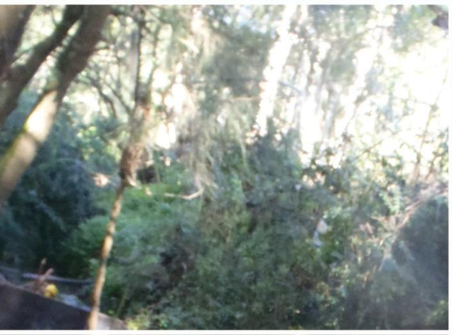
Rooty Hill Regional Distribution Centre

Annual Environmental Monitoring Report 2013 - 2014



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Final

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Holcim Regional Distribution Centre Environmental Monitoring Program

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Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to summarise environmental monitoring data recorded between September 2013 and August 2014 at the Rooty Hill Regional Distribution construction site in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

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1. Introduction

1.1 Project overview

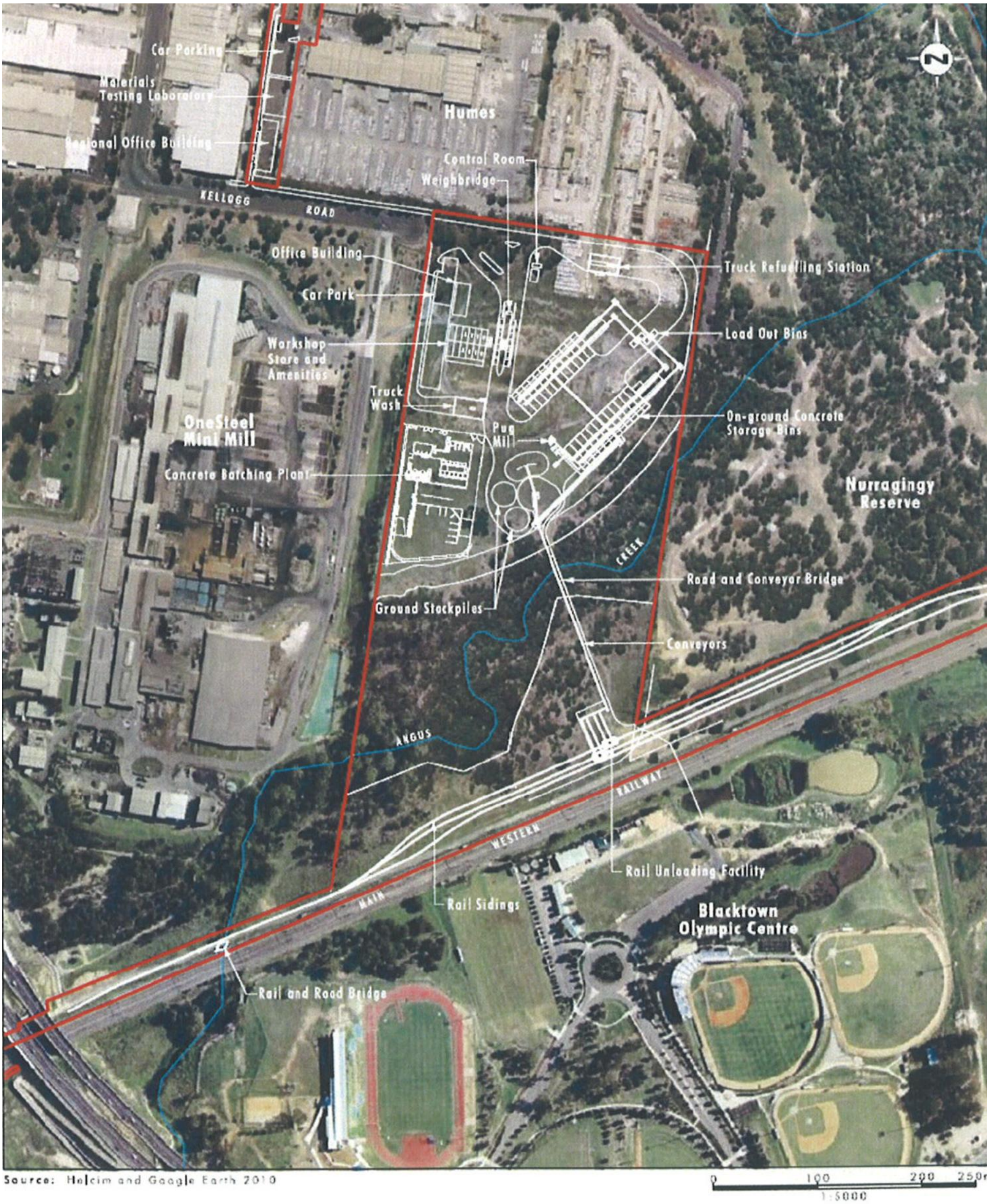
The Rooty Hill Regional Distribution Centre (RDC), located at Kellogg Road, Rooty Hill, within the Blacktown Local Government Area (LGA), will allow Holcim to receive construction material by rail from quarries located outside of the Sydney Basin, blend the materials to meet customer specifications and distribute these by road to the Sydney market.

The Project involves construction of a rail siding with aggregate unloading facility, on-ground concrete storage bins and truck load out facility, a conveyor system linking the unloading station to the storage and truck facilities, site offices, bridges over Angus Creek, truck wash down, refuelling, weighbridge and parking facilities, a radial stacker, a blending plant/pug mill, a concrete batching plant, a regional office building and quarry and concrete testing laboratory.

The site is 15 hectares, bound by the Main Western Railway Line to the south, the Nurragingy Reserve to the East, the OneSteel Mini Mill and the Humes and other industrial facilities to the north. Angus Creek, a tributary of Eastern Creek, flows through the southern portion of the site (Figure 1-1).

Construction is being undertaken in accordance with the requirements of the Environmental Assessment Report (EAR), Submissions Report, Modification Report, final Statement of Commitments (SoC) and the final Minister's Conditions of Approval (MCoA 05-0051).

- **Figure 1-1 Site Layout Plan**



1.2 Monitoring program

Environmental monitoring involves collecting and interpreting data to quantify the effectiveness of Holcim's Environmental Management System. The monitoring programs will assist in the auditing of safeguard measures to ensure they achieve their objectives and to facilitate modification where necessary.

A number of parameters have been included in the monitoring program, in line with requirements of the Construction Environmental Management Plan (CEMP), its sub-plans and relevant conditions of project approval and statement of commitments. The monitoring parameters included in the program and references to relevant sections within this report are summarised in Table 1-1.

Table 1-1 Monitoring parameters

Description		Frequency	Requirement			Where to find in this report
			Conditions of approval	Statement of commitments	CEMP	
Meteorology		Monthly	-	3.3, 10.4, 15.3	✓	Section 2
Aquatic ecology	Macro invertebrates	6 monthly	2.28A	7.5, 10.4, 15.2	✓	Section 3
	Fish	6 monthly	2.28A	7.5, 10.4, 15.2	✓	
	Habitat condition and aquatic vegetation	Quarterly	2.28A	7.5, 10.4, 15.3	✓	Section 4
Terrestrial ecology	Flora and fauna	Quarterly	2.24, 2.25, 2.26	7.4	✓	Section 4
Water quality		Quarterly	2.28A	7.5, 10.4, 15.3	✓	Section 5
Air quality	Depositional dust	Monthly	2.8, 5.3 c)	4.1, 10.4, 15.3	✓	Section 6
	PM_{10}	Weekly	2.8, 5.3 d)	4.1, 10.4, 15.3	✓	Section 6
Noise		Monthly	5.3 b)	10.4, 15.3	✓	Section 7
Groundwater		Quarterly	-	-	✓	Section 8

1.3 Scope of this report

The monitoring program of 2013-14 commenced in September 2013, and followed from previous monitoring completed by Jacobs up to this time. This report incorporates all monitoring results from September 2013 to August 2014 inclusive.

This report describes the methods and the results of conducting environmental monitoring. Environmental assessment criteria are presented, where relevant, for ready comparison with results; however this report does not represent a review of environmental performance over the monitoring period and hence, does not represent an Annual Environmental Management Review.

Monitoring methodologies, including dates, instrumentation, calibration details and measurement locations, and results for each parameter described in Table 1-1 are presented individually in the sections listed in the table.

2. Meteorology

Summary

Meteorological monitoring indicated that a large proportion of winds are from the south and south east and are generally light. During all but the winter months, south to south-easterly breezes dominated but in June and July, the breeze came largely from the west northwest.

Temperatures at the RDC generally reach mid to high 20's in the summer with several days exceeding 30 degrees. The maximum observed temperature was 41 degrees in January. Winter temperatures are generally in the mid-teens with many days dropping below 10 degrees. The lowest recorded temperature was in July at -1 degree.

Total rainfall in the period was 445 mm over 197 rain days, lower than the nearby Prospect Reservoir, which was around 900 mm. The timing and rainfall for the majority of observed rain days are similar for each site. This difference is relatively large and may indicate localised storm activity or that the Rooty Hill monitoring station is less sensitive to some rainfall events.

The highest UV exposure is during the summer months, with several days exceeding the "Extreme" classification. During winter, most days presented low to moderate UV exposure. Average daily solar radiation follows the trend of the UV index, with highest levels experienced in summer.

