

# Annual Water Monitoring Report

## Pacific Highway Upgrade: Woolgoolga to Ballina Section 2 – July 2015 to June 2016



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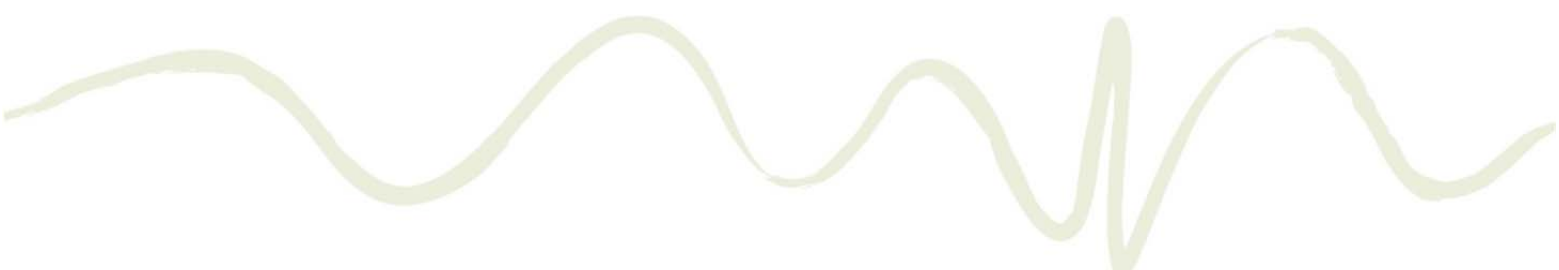
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## Executive Summary

This is the first annual water monitoring report for the construction phase of the Halfway Creek to Glenugie project, which is Section 2 of the Woolgoolga to Ballina (W2B) Pacific Highway upgrade. The reporting period for this annual report is 1 July 2015 to 30 June 2016. The monitoring undertaken during the reporting period includes surface water quality, groundwater quality and groundwater levels.

The water quality monitoring program is described in the Pacific Highway Upgrade – Woolgoolga to Glenugie: Water Quality Monitoring Program (WQMP) (dated 27/03/2015, GeoLINK ref: 2134-1118). The WQMP proposes that water quality monitoring results be assessed by comparing sampling results to the corresponding 80<sup>th</sup> percentile (P80) figure and/or 20<sup>th</sup> percentile (P20) figure (as relevant) from the baseline data. If a sampling result exceeds the corresponding 80<sup>th</sup> percentile figure and/or is less than the corresponding 20<sup>th</sup> percentile figure, this highlights the possibility of the highway construction impacting on water quality.

Some exceedances of the criteria were recorded during the surface water quality monitoring. These exceedances have been adequately closed out as part of the regular environmental inspections and meetings that occurred during the reporting period. No further action is recommended.

During the groundwater quality monitoring, results outside the baseline range were recorded for pH, turbidity and total phosphorus at GWB30 and GWB31. Road construction activities in the vicinity of these locations have been reviewed and no construction activities were identified that have the potential to influence the results. No further action is recommended.

With regard to groundwater levels, the following bore pairs significantly exceeded the baseline criteria:

- GWB29 and GWB28 significantly exceeded the criteria (baseline P20 of -3.8%) from 01/07/15 to 14/11/15 (approximately 4.5 months) and from 19/11/15 to 09/12/15 (3 weeks). The relative difference during these periods reached a maximum of approximately -13%.
- GWB31 and GWB30 significantly exceeded the criteria (baseline P80 of 2.3%) from 01/07/15 to 30/06/16 (approximately 1 year; excluding a two week period of compliance in June 2016). The relative difference during this period reached a maximum of approximately 170% (although was typically significantly lower than 100%).

These exceedances indicate a possibility of these highway cuttings impacting on groundwater flows. However, the nature and extent of works associated with these highway cuttings have been reviewed and it has been determined that it is unlikely that the cuttings have influenced the observed exceedances. No further action is recommended.

It is recommended that the monitoring program continue in its current form.

With regard to surface water monitoring location SW11 – Glenugie Creek, the construction contractor (pers. comm. CMC, 15/11/16) notes that *“it is recommended that dry event monitoring cease at this location due to fluctuations in results associated with monitoring from small free standing pools with no natural flow and no identifiable construction influence”*.

Rather than cease dry event monitoring altogether, a potential approach is to only undertake monitoring if there is sufficient water for the creek to be a continuous, connected waterway (i.e. if the creek is simply a series of isolated pools, do not monitor in that round). It is recommended that this potential approach be discussed with the project Environmental Review Group.



# 1. Introduction

## 1.1 Background

This is the first annual water monitoring report for the construction phase of the Halfway Creek to Glenugie project, which is Section 2 of the Woolgoolga to Ballina (W2B) Pacific Highway upgrade. The reporting period for this annual report is 1 July 2015 to 30 June 2016.

## 1.2 Overview of Monitoring Program

The water quality monitoring program is described in the Pacific Highway Upgrade – Woolgoolga to Glenugie: Water Quality Monitoring Program (WQMP) (dated 27/03/2015, GeoLINK ref: 2134-1118).

### 1.2.1 Objectives

The purpose of the WQMP is to monitor and manage the construction and operation impacts of the highway upgrade on surface water bodies and groundwater resources.

The key surface water quality objective of the broader W2B project is to protect downstream environments from the potential impacts of surface runoff during the construction and operational phases of the project (RMS, Aurecon, SKM, 2012a). Similarly, the key groundwater objective of the W2B project is to protect environmental receivers of groundwater flows and groundwater users from the potential impacts on groundwater levels and quality during the construction and operational phases of the project (RMS, Aurecon, SKM, 2012b).

The outcomes of the WQMP will assist with achieving water quality and hydrology related management objectives for the W2G project including:

- Mitigating impacts to surface water quality in order to protect aquatic ecology and ecosystem characteristics in adjacent catchments.
- Mitigating impacts to groundwater hydrology in order to protect licensed bores and dams, water bodies and groundwater dependant ecosystems.

## 2. Monitoring Methodology

### 2.1 Surface Water Quality

#### 2.1.1 Monitoring Locations

The surface water monitoring locations are described in Section 2.1 and Appendix C of the WQMP. There was no change to the monitoring locations during the reporting period.

#### 2.1.2 Sampling Regime and Parameters

As per Section 4.2.1 of the WQMP, the required frequency of sampling and the sampling parameters are as follows:

- Two wet event sampling rounds per month with:
  - Assess Type A parameters every round (refer to **Table 2.1**).
  - Assess Type B parameters every second round (refer to **Table 2.2**).
- One dry event sampling round per month:
  - Assess Type A parameters every month.
  - Assess Type B parameters every second month.

**Table 2.1 Surface Water Sampling Parameters**

<b>Parameter</b>	<b>Type A Parameters</b>	<b>Type B Parameters</b>
pH	X	
Temperature	X	
Electrical Conductivity (EC)	X	
Dissolved Oxygen (DO)	X	
Turbidity	X	
Total Suspended Solids (TSS)	X	
Total Oils and Grease	X	
Total Phosphorous, Total Nitrogen	X	
Phosphate, Ammonia, Nitrate, Nitrite		X
Total Recoverable Hydrocarbons (TRH)	*	X

\* Note: TRH is to be included as a Type A parameter if oil/grease is visible at sampling location

The WQMP listed Total Petroleum Hydrocarbons (TPH) as the last parameter in the above table. This parameter has been updated to Total Recoverable Hydrocarbons (TRH) in line with industry best practice.

Wet events are defined as 10 mm or more of rain within 24 hours. Wet event sampling is to be undertaken within 24 hours of the rain event.

The monitoring undertaken during the reporting period complied with the above requirements.

### 2.1.3 Sample and Data Collection

The collection of in-situ water quality data and the collection of water samples for laboratory analysis were undertaken in accordance with the methodology described in Sections 5.1 and 5.2 of the WQMP.

## 2.2 Groundwater Quality

### 2.2.1 Monitoring Locations

The groundwater quality monitoring locations are described in Section 2.2 and Appendix C of the WQMP. There was no change to the monitoring locations during the reporting period.

### 2.2.2 Sampling Regime and Parameters

As per Section 4.3.2.1 of the WQMP, the required frequency of sampling is quarterly and the sampling parameters are as per **Table 2.2** below.

**Table 2.2 Groundwater Quality Sampling Parameters**

<i>Parameter Group</i>	<i>Parameter</i>	<i>Field Analysis</i>	<i>Laboratory Analysis</i>
Physical and Chemical Properties	pH	X	
	Temperature	X	
	Electrical Conductivity (EC)	X	
	Dissolved Oxygen (DO)	X	
	Turbidity	X	
	Total Dissolved Solids (TDS)		X
Hydrocarbons	Total Recoverable Hydrocarbons (TRH)		X
Nutrients	Total Phosphorous, Total Nitrogen		X
Major Cations	Sodium (Na+), Potassium (K+), Calcium (Ca2+), Magnesium (Mg2+)		X
Major Anions	Chloride (Cl-), Sulfate (SO42-), Bicarbonate (HCO3-)		X
Heavy Metals (Dissolved)	Aluminium, Cadmium, Copper, Lead, Zinc		X

The monitoring undertaken during the reporting period did not fully comply with the above requirements due to the following:

- Only three rounds of monitoring were undertaken during the reporting period rather than the required four.

### 2.2.3 Sample and Data Collection

The collection of in-situ water quality data and the collection of water samples for laboratory analysis were undertaken in accordance with the methodology described in Sections 5.1 and 5.3 of the WQMP. Purging of groundwater bores was undertaken prior to the collection of samples.





## 2.3 Groundwater Levels

### 2.3.1 Monitoring Locations

The groundwater level monitoring locations are described in Section 2.2 and Appendix C of the WQMP. There was no change to the monitoring locations during the reporting period.

### 2.3.2 Sampling Regime

As per Section 4.3.1.1 of the WQMP, the required frequency of monitoring is for the automatic water level recorders to be downloaded quarterly, with physical measurement of the depth to standing water level taken at the same time.

The monitoring undertaken during the reporting period did not fully comply with the above requirements due to the following:

- The frequency of monitoring was not quarterly, with only three rounds of water level recorder downloads and physical measurements during the 12 month reporting period.

### 2.3.3 Sample and Data Collection

The collection of groundwater level data was undertaken in accordance with the methodology described in Sections 5.1 and 5.3 of the WQMP.



## 3. Results

### 3.1 Interpretation Approach

#### 3.1.1 Surface Water Quality

The WQMP proposes that surface water quality monitoring results be assessed by comparing sampling results to the corresponding 80<sup>th</sup> percentile (P80) figure and/or 20<sup>th</sup> percentile (P20) figure (as relevant) from the baseline data.

The 80<sup>th</sup> percentile figure is applicable to parameters where high values are potentially an issue (e.g. turbidity), while the 20<sup>th</sup> percentile figure is applicable to parameters where low values are potentially an issue (e.g. dissolved oxygen), and both figures are relevant for parameters where either a high value or a low value are potentially an issue (e.g. pH).

The WQMP suggests that, if a sampling result exceeds the corresponding 80<sup>th</sup> percentile figure and/or is less than the corresponding 20<sup>th</sup> percentile figure, this highlights the possibility of the highway construction impacting on water quality.

The original baseline data set is the pre-construction data collected between May 2013 and April 2014. As per Section 7.1.2 of the WQMP, the baseline data is to be supplemented with the data collected from upstream monitoring sites during the construction and operational phases of the project. The upstream monitoring sites represent sites not impacted by the highway upgrade and therefore reflect 'baseline' data. This process will provide a more robust set of baseline data over the course of the project.

#### 3.1.2 Groundwater Quality

The WQMP proposes that groundwater quality monitoring results be assessed using comparisons to the 80<sup>th</sup> percentile and 20<sup>th</sup> percentile values from the baseline data, as per the surface water quality approach described above.

The baseline data set is the pre-construction data collected between November 2013 and April 2014.

#### 3.1.3 Groundwater Levels

The WQMP proposes that the groundwater level data be assessed by initially calculating the 80<sup>th</sup> percentile of the relative difference between the groundwater levels in the bores on either side a cutting during the baseline (pre-construction) period. The relative difference between the groundwater levels in the two bores during the construction phase is then compared to the 80<sup>th</sup> percentile value. If the relative difference during the construction phase exceeds the 80<sup>th</sup> percentile value, this highlights the possibility of the highway construction impacting on groundwater levels.

The baseline data set is the pre-construction data collected between April 2013 and March 2014 inclusive.



## 3.2 Surface Water Quality

The surface water quality monitoring results are provided in **Appendix A**. Results that exceed the corresponding 80<sup>th</sup> percentile figure and/or are less than the corresponding 20<sup>th</sup> percentile figure are highlighted in red.

