Transport
Roads & Maritime Services

Nambucca Heads to Urunga Pacific Highway Upgrade

Water Quality Monitoring Annual Report

Roads and Maritime Services | August 2019

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Water Quality Monitoring Annual Report – August 2019

Report Prepared for:

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Prepared By:

Aquatic Science and Management

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1 Introduction

1.1 Introduction and Background

The Pacific Highway upgrade between Nambucca Heads and Urunga is operational. Monitoring of surface and groundwater quality has been ongoing in the pre-construction and construction phases and is to be undertaken for the first three years of operation according to the Surface Water Monitoring Program (GeoLINK 2013a) and the Groundwater Monitoring Program (GeoLINK 2013b).

This document presents the surface water and groundwater monitoring results obtained between 1 September 2018 and 31 August 2019 for the Pacific Highway upgrade between Nambucca Heads and Urunga (NH2U upgrade).

1.1.1 Aims and Objectives

The objective of ongoing surface water and groundwater monitoring is to evaluate the impact of the Pacific Highway upgrade on water quality in the relevant waterways and aquifers from Nambucca Heads to Urunga and to comply with the Department of Planning and Environment (DP&E) Ministers condition of approval B17 (MCoA B17).

RMS and the NSW government both have stated commitments and objectives with respect to the preservation of surface and groundwater quality, levels and flow. These are met by the general objective of the Statement of Commitment No. W3:- *Monitoring of groundwater impacts and surface water quality upstream and downstream of the site during construction will determine the effectiveness of mitigation strategies. Implementation of additional feasible and reasonable management measure will occur if necessary.*

Ministers Condition of Approval (MP 07_0112) B17, required RMS *to prepare and implement a Water Quality Monitoring Program to monitor the impacts of the project on SEPP 14 wetlands, surface water quality and groundwater resources during construction and operation.* In accordance with MCoA B17, RMS prepared and the Department of Planning and Environment approved the Surface Water Monitoring Program (SWMP) and the Groundwater Monitoring Program (GMP) . These documents provide guidance to:

- Monitor the impacts of the project on SEPP 14 wetlands, surface water quality and groundwater resources during construction and operation;

- Have provisions to provide RMS with timely advice about surface and groundwater quality and how they compare to relevant and appropriate guideline levels;

The aim of this report is to provide a summary of water quality sampling and analysis activities for the 2019 annual reporting period (1 September 2018 – 31 August 2019). This report is required to comply with DP&E MCoA B17.

1.2 Water Quality Guidelines and Objectives

There are a variety of guidelines available for the comparison and assessment of results obtained from surface water and groundwater sampling. Choosing appropriate guidelines to assess water quality depends on the environmental values of the site, human uses, the objectives for water quality, the level of protection required for the site and the issues and associated risks present.

Most often, guidelines are derived from the Australian and New Zealand Environment Conservation Council (ANZECC) Guidelines for Water Quality (ANZECC 2000), The Australian Drinking Water Guidelines (National Health and Medical Research Council (NHMRC) 2013) and the Guidelines for Managing Risks in Recreational Waters (NHMRC 2011).

In the case of large datasets collected regularly over time and with an appropriate sampling design the ANZECC Guidelines suggest the use of median and 80th percentile (P80) concentrations from the collected data as guideline values. The SWMP and the GMP employ a before/after, control/impact (BACI) sampling design to assess the impact of the highway upgrade on water quality. They recommend the use of the median values from the impact (downstream) sites and the P80 values from the control (upstream) sites for assessing impacts with the intention of informing ongoing management of water quality.

The ANZECC guidelines prescribe default guideline values for many water quality parameters. The individual values depend on the desired use of the water, perceived values of the water and the level of protection required. The default guideline values are intended to trigger further water quality investigations and to be used where there is an absence of locally derived guideline values. The ANZECC default guideline concentrations will be used in this report for providing context where potential impacts upon surface water and groundwater from highway operation are identified. The relevant ANZECC guideline concentrations are presented in **Table 1.1**.

The Australian Drinking Water Guidelines (ADWG, NHMRC 2013) provide guideline values for many water quality parameters that have potential impacts upon human health. In accordance with the Guidelines for the Assessment and Management of Groundwater Contamination (DEC 2007) the ADWG guidelines will be used in conjunction with the relevant ANZECC guidelines to provide quantitative context where potential impacts upon groundwater from highway operation are identified. Importantly, results that exceed the ANZECC and ADWG guidelines are not necessarily an indication of an impact. The relevant ADWG concentrations are presented in **Table 1.1**.

Table 1.1 Available ANZECC and ADWG guideline concentrations for relevant parameters

Parameter	***ANZECC Guideline Concentrations for Aquatic Ecosystem Protection (95% of spp.) in moderately disturbed ecosystems***		***ADWG Concentrations***
	Freshwater	***Marine***	
Silver (µg/L)	0.05	1.4	100
Aluminium (µg/L)	55	0.5[a]	200[b]
Antimony	9	270	3
Arsenic (V) (µg/L)	13	4.5[a]	10
Cadmium (µg/L)	0.2	5.5	2
Chromium (VI) (µg/L)	1.0	4.4	50
Copper (µg/L)	1.4	1.3	2000
Iron (µg/L)	-	-	300[b]
Manganese (µg/L)	1900	-	500
Nickel (µg/L)	11	7	20
Lead (µg/L)	3.4	4.4	10
Selenium (µg/L)	5	-	10
Zinc (µg/L)	8.0	15	300[b]
Mercury (µg/L)	0.05	0.1	1
Total Nitrogen in water (mg/L)	0.5	0.3	-
Nitrite as N in water (mg/L)	0.04(NOx)	0.015(NOx)	3
Nitrate as N in water (mg/L)	0.04(NOx)	0.015(NOx)	50
Ammonia as N in water (mg/L)	0.02	0.015	0.5[b]
Total Phosphorus (mg/L)	0.05	0.03	-
Phosphate as P in water (mg/L)	0.02	0.005	-
Total Suspended Solids (mg/L)	-	-	-
Temperature (°C)	-	-	-
pH	6.5 – 8.0	7.0 – 8.5	6.5 – 8.5
Conductivity (mS/cm)	0.125 – 2.2	-	-
Turbidity (NTU)	6 - 50	0.5 - 10	5[b]
Dissolved Oxygen (% sat)	85-110% saturation	80 – 110% saturation	85% saturataion[b]

a – ANZECC low reliability trigger

b – No health-based guideline value, aesthetic value applied.

2 Methods

2.1 Locations

2.1.1 Surface Water Monitoring Sites

There are eleven surface water locations (20 sites) where ongoing surface water monitoring is required. Maps of the site locations are presented in **Illustrations 2.1 to 2.4** (GeoLINK 2013a). The locations (from south to north) are as follows:

- Boggy Creek, approximate chainage 62700, sites SW208U and SW208D
- Cow Creek, approximate chainage 63600, sites SW217U and SW217D
- Deep Creek, approximate chainage 65000, sites SW231U and SW231D
- Unnamed Tributary of Oyster Creek, approximate chainages 68000 and 68100, Sites SW261 and SW262
- McGraths Creek, approximate chainage 72000, sites SW301U and 3SW01D
- Dalhousie Creek, approximate chainage 73400, sites SW315U and SW315D
- Kalang River, approximate chainage 77800, sites SW359U and SW359D
- Unnamed Tributary of SEPP Wetland No 353, approximate chainage 77900, sites SW360U and SW360D
- Unnamed Tributary of SEPP Wetland No 351, approximate chainage 79900 and 80000, sites SW380 and SW381
- SEPP Wetland No. 353, approximate chainage 78000, site SW353
- SEPP Wetland No. 351, approximate chainage 80900, site SW351

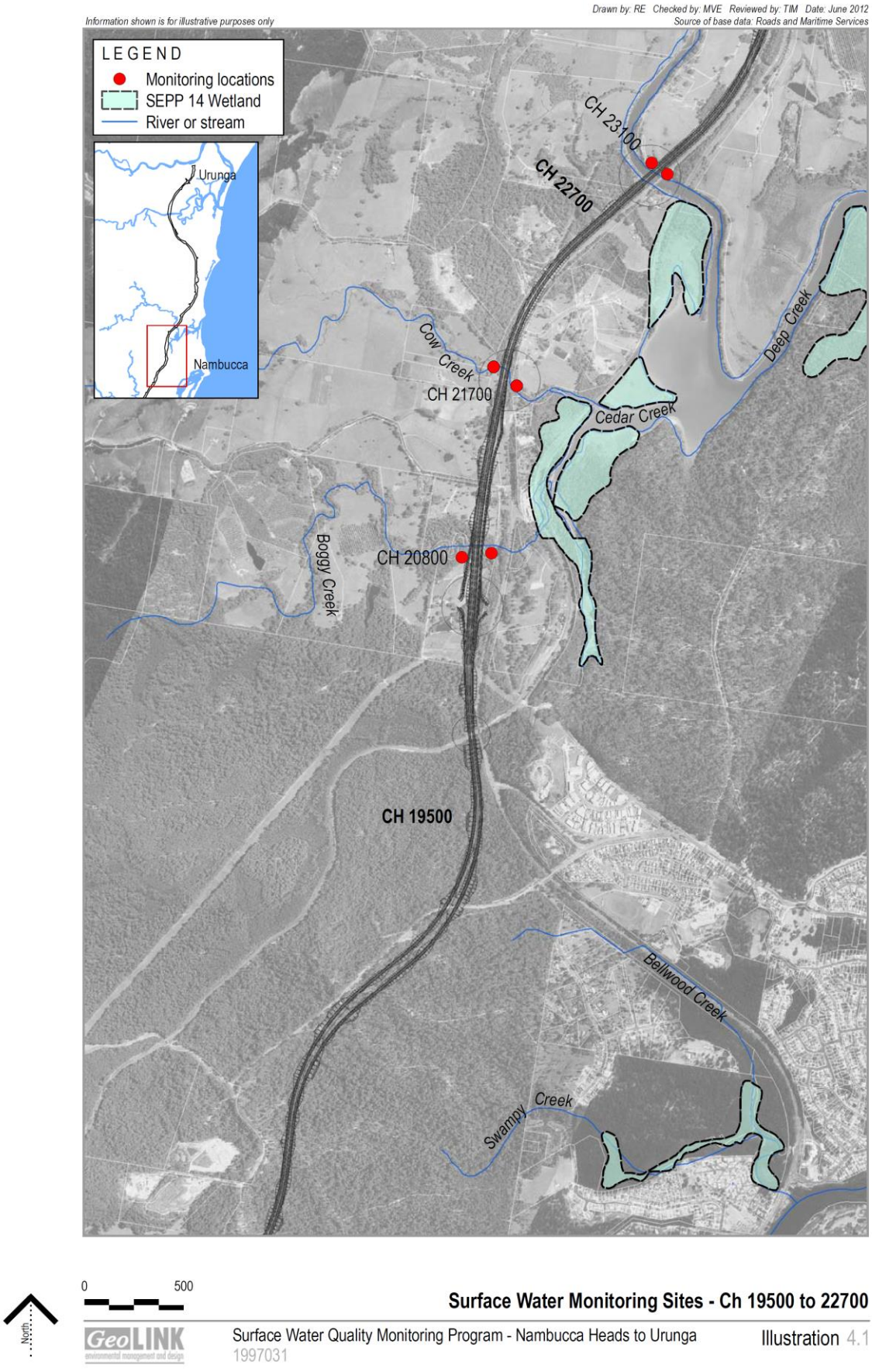


Illustration 2.1 Surface water monitoring sites – Ch 19500 to 22700 (GeoLINK 2013a)

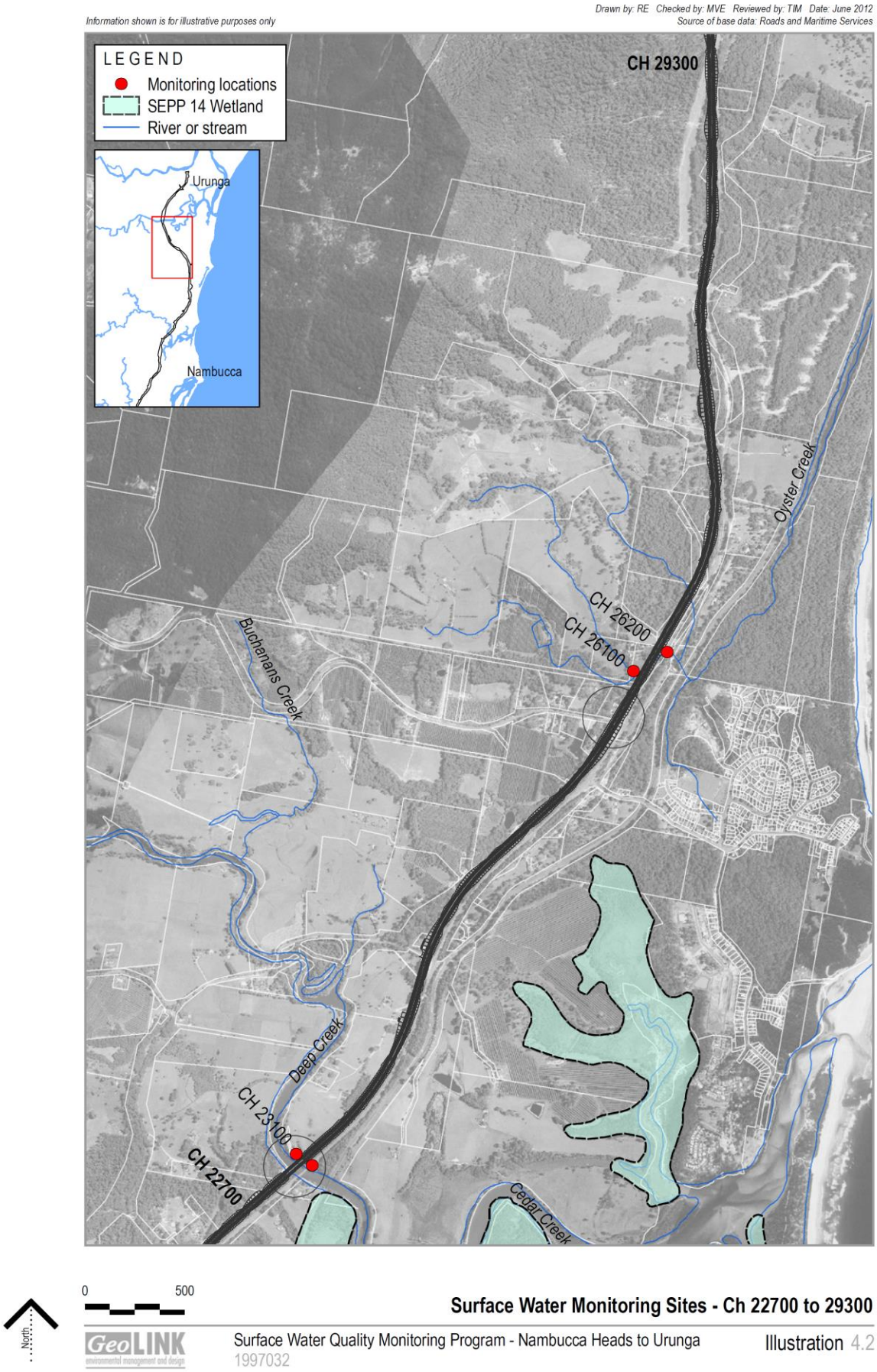


Illustration 2.2 Surface water monitoring sites – Ch 22700 to 29300 (GeoLINK 2013a)

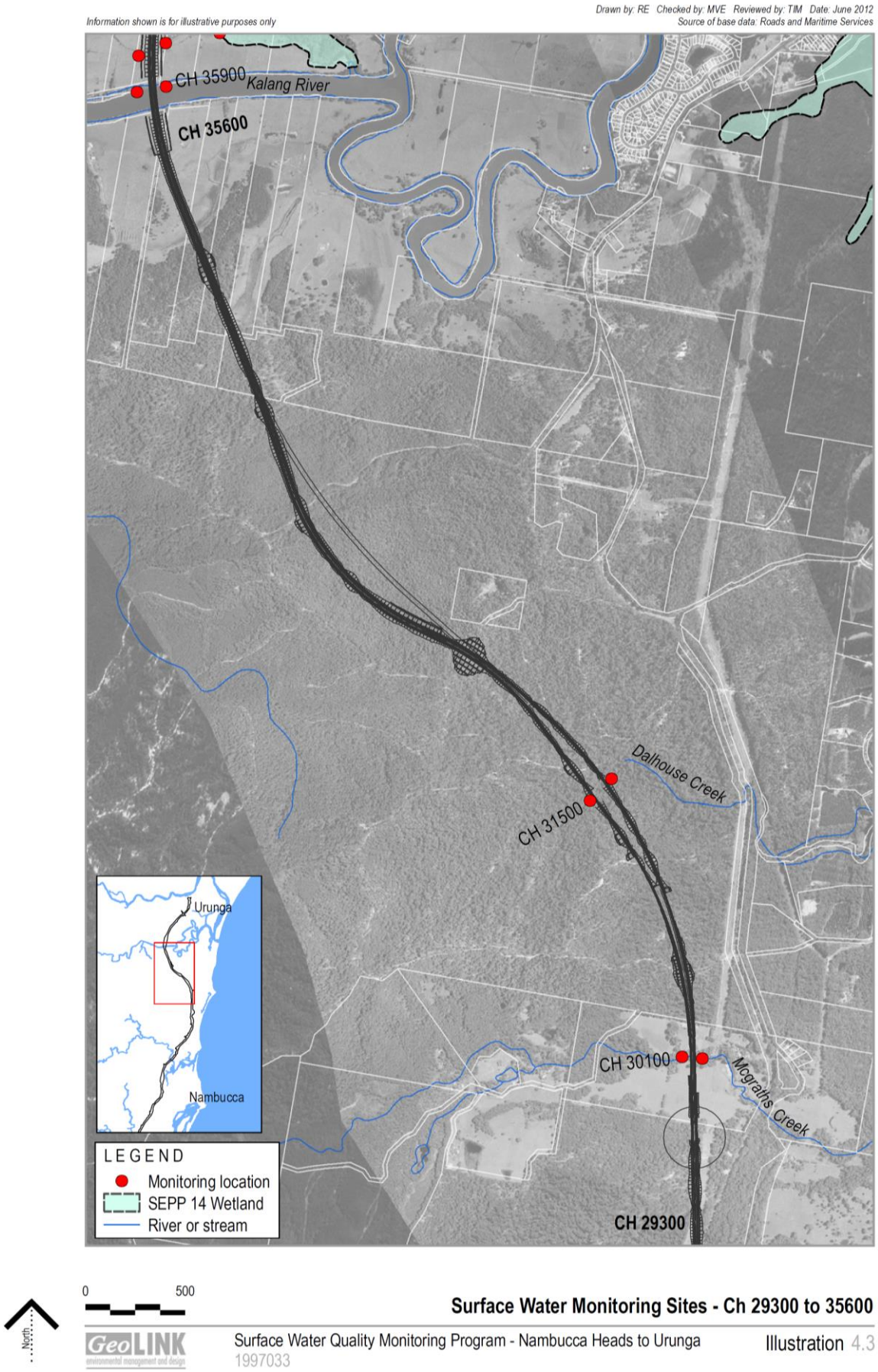


Illustration 2.3 Surface water monitoring sites – Ch 29300 to 35600 (GeoLINK 2013a)

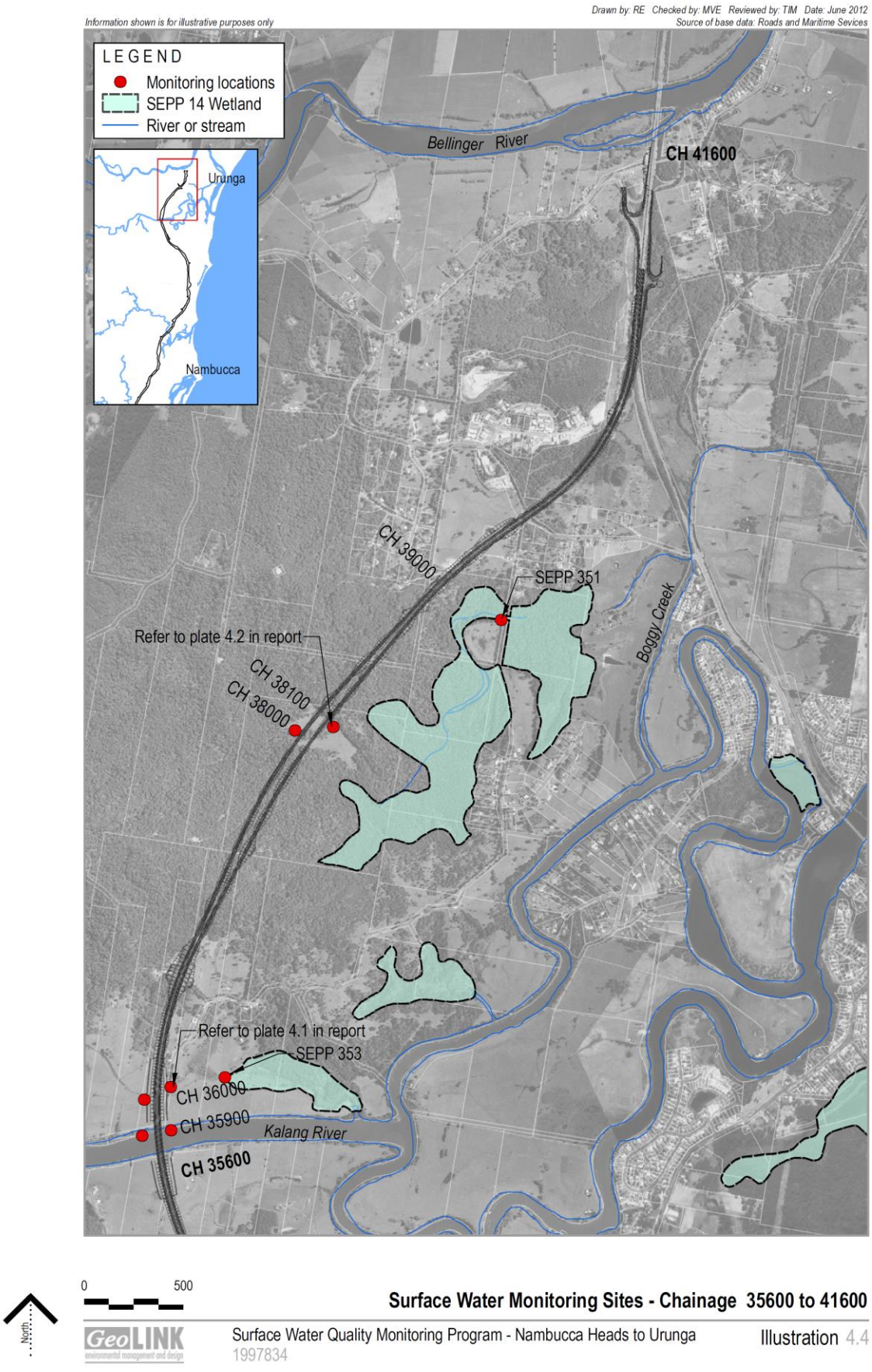


Illustration 2.4 Surface water monitoring sites – Ch 35600 to 41600 (GeoLINK 2013a)

2.1.2 Groundwater Monitoring Sites

There are six locations (11 piezometers) where ongoing groundwater monitoring is required. Maps of the site locations are presented in **Illustrations 2.5 to 2.7** (GeoLINK 2013b). The locations (from south to north) are as follows:

- Cutting No 3.5, approximate chainage 63200
- Fill upslope of SEPP Wetland No. 357, approximate chainage 64600
- Cutting No. 4.2, approximate chainage 72400
- Cutting No. 4.5, approximate chainage 74400
- Cutting No. 4.7, approximate chainage 75500
- Cutting No. 4.10, approximate chainage 78500

Monitoring at Cutting No. 4.14 (approximate chainage 80700) ceased prior to the construction phase.

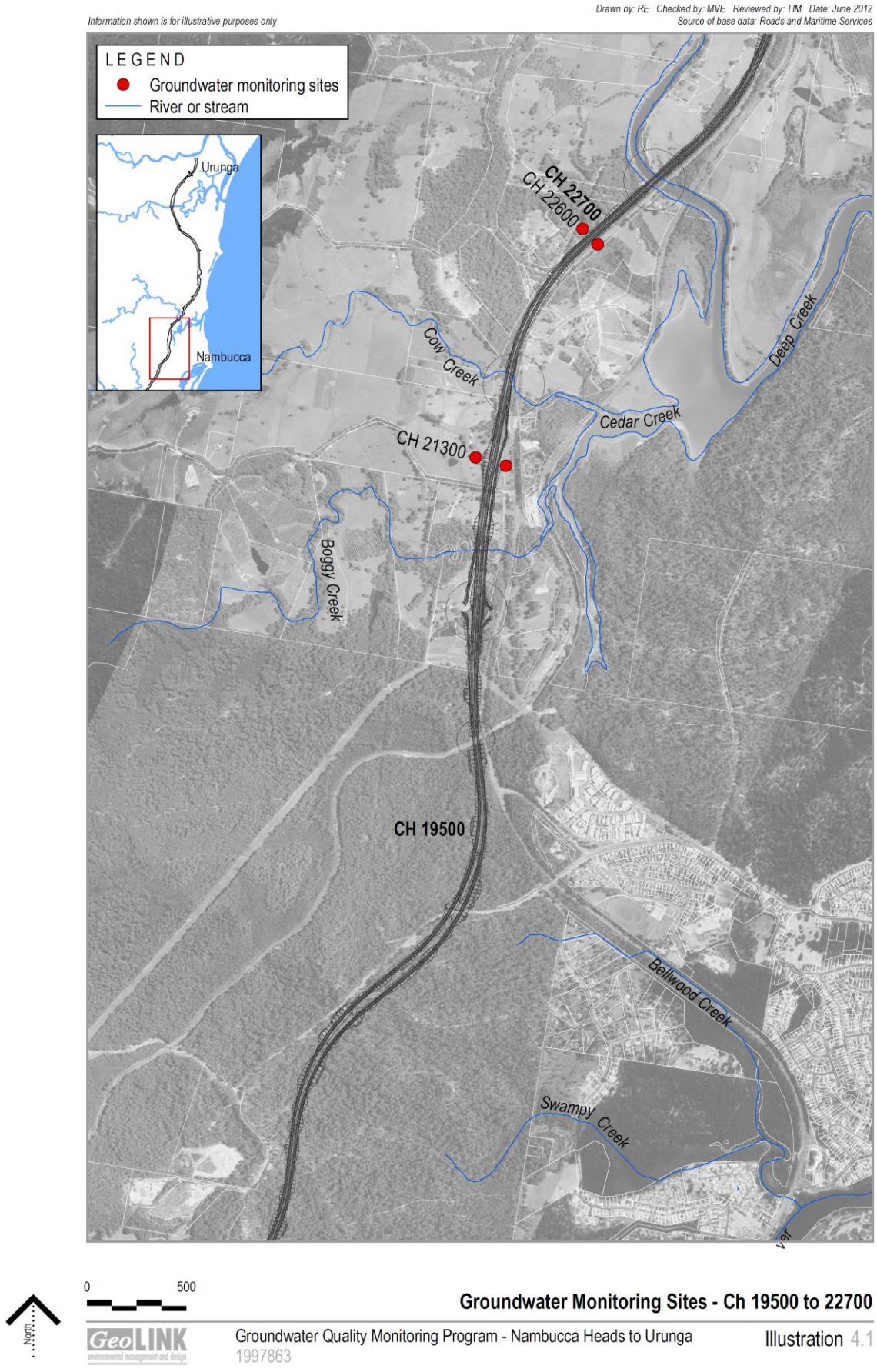


Illustration 2.5 Groundwater monitoring sites – Ch 19500 to 22700 (GeoLINK 2013b)

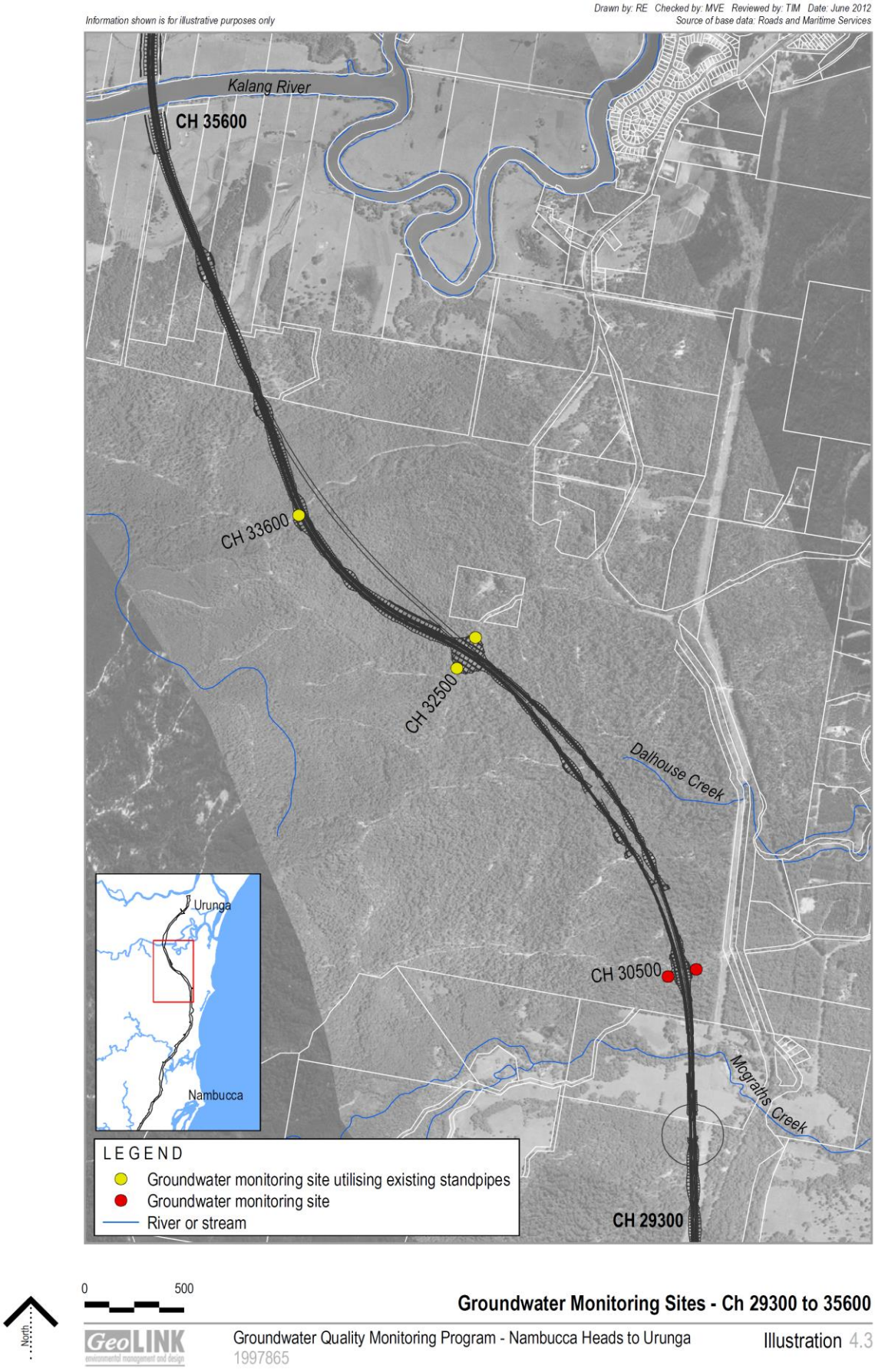


Illustration 2.6 Groundwater monitoring sites – Ch 29300 to 35600 (GeoLINK 2013b)

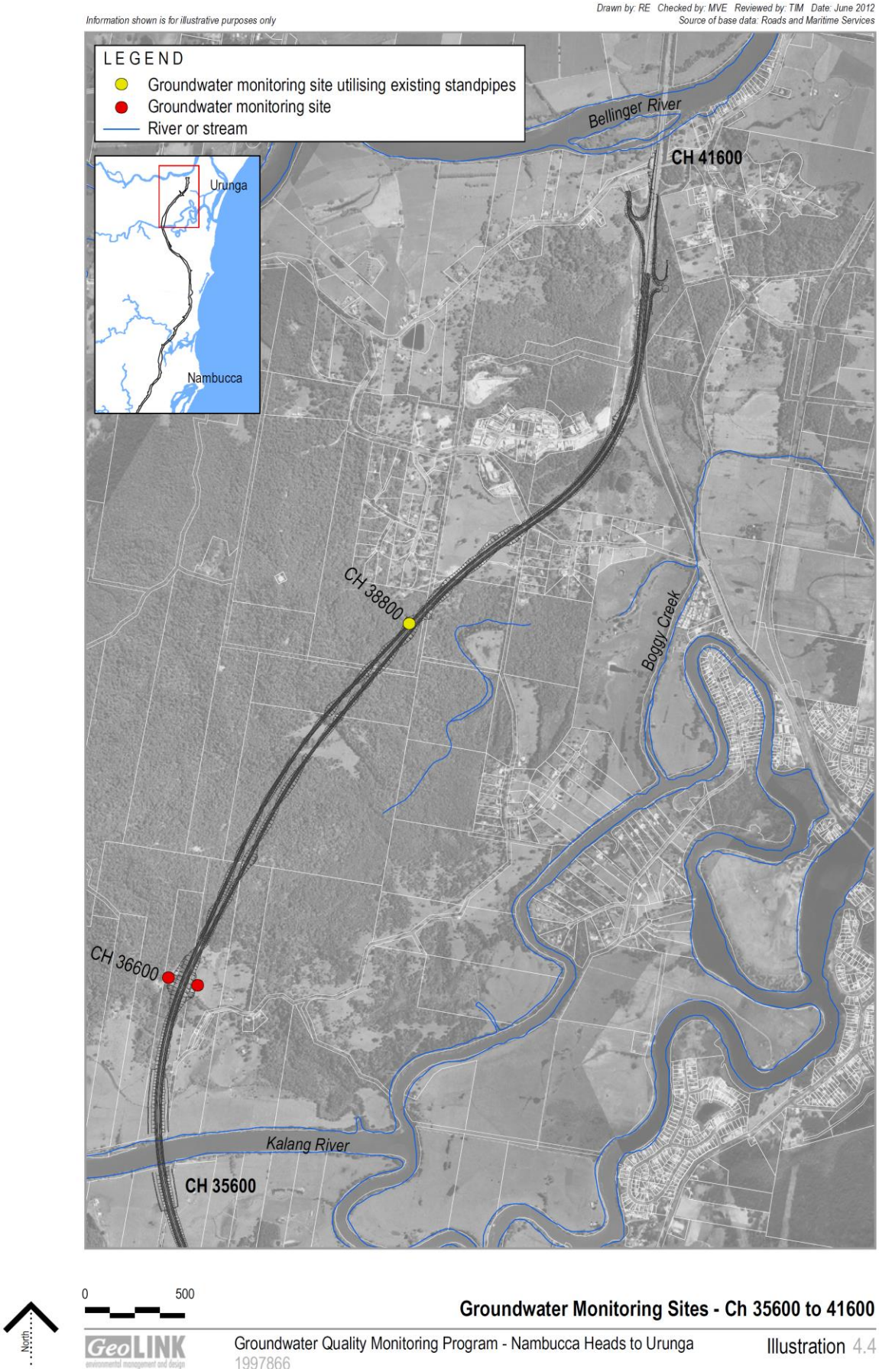


Illustration 2.7 Groundwater monitoring sites – Ch 35600 to 41600 (GeoLINK 2013b)

2.2 Sampling and Analysis

2.2.1 Surface Water Quality Monitoring

The SWMP outlines the parameters required for monitoring in the operational phase of the project. The requirement for monitoring of total petroleum hydrocarbons (TPH or TRH – total recoverable hydrocarbons) outlined in the SWMP was upgraded prior to the start of operational monitoring to include monitoring of a variety of hydrocarbon sub-groups. The complete list of parameters monitored is presented in **Table 2.1**.