2.1 Methodology

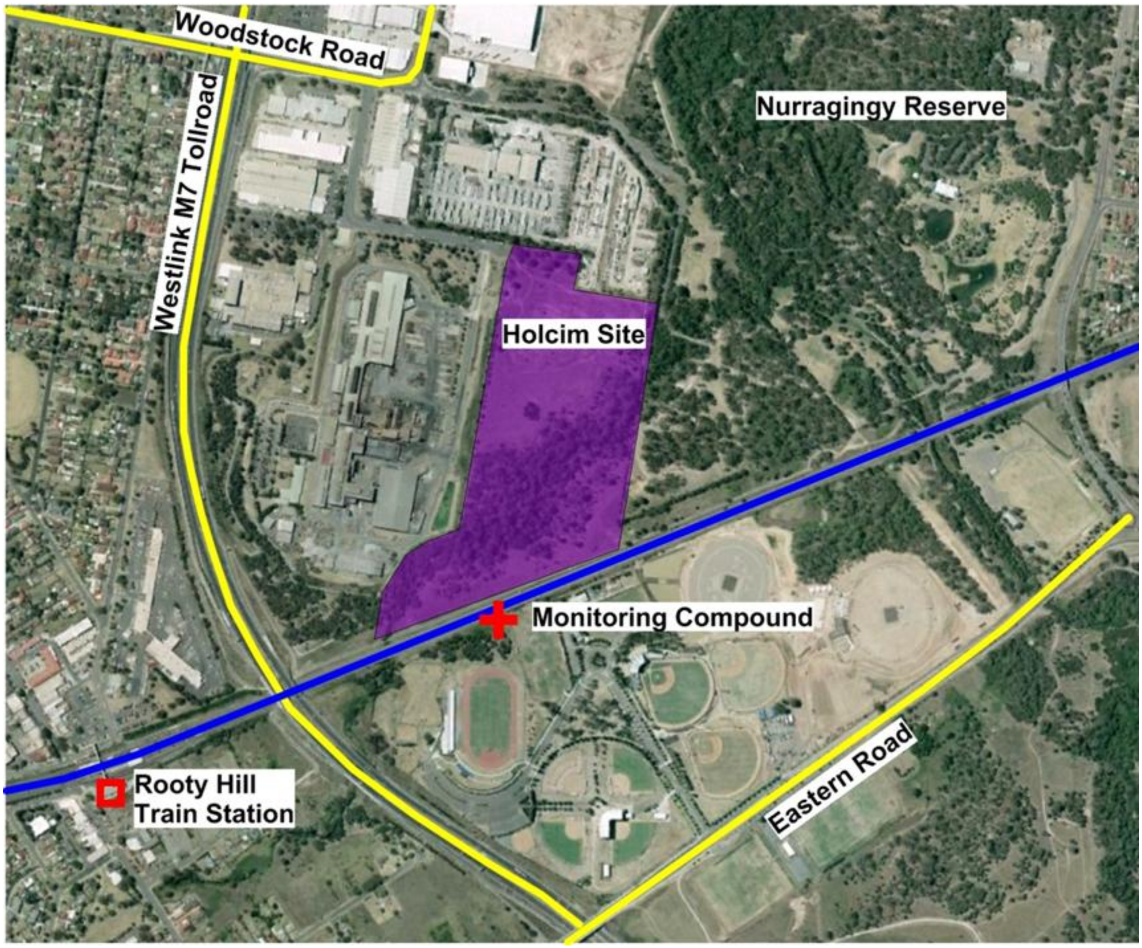
Meteorological conditions were monitored using a Davis Vantage Pro2 Plus monitoring unit. This unit was positioned in accordance with AS2923-1987 *Ambient air – Guide for measurement of horizontal wind for air quality applications* and the location is illustrated in Figure 2-1.

Meteorological parameters monitored included:

- Wind speed and direction
- Temperature
- Humidity
- Rainfall
- Barometric pressure
- Solar radiation

The meteorological station does not satisfy the accuracy requirements of AS 3580.14-2011 for wind speed and direction measurements. However, no monitoring standards are specified in the Project Approval and the accuracy of the proposed unit is sufficient for the purposes of construction impact management. The integrity of the meteorological monitoring station is checked every six days and data collected on a monthly basis.

Figure 2-1 Meteorological monitoring station location



2.2 Wind speed and direction

Available wind speed and direction data have been summarised for each month in Figure 2-2. It can be seen that a large proportion of winds are from the south and south east and are generally light. During all but the winter months, south to south-easterly breezes dominated, however in June and July the breeze came largely from the west northwest.

2.3 Temperature

Temperature data are summarised in Figure 2-3. A clear distinction between summer and winter months is evident, with maximum temperatures generally reaching mid to high 20's in the summer and several days exceeding 30 degrees. The maximum observed temperature was 41 degrees in January. Winter temperatures are generally in the mid-teens with many days dropping below 10 degrees. The lowest recorded temperature was -1 degrees in July.

2.4 Rainfall

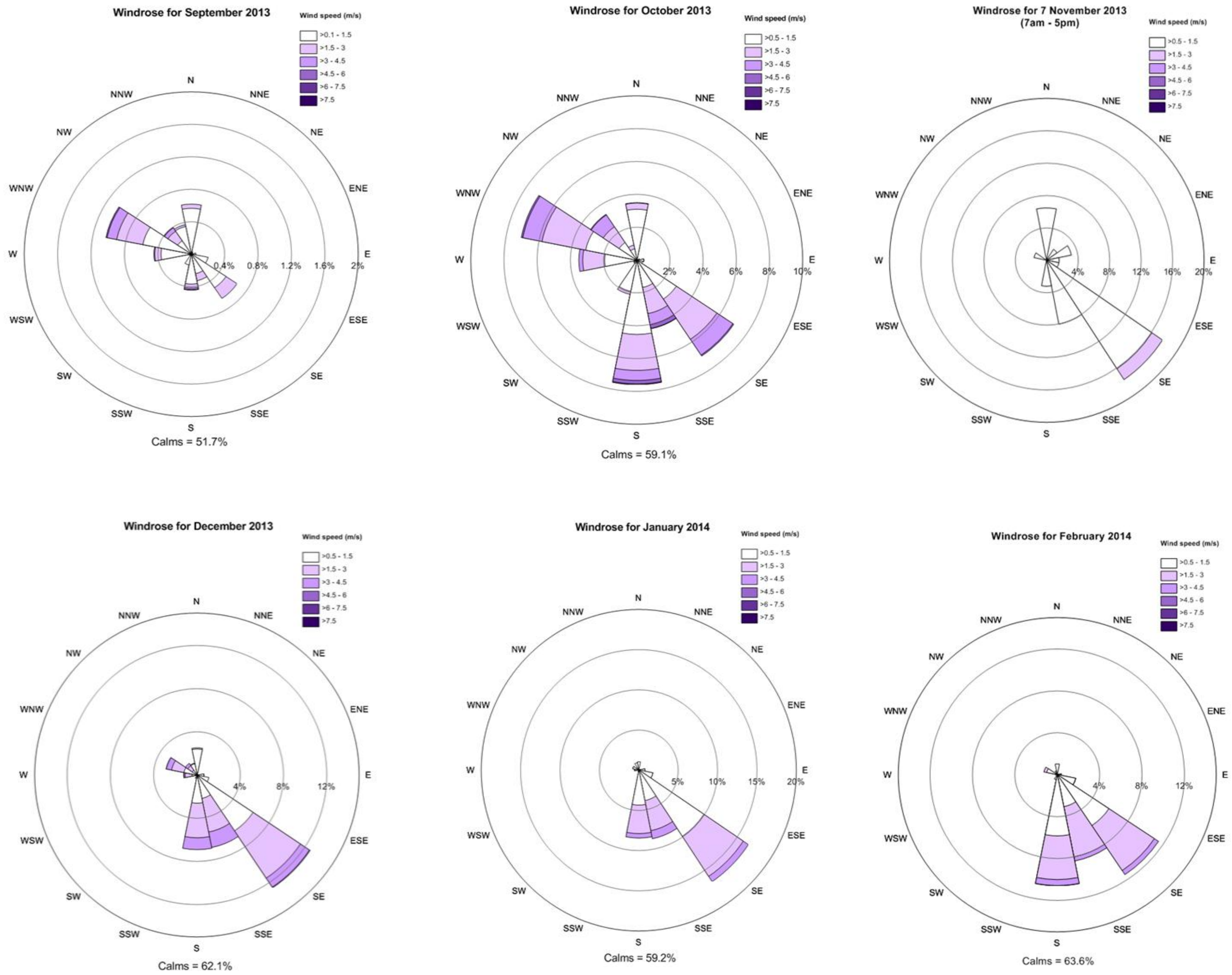
Results of rainfall observations are summarised in Figure 2-4. Total rainfall in the period was 445 mm over 197 rain days, lower than the nearby Prospect Reservoir, which was around 900 mm. The timing and rainfall for the majority of observed rain days are similar for each site. This difference is relatively large and may indicate localised storm activity or that the Rooty Hill monitoring station is less sensitive to some rainfall events.