A discussion of the results is presented in the following sections and focuses on results from downstream sites that are significantly outside of the prescribed range (e.g. above the 80<sup>th</sup> percentile or below the 20<sup>th</sup> percentile of the baseline data) and are significantly different to the corresponding upstream data for the same date. Where relevant, monitoring results from the upstream sites are discussed in accordance with the approach to assessing the data that is outlined in Section 7 and Figure 7.1 of the WQMP.

It should be noted that the baseline data comprises approximately monthly (and in some case less frequent) 'snapshots' over a 12 month period of a set of parameters, which likely fluctuate on time scales as short as hours. While this relatively limited baseline data set creates challenges in associating changes in water quality to construction activities, it is considered that the use of upstream sites as control sites assists in offsetting this limitation.

Where considered relevant, some notes are provided in the sections below where there may be a correlation between parameters recorded at the same time and site and/or where field notes provide further context that may help explain elevated (or depressed) water quality results.

### 3.2.1 SW09 – Halfway Creek

#### 3.2.1.1 Dry Event Monitoring Results

- Whilst pH, electrical conductivity and dissolved oxygen readings were occasionally outside of the P20 to P80 range they were typically not significantly different to corresponding upstream data and are therefore considered unlikely to be attributable to construction activities.
- There were no significant exceedances of the criteria and upstream results for any other parameters.

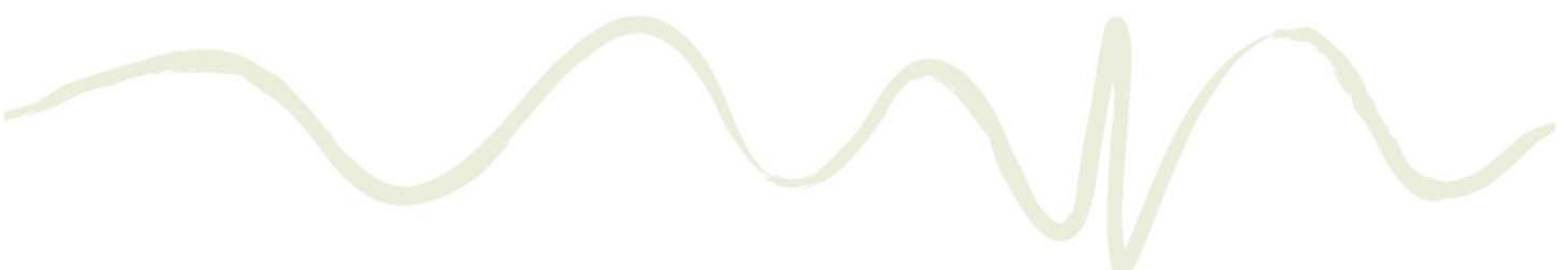
#### 3.2.1.2 Wet Event Monitoring Results

- Whilst pH, electrical conductivity and dissolved oxygen readings were occasionally outside of the P20 to P80 range they were typically not significantly different to corresponding upstream data and are therefore considered unlikely to be attributable to construction activities.
- Turbidity P80 exceedances were recorded on 17/11/15 and 10/12/15 and were above corresponding upstream measurements. However, it is noted that the exceedances were marginal and it is considered unlikely that construction activities were having a significant contribution to the elevated results.

### 3.2.2 SW10 – Wells Crossing

#### 3.2.2.1 Dry Event Monitoring Results

- Whilst pH and electrical conductivity were occasionally outside of the P20 to P80 range they were typically not significantly different to corresponding upstream data and are therefore considered



unlikely to be attributable to construction activities.

- On four occasions (26/11/15, 09/12/15, 11/01/16, 02/02/16) turbidity levels were significantly higher than the P80 and the corresponding upstream turbidity levels indicating that construction activities were potentially mobilising sediment in/into the waterway. Suspended solids levels on two of these dates (26/11/15 and 11/01/16) were also significantly higher than the P80 and the corresponding upstream levels.
- The TPH concentration of 130 mg/L on 26/11/15 was significantly above the upstream concentration of <50 mg/L indicating a potential source of hydrocarbon contamination from construction activities or the existing Pacific Highway, noting that the sampling location is downstream of the existing Wells Crossing Bridge. Pacific Complete personnel have advised that a review of the project incident register indicates that no spills have occurred in this location.
- There were no significant exceedances of the criteria and upstream results for any other parameters.

### 3.2.2.2 Wet Event Monitoring Results

- Whilst pH and electrical conductivity were occasionally outside of the P20 to P80 range they were typically not significantly different to corresponding upstream data and are therefore considered unlikely to be attributable to construction activities.
- On five occasions (3/12/15, 10/12/15, 6/01/16, 27/01/16 and 09/04/16) turbidity levels were significantly higher than the P80 and the corresponding upstream turbidity levels indicating that construction activities were potentially mobilising sediment in/into the waterway. There were also five occasions on which suspended solids levels were significantly higher than the P80 and the corresponding upstream levels (17/11/15, 03/12/15, 10/12/15, 27/01/16 and 09/04/16). The construction contractor (pers. comm. CMC, 15/11/16) has provided the following notes:  
*“Exceedances recorded on the 10/12/16 can be attributed to natural discharge from Basin 15 (2251L) located directly north of Wells crossing. From January 2016 additional monitoring was conducted of the 16 interconnected ponds that make up Wells crossing. Water quality results improved rapidly directly downstream from the sampling point, with results presented at monthly Environmental Review Group (ERG) meetings. The Environmental Review Group was satisfied with the management actions which resulted in improved water quality monitoring results. These management actions included replacement of turf reinforce matting specified in the north-east table drain with rock and geotextile which [provided] much greater stability and associated water quality and cement stabilisation of the surface of the bridge construction access platform which also resulted in improved water quality outcomes, particularly for major flooding events associated with major east coast lows in June 2016.”*
- The TPH concentration of 140 mg/L on 06/01/16 was significantly above the upstream concentration of <50 mg/L indicating a potential source of hydrocarbon contamination from construction activities or the existing Pacific Highway. As noted above, Pacific Complete personnel have advised that a review of the project incident register indicates that no spills have occurred in this location.
- There were no significant exceedances of the criteria and upstream results for any other parameters.

The construction contractor (pers. comm. CMC, 15/11/16) has provided the following notes:

*“Where construction activities are considered the likely source of water quality impact then (additional) management measures have been implemented in liaison with the project Environmental Review Group and monitored for efficacy during monthly scheduled meetings ... Wells Crossing has been the focus of several ERG inspections resulting in the implementation of several management initiatives.*



These have included:

- Deletion of Enkamat (Turf reinforced matting) throughout the north eastern table drain and replace with geotextile surface lining with scour rock cover,
- Improved sump capacity for disturbed areas not directed to sediment basins,
- Lining exposed abutments with Geofabric,
- Fast tracking batter stabilisation,
- Additional downstream monitoring of the Wells Crossing system, and
- Cement stabilisation of surface of bridge access platform”

### 3.2.3 SW11 – Glenugie Creek

#### 3.2.3.1 Dry Event Monitoring Results

- The pH of 3.70 recorded on 07/07/15 was significantly below the P20 (6.68). The upstream pH on this date was also low (5.97). It is unclear what caused this low pH.
- Dissolved Oxygen concentrations were often recorded below the relevant P20 and upstream results. It is possible that elevated nutrient levels (compared to P80 and upstream data) across all monitoring events may be related to depressed DO concentrations at this site. It is unclear what the source of the nutrients may have been, although the field notes mention the presence of microbats.
- Whilst electrical conductivity was frequently outside of the P20 to P80 range it was typically not significantly different to corresponding upstream data and are therefore considered unlikely to be attributable to construction activities.
- Turbidity and suspended solids levels were significantly higher than the P80 and the corresponding upstream levels on 02/02/16 indicating the possibility that construction activities were mobilising sediment in/into the waterway.
- The construction contractor (pers. comm. CMC, 15/11/16) notes that “*the ephemeral nature of the system resulting in dry sampling from a small still standing pool with no natural inflows may also be a contributing factor to significant fluctuations in the overall results*”.
- The construction contractor (pers. comm. CMC, 15/11/16) notes that “*it is recommended that dry event monitoring cease at this location due to fluctuations in results associated with monitoring from small free standing pools with no natural flow and no identifiable construction influence.*”

#### 3.2.3.2 Wet Event Monitoring Results

- Whilst pH and electrical conductivity were occasionally outside of the P20 to P80 range they were typically not significantly different to corresponding upstream data and are therefore considered unlikely to be attributable to construction activities.
- Dissolved Oxygen concentrations were often recorded below the relevant P20 and upstream results. It is considered possible that elevated nutrient levels (compared to P80 and upstream data) across most monitoring events may be correlated to depressed DO concentrations at this site. As with the dry event monitoring, it is unclear what the source of the nutrients may have been, although the field notes mention the presence of microbats.
- There were no significant exceedances of the criteria and upstream results for any other parameters.



### 3.3 Groundwater Quality

The groundwater quality monitoring results are provided in **Appendix B**.

Overall, there are numerous results during the reporting period that either exceed the 80<sup>th</sup> percentile figure or are lower than the 20<sup>th</sup> percentile figure for the relevant site. However, in most cases it is expected that these results are still within the range of natural variability for the site and are not a result of road construction impacts. This is because only limited data were collected for the baseline data set in the pre-construction phase. For GWB30, three rounds of pre-construction data were collected over a six month period. However, it was only possible to analyse some parameters in two of the sampling rounds due to insufficient water being available because of the low yield of the bore. GWB31 also had a low yield and therefore insufficient water was available to collect a sample for two of the sampling rounds. Only some parameters were analysed in the other sampling round, also due to the lack of available water

Three sets of data (or less) collected over a six month period are unlikely to capture the full range of natural variability of each parameter at each site. The limited amount of baseline data was discussed in the WQMP. The intention was to utilise the broader set of pre-construction groundwater quality data to provide an indication of baseline data for the sites. Therefore, the analysis of the construction phase results for a specific site has taken into consideration the baseline data for that site, as well as the whole set of pre-construction data presented in the WQMP.

In **Appendix B**, the first table presents statistics for the whole set of pre-construction data combined. In the following tables, results that exceed the corresponding 80<sup>th</sup> percentile figure and/or are less than the corresponding 20<sup>th</sup> percentile figure for the whole baseline data set are highlighted in red. Results that either exceed the maximum or are less than the minimum are highlighted in red with orange shading. The discussion of the results presented in the following section focuses on these results.

#### 3.3.1 GWB30 and GWB31

- Relatively high pH levels of 7.9 (11/09/15) and 9.1 (16/12/15) were recorded at GWB30. A relatively high pH level of 8.3 was also recorded at GWB31 on 16/12/15.
- Temperature and electrical conductivity are expected to vary across the sites and over time. The results are within the expected ranges.
- All of the dissolved oxygen levels were above the baseline 20<sup>th</sup> percentile.
- Relatively high turbidity levels (up to 800 NTU) were recorded at GWB30 and GWB31 during the reporting period. It is considered unlikely that turbidity levels in the groundwater would be influenced by road construction activities, unless there is a relatively direct hydraulic pathway between surface sources of turbid water and the groundwater.
- Relatively high total phosphorus levels were recorded at both sites, with the highest level being 0.45 mg/L at GWB31 on 11/09/15. Three of the six results were above the maximum level recorded across all sites during the pre-construction monitoring. Given the lack of pre-construction total phosphorus data for these specific sites (only one measurement at GWB30), it is not possible to infer whether the levels recorded during the construction phase are within the range of natural variability.
- No hydrocarbons were detected.
- The levels of major cations and anions are within the expected ranges, based on the pre-construction results.
- The levels of heavy metals were within the expected ranges based on the pre-construction data.

## 3.4 Groundwater Levels

**Table 3.1** presents a summary of the groundwater level data collected during the reporting period. In this table, shaded cells indicate that data was downloaded from groundwater level loggers for that period, while no shading indicates that no data was downloaded for that period.

**Table 3.1 Summary of Groundwater Level Data**

Bore	June - Sept 2015	Sept - Dec 2015	Dec 2015 – Mid May 2016	Mid May – End May 2016
GWB24	See notes <sup>1,2</sup>			See note <sup>2</sup>
GWB25	See notes <sup>1,2</sup>	See note <sup>3</sup>		See note <sup>2</sup>
GWB28	See notes <sup>1,2</sup>	See note <sup>3</sup>		See note <sup>2</sup>
GWB29	See notes <sup>1,2</sup>	See note <sup>2</sup>		See note <sup>2</sup>
GWB30	See notes <sup>1,2</sup>	See note <sup>2</sup>		
GWB31	See notes <sup>1,2</sup>	See note <sup>2</sup>		

<sup>1</sup> Data for this bore hole, during this period, ended prior to the reference level (water level from top of pipe (m)) being taken (time difference was typically about 1 day). Therefore time of last data point was used as the time point for reference level correction.

