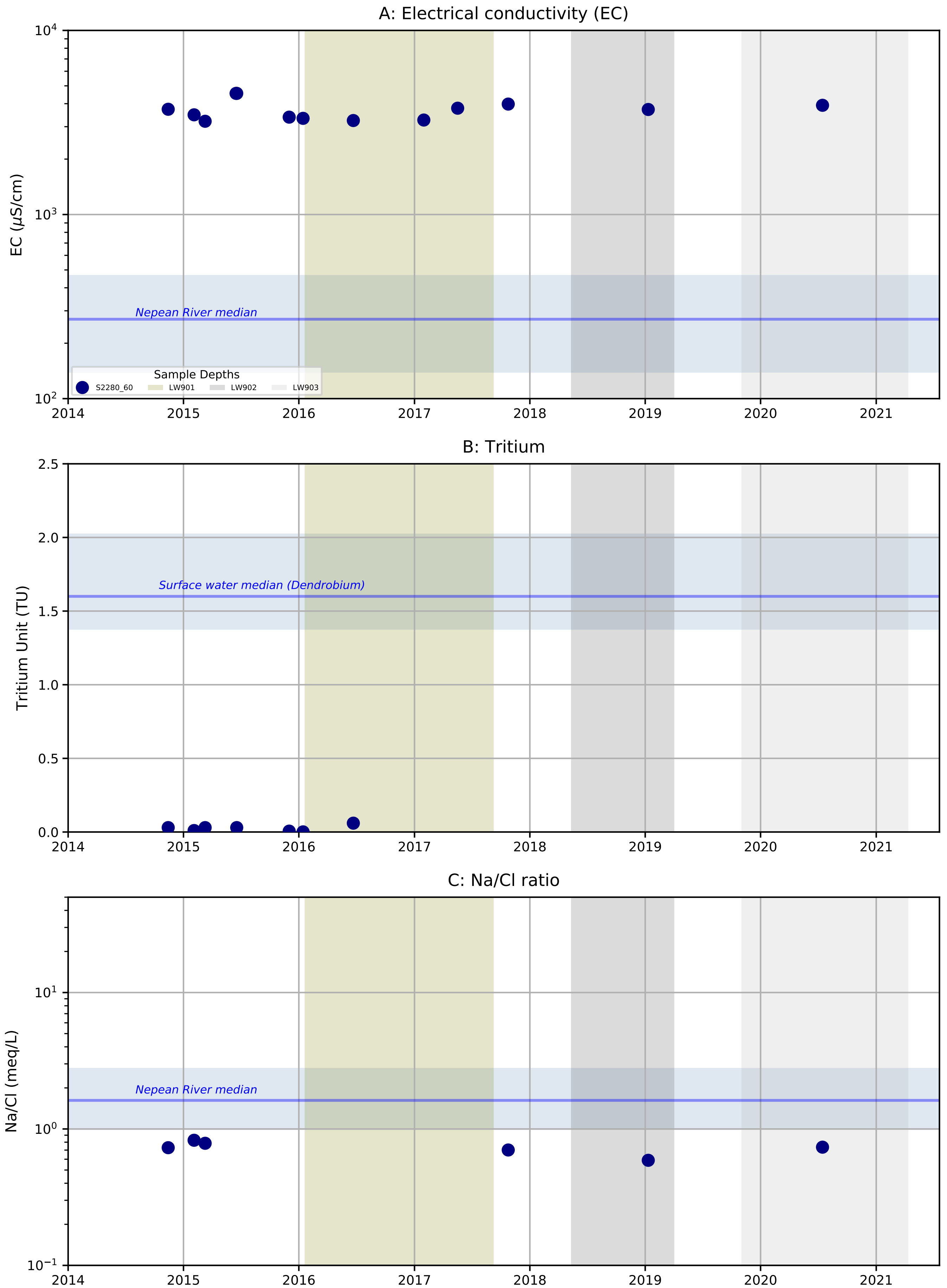
Groundwater chemistry: Appin Bore S1954



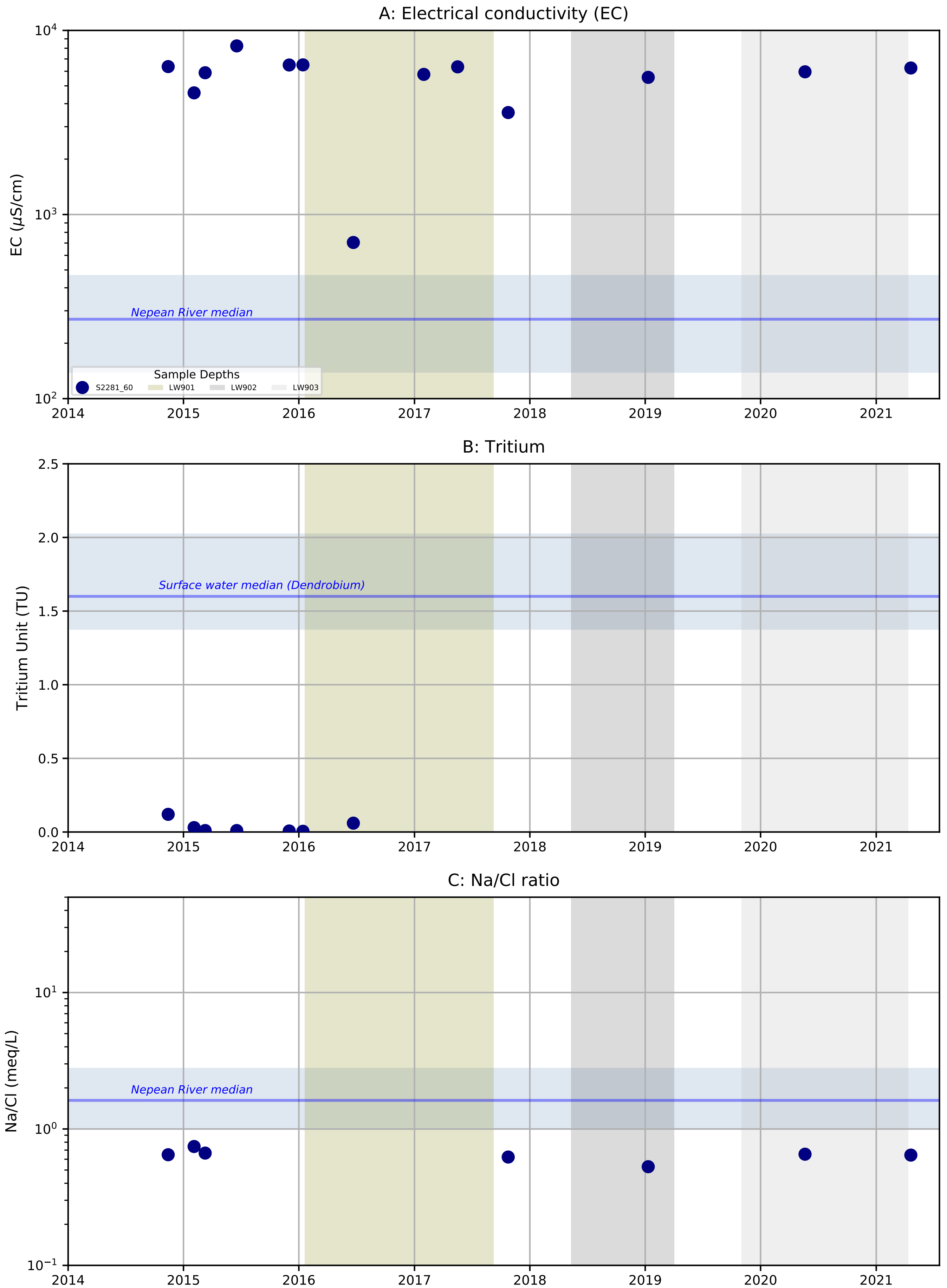
Groundwater chemistry: Appin Bore S2080



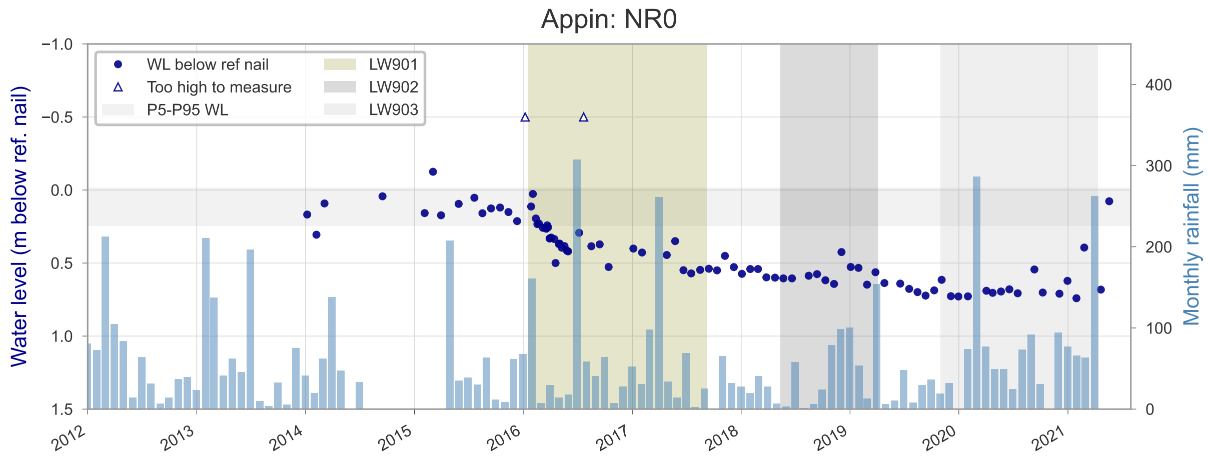
Groundwater chemistry: Appin Bore S2280

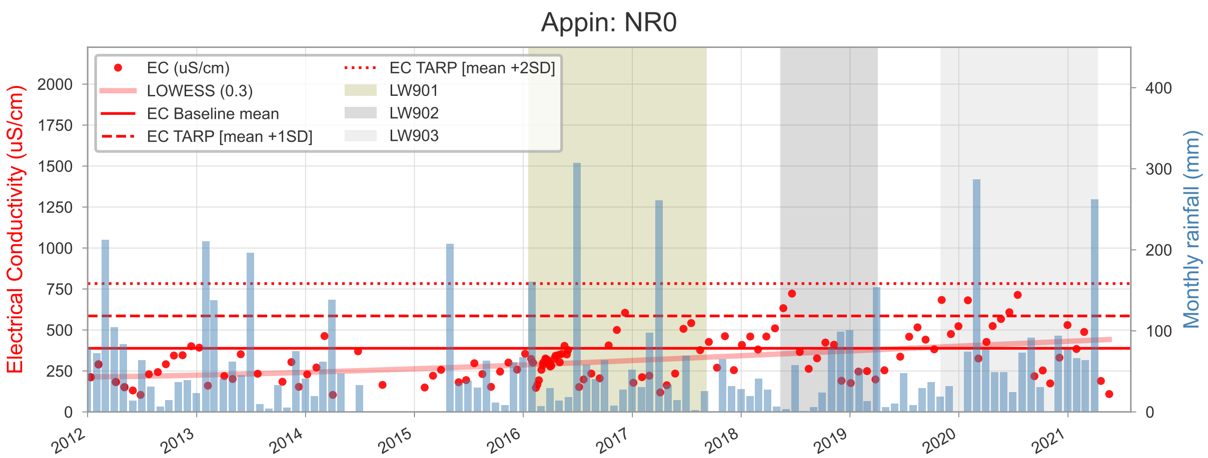


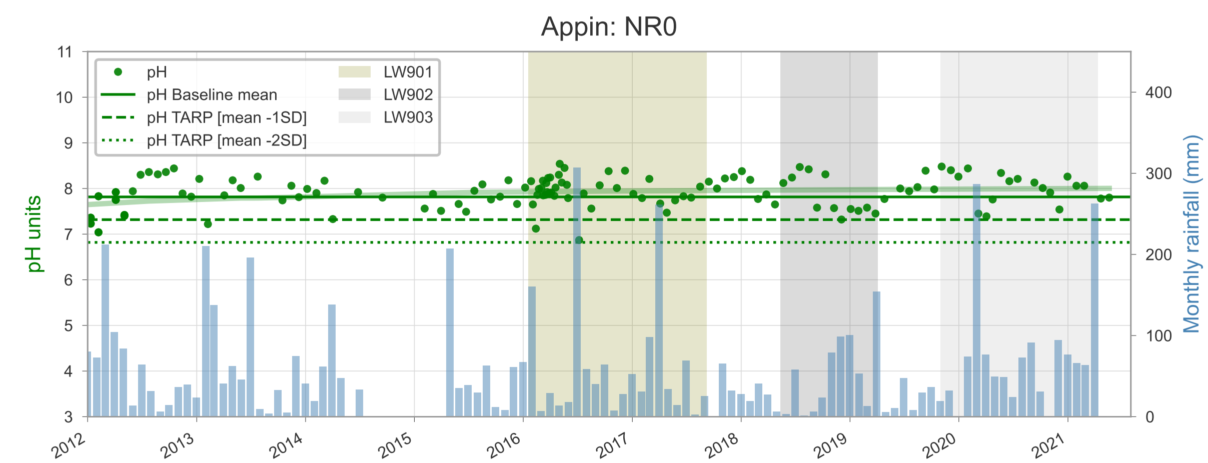
Groundwater chemistry: Appin Bore S2281

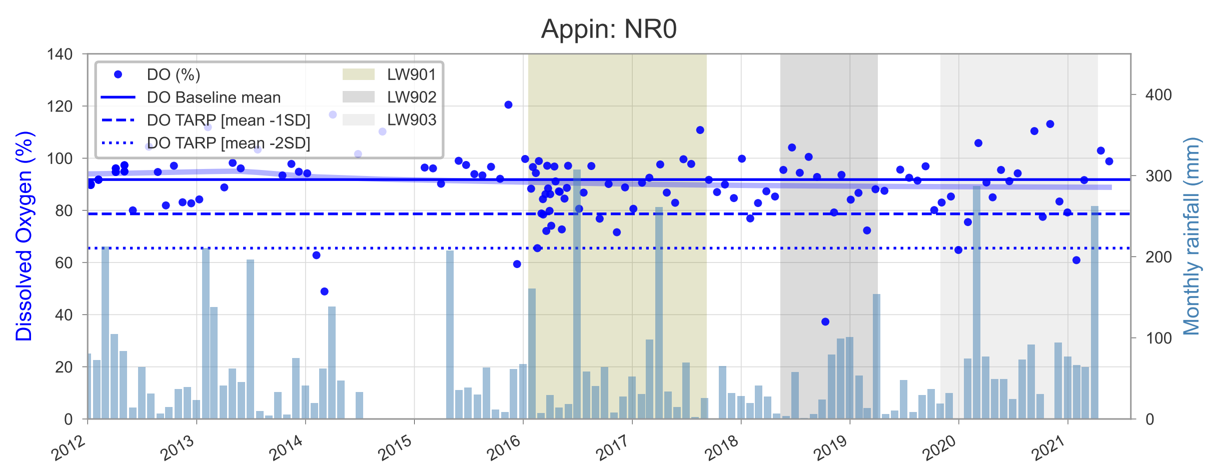


APPENDIX 3 – Surface water chemistry time-series plots

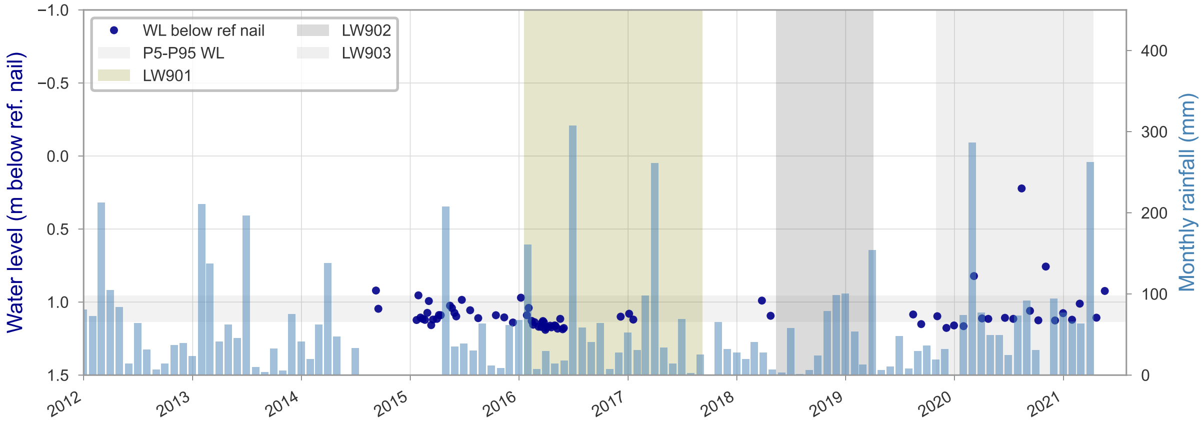

Appin: NR0
Water level (m below ref. nail)
Monthly rainfall (mm)
WL below ref nail
Too high to measure
P5-P95 WL
LW901
LW902
LW903


Appin: NR0
Electrical Conductivity (uS/cm)
Monthly rainfall (mm)
EC (uS/cm)
LOWESS (0.3)
EC Baseline mean
EC TARP [mean +1SD]
EC TARP [mean +2SD]
LW901
LW902
LW903

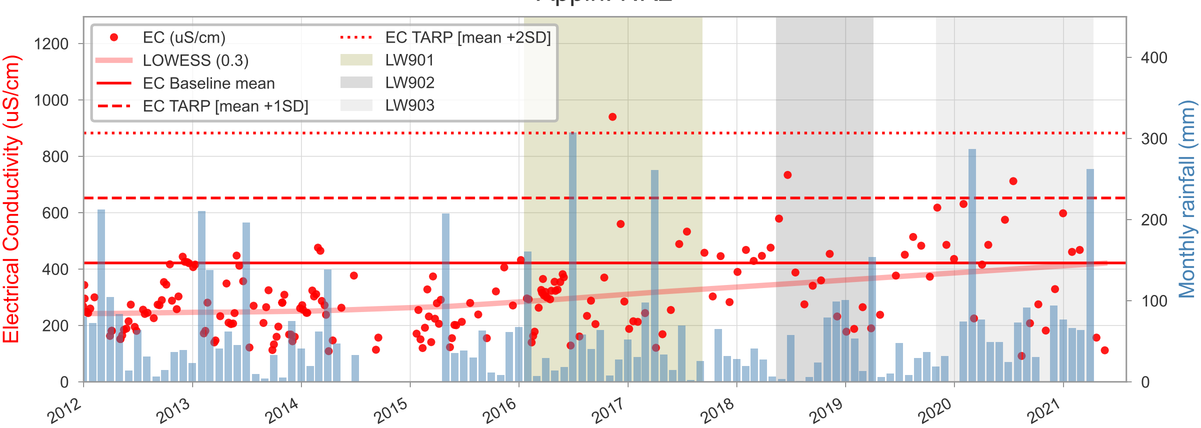

Appin: NR0
pH units
Monthly rainfall (mm)
pH
pH Baseline mean
pH TARP [mean -1SD]
pH TARP [mean -2SD]
LW901
LW902
LW903


Appin: NR0
Dissolved Oxygen (%)
Monthly rainfall (mm)
DO (%)
DO Baseline mean
DO TARP [mean -1SD]
DO TARP [mean -2SD]
LW901
LW902
LW903