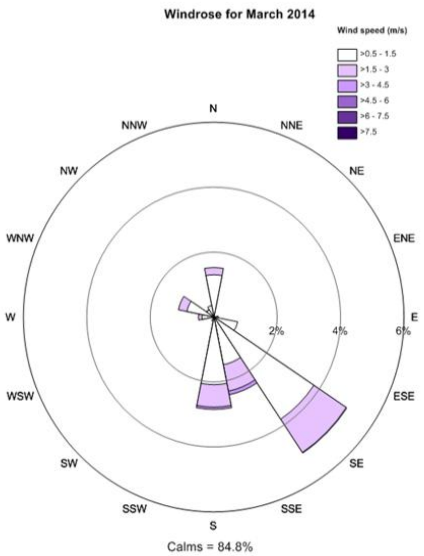
2.5 Solar exposure

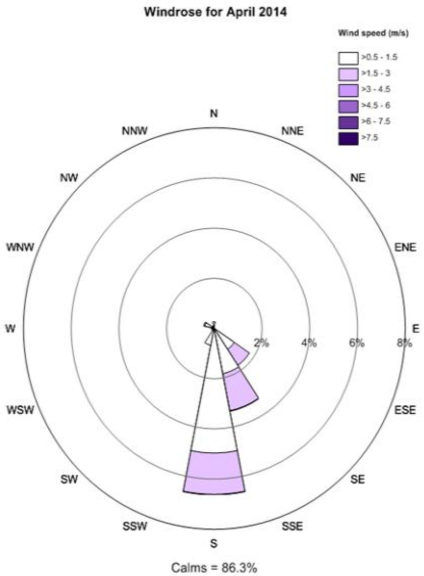
Solar radiation and UV index were recorded from September 2013. A summary of the UV index is presented in Figure 2-5. It can be seen that the highest UV exposure is during the summer months, with several days exceeding the “Extreme” classification. During winter, most days presented low to moderate UV exposure.

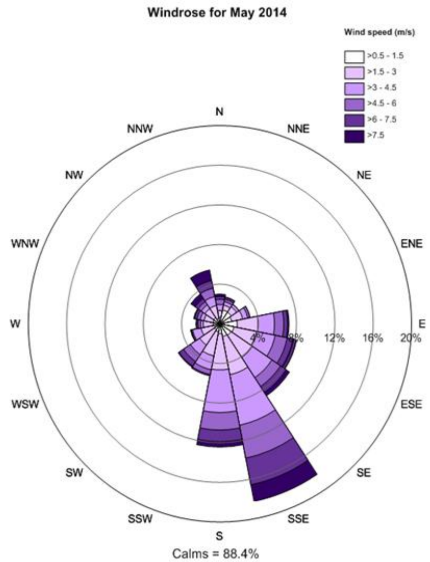
Average daily solar radiation is summarised in Figure 2-6. The trend in solar radiation follows the UV index, with highest levels experienced in summer.

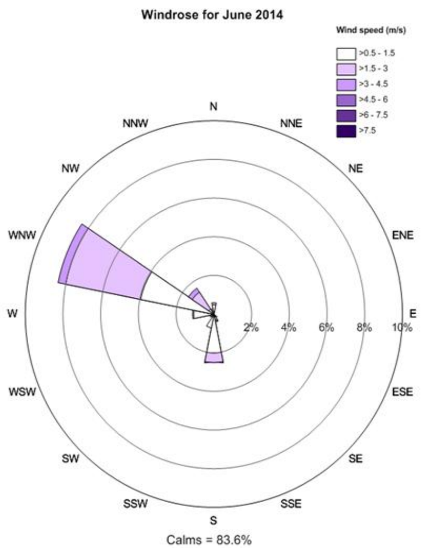
Figure 2-2 Monthly wind roses – September 2013 to August 2014

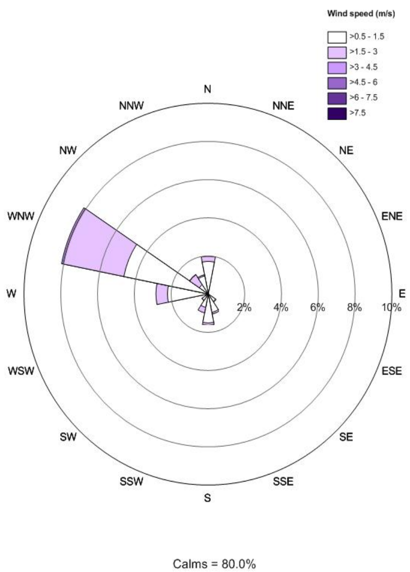



Windrose for March 2014
Wind speed (m/s)
>0.5 - 1.5
>1.5 - 3
>3 - 4.5
>4.5 - 6
>6 - 7.5
>7.5
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
2%
4%
6%
Calms = 84.8%


Windrose for April 2014
Wind speed (m/s)
>0.5 - 1.5
>1.5 - 3
>3 - 4.5
>4.5 - 6
>6 - 7.5
>7.5
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
2%
4%
6%
8%
Calms = 86.3%


Windrose for May 2014
Wind speed (m/s)
>0.5 - 1.5
>1.5 - 3
>3 - 4.5
>4.5 - 6
>6 - 7.5
>7.5
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
4%
8%
12%
16%
20%
Calms = 88.4%


Windrose for June 2014
Wind speed (m/s)
>0.5 - 1.5
>1.5 - 3
>3 - 4.5
>4.5 - 6
>6 - 7.5
>7.5
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
2%
4%
6%
8%
10%
Calms = 83.6%


Wind speed (m/s)
>0.5 - 1.5
>1.5 - 3
>3 - 4.5
>4.5 - 6
>6 - 7.5
>7.5
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
2%
4%
6%
8%
10%
Calms = 80.0%

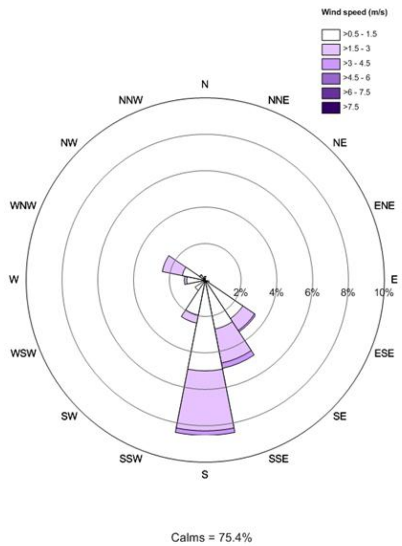

Wind speed (m/s)
>0.5 - 1.5
>1.5 - 3
>3 - 4.5
>4.5 - 6
>6 - 7.5
>7.5
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
2%
4%
6%
8%
10%
Calms = 75.4%