<sup>2</sup> The barometric data set finished prior to the time of the last data point and so it was assumed that the value of the last barometric pressure measurement was applicable to the reference time.

<sup>3</sup> No reference level available for this period; therefore previous or next period's reference level was used.

As per the WQMP, the groundwater level data has been assessed by initially calculating the 80<sup>th</sup> percentile (P80) of the relative difference between the groundwater levels in the bores on either side a cutting during the baseline (pre-construction) period. The relative difference between the groundwater levels in the two bores during the construction phase is then compared to the baseline 80<sup>th</sup> percentile value, with an exceedance being when the construction phase relative difference exceeds the 80<sup>th</sup> percentile. In situations where a negative relative difference is the issue, the baseline 20<sup>th</sup> percentile (P20) has been calculated and an exceedance is when the relative difference of the construction phase data is less than the baseline 20<sup>th</sup> percentile.

**Table 3.2** presents a summary of the exceedances and indicates which criterion has been adopted for each pair of bores. For the purposes of this report, a significant exceedance is considered to be when the relative difference exceeds the baseline P80 (or is lower than the baseline P20, where relevant) for a period of at least one week, and the relative difference exceeds the baseline P80 (or is lower than the baseline P20, where relevant) by at least 5% during this period. The following sections present charts of the groundwater levels and comments.

**Table 3.2 Summary of Groundwater Level Exceedances**

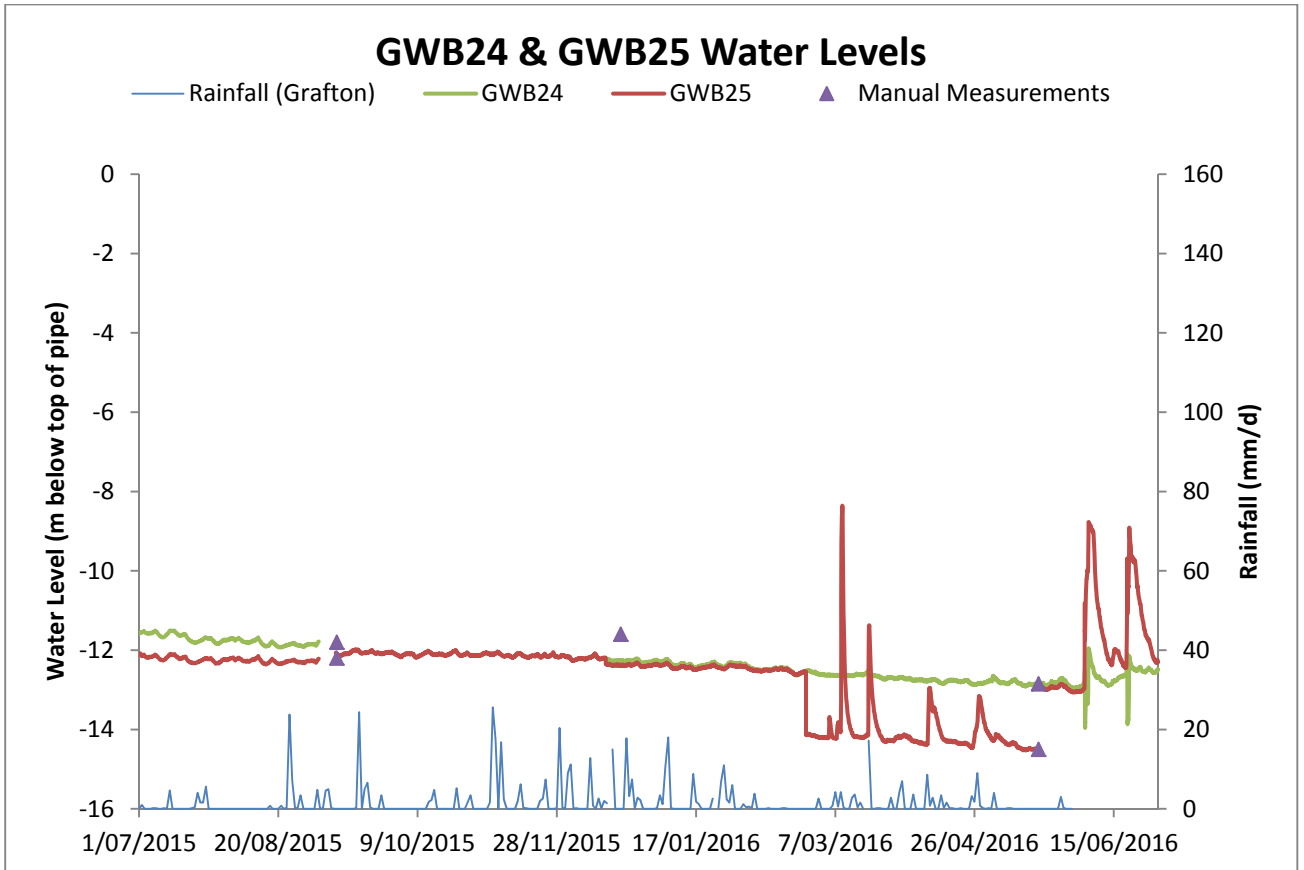
<i>Bore Pair<sup>1</sup></i>	<i>P80 (%)</i>	<i>P20 (%)</i>	<i>Periods when relative difference between bore hole pairs is &gt; P80 or &lt;P20 of baseline relative differences (<b>bold text</b> indicates periods of significant exceedances)</i>	<i>Comments</i>
GWB24 & GWB25		-7.7	No significant exceedances	Note: there were several periods from February to May 2016 when the relative difference reached a minimum of approximately -12% (considered a negligible exceedance of the P20 criteria)
GWB29 & GWB28		-3.8	<b>1/07/15 – 14/11/15 (4.5 months) and 19/11/15 – 9/12/15 (3 weeks)</b>	The relative difference during these periods reached a minimum of approximately -13% Also, the relative difference during 29/12/15 – 19/01/16 reached a minimum of approximately -5.3% (considered a negligible exceedance of the P80 criteria)
GWB31 & GWB30	2.3		<b>01/07/15 – 30/06/16 (1 year; excluding a 2 week period of compliance in June 2016)</b>	The relative difference during this period reached a maximum of approximately 170% (although was typically significantly lower than 100%)

<sup>1</sup>The western-most (or in some cases southern-most) bore is listed first in each bore pair



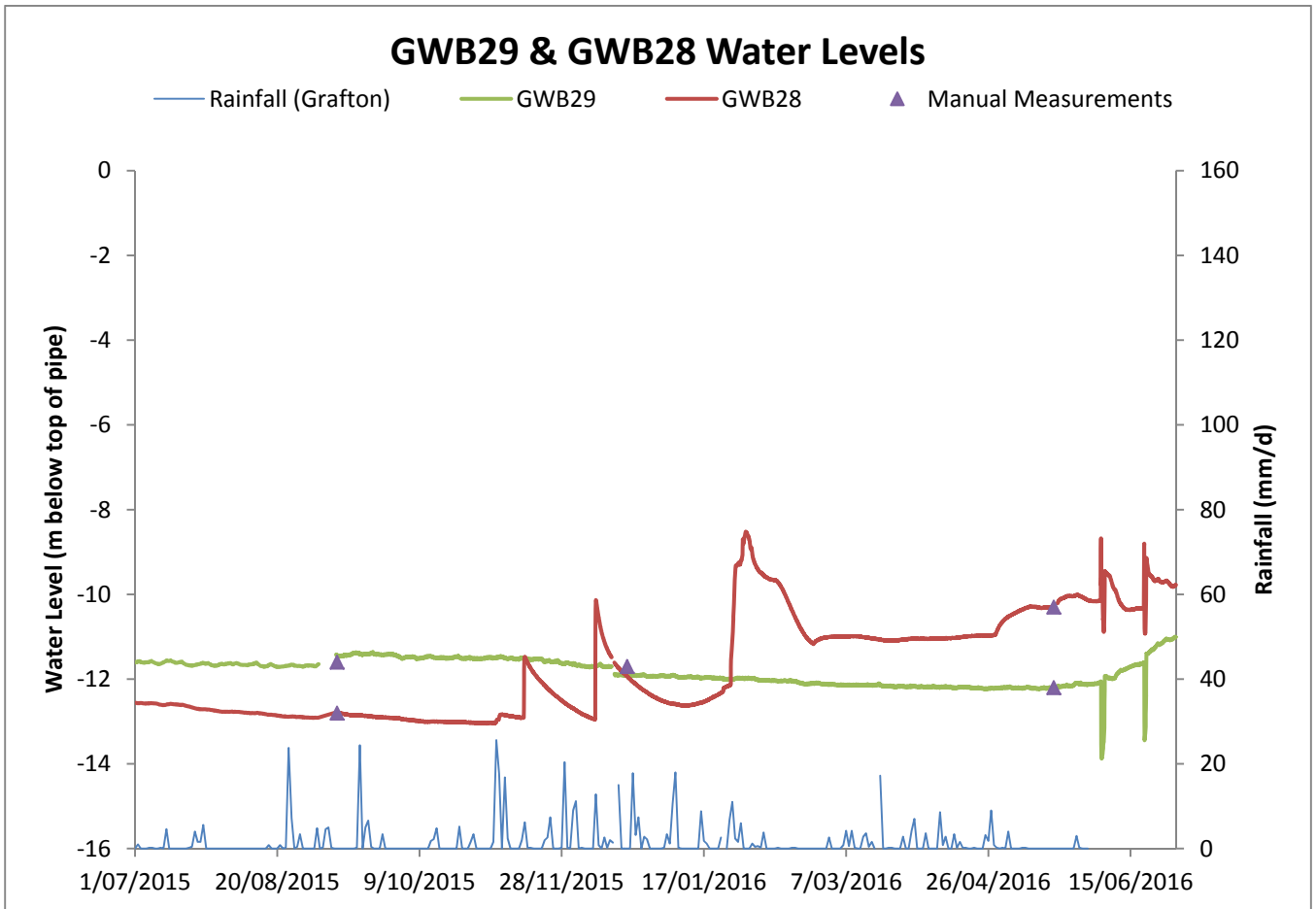
### 3.4.1 GWB24 and GWB25

There were no exceedances of the criteria for this bore pair during the reporting period. Water level (metres below top of pipe) for both bores is presented in the chart below along with rainfall data for the period.



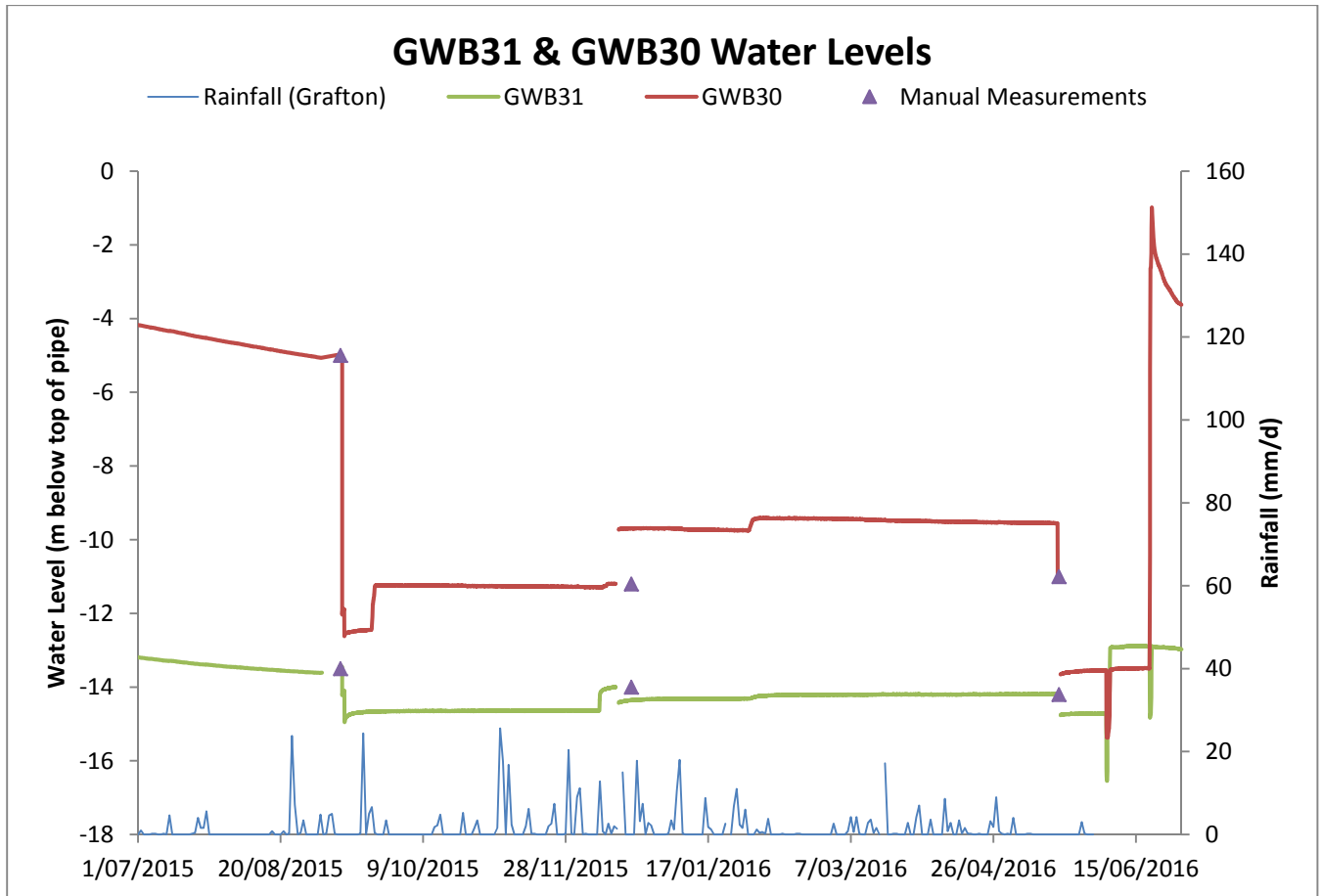
### 3.4.2 GWB29 and GWB28

As per **Table 3.2**, the relative difference in groundwater level between GWB29 and GWB28 significantly exceeded the criteria (baseline P20 of -3.8%) from 01/07/15 to 14/11/15 (approximately 4.5 months) and from 19/11/15 to 09/12/15 (3 weeks). The relative difference during these periods reached a maximum of approximately -13%. Water level (metres below top of pipe) for both bores is presented in the chart below along with rainfall data for the period.