Table 2.1 Surface water parameters for operational monitoring

Group	***Analytes***	***Method of Analysis***
Physicochemical	Temperature	Field measurement – HORIBA U52
	Electrical Conductivity (EC)	Field measurement – HORIBA U52
	pH	Field measurement – HORIBA U52
	Dissolved Oxygen (DO)	Field measurement – HORIBA U52
	Turbidity	Field measurement – HORIBA U52
	Total Suspended Solids (TSS)	Laboratory Analysis – Inorg-019
Hydrocarbons	Total Recoverable Hydrocarbons (TRH) C6 - C9	Laboratory Analysis – Org-016
	TRH C6 - C10	Laboratory Analysis – Org-016
	TRH C10 - C14	Laboratory Analysis – Org-003
	TRH C15 - C28	Laboratory Analysis – Org-003
	TRH C29 - C36	Laboratory Analysis – Org-003
	TRH >C10 - C16	Laboratory Analysis – Org-003
	TRH >C16 - C34	Laboratory Analysis – Org-003
	TRH >C34 - C40	Laboratory Analysis – Org-003
Metals	Copper (Cu)	Laboratory Analysis – Metals-022
	Lead (Pb)	Laboratory Analysis – Metals-022
	Cadmium (Cd)	Laboratory Analysis – Metals-022
	Zinc (Zn)	Laboratory Analysis – Metals-022
	Arsenic (As)	Laboratory Analysis – Metals-022
	Selenium (Se)	Laboratory Analysis – Metals-022
	Iron (Fe)	Laboratory Analysis – Metals-022
	Manganese (Mn)	Laboratory Analysis – Metals-022
	Silver (Ag)	Laboratory Analysis – Metals-022
	Chromium (Cr)	Laboratory Analysis – Metals-022
	Nickel (Ni)	Laboratory Analysis – Metals-022
	Aluminium (Al)	Laboratory Analysis – Metals-022
	Mercury (Hg)	Laboratory Analysis – Metals-021

Group	*Analytes*	*Method of Analysis*
Nutrients	Total Nitrogen (TN)	Laboratory Analysis – Inorg-055/062
	Total Phosphorus (TP)	Laboratory Analysis – Metals-020
	Nitrate (NO_3)	Laboratory Analysis – Inorg-055
	Nitrite (NO_2)	Laboratory Analysis – Inorg-055
	Ammonia (NH_4)	Laboratory Analysis – Inorg-057
	Phosphate (PO_4)	Laboratory Analysis – Inorg-060

The SWMP also defines the sampling frequency for operational monitoring, which started in September 2016. This is presented in **Table 2.2**. The pre-construction phase monitoring period was between September 2012 and February 2013. The construction phase monitoring period was between March 2013 and August 2016.

Table 2.2 Operational phase sample frequency (GeoLINK 2013a)

Period	*Dates*	*Parameters*	*Sample Frequency*
First & Second Year	September 2016 – August 2018	Physicochemical	1 wet sample monthly and 1 dry sample six-monthly
		Hydrocarbons, Metals, Nutrients and Solids	1 wet sample bi-monthly and 1 dry sample six-monthly
Third Year	September 2018 – August 2019	Physicochemical	1 wet sample bi-monthly and 1 dry sample six-monthly
		Hydrocarbons, Metals, Nutrients and Solids	1 wet sample six-monthly and 1 dry sample six-monthly
Fourth Year	September 2019 – June 2020	Physicochemical	1 wet sample six-monthly and 1 dry sample six-monthly
		Hydrocarbons, Metals, Nutrients and Solids	1 wet sample six-monthly and 1 dry sample six-monthly

The dates of surface water quality monitoring sampling for the third year operational phase monitoring are presented in **Table 2.3**.

One of the wet samples was not collected within the specified 2-month period of December 2018/January 2019. There were no suitable rainfall events in January 2019 and the suitable rainfall events in December 2018 were missed due to logistical reasons, including staff availability and laboratory holiday closures. In order to ensure this issue is not repeated in further monitoring extra staff availability has been arranged.

Table 2.3 Surface water sampling dates for third year operational phase sampling

Month	*Date*	*Sample Type*	*Parameters*				*Notes*
			Physicochemical	*Hydrocarbons*	*Metals*	*Nutrients*	
*Jul 2018	3/7/18	Wet	Y	Y	Y	Y	2nd year sample (previous report). All samples collected.
*Aug 2018	9/8/18	Dry	Y	Y	Y	Y	2nd year sample (previous report). Dalhousie Creek dry upstream and downstream.
Sep 2018	4/09/18	Wet	Y	N	N	N	3rd year sample. Dalhousie Creek dry upstream and downstream.
Oct 2018	6/10/18	Wet	Y	N	N	N	3rd year sample. Dalhousie Creek dry upstream and downstream.
	12/10/18	Wet	Y	N	N	N	3rd year sample. Catch - up sample for missed sample in 2nd year due to low rainfall. Dalhousie Creek dry upstream and downstream.
Dec 2018	-	-	-	-	-	-	No samples collected – lab closures and staff availability.
Jan 2018	-	-	-	-	-	-	No sample collected – lack of rainfall events in January 2019.
Feb 2018	22/02/19	Wet	Y	Y	Y	Y	3rd year sample. Catch-up for missed December – January sample. Dalhousie Creek dry upstream and downstream. Oyster Creek tributary dry upstream.
Mar 2018	18/03/19	Wet	Y	N	N	N	3rd year sample. All samples collected.
May 2018	17/05/19	Wet	Y	N	N	N	3rd year sample. All samples collected.
	29/05/19	Dry	Y	Y	Y	Y	3rd year sample. Dalhousie Creek upstream site dry.
Aug 2018	15/08/19	Dry	Y	Y	Y	Y	3rd year sample. Dalhousie Creek dry upstream and downstream. No suitable wet event

Highlighted samples collected during the current reporting period.
*** samples collected during the previous reporting period.**

Rainfall conditions at the time of sampling are presented in **Figure 3.1**.

During the operational phase monitoring surface waters were sampled from a depth of approximately 0.1 – 0.2 m. Samples were collected by dipping the sampling vessel into the water by sampling pole. Sample vessels were 500 mL plastic containers, sample rinsed three times. Separate 100 mL plastic containers pre-charged with acid were used for analyses of metals and separate 40 mL glass containers were used for hydrocarbon analyses.

All samples with a requirement for laboratory analysis were sent in cooled eskys by overnight courier to Envirolab in Chatswood, NSW on the day of collection.

2.2.2 Groundwater Quality Monitoring

The GMP outlines the parameters required for monitoring in the operational phase of the project. The requirement for monitoring of total petroleum hydrocarbons (TPH, or total recoverable hydrocarbons – TRH) outlined in the GMP was upgraded prior to the start of operational monitoring to include monitoring of a variety of hydrocarbon sub-groups. The complete list of parameters monitored is the same as for surface water (see **Table 2.1**), except there is no requirement to measure DO concentration or turbidity.

The frequency of groundwater quality monitoring is also defined by the GMP. This is presented in **Table 2.4**. Groundwater quality measurements were collected four times during this reporting period, on the 8/10/2018, 18/01/2019, 6/05/2018 and 25/07/2018. The groundwater samples were not collected at exactly the intervals specified in the GMP. The variation from the specified intervals was between 1 and 3 weeks in each case and would not have resulted in any impacts to the quality or integrity of the data collected.

Table 2.4 Operational phase groundwater sample frequency (GeoLINK 2013b)

Period	***Dates***	***Parameters***	***Sample Frequency***
Entire Monitoring Period	September 2016 – June 2020	Physicochemical	1 sample three-monthly
		Hydrocarbons, Metals, Nutrients and Solids	1 sample six-monthly

2.2.3 Groundwater Level Monitoring

Groundwater levels are monitored using HOBO data loggers for the operational phase monitoring. These were deployed at most sites in 29 July 2017, collecting data at 2-hour intervals

(2-hour intervals chosen as a suitable period to collect data in adequate detail and extend battery life). The HOBO loggers are deployed at a point approximately 0.3 m above the bottom of each piezometer. There is an extra HOBO deployed at Chainage 63200 that captures barometric pressure information, later used to offset barometric pressure fluctuations in the data collected from the piezometers. Logged data was retrieved at approximately 3-month intervals.

Some of the groundwater piezometers used for monitoring in the pre-construction phase were decommissioned during the construction phase and new piezometers constructed. These include the groundwater piezometers at approximate chainages 63200 (upgradient), 64600 (upgradient), 72400 (downgradient), 74300 (upgradient and downgradient) and 75500 (upgradient). The monitoring bore at approximate chainage 63200 (upgradient) was found to be collapsed during an inspection on 29/06/2017 and a new bore was constructed.

3 Results and Discussion

3.1 Rainfall

The surface water monitoring is governed by rainfall. A rainfall event triggering a wet episode sample is a minimum of 10 mm rain in 24 hours. A dry episode sampling run is triggered by 96 hours with no rainfall and 240 hours with less than 20mm rainfall. Three Bureau of Meteorology (BOM) stations, Kalang, Kooroowi and Nambucca Heads, were monitored to ensure wet conditions or dry conditions occurred across the entire upgrade section. Daily rainfall for the reporting period is displayed in **Figure 3.1**.

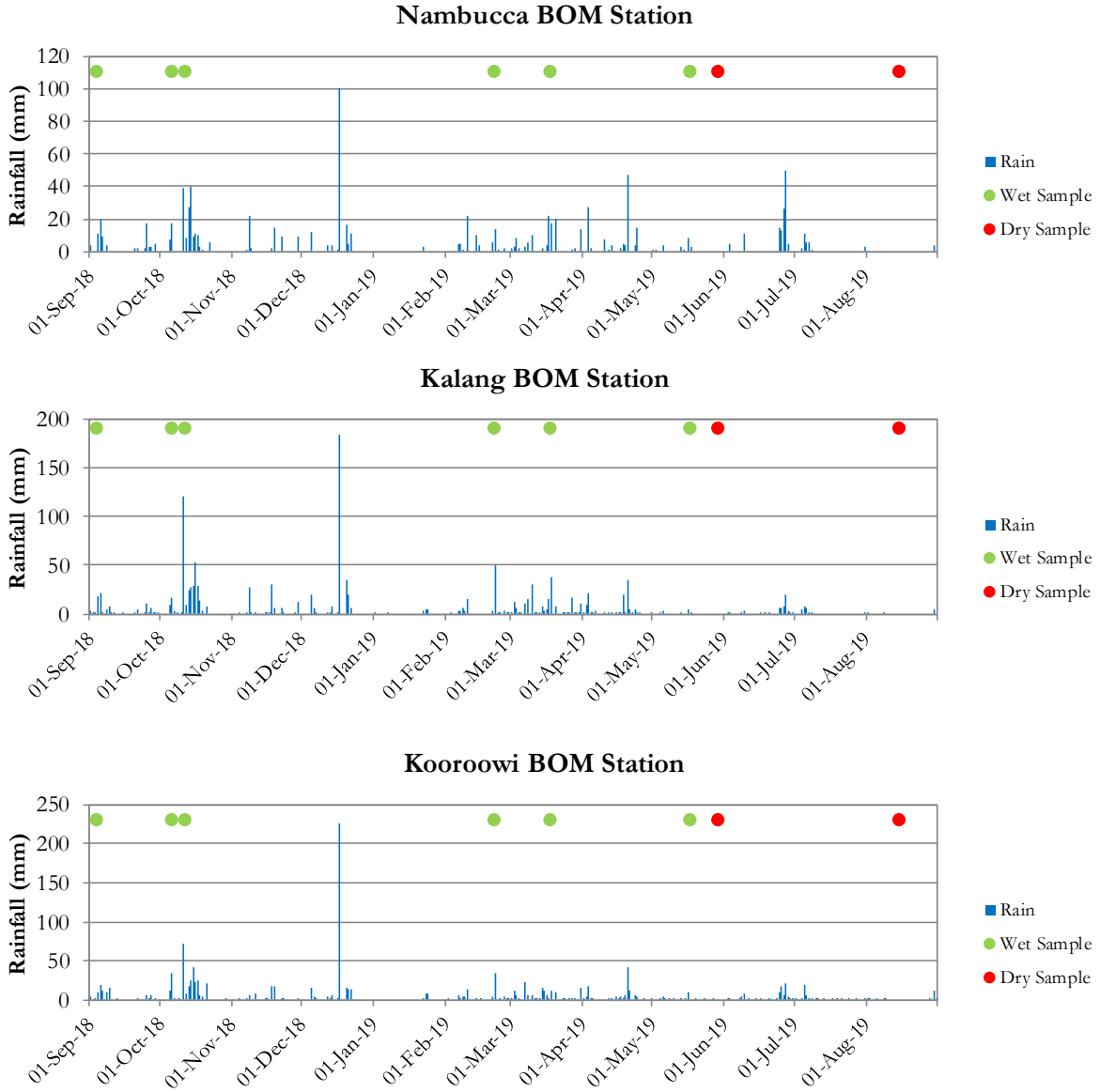


Figure 3.1 Daily rainfall at the Kalang, Kooroowi and Nambucca weather stations for the reporting period (BOM 2019)

Rainfall was relatively evenly distributed throughout the reporting period although the end of the reporting period was very dry. Overall, the reporting period was dry, with the total rainfall at the Nambucca Heads Bellwood BOM station (959 mm) just higher that the long term 10th percentile figure for the Nambucca area (941.5 mm) The wettest months of the reporting period were October and December 2018 and the driest months were January and August 2019.

3.2 Surface Water

Summary surface water quality results are provided in **Appendix A**.

Sampling dates for all surface water samples collected during this reporting period are displayed in **Table 2.3**. The sampling program was up-to-date at the end of the reporting period.

The SWMP suggests that the analysis of impacts can involve a comparison of the median sampling results from downstream (impact) sites with the 80th percentile (P80) value of upstream (control) sites. The downstream median data for the operational monitoring period from each site is presented in Appendix A with the rolling upstream P80 values. To provide historical context the summary data from the pre-construction and construction phases, in addition to the summary data at the end of the first year of operational phase monitoring is also presented.

A summary of relevant statistics for each waterway is presented in **Tables A.1** to **A.11** (**Appendix A**). A brief description of the summary results from each waterway follows.

For the purposes of analysing the results of operational phase monitoring we have defined results of interest as those where the operational phase downstream median is greater than the combined preconstruction/construction/operational phase upstream P80.

3.2.1 SEPP 14 Wetland No.351

There were few results of interest from SEPP 14 wetland No.351 (**Table A.1**). Results of interest were the downstream median TN and DO concentrations. However, the TN concentrations measured during this reporting period were within the limits of variation measured during pre-construction and construction phase monitoring (**Figure 3.5**). Additionally, the median

downstream TN concentration measured during the operational phase to date is lower than the median downstream TN concentration from either the pre-construction or construction phase monitoring (**Table A.1**). There is no indication that operation of the NH2U upgrade is having an impact on downstream TN concentrations in SEPP 14 Wetland no.351. The DO measurements collected from SEPP 14 wetland No.351 during this reporting period were very low on some occasions (**Figure 3.6**). Additionally, the downstream operational median DO concentration from SEPP 14 wetland No.351 has trended downwards over the three years of operational phase monitoring (**Table A.1**). However, the low concentrations measured during this monitoring period have coincided with very low water levels and no flow at the monitoring site. It is highly likely that the low DO concentrations are a result of stagnant water at that site as opposed to an impact from highway operation.

Turbidity, TSS and pH measurements during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figures 3.2**, **3.3** and **3.4**).

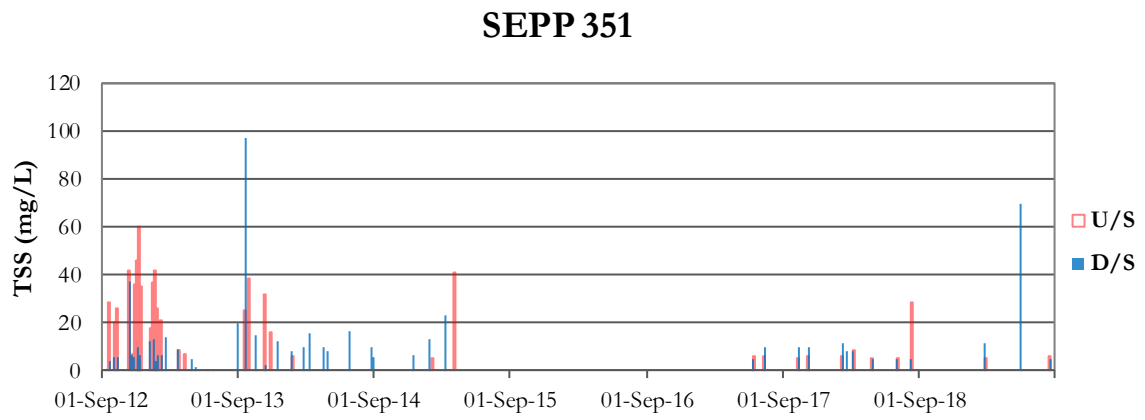


Figure 3.2 Total Suspended Sediment concentrations from SEPP 351 wetland and upstream waters since September 2012

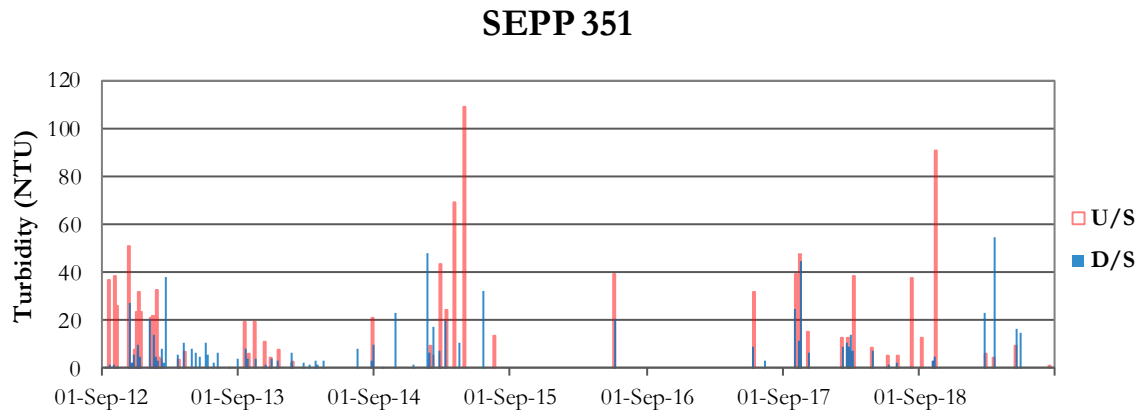


Figure 3.3 Turbidity measurements from SEPP 351 wetland and upstream waters since September 2012

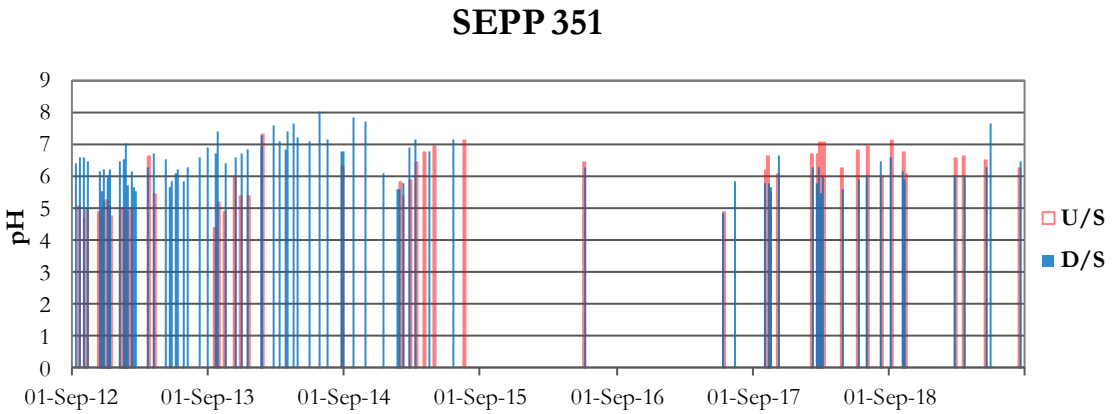


Figure 3.4 pH measurements from SEPP 351 wetland and upstream waters since September 2012

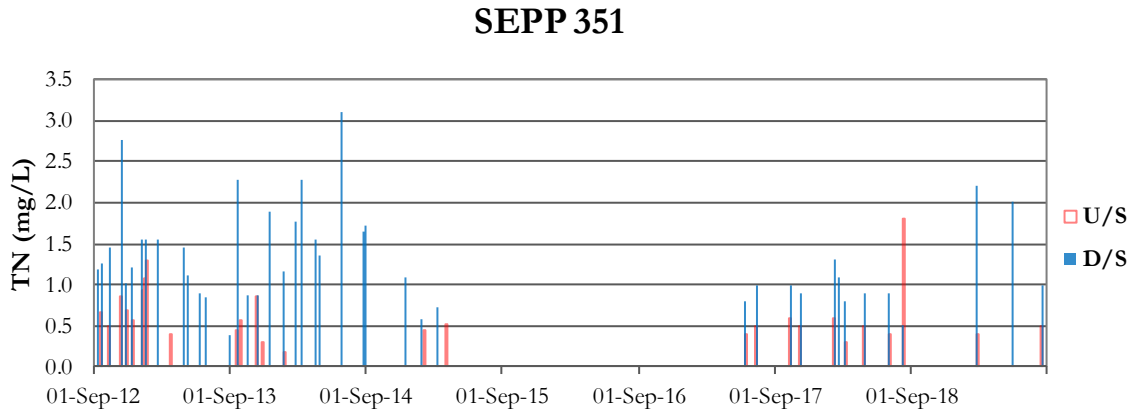


Figure 3.5 Total nitrogen concentrations from SEPP 351 wetland and upstream waters since September 2012

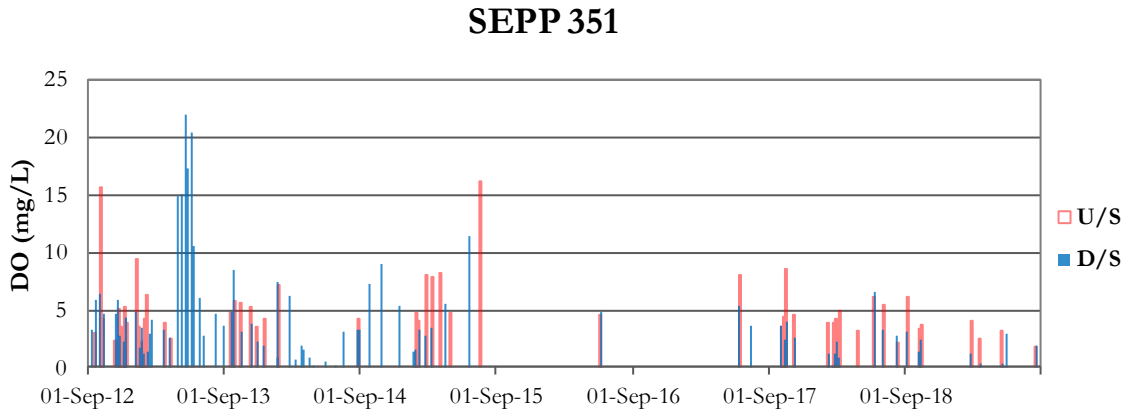


Figure 3.6 Dissolved Oxygen concentrations from SEPP 351 wetland and upstream waters since September 2012

Summary for SEPP Wetland No. 351 – Results of interest included the median downstream TN and DO concentrations. However, higher concentrations of TN were measured in the

construction and operational phases, both upstream and downstream of the highway (with the exception of one upstream measurement during the operational phase). Reduced concentrations of DO measured during this reporting period in the downstream environment associated with low rainfall. No indication of impact from highway operation.

3.2.2 SEPP14 Wetland No. 353

There were no results of interest from SEPP14 wetland No.353 (**Table A.2**).

During this reporting period the downstream TSS and turbidity measurements from SEPP 14 wetland No. 353 were all lower than the upstream measurements, indicating good management of sediment from highway operations (**Figures 3.7** and **3.8**). The downstream pH measurements were all within the ranges of pre-construction measurements and typically lower than the upstream measurements (**Figure 3.9**), indicating no impact from highway operation on pH.

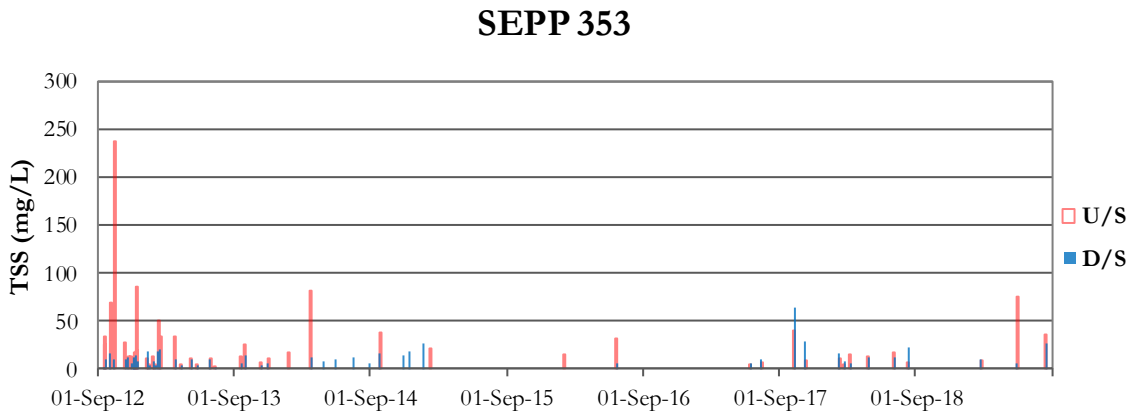


Figure 3.7 TSS concentrations from SEPP 353 wetland and upstream waters since September 2012

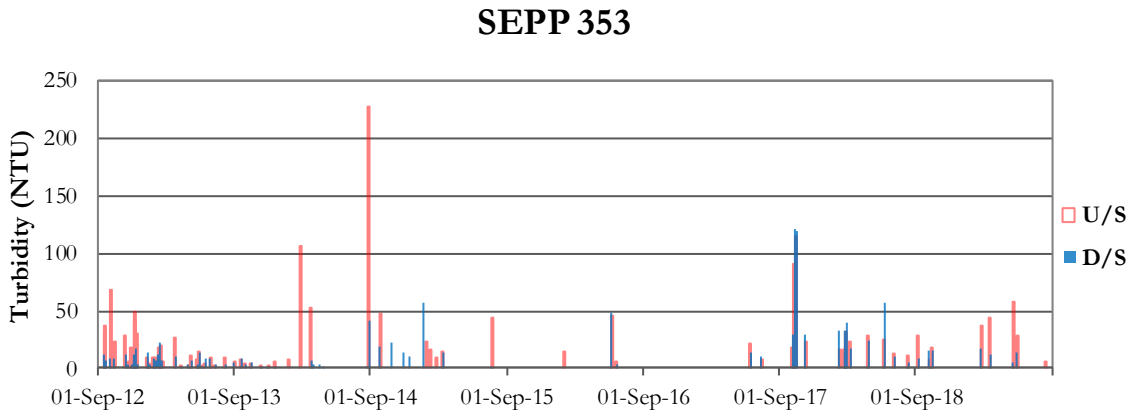
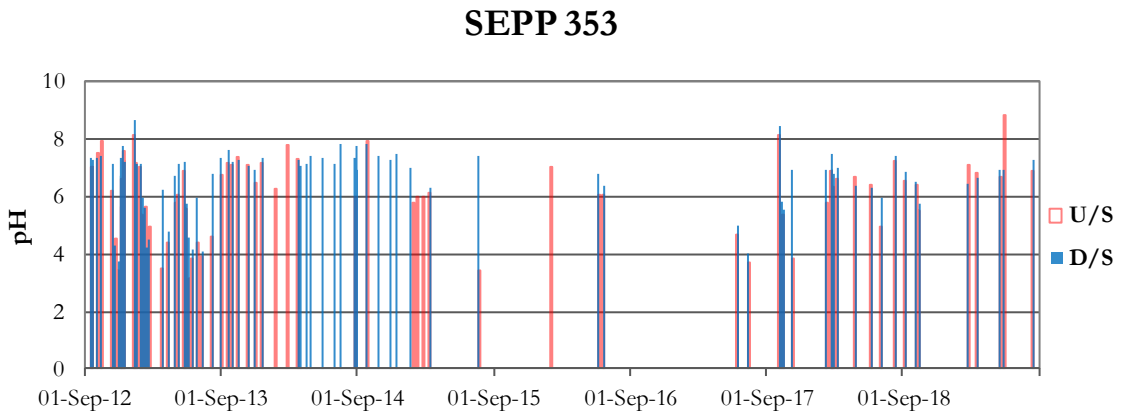


Figure 3.8 Turbidity measurements from SEPP 353 wetland and upstream waters since September 2012



ou

Figure 3.9 pH measurements from SEPP 353 wetland and upstream waters since September 2012

Summary for SEPP Wetland No. 353 – There were no results of interest and no indication of impacts from highway operation.