Figure 2-3 Summary of temperature data

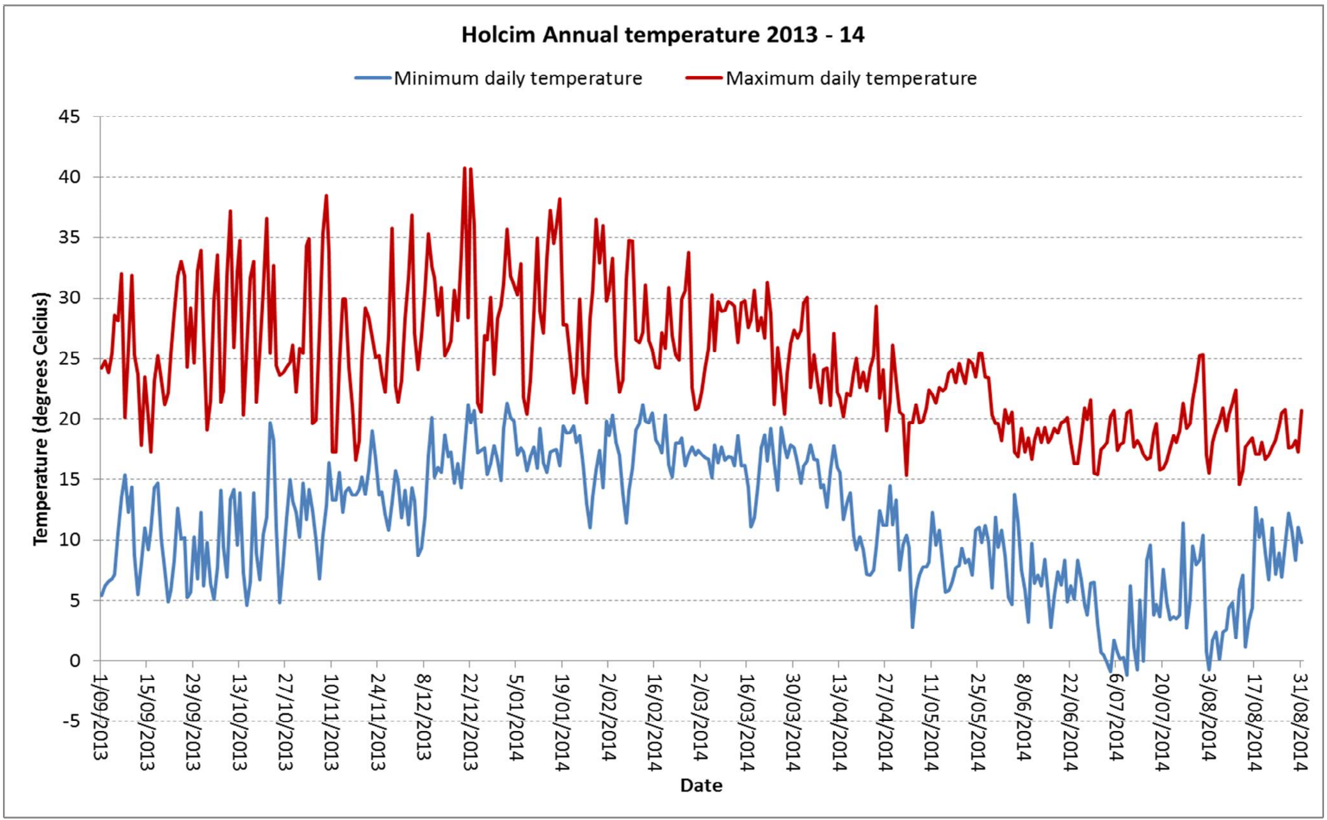


Figure 2-4 Daily rainfall

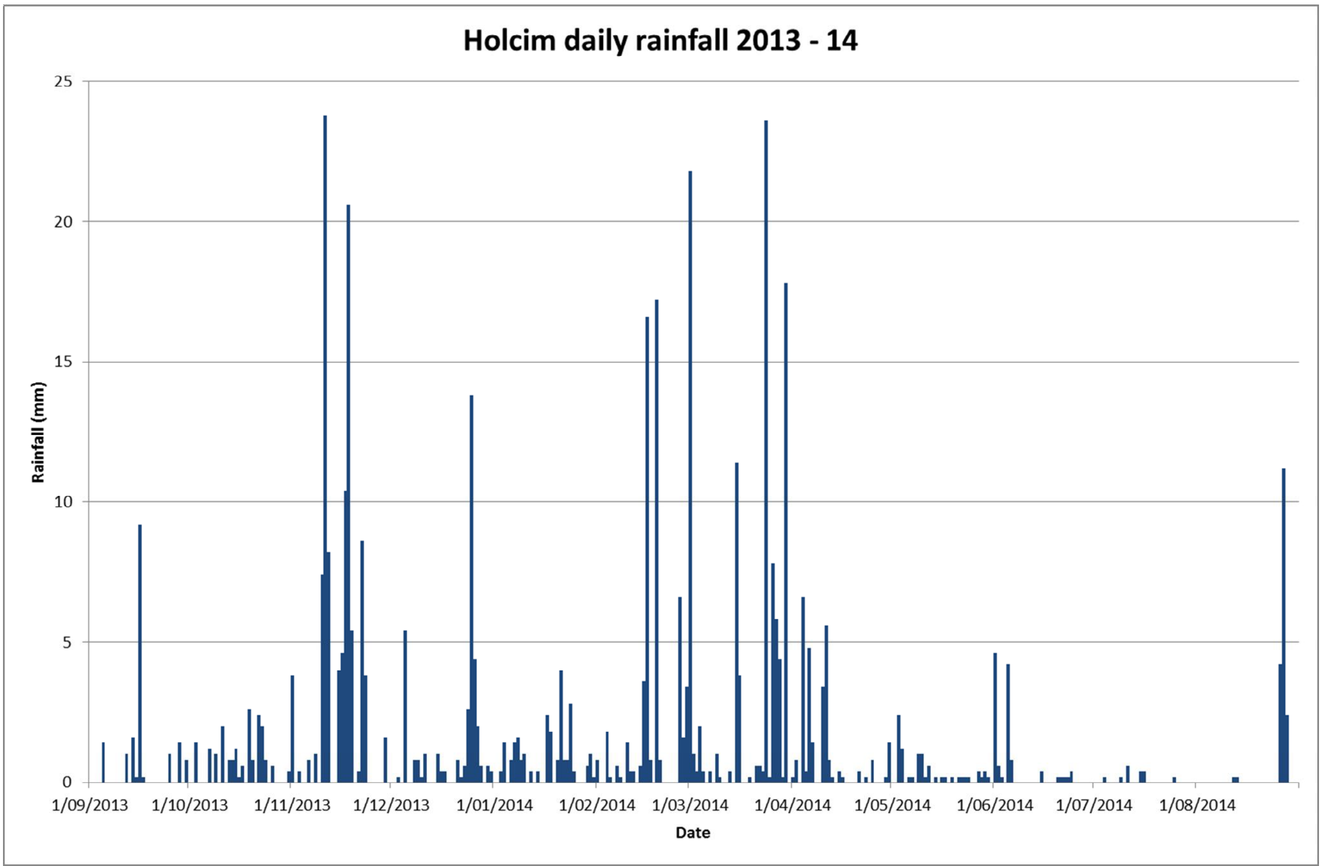


Figure 2-5 UV index

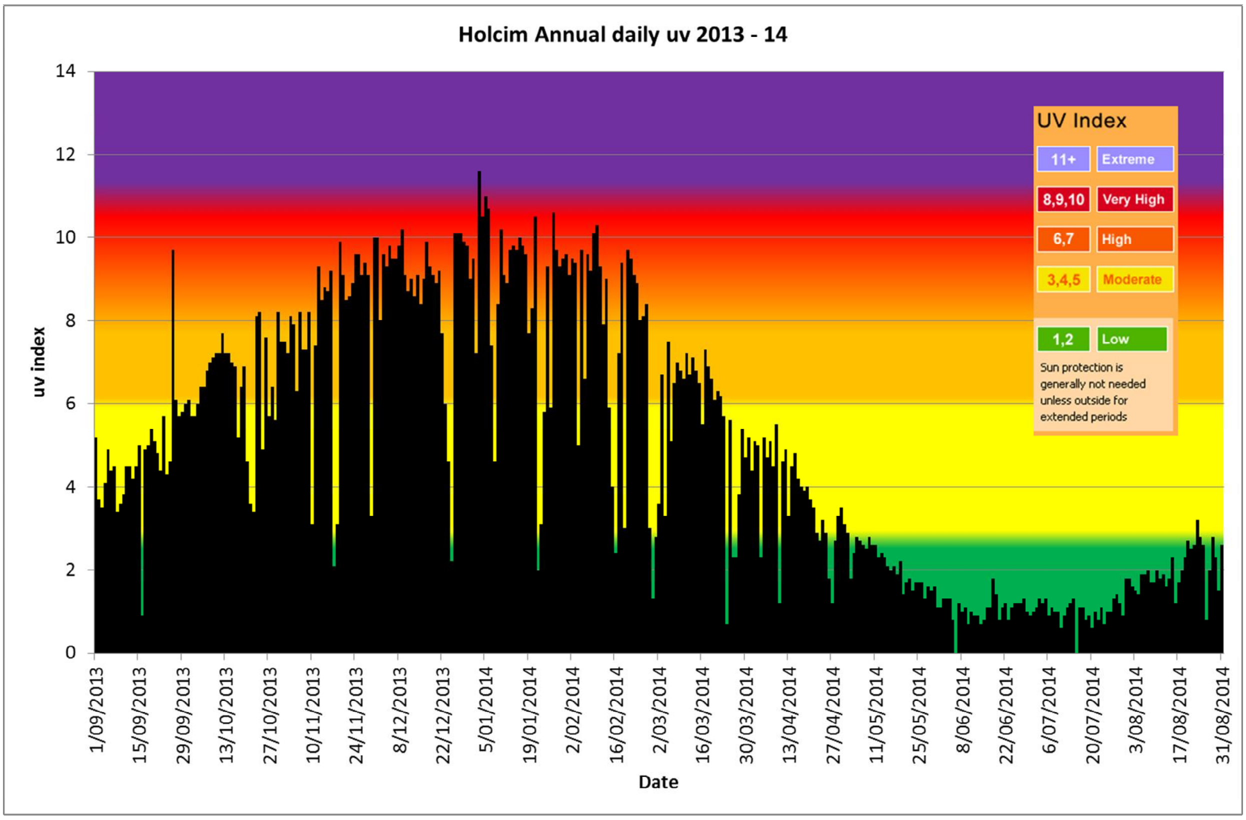
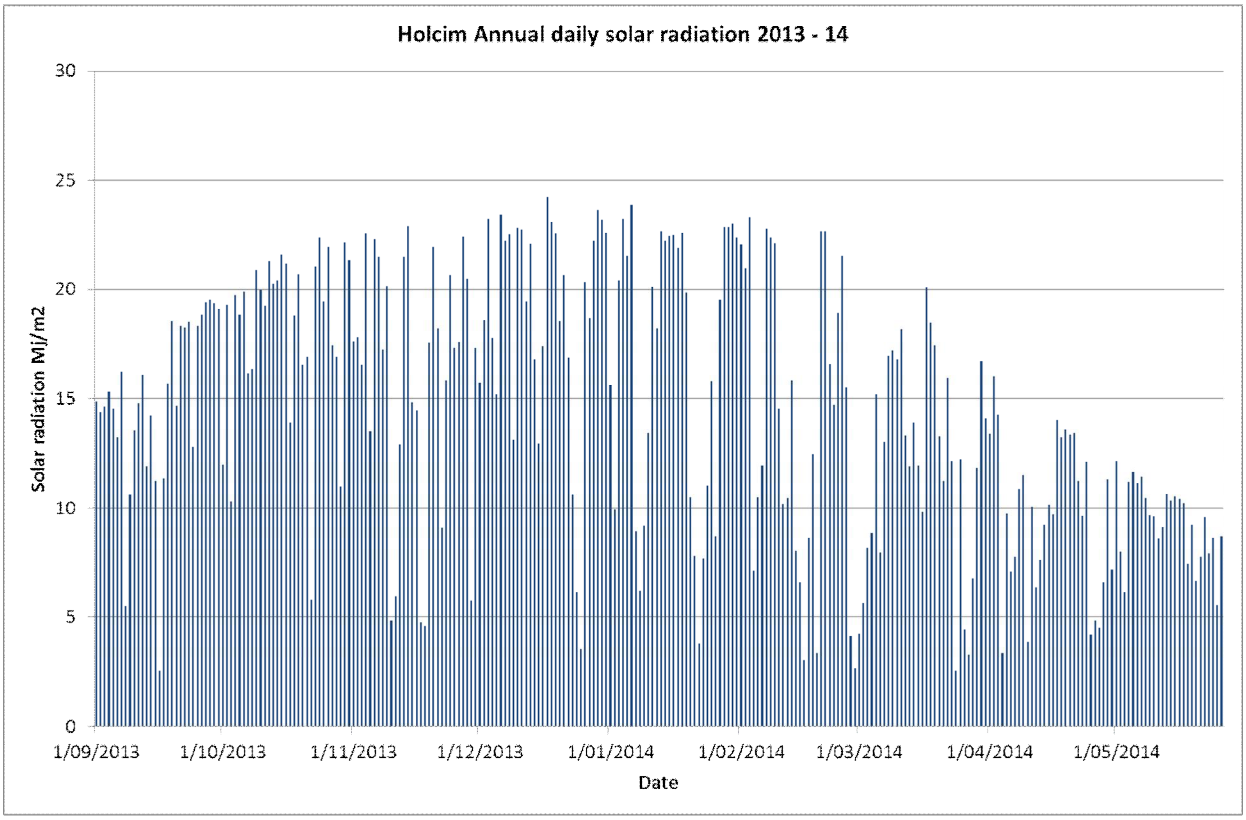