### 3.4.3 GWB31 and GWB30

As per **Table 3.2**, the relative difference in groundwater level between GWB31 and GWB30 significantly exceeded the criteria (baseline P80 of 2.3%) from 01/07/15 to 30/06/16 (approximately 1 year; excluding a two week period of compliance in June 2016). The relative difference during this period reached a maximum of approximately 170% (although was typically significantly lower than 100%). Water level (metres below top of pipe) for both bores is presented in the chart below along with rainfall data for the period.





## 4. Recommendations

### 4.1 Surface Water Quality

The exceedances noted in **Section 3.2** have been adequately closed out as part of the regular environmental inspections and meetings that occurred during the reporting period. No further action is recommended.

### 4.2 Groundwater Quality

Road construction activities in the vicinity of GWB30 and GWB31 have been reviewed with regard to the relatively high pH, turbidity and total phosphorus results discussed in **Section 3.3**. No construction activities were identified that have the potential to influence the results. No further action is recommended.

### 4.3 Groundwater Levels

The following bore pairs significantly exceeded the baseline criteria:

- GWB29 and GWB28 significantly exceeded the criteria (baseline P20 of -3.8%) from 01/07/15 to 14/11/15 (approximately 4.5 months) and from 19/11/15 to 09/12/15 (3 weeks). The relative difference during these periods reached a maximum of approximately -13%.
- GWB31 and GWB30 significantly exceeded the criteria (baseline P80 of 2.3%) from 01/07/15 to 30/06/16 (approximately 1 year; excluding a two week period of compliance in June 2016). The relative difference during this period reached a maximum of approximately 170% (although was typically significantly lower than 100%).

These exceedances indicate a possibility of these highway cuttings impacting on groundwater flows.

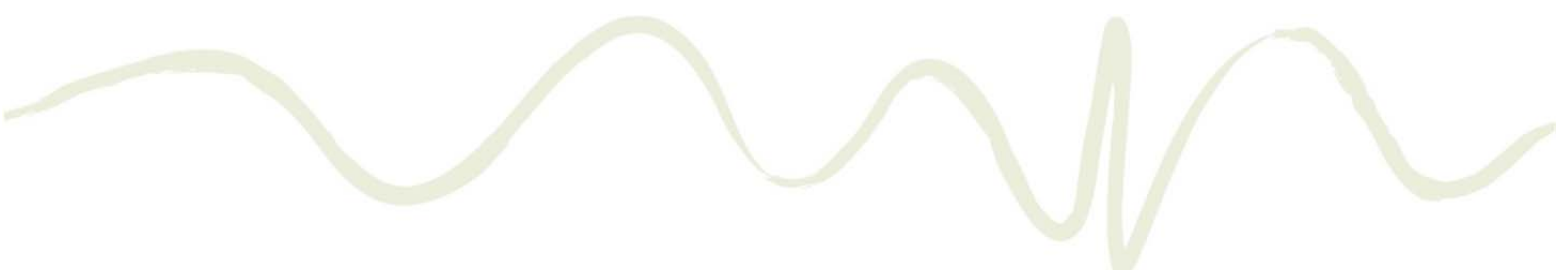
The nature and extent of works associated with these highway cuttings have been reviewed. Visual inspections of cuttings by Surveillance Officers and Environmental Officers have not identified interception of groundwater. In addition, no engineering solutions have been required to manage any groundwater inflows. Finally, the project is aligned on the catchment divide, which further reduces the potential for interception of directional groundwater flows.

On the basis of the above, it has been determined that it is unlikely that the cuttings have influenced the noted exceedances. No further action is recommended.

### 4.4 Monitoring Program

It is recommended that the monitoring program continue in its current form.

With regard to surface water monitoring location SW11 – Glenugie Creek, the construction contractor (pers. comm. CMC, 15/11/16) notes that *“it is recommended that dry event monitoring cease at this location due to fluctuations in results associated with monitoring from small free standing pools with no natural flow and no identifiable construction influence”*.



Rather than cease dry event monitoring altogether, a potential approach is to only undertake monitoring if there is sufficient water for the creek to be a continuous, connected waterway (i.e. if the creek is simply a series of isolated pools, do not monitor in that round). It is recommended that this potential approach be discussed with the project Environmental Review Group.



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## Appendix A

# Surface Water Quality Results



SW09 (Dry) - Halfway Creek

Dry Event Monitoring

Monitoring Location	Field Notes	Date	pH (field)	Temperature (field)	Electrical Conductivity (field)	Dissolved Oxygen (field)	Turbidity (field)	Suspended Solids (SS)	Oil & Grease	Total Phosphorus	Total Nitrogen	Phosphate	Ammonia	Nitrate	Nitrite	TPH
			pH unit	°C	µS/cm	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ppm
<b>Downstream Monitoring</b>																
SW09-Halfway Ck D/S		7/07/15	7.73	11.50	0.15	6.04	10.70	<2		0.03	0.18	0.03	0.05	0.05	0.05	N/A
SW09-Halfway Ck D/S	Dry event piling pad under construction	19/08/15	6.60	13.70	0.16	9.00	7.50	3.00		<0.03	0.23	<0.03	<0.05	<0.05	<0.05	N/A
SW09-Halfway Ck D/S	Dry stagnant looking	14/09/15	7.01	14.00	0.16	4.10	9.09	6.00		0.01	0.30	<0.01	<0.01	0.06	<0.01	N/A
SW09-Halfway Ck D/S	Dry-Type B	6/10/15	7.64	15.90	0.17	2.00	9.25	N/A		N/A	N/A	<0.03	<0.05	<0.05	<0.05	N/A
SW09-Halfway Ck D/S	pH and DO marginally below P80 results. TSS, NTU and nitrogen nutrients above background but reflective of upstream values All other parameters within P80 guidelines	26/11/15	6.57	27.60	0.13	2.70	21.50	21.00		0.03	0.58	<0.03	<0.05	0.06	<0.05	<50
SW09-Halfway Ck D/S	All parameters within p80 guidelines	9/12/15	6.45	25.40	0.17	2.70	18.25	11.00		0.04	0.54	<0.03	<0.05	<0.05	<0.05	<50
SW09-Halfway Ck D/S	All results within p80 guidelines	11/01/16	6.10	24.80	0.20	2.10	11.06	7.00		<0.03	0.39	<0.03	<0.05	<0.05	<0.05	<50
SW09-Halfway Ck D/S	Results within P80 guidelines with the exception of TSS and NTU which recorded marginally above upstream and P80 but well within the maximum result recorded.	2/02/16	6.77	24.98	0.23	1.90	31.70	15.00		<0.03	0.40	<0.03	<0.05	<0.05	<0.05	<50
SW09-Halfway Ck D/S	All results compliant with P80 guidelines	23/03/16	6.62	24.40	0.25	2.20	30.10	13.00		<0.03	0.35	N/A	N/A	N/A	N/A	50.00
SW09-Halfway Ck D/S	All results compliant with P80 guidelines	7/04/16	6.49	25.20	0.29	2.10	16.34	7.00		<0.03	0.34	<0.03	<0.05	<0.05	<0.05	Nil
SW09-Halfway Ck D/S	All results compliant with the exception of EC (0.015) marginally above background P80	6/05/16	6.63	23.00	0.30	2.60	11.09	6.00		<0.03	0.35	N/A	N/A	N/A	N/A	Nil
<b>P80 &amp; P20 Values</b> (calculated from baseline and upstream data below)																
P80 (80th Percentile)			6.876		0.2342		18.684	11	1	0.072	0.464	0.078	0.05	0.056	0.05	160
P20 (20th Percentile)			6.28		0.1538	1.98										
<b>Baseline (pre-construction) Monitoring</b>																
SW09-Halfway Creek		15/05/2013	6.41	16.84	0.13	5.36	11.00	5.00	1.00	0.01	0.17					
SW09-Halfway Creek		13/06/2013														
SW09-Halfway Creek		18/07/2013	6.54	14.49	0.15	10.60	10.90	4.00	1.00	0.01	0.09		0.05	0.03		
SW09-Halfway Creek		21/08/2013	6.60	11.58	0.16	11.25	9.80	0.50	1.00	0.02	0.13					
SW09-Halfway Creek		17/09/2013														
SW09-Halfway Creek		25/10/2013	6.55	19.62	0.19	2.71	8.00	9.00	1.00	0.03	0.42					
SW09-Halfway Creek		26/11/2013	6.29	21.43	0.18	5.86	6.40	4.00	1.00	0.02	0.24					
SW09-Halfway Creek		20/12/2013	6.00	19.79	0.21	1.37	9.00	2.00	1.00	0.02	0.17					
SW09-Halfway Creek		9/01/2014	6.36	20.42	0.24	0.63	9.30	11.00	1.00	0.03	0.21					
SW09-Halfway Creek		26/02/2014	6.90	20.49	0.30	1.15	6.50	11.00	1.00	0.04	0.72					
SW09-Halfway Creek		21/03/2014														
SW09-Halfway Creek		7/04/2014	6.24	20.95	0.23	4.52	3.80	3.00	6.20	0.01	0.34					
<b>Upstream Monitoring</b>																
SW09-Halfway Ch. U/S	Dry type A and B	2/02/2016	6.60	24.68	0.26	1.90	19.10	13.00		0.03	0.56	<0.03	0.05	<0.05	<0.05	<50
SW09-Halfway Ch. U/S		7/07/2015	7.42	11.40	0.16	5.29	11.40	3.00		0.03	0.17	0.03	0.05	0.05	0.05	N/A
SW09-Halfway Ch. U/S	Dry event piling pad under construction	19/08/2015	6.60	13.40	0.15	9.20	6.50	2.00		<0.03	0.24	<0.03	<0.05	<0.05	<0.05	N/A
SW09-Halfway Ch. U/S	Dry level dropped significantly	14/09/2015	7.11	13.60	0.14	3.90	8.33	<5		<0.01	0.30	<0.01	<0.01	0.06	<0.01	N/A
SW09-Halfway Ch. U/S	Dry-Type B	6/10/2015	7.92	15.60	0.18	2.60	7.96	N/A		N/A	N/A	<0.03	<0.05	<0.05	<0.05	N/A
SW09-Halfway Ch. U/S	Dry type A	26/11/2015	6.52	25.60	0.20	2.40	26.70	13.00		0.14	0.44	0.09	<0.05	<0.05	<0.05	<50
SW09-Halfway Ch. U/S	Dry type A	9/12/2015	6.87	25.30	0.12	2.80	17.63	10.00		0.07	0.50	<0.03	<0.05	<0.05	<0.05	<50
SW09-Halfway Ch. U/S	Dry Type B	11/01/2016	6.03	24.70	0.19	2.00	0.00	10.00		<0.03	0.39	<0.03	0.05	<0.05	<0.05	<50
SW09-Halfway Ch. U/S	Dry type A	23/03/2016	6.65	23.40	0.17	2.30	36.50	22.00		0.15	0.42	N/A	N/A	N/A	N/A	160
SW09-Halfway Ch. U/S	Dry type A and B	7/04/2016	6.23	23.70	0.37	3.20	18.58	8.00		0.08	0.62	<0.03	<0.05	<0.05	<0.05	Nil
SW09-Halfway Ch. U/S	Dry type A	6/05/2016	6.61	20.80	0.23	2.50	34.10	9.00		<0.03	0.39	N/A	N/A	N/A	N/A	Nil