3.2.3 Unnamed Tributary to SEPP14 Wetland No. 351

The only result of interest from the unnamed tributary to SEPP14 wetland No.351 was the downstream median pH measurement (**Table A.3**). The downstream pH measurements collected during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figure 3.12**). Additionally, the pH measurements from

upstream waters were also high during this reporting period, indicating that the high values may not be related to the highway operation.

Turbidity and TSS measurements during this reporting period remained low and were within the variation observed in pre-construction and construction phase monitoring with the exception of one sample collected on 22 February 2019, when water levels were very low and the bottom was disturbed during sample collection (**Figures 3.10** and **3.11**).

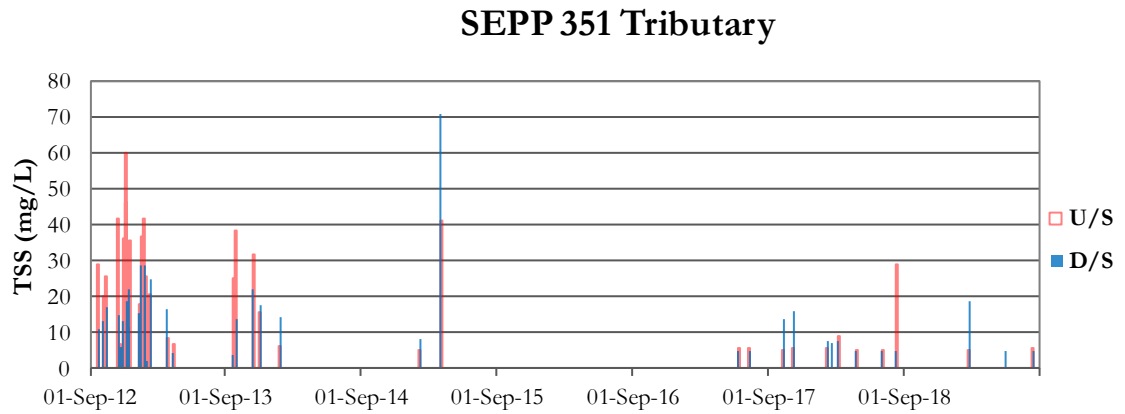


Figure 3.10 TSS concentrations from SEPP 351 tributary and upstream waters since September 2012

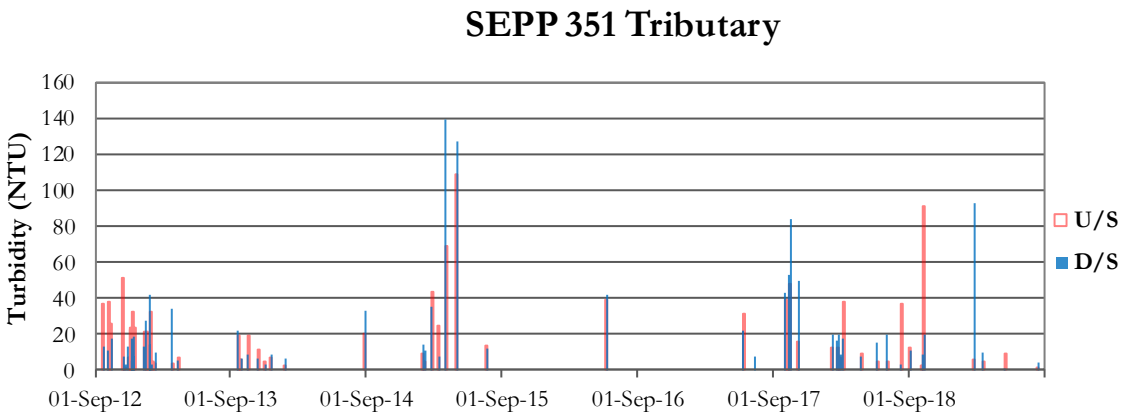


Figure 3.11 Turbidity measurements from SEPP 351 tributary and upstream waters since September 2012

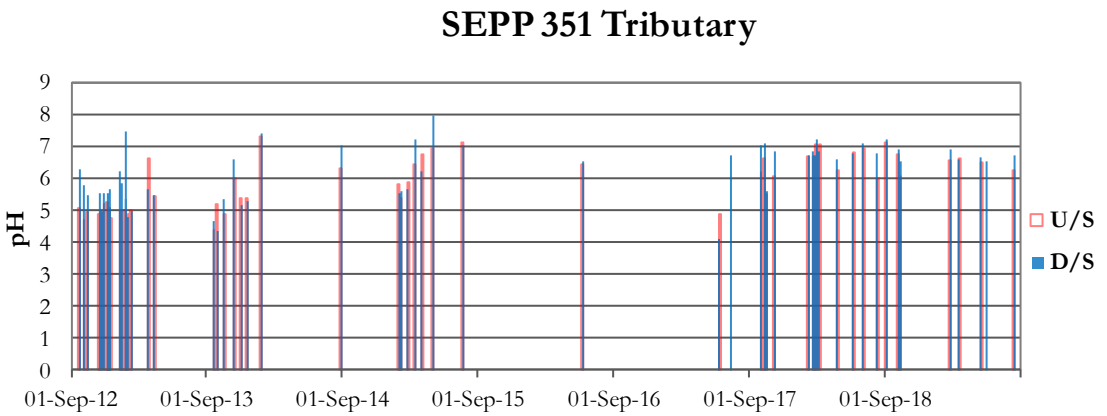


Figure 3.12 pH measurements from SEPP 351 tributary and upstream waters since September 2012

Summary for tributary to SEPP Wetland No. 351 – The median downstream construction phase pH measurement was a result of interest. However, elevated downstream pH measurements have mostly been associated with elevated downstream measurements, indicating that there has not been an impact of highway operation on pH at this site.

3.2.4 Unnamed Tributary to SEPP14 Wetland No. 353

The only result of interest from the unnamed tributary to SEPP14 wetland No.353 was the downstream median NO_3 concentration (**Table A.4**). Downstream NO_3 concentrations at the unnamed tributary to SEPP14 wetland No.353 have been relatively high on several occasions during the construction phase and are typically higher than the upstream concentrations (**Figure 3.16**). This indicates a possible influence from highway operation.

The upstream and downstream TSS, turbidity and pH measurements collected during this reporting period were all within the variation observed in construction phase monitoring (**Figures 3.13**, **3.14** and **3.15**) with the exception of one upstream measurement.

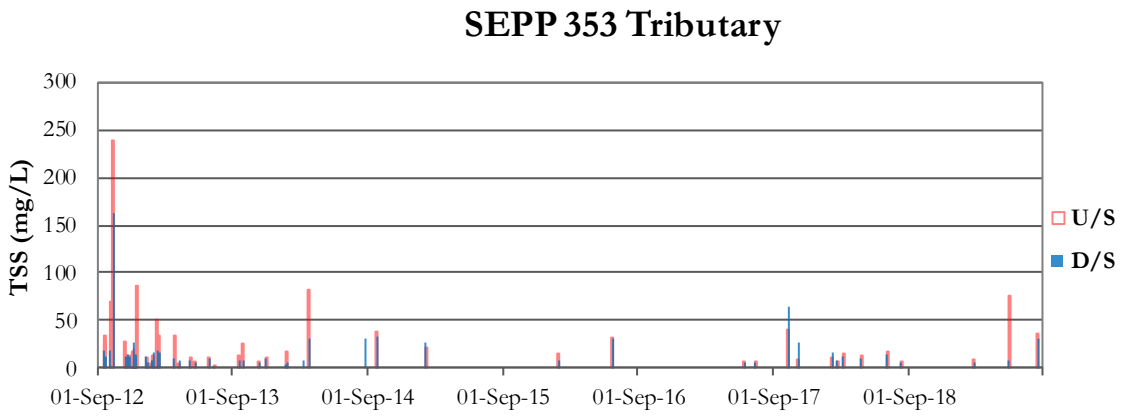


Figure 3.13 TSS concentrations from SEPP 353 tributary and upstream waters since September 2012

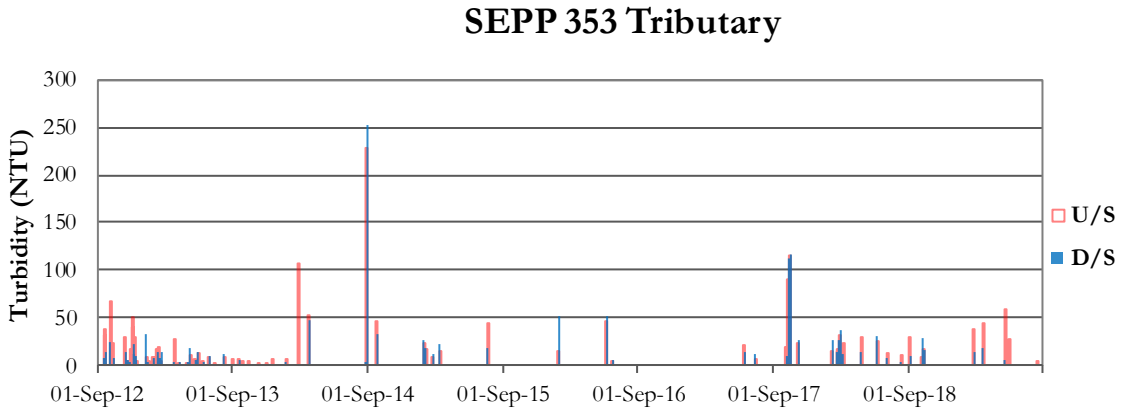


Figure 3.14 Turbidity measurements from SEPP 353 tributary and upstream waters since September 2012

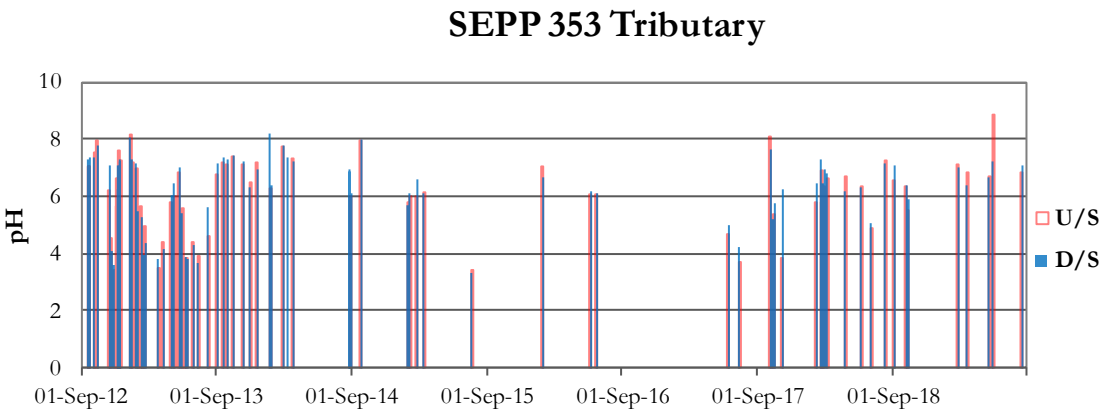


Figure 3.15 pH measurements from SEPP 353 tributary and upstream waters since September 2012

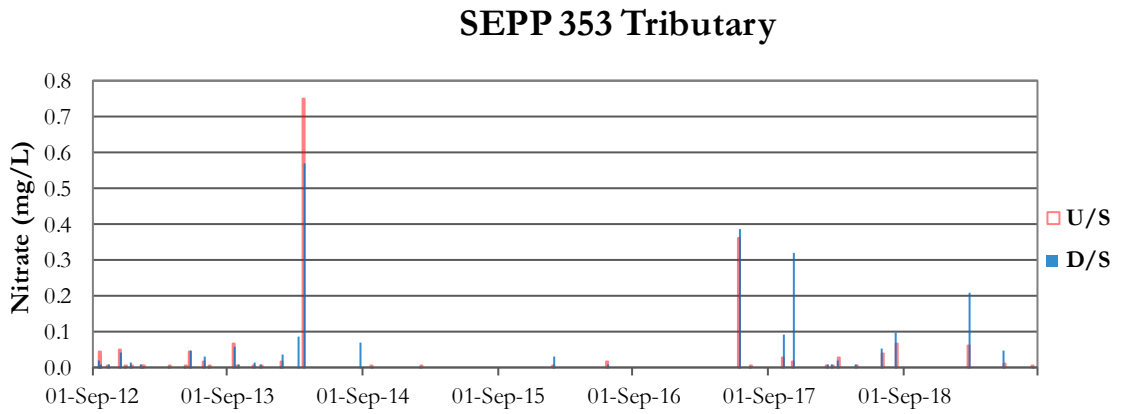


Figure 3.16 Nitrate measurements from SEPP 353 tributary and upstream waters since September 2012

Summary for tributary to SEPP Wetland No. 353 – Only one result of interest generated from this site. Several high downstream measurements of the NO_3 concentration have indicated some potential for an impact from highway operation. However, downstream NO_3 concentrations appear to have been trending downwards since the start of the operational monitoring phase.

3.2.5 Kalang River

Results of interest from the Kalang River were the downstream median Al, Fe and PO_4 concentrations (**Table A.5**). Of the results of interest two pairs of upstream and downstream Fe and Al concentrations measured during wet events in the operational monitoring phase have been outside of the variation observed in pre-construction and construction phase monitoring (**Figures 3.18** and **3.19**). However, because the Kalang is strongly tidal underneath the highway alignment it is not certain whether the Al and Fe originate at the highway crossing, further down or further up the catchment. A number of the upstream and downstream PO_4 concentrations measured in the operational monitoring phase were also outside of the range of measurements collected during both pre-construction and construction phase monitoring. For the majority of samples, upstream and downstream Al, Fe and PO_4 concentrations have been equivalent. The results from samples collected during the current reporting period (ie 2018 – 2019) have all been within the variation observed during pre-construction phase monitoring.

Upstream and downstream turbidity, TSS and pH measurements collected during this reporting period were within the variation observed in pre-construction and construction phase monitoring (**Figures 3.17**, **3.18** and **3.19**).

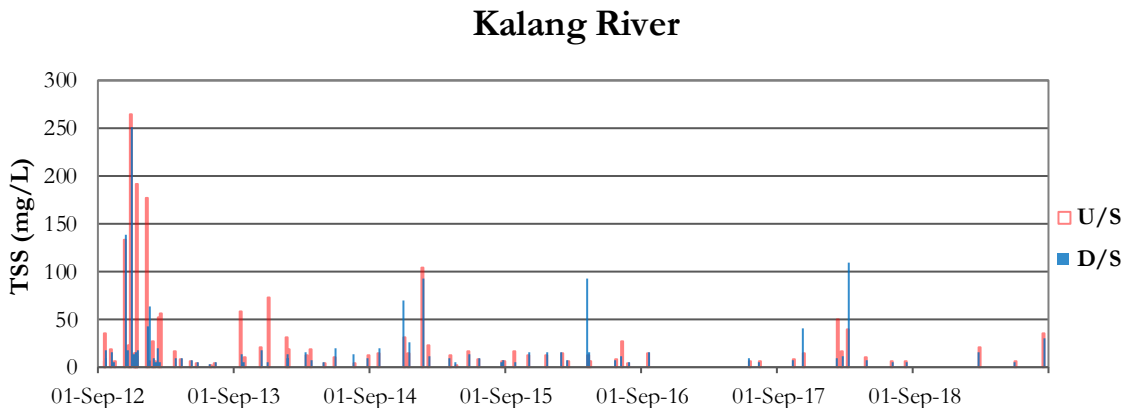


Figure 3.17 TSS concentrations from the Kalang River since September 2012

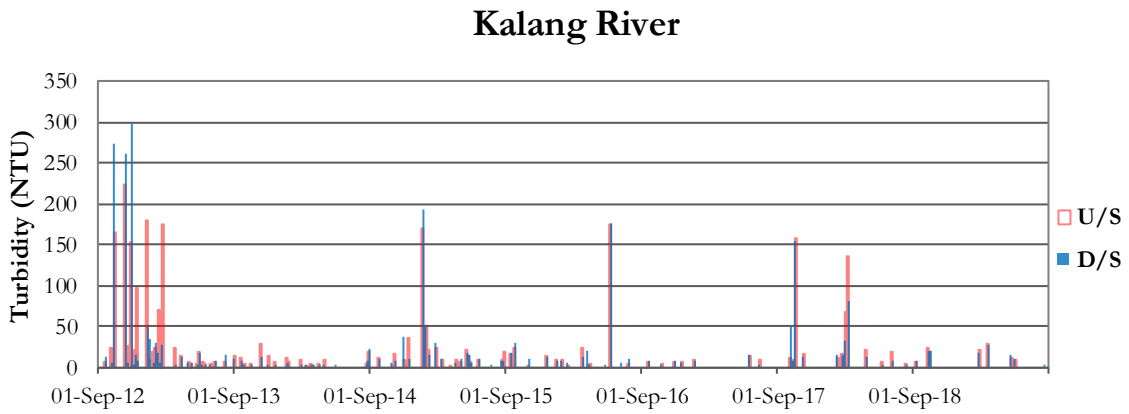


Figure 3.18 Turbidity measurements from the Kalang River since September 2012

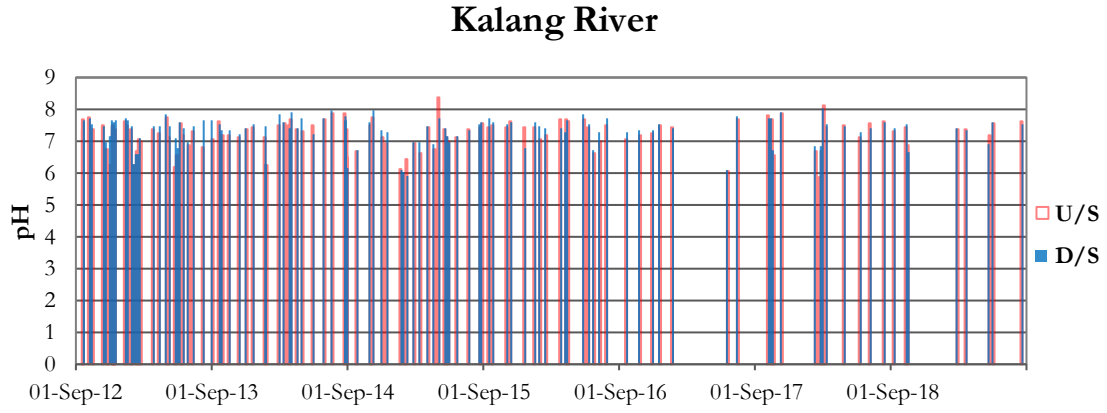


Figure 3.19 pH measurements from the Kalang River since September 2012

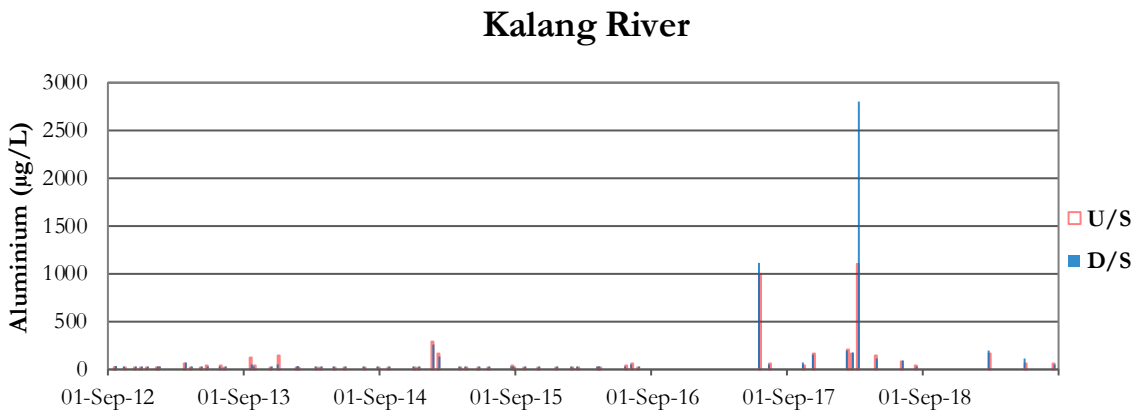


Figure 3.20 Aluminium measurements from the Kalang River since September 2012

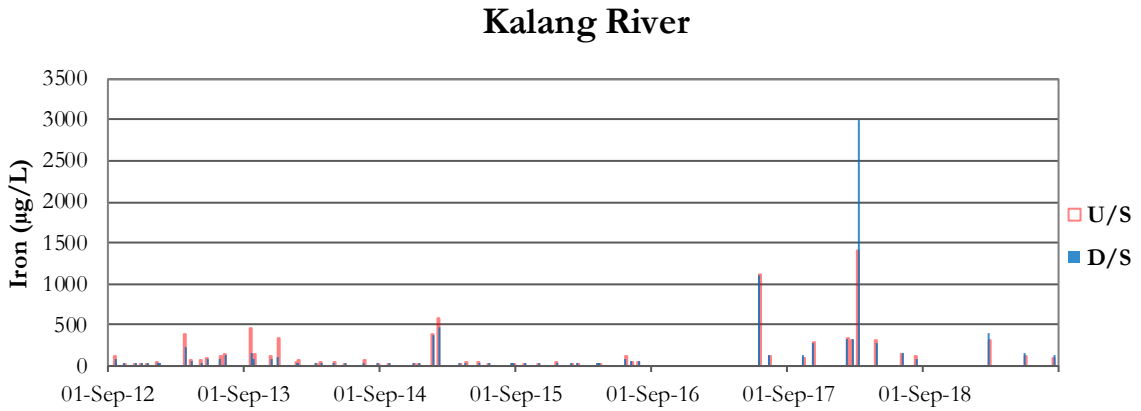


Figure 3.21 Iron measurements from the Kalang River since September 2012

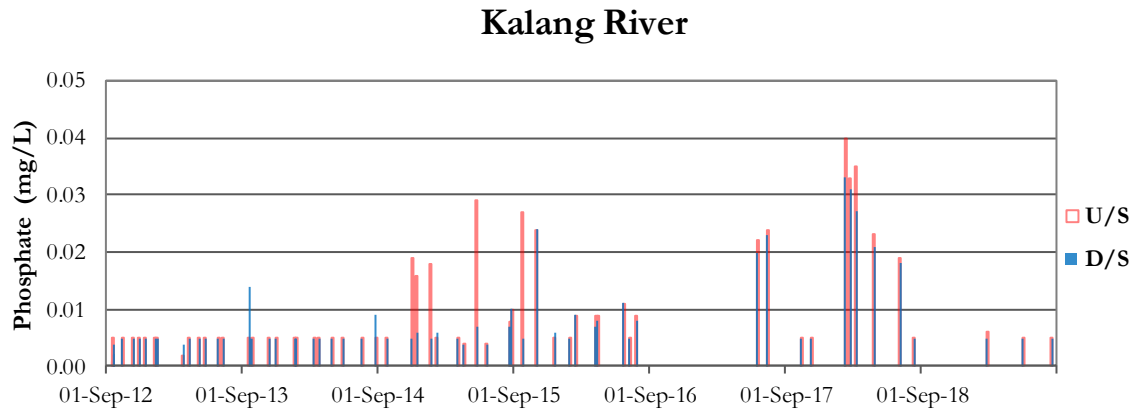


Figure 3.22 Phosphate measurements from the Kalang River since September 2012

For Fe, Al and PO_4 the highest concentrations both upstream and downstream of the Kalang River Bridge in the construction and operational phases have been higher than the ranges measured in the pre-construction phase (**Figures 3.20, 3.21** and **3.22**).

Summary for the Kalang River – Highest concentrations of Fe, Al, and PO_4 both upstream and downstream measured in the operational phase of monitoring. Lower concentrations of these parameters measured during this reporting period.

3.2.6 Dalhousie Creek

There were no results of interest from Dalhousie Creek (**Table A.6**).

Dalhousie Creek was dry upstream and downstream of the highway crossing at the time of most sample runs during this reporting period. The TSS and pH measurements during this reporting period were within the variation observed in both pre-construction and construction phase monitoring (**Figures 3.23** and **3.25**). The turbidity measurements collected during this reporting period were all within the variation observed in the pre-construction and construction phase monitoring with the exception of 1 upstream measurement (**Figure 3.24**).

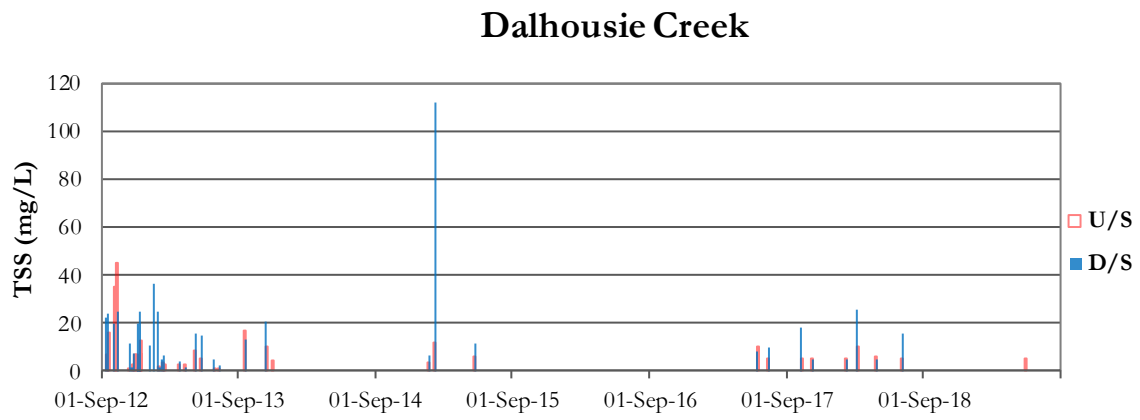


Figure 3.23 TSS concentrations from Dalhousie Creek since September 2012

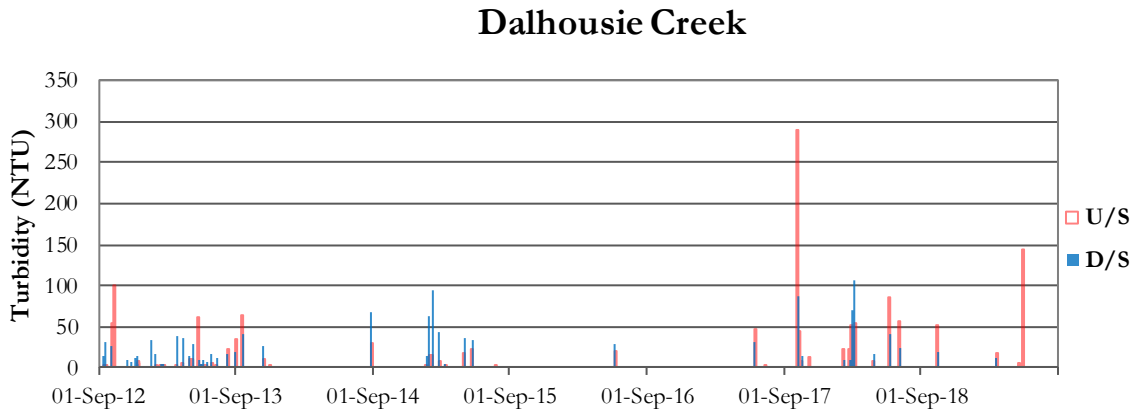


Figure 3.24 Turbidity measurements from Dalhousie Creek since September 2012

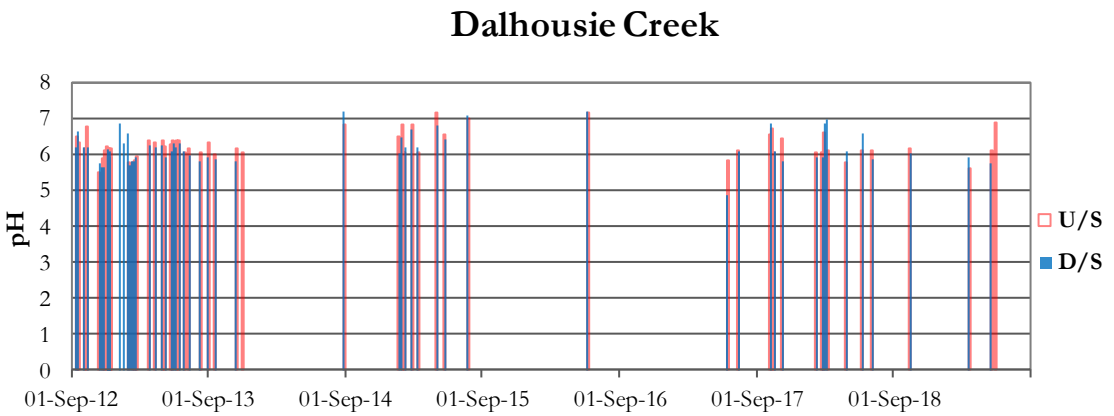


Figure 3.25 pH measurements from Dalhousie Creek since September 2012

Summary for Dalhousie Creek – Highest upstream and downstream turbidity measurements collected in the operational phases of monitoring. However, there were no results of interest generated for Dalhousie Creek during this monitoring period and no indication of impacts from highway operation.

3.2.7 McGraths Creek

There were two results of interest from McGraths Creek (**Table A.7**). Results of interest were the downstream median PO_4 concentrations and turbidity measurements. Both and PO_4 concentrations and turbidity measurements collected upstream and downstream of the crossing during operational phase monitoring have been outside of the variation observed in pre-construction phase monitoring (**Figures 3.27** and **3.29**). However, in each of these cases high measurements were collected both downstream and upstream of the highway during wet events, indicating that they may have originated upstream of the highway crossing and diminishing the likelihood of an impact from highway operation. In addition, measurements of PO_4 and turbidity collected during this reporting period have been lower than those collected during the earlier stages of operational phase monitoring, indicating a downward trend for both parameters.

TSS and pH measurements during this reporting period were within the variation observed upstream of the crossing in pre-construction and construction phase monitoring (**Figures 3.26** and **3.28**). In the operational phase, elevated TSS measurements in downstream waters have been accompanied by elevated measurements in upstream waters indicating that sediment may be entering the site from the catchment upstream of the crossing.