Figure 2-6 Solar radiation



3. Aquatic ecology

Summary

Fish and macroinvertebrate sampling results indicate that Angus and Eastern Creeks are impaired and representative of a degraded catchment influenced by mixed rural and urban landuses with low diversity of macroinvertebrates and fish species of only the most tolerant taxa.

Large numbers of the introduced species Gambusia were observed at all sites. Gambusia are hardier in degraded conditions compared to most native fish species.

Shallow, stagnant and muddy pools were observed at site AE6 following the commencement of construction. Historically there has been a consistent trend of decreasing biological impairment (measured through AUSRIVAS bands and OE50 scores) moving downstream from AE6 to AE4, with the best performing site being AE5 above the confluence with Angus Creek.

Water quality of Angus Creek shows no noticeable deterioration downstream of the Holcim Compound (AE1) and is not reflected by a change in the fish community or historical macroinvertebrate data. It would appear therefore that while there are significant localised land use disturbances, the Holcim site *per se* is not a major contributor to impaired macroinvertebrate and fish communities in these waterways.

3.1 Sampling methodology

3.1.1 Sampling locations

Aquatic ecology (fish and macroinvertebrate) sampling was conducted at six sites, four of which were located on Angus Creek and two on Eastern Creek (Figure 3-1). Table 3-1 provides a list of the sites, which are illustrated in Figure 3-1.

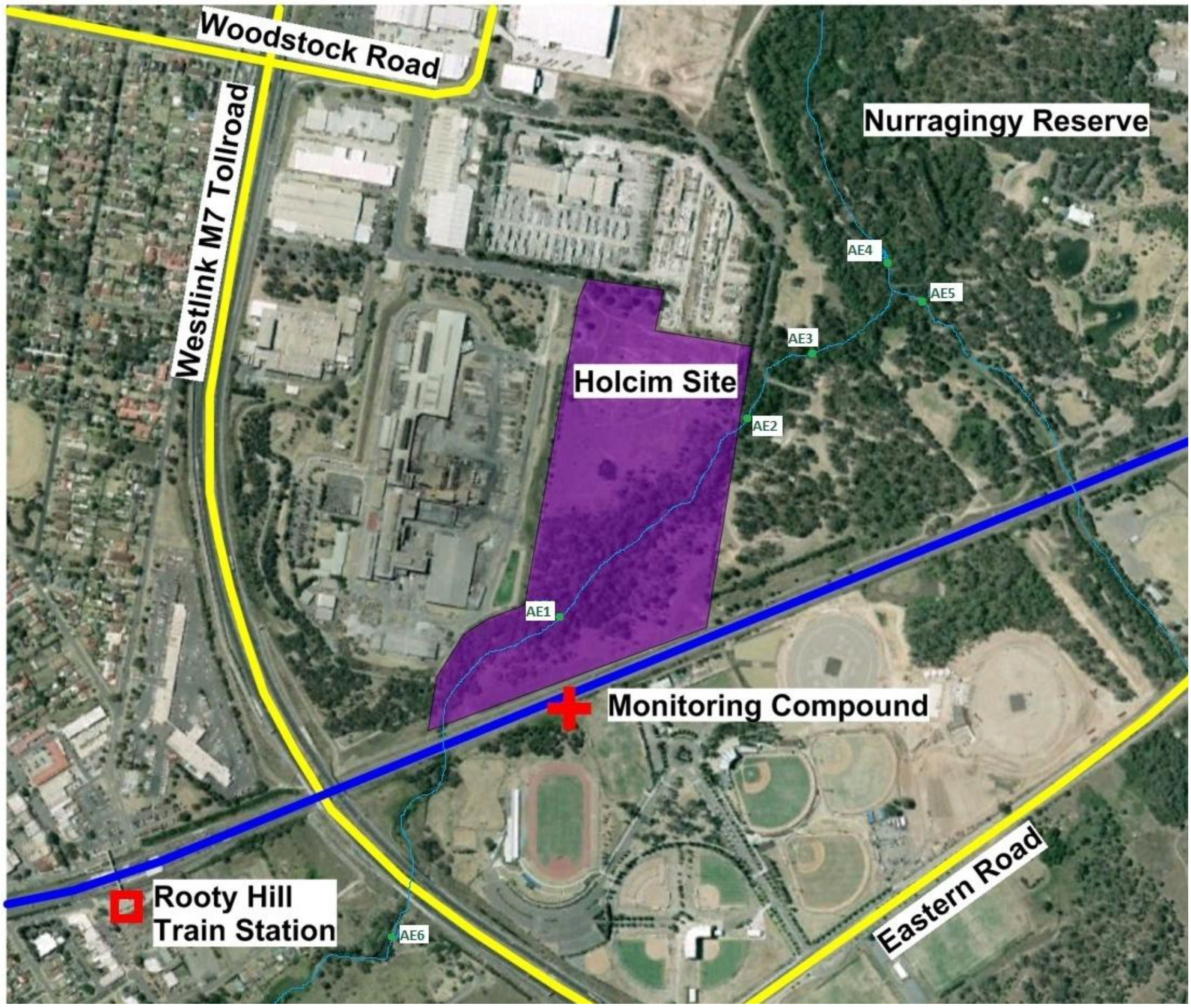
Table 3-1 Site Location

Site Code	Location	Easting	Northing
AE6	Angus Creek, 500m upstream RDC^	300836	6261037
AE1	Angus Creek at upstream boundary of RDC	301056	6261486
AE2	Angus Creek at downstream boundary of RDC	301349	6261811
AE3	Angus Creek 150m downstream of RDC culvert	301414	6261845
AE4	Eastern Creek downstream of Angus Creek confluence	301492	6261990
AE5	Eastern Creek upstream of Angus Creek confluence^	301580	6261910

^These sites will be adopted as control sites (MCoA 2.28A)

Jacobs ecologists are licensed to conduct field surveys under the National Parks and Wildlife Service Scientific Research Permit SL100044, Fisheries Permit P06/0066.4 and the Department of Primary Industries Animal Research Authority (09/1895).

Figure 3-1 Aquatic ecology monitoring locations



3.1.2 Macroinvertebrate

Macroinvertebrates were sampled at each of the six locations in accordance with the NSW AUSRIVAS protocol during Spring (15th September to 15th December) and Autumn (15th March to 15th June) sampling period. Chemical and physical variables (environmental data) were recorded at each site to be used as predictor variables in the AUSRIVAS model.

Aquatic macroinvertebrate sampling followed Rapid Bio-assessment (RBA) protocols, in accordance with the NSW AUSRIVAS Sampling and Processing Manual (Turak *et al* 2004). The AUSRIVAS program is a nationally recognised, standardised sampling protocol used to assess the health of Australian Rivers and developed for the Australia's National River Health Program (NRHP). This method is consistent with the recommended method in the Environmental Assessment Report (EAR) (Umwelt 2006) for monitoring macroinvertebrates.

The AUSRIVAS sampling site at each location was 100m in length. At each of the six locations macroinvertebrates were collected from edge habitats. Edge habitats are defined as the creek bank in areas of little or no flow, including alcoves and backwaters, with abundant leaf litter, fine sediment deposits, macrophyte beds and overhanging bank vegetation (Turak et al 2004). Edge samples were collected from 10m of representative edge sub-habitats using a 0.25mm mesh size kick net to dislodge macroinvertebrates, whilst noting physical habitat conditions of the sampled locations. Care was taken to ensure all sub-habitats within the site were represented within the sample.

Riffle habitats, areas of broken water with rapid current, were not sampled at any location due to a lack of suitable riffle habitat.

Macroinvertebrate samples were live-sorted in the field for a minimum of 40 minutes. If new taxa were collected between the 30 to 40 minute period, picking continued for an additional 10 minutes. If no new taxa were found after the additional 10 minutes, sorting stopped. The maximum sorting time was 60 minutes. All picked animals were preserved in ethanol and transferred to the laboratory for identification. Specific care was taken to ensure cryptic, fast moving or micro-crustacean taxa were represented.