SW09 (Wet) - Halfway Creek

Dry Event Monitoring

Monitoring Location	Field Notes	Date	pH (field)	Temperature (field)	Electrical Conductivity (field)	Dissolved Oxygen (field)	Turbidity (field)	Suspended Solids (SS)	Oil & Grease	Total Phosphorus as P	Total Nitrogen as N	Phosphate	Ammonia	Nitrate	Nitrite	TPH
			pH unit	°C	µS/cm	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ppm
<b>Downstream Monitoring</b>																
SW09-Halfway Ck D/S	Wet	22/07/2015	5.97	13.10	0.14	6.41	10.90	3.00		<0.03	0.16	<0.03	<0.05	<0.05	<0.05	N/A
SW09-Halfway Ck D/S	Wet event piling pad under construction	25/08/2015	6.40	12.20	0.21	8.10	17.00	14.00		<0.03	0.38	<0.03	<0.05	0.06	<0.05	N/A
SW09-Halfway Ck D/S	Wet	18/09/2015	6.89	20.80	0.13	3.60	12.38	7.00		<0.03	0.26	N/A	N/A	N/A	N/A	N/A
SW09-Halfway Ck D/S	Wet Type A all parameters within pre construction guidelines	13/10/2015	6.79	24.70	0.19	2.40	10.79	11.00		<0.03	0.33	N/A	N/A	N/A	N/A	N/A
SW09-Halfway Ck D/S	Wet type A and B 12mm all results within P80 guidelines with the exception of DO which is still within the minimum pre-construction range recorded	23/10/2015	6.60	23.10	0.22	2.10	12.00	9.00		<0.03	0.41	<0.03	<0.05	<0.05	<0.05	N/A
SW09-Halfway Ck D/S	All parameters within P80 guidelines. DO result is low but within recorded minimum wet event for this parameter	4/11/2015	6.60	24.70	0.32	2.50	12.48	10.00		0.39	0.40	0.31	<0.05	<0.05	<0.05	N/A
SW09-Halfway Ck D/S	NTU and DO marginally above background. All other parameters within P80 guidelines.	17/11/2015	6.92	23.80	0.12	3.50	50.40	21.00		<0.03	0.38	N/A	N/A	N/A	N/A	N/A
SW09-Halfway Ck D/S	All results within p80 guidelines with the exception of DO and pH marginally (0.3) above p80 guidelines	3/12/2015	7.02	22.70	0.14	3.40	15.36	10.00		0.07	0.48	<0.03	<0.05	<0.05	<0.05	<50
SW09-Halfway Ck D/S	All parameters within p80 guidelines	10/12/2015	6.50	25.30	0.16	3.10	28.80	11.00		0.03	0.53	<0.03	<0.05	<0.05	<0.05	<50
SW09-Halfway Ck D/S	Results within p80 levels	6/01/2016	6.34	25.20	0.19	2.00	15.16	13.00		<0.03	0.55	<0.03	<0.05	<0.05	<0.05	<50
SW09-Halfway Ck D/S	Results within p80 guidelines	27/01/2016	6.75	24.90	0.23	3.10	23.60	16.00		N/A	N/A	<0.03	0.05	<0.05	<0.05	<50
SW09-Halfway Ck D/S	Natural leachate visible on surface. All parameters within P80 guidelines with the exception of pH (0.2) above background.	19/02/2016	6.80	26.30	0.25	2.60	20.90	5.00		<0.03	0.30	<0.03	<0.05	<0.05	<0.05	<50
SW09-Halfway Ck D/S	pH, and EC marginally above P80 but consistent with upstream result. TSS above p80 but less than US result. All other results compliant.	3/03/2016	7.30	25.70	0.30	3.90	22.60	29.00		0.03	0.46	<0.03	0.09	<0.05	<0.05	N/A
SW09-Halfway Ck D/S	All results compliant with P80 guidelines	9/03/2016	6.95	25.20	0.29	3.10	14.68	10.00		<0.03	0.40	N/A	N/A	N/A	N/A	N/A
SW09-Halfway Ck D/S	pH (0.21) and EC (0.5) marginally above p80 but similar to upstream readings. All other results compliant.	9/04/2016	6.81	24.10	0.31	3.70	9.38	7.00		<0.03	0.33	<0.03	<0.05	<0.05	<0.05	Nil
SW09-Halfway Ck D/S	pH (0.27) and EC (0.045) marginally higher than P80 but similar to upstream reading. All other results compliant	25/04/2016	6.87	19.50	0.30	2.70	6.72	6.00		<0.03	0.30	N/A	N/A	N/A	N/A	Nil
<b>P80 &amp; P20 Values (calculated from baseline and upstream data below)</b>																
P80 (80th Percentile)			6.904		0.2234		27.58	16.2	2.44	0.27	0.578	1.382	0.254	0.017	0.007	#NUM!
P20 (20th Percentile)			6.348		0.1378	2.3										
<b>Baseline (pre-construction) Monitoring</b>																
SW09-Halfway Creek		15/05/2013														
SW09-Halfway Creek		13/06/2013	6.27	16.82	0.14	9.63	37.90	21.00	3.40	0.02	0.21					
SW09-Halfway Creek		18/07/2013														
SW09-Halfway Creek		21/08/2013														
SW09-Halfway Creek		17/09/2013	6.53	17.68	0.19	6.60	26.70	18.00	1.00	0.04	0.55					
SW09-Halfway Creek		25/10/2013														
SW09-Halfway Creek		26/11/2013														
SW09-Halfway Creek		20/12/2013														
SW09-Halfway Creek		9/01/2014														
SW09-Halfway Creek		26/02/2014														
SW09-Halfway Creek		21/03/2014	6.52	20.49	0.22	1.90	24.70	11.00	1.00	0.03	0.71		0.52	0.02	0.01	
SW09-Halfway Creek		7/04/2014														
<b>Upstream Monitoring</b>																
SW09-Halfway Ch. U/S	Wet	22/07/2015	6.07	13.00	0.13	7.12	15.90	3.00		<0.03	0.14	<0.03	<0.05	<0.05	<0.05	N/A
SW09-Halfway Ch. U/S	Wet event piling pad under construction	25/08/2015	6.40	12.30	0.20	8.00	13.00	11.00		<0.03	0.35	<0.03	<0.05	<0.05	<0.05	N/A
SW09-Halfway Ch. U/S	Wet	18/09/2015	6.90	20.10	0.12	4.30	10.64	3.00		<0.03	0.25	N/A	N/A	N/A	N/A	N/A
SW09-Halfway Ch. U/S	Wet Type A all parameters within pre construction guidelines	13/10/2015	6.91	23.90	0.15	3.80	11.32	9.00		0.03	0.35	N/A	N/A	N/A	N/A	N/A
SW09-Halfway Ch. U/S	Wet type A and B 12mm	23/10/2015	6.67	22.30	0.20	2.10	14.46	10.00		<0.03	0.43	<0.03	<0.05	<0.05	<0.05	N/A
SW09-Halfway Ch. U/S	Wet type A and B	4/11/2015	6.80	24.20	0.28	2.00	18.90	9.00		<0.04	0.40	<0.03	<0.05	0.01	<0.05	N/A
SW09-Halfway Ch. U/S	Wet type A	17/11/2015	7.05	23.60	0.12	3.90	42.60	11.00		1.01	0.39	N/A	N/A	N/A	N/A	N/A
SW09-Halfway Ch. U/S	Wet Type A and B	3/12/2015	6.76	22.70	0.13	2.90	14.73	5.00		<0.03	0.34	<0.03	<0.05	<0.05	<0.05	<50
SW09-Halfway Ch. U/S	Wet type A	10/12/2015	6.70	24.00	0.19	2.50	17.56	9.00		0.05	0.59	<0.03	<0.05	<0.05	<0.05	<50
SW09-Halfway Ch. U/S	Wet type A and B: water level low	6/01/2016	6.05	25.00	0.19	2.30	10.88	12.00		0.05	0.87	<0.03	<0.05	<0.05	<0.05	<50
SW09-Halfway Ch. U/S	Wet type B	27/01/2016	7.09	23.80	0.22	2.50	18.56	9.00		Type B	Type B	1.68	0.06	<0.05	<0.05	<50
SW09-Halfway Ch. U/S	Wet A and B	19/02/2016	6.06	26.30	0.28	2.40	28.90	5.00		0.60	0.83	<0.03	<0.05	<0.05	<0.05	<50
SW09-Halfway Ch. U/S	Wet A and B	3/03/2016	7.10	24.70	0.25	2.60	34.80	37.00		0.23	0.42	0.19	0.05	<0.05	<0.05	N/A
SW09-Halfway Ch. U/S	Wet A	9/03/2016	6.57	24.80	0.22	2.30	14.99	15.00		0.28	0.56	N/A	N/A	N/A	N/A	N/A
SW09-Halfway Ch. U/S	Wet A and B	9/04/2016	6.67	23.90	0.22	3.10	24.90	18.00		0.05	0.48	<0.03	0.08	<0.05	<0.05	Nil
SW09-Halfway Ch. U/S	Wet type A	25/04/2016	6.78	19.10	0.23	3.30	13.91	7.00		0.05	0.37	N/A	N/A	N/A	N/A	Nil