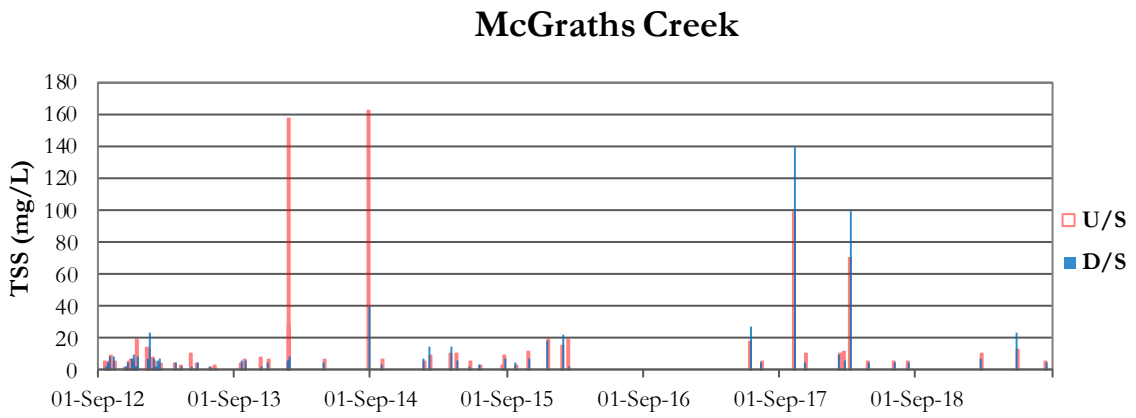


Figure 3.26 TSS concentrations from McGraths Creek since September 2012

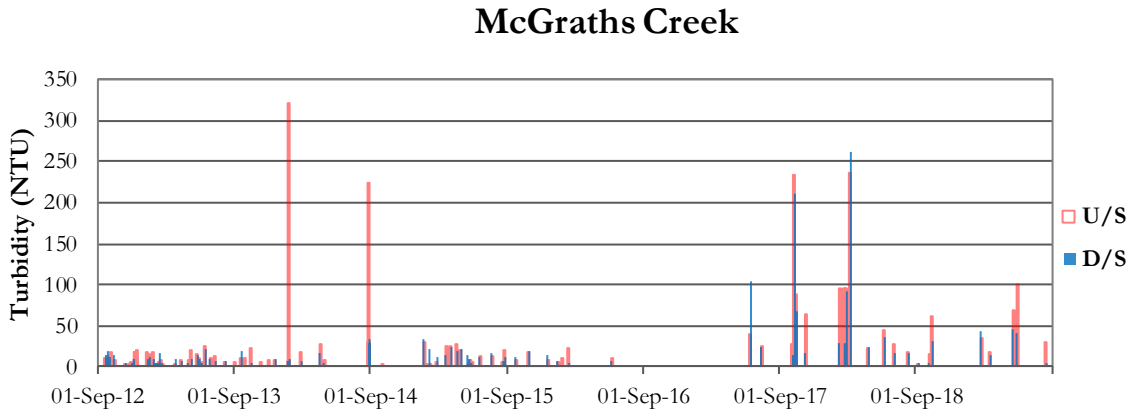


Figure 3.27 Turbidity measurements from McGraths Creek since September 2012

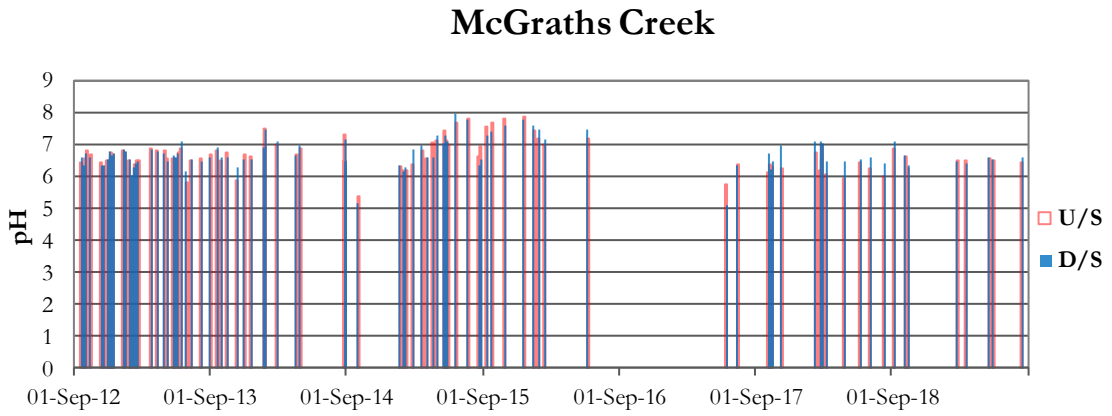


Figure 3.28 pH measurements from McGraths Creek since September 2012

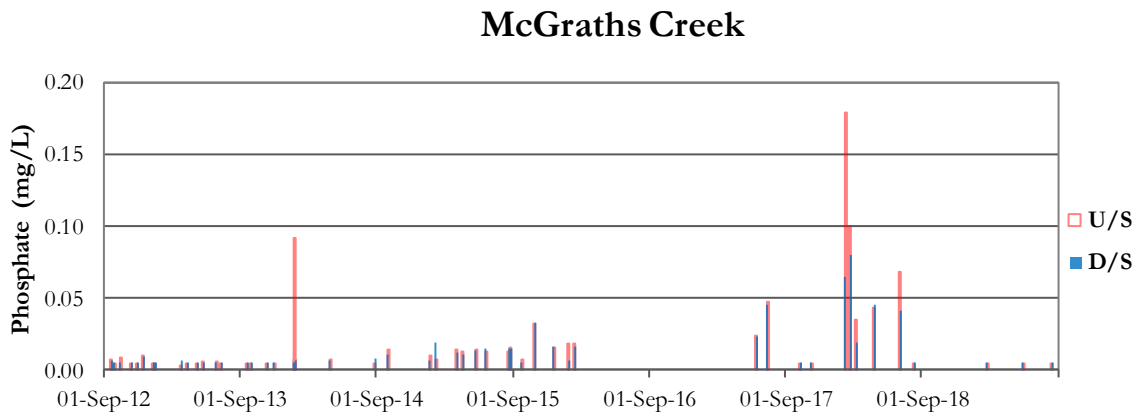


Figure 3.29 Phosphate measurements from McGraths Creek since September 2012

For TSS, turbidity and PO_4 the highest measurements from McGraths Creek in the construction and operational phases have been higher than the ranges measured in the pre-construction phase (**Figures 3.26**, **3.27** and **3.29**). Measurements of TSS and PO_4 during the current reporting period have all been within the ranges of pre-construction phase monitoring and measurements of turbidity have reduced since the earlier stages of operational phase monitoring.

Summary for McGraths Creek – Highest measurements of TSS, turbidity and PO_4 collected in the construction and operational phases of monitoring. High concentrations/measurements of each of these parameters in the operational phase occurring both downstream and upstream of the highway crossing, indicating a potential source other than the highway.

3.2.8 Oyster Creek

There were no results of interest from Oyster Creek (**Table A.8**). TSS, turbidity and pH measurements during this reporting period were within the variation observed in pre-construction and construction phase monitoring with the exception of one upstream TSS measurement (**Figures 3.30** to **3.32**).

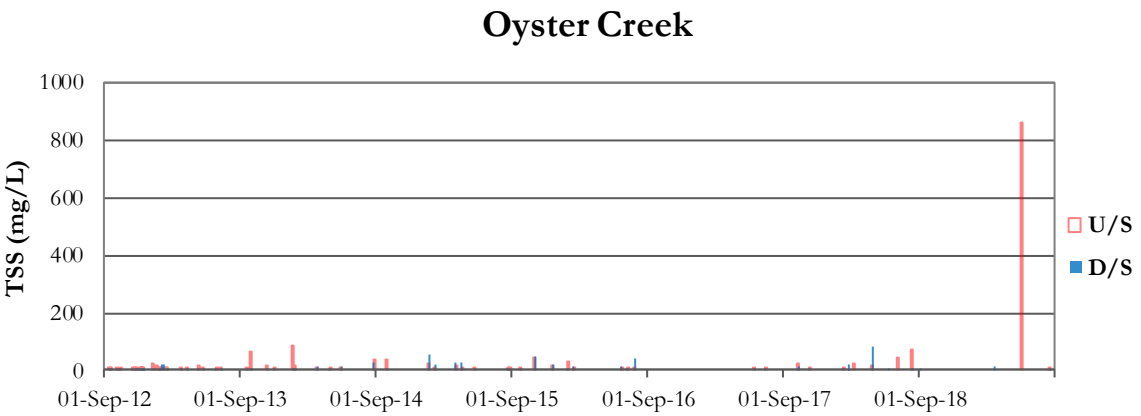


Figure 3.30 TSS concentrations from Oyster Creek since September 2012

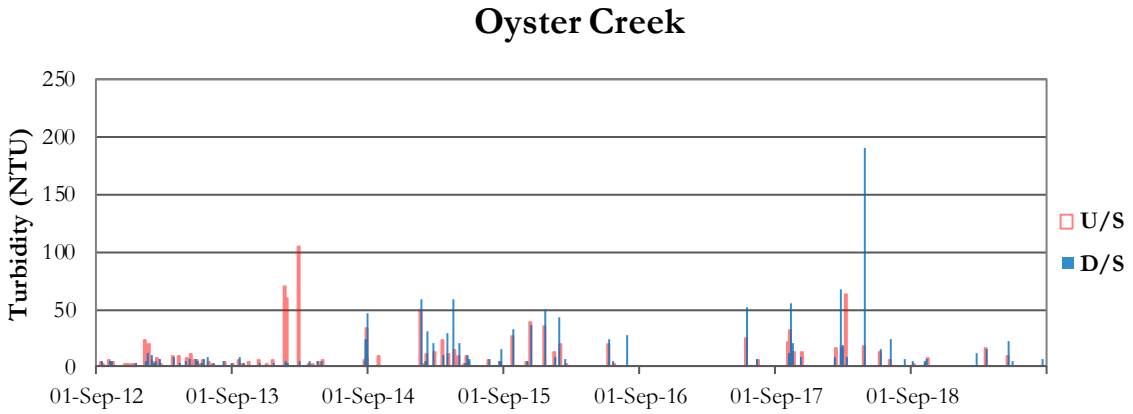


Figure 3.31 Turbidity measurements from Oyster Creek since September 2012

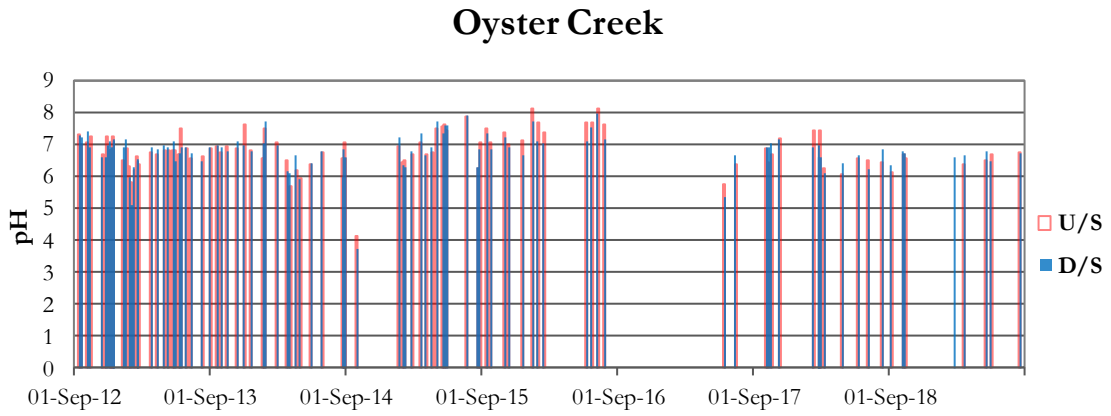


Figure 3.32 pH measurements from Oyster Creek since September 2012

There have been some elevated downstream turbidity measurements from Oyster Creek in the construction and operational phases but downstream TSS and pH measurements have almost all been within the ranges measured during the pre-construction monitoring phase (**Figures 3.30** to **3.32**).

Summary for Oyster Creek – No results of interest from Oyster Creek. The highest downstream measurements of turbidity were collected in the early operational phase of monitoring. However, most operational phase downstream turbidity measurements have been lower than the relevant default ANZECC guideline of 50 NTU (**Table 1.1**).

3.2.9 Deep Creek

There was one result of interest from Deep Creek, the downstream median PO_4 concentration (**Table A.9**). However, the PO_4 concentrations measured in Deep Creek in the operational phase have all been within the range measured during the construction phase (**Figure 3.36**). Additionally, the highest downstream PO_4 measurements from the operational phase have been accompanied by high upstream measurements and because Deep Creek is strongly tidal at the point of the highway crossing it is not possible to identify whether the source is upstream, downstream or the highway crossing itself. Finally, the PO_4 concentrations measured during the current reporting period have all been very low.

TSS, turbidity and pH measurements during this reporting period were within the variation observed in pre- construction phase monitoring with the exception of one pair of TSS measurements (**Figures 3.33** to **3.35**).

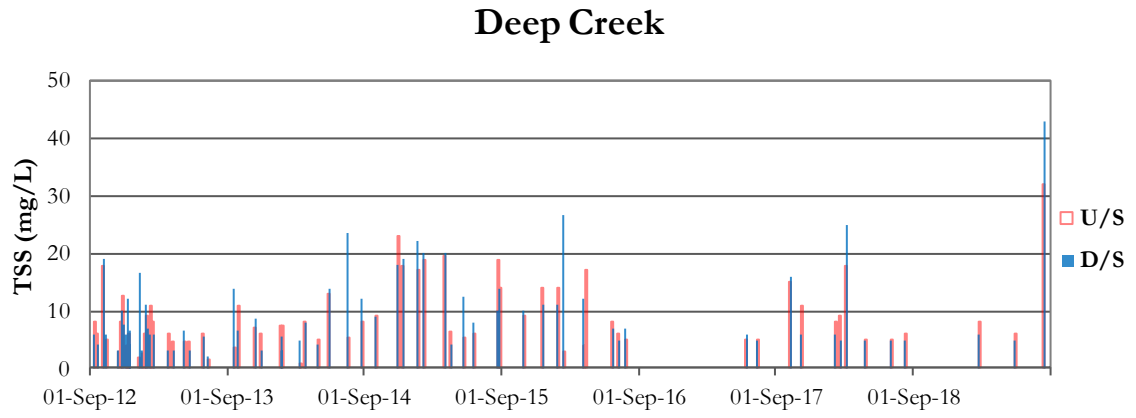


Figure 3.33 TSS concentrations from Deep Creek since September 2012

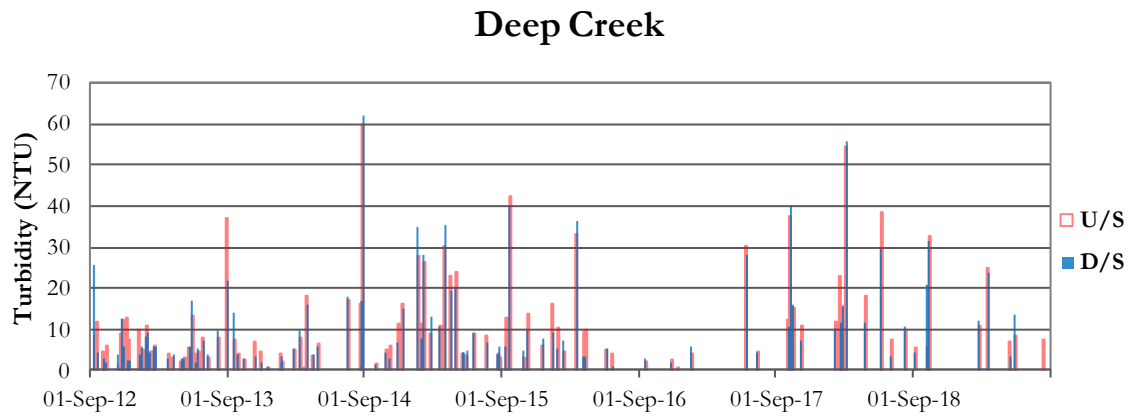


Figure 3.34 Turbidity measurements from Deep Creek since September 2012

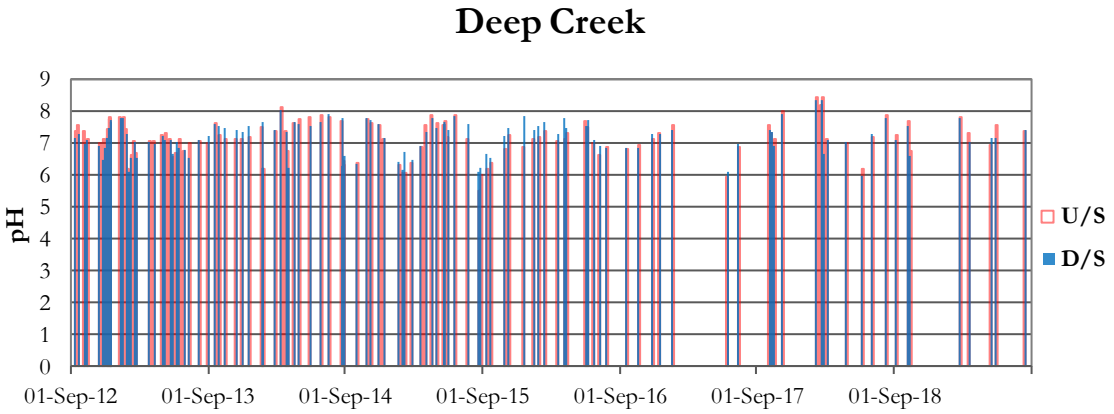


Figure 3.35 pH measurements from Deep Creek since September 2012

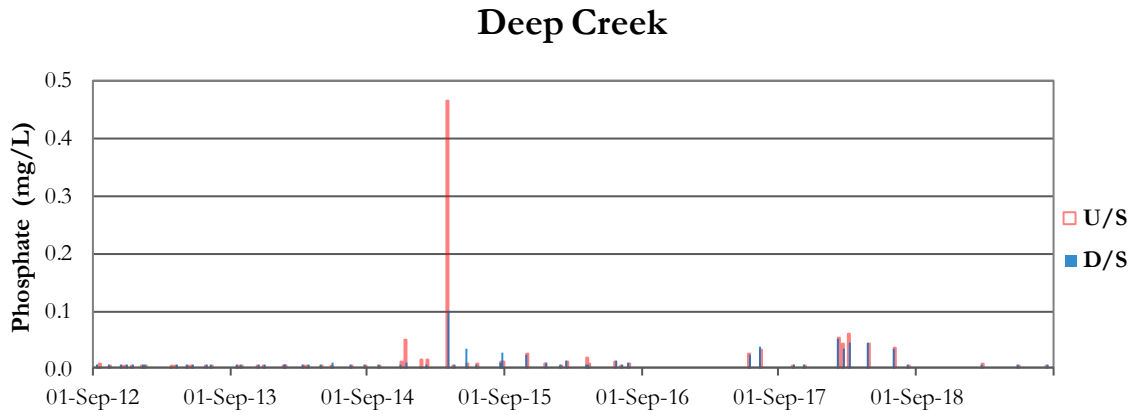


Figure 3.36 Phosphate measurements from Deep Creek since September 2012

For PO_4, TSS and turbidity the highest downstream measurements from Deep Creek in the construction and operational phases have been higher than the ranges measured in the pre-

construction phase (**Figures 3.33, 3.34** and **3.36**). The turbidity and PO_4 measurements both appear to be trending downwards as the operational phase monitoring progresses.

Summary for Deep Creek – Only one result of interest. Highest measurements of PO_4, TSS and turbidity collected in the construction and operational phases of monitoring. High measurements of these parameters have been collected both upstream and downstream of the highway crossing. Deep Creek is tidal at the point of the highway crossing, making it difficult to draw conclusions about the source.

3.2.10 Cow Creek

There were two results of interest from Cow Creek (**Table A.10**). Results of interest were the downstream median PO_4, and turbidity measurements. Although the highest downstream PO_4 concentration was collected during operational monitoring all of the elevated downstream PO_4 concentrations during operational phase monitoring have been associated with high upstream concentrations (**Figure 3.40**). In addition, PO_4 concentrations measured during this reporting period have all been within the ranges observed in pre-construction monitoring and a downward trend is apparent. The highest downstream measurements of turbidity during operational monitoring have all been associated with high upstream measurements, indicating that the source of turbid water could be upstream of the highway crossing (**Figure 3.38**).

TSS and pH measurements during this reporting period were within the variation observed in construction phase monitoring (**Figures 3.37** and **3.39**). (Note: There were only three samples from Cow Creek collected during pre-construction monitoring and they were limited to physicochemical parameters.)

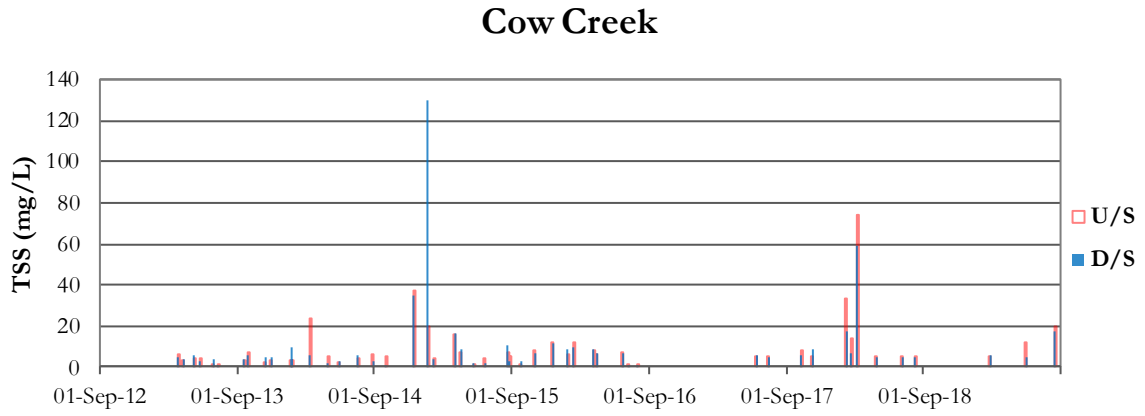


Figure 3.37 TSS concentrations from Cow Creek since September 2012

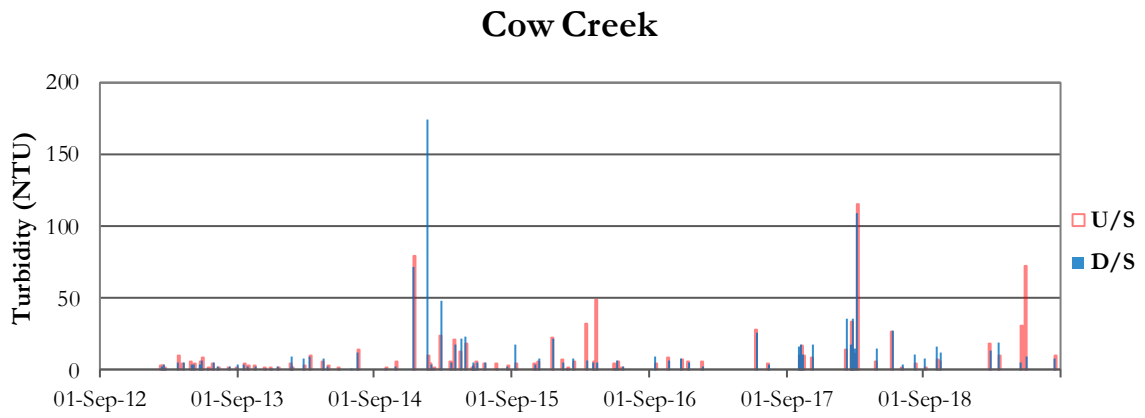


Figure 3.38 Turbidity measurements from Cow Creek since September 2012

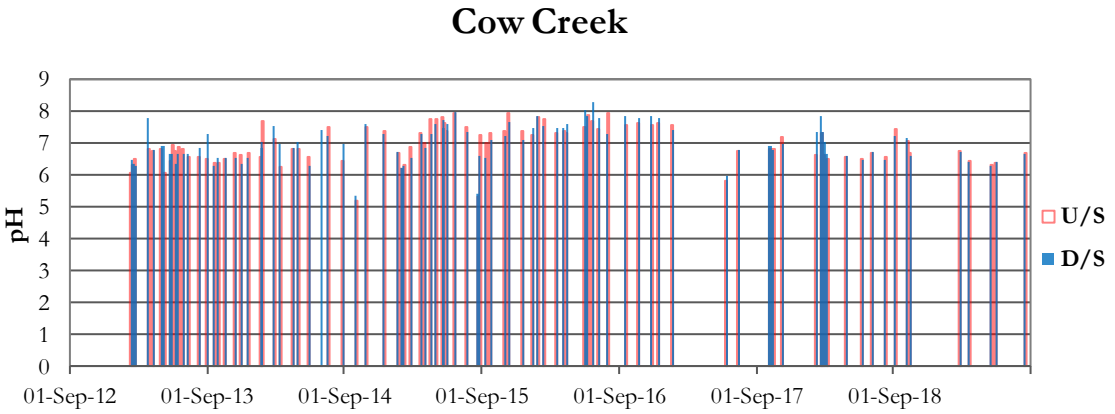


Figure 3.39 pH measurements from Cow Creek since September 2012

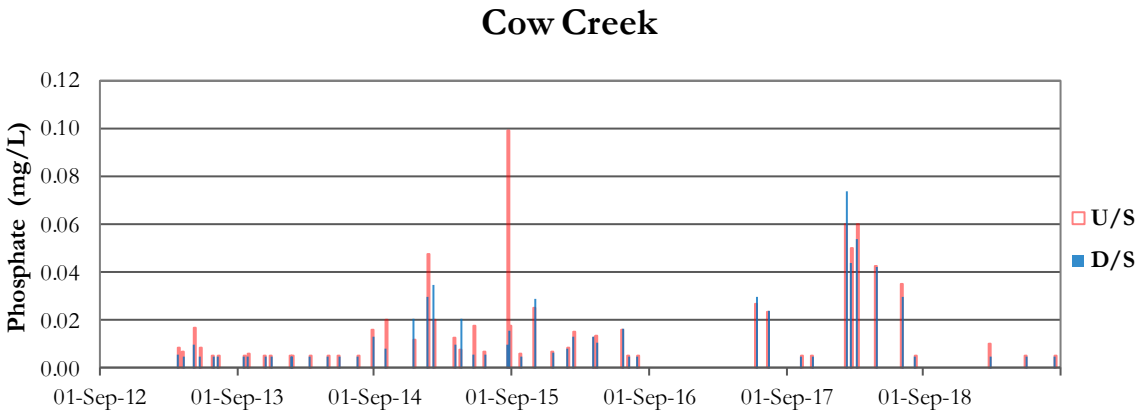


Figure 3.40 Phosphate measurements from Cow Creek since September 2012

Summary for Cow Creek – Only two results of interest. Limited pre-construction data available. Elevated measurements of all parameters that registered a result of interest were collected both upstream and downstream of the highway crossing.

3.2.11 Boggy Creek

The only result of interest from Boggy Creek was the median downstream Fe concentration (**Table A.11**). Although the highest downstream Fe concentration since monitoring began occurred during the operational phase all of the elevated downstream Fe concentrations collected during operational phase monitoring have been associated with elevated upstream concentrations (**Figure 3.44**), indicating that the source of higher iron concentrations could be upstream of the highway crossing.

With the exception of one downstream TSS measurement, TSS and pH measurements from operational phase monitoring have been within the variation observed in pre-construction and construction phase monitoring (**Figures 3.41** and **3.43**). Although some relatively high downstream turbidity measurements have been collected during operational phase monitoring they have all been associated with elevated upstream measurements (**Figure 3.42**).

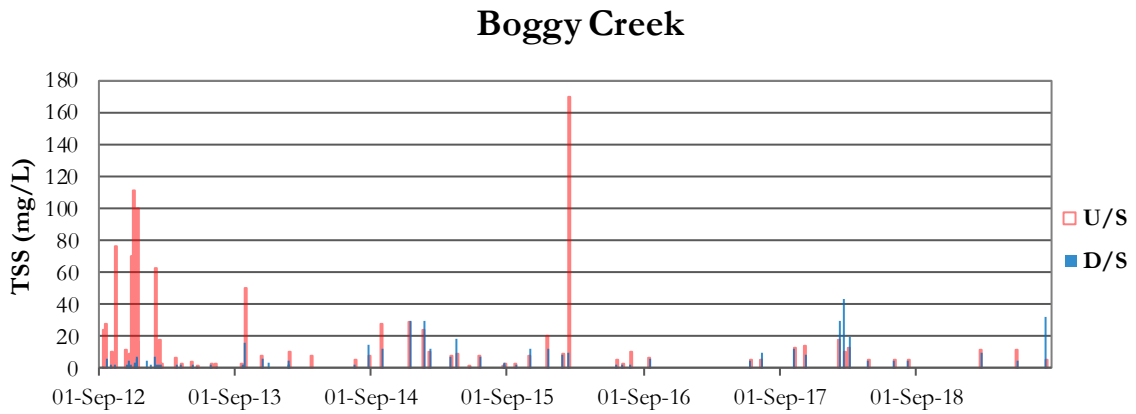


Figure 3.41 TSS concentrations from Boggy Creek since September 2012

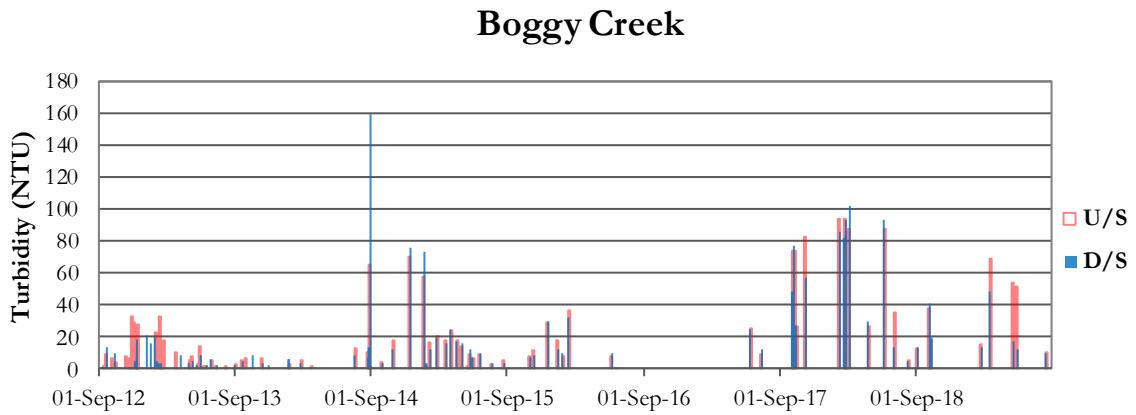


Figure 3.42 Turbidity measurements from Boggy Creek since September 2012

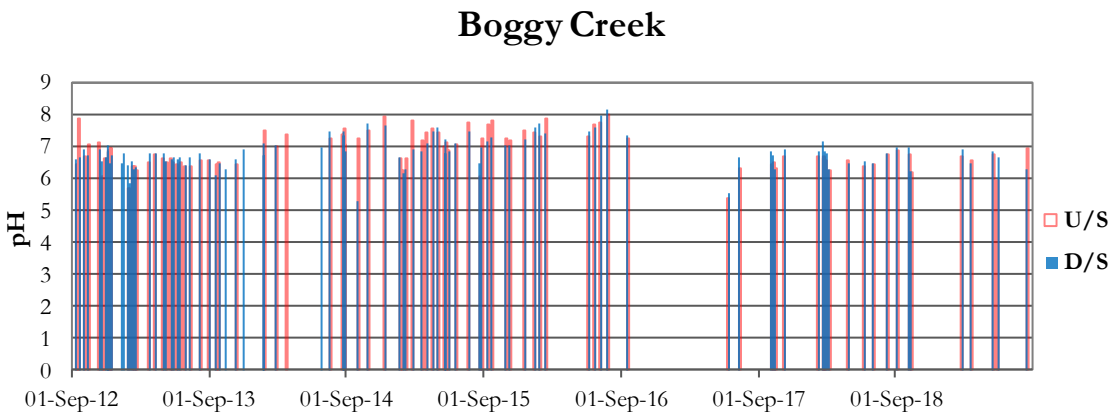


Figure 3.43 pH measurements from Boggy Creek since September 2012

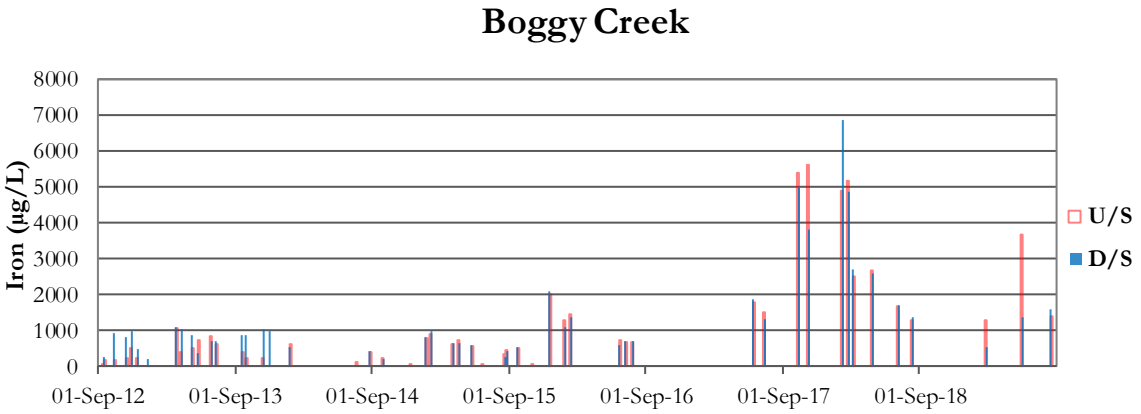


Figure 3.44 Iron measurements from Boggy Creek since September 2012

The highest measurements of turbidity and Fe from Boggy Creek have occurred during the construction and operational phases of monitoring (**Figures 3.42** and **3.44**).