3.1.3 Fish

Fish surveys were conducted at the six sites (AE1 - AE6) using passive fish sampling techniques. The variety of these sampling methodologies increases the probability of sampling a wider range of species and size classes. A description of the fish sampling methodologies is provided below.

Fyke nets were used to trap mobile, large bodied fish. Depending upon habitat availability between two to four fyke nets were set for a minimum of two hours. Large single-wing fyke nets with 4m leaders were set with the cod-end on one bank with the wing attached midstream. The cod-end of each fyke was always suspended out of the water to avoid the mortality of captured air breathing vertebrates.

Bait traps were used to trap mobile, small bodied fish. At each site, 10 bait traps (unbaited 45 × 25 × 25 cm traps) were set in shallow habitats for a minimum of two hours. Where possible, traps were set in stands of emergent vegetation, areas with submerged vegetation, or snag piles, as these areas are likely to have a greater diversity and abundance of small bodied fish.

Seine nets were not used due to the large abundance of woody snags throughout the channel, preventing the seine net from being pulled through the water. Backpack electrofishing was also not conducted due to the elevated conductivities within the study area and associated health hazards.

All fish captured were identified and measured to the nearest 1mm. Fork length were measured for fork-tailed species and total length for all other fish species. Before release each fish was examined on both sides for any injuries, diseases, parasites, or abnormalities. Eels can occur in large numbers at some sites and can be difficult to handle, so to minimise handling stress and the risk of injury to the eels they were netted and whilst in the net identified and examined. Eel lengths were estimated to the nearest 20mm. Any fish seen but not captured were identified and listed as an observed individual where possible.

Total fish abundance (number of individuals), richness (number of taxa) and the ratio of native to alien fish diversity were recorded and reported.

3.2 Data analysis

All macroinvertebrates were identified to the family level of taxonomic resolution, with the exception of Oligochaeta (class), Ostracoda (subclass), Acarina (order), Nematoda (Phylum) and Chironomidae (subfamily) as per the AUSRIVAS model requirements.

The total abundance (number of individuals collected), richness (number of taxonomic groups) and EPT richness were calculated for both seasons. EPT richness is the sum of the number of families from the orders Ephemeroptera, Plecoptera and Trichoptera. EPT families are typically sensitive to disturbance so their presence or absence can provide information about stream health. Values less than 1 indicate poor ecological conditions; values between 2 and 5 indicate moderate ecological conditions and anything greater indicate good ecological conditions.

The AUSRIVAS program uses mathematical models to compare observed macroinvertebrate taxa against a modelled reference condition. These comparisons provide a measure of biological impairment. Predictor variables (including physical habitat variables, latitude, longitude, altitude, slope and distance from source) are used to model the predicted reference condition for each sampling site. Latitude, longitude, altitude, slope and distance from source were determined from 1:25,000 topographic maps. Physical habitat variables were qualitatively assessed or directly measured at each site during the field surveys.

The AUSRIVAS model software outputs specify the 'Observed' (macroinvertebrates collected during sampling) and 'Expected Ratios' (macroinvertebrates which are predicted to occur in reference conditions). Both measures relate to macroinvertebrates that have a predicted probability greater than 50% of occurring at the site if it is in reference condition. The 'Observed' value is the number of these macroinvertebrate families that were actually collected at the site. Each observed family contributes a score of 1 to the 'Observed' value. The 'Expected' value is the sum of the probabilities for all taxa that are predicted to occur at that site with a probability greater than 50%. Families that have a 50% probability of occurring at the site contribute a score of 0.5 to the 'Expected' value, while families that have a 90% probability of occurrence contribute a score of 0.9. An Observed to Expected ratio (O/E50 score) close to 1 indicates that the macroinvertebrate fauna are similar to those of the modelled reference condition. A ratio close to zero, indicates severe impairment compared to reference condition. Based upon these O/E50 scores, a band ranking indicating the ecological health of the river can be assigned (Table 3-2).

Table 3-2 AUSRIVAS OE50 upper limits and associated band categories

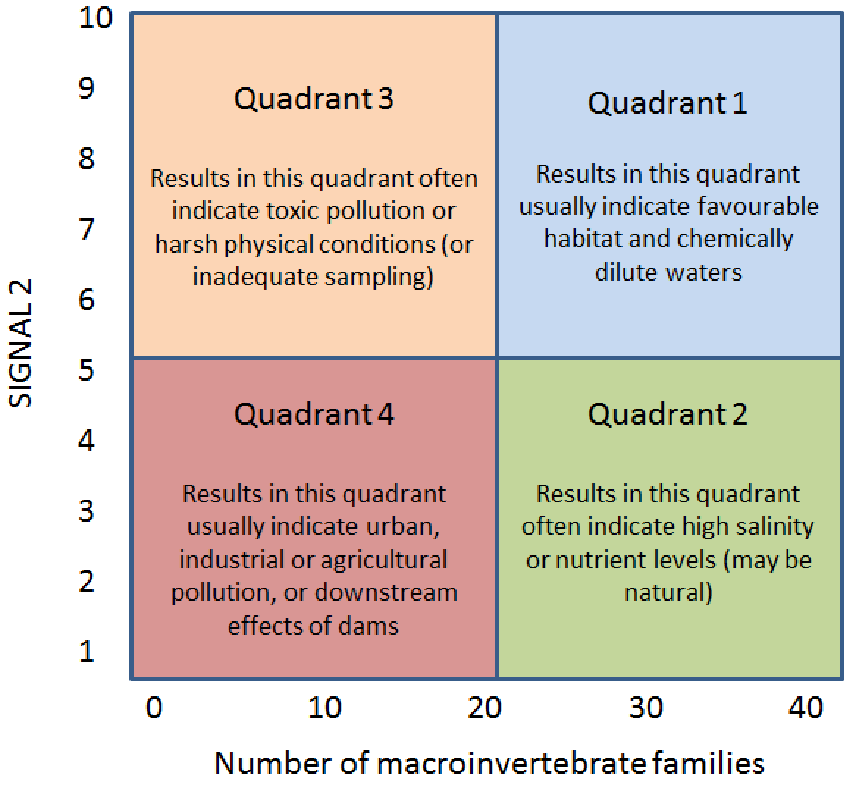
OE50 upper limit (Autumn)	OE50 upper limit (Spring)	Band		Interpretation
-	-	X	More biologically diverse than reference sites	Possible organic enrichment or a biodiversity hotspot as more taxa occur compared to reference site
1.17	1.16	A	Reference condition	Families collected are the same or similar to reference sites
0.81	0.83	B	Significantly impaired	Some taxa missing, possibly from impacts to water quality or habitat
0.46	0.51	C	Severely impaired	Several taxa missing. Impacts to water quality and/or habitat are more severe
0.11	0.19	D	Extremely impaired	Few of the taxa expected at reference sites were collected. Water quality and habitat are poor and highly degraded

SIGNAL (Stream Invertebrate Grade Number - Average Level) scoring gives an indication of water quality of the water body from which a sample was collected. High SIGNAL scores are likely to be of low salinity, turbidity and nutrients such as phosphorous and nitrogen and high in dissolved oxygen.

SIGNAL scores for each site were calculated using the method outlined in Chessman (2004), based on the sensitivity grades of the macroinvertebrates collected, scaled from 1 to 10, where 1 are taxa very tolerant to pollution and 10 are very sensitive. These scores are weighted by the abundance of the taxa collected and provides and overall indication of site impairment. Sites where sensitive taxa are present are less likely to have been affected by disturbance.

Signal scores were plotted against the number of taxa collected (richness). The biplot is divided into four quadrants (see Figure 3-2), and where the data point falls is indicative of the type of disturbance. The lines of division on the biplot are adjustable and are determined based on knowledge of the sites and reference conditions.

Figure 3-2 Signal 2 versus richness biplot (Chessman 2004).



3.3 Results

3.3.1 Macroinvertebrates

Macroinvertebrate assemblages suggest biological impairment at all sites, including reference (AE6 Angus Creek upstream of RDC and AE5 Eastern Creek, upstream of the confluence with Angus Creek) and impact sites. Although seasonal differences existed between Spring and Autumn, overall macroinvertebrate diversity was low and mostly consisted of taxa more tolerant to changing environmental conditions (Table 3-3).

Generally taxa richness and SIGNAL scores were higher in Spring indicating more taxa with higher sensitivities to pollutants were collected. During both seasons, taxa richness and total abundance was greatest at AE1 with 91 individuals collected in Spring and 122 in Autumn.

The presence of families from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) were very low. These are sensitive taxa which are a good indicator of impairment when missing.

In Spring, EPT taxa were only observed within Eastern Creek, with only one family at sites AE4 & AE5, whilst in autumn, one family was collected at AE4 and two families were collected at AE5.