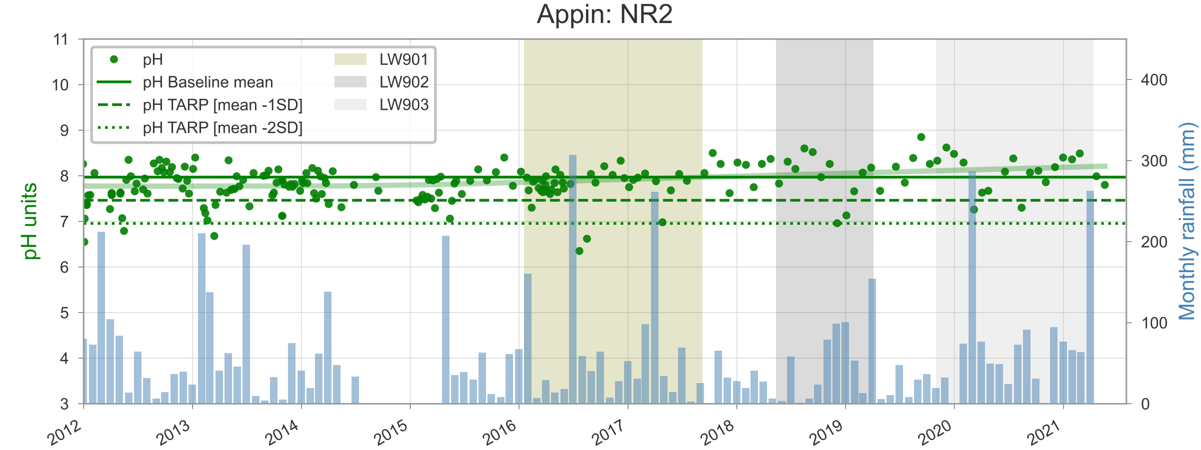
Appin: NR2



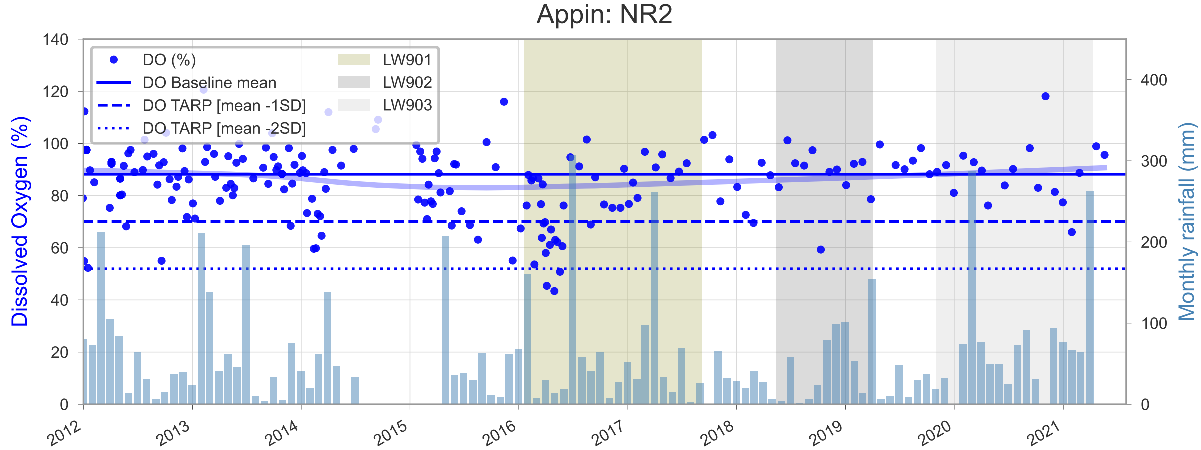
Appin: NR2

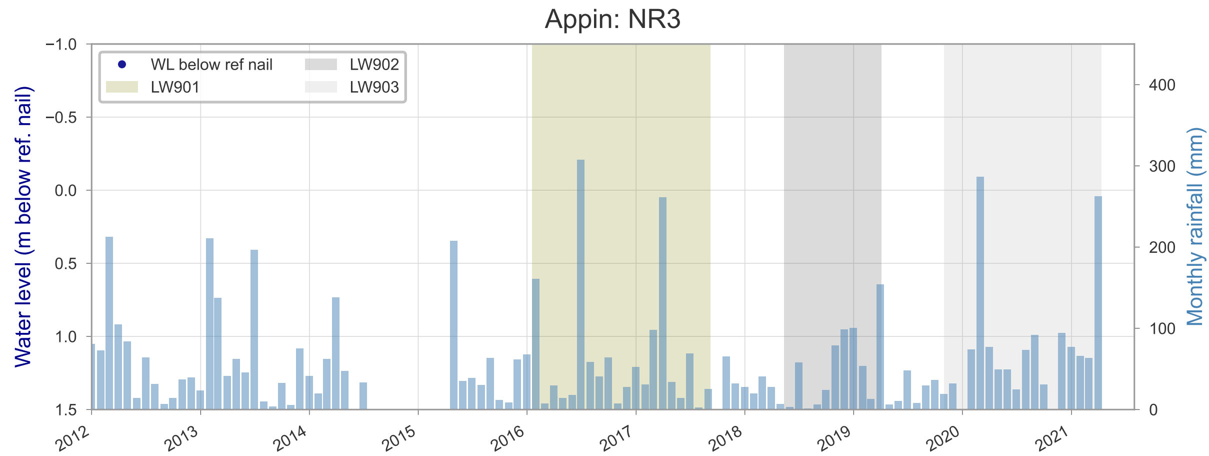


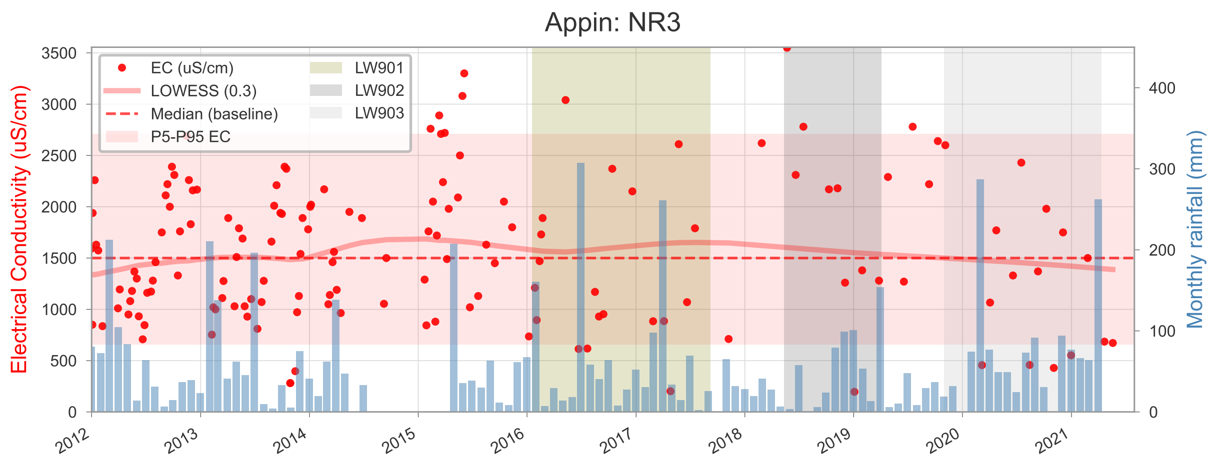
Appin: NR2

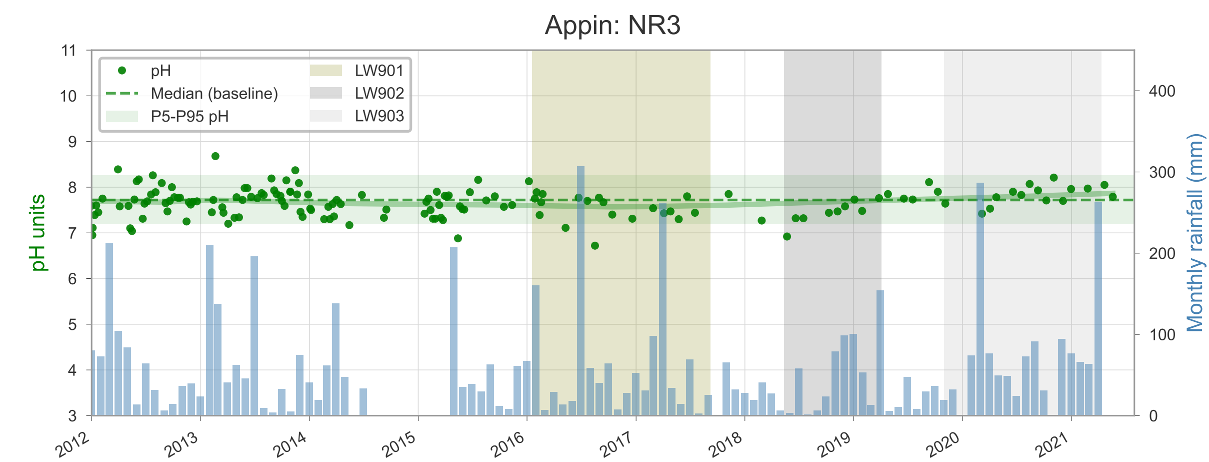


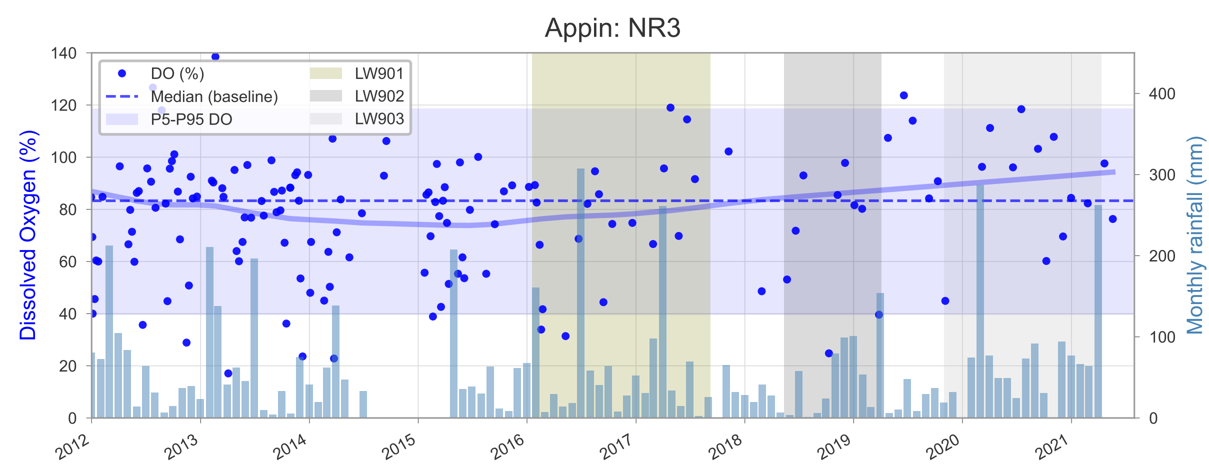
Appin: NR2

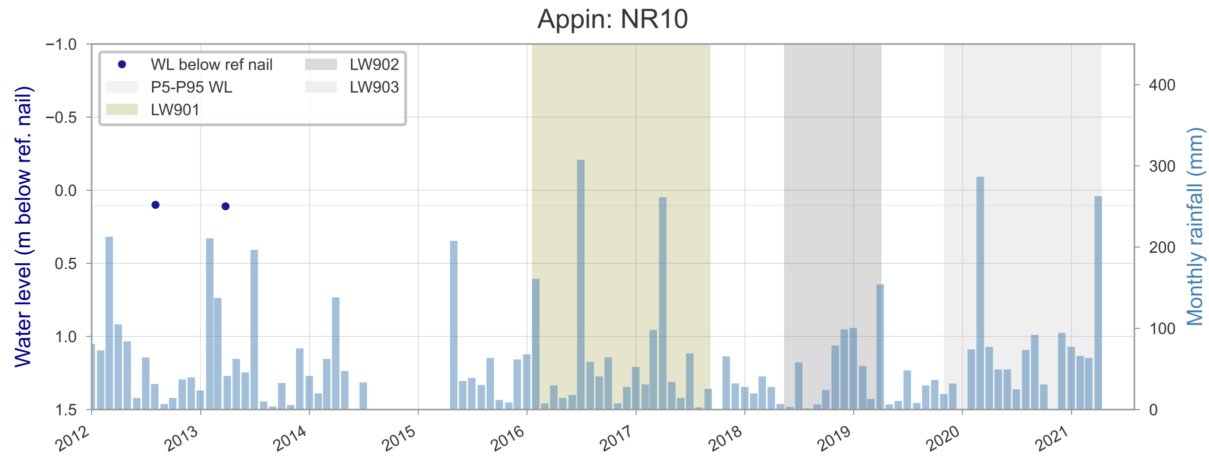


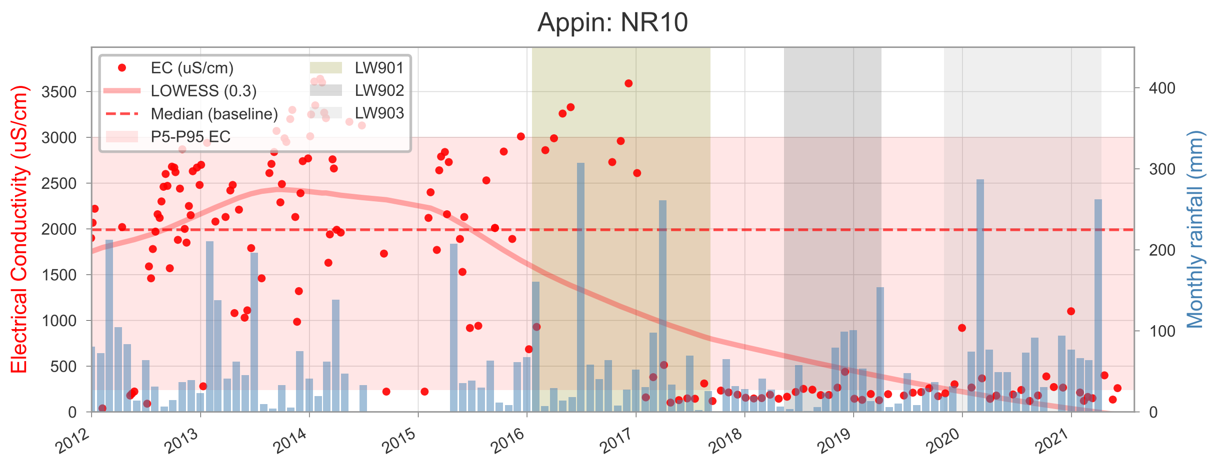

Appin: NR3
WL below ref nail
LW901
LW902
LW903
Water level (m below ref. nail)
Monthly rainfall (mm)
−1.0
−0.5
0.0
0.5
1.0
1.5
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

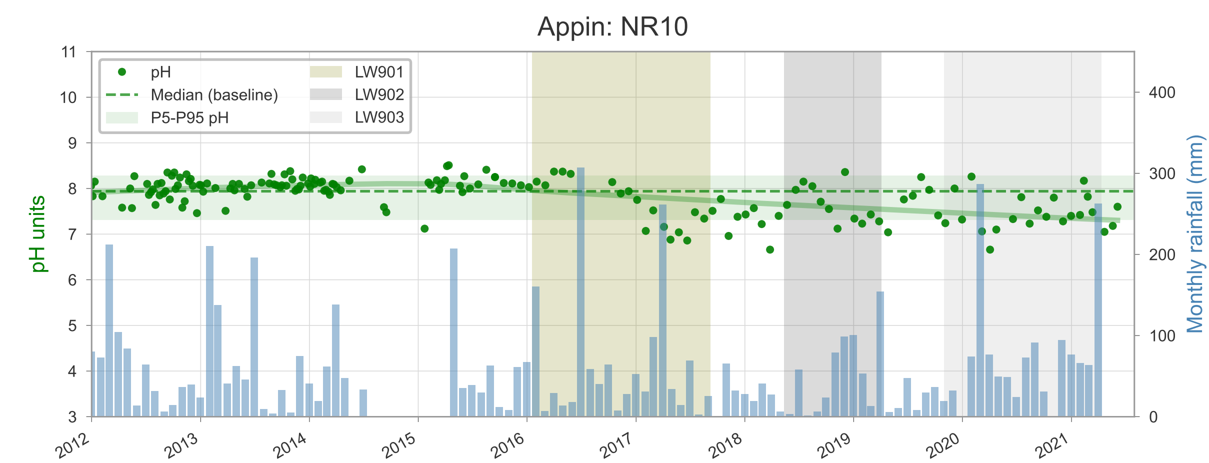

Appin: NR3
EC (uS/cm)
LOWESS (0.3)
Median (baseline)
P5-P95 EC
LW901
LW902
LW903
Electrical Conductivity (uS/cm)
Monthly rainfall (mm)
0
500
1000
1500
2000
2500
3000
3500
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

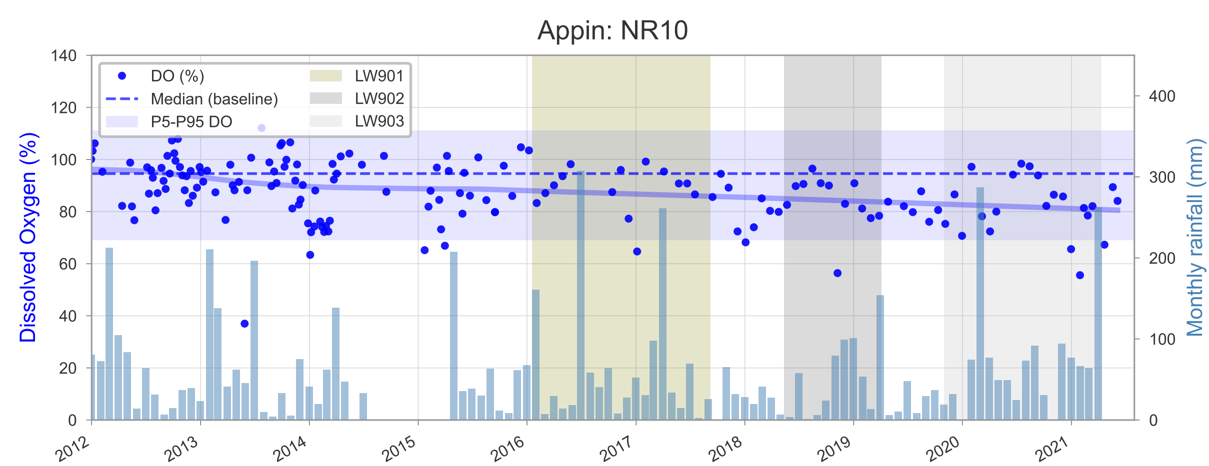

Appin: NR3
pH
Median (baseline)
P5-P95 pH
LW901
LW902
LW903
pH units
Monthly rainfall (mm)
3
4
5
6
7
8
9
10
11
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

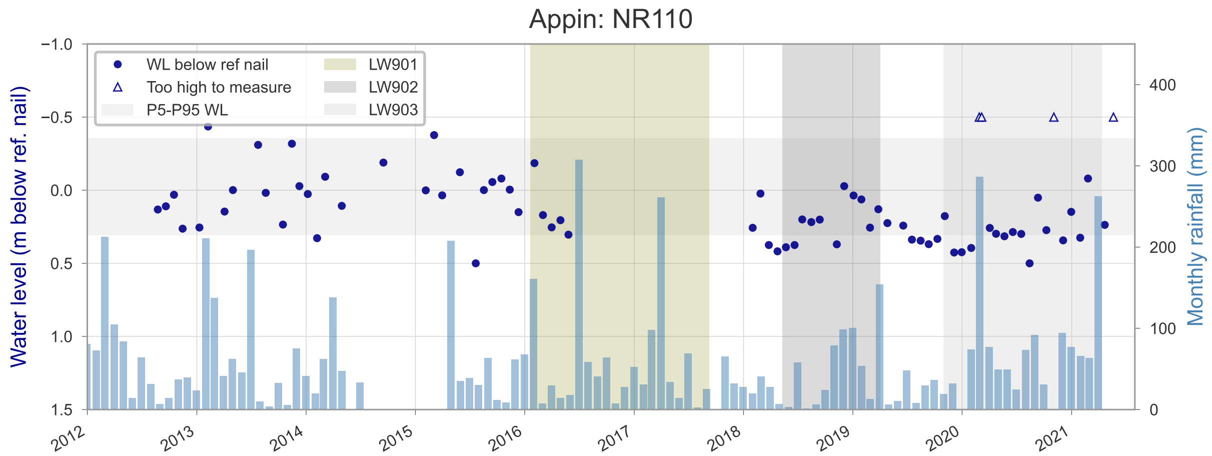

Appin: NR3
DO (%)
Median (baseline)
P5-P95 DO
LW901
LW902
LW903
Dissolved Oxygen (%)
Monthly rainfall (mm)
0
20
40
60
80
100
120
140
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

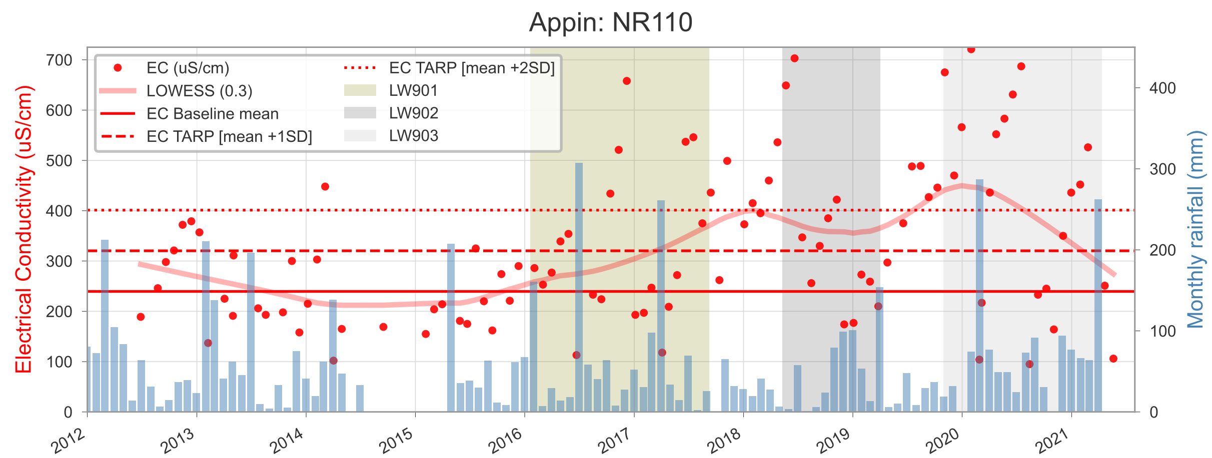

Appin: NR10
WL below ref nail
P5-P95 WL
LW901
LW902
LW903
Water level (m below ref. nail)
Monthly rainfall (mm)