Summary for Boggy Creek – The highest measurements of Fe and turbidity collected in the construction and operational phases of monitoring. During the operational monitoring period high concentrations of each of these parameters have been measured both upstream and downstream of the highway crossing.

3.3 Groundwater

3.3.1 Groundwater Quality

A summary of groundwater quality results to date is provided in **Appendix B**.

Sampling dates for all groundwater samples collected during this reporting period are displayed in **Table 3.1**. The slight deviations from the 3-monthly sampling period specified in the GMP are clarified in **Section 2.2.2**.

Table 3.1 Groundwater quality sampling undertaken during this reporting period

Date	*Parameters*
08/10/2018	All parameters and data loggers
18/01/2019	Field parameters and data loggers
06/05/2019	All parameters and data loggers
25/07/2019	Field parameters and data loggers

The GMP suggests that the analysis of impacts should involve a comparison of the median sampling results from downgradient (impact) sites with the 80th percentile (P80) value of upgradient (control) sites. The summary data from each site is presented in **Appendix B** with the upgradient P80 values from the combined preconstruction, construction and operational phases.

The relevant summary statistics for each groundwater site are presented in **Tables B.1** to **B.6**. A brief description of the summary results from each waterway follows. For the purposes of assessing the results of operational phase monitoring with earlier results we have defined results of interest as those where the operational phase downgradient median is greater than the combined preconstruction, construction and operational phase upgradient P80.

3.3.2 Ch 63200

Results of interest from Ch 63200 (Table B.1) were the downgradient median As, Cu, Fe, TN, TP, PO_4 and Ca^+ measurements. There was no water in the upgradient piezometer for the early part of the construction phase monitoring. A new piezometer was constructed in September 2017 when the existing piezometer was found to be collapsed. The lack of upgradient construction phase data and missing upgradient data from the earlier stages of operational phase monitoring limit the capacity to draw conclusions about potential impacts from highway operation. All of the parameters that generated a result of interest had a reduced downgradient operational phase median as a result of reduced measurements collected during the current reporting period (**Figures 3.46** to **3.52**), with the exception of Ca+, which is no longer measured. The pH measurements collected during the current reporting period were all within

the range of variation observed during the pre-construction monitoring phase, with the exception of one upgradient result (**Figure 3.45**).

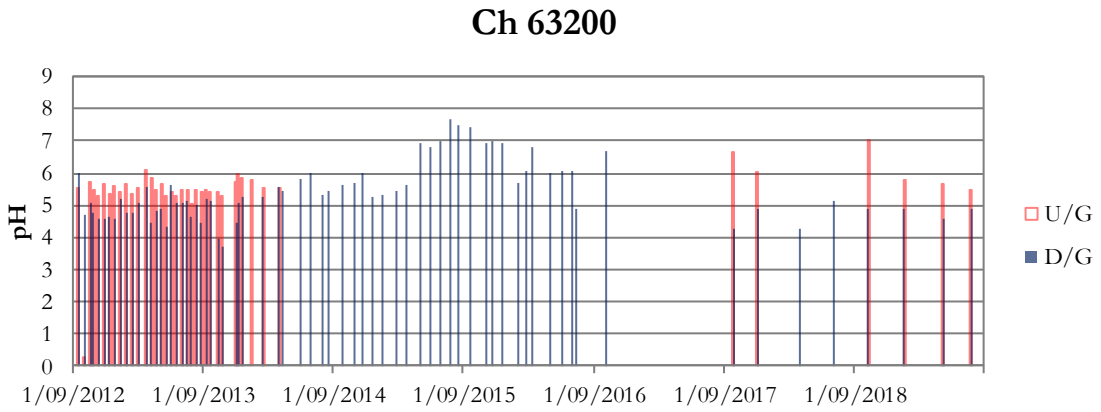


Figure 3.45 pH concentrations from Ch 63200 since September 2012

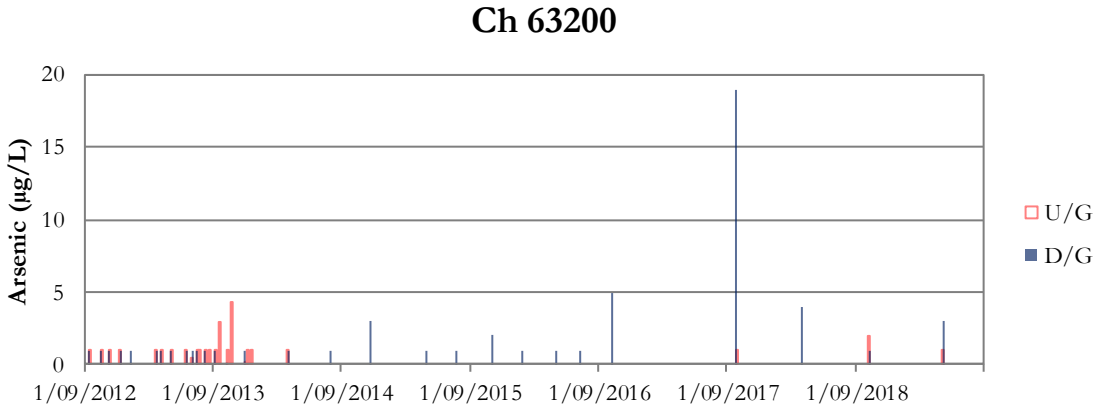


Figure 3.46 Arsenic concentrations from Ch 63200 since September 2012

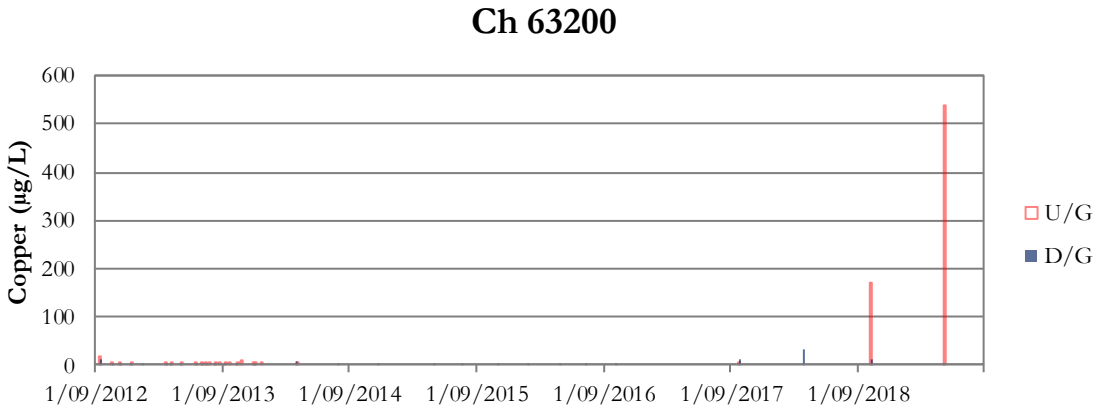


Figure 3.47 Copper concentrations from Ch 63200 since September 2012

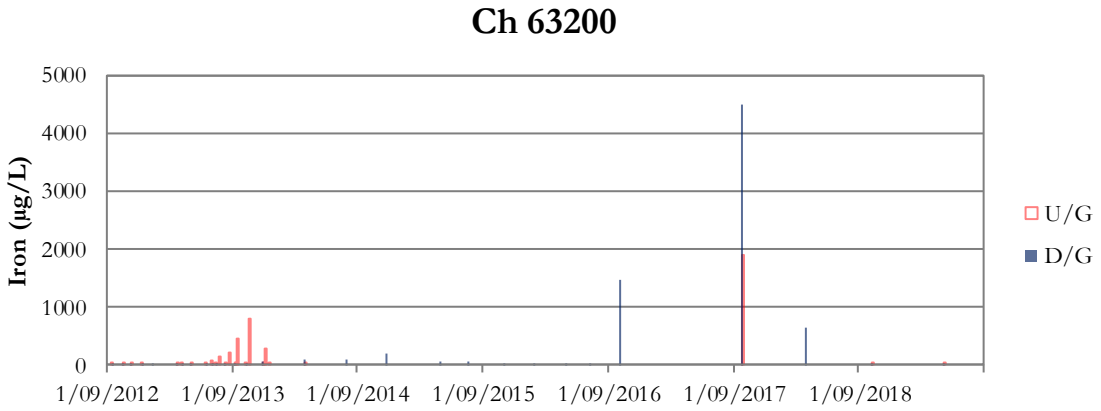


Figure 3.48 Iron concentrations from Ch 63200 since September 2012

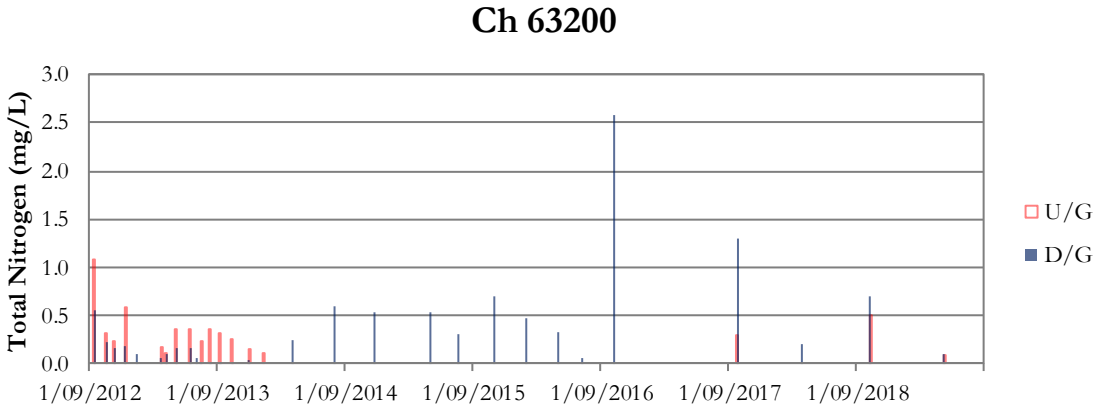


Figure 3.49 TN concentrations from Ch 63200 since September 2012

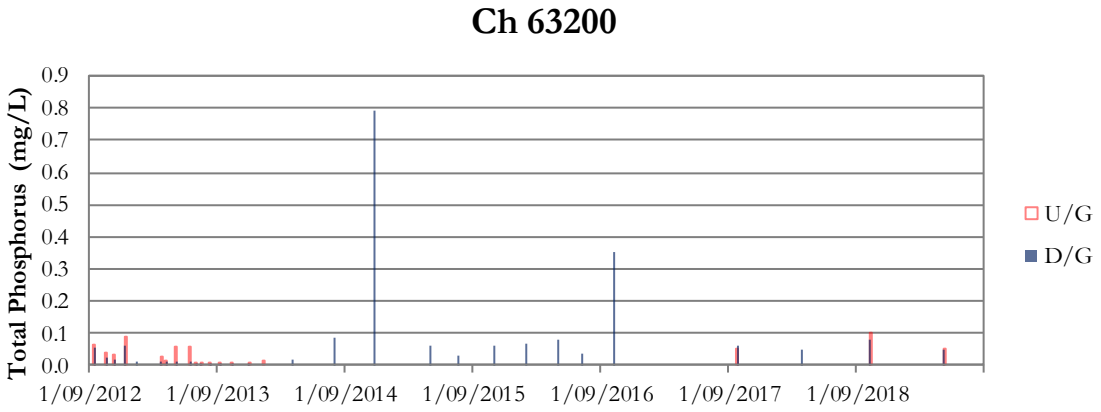


Figure 3.50 TP concentrations from Ch 63200 since September 2012

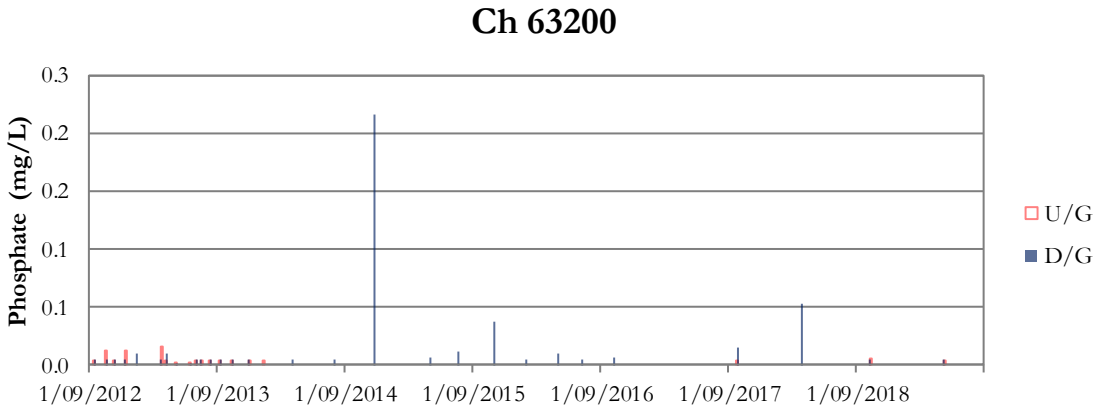


Figure 3.51 Phosphate measurements from Ch 63200 since September 2012

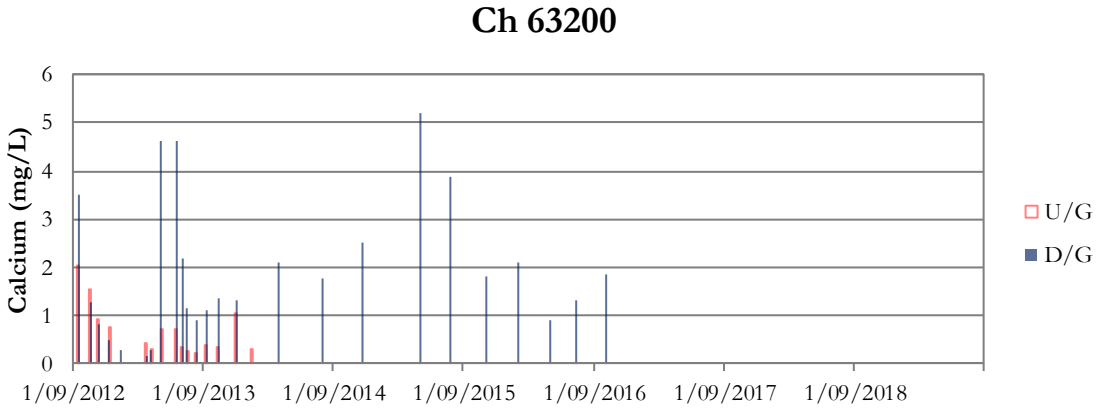


Figure 3.52 Calcium ion concentrations from Ch 63200 since September 2012

Summary for Ch 63200: Highest downgradient As, Cu, Fe and TN concentrations since the start of monitoring occurred in the early stages of operational phase monitoring. Downgradient medians for all parameters that registered a result of interest have reduced this year. Dry upgradient piezometer for most of the construction phase monitoring period and some of the early operational phase monitoring period limits the capacity to draw conclusions about potential impacts from construction and operation.

3.3.3 Ch 64600

Results of interest from Ch 64600 (**Table B.2**) were the downgradient median Ni, and HCO_3^- concentrations and temperature measurements. All elevated downgradient Ni concentrations measured during the operational phase monitoring have been associated with high upgradient

concentrations (**Figure 3.54**) indicating that they may not be associated with highway operation. Downgradient temperature measurements were all within the levels of variation observed in pre-construction and construction phase monitoring (**Figure 3.55**). The HCO_3^- measurement collected during operational phase monitoring was also within the levels of variation observed in pre-construction phase monitoring (**Figure 3.56**).

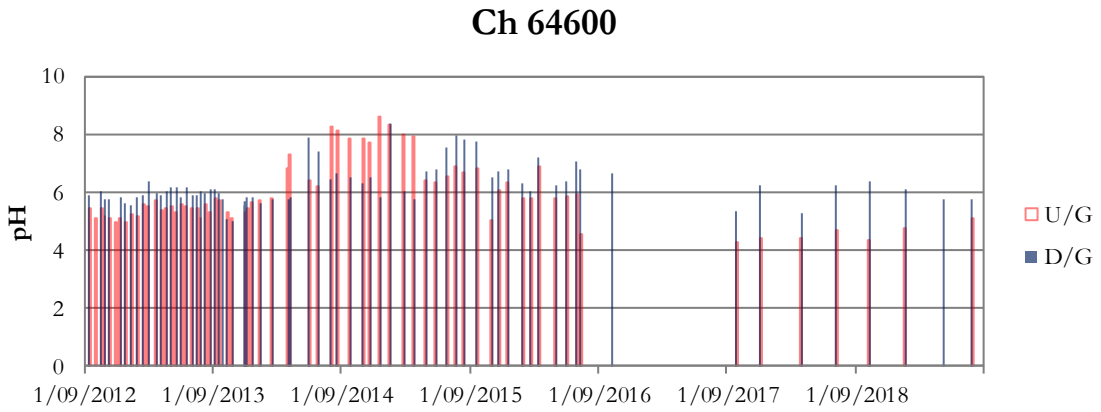


Figure 3.53 pH concentrations from Ch 64600 since September 2012

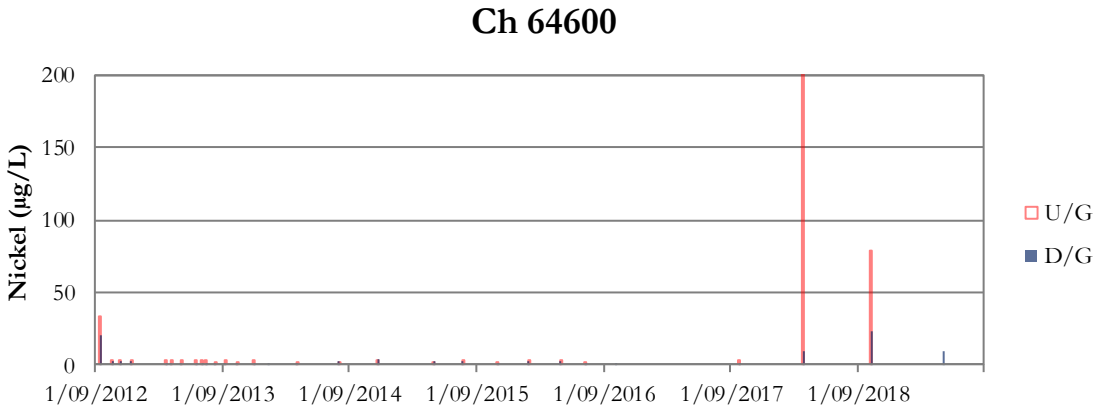


Figure 3.54 Nickel measurements from Ch 64600 since September 2012

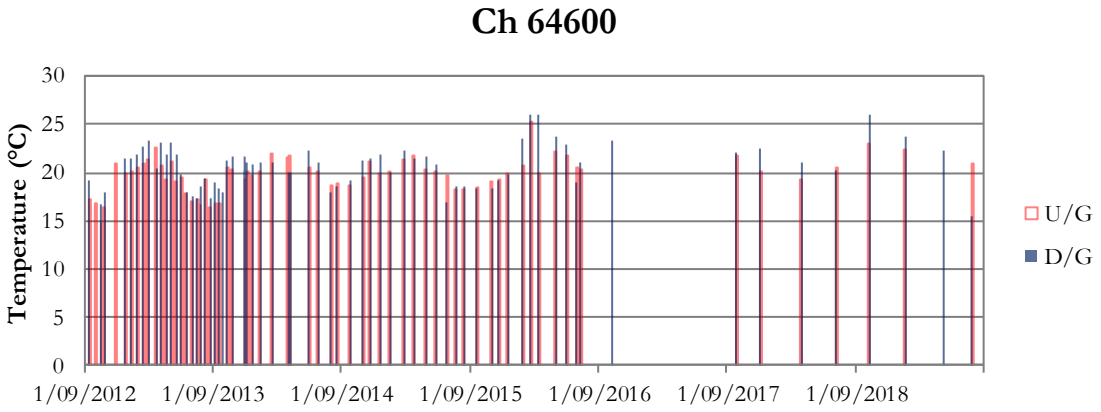


Figure 3.55 Temperature measurements from Ch 64600 since September 2012

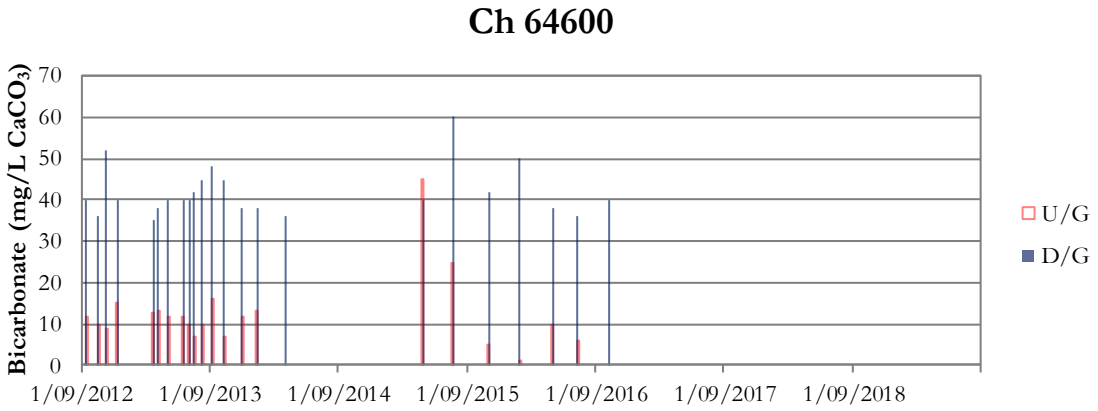


Figure 3.56 Bicarbonate measurements from Ch 64600 since September 2012

Summary for Ch 64600: Although there were three results of interest there is no indication of impacts from highway operation.

3.3.4 Ch 72400

Results of interest from Ch 72400 (**Table B.3**) were the downgradient median As, Cu, Ni, NH_4, PO_4, pH, HCO_3^-, K^+, Ca^{2+} and Mg^{2+} measurements. There was no water in the upgradient piezometer during this reporting period, the previous reporting period or most of the construction phase monitoring period, limiting the capacity to draw conclusions about groundwater quality. With the exception of Cu all of the parameters that generated a result of interest were measured during this reporting period within the ranges observed during construction phase monitoring (**Figures 3.57** to **3.66**). The downgradient median Cu concentration was also the only downgradient median result to increase during this reporting period. Measurements of HCO_3^-, K^+, Ca^{2+} and Mg^{2+} are no longer collected.