Table 3-3 Summary of macroinvertebrate results, spring 2013 and autumn 2014

Site	Spring 2013						Autumn 2014					
	Richness	Abundance	EPT	% Tolerant (≤4)	SIGNAL	AUSRIVAS band	Richness	Abundance	EPT	% Tolerant (≤4)	SIGNAL	AUSRIVAS band
AE6	10	366	0	93.7	2.6	D	19	122	0	84.8	2.09	C
AE1	12	238	0	88.5	3.03	C	14	112	0	95.3	2.17	C
AE2	10	174	0	93.6	3.41	C	20	254	0	89.4	2.24	C
AE3	18	485	0	91.7	3.06	C	20	283	2	77.1	2.29	C
AE4	8	24	1	88.9	2.6	D	21	96	2	72.7	2.89	C
AE5	16	54	0	97.5	2.28	C	21	139	0	95.9	2.48	B

Site SIGNAL scores indicated that all sites contained taxa tolerant and moderately tolerant to a range of environmental conditions (Table 3-3). The number of taxa in each SIGNAL grade contributing to overall site SIGNAL scores are displayed Figure 3-3.

The stacked bars represent the number of taxa which contribute to each SIGNAL score grade, where red bars represent the more tolerant species and yellow and green bars represent the more sensitive species. Sites are listed in order from upstream (AE6) on Angus Creek to downstream. Sites AE4 and AE5 are downstream on Eastern Creek.

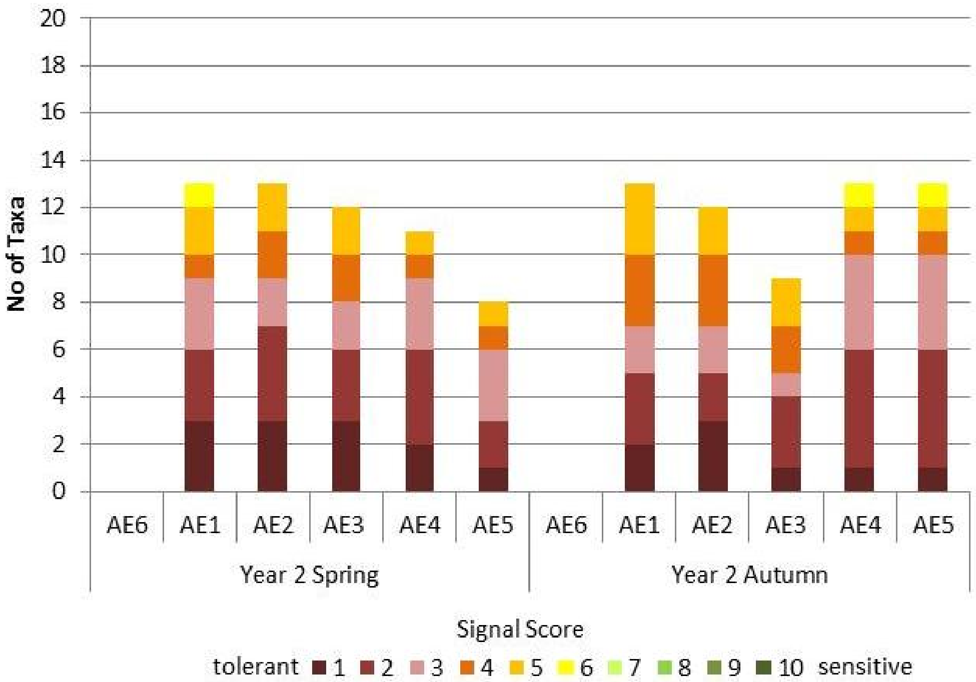
A large proportion of taxa were tolerant and moderately tolerant, from SIGNAL grades 1, 2 and 3. Generally over 70% of taxa were from the SIGNAL grades 4 and below. Taxa sensitive to most forms of pollution or disturbance were not found at any of the sites in either season.

AUSRIVAS OE50 scores (and resulting Bands) also indicated that sites were severely (band C) or extremely (band D) impaired (Table 3-3), except AE5 which was significantly impaired (band B) in Autumn.

Several taxa expected to occur at the sites under reference conditions were absent. The most notable, and with ~90% chance of being collected, were the caddisfly Leptoceridae (only collected during Autumn at AE4 and AE5), the Gerridae (not collected), the mayfly Leptophlebiidae (not collected) and the mite Acarina (collected at AE1 during Spring).

The absence of Leptophlebiidae may be explained by its sensitivity to changing environmental conditions (SIGNAL grade 8). However other absent taxa were moderately tolerant (SIGNAL grades 3-6). Different macroinvertebrates are sensitive to certain types of disturbances which may explain their absence despite taxa with similar SIGNAL scores being present.

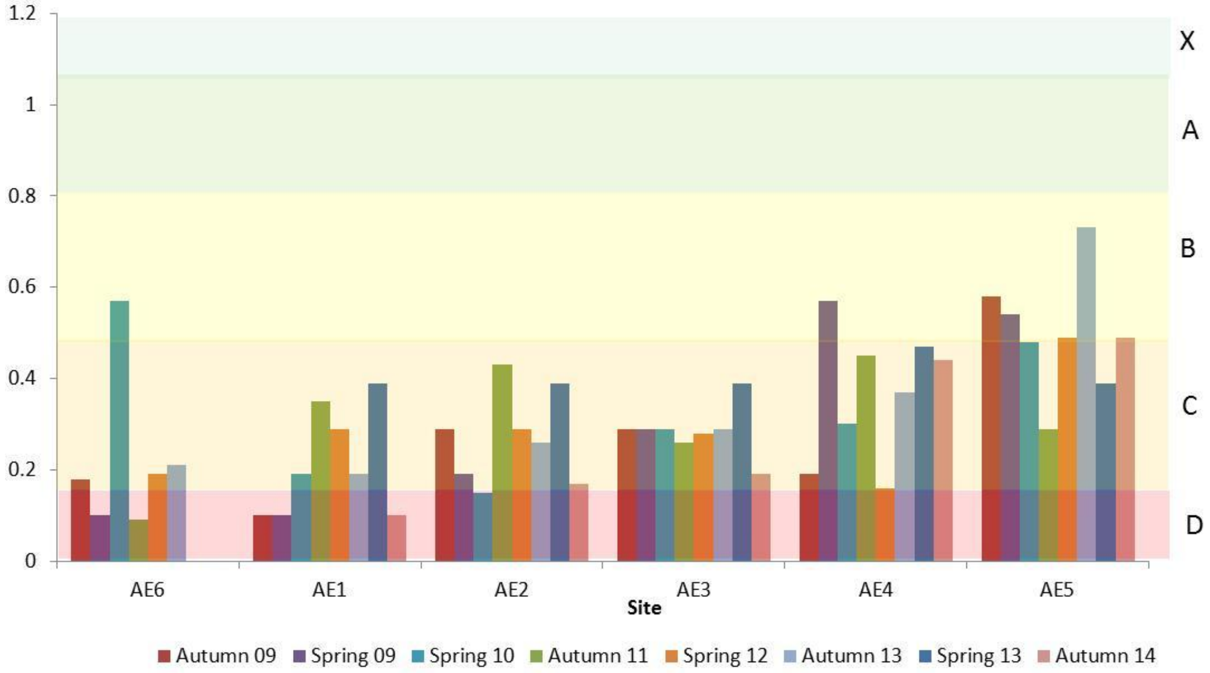
Figure 3-3 Contribution of macroinvertebrate taxa to SIGNAL scores (2013-14).



AUSRIVAS OE50 scores and the associated condition bands from 2009 to 2014 (Figure 3-4) indicate an overall increasing trend in AUSRIVAS OE50 scores from the upstream (AE6) reference site downstream along Angus Creek (AE1, AE2 and AE3 respectively) and to Eastern Creek (AE4 and AE5). Site AE4 is downstream of the confluence with Angus creek while AE5 is upstream of the confluence

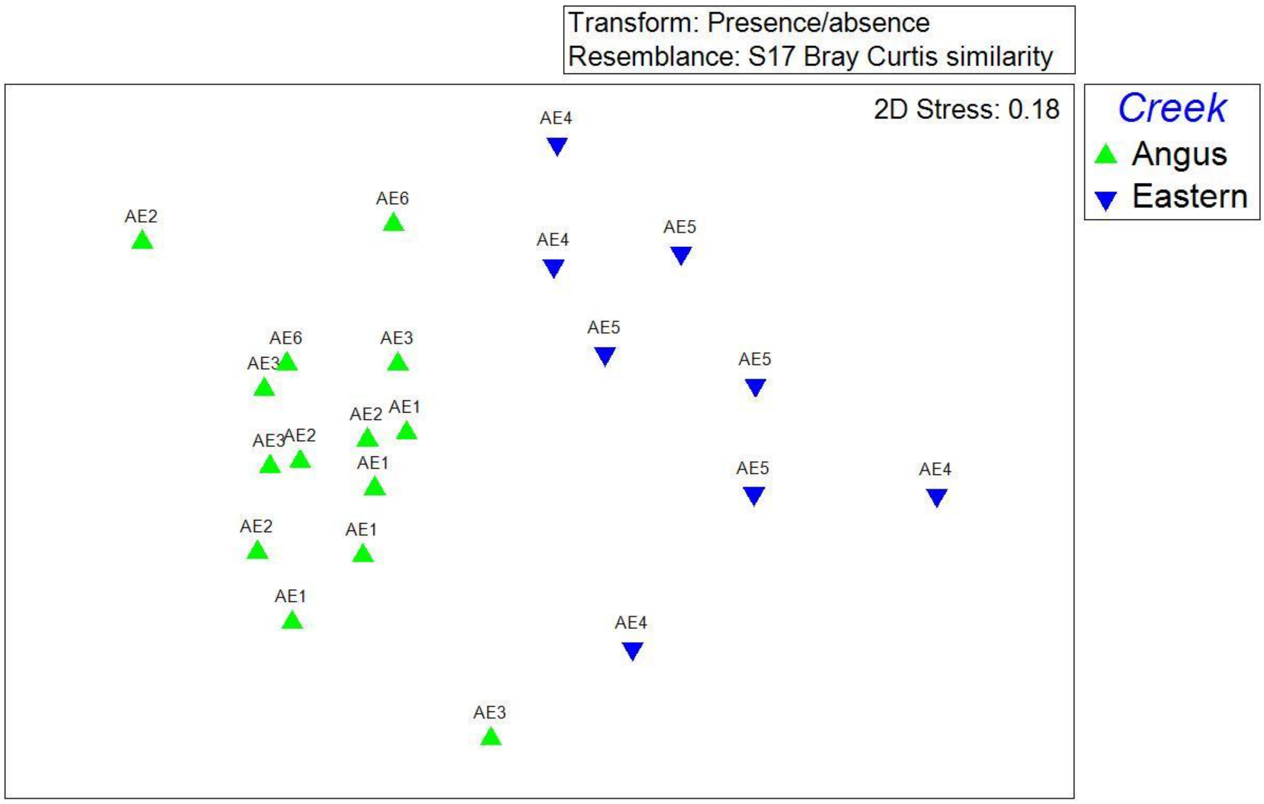
The data suggests that the inflow from Angus Creek may be reducing water quality at site AE4 although localised disturbance at this site as shown by the water quality data cannot be ruled out. Inter-seasonal variability is also quite high, with some sites fluctuating between AUSRIVAS bands D and B (e.g. Site AE6). The best performing site is AE5 on Eastern Creek, which displayed its highest AUSRIVAS band of all sites (band B) in Autumn 2013.