SW10 (Dry) - Wells Crossing

Dry Event Monitoring

Monitoring Location	Field Notes	Date	pH (field)	Temperature (field)	Electrical Conductivity (field)	Dissolved Oxygen (field)	Turbidity (field)	Suspended Solids (SS)	Oil & Grease	Total Phosphorus	Total Nitrogen	Phosphate	Ammonia	Nitrate	Nitrite	TPH
			pH unit	°C	µS/cm	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ppm
<b>Downstream Monitoring</b>																
SW10-Wells Crossing D/S		7/07/15	5.90	10.70	0.18	5.97	11.11	<2		0.03	0.35	0.03	0.05	0.05	0.05	N/A
SW10-Wells Crossing D/S	Dry event basin construction about B	19/08/15	6.20	12.60	0.21	8.10	3.20	<2		<0.03	0.34	<0.03	<0.05	<0.05	<0.05	N/A
SW10-Wells Crossing D/S	dry event seems to have stopped running	14/09/15	6.44	15.60	0.23	3.30	3.87	5.00		0.01	0.30	<0.01	<0.01	0.02	<0.01	N/A
SW10-Wells Crossing D/S	Dry-Type B	6/10/15	7.47	19.00	0.31	3.00	6.29	N/A		N/A	N/A	<0.03	<0.05	<0.05	<0.05	N/A
SW10-Wells Crossing D/S	TSS and NTU above P80 levels. Nutrients marginally higher than p80 values but similar to upstream results. All other results within P80 guidelines	26/11/15	6.54	26.20	0.49	3.20	84.60	61.00		0.11	0.53	<0.03	<0.05	<0.05	<0.05	130.00
SW10-Wells Crossing D/S	All parameters within p80 guidelines	9/12/15	4.58	23.20	0.31	5.10	39.80	14.00		0.03	0.29	<0.03	<0.05	<0.05	<0.05	<50
SW10-Wells Crossing D/S	All results within pre-construction guidelines	11/01/16	6.36	25.10	0.28	3.60	142.00	32.00		<0.03	0.29	<0.03	<0.05	<0.05	<0.05	<50
SW10-Wells Crossing D/S	pH, EC marginally above P80 but consistent with upstream result. TSS and NTU above P80 guidelines but within maximum recorded dry result for area. Nitrate above P80 may be due to natural fluctuation.	2/02/16	6.74	25.20	0.47	2.80	33.70	18.00		<0.03	0.33	<0.03	<0.05	0.07	<0.05	<50
SW10-Wells Crossing D/S	pH (0.48) marginally above p80 but similar to upstream record. All other results compliant	23/03/16	6.60	24.50	0.45	3.60	17.68	12.00		<0.03	0.17	N/A	N/A	N/A	N/A	<50
SW10-Wells Crossing D/S	pH (0.4) and EC (0.11) marginally above p80 all other results compliant	7/04/16	6.50	25.00	0.59	4.20	14.56	7.00		<0.03	0.21	<0.03	<0.05	<0.05	<0.05	Nil
SW10-Wells Crossing D/S	pH (0.52) and Total Nitrogen (0.08) marginally above P80 all other results compliant	6/05/16	6.62	23.00	0.45	4.10	16.03	8.00		<0.03	0.15	N/A	N/A	N/A	N/A	Nil
<b>P80 &amp; P20 Values (calculated from baseline and upstream data below)</b>																
P80 (80th Percentile)			6.584		0.4088		12.744	27	2.82	0.084	0.564	0.252	0.104	0.044	0.05	#NUM!
P20 (20th Percentile)			5.47		0.19436	2.484										
<b>Baseline (pre-construction) Monitoring</b>																
SW10-Wells Crossing		15/05/2013	5.68	16.22	0.13	9.80	10.60	133.00	2.10	0.13	1.43					
SW10-Wells Crossing		13/06/2013														
SW10-Wells Crossing		18/07/2013	5.39	14.56	0.16	4.58	5.20	11.00	1.00	0.03	0.28		0.01			
SW10-Wells Crossing		21/08/2013	5.73	13.06	0.19	5.30	10.30	12.00	3.30	0.02	0.37					
SW10-Wells Crossing		17/09/2013														
SW10-Wells Crossing		25/10/2013	5.75	22.54	0.22	4.54	6.70	21.00	1.00	0.05	0.84					
SW10-Wells Crossing		26/11/2013	4.65	25.00	0.36	2.42	1.50	2.00	2.50	0.02	0.49					
SW10-Wells Crossing		20/12/2013	5.49	27.09	0.39	3.80	8.10	7.00	1.00	0.02	0.33					
SW10-Wells Crossing		9/01/2014	5.58	23.74	0.37	3.34	32.00	76.00	1.00	0.06	0.60					
SW10-Wells Crossing		26/02/2014	6.09	26.29	0.40	3.98	2.80	8.00	1.00	0.02	0.37					
SW10-Wells Crossing		21/03/2014														
SW10-Wells Crossing		7/04/2014	5.67	22.79	0.18	1.52	2.50	11.00	6.10	0.04	1.26					
<b>Upstream Monitoring</b>																
SW10-Wells Crossing U/S	Particulate matter present slight tannin colour evident	7/07/2015	4.36	11.20	0.19	5.94	4.60	2.00		0.03	0.41	0.03	0.05	0.05	0.05	N/A
SW10-Wells Crossing U/S	Dry event basin construction about B	19/08/2015	5.90	13.50	0.22	8.00	1.70	4.00		<0.03	0.38	<0.03	<0.05	<0.05	<0.05	N/A
SW10-Wells Crossing U/S	Dry event	14/09/2015	6.60	16.00	0.27	3.30	0.98	<5		0.02	0.30	<0.01	0.14	0.02	<0.01	N/A
SW10-Wells Crossing U/S	Dry-Type B: Shallow water level large amount of macrophytes present	6/10/2015	7.38	16.80	0.36	2.50	0.64	N/A		N/A	N/A	<0.03	<0.05	<0.05	<0.05	N/A
SW10-Wells Crossing U/S	Dry type A	26/11/2015	6.46	27.00	0.45	2.30	12.47	11.00		<0.03	0.36	<0.03	<0.05	<0.05	<0.05	<50
SW10-Wells Crossing U/S	Dry type A	9/12/2015	3.10	25.00	0.83	2.50	6.75	7.00		0.10	0.54	0.09	<0.05	<0.05	<0.05	<50
SW10-Wells Crossing U/S	Dry Type B	11/01/2016	6.21	25.40	0.40	3.10	5.11	21.00		<0.03	0.40	<0.03	<0.05	<0.05	<0.05	<50
SW10-Wells Crossing U/S	Dry type A and B	2/02/2016	6.61	25.58	0.39	2.90	10.68	8.00		0.36	0.28	0.36	<0.05	<0.05	0.05	<50
SW10-Wells Crossing U/S	Dry type A	23/03/2016	6.58	24.30	0.46	2.20	17.74	12.00		<0.03	0.29	N/A	N/A	N/A	N/A	<50
SW10-Wells Crossing U/S	Dry type A and B	7/04/2016	6.49	25.60	0.50	3.80	13.84	31.00		<0.03	0.29	<0.03	<0.05	<0.05	<0.05	Nil
SW10-Wells Crossing U/S	Dry type A	6/05/2016	6.62	22.70	0.37	3.70	30.20	33.00		<0.03	0.40	N/A	N/A	N/A	N/A	Nil

**SW10 (Wet) - Wells Crossing**

**Wet Event Monitoring**

Monitoring Location	Field Notes	Date	pH (field)	Temperature (field)	Electrical Conductivity (field)	Dissolved Oxygen (field)	Turbidity (field)	Suspended Solids (SS)	Oil & Grease	Total Phosphorus as P	Total Nitrogen as N	Phosphate	Ammonia	Nitrate	Nitrite	TPH
			pH unit	°C	µS/cm	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ppm
<b>Downstream Monitoring</b>																
SW10-Wells Crossing D/S	Wet	22/07/2015	6.27	12.10	0.20	5.04	6.90	3.00		<0.03	0.31	<0.03	<0.05	<0.05	<0.05	N/A
SW10-Wells Crossing D/S	Wet event basin construction about A and B	25/08/2015	6.00	12.60	0.22	7.40	13.00	5.00		<0.03	0.28	<0.03	<0.05	<0.05	<0.05	N/A
SW10-Wells Crossing D/S	Wet	18/09/2015	6.52	20.50	0.22	3.70	10.23	8.00		<0.03	0.28	N/A	N/A	N/A	N/A	N/A
SW10-Wells Crossing D/S	Wet Type A all parameters within pre construction guidelines	13/10/2015	6.42	24.40	0.30	2.90	10.84	5.00		<0.03	0.32	N/A	N/A	N/A	N/A	N/A
SW10-Wells Crossing D/S	Wet type A and B 12mm pH, EC, DO marginally outside of P80 guidelines All other results compliant	23/10/2015	6.31	23.70	0.32	2.60	6.86	5.00		<0.03	0.33	<0.03	<0.05	<0.05	<0.05	N/A
SW10-Wells Crossing D/S	All parameters within P80 guidelines	4/11/2015	6.76	24.30	0.24	3.10	23.40	17.00		<0.03	0.40	<0.03	<0.05	<0.05	<0.05	N/A
SW10-Wells Crossing D/S	All parameters within P80 guidelines with the exception of TSS and NTU. DO below P80 but above minimum record for site	17/11/2015	5.99	24.40	0.22	3.10	-	334.00		0.03	0.88	N/A	N/A	N/A	N/A	N/A
SW10-Wells Crossing D/S	NTU exceeds P80 . TSS still within maximum record all other results with the exception of DO within pre-construction	3/12/2015	6.50	22.90	0.27	3.20	200.00	48.00		0.03	0.42	<0.03	<0.05	<0.05	<0.05	<50
SW10-Wells Crossing D/S	Wet type A, B15 natural discharge (75mm recorded at Franklins rd.) EC TSS and NTU above P80 all other results within guidelines	10/12/2015	6.20	23.80	0.22	3.30	642.00	452.00		0.04	0.71	<0.03	<0.05	0.06	<0.05	<50
SW10-Wells Crossing D/S	pH, Tss and Ntu marginally higher than P80 guidelines. TPH higher than upstream record may be a result from highway runoff. No oil or grease visible.	6/01/2016	6.48	25.90	0.28	3.30	56.40	27.00		<0.03	0.31	<0.03	<0.05	<0.05	<0.05	140.00
SW10-Wells Crossing D/S	NTU and TSS above p80. Note: both results improve rapidly directly downstream. All other results compliant with p80	27/01/2016	6.46	26.70	0.32	3.10	180.20	56.00		N/A	N/A	<0.03	<0.05	0.22	<0.05	<50
SW10-Wells Crossing D/S	pH (0.39) and EC (0.214) above P80, all other parameters P80 compliant	19/02/2016	6.69	26.90	0.61	3.70	22.30	6.00		<0.03	0.24	<0.03	<0.05	<0.05	<0.05	<50
SW10-Wells Crossing D/S	pH (0.5) and EC (0.264) above P80. Nitrate, Nitrite and Ammonia all above P80 which may be attributed to natural fluctuation due to extended dry period. All other parameter within P80 guidelines	3/03/2016	6.80	25.20	0.66	4.10	10.78	19.00		<0.03	0.77	<0.03	0.13	0.09	0.05	N/A
SW10-Wells Crossing D/S	pH (0.3) and TSS (0.185) above p80 all other results compliant	9/03/2016	6.88	25.10	0.66	3.60	11.02	7.00		<0.03	0.19	N/A	N/A	N/A	N/A	N/A
SW10-Wells Crossing D/S	pH (0.48) and EC (0.32) marginally above P80. TSS 53.7 above wet event P80 but within the 133 maximum P80 recorded for all events. NTU 73.1 above wet event P80, this result however, reduces significantly immediately downstream.	9/04/2016	6.72	24.00	0.43	3.00	121.00	74.00		<0.03	0.33	<0.03	<0.05	<0.05	<0.05	N/A
SW10-Wells Crossing D/S	pH (0.44) and EC (0.049) marginally higher than P80 but similar to upstream reading. All other results compliant	25/04/2016	6.74	19.40	0.45	4.10	17.04	17.00		<0.03	0.21	N/A	N/A	N/A	N/A	N/A
<b>P80 &amp; P20 Values (calculated from baseline and upstream data below)</b>																
P80 (80th Percentile)			6.774	0.3778		23.44	28.2	4.84	0.042	0.79	#NUM!	0.1104	0.006	#NUM!		50
P20 (20th Percentile)			6.13	0.2105		2.52										
<b>Baseline (pre-construction) Monitoring</b>																
SW10-Wells Crossing		15/05/2013														
SW10-Wells Crossing		13/06/2013	5.60	17.22	0.09	5.92	25.00	12.00	4.30	0.02	0.50					
SW10-Wells Crossing		18/07/2013														
SW10-Wells Crossing		21/08/2013														
SW10-Wells Crossing		17/09/2013	5.50	19.38	0.16	3.48	37.00	16.00	1.00	0.04	0.61					
SW10-Wells Crossing		25/10/2013														
SW10-Wells Crossing		28/11/2013														
SW10-Wells Crossing		20/12/2013														
SW10-Wells Crossing		9/01/2014														
SW10-Wells Crossing		26/02/2014														
SW10-Wells Crossing		21/03/2014	6.15	24.07	0.34	3.40	5.90	18.00	5.20	0.05	0.86		0.11	0.01		
SW10-Wells Crossing		7/04/2014														
<b>Upstream Monitoring</b>																
Wells Crossing U/S	Wet	22/07/2015	6.28	13.00	0.18	6.17	6.27	19.00		<0.03	0.53	<0.03	<0.05	<0.05	<0.05	N/A
Wells Crossing U/S	Wet event basin construction about A and B	25/08/2015	5.70	12.90	0.23	7.10	3.70	7.00		<0.03	0.32	<0.03	<0.05	<0.05	<0.05	N/A
Wells Crossing U/S	Wet	18/09/2015	6.57	19.50	0.25	3.60	3.19	<2		<0.03	0.30	N/A	N/A	N/A	N/A	N/A
Wells Crossing U/S	Wet Type A all parameters within pre construction guidelines Rock platform crossing under construction	13/10/2015	6.49	23.40	0.33	3.30	4.85	20.00		<0.03	0.40	N/A	N/A	N/A	N/A	N/A
Wells Crossing U/S	Wet type A and B 12mm	23/10/2015	6.37	23.20	0.36	1.90	7.63	20.00		0.03	0.58	<0.03	<0.05	<0.05	<0.05	N/A
Wells Crossing U/S	Wet type A and B	4/11/2015	6.83	23.80	0.33	1.80	12.02	27.00		0.03	0.70	<0.03	<0.05	<0.05	<0.05	N/A
Wells Crossing U/S	Wet type A	17/11/2015	6.24	23.60	0.17	2.40	20.00	10.00		<0.03	0.54	N/A	N/A	N/A	N/A	N/A
Wells Crossing U/S	Wet Type A and B	3/12/2015	6.42	22.90	0.45	2.70	7.53	18.00		0.04	0.51	<0.03	<0.05	<0.05	<0.05	50
Wells Crossing U/S	Wet type A	10/12/2015	6.10	25.60	0.30	2.60	78.00	49.00		0.04	0.64	<0.03	<0.05	<0.05	<0.05	<50
Wells Crossing U/S	Wet type A and B: water level low particulate matter from macrophytes in sample	6/01/2016	6.31	25.10	0.38	1.80	12.52	11.00		<0.03	0.58	<0.03	<0.05	<0.05	<0.05	<50
Wells Crossing U/S	Wet type B	27/01/2016	6.33	26.80	0.43	3.30	8.19	4.00		N/A	N/A	<0.03	<0.05	<0.05	<0.05	<50
Wells Crossing U/S	Wet A and B	19/02/2016	6.71	26.90	0.48	2.90	22.40	21.00		<0.03	0.47	<0.03	<0.05	<0.05	<0.05	<50
Wells Crossing U/S	Wet A and B: particulate matter from macrophytes in upstream sample	3/03/2016	6.90	25.10	0.29	3.80	9.86	129.00		0.04	0.97	<0.03	0.10	<0.05	<0.05	N/A
Wells Crossing U/S	Wet A	9/03/2016	6.90	25.60	0.35	4.80	14.37	20.00		0.03	0.88	N/A	N/A	N/A	N/A	N/A
Wells Crossing U/S	Wet A and B	9/04/2016	6.78	24.00	0.38	4.30	42.60	29.00		<0.03	0.44	<0.03	<0.05	<0.05	<0.05	N/A
Wells Crossing U/S	Wet type A High TSS result possibly from difficulty in obtaining sample without macrophyte debris. NTU compliant	25/04/2016	6.77	19.30	0.35	3.90	10.45	209.00		0.05	0.85	N/A	N/A	N/A	N/A	N/A