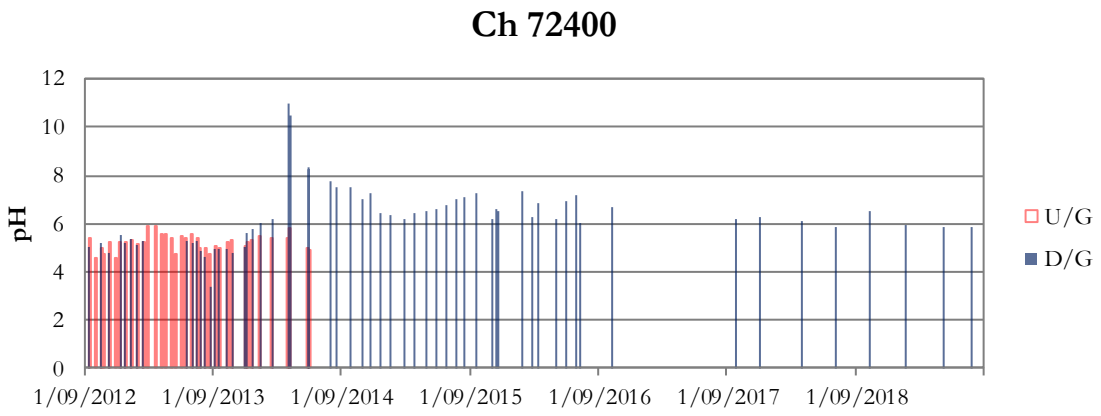


Figure 3.57 pH concentrations from Ch 72400 since September 2012

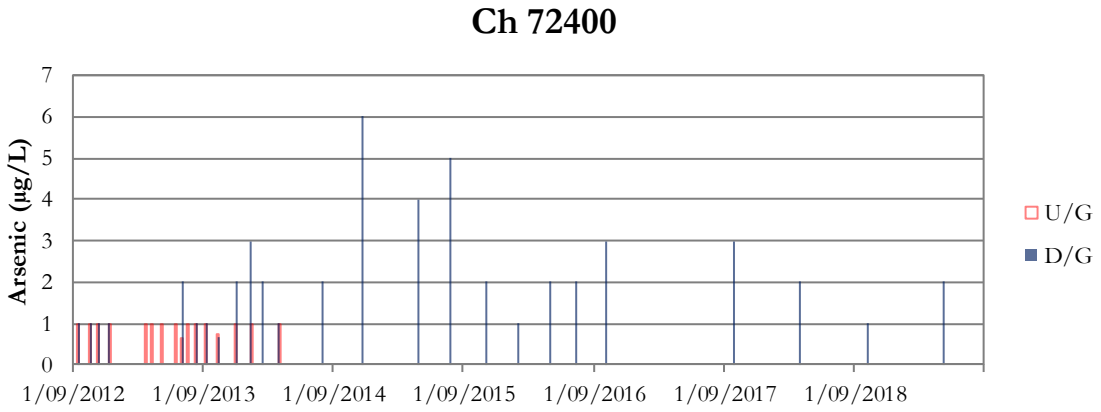


Figure 3.58 Arsenic concentrations from Ch 72400 since September 2012

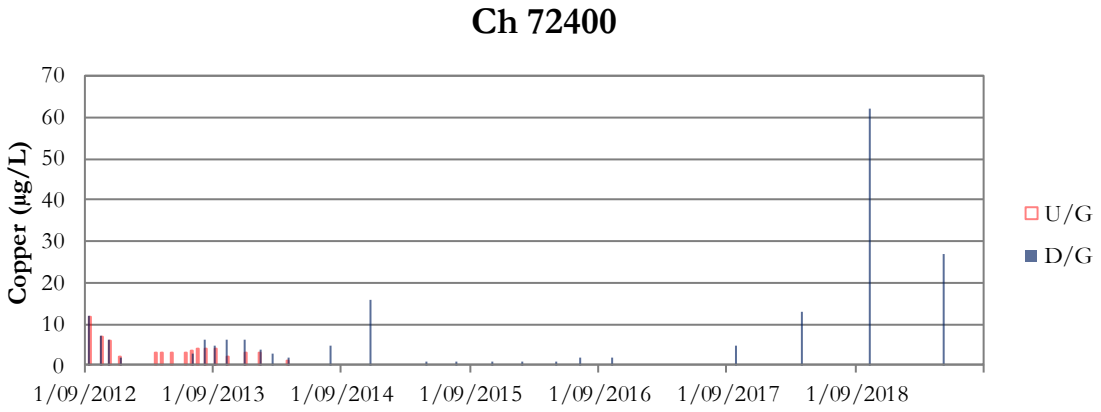


Figure 3.59 Copper concentrations from Ch 72400 since September 2012

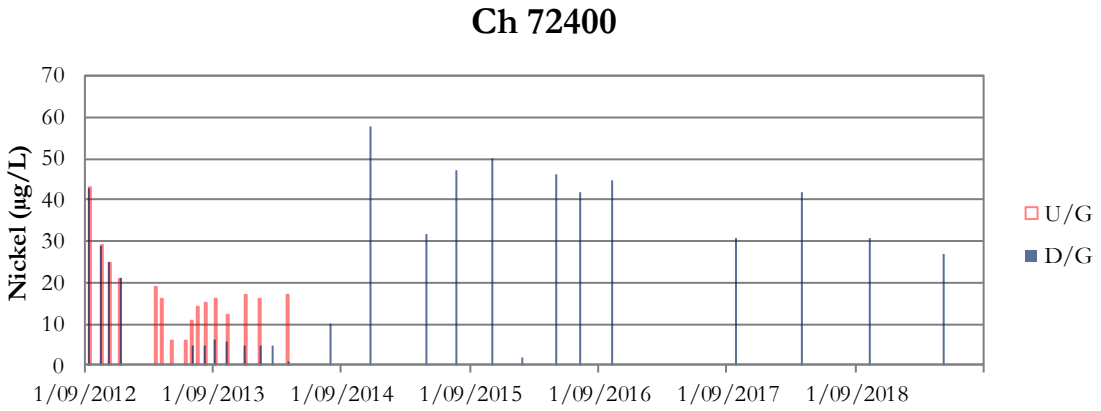


Figure 3.60 Nickel concentrations from Ch 72400 since September 2012

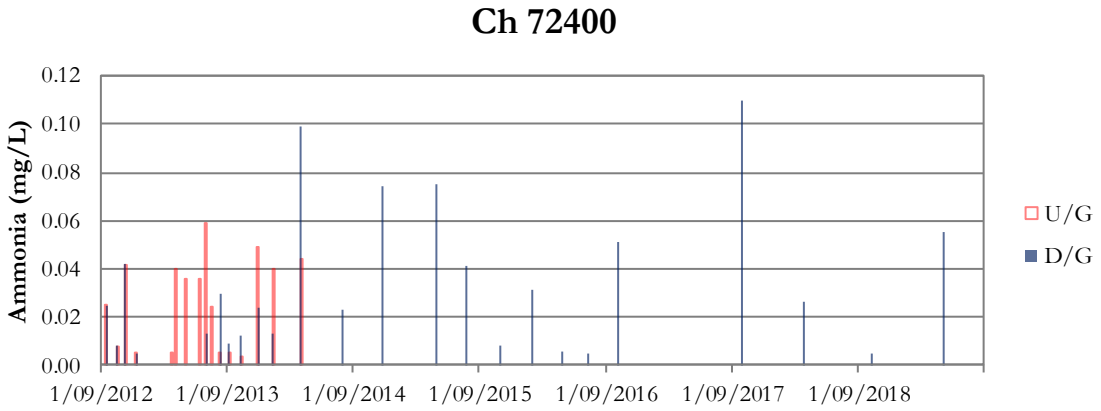


Figure 3.61 Ammonia measurements from Ch 72400 since September 2012

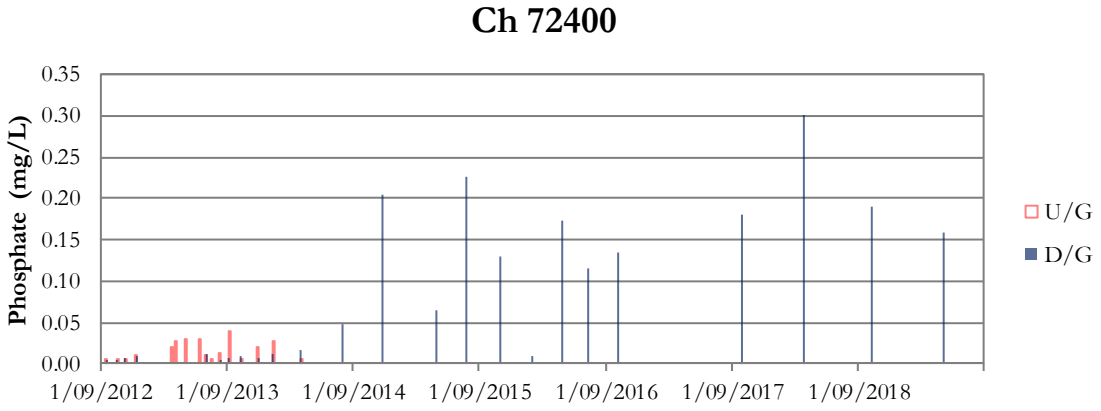


Figure 3.62 Phosphate measurements from Ch 72400 since September 2012

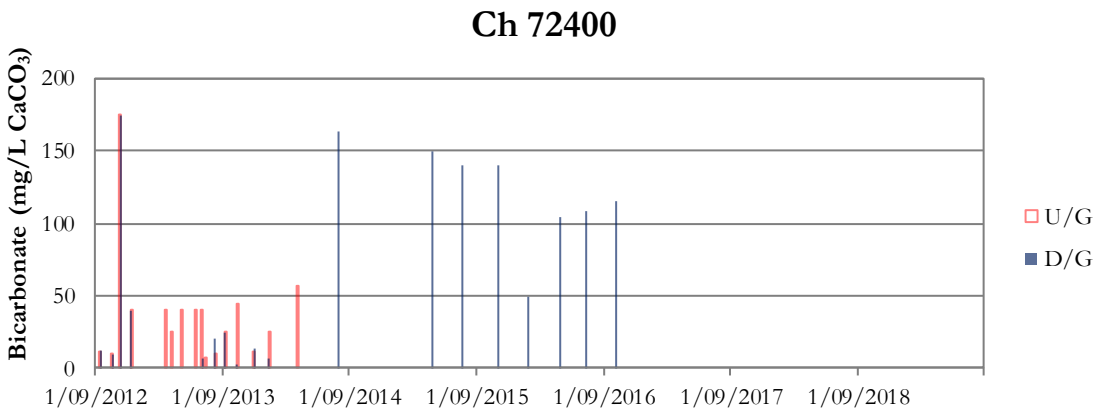


Figure 3.63 Bicarbonate measurements from Ch 72400 since September 2012

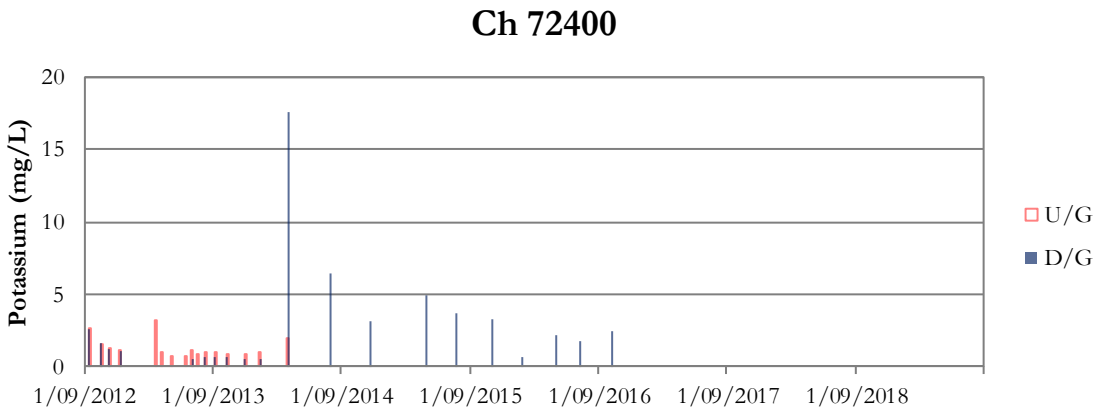


Figure 3.64 Potassium measurements from Ch 72400 since September 2012

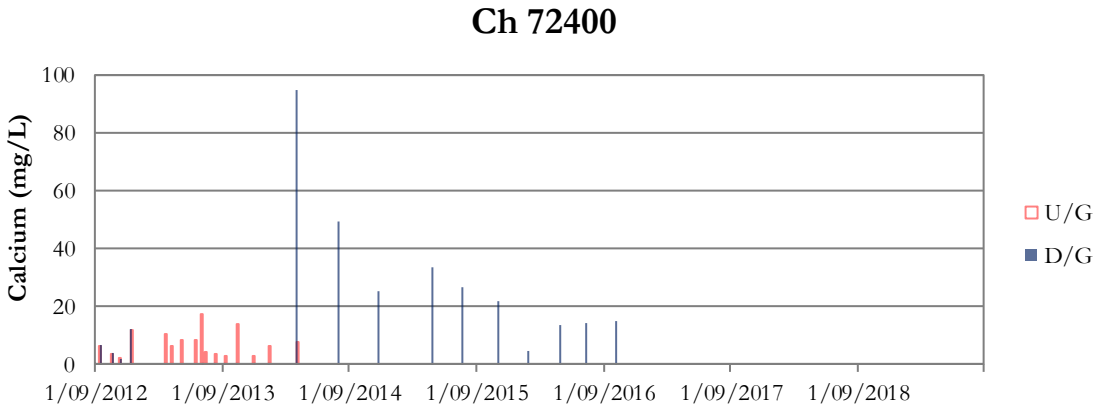


Figure 3.65 Calcium measurements from Ch 72400 since September 2012

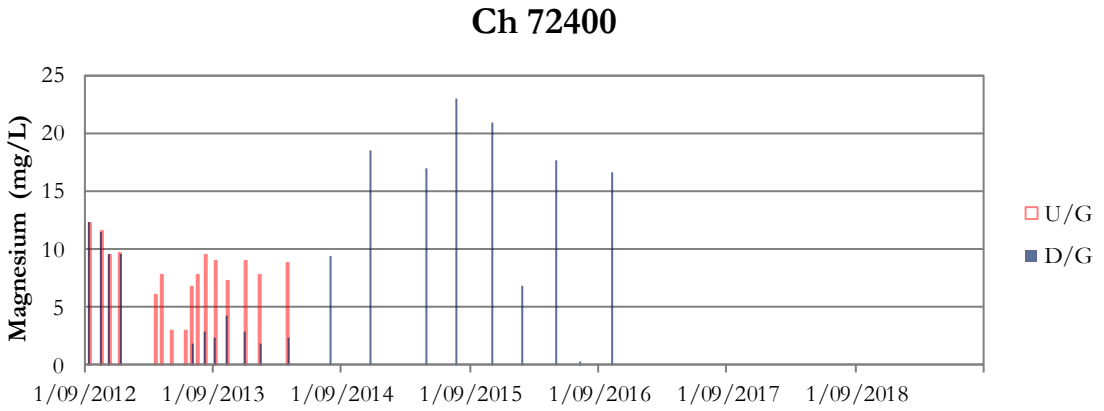


Figure 3.66 Magnesium measurements from Ch 72400 since September 2012

Summary for Ch 72400: All of the parameters that generated a result of interest have been measured during the operational phase within the ranges observed during construction phase monitoring except for Cu, NH_3 and PO_4. The highest downgradient measurements of all parameters that generated a result of interest have been measured during the construction or operational phases of monitoring. All downgradient median results decreased with the exception of Cu. Cu has been measured at concentrations far below the ADWG guideline concentration (**Table 1.1**). The capacity to draw conclusions about the source of elevated concentrations is limited by the dry upgradient piezometer.

3.3.5 Ch 74400

Results of interest from Ch 74400 (**Table B.4**) were the downgradient median Ni, NO_3, HCO_3^- and Cl^- and Mg^{2+} measurements. All of the parameters that generated a result of interest were measured at the downgradient piezometers during this monitoring period within the ranges observed during construction phase monitoring. Ni, Cl^- and Mg^{2+} were also measured this monitoring period within the ranges observed during pre-construction monitoring (**Figures 3.68** to **3.72**).

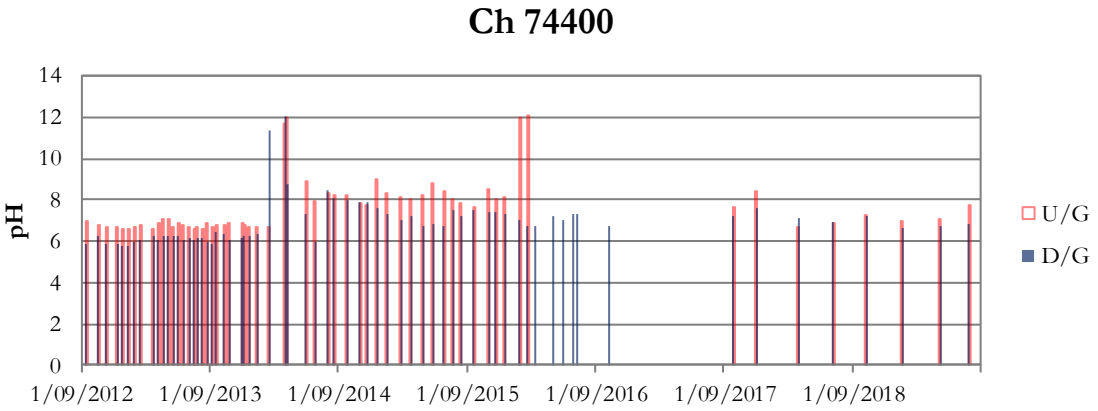


Figure 3.67 pH measurements from Ch 74400 since September 2012

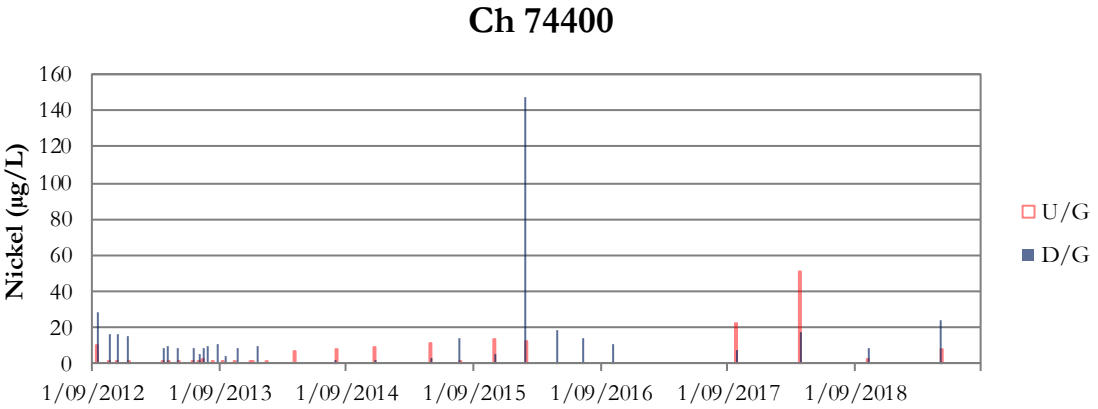


Figure 3.68 Nickel measurements from Ch 74400 since September 2012

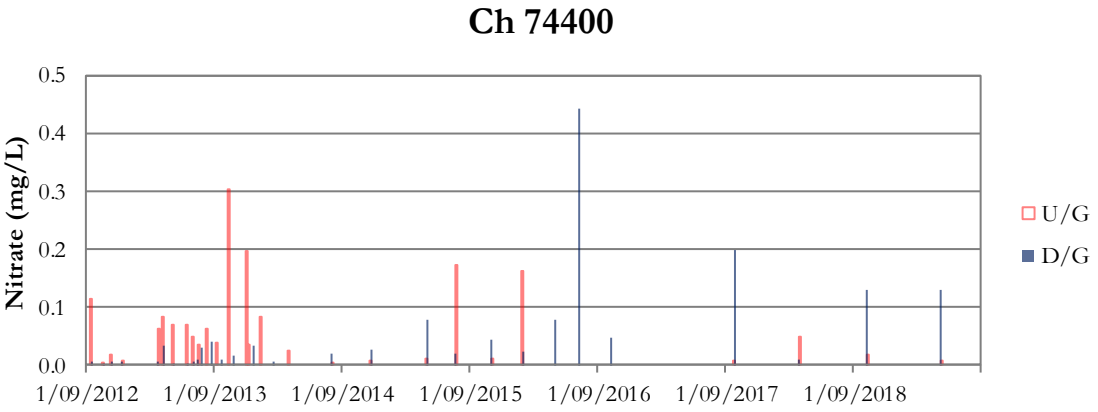


Figure 3.69 Nitrate measurements from Ch 74400 since September 2012

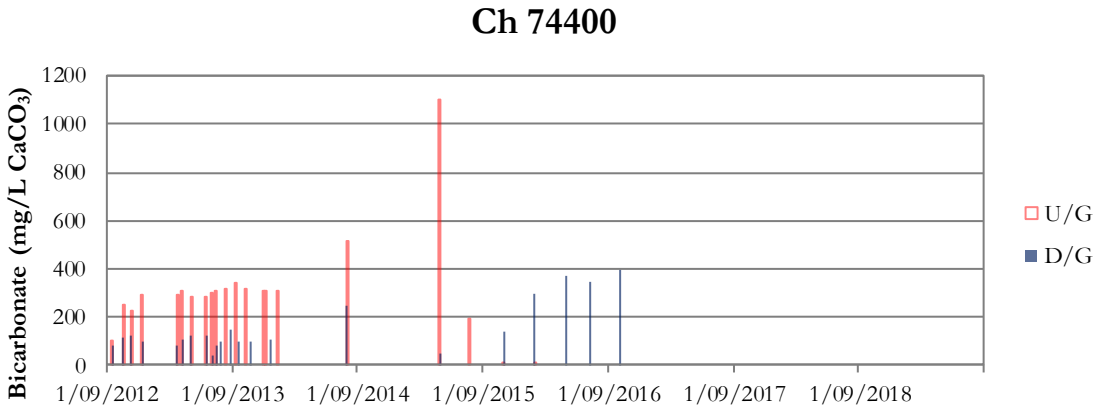


Figure 3.70 Bicarbonate measurements from Ch 74400 since September 2012

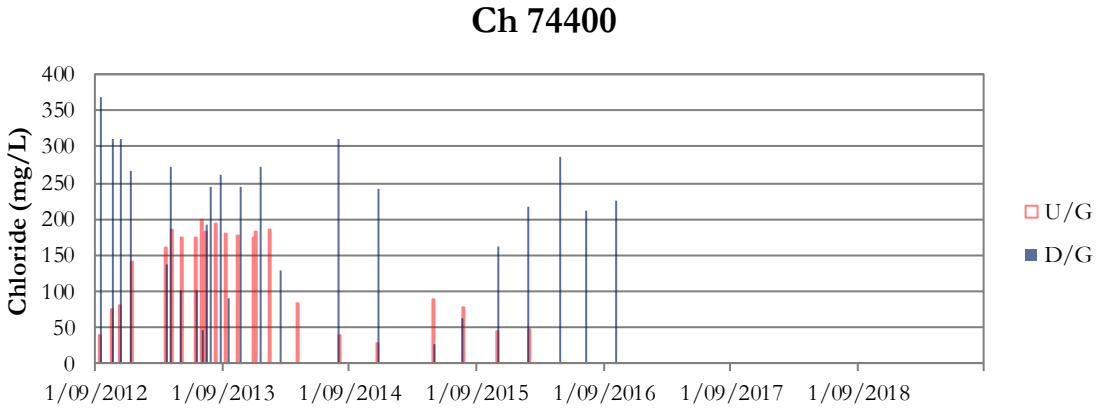


Figure 3.71 Chloride measurements from Ch 74400 since September 2012

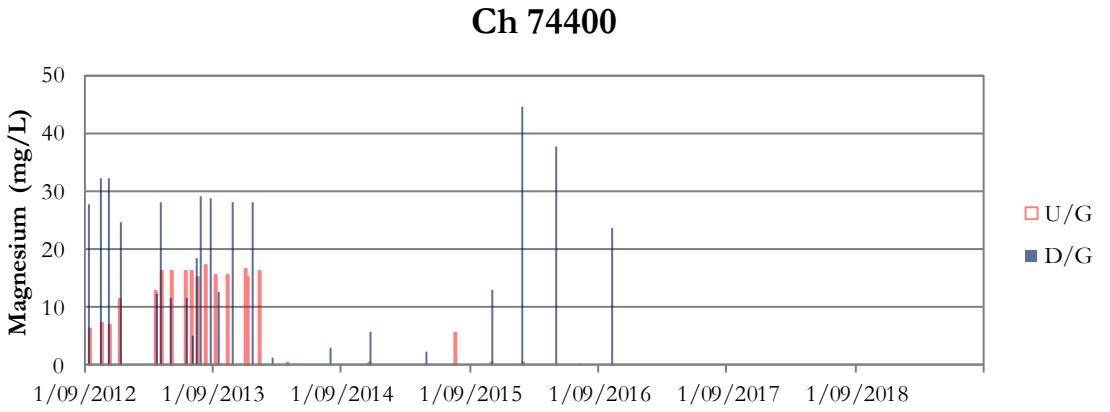


Figure 3.72 Magnesium measurements from Ch 74400 since September 2012

Summary for Ch 74400: All of the parameters that generated a result of interest were measured within the ranges observed during pre-construction and/or construction phase monitoring. The

upgradient piezometer at this location appears to be disconnected from the water table (see **Figure 3.82**), limiting the capacity to draw conclusions about the source of elevated concentrations.

3.3.6 Ch 75500

There were no results of interest from Ch 75500 (**Table B.5**). There is no downgradient piezometer at Ch 75500, limiting the capacity to draw conclusions about groundwater quality. All measurements at the upgradient piezometer were within the ranges observed during preconstruction and construction phase monitoring.

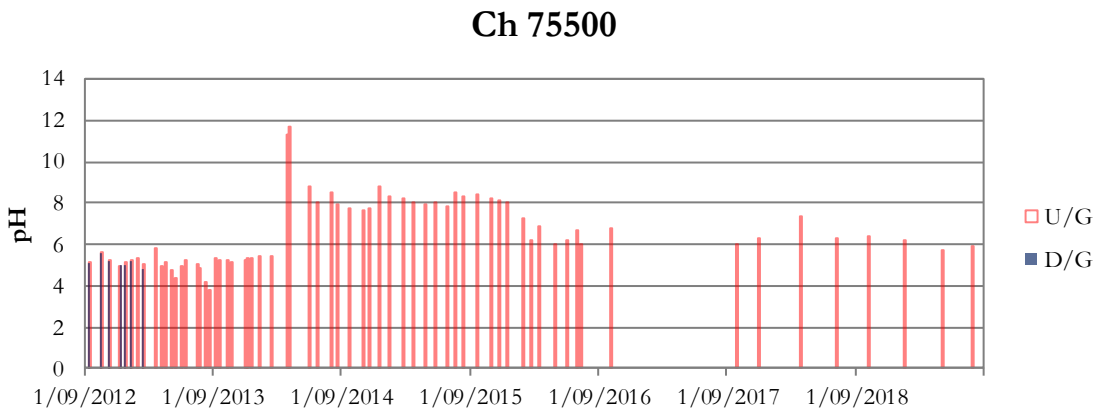


Figure 3.73 pH measurements from Ch 74400 since September 2012

Summary for Ch 75500: No results of interest from Ch75500.

3.3.7 Ch 78500

There were no results of interest from Ch 78500 (**Table B.6**). There was no water in the upgradient piezometer during this reporting period or most of the construction phase monitoring period, limiting the capacity to draw conclusions about groundwater quality.

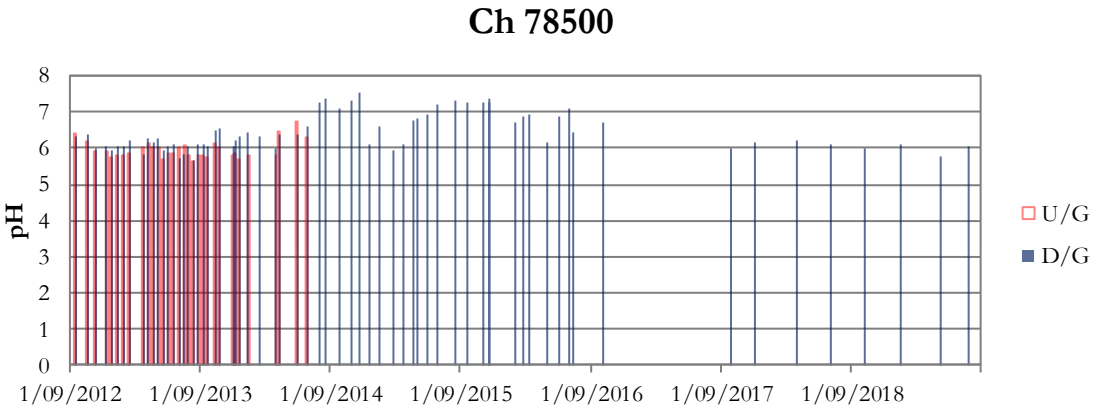


Figure 3.74 pH measurements from Ch 78500 since September 2012

Summary for Ch 78500: No results of interest from Ch78500.

3.3.8 Groundwater Level

The logged groundwater results for the period between 1 September 2018 and 31 August 2019 are displayed in **Figures 3.75 to 3.80**.

The median relative difference between groundwater levels at the pair of bores at Ch63200 was 5.5 m during pre-construction monitoring. For the two years operational phase monitoring displayed in **Figure 3.75** the median relative difference was 3.56 m.

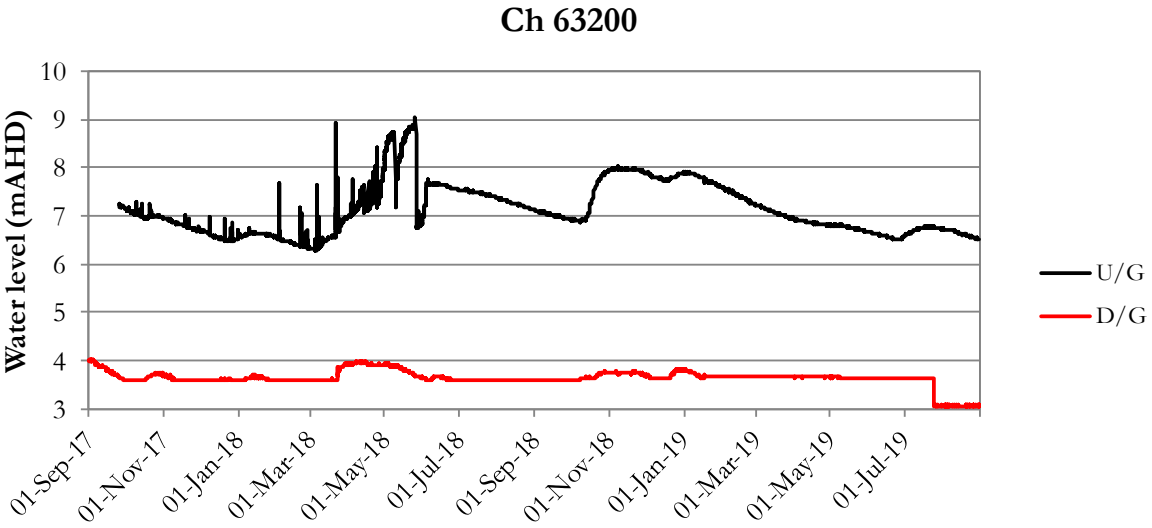


Figure 3.75 Groundwater levels at chainage 63200

The median relative difference between groundwater level at the pair of bores at Ch64600 was 0.16m during pre-construction monitoring. Between September 2017 and August 2019 the median difference was 0.72 m (**Figure 3.76**).

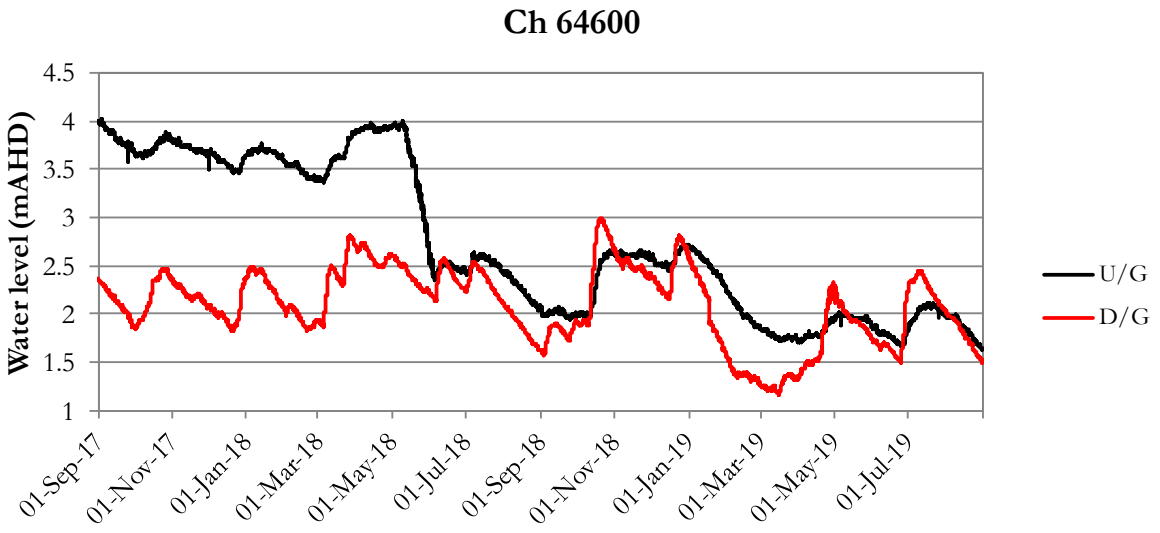


Figure 3.76 Groundwater levels at chainage 64600

The median relative pre-construction difference between groundwater level at the pair of bores at Ch72400 was not reported because the upgradient well (30500.1) was dry. During the current reporting period the upgradient well was also dry (**Figure 3.77**).

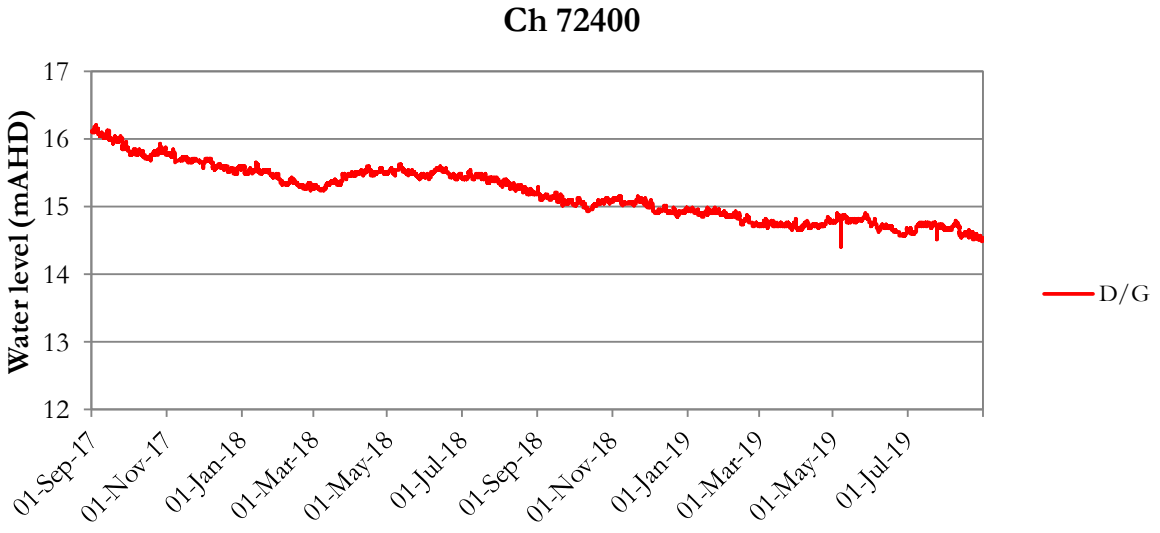


Figure 3.77 Groundwater levels at chainage 72400

The median relative difference between groundwater level at the pair of bores at Ch74400 was not reported for the pre-construction period because the second well monitored (32500.1) was not located on the correct side of the cut. The level of the upstream bore at 74400 was static during the current monitoring period indicating that the water level is below the screened area and the well is effectively dry (**Figure 3.78**).

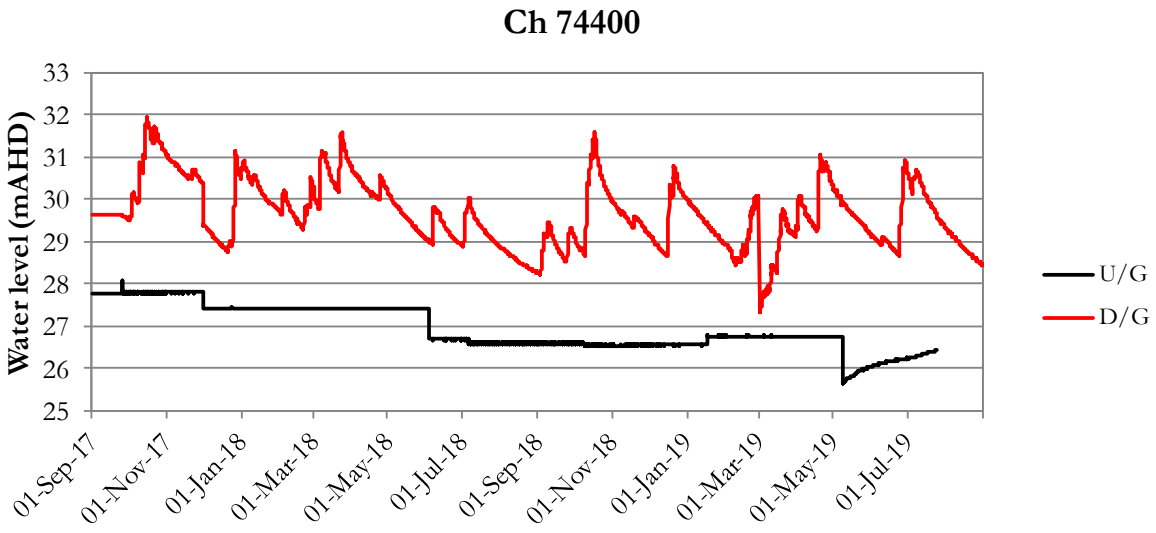


Figure 3.78 Groundwater levels at chainage 74400

There was no downgradient bore installed at approximate chainage 75500 for the pre-construction period and no relative difference between levels reported (**Figure 3.79**).