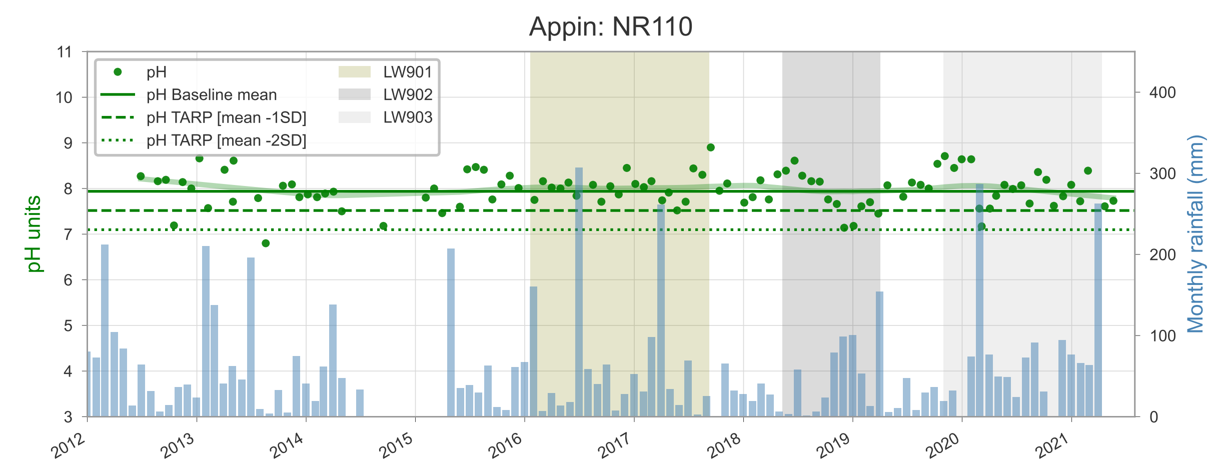

Appin: NR10
EC (uS/cm)
LOWESS (0.3)
Median (baseline)
P5-P95 EC
LW901
LW902
LW903
Electrical Conductivity (uS/cm)
Monthly rainfall (mm)

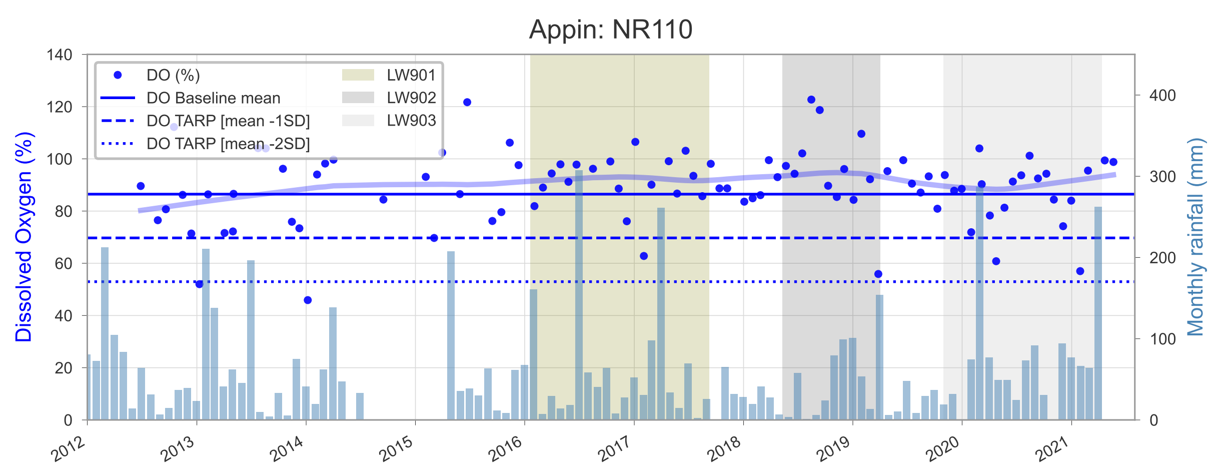

Appin: NR10
pH
Median (baseline)
P5-P95 pH
LW901
LW902
LW903
pH units
Monthly rainfall (mm)

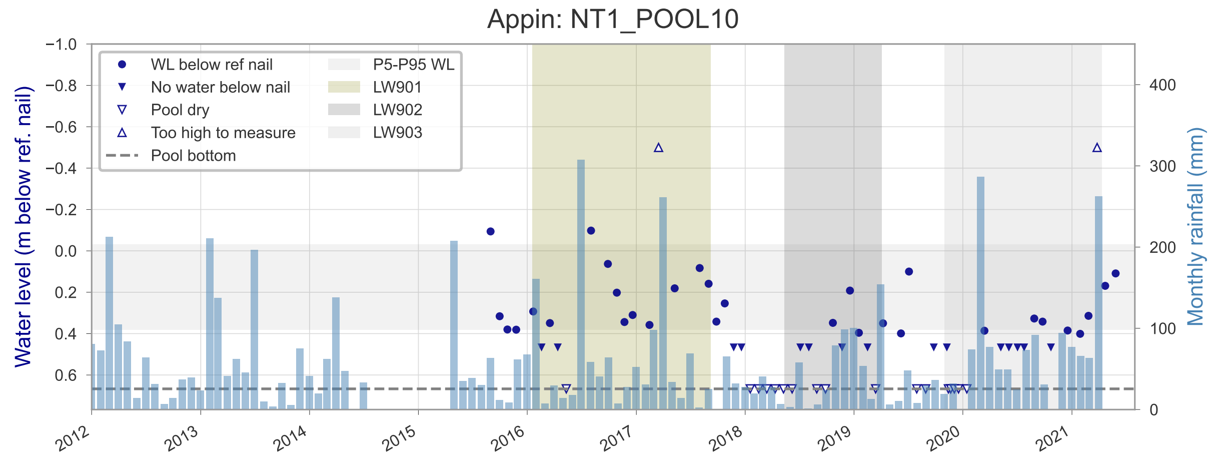

Appin: NR10
DO (%)
Median (baseline)
P5-P95 DO
LW901
LW902
LW903
Dissolved Oxygen (%)
Monthly rainfall (mm)


Appin: NR110
WL below ref nail
Too high to measure
P5-P95 WL
LW901
LW902
LW903
Water level (m below ref. nail)
Monthly rainfall (mm)
−1.0
−0.5
0.0
0.5
1.0
1.5
400
300
200
100
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

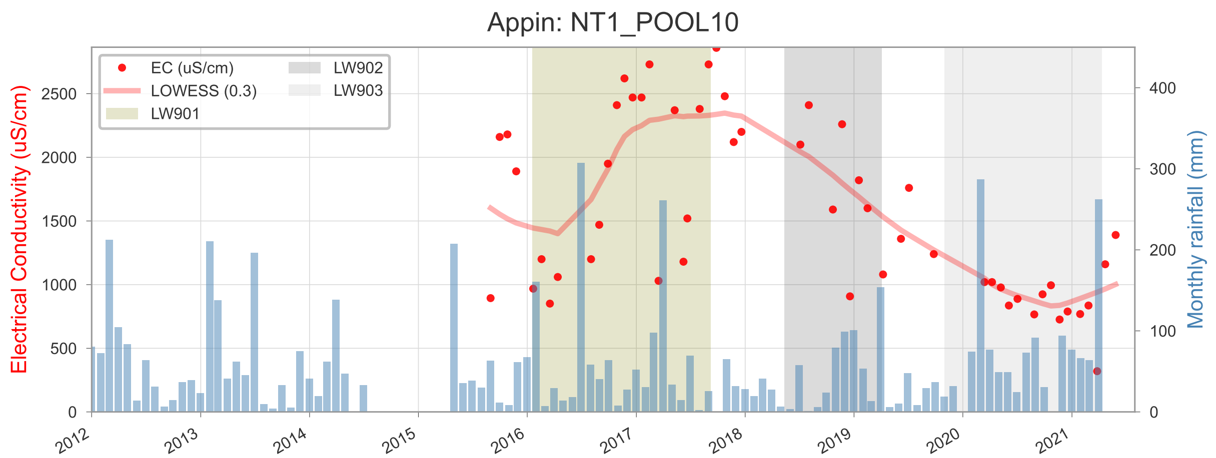

Appin: NR110
EC (uS/cm)
LOWESS (0.3)
EC Baseline mean
EC TARP [mean +1SD]
EC TARP [mean +2SD]
LW901
LW902
LW903
Electrical Conductivity (uS/cm)
Monthly rainfall (mm)
700
600
500
400
300
200
100
0
400
300
200
100
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021


Appin: NR110
pH
pH Baseline mean
pH TARP [mean -1SD]
pH TARP [mean -2SD]
LW901
LW902
LW903
pH units
Monthly rainfall (mm)
11
10
9
8
7
6
5
4
3
400
300
200
100
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

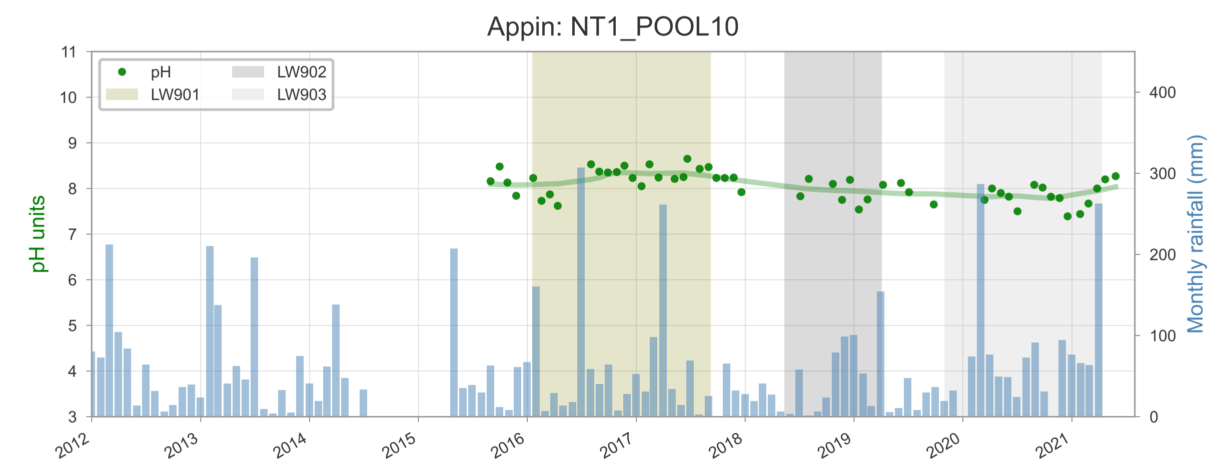

Appin: NR110
DO (%)
DO Baseline mean
DO TARP [mean -1SD]
DO TARP [mean -2SD]
LW901
LW902
LW903
Dissolved Oxygen (%)
Monthly rainfall (mm)
140
120
100
80
60
40
20
0
400
300
200
100
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021



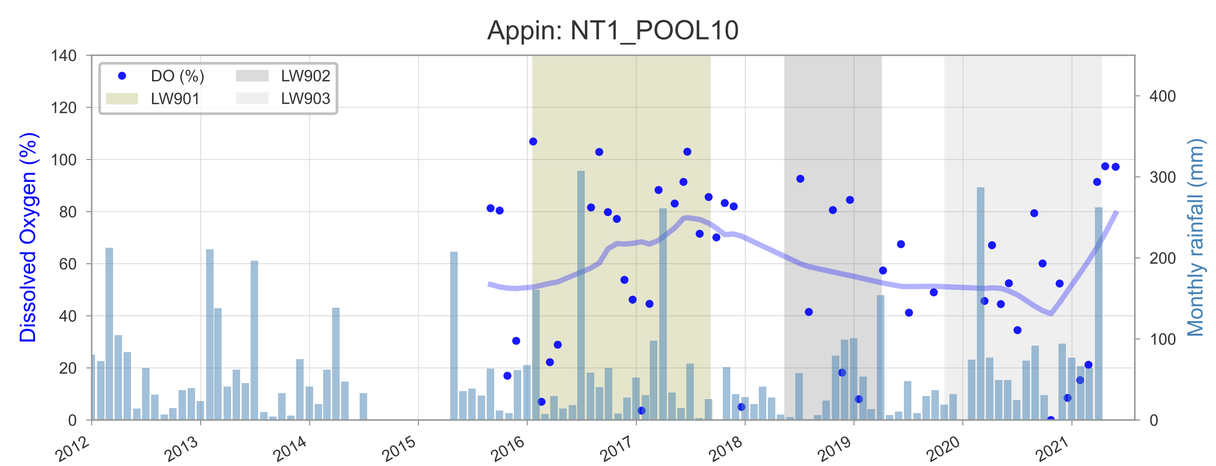
Appin: NT1_POOL10
Water level (m below ref. nail)
Monthly rainfall (mm)
WL below ref nail
No water below nail
Pool dry
Too high to measure
Pool bottom
P5-P95 WL
LW901
LW902
LW903



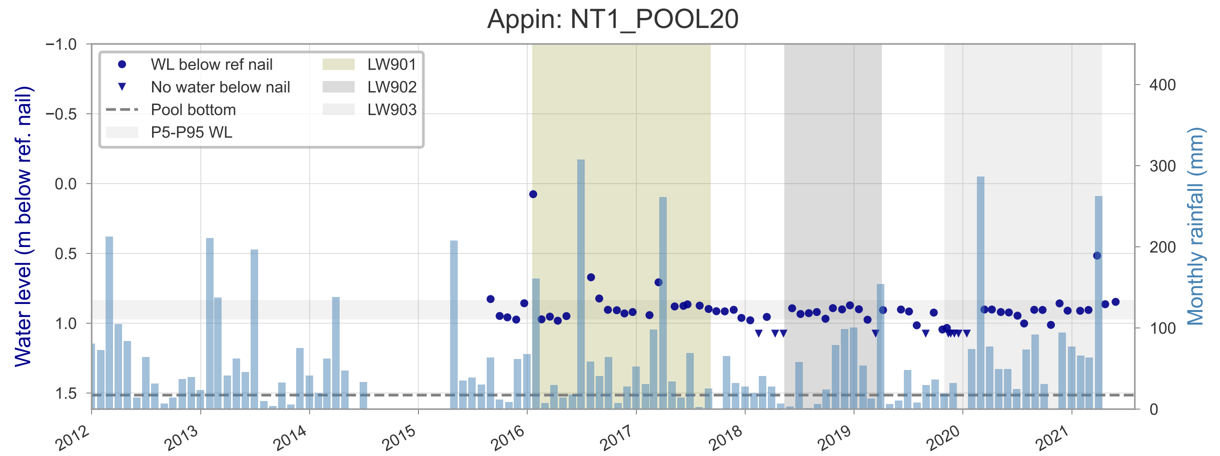
Appin: NT1_POOL10
Electrical Conductivity (uS/cm)
Monthly rainfall (mm)
EC (uS/cm)
LOWESS (0.3)
LW901
LW902
LW903

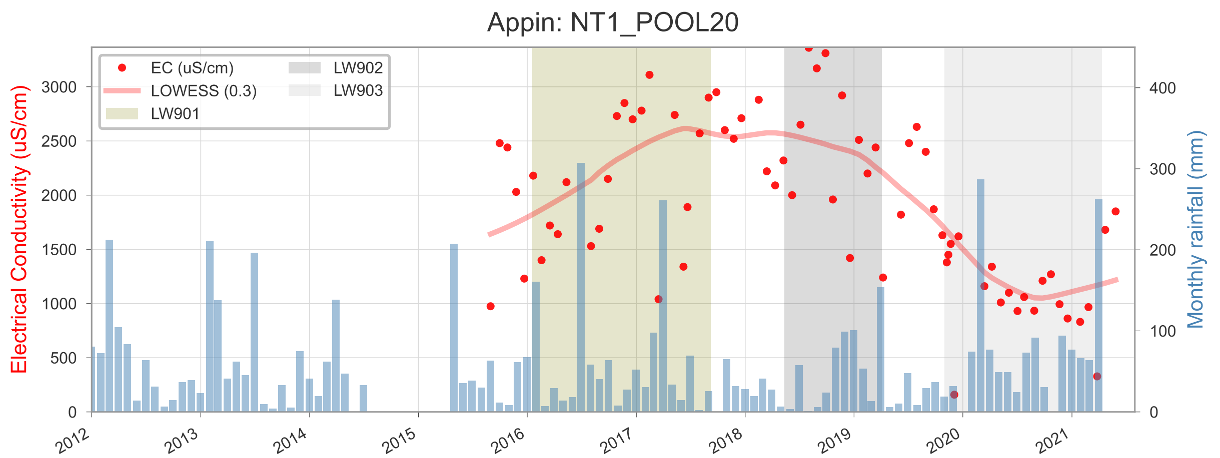


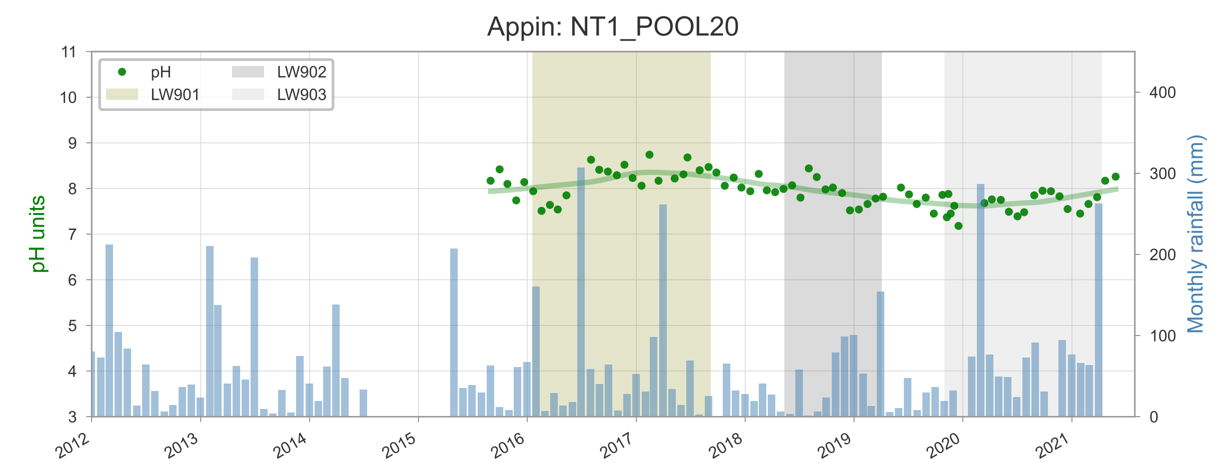
Appin: NT1_POOL10
pH units
Monthly rainfall (mm)
pH
LW901
LW902
LW903

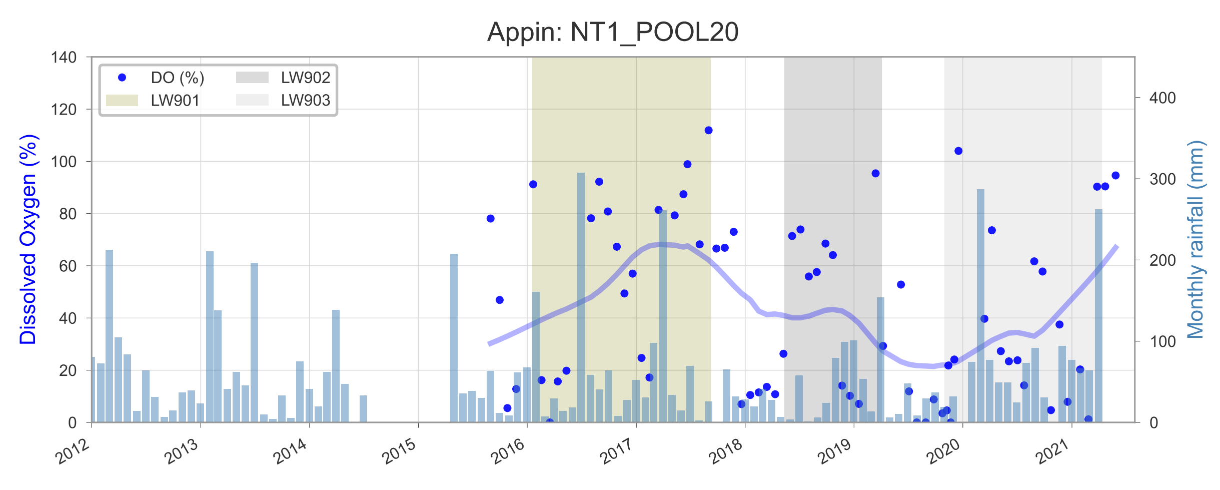


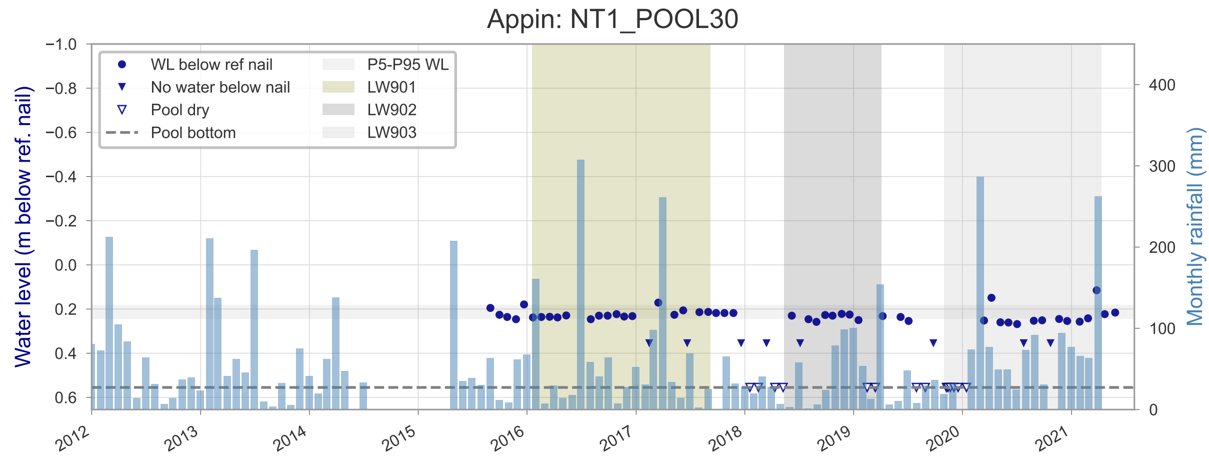
Appin: NT1_POOL10
Dissolved Oxygen (%)
Monthly rainfall (mm)
DO (%)
LW901
LW902
LW903