SW11 (Dry) - Glenugie Creek

Dry Event Monitoring

Monitoring Location	Field Notes	Date	pH (field)	Temperature (field)	Electrical Conductivity (field)	Dissolved Oxygen (field)	Turbidity (field)	Suspended Solids (SS)	Oil & Grease	Total Phosphorus	Total Nitrogen as N	Phosphate	Ammonia	Nitrate	Nitrite	TPH
			pH unit	°C	µS/cm	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ppm
<b>Downstream Monitoring</b>																
SW11-Glenugie Ck D/S	Pooled water no flow algae on surface	7/07/15	3.70	5.61	0.38	3.70	44.50	3.00		0.05	1.71	0.03	0.57	0.52	0.05	N/A
SW11-Glenugie Ck D/S	Pooled water no flow algae on surface	19/08/15	7.60	10.50	0.43	5.30	9.00	4.00		0.03	1.25	<0.03	0.06	0.49	<0.05	N/A
SW11-Glenugie Ck D/S	dry event high amounts of debris on surface	14/09/15	6.34	14.90	0.19	3.90	40.70	8.00		0.03	1.00	<0.01	0.04	0.39	0.02	N/A
SW11-Glenugie Ck D/S	Dry-Type B no flow algae and natural leachate on surface	6/10/15	7.15	16.00	0.32	1.70	8.74	N/A		N/A	N/A	<0.03	0.42	0.32	<0.05	N/A
SW11-Glenugie Ck D/S	All parameters within P80 guidelines. All nutrients above pre-construction values	26/11/15	6.75	27.60	0.17	2.60	20.90	14.00		0.05	1.54	<0.03	0.40	0.21	<0.05	210.00
SW11-Glenugie Ck D/S	EC, Nitrate, total Phosphorus and Nitrogen all above P80 which may be due to natural fluctuations within the system	9/12/15	7.20	25.10	0.10	2.80	28.50	8.00		0.06	1.02	<0.03	0.28	0.15	<0.05	<50
SW11-Glenugie Ck D/S	Results within P80 Guidelines with the exception of Nitrate, Nitrite and Total Nitrogen. Increased nutrient levels possibly due to large microbat colony	11/01/16	6.55	25.00	0.20	1.90	49.20	23.00		<0.03	0.91	<0.03	0.30	0.07	<0.05	<50
SW11-Glenugie Ck D/S	pH marginally below P80. TSS above p80 and marginally (5) above maximum dry record. NTU Above p80 but within maximum record. Ammonia above p80 possibly due to natural fluctuations.	2/02/16	6.90	25.20	0.22	1.70	80.20	33.00		0.03	0.80	<0.03	0.12	<0.05	<0.05	<50
SW11-Glenugie Ck D/S	Total Nitrogen (0.69) and Total Phosphorus (0.022) above P80 all other results compliant	23/03/16	7.07	25.10	0.19	1.90	21.00	11.00		0.05	1.41	N/A	N/A	N/A	N/A	<50
SW11-Glenugie Ck D/S	All results compliant with P80 with the exception of total nitrogen 0.43 above background. This result may be attributed to the bebo arch microbat colony.	7/04/16	6.87	24.50	0.17	1.60	14.99	7.00		0.04	1.25	<0.03	0.64	0.07	<0.05	Nil
SW11-Glenugie Ck D/S	pH (0.02) below P80 Total Nitrogen (0.37) and Total Phosphorus (0.220) above P80 possibly a result of the large Microbat colony residing in adjacent Bebo arch all other parameters compliant	6/05/16	6.98	23.00	0.17	2.20	23.20	11.00		0.05	1.09	N/A	N/A	N/A	N/A	Nil
<b>P80 &amp; P20 Values</b> (calculated from baseline and upstream data below)																
P80 (80th Percentile)			7.222		0.4024		46.74	19.2	1.76	0.03	0.58	0.0252	0.3178	0.046	0.05	188
P20 (20th Percentile)			6.68		0.2382	2.384										
<b>Baseline (pre-construction) Monitoring</b>																
SW11-Glenugie Creek		15/05/2013	7.00	17.42	0.49	2.70	19.10	11.00	1.00	0.02	0.27					
SW11-Glenugie Creek		13/06/2013														
SW11-Glenugie Creek		18/07/2013	6.87	14.69	0.35	10.33	19.70	5.00	1.00	0.02	0.33	0.01	0.03	0.01		
SW11-Glenugie Creek		21/08/2013	7.02	12.39	0.49	3.30	15.50	3.00	1.00	0.02	0.28					
SW11-Glenugie Creek		17/09/2013														
SW11-Glenugie Creek		25/10/2013	7.33	20.65	0.39	2.43	10.10	7.00	1.00	0.02	0.49					
SW11-Glenugie Creek		26/11/2013	6.81	22.14	0.25	3.45	104.00	28.00	1.00	0.03	0.82					
SW11-Glenugie Creek		20/12/2013	6.91	21.99	0.40	2.10	10.30	4.00	1.00	0.02	0.38					
SW11-Glenugie Creek		9/01/2014	7.23	21.69	0.31	0.71	16.20	10.00	1.00	0.03	0.37					
SW11-Glenugie Creek		26/02/2014	7.22	23.07	0.39	1.83	3.60	3.00	6.50	0.02	0.58					
SW11-Glenugie Creek		21/03/2014														
SW11-Glenugie Creek		7/04/2014	6.91	22.25	0.29	3.24	63.00	18.00	2.90	0.02	0.52					
<b>Upstream Monitoring</b>																
SW11-Glenugie Ck U/S	Pooled water no flow	7/07/2015	5.87	11.60	0.40	7.75	43.60	9.00		0.03	0.55	0.03	0.39	0.05	0.05	N/A
SW11-Glenugie Ck U/S	Pooled water no flow	19/08/2015	7.90	11.20	0.51	8.20	19.00	9.00		<0.03	0.53	<0.03	<0.05	<0.05	<0.05	N/A
SW11-Glenugie Ck U/S	dry event no flow	14/09/2015	6.64	14.10	0.30	2.60	8.41	14.00		0.02	0.40	<0.01	<0.01	0.04	<0.01	N/A
SW11-Glenugie Ck U/S	Dry-Type B: stagnant	6/10/2015	7.31	16.10	0.27	3.00	47.30	N/A		N/A	N/A	<0.03	<0.05	<0.05	<0.05	N/A
SW11-Glenugie Ck U/S	Dry type A	26/11/2015	6.45	28.50	0.30	3.10	22.40	36.00		<0.03	0.58	<0.03	<0.05	<0.05	<0.05	100
SW11-Glenugie Ck U/S	Dry type A	9/12/2015	6.90	25.00	0.18	2.20	8.29	13.00		0.05	0.64	<0.03	<0.05	<0.05	<0.05	<50
SW11-Glenugie Ck U/S	Dry Type B	11/01/2016	6.45	25.00	0.15	2.60	92.00	21.00		<0.03	0.52	<0.03	<0.05	<0.05	<0.05	<50
SW11-Glenugie Ck U/S	Dry type A and B	2/02/2016	6.80	25.10	0.28	3.00	46.60	17.00		<0.03	0.53	<0.03	<0.05	<0.05	<0.05	<50
SW11-Glenugie Ck U/S	Dry type A	23/03/2016	6.98	24.20	0.15	3.40	15.40	12.00		<0.03	0.38	N/A	N/A	N/A	N/A	210
SW11-Glenugie Ck U/S	Dry type A and B	7/04/2016	6.76	24.90	0.18	3.10	30.90	8.00		<0.03	0.38	<0.03	<0.05	<0.05	<0.05	Nil
SW11-Glenugie Ck U/S	Dry type A	6/05/2016	6.69	22.80	0.28	3.80	44.60	23.00		0.03	0.69	N/A	N/A	N/A	N/A	Nil