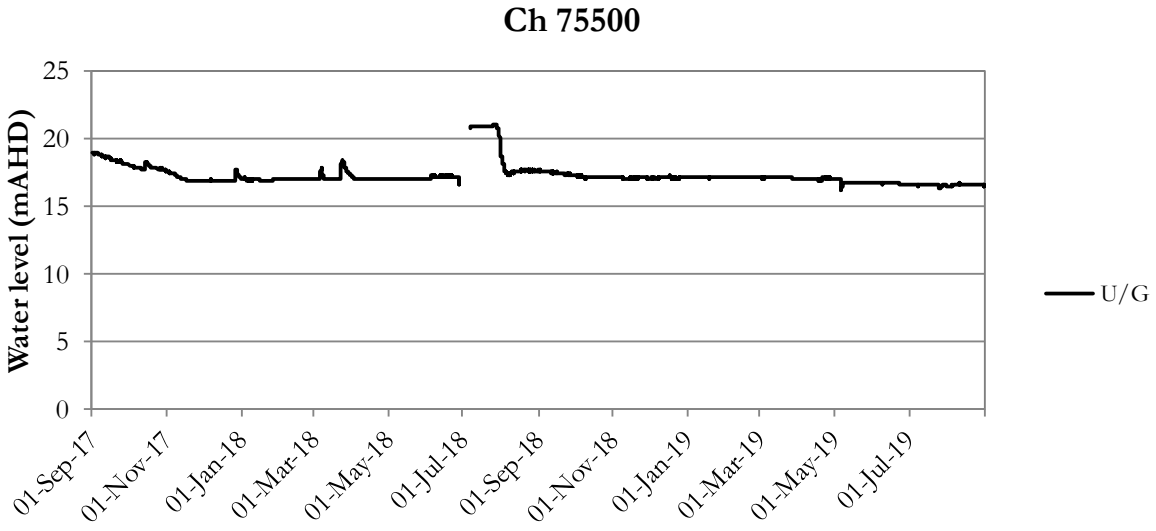


Figure 3.79 Groundwater levels at chainage 75500

The median relative difference in the groundwater levels for the two piezometers at approximate chainage 78500 was reported as 4.70m for the pre-construction period. During the current monitoring period the upgradient well was dry (**Figure 3.80**).

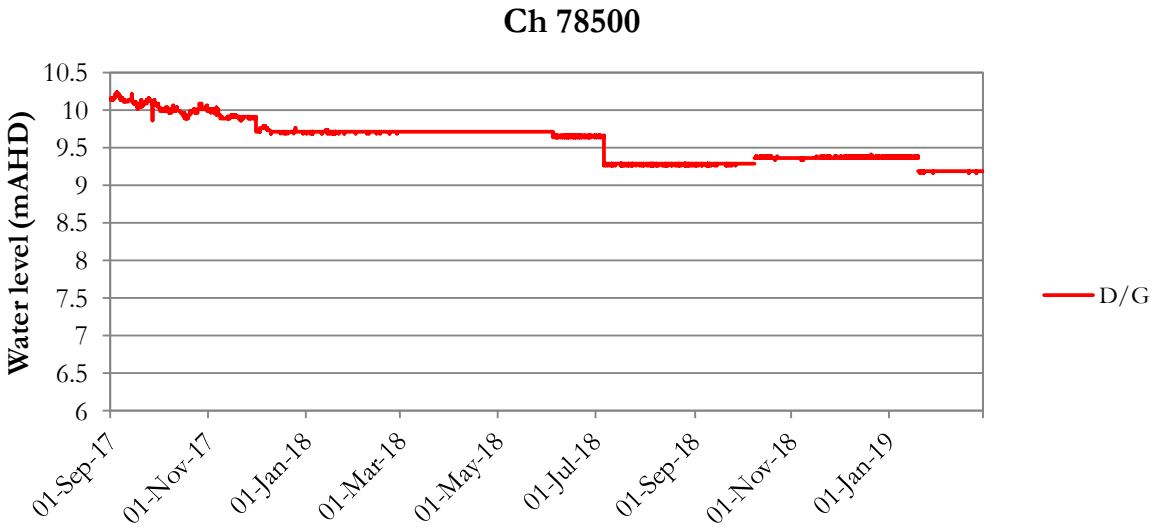


Figure 3.80 Groundwater levels at chainage 78500

4 Conclusions

Monitoring during this reporting period was undertaken according to the requirements of the GMP and SWMP with the exception of some deviations from the specified timings for groundwater and surface water samples. Deviations from the specified timings occurred as a result of logistical issues and the timing of suitable weather conditions. These are discussed further in **Sections 2.2.1** and **2.2.2**.

The following general conclusions can be drawn from the past 12 months of operational monitoring:

- The majority of results indicate that water quality protection measures have been successful, and that there has not been a significant impact from operation of the NH2U upgrade upon surface water quality. However, there have been several results of interest identified at this stage in the operational monitoring.
- There were fewer results of interest generated during this reporting period than the previous reporting period for both groundwater and surface water. As the operational monitoring data set grows, there is a lower impact from outlying results upon the summary statistics.
- Hydrocarbons have only been detected in two groundwater samples at this stage of operational monitoring. No hydrocarbons have been detected in any surface water samples. There were no results of interest generated from hydrocarbon analyses.
- In most cases the data suggests that the source of the higher concentrations of parameters generating a result of interest is upstream of the highway crossings, because upstream concentrations have also been elevated.
- There are some indications of generally increased concentrations of some parameters in surface waters at both control and impact sites in the operational data when compared with the pre-construction data. In particular, concentrations of iron, aluminium and phosphate are higher both upstream and downstream at many surface water sites in the operational dataset. There is no default ANZECC guideline concentration for iron and iron concentrations vary widely in waterways in relation to local geology and other chemical components (ANZECC 2000). The median construction phase downstream concentrations of aluminium in surface water are all significantly greater than the

relevant default ANZECC guideline concentration of 55 µg/L. However, the upstream p80 aluminium concentrations at all sites are also greater than the relevant default ANZECC guideline concentration. The median downstream concentrations of phosphate are mostly close to or below the relevant ANZECC guideline concentration of 0.02 mg/L.

- The highest downstream TSS concentrations and turbidity measurements since monitoring began have been collected during the operational phase at some sites. The downstream median turbidity measurements at McGraths Creek and Cow Creek were results of interest. However, at all sites except the Kalang River, McGraths Creek, Deep Creek and Boggy Creek the operational downstream median turbidity and TSS values have reduced or remained stable in relation to the previous annual reporting period. In all cases the operational phase downstream median surface water turbidity measurements were less than the relevant default ANZECC guideline value of 50 NTU.

- The results include some elevated measured concentrations of various groundwater parameters at some of the cuttings and embankments. Comparisons of summary statistics have drawn attention to some results of interest among the groundwater quality monitoring data. However;

    - In many cases the capacity to draw conclusions about groundwater quality is restricted by a lack of upgradient data.

    - Operational phase downgradient median concentrations of most parameters have reduced or remained stable at all sites since the previous annual report. Where there were exceptions to this few of them resulted in results of interest that had not been previously identified.

- The proportion of sites where operational phase downgradient median iron and aluminium concentrations have registered as results of interest reduced in this reporting period compared to the previous reporting period.

- The number of results of interest that exceeded ANZECC and ADWG guideline values also reduced. The results that did exceed guideline values were as follows:

    - At Ch 63200 the downgradient median iron concentration was greater than the relevant ADWG guideline value and the median copper, total nitrogen and total

phosphorus concentrations were greater than the relevant ANZECC guideline value.

- At Ch72400 the downgradient median copper, nickel, ammonia and phosphate concentrations were greater than the relevant ANZECC guideline values. At this site the upgradient p80 values for all of these parameters were also greater than the relevant ANZECC guideline values. There has been no water in the upgradient piezometer at this site since the pre-construction phase.
- At Ch74400 the downgradient median nitrate concentration was greater than the relevant ANZECC guideline value. The upgradient p80 concentration was also greater. At this location the upgradient piezometer appears to be disconnected from the groundwater table, limiting the capacity to draw conclusions.

- Measured groundwater levels declined overall at all sites with water between 1 September 2018 and 31 August 2019. Rainfall was below average for much of the period measured. At one site (Ch63200) where comparisons of relative groundwater levels from the pre-construction period are available, the operational relative levels appear to be relatively consistent with pre-construction observations. At Ch64600 a reduction in the upgradient water level in May 2018 made relative levels more consistent with pre-construction observations. At the other site (Ch78500) the upgradient piezometer ran dry during the construction period.
- Generating conclusions about groundwater levels and quality may be restricted by the fact that several piezometers were decommissioned during construction, new piezometers were relocated, and some piezometers ran dry.
- Some of the groundwater loggers are returning results suggesting that groundwater levels are below the screened section. Specifically, the upgradient piezometers at Ch72400, Ch74400 and Ch78500, and the downgradient piezometers at Ch63200 and Ch78500 are either dry, not recharging or not consistently recharging.
- The upgradient piezometer at Ch72400 is dry but was also dry during the pre-construction phase monitoring, so no change in level or water quality can been detected at that site.

- The upgradient piezometer at Ch78500 became dry during construction phase monitoring and has not recharged since. The summary results from the downstream piezometer do not indicate that there have been impacts in the operational phase.
- The upgradient piezometer at Ch74400 and the downgradient piezometers at Ch63200 and Ch78500 have water in them but are not recharging consistently, indicating that groundwater levels may have dropped below the screened section. As a result, water quality information collected from these piezometers may not always be reliable. However, the information available does not indicate that there have been any consistent operational phase impacts at any of these sites.

The following factors need to be considered in the interpretation of the results presented:

- The PQLs for some of the pre-construction analyses were lower than those utilised for operational monitoring. Some of the results included in this report need to be interpreted carefully as a result.
- The comparison between upstream P80 and downstream median values will continue to increase in value as more data is collected.

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Appendix A
Surface Water – Summary Monitoring Data

Table A.1 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for SEPP14 Wetland Number 351

Parameter	*PQL*	*Upstream SW380 Pre P80*	*Downstream SW351 Pre Med*	*Upstream SW380 Pre/Con P80*	*Downstream SW351 Con Med*	*Upstream SW380 Pre/Con/Op P80*	*Downstream SW351 Op Med (2016-17)*	*Downstream SW351 Op Med (2016-18)*	*Downstream SW351 Op Med (2016-19)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10	10	10
TRH C6 - C10 (µg/L)	10					10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50		50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100		100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100		100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50		50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100		100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100		100	100	100	100
Silver-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	149.80	106.50	330.78	184.00	424.20	790.00	250.00	260.00
Arsenic-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10	0.10	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	2.50	1.00	1.00
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.60	1.00	1.00	1.00
Iron-Total (µg/L)	10	727.67	390.50	3017.80	864.50	2452.60	1400.00	1700.00	1700.00
Manganese-Total (µg/L)	5	335.20	29.51	329.62	43.51	294.80	22.00	67.00	66.00
Nickel-Total (µg/L)	1	3.00	1.00	3.00	1.00	3.00	1.00	1.00	1.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	2.00	1.00	2.00	2.00	2.00	1.00	1.00	1.00
Zinc-Total (µg/L)	1	4.60	3.50	6.64	3.50	6.00	3.50	3.00	3.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	1.02	1.36	0.87	1.35	0.82	0.90	0.90	1.00
Nitrite as N (mg/L)	0.005	0.002	0.005	0.006	0.008	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.006	0.009	0.006	0.005	0.006	0.005	0.005	0.005
Ammonia as N (mg/L)	0.005	0.646	0.198	0.475	0.095	0.370	0.008	0.005	0.011
Total Phosphorus (mg/L)	0.05	0.02	0.06	0.03	0.04	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.005	0.005	0.005	0.005	0.013	0.012	0.013	0.011
Total Suspended Solids (mg/L)	5	41.80	6.00	39.16	10.00	36.40	7.50	8.00	8.00
Temperature (°C)	0.01	23.24	23.16	23.25	20.82	23.63	11.75	20.12	18.40
pH	0.01	5.09	6.19	6.36	6.79	6.72	5.37	5.87	6.03
Conductivity (mS/cm)	0.01	0.90	0.55	0.89	1.04	0.83	0.11	0.24	0.27
Turbidity (NTU)	0.01	33.20	4.45	34.80	4.60	37.28	6.00	9.10	9.10
Dissolved O_2 (mg/L) (P20)*	0.01	2.36	3.36	3.30	3.53	3.21	4.56	2.65	2.42

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.2 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for SEPP14 Wetland Number 353

Parameter	PQL	*Upstream SW360U Pre P80*	*Downstream SW353 Pre Med*	*Upstream SW360U Pre/Con P80*	*Downstream SW353 Con Med*	*Upstream SW360U Pre/Con/Op P80*	*Downstream SW353 Op Med (2016-17)*	*Downstream SW353 Op Med (2016-18)*	*Downstream SW353 Op Med (2016-19)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10	10	10
TRH C6 - C10 (µg/L)	10					10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50		50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100		100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100		100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50		50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100		100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100		100	100	100	100
Silver-Total (µg/L)	1	3.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	12.80	5.00	401.20	35.50	596.00	1025.00	340.00	300.00
Arsenic-Total (µg/L)	1	1.60	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10	0.10	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50	1.00	1.00
Iron-Total (µg/L)	10	913.60	52.20	2702.40	255.86	2920.00	3300.00	1700.00	1200.00
Manganese-Total (µg/L)	5	388.00	118.11	422.80	131.00	398.00	238.00	215.00	190.00
Nickel-Total (µg/L)	1	10.60	2.50	13.20	2.00	12.00	6.00	3.50	3.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	9.60	3.00	5.00	2.00	3.80	1.00	1.00	1.00
Zinc-Total (µg/L)	1	64.40	6.50	69.40	8.50	65.40	26.00	12.50	12.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	1.65	0.72	1.29	0.55	1.10	0.80	0.70	0.60
Nitrite as N (mg/L)	0.005	0.004	0.002	0.007	0.004	0.006	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.041	0.015	0.039	0.026	0.043	0.199	0.048	0.040
Ammonia as N (mg/L)	0.005	0.239	0.087	0.314	0.119	0.297	0.029	0.125	0.110
Total Phosphorus (mg/L)	0.05	0.07	0.02	0.06	0.02	0.06	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.005	0.005	0.006	0.005	0.012	0.020	0.022	0.011
Total Suspended Solids (mg/L)	5	47.80	10.00	34.60	9.75	35.00	8.00	12.00	12.00
Temperature (°C)	0.01	27.14	24.59	25.87	21.40	25.40	13.00	22.09	20.83
pH	0.01	7.41	7.16	7.19	7.11	7.14	4.51	6.80	6.80
Conductivity (mS/cm)	0.01	31.20	28.00	30.92	20.90	32.00	1.63	11.20	22.40
Turbidity (NTU)	0.01	35.26	8.95	34.04	4.00	36.20	11.85	29.20	15.80
Dissolved O_2 (mg/L) (P20)*	0.01	3.77	7.65	3.96	4.66	3.25	6.18	3.98	3.90

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.3 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for the unnamed tributary to SEPP Wetland No. 351

Parameter	PQL	*Upstream SW380 Pre P80*	*Downstream SW381 Pre Med*	*Upstream SW380 Pre/Con P80*	*Downstream SW381 Con Med*	*Upstream SW380 Pre/Con/Op P80*	*Downstream SW381 Op Med (2016-17)*	*Downstream SW381 Op Med (2016-18)*	*Downstream SW381 Op Med (2016-19)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10	10	10
TRH C6 - C10 (µg/L)	10					10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50		50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100		100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100		100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50		50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100		100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100		100	100	100	100
Silver-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	149.80	64.50	330.78	262.00	424.20	1200.00	360.00	300.00
Arsenic-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10	0.10	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50	1.00	1.00
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.60	1.50	1.00	1.00
Iron-Total (µg/L)	10	727.67	475.38	3017.80	1330.00	2452.60	1130.00	695.00	630.00
Manganese-Total (µg/L)	5	335.20	295.00	329.62	150.24	294.80	19.00	42.50	35.00
Nickel-Total (µg/L)	1	3.00	2.00	3.00	2.00	3.00	1.50	1.00	1.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	2.00	1.00	2.00	2.00	2.00	1.00	1.00	1.00
Zinc-Total (µg/L)	1	4.60	4.00	6.64	4.00	6.00	4.00	3.00	3.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	1.02	0.79	0.87	0.48	0.82	0.50	0.45	0.50
Nitrite as N (mg/L)	0.005	0.002	0.002	0.006	0.005	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.006	0.005	0.006	0.009	0.006	0.005	0.005	0.005
Ammonia as N (mg/L)	0.005	0.646	0.033	0.475	0.101	0.370	0.005	0.005	0.005
Total Phosphorus (mg/L)	0.05	0.02	0.06	0.03	0.04	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.005	0.005	0.005	0.006	0.013	0.015	0.011	0.008
Total Suspended Solids (mg/L)	5	41.80	15.25	39.16	14.40	36.40	5.00	6.00	5.00
Temperature (°C)	0.01	23.24	24.28	23.25	22.13	23.63	13.86	20.75	19.22
pH	0.01	5.09	5.53	6.36	5.68	6.72	5.42	6.80	6.80
Conductivity (mS/cm)	0.01	0.90	0.69	0.89	0.38	0.83	0.23	0.21	0.20
Turbidity (NTU)	0.01	33.20	13.00	34.80	11.40	37.28	14.90	19.80	17.10
Dissolved O_2 (mg/L) (P20)*	0.01	2.36	5.44	3.30	5.33	3.21	7.71	4.30	4.22

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.4 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for the unnamed tributary to SEPP Wetland No. 353

Parameter	PQL	*Upstream SW360U Pre P80*	*Downstream SW360D Pre Med*	*Upstream SW360U Pre/Con P80*	*Downstream SW360D Con Med*	*Upstream SW360U Pre/Con/Op P80*	*Downstream SW360D Op Med (2016-17)*	*Downstream SW360D Op Med (2016-18)*	*Downstream SW360D Op Med (2016-19)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10	10	10
TRH C6 - C10 (µg/L)	10					10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50		50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100		100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100		100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50		50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100		100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100		100	100	100	100
Silver-Total (µg/L)	1	3.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	12.80	5.00	401.20	37.00	596.00	985.00	600.00	340.00
Arsenic-Total (µg/L)	1	1.60	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10	0.10	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50	1.00	1.00
Iron-Total (µg/L)	10	913.60	35.50	2702.40	392.00	2920.00	3600.00	2000.00	1600.00
Manganese-Total (µg/L)	5	388.00	171.50	422.80	231.00	398.00	245.50	250.00	220.00
Nickel-Total (µg/L)	1	10.60	2.50	13.20	4.00	12.00	6.00	5.00	4.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	9.60	6.50	5.00	2.00	3.80	1.00	1.00	1.00
Zinc-Total (µg/L)	1	64.40	4.50	69.40	7.00	65.40	24.50	23.00	12.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	1.65	0.79	1.29	0.67	1.10	0.80	0.70	0.60
Nitrite as N (mg/L)	0.005	0.004	0.001	0.007	0.006	0.006	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.041	0.010	0.039	0.011	0.043	0.198	0.038	0.050
Ammonia as N (mg/L)	0.005	0.239	0.046	0.314	0.173	0.297	0.025	0.145	0.140
Total Phosphorus (mg/L)	0.05	0.07	0.04	0.06	0.03	0.06	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.005	0.005	0.006	0.005	0.012	0.025	0.026	0.011
Total Suspended Solids (mg/L)	5	47.80	14.00	34.60	8.00	35.00	5.00	11.00	10.00
Temperature (°C)	0.01	27.14	25.08	25.87	21.78	25.40	12.80	22.64	20.65
pH	0.01	7.41	7.12	7.19	6.37	7.14	4.60	6.33	6.46
Conductivity (mS/cm)	0.01	31.20	20.10	30.92	11.20	32.00	1.58	7.67	13.20
Turbidity (NTU)	0.01	35.26	9.30	34.04	4.50	36.20	13.05	14.90	14.70
Dissolved O_2 (mg/L) (P20)*	0.01	3.77	8.71	3.96	5.01	3.25	5.94	3.87	3.71

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.5 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for the Kalang River

Parameter	*PQL*	*Upstream SW359U Pre P80*	*Downstream SW359D Pre Med*	*Upstream SW359U Pre/Con P80*	*Downstream SW359D Con Med*	*Upstream SW359U Pre/Con/Op P80*	*Downstream SW359D Op Med (2016-17)*	*Downstream SW359D Op Med (2016-18)*	*Downstream SW359D Op Med (2016-19)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10	10	10
TRH C6 - C10 (µg/L)	10					10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50		50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100		100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100		100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50		50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100		100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100		100	100	100	100
Silver-Total (µg/L)	1	3.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	5.60	5.00	26.40	13.00	65.20	575.00	130.00	110.00
Arsenic-Total (µg/L)	1	2.00	2.00	2.80	1.00	2.00	1.00	1.00	1.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10	0.10	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Copper-Total (µg/L)	1	1.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00
Iron-Total (µg/L)	10	28.00	15.50	101.00	22.00	170.00	610.00	265.00	260.00
Manganese-Total (µg/L)	5	99.40	11.00	47.96	28.00	67.80	33.50	62.50	59.00
Nickel-Total (µg/L)	1	2.15	1.50	2.00	1.00	1.20	1.00	1.00	1.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	11.40	9.50	10.00	3.00	10.00	1.00	1.00	1.00
Zinc-Total (µg/L)	1	3.60	1.50	10.00	3.00	6.60	3.00	2.00	2.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	1.19	0.40	0.43	0.24	0.41	0.45	0.30	0.20
Nitrite as N (mg/L)	0.005	0.003	0.002	0.005	0.001	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.036	0.010	0.043	0.012	0.028	0.069	0.008	0.005
Ammonia as N (mg/L)	0.005	0.046	0.018	0.073	0.017	0.068	0.014	0.019	0.021
Total Phosphorus (mg/L)	0.05	0.09	0.04	0.03	0.02	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.005	0.005	0.009	0.005	0.016	0.022	0.021	0.018
Total Suspended Solids (mg/L)	5	117.60	16.00	32.00	9.00	32.00	9.00	9.00	9.50
Temperature (°C)	0.01	26.31	25.55	25.47	22.01	25.67	23.30	23.32	22.74
pH	0.01	7.51	7.52	7.55	7.45	7.58	7.37	7.39	7.39
Conductivity (mS/cm)	0.01	36.00	33.15	37.90	33.27	39.18	32.70	36.05	37.60
Turbidity (NTU)	0.01	160.80	13.35	23.00	6.80	22.88	6.90	10.00	11.90
Dissolved O_2 (mg/L) (P20)*	0.01	5.32	6.14	4.49	5.78	3.94	6.19	3.93	3.98

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.6 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for Dalhousie Creek

Parameter	PQL	*Upstream SW315U Pre P80*	*Downstream SW315D Pre Med*	*Upstream SW315U Pre/Con P80*	*Downstream SW315D Con Med*	*Upstream SW315U Pre/Con/Op P80*	*Downstream SW315D Op Med (2016-17)*	*Downstream SW315D Op Med (2016-18)*	*Downstream SW315D Op Med (2016-19)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10	10	10
TRH C6 - C10 (µg/L)	10					10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50		50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100		100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100		100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50		50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100		100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100		100	100	100	100
Silver-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	17.00	5.00	87.40	56.00	712.80	1900.00	480.00	480.00
Arsenic-Total (µg/L)	1	2.00	1.00	3.60	3.00	3.00	1.50	1.00	1.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10	0.10	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	2.00	1.50	1.50	1.50
Iron-Total (µg/L)	10	1391.00	934.00	3830.90	3139.00	2536.20	1420.00	1550.00	1550.00
Manganese-Total (µg/L)	5	904.00	511.50	493.40	280.00	399.50	57.00	68.00	68.00
Nickel-Total (µg/L)	1	3.00	2.00	2.60	2.00	2.00	1.50	1.50	1.50
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	1.00	1.00	2.00	2.00	2.00	1.00	1.00	1.00
Zinc-Total (µg/L)	1	12.00	4.50	6.00	5.00	5.00	4.00	5.00	5.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	0.26	0.24	0.32	0.21	0.35	0.35	0.20	0.20
Nitrite as N (mg/L)	0.005	0.001	0.001	0.004	0.003	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.018	0.005	0.015	0.010	0.020	0.005	0.006	0.006
Ammonia as N (mg/L)	0.005	0.138	0.170	0.123	0.063	0.090	0.005	0.005	0.005
Total Phosphorus (mg/L)	0.05	0.05	0.01	0.03	0.01	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.005	0.005	0.007	0.005	0.024	0.023	0.021	0.021
Total Suspended Solids (mg/L)	5	14.20	20.00	12.00	12.00	10.00	9.00	9.00	9.00
Temperature (°C)	0.01	20.69	20.21	22.08	18.76	22.48	15.24	20.61	20.32
pH	0.01	6.23	6.05	6.52	6.21	6.54	5.48	6.09	6.05
Conductivity (mS/cm)	0.01	0.95	0.88	0.91	0.54	0.88	0.24	0.23	0.23
Turbidity (NTU)	0.01	6.86	6.70	22.00	22.45	45.94	15.55	20.85	16.70
Dissolved O_2 (mg/L) (P20)*	0.01	2.28	2.44	3.31	5.26	3.18	5.35	3.35	3.22

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.7 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for McGraths Creek

Parameter	*PQL*	*Upstream SW301U Pre P80*	*Downstream SW301D Pre Med*	*Upstream SW301U Pre/Con P80*	*Downstream SW301D Con Med*	*Upstream SW301U Pre/Con/Op P80*	*Downstream SW301D Op Med (2016-17)*	*Downstream SW301D Op Med (2016-18)*	*Downstream SW301D Op Med (2016-19)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10	10	10
TRH C6 - C10 (µg/L)	10					10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50		50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100		100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100		100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50		50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100		100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100		100	100	100	100
Silver-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	20.80	9.00	100.00	41.62	112.40	2490.00	265.00	80.00
Arsenic-Total (µg/L)	1	3.79	1.00	2.47	1.00	4.00	2.50	2.00	2.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10	0.10	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	2.50	1.00	1.00
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	2.50	1.00	1.00
Iron-Total (µg/L)	10	2555.60	491.08	1810.00	874.00	2784.20	2700.00	1950.00	2200.00
Manganese-Total (µg/L)	5	454.85	120.00	332.00	89.50	345.60	62.00	94.00	100.00
Nickel-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50	1.00	1.00
Selenium-Total (µg/L)	1	1.60	1.00	2.00	2.00	2.00	1.00	1.00	1.00
Zinc-Total (µg/L)	1	6.60	2.00	5.00	2.00	5.00	4.50	2.50	2.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	1.33	0.53	0.53	0.26	0.54	0.50	0.30	0.30
Nitrite as N (mg/L)	0.005	0.002	0.002	0.006	0.004	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.049	0.017	0.053	0.016	0.049	0.047	0.005	0.005
Ammonia as N (mg/L)	0.005	0.676	0.094	0.149	0.043	0.119	0.023	0.005	0.005
Total Phosphorus (mg/L)	0.05	0.10	0.04	0.06	0.03	0.06	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.008	0.005	0.014	0.007	0.019	0.035	0.033	0.020
Total Suspended Solids (mg/L)	5	8.80	7.00	12.20	5.25	13.00	16.00	5.50	6.00
Temperature (°C)	0.01	22.67	22.33	23.53	20.87	23.31	14.54	21.72	19.84
pH	0.01	6.75	6.57	7.11	6.80	6.99	5.75	6.54	6.54
Conductivity (mS/cm)	0.01	0.77	0.69	0.77	0.55	0.73	0.24	0.34	0.38
Turbidity (NTU)	0.01	17.42	9.40	20.84	9.20	29.22	64.00	30.10	30.10
Dissolved O_2 (mg/L) (P20)*	0.01	1.82	6.14	3.94	6.04	2.51	7.32	4.42	4.34

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.8 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for the tributary to Oyster Creek

Parameter	*PQL*	*Upstream SW261 Pre P80*	*Downstream SW262 Pre Med*	*Upstream SW261 Pre/Con P80*	*Downstream SW262 Con Med*	*Upstream SW261 Pre/Con/Op P80*	*Downstream SW262 Op Med (2016-17)*	*Downstream SW262 Op Med (2016-18)*	*Downstream SW262 Op Med (2016-19)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10	10	10
TRH C6 - C10 (µg/L)	10					10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50		50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100		100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100		100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50		50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100		100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100		100	100	100	100
Silver-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	54.40	60.00	156.80	95.00	210.00	950.00	180.00	140.00
Arsenic-Total (µg/L)	1	2.00	1.00	2.01	1.00	3.00	1.50	3.00	2.50
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10	0.10	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50	1.00	1.00
Copper-Total (µg/L)	1	1.00	1.00	2.00	1.00	2.00	1.50	1.00	1.00
Iron-Total (µg/L)	10	1683.20	1485.00	1870.80	1182.00	2700.00	1550.00	2500.00	2050.00
Manganese-Total (µg/L)	5	58.00	27.00	127.80	36.00	191.28	33.50	120.00	135.00
Nickel-Total (µg/L)	1	1.00	1.00	2.00	1.00	2.00	1.00	1.00	1.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	1.60	1.00	2.00	2.00	2.00	1.00	1.00	1.00
Zinc-Total (µg/L)	1	4.60	2.00	8.20	3.04	8.00	5.50	5.00	5.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	0.63	0.46	0.49	0.30	0.61	0.55	0.40	0.40
Nitrite as N (mg/L)	0.005	0.007	0.003	0.009	0.005	0.007	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.018	0.017	0.028	0.016	0.030	0.105	0.010	0.010
Ammonia as N (mg/L)	0.005	0.045	0.040	0.060	0.043	0.053	0.005	0.005	0.006
Total Phosphorus (mg/L)	0.05	0.09	0.04	0.06	0.03	0.07	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.005	0.005	0.009	0.005	0.013	0.020	0.021	0.012
Total Suspended Solids (mg/L)	5	7.60	5.00	17.90	5.25	21.20	6.50	5.00	5.00
Temperature (°C)	0.01	23.31	22.12	23.64	21.06	23.64	14.30	21.41	20.45
pH	0.01	7.21	6.91	7.40	6.91	7.30	6.02	6.66	6.66
Conductivity (mS/cm)	0.01	0.52	0.27	0.80	0.28	0.57	0.15	0.23	0.23
Turbidity (NTU)	0.01	6.46	3.90	12.62	5.80	16.60	29.35	17.40	12.25
Dissolved O_2 (mg/L) (P20)*	0.01	2.51	4.61	2.69	5.75	2.49	7.63	4.34	4.55

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.9 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for Deep Creek