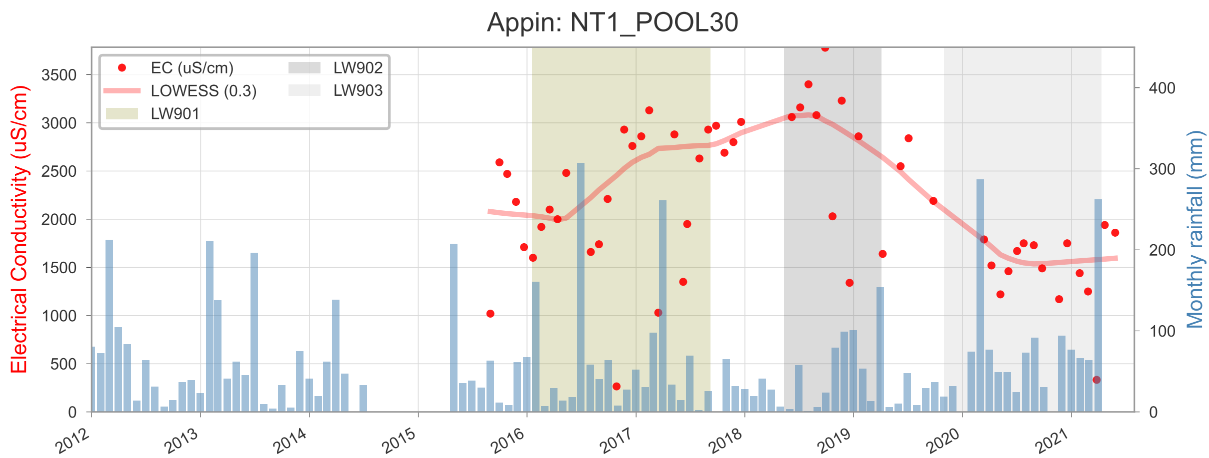

Appin: NT1_POOL20
WL below ref nail
No water below nail
Pool bottom
P5-P95 WL
LW901
LW902
LW903
Water level (m below ref. nail)
Monthly rainfall (mm)

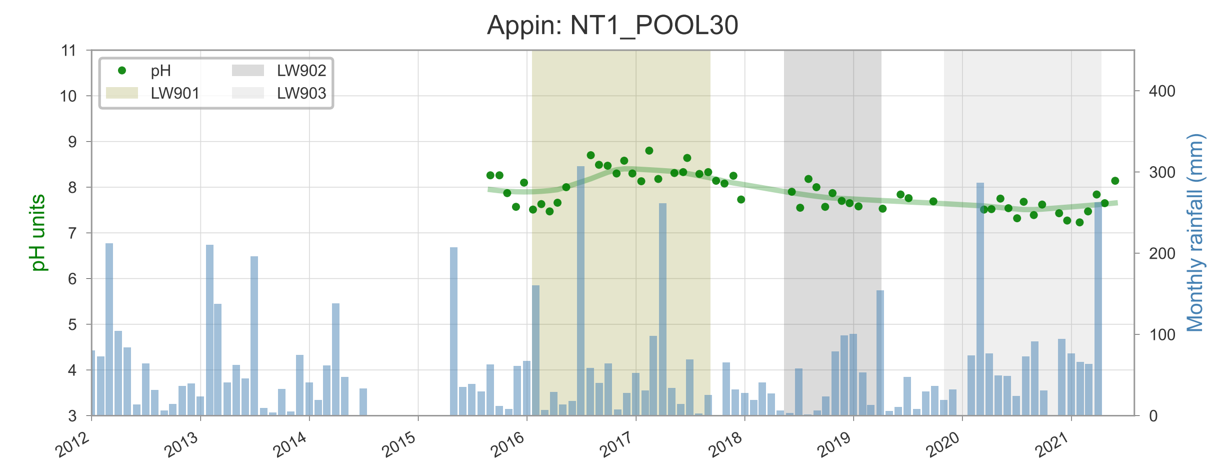

Appin: NT1_POOL20
EC (uS/cm)
LOWESS (0.3)
LW901
LW902
LW903
Electrical Conductivity (uS/cm)
Monthly rainfall (mm)

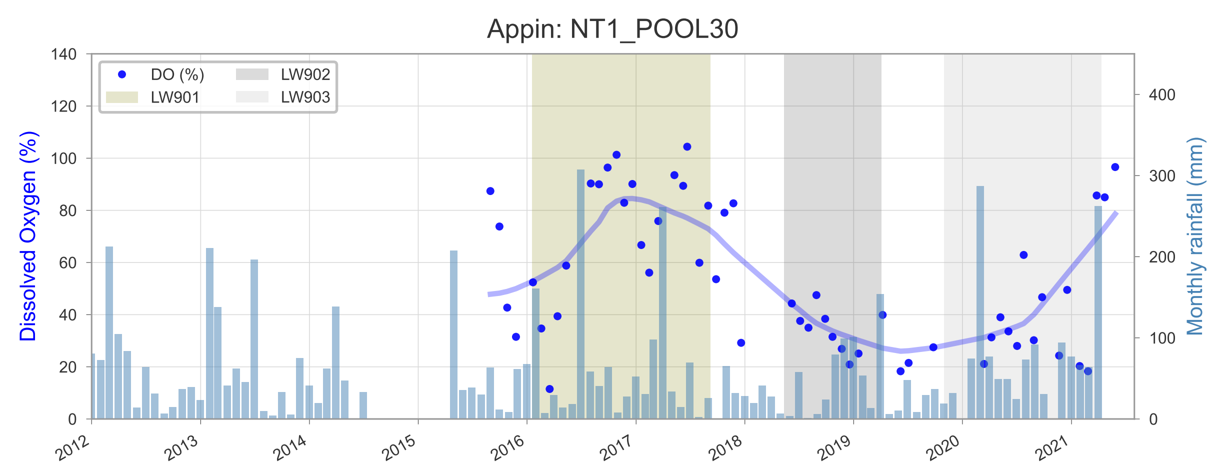

Appin: NT1_POOL20
pH
LW901
LW902
LW903
pH units
Monthly rainfall (mm)

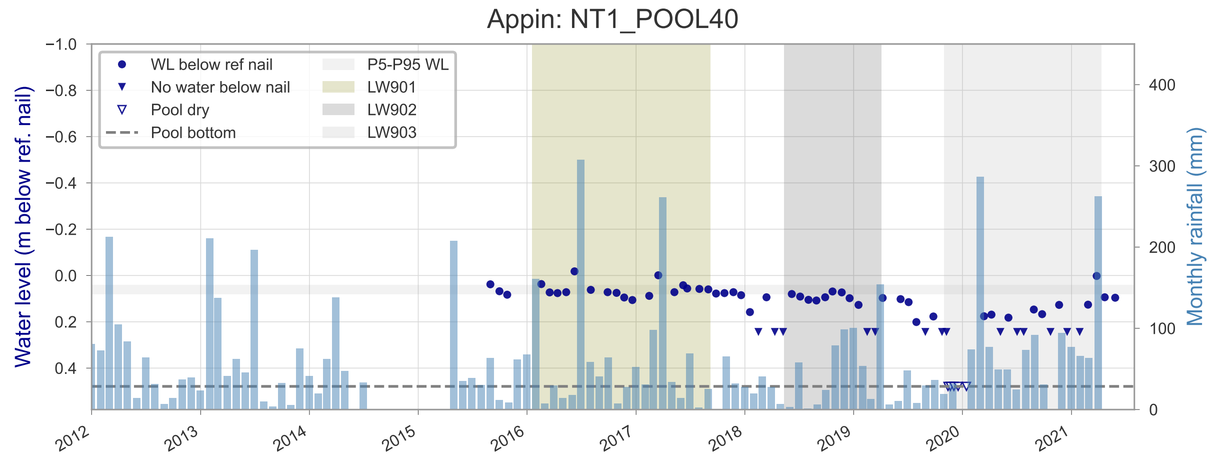

Appin: NT1_POOL20
DO (%)
LW901
LW902
LW903
Dissolved Oxygen (%)
Monthly rainfall (mm)

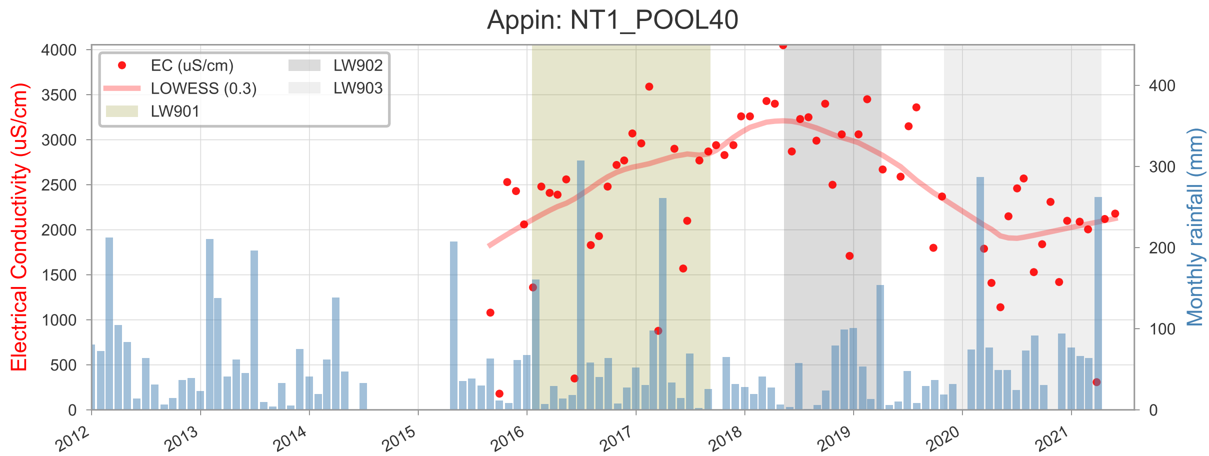

Appin: NT1_POOL30
WL below ref nail
No water below nail
Pool dry
Pool bottom
P5-P95 WL
LW901
LW902
LW903
Water level (m below ref. nail)
Monthly rainfall (mm)

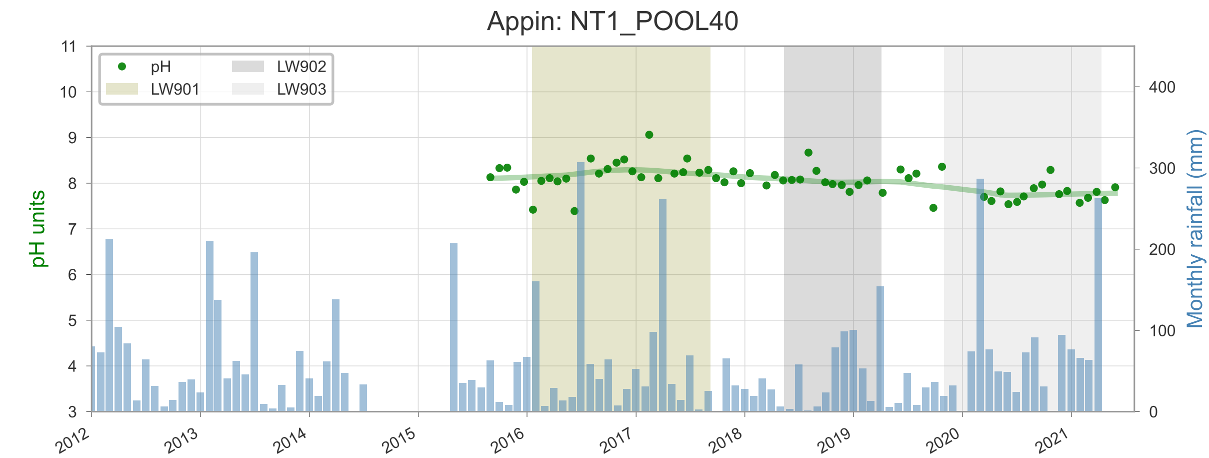

Appin: NT1_POOL30
EC (uS/cm)
LOWESS (0.3)
LW901
LW902
LW903
Electrical Conductivity (uS/cm)
Monthly rainfall (mm)

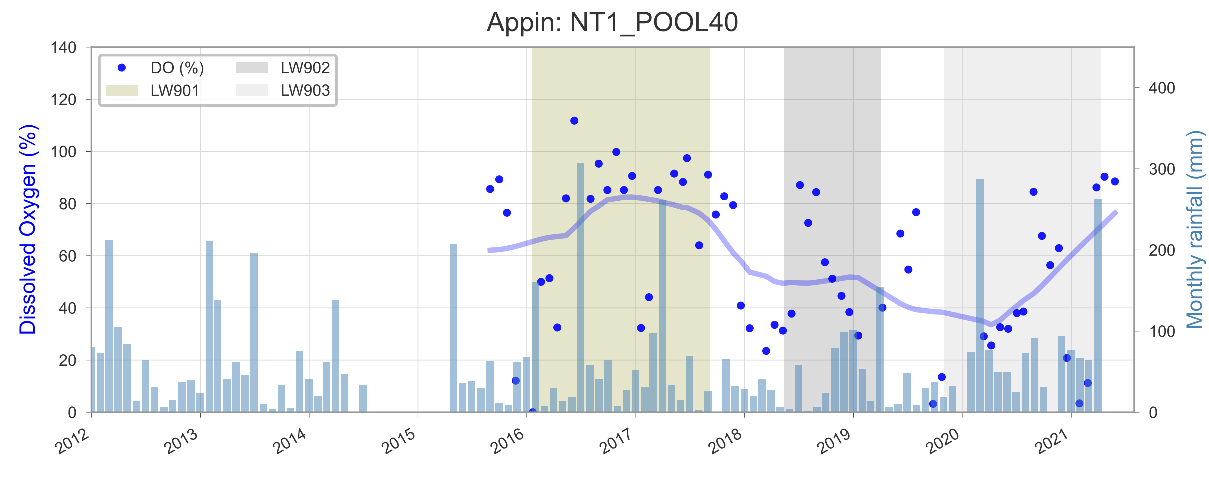

Appin: NT1_POOL30
pH
LW901
LW902
LW903
pH units
Monthly rainfall (mm)

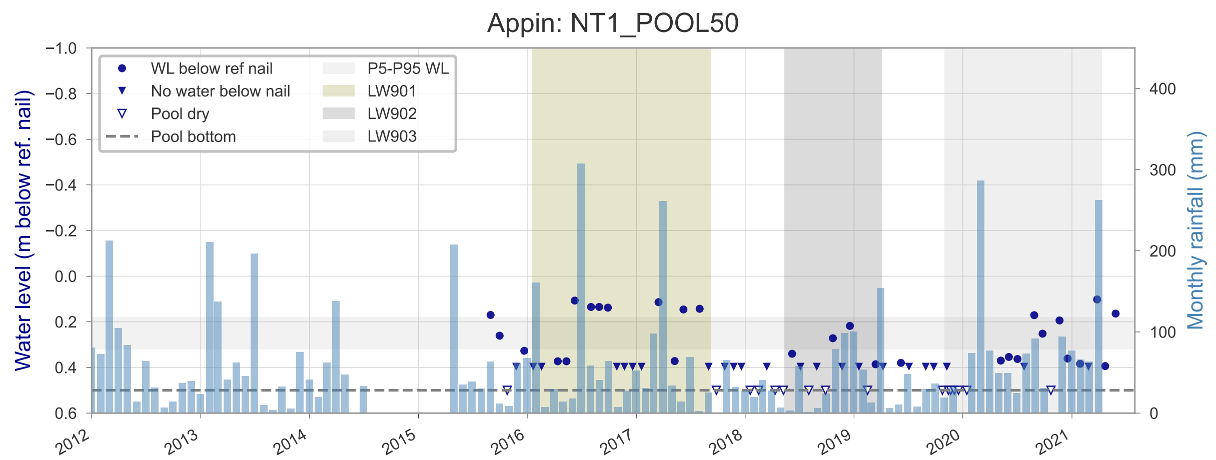

Appin: NT1_POOL30
DO (%)
LW901
LW902
LW903
Dissolved Oxygen (%)
Monthly rainfall (mm)

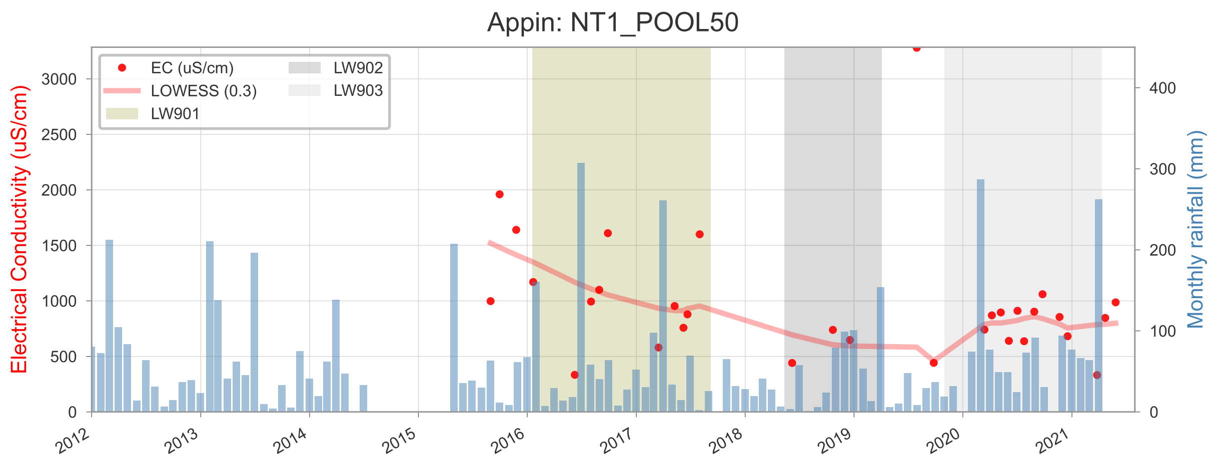

Appin: NT1_POOL40
WL below ref nail
No water below nail
Pool dry
Pool bottom
P5-P95 WL
LW901
LW902
LW903
Water level (m below ref. nail)
Monthly rainfall (mm)

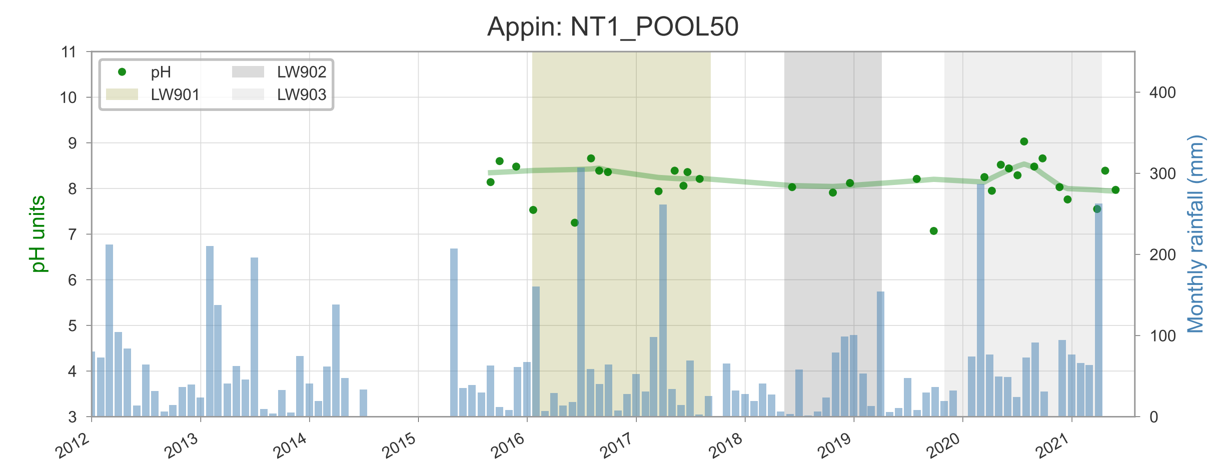

Appin: NT1_POOL40
EC (uS/cm)
LOWESS (0.3)
LW901
LW902
LW903
Electrical Conductivity (uS/cm)
Monthly rainfall (mm)