SW11 (Wet) - Glenugie Creek

Wet Event Monitoring

Monitoring Location	Field Notes	Date	pH (field)	Temperature (field)	Electrical Conductivity (field)	Dissolved Oxygen (field)	Turbidity (field)	Suspended Solids (SS)	Total Phosphorus as P	Total Nitrogen as N	Phosphate	Ammonia	Nitrate	Nitrite	TPH
			pH unit	°C	µS/cm	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ppm
<b>Downstream Monitoring</b>															
SW11-Glenugie Ck D/S	Wet-No Flow	22/07/2015	5.90	10.90	0.39	3.70	31.90	8.00	0.04	1.70	<0.03	0.05	0.83	<0.05	N/A
SW11-Glenugie Ck D/S	Dry Pooled water no flow algae on surface	25/08/2015	7.50	12.80	0.21	7.50	50.00	22.00	<0.03	0.53	<0.03	0.05	0.12	<0.05	N/A
SW11-Glenugie Ck D/S	Rising water very milky in appearance	18/09/2015	6.65	19.80	0.16	3.70	44.50	27.00	<0.03	0.48	N/A	N/A	N/A	N/A	N/A
SW11-Glenugie Ck D/S	Wet Type A no flow, water quality better than upstream readings	13/10/2015	7.15	22.90	0.29	2.30	4.68	3.00	0.06	1.88	N/A	N/A	N/A	N/A	N/A
SW11-Glenugie Ck D/S	Wet type A and B 12mm all parameters within P80 guidelines with the exception of DO total Phosphorus and total Nitrogen which may be due to seasonal fluctuations	23/10/2015	6.72	23.30	0.34	1.90	3.75	5.00	0.07	1.72	0.03	0.28	0.43	<0.05	N/A
SW11-Glenugie Ck D/S	Nutrients higher than P80 and upstream results which may be due to increased micro-bat activity. All other parameters within or better than P80 guidelines with the exception of DO	4/11/2015	6.78	23.30	0.31	1.70	3.47	3.00	0.06	1.90	0.04	0.62	0.42	0.14	N/A
SW11-Glenugie Ck D/S	pH and DO marginally below P80 results. All other parameters within P80 guidelines	17/11/2015	6.21	23.40	0.12	3.10	44.80	16.00	0.04	0.72	N/A	N/A	N/A	N/A	N/A
SW11-Glenugie Ck D/S	All parameters within p80 guidelines. Nitrate, Ammonia and total Nitrogen above p80 may be due to natural fluctuations within the system	3/12/2015	6.70	22.60	0.16	2.40	21.60	17.00	0.04	0.81	<0.03	0.17	0.12	<0.05	<50
SW11-Glenugie Ck D/S	B26 and operational basin natural discharge. TSS, NTU, Nitrate, total Nitrogen and Phosphate above p80 but similar to upstream results. Increased turbidity and TSS likely to be due from surrounding area.	10/12/2015	6.40	25.20	0.14	3.80	550.00	1482.00	0.09	1.71	<0.03	<0.05	0.13	<0.05	<50
SW11-Glenugie Ck D/S	All results within P80 guidelines. TPH lower than upstream result	6/01/2016	6.71	25.30	0.18	2.30	82.40	29.00	<0.03	0.73	<0.03	0.16	<0.05	<0.05	160.00
SW11-Glenugie Ck D/S	All results within p80 guidelines	27/01/2016	6.67	26.10	0.10	2.40	133.00	35.00	N/A	N/A	<0.03	0.08	0.06	<0.05	<50
SW11-Glenugie Ck D/S	Natural leachate visible on surface. EC slightly higher (0.106) than P80 but consistent with U/S result. All other parameters P80 compliant	19/02/2016	7.01	26.30	0.35	2.40	10.08	6.00	0.04	0.10	<0.03	0.10	0.08	<0.05	<50
SW11-Glenugie Ck D/S	EC marginally above P80 (0.074) all other results compliant	3/03/2016	7.10	24.70	0.31	2.90	22.00	10.00	<0.03	0.18	<0.03	<0.05	<0.05	<0.05	N/A
SW11-Glenugie Ck D/S	All results compliant with P80 guidelines	9/03/2016	7.16	25.10	0.18	3.50	47.20	21.00	<0.03	0.56	N/A	N/A	N/A	N/A	N/A
SW11-Glenugie Ck D/S	Nitrate, Ammonia and Total Nitrogen all above P80 possibly a result of the large Microbat colony residing in adjacent Bebo arch. All other results compliant.	9/04/2016	7.12	24.00	0.12	2.70	43.30	17.00	0.04	0.97	<0.03	0.20	0.11	<0.05	Nil
SW11-Glenugie Ck D/S	Total Nitrogen (0.22) above P80 all other results compliant	25/04/2016	7.30	19.30	0.16	3.60	39.10	21.00	0.05	1.15	N/A	N/A	N/A	N/A	Nil
<b>P80 &amp; P20 Values</b> (calculated from baseline and upstream data below)															
P80 (80th Percentile)			7.022		0.298		108.6	45.2	0.05	0.69	0.005	0.1008	0.096	0.004	392
P20 (20th Percentile)			6.524		0.09748	3.04									
<b>Baseline (pre-construction) Monitoring</b>															
SW11-Glenugie Creek		15/05/2013													
SW11-Glenugie Creek		13/06/2013	6.89	17.67	0.13	5.35	269.00	125.00	0.05	0.81					
SW11-Glenugie Creek		18/07/2013													
SW11-Glenugie Creek		21/08/2013													
SW11-Glenugie Creek		17/09/2013	6.42	21.26	0.20	5.30	51.00	28.00	0.03	0.65					
SW11-Glenugie Creek		25/10/2013													
SW11-Glenugie Creek		26/11/2013													
SW11-Glenugie Creek		20/12/2013													
SW11-Glenugie Creek		9/01/2014													
SW11-Glenugie Creek		26/02/2014													
SW11-Glenugie Creek		21/03/2014	7.11	23.19	0.19	4.97	109.00	37.00	0.02	0.46	0.01	0.11	0.08	0.00	
SW11-Glenugie Creek		7/04/2014													
<b>Upstream Monitoring</b>															
SW11-Glenugie Ck U/S	Wet-No Flow	22/07/2015	6.20	13.20	0.44	5.47	26.10	12.00	<0.03	0.55	<0.03	<0.05	<0.05	<0.05	N/A
SW11-Glenugie Ck U/S	Pooled water no flow	25/08/2015	7.40	13.20	0.12	8.20	50.00	28.00	<0.03	0.45	<0.03	<0.05	0.05	<0.05	N/A
SW11-Glenugie Ck U/S	Noticeable flow	18/09/2015	6.71	19.60	0.11	3.90	59.40	20.00	<0.03	0.55	N/A	N/A	N/A	N/A	N/A
SW11-Glenugie Ck U/S	Wet Type A. No flow sediment evident in water	13/10/2015	6.70	23.70	0.32	2.60	60.10	38.00	0.03	0.69	N/A	N/A	N/A	N/A	N/A
SW11-Glenugie Ck U/S	Wet type A and B 12mm	23/10/2015	6.36	23.40	0.46	1.80	62.90	62.00	0.05	0.88	<0.03	<0.05	0.06	<0.05	N/A
SW11-Glenugie Ck U/S		4/11/2015													
SW11-Glenugie Ck U/S	Wet type A	17/11/2015	6.20	23.40	0.05	3.40	75.10	19.00	0.03	0.49	N/A	N/A	N/A	N/A	N/A
SW11-Glenugie Ck U/S	Wet Type A and B	3/12/2015	6.73	22.60	0.08	3.30	53.40	22.00	0.03	0.56	<0.03	<0.05	<0.05	<0.05	<50
SW11-Glenugie Ck U/S	Wet type A	10/12/2015	6.80	25.60	0.12	3.20	550.00	1132.00	0.08	1.66	<0.03	<0.05	0.12	<0.05	<50
SW11-Glenugie Ck U/S	Wet type A and B	6/01/2016	6.68	25.30	0.09	3.10	108.00	50.00	0.03	0.64	<0.03	<0.05	<0.05	<0.05	460
SW11-Glenugie Ck U/S	Wet type B	27/01/2016	6.72	26.40	0.09	3.10	114.00	27.00	N/A	N/A	<0.03	0.06	<0.05	<0.05	<50
SW11-Glenugie Ck U/S	Wet A and B	19/02/2016	6.78	26.80	0.47	2.90	26.00	9.00	<0.03	<0.05	<0.03	<0.05	<0.05	<0.05	120
SW11-Glenugie Ck U/S	Wet A and B	3/03/2016	7.13	25.60	0.13	3.50	31.90	21.00	<0.03	0.40	<0.03	<0.05	0.09	<0.05	N/A
SW11-Glenugie Ck U/S	Wet A	9/03/2016	7.23	25.10	0.15	3.00	75.20	25.00	<0.03	0.61	N/A	N/A	N/A	N/A	N/A
SW11-Glenugie Ck U/S	Wet A and B	9/04/2016	6.84	24.00	0.21	3.10	28.70	12.00	<0.03	0.45	<0.03	<0.05	<0.05	<0.05	Nil
SW11-Glenugie Ck U/S	Wet type A	25/04/2016	6.87	19.20	0.26	3.80	36.80	18.00	<0.03	0.44	N/A	N/A	N/A	N/A	Nil



## Appendix B

# Groundwater Quality Results

Baseline data statistics for all sites

	pH	EC (mS/cm)	DO (mg/L)	Turbidity (NTU)	TDS (g/L)	Bicarbonate (Alkalinity) (mg/L CaCO <sub>3</sub> equiv)	Total Phosphorus (mg/L P)	Total Nitrogen (mg/L N)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Chloride (mg/L)	Sulfate (mg/L SO <sub>4</sub> <sup>2-</sup> )	Aluminium (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)
Max	7.4	9.7	3.6	509	7.3	735	0.22	5.57	1632	14	232	258	2900	433	0.937	0.144	0.009	1.693
90%ile	7.3	7.9	2.9	190	5.8	462	0.13	2.98	1387	12	196	195	2692	174	0.504	0.089	0.005	0.592
80%ile	7.0	3.5	2.6	131	4.7	370	0.09	1.51	1238	10	81	170	2412	131	0.305	0.041	0.003	0.291
Median	6.2	2.0	2.0	32	1.1	190	0.03	0.25	334	5	25	20	368	72	0.062	0.004	0.001	0.050
Mean	6.2	3.0	2.2	81	2.4	239	0.05	0.94	551	6	60	71	932	87	0.180	0.026	0.002	0.194
20%ile	5.5	0.8	1.7	6	0.6	69	0.01	0.09	211	3	11	11	237	25	0.005	0.001	0.001	0.008
10%ile	5.2	0.6	1.5	5	0.5	43	0.01	0.07	107	2	8	9	155	16	0.003	0.001	0.001	0.004
Min	4.6	0.3	1.3	3	0.3	8	0.01	0.04	54	2	5	5	67	8	0.001	0.000	0.001	0.003



GWB30

Parameter Group	Parameter	Pre-construction Monitoring			Statistics		Construction Monitoring		
		14/11/2013	10/02/2014	09/04/2014	P80	P20	11/09/2015	16/12/2015	20/05/2016
Physical and chemical properties	pH	7.33	7.29	7.41	7.4	7.3	7.9	9.1	7.1
	Temp. (°C)	26.54	26.57	22.46	26.6	-	19.3	23.5	21.8
	EC (mS/cm)	3.02	3.34	3.51	3.4	3.1	1.89	1.89	2.22
	DO (mg/L)	1.69	1.37	2.02	1.9	1.5	5.80	2.88	9.02
	Turbidity (NTU)	5.6	12	5	9	-	240	479	800
	TDS (g/L) (Solids)	1.93			1.93	1.93	1.07	1.083	1.24
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)	5	5	5	5	-			
	TRH C10-C14 Fraction (µg/L or ppb)	4100	2100	660	3300	-			
	TRH C15-C28 Fraction (µg/L or ppb)	190	50	50	134	-			
	TRH C29-C36 Fraction (µg/L or ppb)	50	50	50	50	-			
	TRH C10-C16 Fraction (µg/L or ppb)	4100	2100	640	3300	-			
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)	4100	2100	640	3300	-	Not detected	Not detected	Not detected
	TRH C16-C34 Fraction (µg/L or ppb)	240	50	50	164	-			
TRH C34-C40 Fraction (µg/L or ppb)	50	50	50	50	-				
Nutrients	Total Nitrogen (mg/L N)	5.57			5.57	-	0.74	0.58	0.95
	Total Phosphorus (mg/L P)	0.13			0.13	-	0.150	0.091	0.300
Major Cations	Sodium (mg/L)	661			661	-	383	418	442
	Potassium (mg/L)	2.2			2.2	-	2.3	2.0	2.0
	Calcium (mg/L)	85.6			85.6	-	34.8	34.0	48.0
	Magnesium (mg/L)	15.6			16	-	7.5	8.0	9.0
Major Anions	Chloride (mg/L)	466			466	-	319	375	403
	Sulfate (mg/L SO42)	433			433	-	16	17	16
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)	630			630	-	368	380	450
Heavy Metals (Dissolved)	Aluminium (mg/L)	0.007			0.007	-	0.06	0.02	0.011
	Cadmium (mg/L)	0.0005			0.001	-	<0.001	<0.001	<0.001
	Copper (mg/L)	0			0.000	-	0.011	0.013	0.010
	Lead (mg/L)	0.0005			0.001	-	<0.001	<0.001	<0.001
	Zinc (mg/L)	0.004			0.004	-	0.003	0.005	0.004
BTEX	Benzene (µg/L or ppb)	0.5	0.5	0.5	0.5	-			
	Toluene (µg/L or ppb)	0.5	0.5	0.5	0.5	-			
	Ethylbenzene (µg/L or ppb)	0.5	0.5	0.5	0.5	-			
	m+p-Xylene (µg/L or ppb)	1	1	1	1.0	-			
	o-Xylene (µg/L or ppb)	0.5	0.5	0.5	0.5	-			
	Napthalene (µg/L or ppb)	0.5	0.5	0.5	0.5	-			

## GWB31

Parameter Group	Parameter	Pre-construction Monitoring	Statistics		Construction Monitoring		
		09/04/2014	P80	P20	11/09/2015	16/12/2015	20/05/2016
Physical and chemical properties	pH	6.96	7.0	7.0	7.1	8.3	6.7
	Temp. (°C)	21.51	21.5	-	21.1	23.3	24.0
	EC (mS/cm)	1.48	1.5	1.5	2.55	2.12	2.43
	DO (mg/L)	3.4	3.4	3.4	2.12	2.59	8.89
	Turbidity (NTU)	131	131	-	0	800	771
	TDS (g/L) (Solids)				1.66	1.334	1.743
Hydrocarbons	TRH C6-C9 Fraction (µg/L or ppb)	5	5	-			
	TRH C10-C14 Fraction (µg/L or ppb)	25	25	-			
	TRH C15-C28 Fraction (µg/L or ppb)	50	50	-			
	TRH C29-C36 Fraction (µg/L or ppb)	50	50	-			
	TRH C10-C16 Fraction (µg/L or ppb)	25	25	-			
	TRH C10-C16 less Napthalene Fraction (µg/L or ppb)	25	25	-	Not detected	Not detected	Not detected
	TRH C16-C34 Fraction (µg/L or ppb)	50	50	-			
	TRH C34-C40 Fraction (µg/L or ppb)	50	50	-			
Nutrients	Total Nitrogen (mg/L N)			-	1.01	2.406	0.61
	Total Phosphorus (mg/L P)			-	0.450	0.066	0.25
Major Cations	Sodium (mg/L)			-	414	345	394
	Potassium (mg/L)			-	2.6	3.0	3
	Calcium (mg/L)			-	176	126	171
	Magnesium (mg/L)			-	57.8	50.0	62
Major Anions	Chloride (mg/L)			-	169	156	177
	Sulfate (mg/L SO42)			-	132	101	125
	Bicarbonate (Alkalinity) (mg/L CaCO3 equiv)			-	710	660	830
Heavy Metals (Dissolved)	Aluminium (mg/L)			-	0.013	0.01	0.005
	Cadmium (mg/L)			-	<0.001	<0.001	<0.001
	Copper (mg/L)			-	0.001	0.023	0.013
	Lead (mg/L)			-	<0.001	<0.001	<0.001
	Zinc (mg/L)			-	0.009	0.019	0.027
BTEX	Benzene (µg/L or ppb)	0.5	0.5	-			
	Toluene (µg/L or ppb)	0.5	0.5	-			
	Ethylbenzene (µg/L or ppb)	0.5	0.5	-			
	m+p-Xylene (µg/L or ppb)	1	1.0	-			
	o-Xylene (µg/L or ppb)	0.5	0.5	-			
	Napthalene (µg/L or ppb)	0.5	0.5	-			