Parameter	*PQL*	*Upstream SW231U Pre P80*	*Downstream SW231D Pre Med*	*Upstream SW231U Pre/Con P80*	*Downstream SW231D Con Med*	*Upstream SW231U Pre/Con/Op P80*	*Downstream SW231D Op Med (2016-17)*	*Downstream SW231D Op Med (2016-18)*	*Downstream SW231D Op Med (2016-19)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10	10	10
TRH C6 - C10 (µg/L)	10					10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50		50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100		100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100		100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50		50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100		100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100		100	100	100	100
Silver-Total (µg/L)	1	3.40	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	8.60	5.00	52.00	17.00	113.32	925.00	85.00	100.00
Arsenic-Total (µg/L)	1	3.00	2.00	3.00	2.00	3.00	1.50	2.00	2.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10	0.10	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Copper-Total (µg/L)	1	1.60	1.00	2.00	1.00	1.40	2.00	1.00	1.00
Iron-Total (µg/L)	10	47.80	15.00	168.81	40.50	355.60	1050.00	385.00	250.00
Manganese-Total (µg/L)	5	52.20	26.50	60.20	38.00	66.20	56.50	56.50	41.00
Nickel-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	13.60	7.00	10.00	2.50	10.00	1.00	1.00	1.00
Zinc-Total (µg/L)	1	6.40	2.50	6.00	3.50	6.00	3.50	1.50	2.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	0.34	0.31	0.38	0.29	0.38	0.45	0.30	0.30
Nitrite as N (mg/L)	0.005	0.002	0.002	0.005	0.002	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.021	0.005	0.052	0.008	0.051	0.127	0.015	0.009
Ammonia as N (mg/L)	0.005	0.039	0.035	0.064	0.018	0.050	0.012	0.018	0.022
Total Phosphorus (mg/L)	0.05	0.03	0.02	0.03	0.02	0.05	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.005	0.005	0.011	0.005	0.015	0.032	0.034	0.024
Total Suspended Solids (mg/L)	5	8.80	6.00	13.20	8.50	13.60	5.50	5.50	6.00
Temperature (°C)	0.01	26.51	24.44	25.99	21.35	26.09	19.63	20.89	20.65
pH	0.01	7.70	7.11	7.63	7.38	7.64	6.96	7.28	7.24
Conductivity (mS/cm)	0.01	38.40	22.30	41.32	25.50	41.08	16.30	22.65	25.50
Turbidity (NTU)	0.01	10.48	4.35	12.70	5.35	15.50	2.90	10.40	10.50
Dissolved O_2 (mg/L) (P20)*	0.01	5.78	7.79	4.63	6.55	4.21	7.04	5.61	4.79

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.10 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for Cow Creek

Parameter	*PQL*	*Upstream SW217U Pre P80*	*Downstream SW217D Pre Med*	*Upstream SW217U Pre/Con P80*	*Downstream SW217D Con Med*	*Upstream SW217U Pre/Con/Op P80*	*Downstream SW217D Op Med (2016-17)*	*Downstream SW217D Op Med (2016-18)*	*Downstream SW217D Op Med (2016-19)*
TRH C6 - C9 (µg/L)	10					10	10	10	10
TRH C6 - C10 (µg/L)	10					10	10	10	10
TRH C10 - C14 (µg/L)	50					50	50	50	50
TRH C15 - C28 (µg/L)	100					100	100	100	100
TRH C29 - C36 (µg/L)	100					100	100	100	100
TRH >C10 - C16 (µg/L)	50					50	50	50	50
TRH >C16 - C34 (µg/L)	100					100	100	100	100
TRH >C34 - C40 (µg/L)	100					100	100	100	100
Silver-Total (µg/L)	1			1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10			37.00	14.00	62.00	780.00	90.00	60.00
Arsenic-Total (µg/L)	1			5.80	2.35	6.45	3.50	5.50	5.00
Cadmium-Total (µg/L)	0.1			1.00	1.00	1.00	0.10	0.10	0.10
Chromium-Total (µg/L)	1			1.00	1.00	1.00	1.00	1.00	1.00
Copper-Total (µg/L)	1			1.00	1.00	1.00	1.50	1.00	1.00
Iron-Total (µg/L)	10			1031.40	257.00	1270.80	935.00	1300.00	1100.00
Manganese-Total (µg/L)	5			489.00	130.00	522.37	25.50	193.00	66.00
Nickel-Total (µg/L)	1			1.00	1.00	1.00	1.00	1.00	1.00
Lead-Total (µg/L)	1			1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1			4.40	2.00	2.00	1.00	1.00	1.00
Zinc-Total (µg/L)	1			4.00	2.00	4.00	3.00	2.00	2.00
Mercury-Total (µg/L)	0.05			0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1			0.27	0.24	0.31	0.40	0.30	0.30
Nitrite as N (mg/L)	0.005			0.005	0.002	0.005	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005			0.016	0.012	0.016	0.049	0.006	0.006
Ammonia as N (mg/L)	0.005			0.048	0.030	0.044	0.005	0.005	0.007
Total Phosphorus (mg/L)	0.05			0.05	0.03	0.06	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005			0.017	0.006	0.021	0.027	0.030	0.024
Total Suspended Solids (mg/L)	5			7.80	5.00	12.00	5.50	6.00	6.00
Temperature (°C)	0.01	22.68	23.33	23.87	20.55	24.19	21.03	22.09	20.76
pH	0.01	6.44	6.33	7.54	7.03	7.53	7.78	6.95	6.84
Conductivity (mS/cm)	0.01	3.27	11.30	4.49	4.08	4.03	3.12	2.81	3.14
Turbidity (NTU)	0.01	2.98	3.10	8.56	3.70	12.78	7.00	14.90	12.80
Dissolved O_2 (mg/L) (P20)*	0.01	4.62	5.57	4.37	6.38	3.41	6.95	4.88	4.39

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Table A.11 Operational (Op), construction (Con) and preconstruction (Pre) phase downstream median surface water results and rolling upstream 80th percentile (P80) results for Boggy Creek

Parameter	*PQL*	*Upstream SW208U Pre P80*	*Downstream SW208D Pre Med*	*Upstream SW208U Pre/Con P80*	*Downstream SW208D Con Med*	*Upstream SW208U Pre/Con/Op P80*	*Downstream SW208D Op Med (2016-17)*	*Downstream SW208D Op Med (2016-18)*	*Downstream SW208D Op Med (2016-19)*
TRH C6 - C9 (µg/L)	10	10	10	10		10	10	10	10
TRH C6 - C10 (µg/L)	10					10	10	10	10
TRH C10 - C14 (µg/L)	50	50	50	50		50	50	50	50
TRH C15 - C28 (µg/L)	100	100	100	100		100	100	100	100
TRH C29 - C36 (µg/L)	100	100	100	100		100	100	100	100
TRH >C10 - C16 (µg/L)	50	50	50	50		50	50	50	50
TRH >C16 - C34 (µg/L)	100	100	100	100		100	100	100	100
TRH >C34 - C40 (µg/L)	100	100	100	100		100	100	100	100
Silver-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Aluminium-Total (µg/L)	10	143.00	11.50	154.20	48.00	160.60	1180.00	270.00	150.00
Arsenic-Total (µg/L)	1	3.00	2.50	3.00	2.45	5.00	4.00	5.00	5.00
Cadmium-Total (µg/L)	0.1	1.00	1.00	1.00	1.00	1.00	0.10	0.10	0.10
Chromium-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50	1.00	1.00
Copper-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.50	1.00	1.00
Iron-Total (µg/L)	10	268.00	393.50	743.00	667.00	1580.00	1600.00	2650.00	1900.00
Manganese-Total (µg/L)	5	21.00	268.50	227.60	87.00	552.80	95.50	270.00	260.00
Nickel-Total (µg/L)	1	3.00	1.00	2.00	1.00	2.00	1.00	1.00	1.00
Lead-Total (µg/L)	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Selenium-Total (µg/L)	1	1.00	1.00	2.00	2.00	2.00	1.00	1.00	1.00
Zinc-Total (µg/L)	1	4.00	2.50	5.00	2.00	5.00	3.00	4.00	4.00
Mercury-Total (µg/L)	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05	0.05
Total Nitrogen (mg/L)	0.1	1.41	0.37	0.77	0.26	0.74	0.40	0.45	0.40
Nitrite as N (mg/L)	0.005	0.005	0.003	0.006	0.003	0.006	0.005	0.005	0.005
Nitrate as N (mg/L)	0.005	0.011	0.016	0.014	0.007	0.018	0.023	0.005	0.005
Ammonia as N (mg/L)	0.005	0.302	0.039	0.202	0.033	0.142	0.005	0.005	0.005
Total Phosphorus (mg/L)	0.05	0.16	0.04	0.11	0.03	0.11	0.05	0.05	0.05
Phosphate as P (mg/L)	0.005	0.088	0.007	0.060	0.009	0.060	0.030	0.046	0.020
Total Suspended Solids (mg/L)	5	72.80	3.00	28.00	3.75	22.20	6.10	9.00	9.50
Temperature (°C)	0.01	23.22	20.71	23.27	19.70	23.29	15.41	21.09	19.90
pH	0.01	7.00	6.63	7.52	6.89	7.40	6.64	6.75	6.75
Conductivity (mS/cm)	0.01	0.51	0.82	1.20	0.50	0.86	0.29	0.46	0.47
Turbidity (NTU)	0.01	28.60	3.95	18.36	5.70	33.00	12.90	53.05	28.55
Dissolved O_2 (mg/L) (P20)*	0.01	2.03	3.45	2.92	6.30	2.50	9.90	4.62	4.54

Green Shading – Indicates a result of interest (2016 – 2019) Blue Shading – Indicates a result of interest (2016 - 2018) Red shading – Indicates a result of interest (2016 - 2017).
* - Upstream dissolved oxygen results are P20, not P80.

Appendix B
Summary Groundwater Monitoring Data

Table B.1 Pre-construction, combined pre-construction/construction and operational phase summary groundwater quality results for approximate chainage 63200

Parameter	*Units*	*PQL*	*U/G pre P80 21300.1*	*D/G pre med 21300.2*	*U/G pre/con P80 21300.1*	*D/G con med 21300.2*	*U/G pre/con/op P80 21300.1*	*D/G op med 2018 21300.2*	*D/G op med 2019 21300.2*
TRH C6 - C9	µg/L	10	10	10	10	10	10	10	10
TRH C6 - C10	µg/L	10		10	10	10	10	10	10
TRH C10-C14	µg/L	50	50	50	50	50	50	50	50
TRH C15-C28	µg/L	100	160	100	100	100	100	100	100
TRH C29-C36	µg/L	100	100	100	100	100	100	100	100
TRH >C10-C16	µg/L	50	220	50	50	50	50	50	50
TRH >C16-C34	µg/L	100	100	100	100	100	100	100	100
TRH >C34-C40	µg/L	100	100	100	100	100	100	100	100
Ag-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1	1.0	1
Al-Dissolved	µg/L	10	20.6	101.0	296.3	59.0	299	1500.0	65
As-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1	5.0	4
Cd-Dissolved	µg/L	0.1	1.0	1.0	1.0	1.0	1	0.1	0
Cr-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1	2.0	1
Cu-Dissolved	µg/L	1	9.2	2.0	3.0	1.7	6	13.0	11
Fe-Dissolved	µg/L	10	42.2	15.0	157.0	21.0	189	1488.0	640
Mn-Dissolved	µg/L	5	156.8	40.0	265.0	14.0	259	35.0	10
Ni-Dissolved	µg/L	1	13.4	3.0	5.0	1.0	6	4.0	1
Pb-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1	2.0	1
Se-Dissolved	µg/L	1	1.0	1.0	2.0	2.0	2	1.0	1
Zn-Dissolved	µg/L	1	110.0	41.0	59.0	11.0	69	16.0	16
Hg-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05
Total Nitrogen	mg/L	0.1	0.79	0.18	0.35	0.16	0.352	1.30	0.700
Nitrite	mg/L	0.005	0.030	0.002	0.006	0.001	0.006	0.005	0.005
Nitrate	mg/L	0.005	0.346	0.018	0.156	0.032	0.125	0.088	0.033
Ammonia	mg/L	0.005	0.054	0.015	0.050	0.025	0.043	0.020	0.020
Total Phosphorus	mg/L	0.05	0.07	0.02	0.06	0.01	0.056	0.06	0.060
Phosphate	mg/L	0.005	0.012	0.005	0.006	0.005	0.006	0.016	0.007
Temp	°C	0.01	20.67	19.49	21.00	19.54	21.20	19.81	20.24
pH		0.01	5.66	4.76	5.70	5.46	5.78	4.88	4.87
EC	mS/cm	0.01	0.27	0.14	0.27	0.13	0.27	0.09	0.09
TSS	mg/L	5	1553.6	168.8	1553.6		1135.9	570.0	570.0
TDS	mg/L	1	173.54	96.22	173.54		174		-
Bicarbonate	mg/L CaCO3	1	15.0	4.0	15.0	6.0	15.00	10.00	10.00
Sodium	mg/L	1	42.4	18.4	40.2	14.4	40.22	12.20	12.20
Potassium	mg/L	1	2.71	0.73	1.70	0.41	1.70	0.88	0.88
Calcium	mg/L	1	1.74	0.81	0.94	1.76	0.94	1.84	1.84
Magnesium	mg/L	1	1.90	2.97	1.49	1.88	1.49	1.11	1.11
Chloride	mg/L	1	53.0	39.1	54.4	29.4	54.38	19.5	19.50
Sulfate	mg/L	1	21.2	2.6	7.2	4.0	7.20	4.2	4.20

Red shading – Indicates a result of interest 2018. Blue shading – Indicates a result of interest 2019.

Table B.2 Pre-construction, combined pre-construction/construction and operational phase summary groundwater quality results for approximate chainage 64600

Parameter	*Units*	*PQL*	*U/G*	*D/G*	*U/G*	*D/G*	*U/G*	*D/G*	*D/G*
			pre P80	*pre med*	*pre/con P80*	*con med*	*pre/con/op P80*	*op med 2018*	*op med 2019*
			22600.1	*22600.2*	*22600.1*	*22600.2*	*22600.1*	*22600.2*	*22600.2*
TRH C6 - C9	µg/L	10	10	10	75	10	60	10	10
TRH C6 - C10	µg/L	10			84	10	80	10	10
TRH C10-C14	µg/L	50	50	50	50	50	50	50	50
TRH C15-C28	µg/L	100	100	100	100	100	100	100	100
TRH C29-C36	µg/L	100	100	100	100	100	100	100	100
TRH >C10-C16	µg/L	50	50	50	50	50	50	50	50
TRH >C16-C34	µg/L	100	100	100	100	100	100	100	100
TRH >C34-C40	µg/L	100	100	100	100	100	100	100	100
Ag-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1	1.0	1
Al-Dissolved	µg/L	10	25.8	6.0	2206.6	6.4	3500	10.0	10
As-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	3	2.0	1
Cd-Dissolved	µg/L	0.1	1.0	1.0	1.0	1.0	1	0.1	0
Cr-Dissolved	µg/L	1	2.4	2.5	2.0	1.0	2	1.0	1
Cu-Dissolved	µg/L	1	4.2	1.1	2.6	1.0	4	1.0	2
Fe-Dissolved	µg/L	10	17.4	16.0	62.8	5.0	82	310.0	10
Mn-Dissolved	µg/L	5	25.2	30.5	42.6	20.0	43	21.0	21
Ni-Dissolved	µg/L	1	16.0	2.5	3.7	1.0	4	1.0	9
Pb-Dissolved	µg/L	1	1.0	1.0	3.0	1.0	3	1.0	1
Se-Dissolved	µg/L	1	1.0	1.0	2.0	2.0	2	1.0	1
Zn-Dissolved	µg/L	1	66.6	40.0	34.0	11.0	36	2.0	10
Hg-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05
Total Nitrogen	mg/L	0.1	0.47	0.22	0.31	0.06	0.342	0.10	0.100
Nitrite	mg/L	0.005	0.005	0.002	0.002	0.001	0.005	0.005	0.005
Nitrate	mg/L	0.005	0.022	0.007	0.054	0.007	0.050	0.005	0.005
Ammonia	mg/L	0.005	0.024	0.010	0.057	0.009	0.072	0.047	0.047
Total Phosphorus	mg/L	0.05	0.05	0.03	0.05	0.01	0.067	0.05	0.050
Phosphate	mg/L	0.005	0.008	0.005	0.010	0.006	0.011	0.013	0.005
Temp	°C	0.01	20.80	20.90	20.89	20.60	21.13	22.12	22.35
pH		0.01	5.49	5.82	6.84	6.16	6.75	6.24	6.11
EC	mS/cm	0.01	0.24	0.26	1.40	0.27	1.29	0.25	0.26
TSS	mg/L	5	182.1	75.3	182.1		283.5	52.5	9.0
TDS	mg/L	1	162.11	179.86	162.11		162		-
Bicarbonate	mg/L CaCO3	1	13.2	40.0	13.0	40.0	13.00	40.0	40.00
Sodium	mg/L	1	34.5	35.0	219.2	36.3	219.20	37.8	37.80
Potassium	mg/L	1	0.80	1.00	1.25	0.84	1.25	1.11	1.11
Calcium	mg/L	1	2.06	5.00	5.82	5.02	5.82	5.26	5.26
Magnesium	mg/L	1	4.75	6.87	8.50	7.03	8.50	7.26	7.26
Chloride	mg/L	1	62.6	56.0	332.4	54.0	332.40	55.5	55.50
Sulfate	mg/L	1	5.4	4.0	11.6	3.5	11.60	3.2	3.15

Red shading – Indicates a result of interest. Blue shading – Indicates a result of interest 2019.

Table B.3 Pre-construction, combined pre-construction/construction and operational phase summary groundwater quality results for approximate chainage 72400

Parameter	*Units*	*PQL*	*U/G pre P80 30500.1*	*D/G pre med 30500.2*	*U/G pre/con P80 30500.1*	*D/G con med 30500.2*	*U/G pre/con/op P80 30500.1*	*D/G op med 2018 30500.2*	*D/G op med 2019 30500.2*
TRH C6 - C9	µg/L	10		10	10	10	10	10	10
TRH C6 - C10	µg/L	10			10	10	10	10	10
TRH C10-C14	µg/L	50		50	50	50	50	50	50
TRH C15-C28	µg/L	100		100	100	100	100	100	100
TRH C29-C36	µg/L	100		100	100	100	100	100	100
TRH >C10-C16	µg/L	50	50	50	50	50	50	50	50
TRH >C16-C34	µg/L	100	100	100	100	100	100	100	100
TRH >C34-C40	µg/L	100	100	100	100	100	100	100	100
Ag-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1	1.0	1
Al-Dissolved	µg/L	10	90.0	84.0	165.7	47.5	166	170.0	20
As-Dissolved	µg/L	1	1.0	1.0	1.0	2.0	1	3.0	2
Cd-Dissolved	µg/L	0.1	1.0	1.0	1.0	1.0	1	0.1	0
Cr-Dissolved	µg/L	1	7.4	4.0	3.0	1.0	3	1.0	1
Cu-Dissolved	µg/L	1	9.0	6.5	4.0	3.0	4	5.0	13
Fe-Dissolved	µg/L	10	15.8	13.0	313.8	262.0	314	290.0	10
Mn-Dissolved	µg/L	5	823.2	485.0	388.0	181.0	388	320.0	260
Ni-Dissolved	µg/L	1	34.6	27.0	21.0	5.8	21	42.0	31
Pb-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1	1.0	1
Se-Dissolved	µg/L	1	2.0	1.5	2.0	2.0	2	1.0	1
Zn-Dissolved	µg/L	1	147.0	125.0	107.0	36.0	107	76.0	76
Hg-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05
Total Nitrogen	mg/L	0.1	0.58	0.43	0.40	0.14	0.400	0.40	0.321
Nitrite	mg/L	0.005	0.007	0.002	0.004	0.003	0.004	0.005	0.005
Nitrate	mg/L	0.005	0.027	0.027	0.185	0.020	0.185	0.040	0.040
Ammonia	mg/L	0.005	0.032	0.017	0.042	0.023	0.042	0.051	0.051
Total Phosphorus	mg/L	0.05	0.53	0.42	0.39	0.07	0.390	0.30	0.300
Phosphate	mg/L	0.005	0.008	0.006	0.027	0.017	0.027	0.180	0.180
Temp	°C	0.01	20.98	20.21	21.46	20.24	21.46	20.71	21.34
pH		0.01	5.33	5.24	5.45	6.47	5.45	6.16	6.08
EC	mS/cm	0.01	1.19	1.14	1.12	0.97	1.12	0.90	0.84
TSS	mg/L	5		894.8			-	24.0	13.5
TDS	mg/L	1		812.50			-		-
Bicarbonate	mg/L CaCO3	1	94.0	26.0	40.0	50.0	40.00	115.0	115.00
Sodium	mg/L	1	209.4	204.0	203.0	66.5	203.00	185.0	185.00
Potassium	mg/L	1	2.01	1.43	1.59	1.80	1.59	2.52	2.52
Calcium	mg/L	1	8.95	5.32	10.60	13.80	10.60	15.20	15.20
Magnesium	mg/L	1	11.88	10.62	9.61	4.28	9.61	16.60	16.60
Chloride	mg/L	1	275.6	250.5	249.0	102.0	249.00	210.0	210.00
Sulfate	mg/L	1	105.4	96.0	101.1	38.4	101.10	42.0	42.00

Red shading – Indicates a result of interest. Blue shading – Indicates a result of interest 2019.

Table B.4 Pre-construction, combined pre-construction/construction and operational phase summary groundwater quality results for approximate chainage 74400

Parameter	*Units*	*PQL*	*U/G pre P80 32500.1*	*D/G pre med 32500.2*	*U/G pre/con P80 32500.1*	*D/G con med 32500.2*	*U/G pre/con/op P80 32500.1*	*D/G op med 2018 32500.2*	*D/G op med 2019 32500.2*
TRH C6 - C9	µg/L	10	10	10	10	10	10	10	10
TRH C6 - C10	µg/L	10			10	10	10	10	10
TRH C10-C14	µg/L	50	50	50	55	50	53	50	50
TRH C15-C28	µg/L	100	100	100	100	100	100	100	100
TRH C29-C36	µg/L	100	100	100	100	100	100	100	100
TRH >C10-C16	µg/L	50	50	50	92	50	75	50	50
TRH >C16-C34	µg/L	100	100	100	100	100	100	100	100
TRH >C34-C40	µg/L	100	100	100	100	100	100	100	100
Ag-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1	1.0	1
Al-Dissolved	µg/L	10	44.2	164.5	345.8	63.5	327	560.0	10
As-Dissolved	µg/L	1	5.2	7.5	5.0	3.0	8	2.0	1
Cd-Dissolved	µg/L	0.1	1.0	1.0	1.0	1.0	1	0.2	0
Cr-Dissolved	µg/L	1	11.4	7.0	2.8	1.0	1	2.0	1
Cu-Dissolved	µg/L	1	3.0	2.5	4.0	2.0	4	3.0	3
Fe-Dissolved	µg/L	10	375.0	1006.0	109.4	177.5	112	7100.0	12
Mn-Dissolved	µg/L	5	1547.8	410.0	1875.8	219.0	1832	290.0	260
Ni-Dissolved	µg/L	1	5.2	16.5	8.6	9.0	10	11.0	11
Pb-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1	1.0	1
Se-Dissolved	µg/L	1	1.0	1.0	2.0	2.0	2	1.0	1
Zn-Dissolved	µg/L	1	61.6	55.5	68.2	29.0	58	42.0	42
Hg-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05
Total Nitrogen	mg/L	0.1	1.06	1.47	2.98	0.26	2.601	0.20	0.200
Nitrite	mg/L	0.005	0.005	0.002	0.023	0.005	0.020	0.005	0.005
Nitrate	mg/L	0.005	0.056	0.005	0.102	0.023	0.084	0.047	0.130
Ammonia	mg/L	0.005	0.076	0.027	2.330	0.043	1.933	0.072	0.032
Total Phosphorus	mg/L	0.05	0.07	0.36	0.08	0.10	0.079	0.06	0.060
Phosphate	mg/L	0.005	0.009	0.088	0.010	0.021	0.015	0.011	0.005
Temp	°C	0.01	21.86	19.63	21.60	20.34	21.54	20.26	21.40
pH		0.01	6.81	5.91	8.29	6.79	8.25	7.10	6.92
EC	mS/cm	0.01	1.00	1.61	3.31	1.35	3.10	1.06	1.24
TSS	mg/L	5	72.3	114.9	72.3		62.7	35.5	35.5
TDS	mg/L	1	576.00	1115.50	576.00		576		-
Bicarbonate	mg/L CaCO3	1	271.0	107.5	315.0	108.0	315.00	395.0	395.00
Sodium	mg/L	1	62.2	264.5	224.4	196.0	224.40	209.0	209.00
Potassium	mg/L	1	3.25	2.79	55.32	2.51	55.32	4.86	4.86
Calcium	mg/L	1	101.50	20.10	130.28	21.00	130.28	108.00	108.00
Magnesium	mg/L	1	8.96	29.95	16.31	12.55	16.31	23.80	23.80
Chloride	mg/L	1	105.0	311.5	182.0	203.0	182.00	225.0	225.00
Sulfate	mg/L	1	25.8	201.5	72.2	156.6	72.20	56.7	56.70

Red shading – Indicates a result of interest. Blue shading – Indicates a result of interest 2019.

Table B.5 Pre-construction, combined pre-construction/construction and operational phase summary groundwater quality results for approximate chainage 75500

Parameter	*Units*	*PQL*	*U/G pre P80 33600.1*	*D/G pre med 33600.2*	*U/G pre/con P80 33600.1*	*D/G con med 33600.2*	*U/G pre/con/op P80 33600.1*	*D/G op med 2018 33600.2*	*D/G op med 2019 33600.2*
TRH C6 - C9	µg/L	10	10	10	10		10		
TRH C6 - C10	µg/L	10			10		10		
TRH C10-C14	µg/L	50	474	315	51		50		
TRH C15-C28	µg/L	100	1220	800	100		100		
TRH C29-C36	µg/L	100	100	100	100		100		
TRH >C10-C16	µg/L	50	620	630	50		50		
TRH >C16-C34	µg/L	100	100	100	100		100		
TRH >C34-C40	µg/L	100	100	100	100		100		
Ag-Dissolved	µg/L	1	1.0	1.0	1.0		1		
Al-Dissolved	µg/L	10	1081.8	905.5	523.2		523		
As-Dissolved	µg/L	1	12.4	8.0	3.0		3		
Cd-Dissolved	µg/L	0.1	1.0	1.0	1.0		1		
Cr-Dissolved	µg/L	1	8.4	6.0	3.0		3		
Cu-Dissolved	µg/L	1	78.0	63.5	37.0		28		
Fe-Dissolved	µg/L	10	3254.8	2042.0	988.3		996		
Mn-Dissolved	µg/L	5	414.8	332.0	318.4		246		
Ni-Dissolved	µg/L	1	41.8	36.0	18.4		16		
Pb-Dissolved	µg/L	1	11.6	7.5	3.8		3		
Se-Dissolved	µg/L	1	4.0	3.5	2.4		2		
Zn-Dissolved	µg/L	1	409.8	357.0	261.0		243		
Hg-Dissolved	µg/L	0.05	0.50	0.50	0.50		0.50		
Total Nitrogen	mg/L	0.1	6.05	4.35	0.85		0.784		
Nitrite	mg/L	0.005	0.003	0.003	0.004		0.005		
Nitrate	mg/L	0.005	0.008	0.005	0.022		0.051		
Ammonia	mg/L	0.005	0.751	0.641	0.475		0.338		
Total Phosphorus	mg/L	0.05	0.12	0.12	0.12		0.140		
Phosphate	mg/L	0.005	0.016	0.009	0.026		0.040		
Temp	°C	0.01	21.53	19.93	21.99		21.99		
pH		0.01	5.33	5.13	8.11		8.04		
EC	mS/cm	0.01	2.03	1.90	1.23		1.20		
TSS	mg/L	5	118.2	106.8	118.2		112.7		
TDS	mg/L	1	1289.60	1294.00	1289.60		1,290		
Bicarbonate	mg/L CaCO3	1	31.0	18.8	93.8		86.60		
Sodium	mg/L	1	321.0	285.0	196.2		192.60		
Potassium	mg/L	1	2.85	2.66	16.48		16.14		
Calcium	mg/L	1	4.01	3.38	26.20		25.50		
Magnesium	mg/L	1	41.84	36.25	17.20		16.40		
Chloride	mg/L	1	566.8	504.5	310.0		301.00		
Sulfate	mg/L	1	33.8	28.0	35.4		35.20		

Red shading – Indicates a result of interest. Blue shading – Indicates a result of interest 2019.

Table B.6 Pre-construction, combined pre-construction/construction and operational phase summary groundwater quality results for approximate chainage 78500

Parameter	*Units*	*PQL*	*U/G*	*D/G*	*U/G*	*D/G*	*U/G*	*D/G*	*D/G*
			pre P80	*pre med*	*pre/con P80*	*con med*	*pre/con/op P80*	*op med 2018*	*op med 2019*
			36600.1	*36600.2*	*36600.1*	*36600.2*	*36600.1*	*36600.2*	*36600.2*
TRH C6 - C9	µg/L	10	10	10	10	10	10	10	10
TRH C6 - C10	µg/L	10			10	10	10	10	10
TRH C10-C14	µg/L	50	50	50	50	50	50	50	50
TRH C15-C28	µg/L	100	100	100	100	100	100	100	100
TRH C29-C36	µg/L	100	100	100	100	100	100	100	100
TRH >C10-C16	µg/L	50	50	50	50	50	50	50	50
TRH >C16-C34	µg/L	100	100	100	100	100	100	100	100
TRH >C34-C40	µg/L	100	100	100	100	100	100	100	100
Ag-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1	1.0	1
Al-Dissolved	µg/L	10	70.0	8.5	67.0	14.5	67	220.0	10
As-Dissolved	µg/L	1	7.4	3.0	10.0	4.0	10	5.0	5
Cd-Dissolved	µg/L	0.1	1.4	1.0	1.0	1.0	1	0.1	0
Cr-Dissolved	µg/L	1	7.4	1.5	3.0	1.0	3	1.0	1
Cu-Dissolved	µg/L	1	10.2	1.0	5.0	1.0	5	1.0	2
Fe-Dissolved	µg/L	10	816.8	9.5	620.0	37.0	620	1700.0	39
Mn-Dissolved	µg/L	5	2020.4	506.0	2201.0	458.0	2201	450.0	450
Ni-Dissolved	µg/L	1	99.6	15.0	105.3	16.9	105	14.0	15
Pb-Dissolved	µg/L	1	1.0	1.0	1.0	1.0	1	1.0	1
Se-Dissolved	µg/L	1	50.2	1.0	28.0	2.0	28	1.0	1
Zn-Dissolved	µg/L	1	101.8	57.5	140.0	33.0	140	34.0	45
Hg-Dissolved	µg/L	0.05	0.50	0.50	0.50	0.50	0.50	0.05	0.05
Total Nitrogen	mg/L	0.1	1.21	0.17	0.46	0.12	0.457	0.23	0.200
Nitrite	mg/L	0.005	0.011	0.006	0.004	0.003	0.004	0.005	0.005
Nitrate	mg/L	0.005	0.146	0.008	0.175	0.023	0.175	0.030	0.058
Ammonia	mg/L	0.005	0.050	0.025	0.123	0.020	0.123	0.097	0.097
Total Phosphorus	mg/L	0.05	1.58	0.92	1.64	0.86	1.636	1.10	1.100
Phosphate	mg/L	0.005	1.388	0.577	1.577	0.649	1.577	0.537	0.537
Temp	°C	0.01	21.54	21.80	21.30	20.40	21.30	21.30	21.11
pH		0.01	6.03	6.06	6.11	6.43	6.11	6.18	6.09
EC	mS/cm	0.01	2.79	1.12	3.07	1.23	3.07	1.24	1.27
TSS	mg/L	5	30.6	106.0	30.6		30.6	44.0	20.0
TDS	mg/L	1	1904.00	760.00	1904.00		1,904		-
Bicarbonate	mg/L CaCO3	1	106.0	80.0	100.0	71.9	100.00	75.0	75.00
Sodium	mg/L	1	539.0	203.0	580.0	230.5	580.00	238.0	238.00
Potassium	mg/L	1	3.84	1.09	2.24	0.80	2.24	1.06	1.06
Calcium	mg/L	1	12.04	4.55	4.33	4.60	4.33	3.55	3.55
Magnesium	mg/L	1	31.44	11.20	38.70	13.05	38.70	12.80	12.80
Chloride	mg/L	1	518.0	213.5	700.0	256.0	700.00	243.0	243.00
Sulfate	mg/L	1	457.2	102.7	399.0	102.3	399.00	108.0	108.00

Red shading – Indicates a result of interest. Blue shading – Indicates a result of interest 2019.