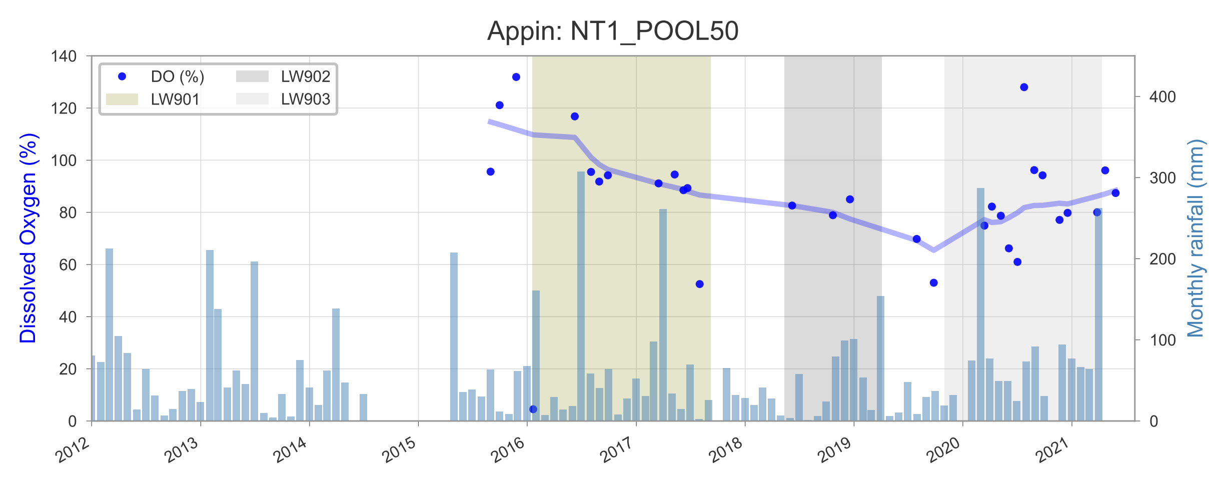

Appin: NT1_POOL40
pH
LW901
LW902
LW903
pH units
Monthly rainfall (mm)

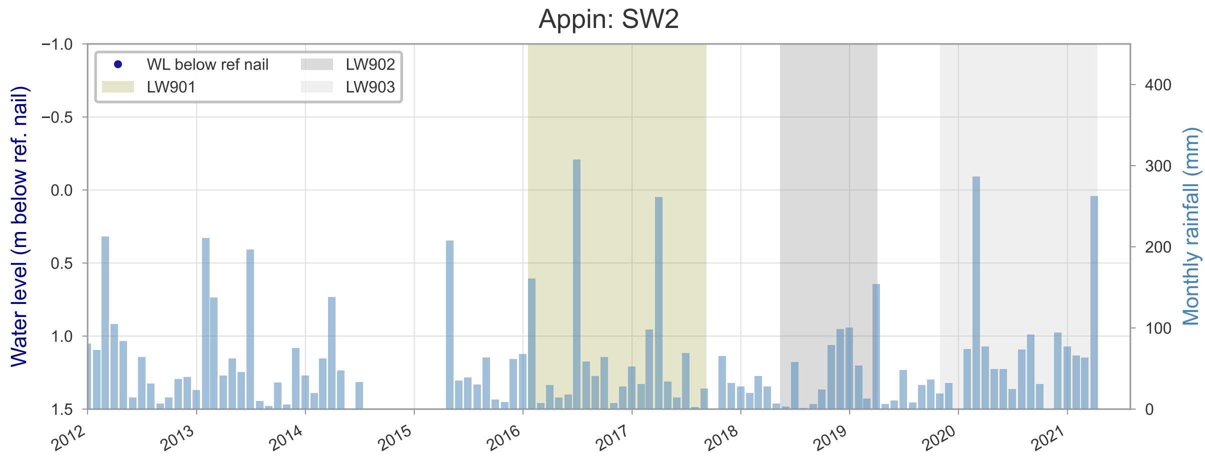

Appin: NT1_POOL40
DO (%)
LW901
LW902
LW903
Dissolved Oxygen (%)
Monthly rainfall (mm)

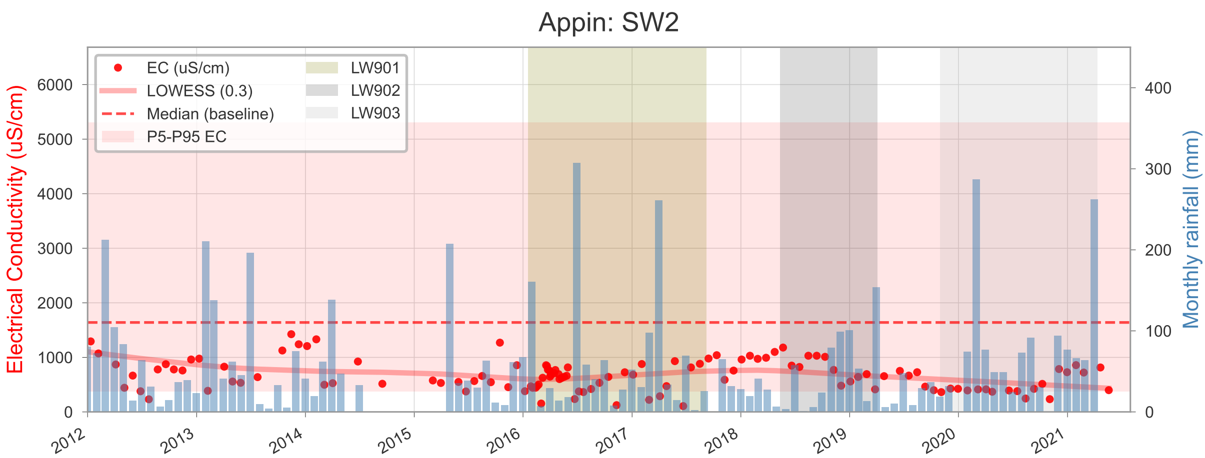

Appin: NT1_POOL50
WL below ref nail
No water below nail
Pool dry
Pool bottom
P5-P95 WL
LW901
LW902
LW903
Water level (m below ref. nail)
Monthly rainfall (mm)

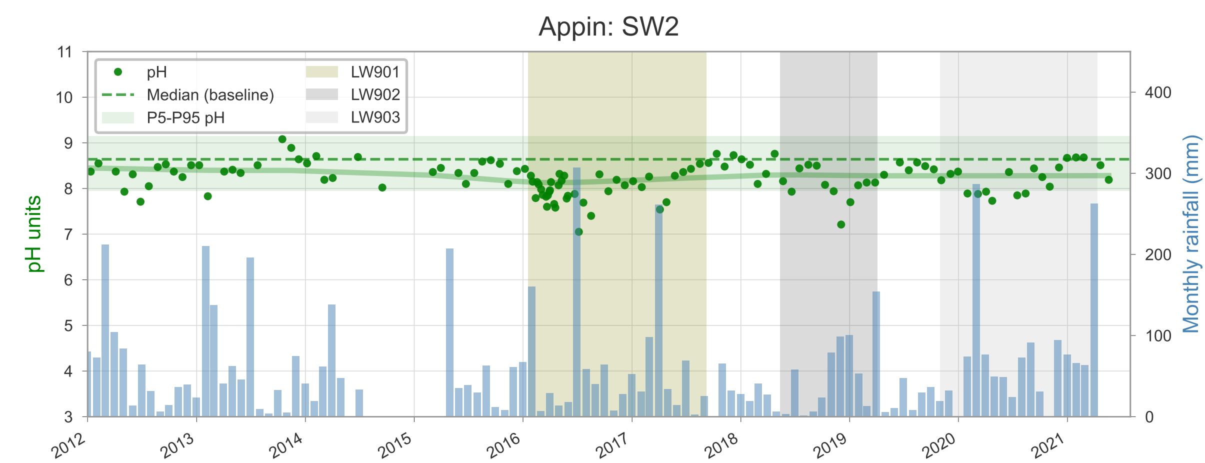

Appin: NT1_POOL50
EC (uS/cm)
LOWESS (0.3)
LW901
LW902
LW903
Electrical Conductivity (uS/cm)
Monthly rainfall (mm)

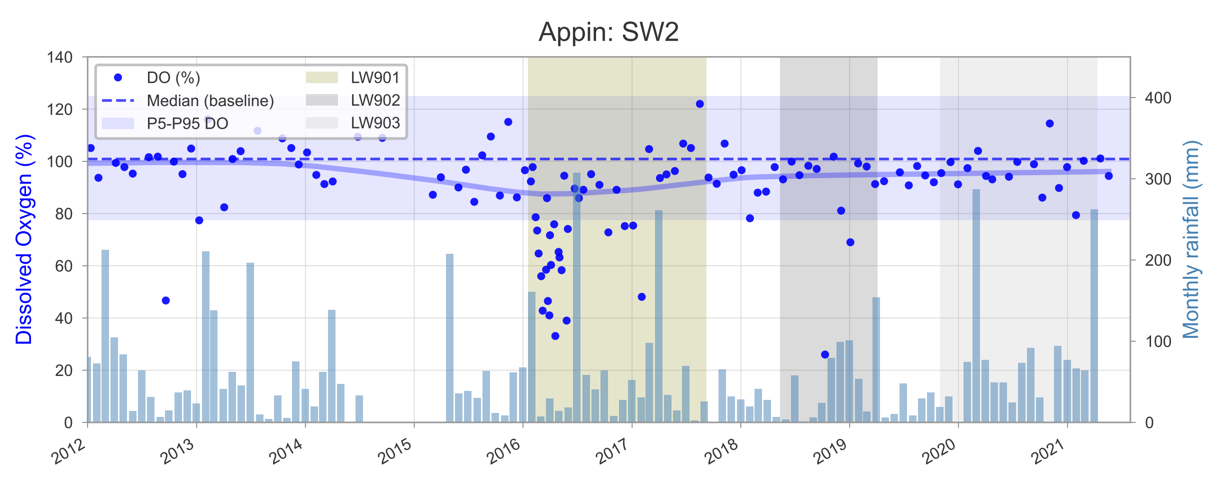

Appin: NT1_POOL50
pH
LW901
LW902
LW903
pH units
Monthly rainfall (mm)

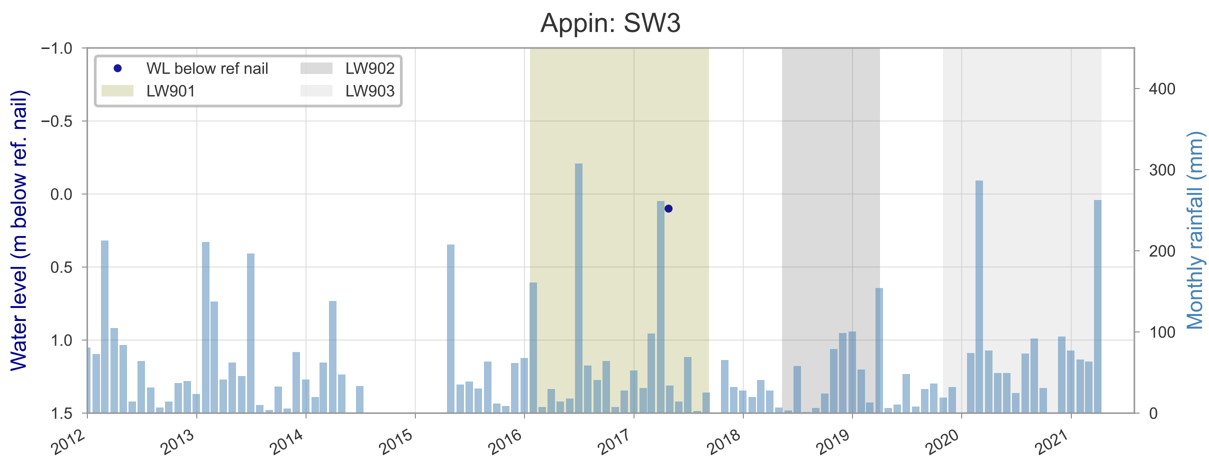

Appin: NT1_POOL50
DO (%)
LW901
LW902
LW903
Dissolved Oxygen (%)
Monthly rainfall (mm)

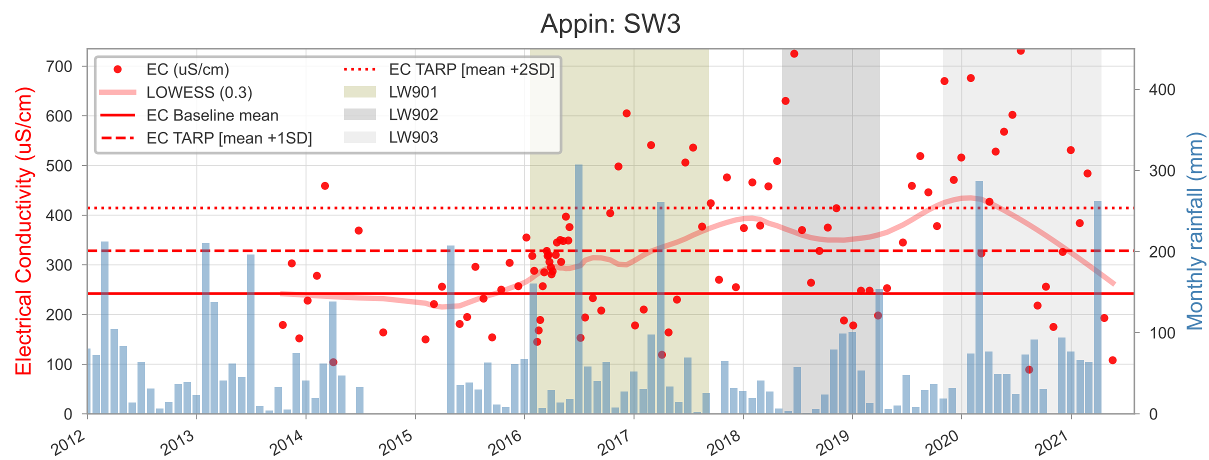

Appin: SW2
WL below ref nail
LW901
LW902
LW903
Water level (m below ref. nail)
Monthly rainfall (mm)
−1.0
−0.5
0.0
0.5
1.0
1.5
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

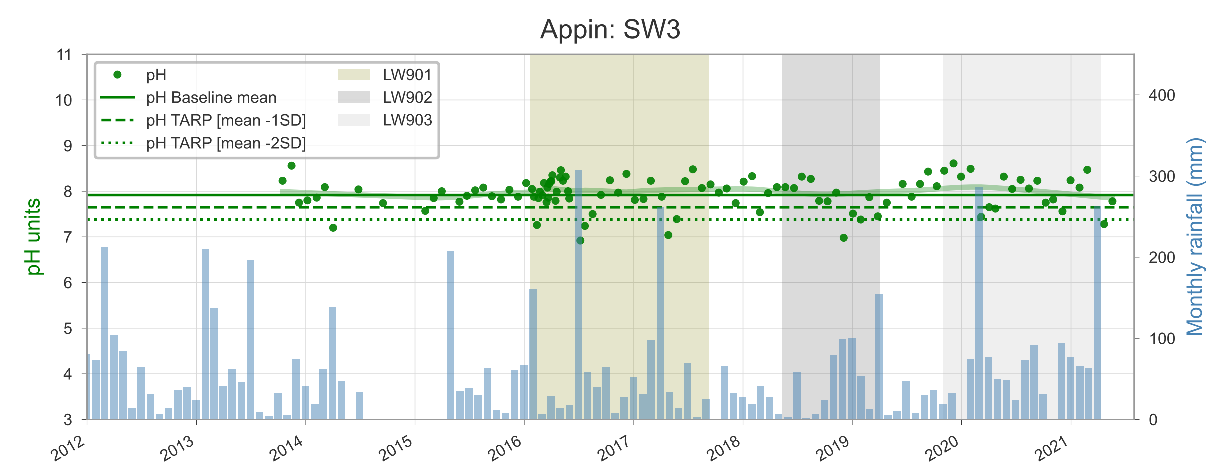

Appin: SW2
EC (uS/cm)
LOWESS (0.3)
Median (baseline)
P5-P95 EC
LW901
LW902
LW903
Electrical Conductivity (uS/cm)
Monthly rainfall (mm)
0
1000
2000
3000
4000
5000
6000
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

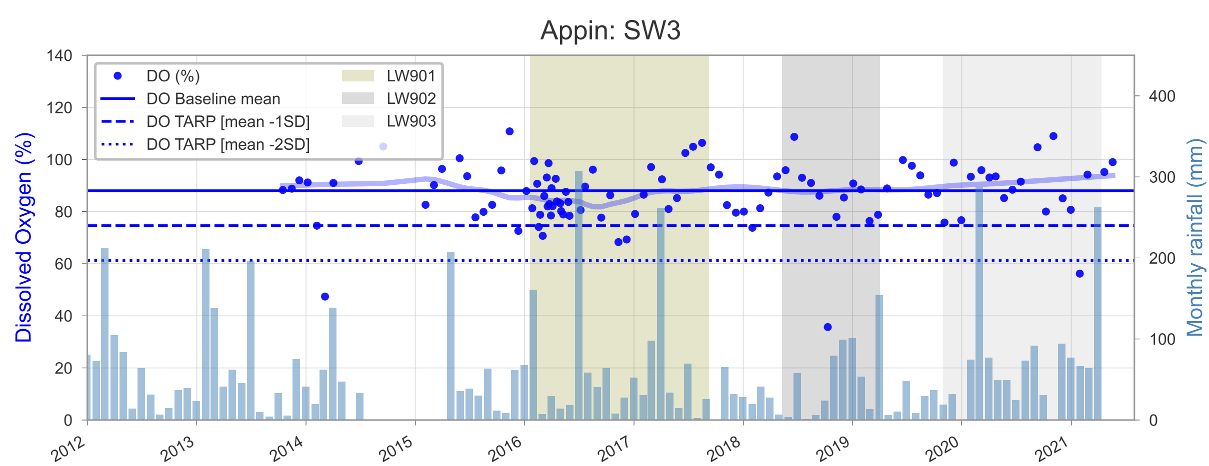

Appin: SW2
pH
Median (baseline)
P5-P95 pH
LW901
LW902
LW903
pH units
Monthly rainfall (mm)
3
4
5
6
7
8
9
10
11
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

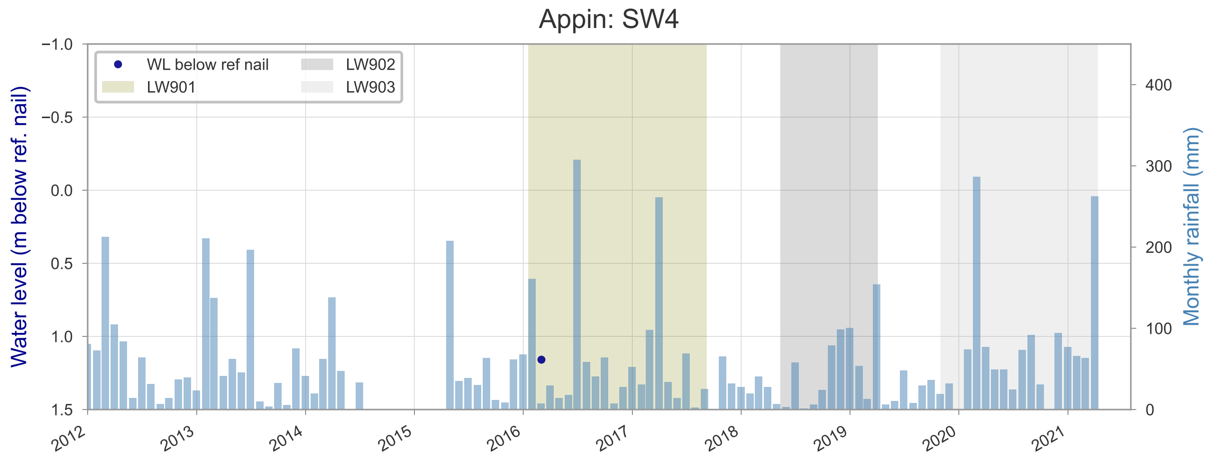

Appin: SW2
DO (%)
Median (baseline)
P5-P95 DO
LW901
LW902
LW903
Dissolved Oxygen (%)
Monthly rainfall (mm)
0
20
40
60
80
100
120
140
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

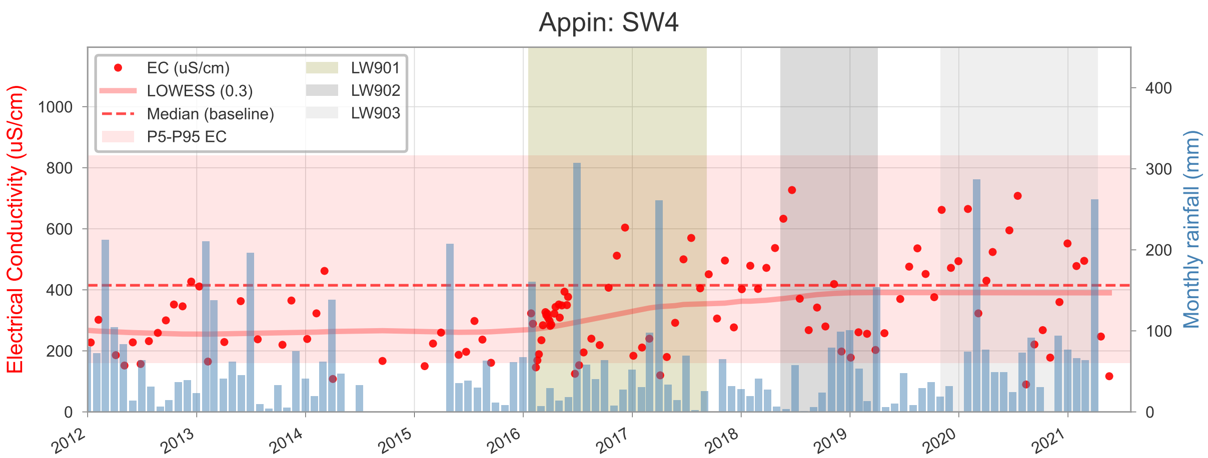

Appin: SW3
WL below ref nail
LW901
LW902
LW903
Water level (m below ref. nail)
Monthly rainfall (mm)

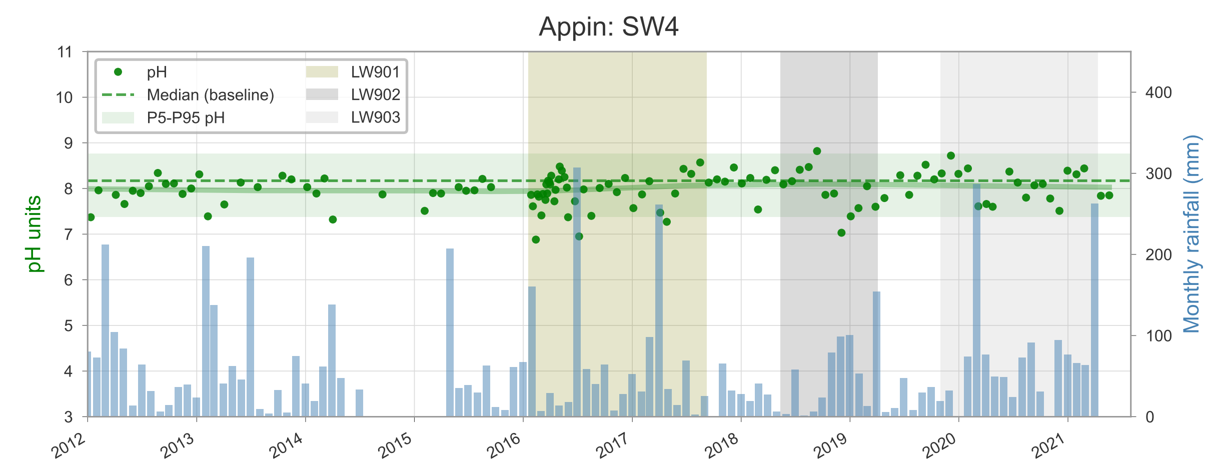

Appin: SW3
EC (uS/cm)
LOWESS (0.3)
EC Baseline mean
EC TARP [mean +1SD]
EC TARP [mean +2SD]
LW901
LW902
LW903
Electrical Conductivity (uS/cm)
Monthly rainfall (mm)

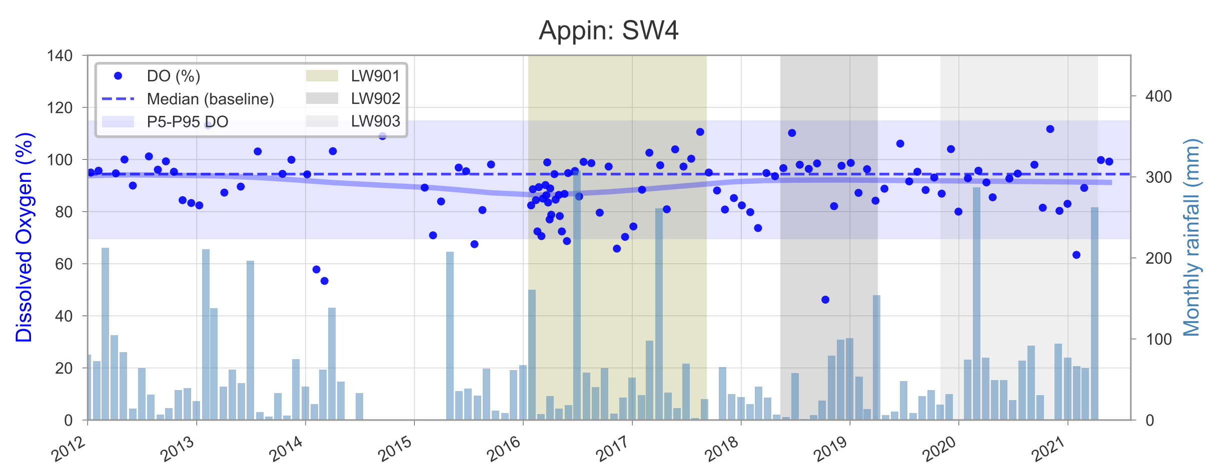

Appin: SW3
pH
pH Baseline mean
pH TARP [mean -1SD]
pH TARP [mean -2SD]
LW901
LW902
LW903
pH units
Monthly rainfall (mm)

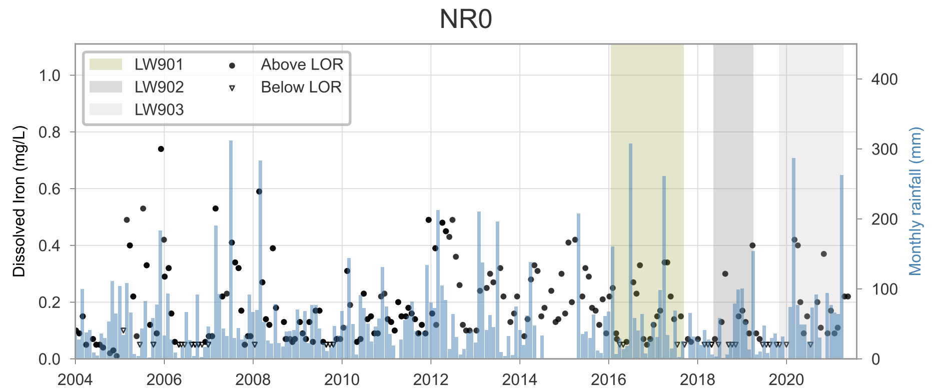

Appin: SW3
DO (%)
DO Baseline mean
DO TARP [mean -1SD]
DO TARP [mean -2SD]
LW901
LW902
LW903
Dissolved Oxygen (%)
Monthly rainfall (mm)

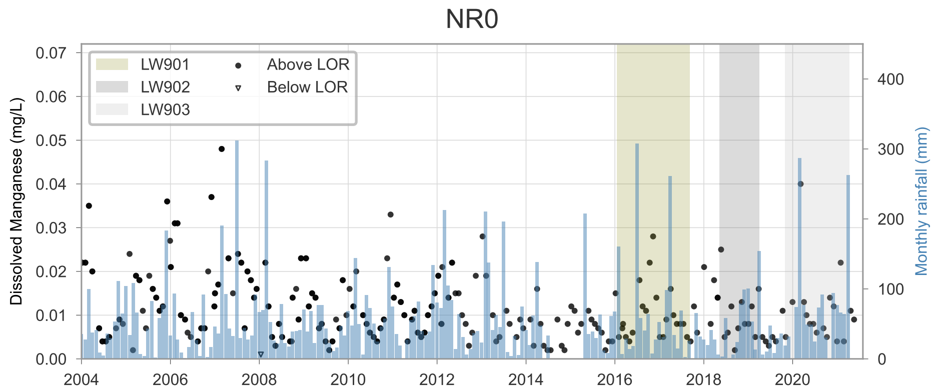

Appin: SW4
WL below ref nail
LW901
LW902
LW903
Water level (m below ref. nail)
Monthly rainfall (mm)
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

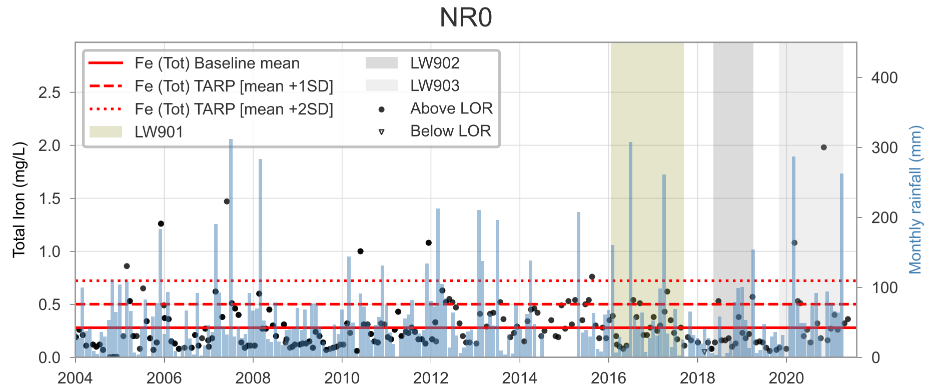

Appin: SW4
EC (uS/cm)
LOWESS (0.3)
Median (baseline)
P5-P95 EC
LW901
LW902
LW903
Electrical Conductivity (uS/cm)
Monthly rainfall (mm)
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

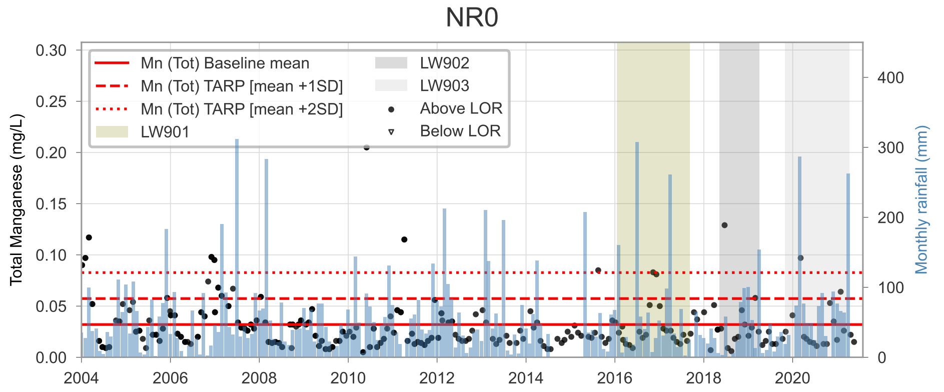

Appin: SW4
pH
Median (baseline)
P5-P95 pH
LW901
LW902
LW903
pH units
Monthly rainfall (mm)
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

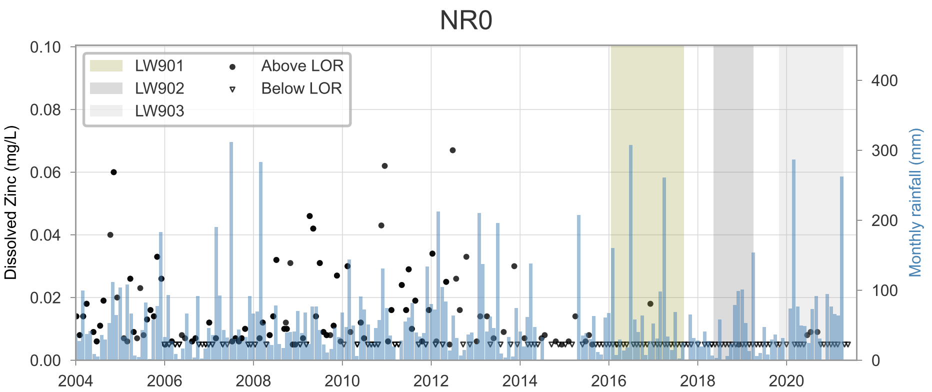

Appin: SW4
DO (%)
Median (baseline)
P5-P95 DO
LW901
LW902
LW903
Dissolved Oxygen (%)
Monthly rainfall (mm)
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

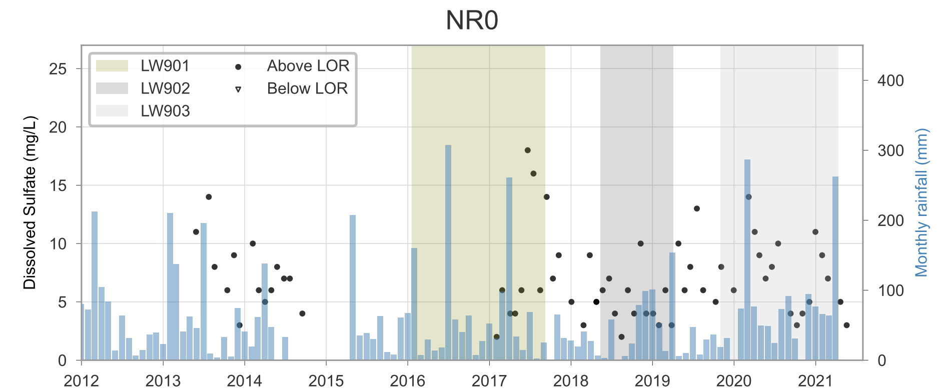

NR0
Dissolved Iron (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR

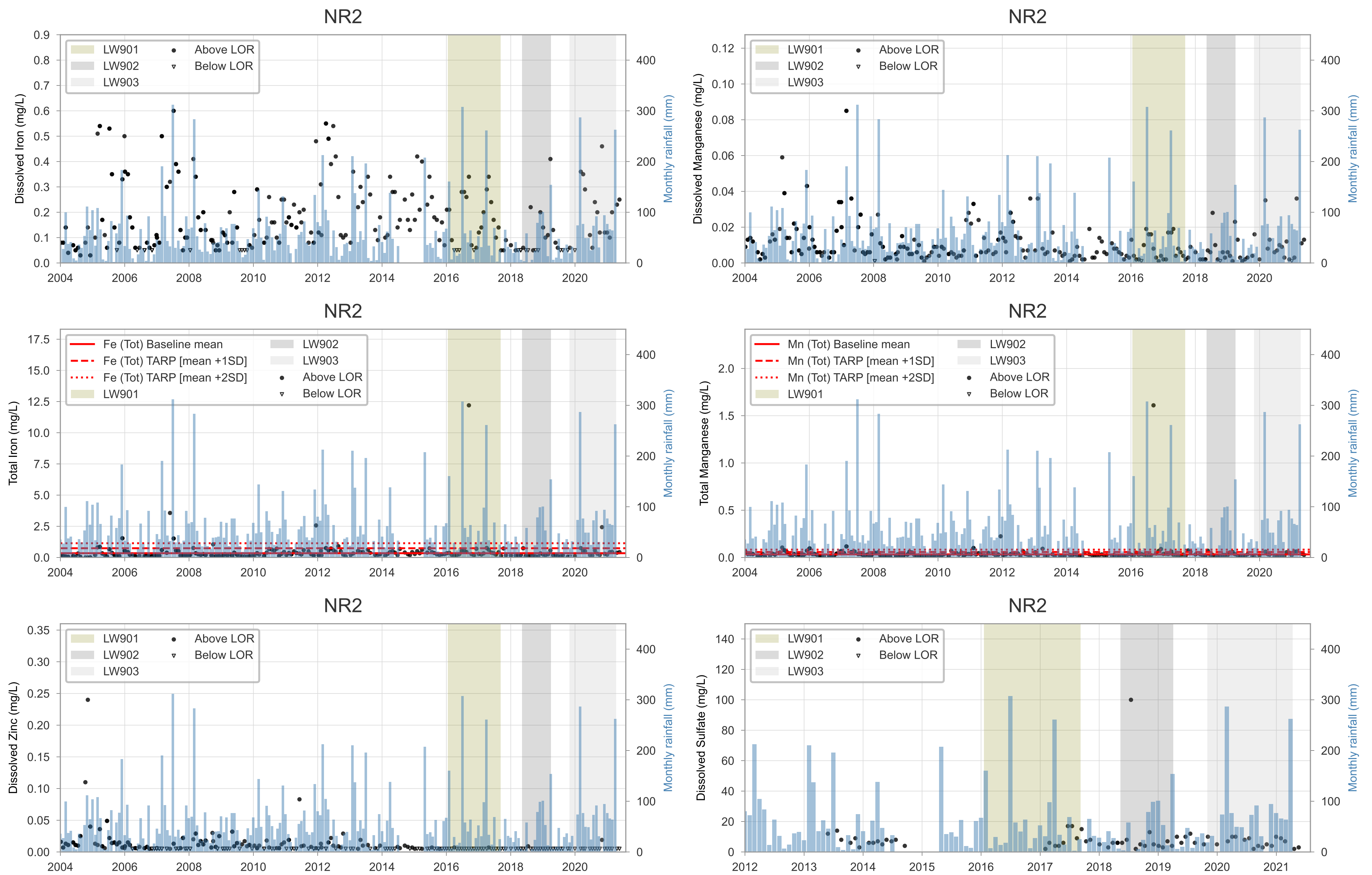

NR0
Dissolved Manganese (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR

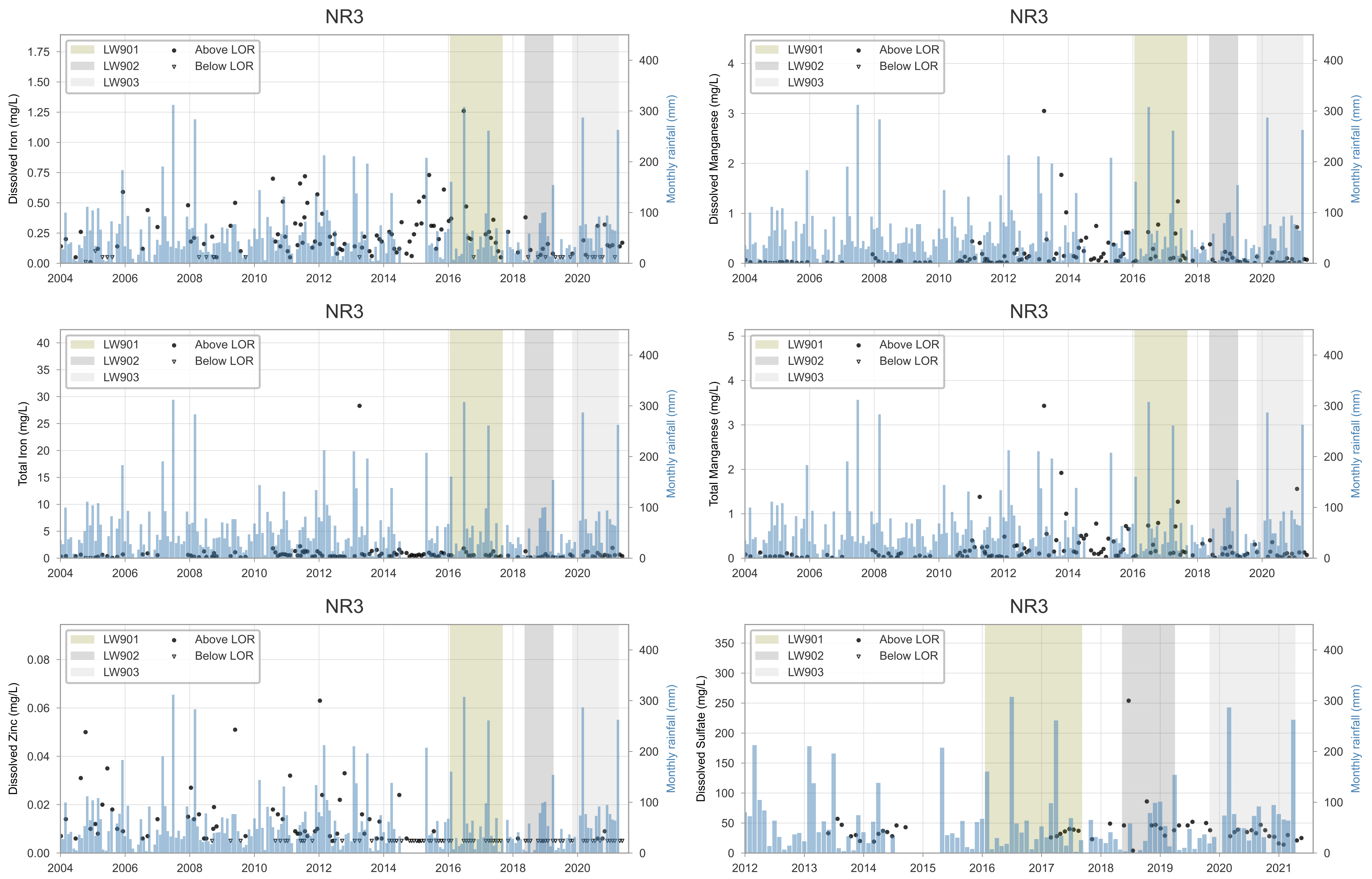

NR0
Total Iron (mg/L)
Monthly rainfall (mm)
Fe (Tot) Baseline mean
Fe (Tot) TARP [mean +1SD]
Fe (Tot) TARP [mean +2SD]
LW901
LW902
LW903
Above LOR
Below LOR

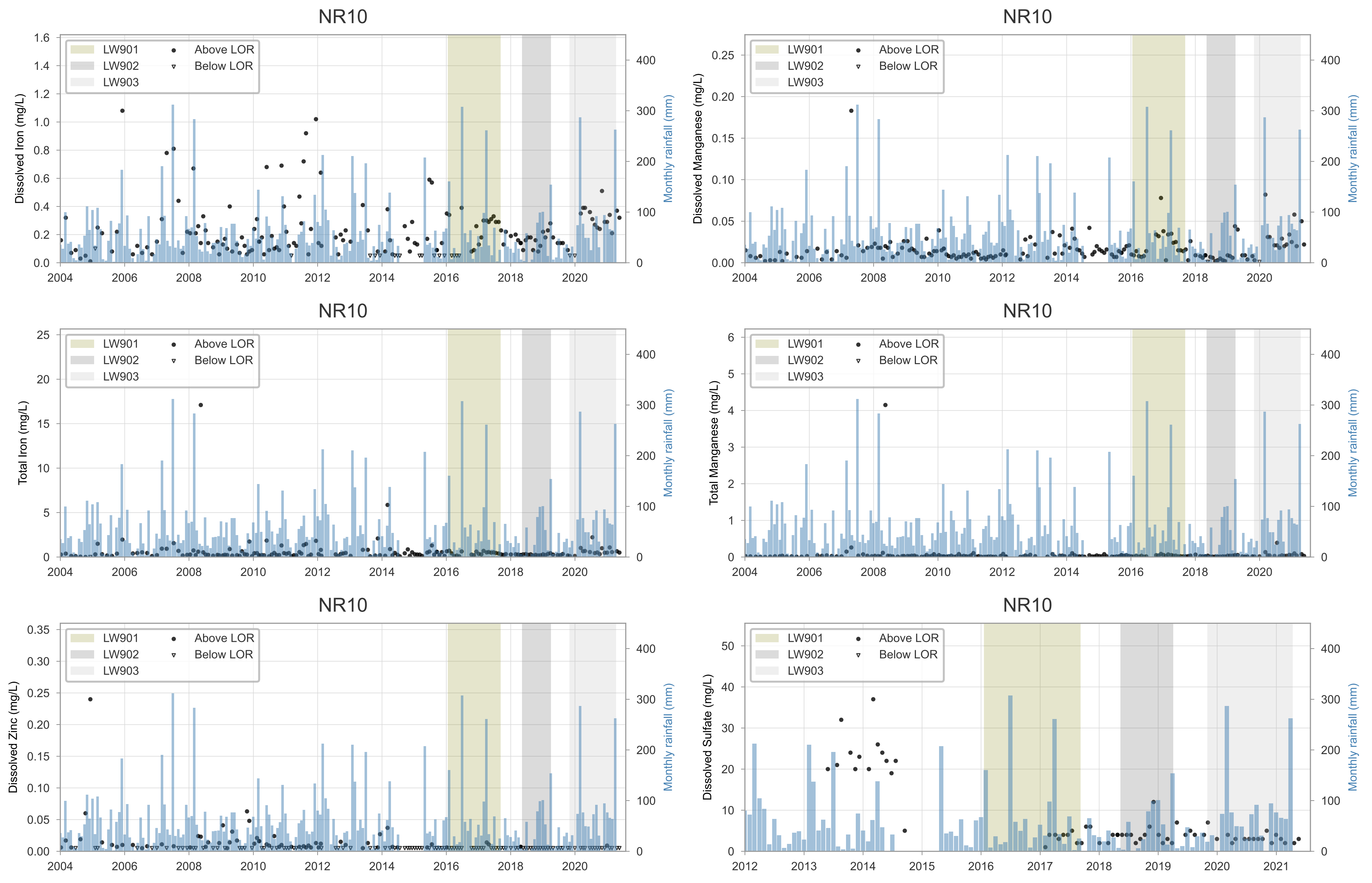

NR0
Total Manganese (mg/L)
Monthly rainfall (mm)
Mn (Tot) Baseline mean
Mn (Tot) TARP [mean +1SD]
Mn (Tot) TARP [mean +2SD]
LW901
LW902
LW903
Above LOR
Below LOR


NR0
Dissolved Zinc (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR

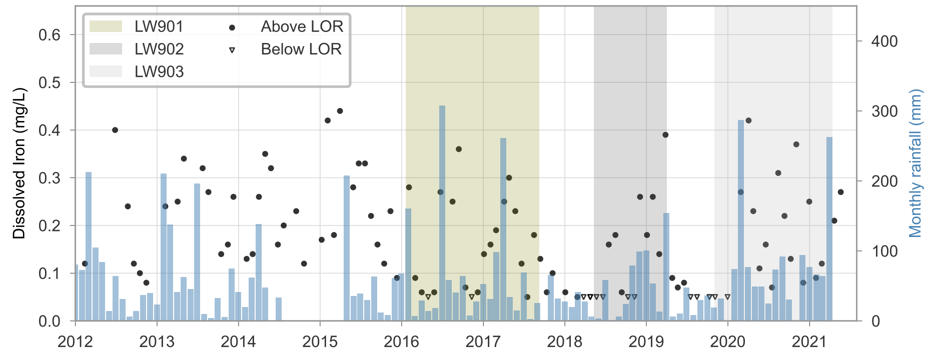

NR0
Dissolved Sulfate (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR


NR2
Dissolved Iron (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR
NR2
Dissolved Manganese (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR
NR2
Total Iron (mg/L)
Monthly rainfall (mm)
Fe (Tot) Baseline mean
Fe (Tot) TARP [mean +1SD]
Fe (Tot) TARP [mean +2SD]
LW901
LW902
LW903
Above LOR
Below LOR
NR2
Total Manganese (mg/L)
Monthly rainfall (mm)
Mn (Tot) Baseline mean
Mn (Tot) TARP [mean +1SD]
Mn (Tot) TARP [mean +2SD]
LW901
LW902
LW903
Above LOR
Below LOR
NR2
Dissolved Zinc (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR
NR2
Dissolved Sulfate (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR

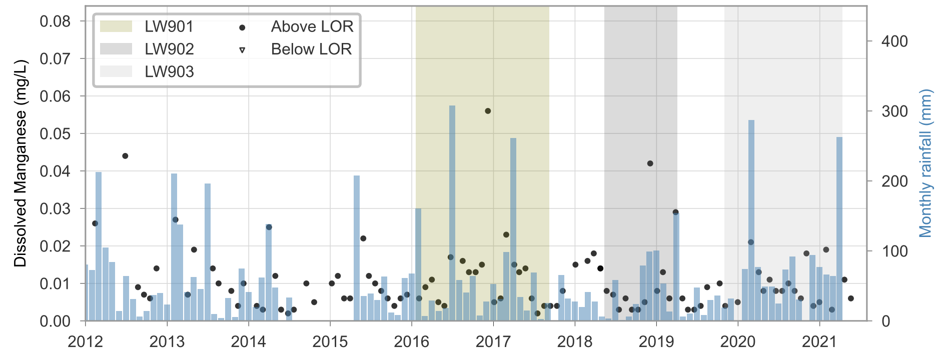

NR3
Dissolved Iron (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR
NR3
Dissolved Manganese (mg/L)
Monthly rainfall (mm)
NR3
Total Iron (mg/L)
Monthly rainfall (mm)
NR3
Total Manganese (mg/L)
Monthly rainfall (mm)
NR3
Dissolved Zinc (mg/L)
Monthly rainfall (mm)
NR3
Dissolved Sulfate (mg/L)
Monthly rainfall (mm)


NR10
Dissolved Iron (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR
NR10
Dissolved Manganese (mg/L)
Monthly rainfall (mm)
NR10
Total Iron (mg/L)
Monthly rainfall (mm)
NR10
Total Manganese (mg/L)
Monthly rainfall (mm)
NR10
Dissolved Zinc (mg/L)
Monthly rainfall (mm)
NR10
Dissolved Sulfate (mg/L)
Monthly rainfall (mm)

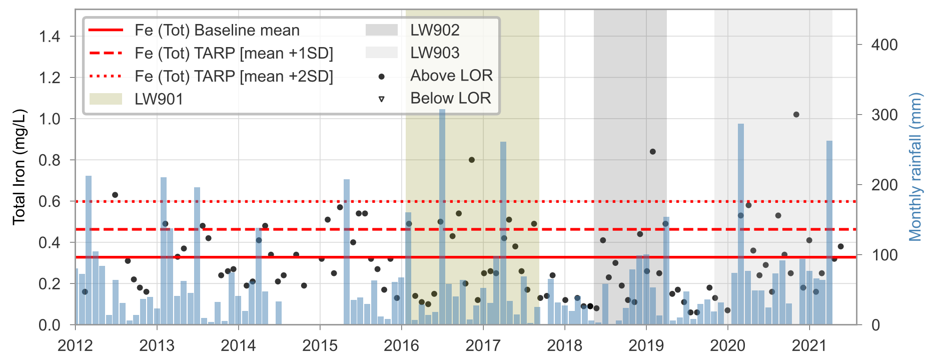
NR110



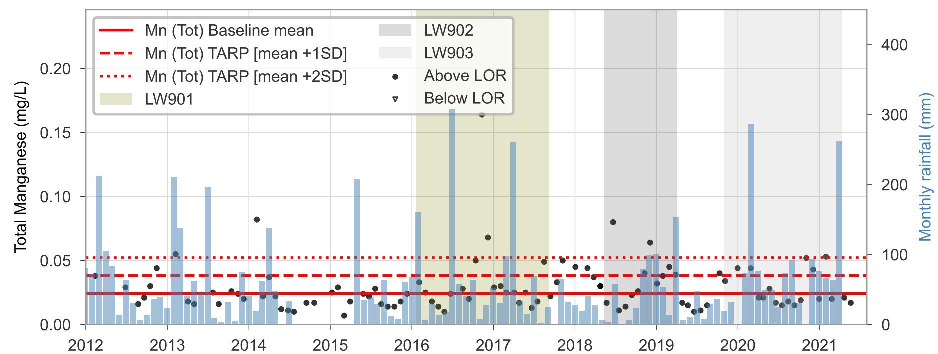
NR110



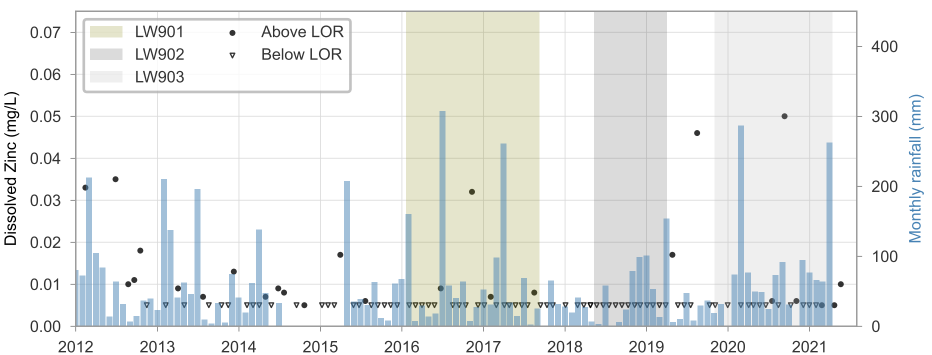
NR110



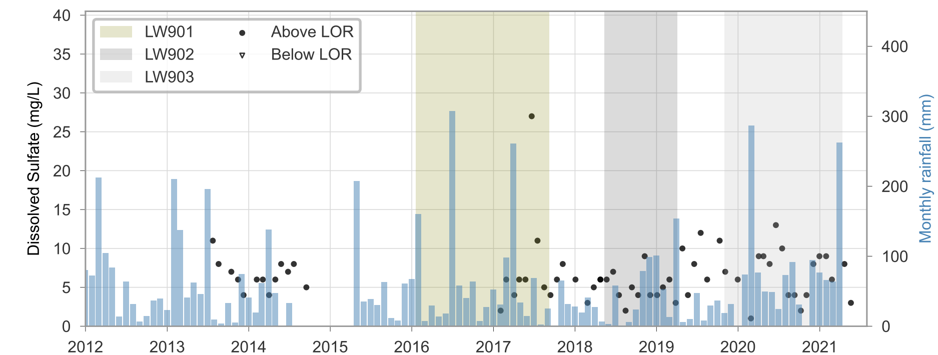
NR110

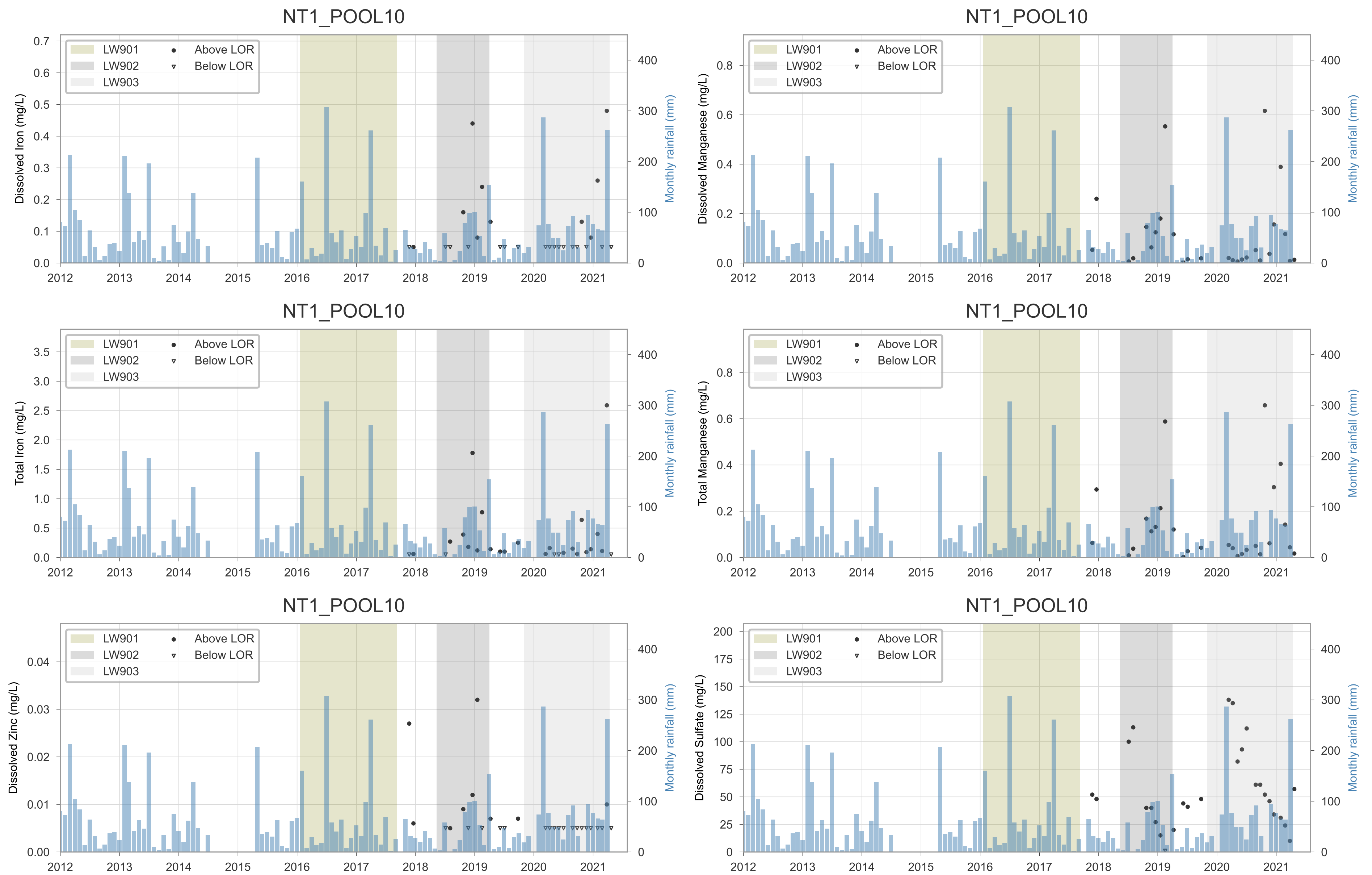


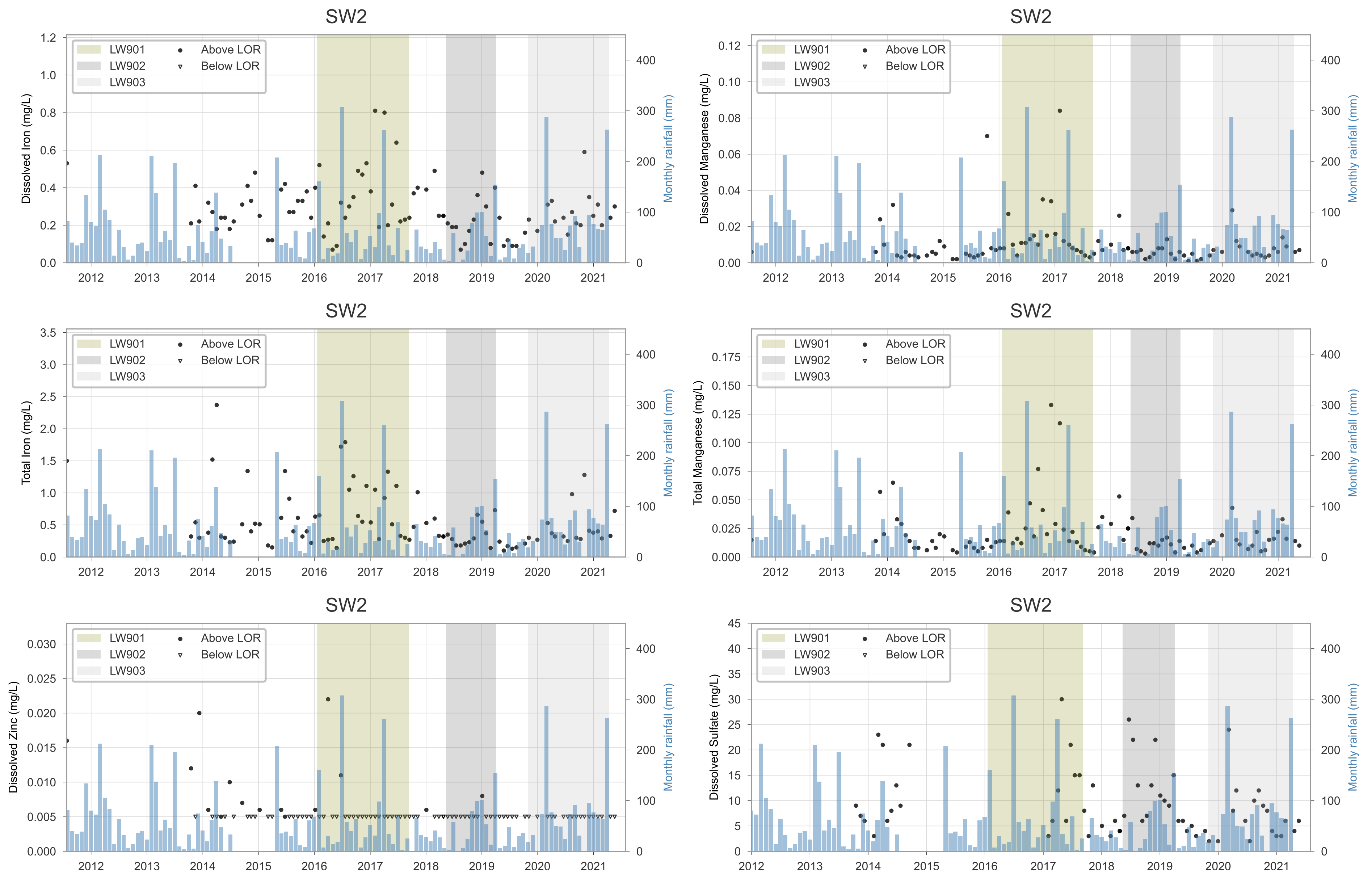
NR110

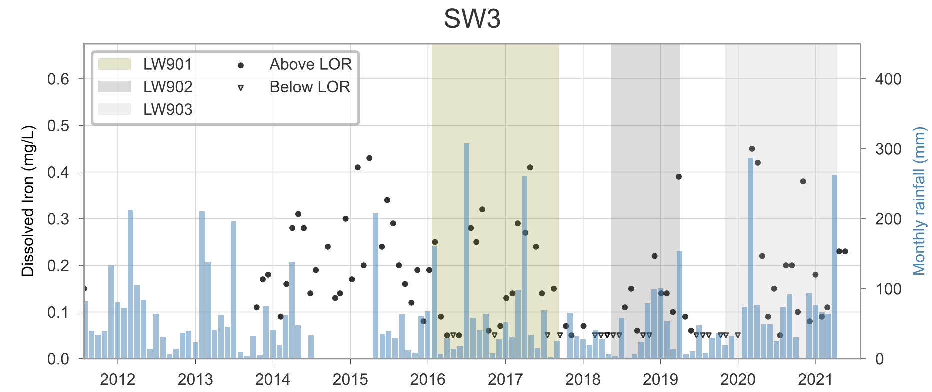


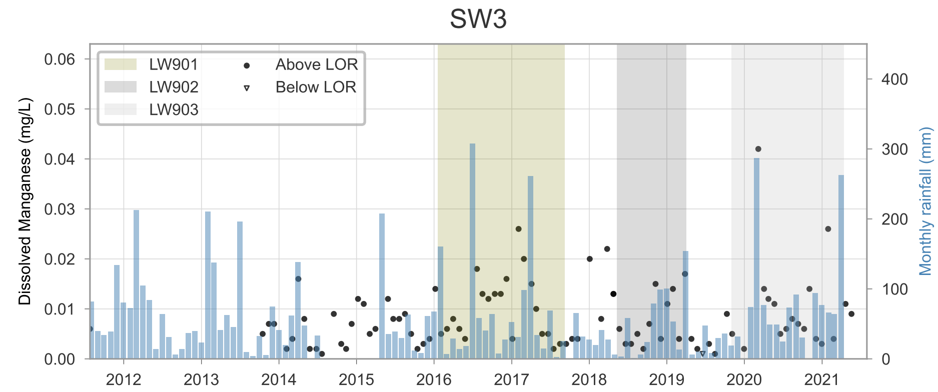
NR110

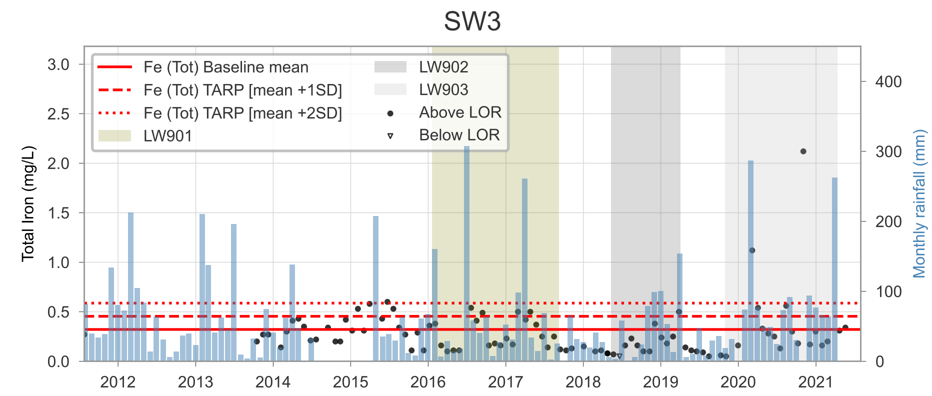


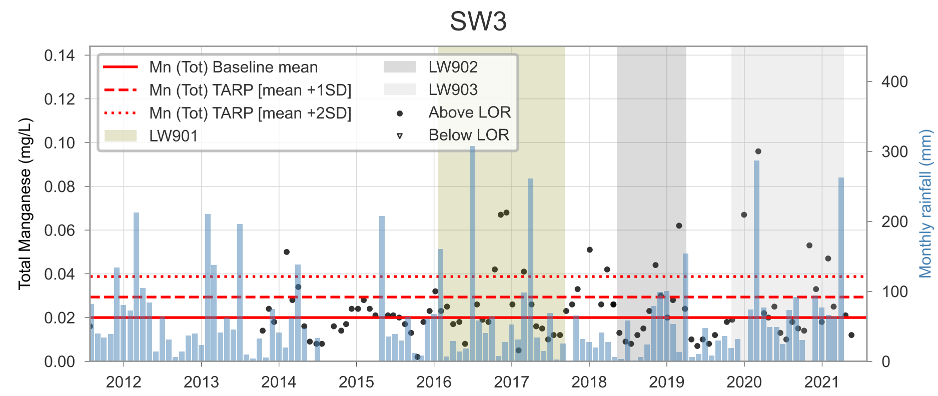

NT1_POOL10
LW901
LW902
LW903
Above LOR
Below LOR
Dissolved Iron (mg/L)
Monthly rainfall (mm)
NT1_POOL10
Dissolved Manganese (mg/L)
NT1_POOL10
Total Iron (mg/L)
NT1_POOL10
Total Manganese (mg/L)
NT1_POOL10
Dissolved Zinc (mg/L)
NT1_POOL10
Dissolved Sulfate (mg/L)

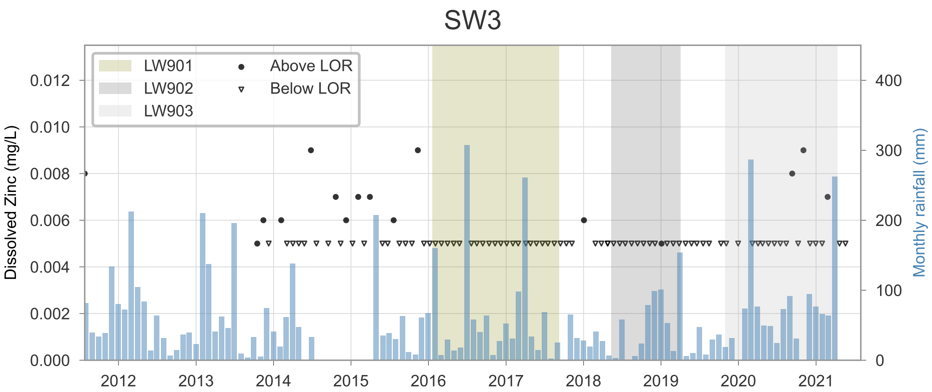

SW2
LW901
LW902
LW903
Above LOR
Below LOR
Dissolved Iron (mg/L)
Monthly rainfall (mm)
SW2
Dissolved Manganese (mg/L)
Monthly rainfall (mm)
SW2
Total Iron (mg/L)
Monthly rainfall (mm)
SW2
Total Manganese (mg/L)
Monthly rainfall (mm)
SW2
Dissolved Zinc (mg/L)
Monthly rainfall (mm)
SW2
Dissolved Sulfate (mg/L)
Monthly rainfall (mm)

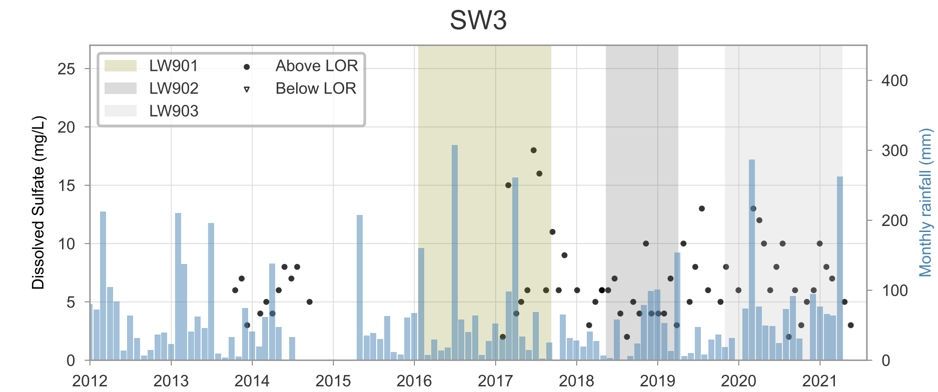

SW3
Dissolved Iron (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR

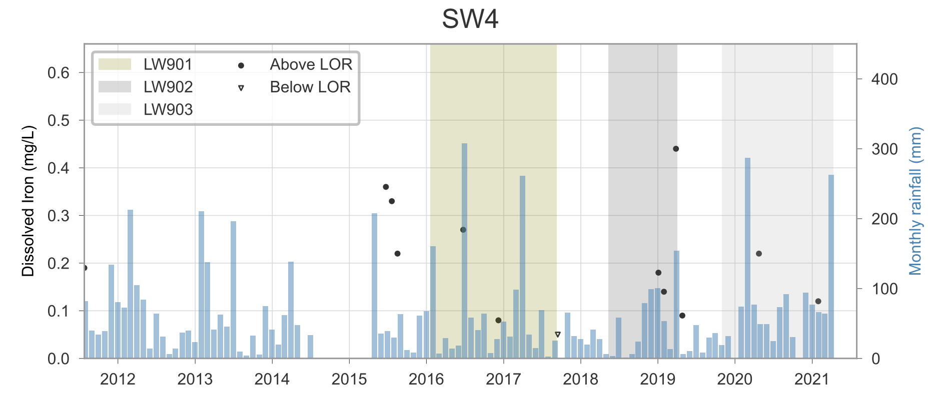

SW3
Dissolved Manganese (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR

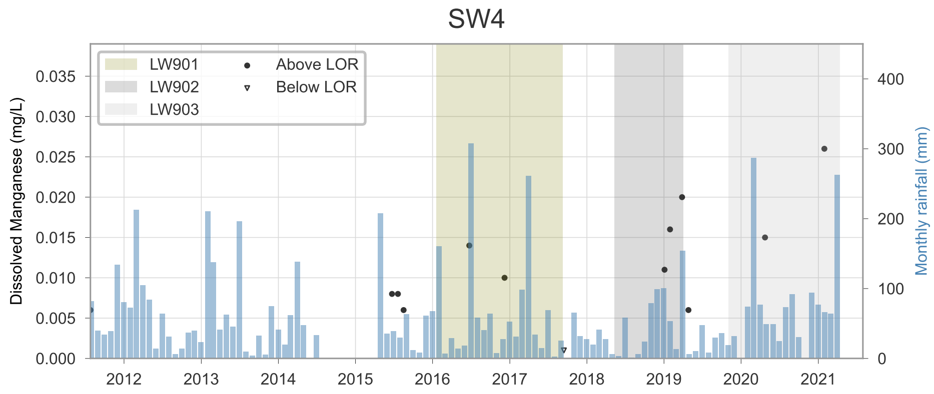

SW3
Total Iron (mg/L)
Monthly rainfall (mm)
Fe (Tot) Baseline mean
Fe (Tot) TARP [mean +1SD]
Fe (Tot) TARP [mean +2SD]
LW901
LW902
LW903
Above LOR
Below LOR

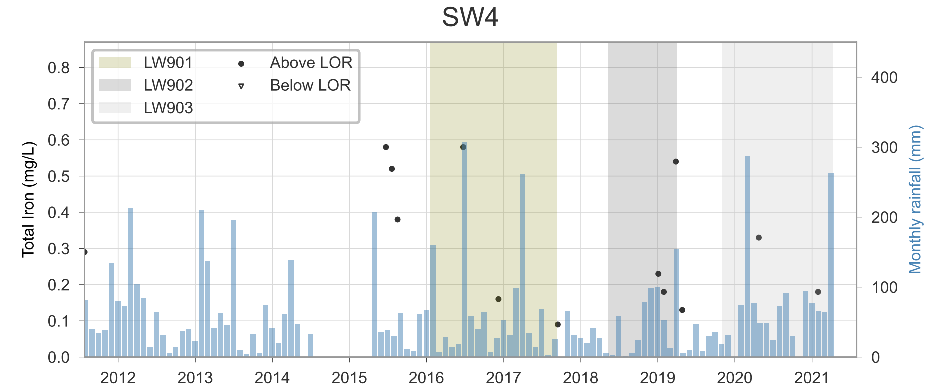

SW3
Total Manganese (mg/L)
Monthly rainfall (mm)
Mn (Tot) Baseline mean
Mn (Tot) TARP [mean +1SD]
Mn (Tot) TARP [mean +2SD]
LW901
LW902
LW903
Above LOR
Below LOR

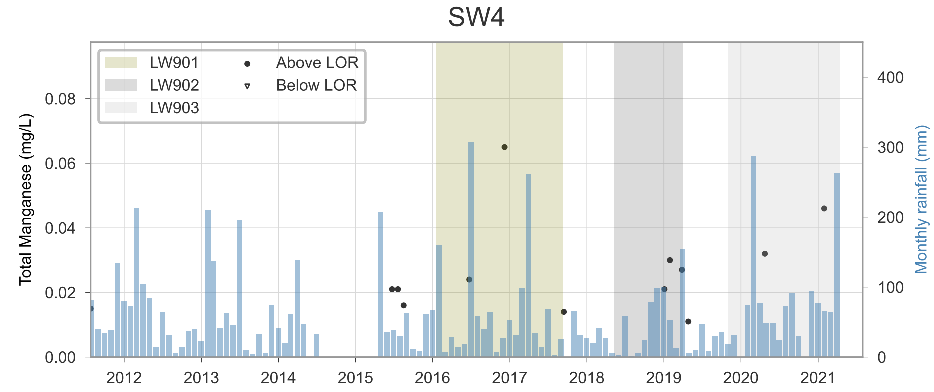

SW3
Dissolved Zinc (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR

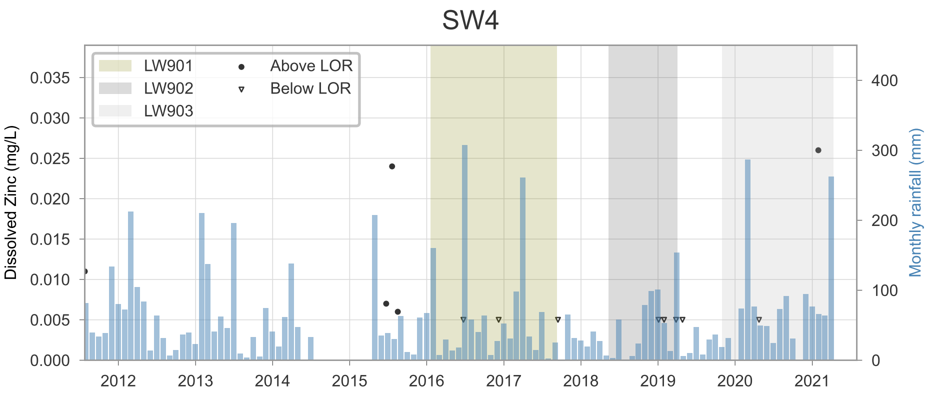

SW3
Dissolved Sulfate (mg/L)
Monthly rainfall (mm)
LW901
LW902
LW903
Above LOR
Below LOR

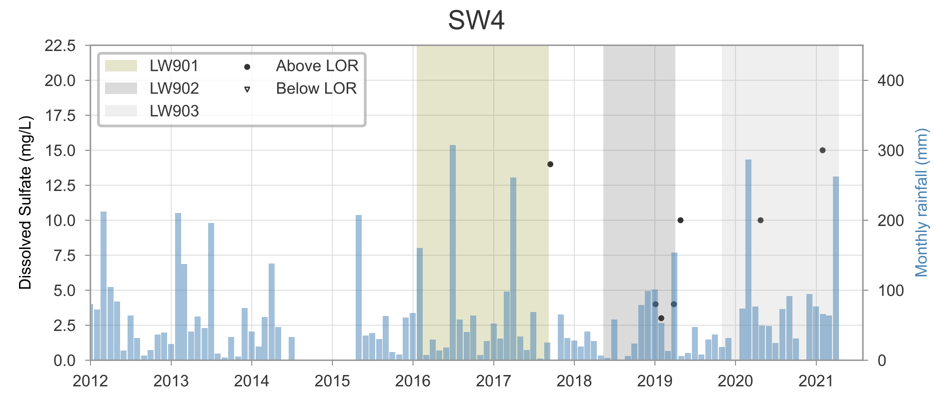

SW4
LW901
LW902
LW903
Above LOR
Below LOR
Dissolved Iron (mg/L)
Monthly rainfall (mm)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021


SW4
LW901
LW902
LW903
Above LOR
Below LOR
Dissolved Manganese (mg/L)
Monthly rainfall (mm)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021


SW4
LW901
LW902
LW903
Above LOR
Below LOR
Total Iron (mg/L)
Monthly rainfall (mm)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021


SW4
LW901
LW902
LW903
Above LOR
Below LOR
Total Manganese (mg/L)
Monthly rainfall (mm)
0.00
0.02
0.04
0.06
0.08
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021


SW4
LW901
LW902
LW903
Above LOR
Below LOR
Dissolved Zinc (mg/L)
Monthly rainfall (mm)
0.000
0.005
0.010
0.015
0.020
0.025
0.030
0.035
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021


SW4
LW901
LW902
LW903
Above LOR
Below LOR
Dissolved Sulfate (mg/L)
Monthly rainfall (mm)
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
0
100
200
300
400
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021

APPENDIX 4 – Surface water chemistry TARP summary

Water quality TARP assessment

Month_End	Site_ID	EC_max	pH_max	DO_max	Fe_tot_max	Mn_tot_ma	EC_TARP	pH_TARP	DO_TARP	Fe_tot_TAR	Mn_tot_TAR
30/11/2019	NR110	675	8.71	93.8	0.13	0.034	2				
31/12/2019	NR110	566	8.64	88.5	0.07	0.044	2				1
31/01/2020	NR110	721	8.64	71.9			2				
29/02/2020	NR110	104	7.56	104	0.53	0.044				1	1
31/03/2020	NR110	217	7.17	90.3				1			
30/04/2020	NR110	552	7.84	78.3	0.58	0.021	2			1	
31/05/2020	NR110	583	8.08	81.3	0.24	0.028	2				
30/06/2020	NR110	631	7.99	91.3	0.29	0.017	2				
31/07/2020	NR110	687	8.07	93.7	0.16	0.015	2				
31/08/2020	NR110	95	7.67	101.2	0.53	0.018				1	
30/09/2020	NR110	233	8.36	92.5	0.34	0.015					
31/10/2020	NR110	245	8.19	94.3	0.25	0.019					
30/11/2020	NR110	164	7.62	84.4	1.02	0.052				2	1
31/12/2020	NR110	436	8.08	84	0.41	0.043	2				1
31/01/2021	NR110	452	7.72	57	0.16	0.053	2		1		2
28/02/2021	NR110	526	8.39	95.5	0.25	0.02	2				
31/03/2021	NR110										
30/04/2021	NR110	251	7.61	99.4	0.32	0.021					
31/05/2021	NR110	106	7.73	98.8	0.38	0.017					
30/11/2019	NR0	683	8.48	83	0.09	0.025	1				
31/12/2019	NR0	523	8.4	85.3	0.08	0.041					
31/01/2020	NR0	681	8.44	75.5			1		1		
29/02/2020	NR0										
31/03/2020	NR0	326	7.45	105.8	1.08	0.097				2	2
30/04/2020	NR0	524	7.76	90.7	0.53	0.02				1	
31/05/2020	NR0	567	8.34	95.5	0.2	0.015					
30/06/2020	NR0	608	8.16	91.2	0.26	0.014	1				
31/07/2020	NR0	714	8.21	94.2	0.14	0.011	1				
31/08/2020	NR0										
30/09/2020	NR0	218	8.13	110.4	0.32	0.013					
31/10/2020	NR0	253	8.01	77.5	0.18	0.013			1		
30/11/2020	NR0	174	7.91	113.1	1.98	0.053				2	
31/12/2020	NR0	530	8.26	83.4	0.27	0.035					
31/01/2021	NR0	384	8.06	60.9	0.4	0.064			2		1
28/02/2021	NR0	488	8.06	91.6	0.26	0.026					
31/03/2021	NR0										
30/04/2021	NR0	189	7.78	102.9	0.32	0.022					
31/05/2021	NR0	109	7.8	98.8	0.36	0.015					
30/11/2019	SW3	670	8.45	75.8	0.05	0.019	2				
31/12/2019	SW3	516	8.61	98.8	0.16	0.067	2				2
31/01/2020	SW3	676	8.49	93.4			2				
29/02/2020	SW3										
31/03/2020	SW3	323	7.44	95.9	1.12	0.096		1		2	2
30/04/2020	SW3	528	7.65	93.5	0.54	0.022	2			1	
31/05/2020	SW3	568	8.32	85.2	0.28	0.025	2				
30/06/2020	SW3	602	8.05	88.4	0.25	0.013	2				
31/07/2020	SW3	731	8.25	91.5	0.13	0.01	2				
31/08/2020	SW3	89	8.06		0.56	0.018				1	
30/09/2020	SW3	218	8.23	104.7	0.3	0.015					
31/10/2020	SW3	256	7.75	80.02	0.18	0.014					
30/11/2020	SW3	175	7.82	109	2.12	0.053				2	2
31/12/2020	SW3	531	8.24	85.1	0.3	0.033	2				1
31/01/2021	SW3	384	8.08	56.2	0.16	0.047	1		2		2
28/02/2021	SW3	484	8.47	94.2	0.2	0.025	2				
31/03/2021	SW3										
30/04/2021	SW3	193	7.28	95.2	0.31	0.021		2			
31/05/2021	SW3	108	7.78	99	0.34	0.012					
30/11/2019	NR2	618	8.33	89.1	0.05	0.003					
31/12/2019	NR2	486	8.62	91.7	0.11	0.02					
31/01/2020	NR2	631	8.29	95.3							
29/02/2020	NR2										
31/03/2020	NR2	225	7.26	92.8	0.75	0.062		1		1	1
30/04/2020	NR2	486	7.67	89.6	0.51	0.034					
31/05/2020	NR2										
30/06/2020	NR2	575	8.09	83.9	0.2	0.016					
31/07/2020	NR2	712	8.38	90.2	0.16	0.014	1				
31/08/2020	NR2	92	7.3		0.56	0.018		1			
30/09/2020	NR2	208	8.07	98.2	0.3	0.019					
31/10/2020	NR2	275	8.11	83	0.2	0.015					
30/11/2020	NR2	182	7.86	118.1	2.43	0.056				2	
31/12/2020	NR2	598	8.4	81.4	0.29	0.05					
31/01/2021	NR2	461	8.36	66	0.43	0.063			1		1
28/02/2021	NR2	468	8.49	88.7	0.45	0.064					1
31/03/2021	NR2										
30/04/2021	NR2	157	7.99	98.9	0.38	0.039					
31/05/2021	NR2	112	7.8	95.6	0.43	0.027					

TARPs triggered		EC	pH	DO	Fe (total)	Mn (Total)
NR110	Upstream control site	2				1
NR0		1			1	
SW3		2			1	1
NR2						1