Figure 3-4 AUSRIVAS bands (Autumn 2009 – Autumn 2014)



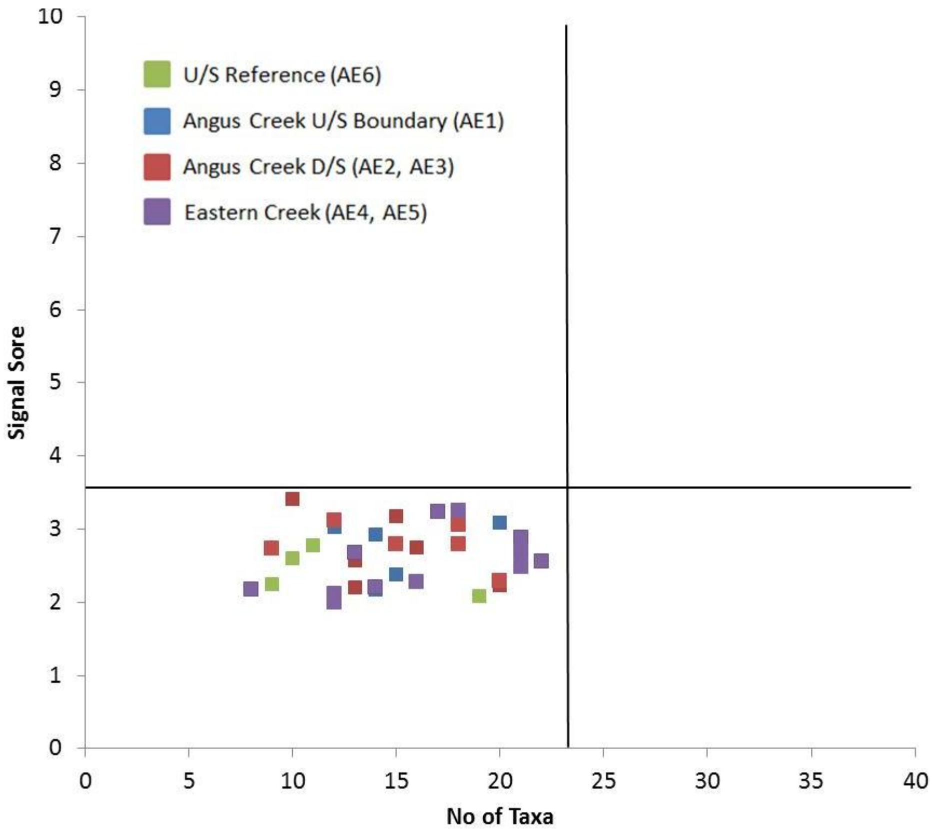
An MDS plot, where sites closest to each other are most similar, is displayed in Figure 3-5. The results intricate the macroinvertebrates communities within Eastern Creek (AE4 and AE5) are generally different to the sites on Angus Creek (AE1, AE2, AE3, AE6) throughout all years and seasons.

Figure 3-5 Nonmetric multidimensional scaling plot of macroinvertebrate sites in Year 1 and Two Spring and Autumn



The 2013-14 macroinvertebrate SIGNAL scores were compared to the available data from 2009. A bi-plot of site SIGNAL scores against the number of taxa (richness) was used to identify any temporal changes in the sites (Figure 3-6). No consistent pattern emerged between sites and season. SIGNAL scores were relatively consistent across all sites and were indicative of sites impacted by urban or industrial pollution (Chessman 2004).

Figure 3-6 Biplot of macroinvertebrate sites over four sampling seasons from 2009 and 2013-14.



Note: Reference sites (AE6: orange and AE5:light blue) did not plot differently to other sites.

3.4 Fish ecology

Six fish taxa (and one turtle) were collected within the study area. Diversity in 2012-13 was greater than the current sampling period, with seven taxa observed (Table 3-4), whilst only three taxa (Gambusia, Short-finned eel & long-finned eel) were observed across both seasons. 2012-13 total abundance (>134 individuals) was also significantly higher than 2013-14 (36 individuals).

During both years the study area was dominated by the invasive species Gambusia (*Gambusia holbrooki)* which was observed at least once at every site, however a much greater abundance of Gambusia was observed in 2012-13 (>128 individuals) compared to 2013-14 (33 individuals). The ratio of native to alien species was 1:21 in 2012-13 and 1:11 in 2013-14. A large number of juvenile Gambusia (<30mm) were collected suggesting on-going recruitment in both Angus and Eastern Creeks. The high number of Gambusia and the low diversity is indicative of a degraded waterway.

In 2013-14, the only native fish species observed were two Short-finned Eels and one Long-finned eel. Both species are classified as tolerant of degraded water quality and low oxygen and are able to survive out of water for long periods by absorbing oxygen from the atmosphere through the skin or by gulping air (Harris & Gerke 1997[1]).

Table 3-4 Fish survey data (spring and autumn combined)

Common Name	Scientific Name	AE1	AE2	AE3	AE4	AE5	AE6
2012-13							
Australian Bass	*Macquaria novemaculeata*					1	
Eastern long-necked turtle	*Chelodina longicollis*						1
Flathead gudgeon	*Philypnodon grandiceps*				1		
Gambusia	*Gambusia holbrooki*	7	14	12	>44	5	46
Long Finned Eel	*Anguilla reinhardtii*						
Short-finned eel	*Anguilla australis*	1					
Striped gudgeon	*Gobiomorphus australis*	1				1	
2013-14							
Australian Bass	*Macquaria novemaculeata*						
Eastern long-necked turtle	*Chelodina longicollis*						
Flathead gudgeon	*Philypnodon grandiceps*						
Gambusia	*Gambusia holbrooki*	22	2	9			
Long Finned Eel	*Anguilla reinhardtii*				1		
Short-finned eel	*Anguilla australis*	1	1				
Striped gudgeon	*Gobiomorphus australis*						

[1] Harris, JH & Gerke, PC (eds.) (1997). *Fish and rivers in stress—The NSW rivers survey.* NSW Fisheries Office of Conservation and the Cooperative Research Centre for Freshwater Ecology: Cronulla and Canberra. 298 pp.

4. Terrestrial ecology

Summary

Quarterly monitoring has been successful in identifying trends in ecological health of natural site values at the Rooty Hill RDC site and off-site reference points in the 2013 to 2014 monitoring period. Ecological condition has remained consistent for both riparian and woodland sites and there has been substantial population growth in the southern grevillea population. In all instances, the Rooty Hill RDC monitoring locations have maintained their ecological value from the baseline survey period (spring 2012 – pre-construction) throughout the construction period which commenced in summer 2012 and continues to the current time. These values generally exceed the conditions of adjacent reference monitoring sites.

4.1 Overview

Terrestrial ecology was monitored on a quarterly basis between Spring 2013 and Winter 2014. The report provides an assessment of the trends in condition of ecological variables required to determine whether the project is having an impact on the natural environmental values at the site.

This includes monitoring of two populations of threatened Juniper-leaved Grevillea (Grevillea juniperina subsp. Juniperina), as well as value and condition assessments for riparian environments (listed as River-flat Eucalypt Forest endangered ecological community under NSW threatened species legislation) and the commonwealth and state listed Cumberland Plain Woodland critically endangered/endangered ecological community.

It also includes an assessment of the integrity of the riparian channel of Angus Creek, and monitoring of a number of reference sites in proximity to the Rooty Hill RDC site to confirm whether trends in condition are as a result of site development or natural stochastic events.

4.2 Monitoring timing and locations

Table 4-1 identifies the dates monitoring was undertaken at the Rooty Hill RDC site. Monitoring locations are illustrated in Figure 4-1.

Table 4-1 Monitoring dates between Spring 2013 and Winter 2014

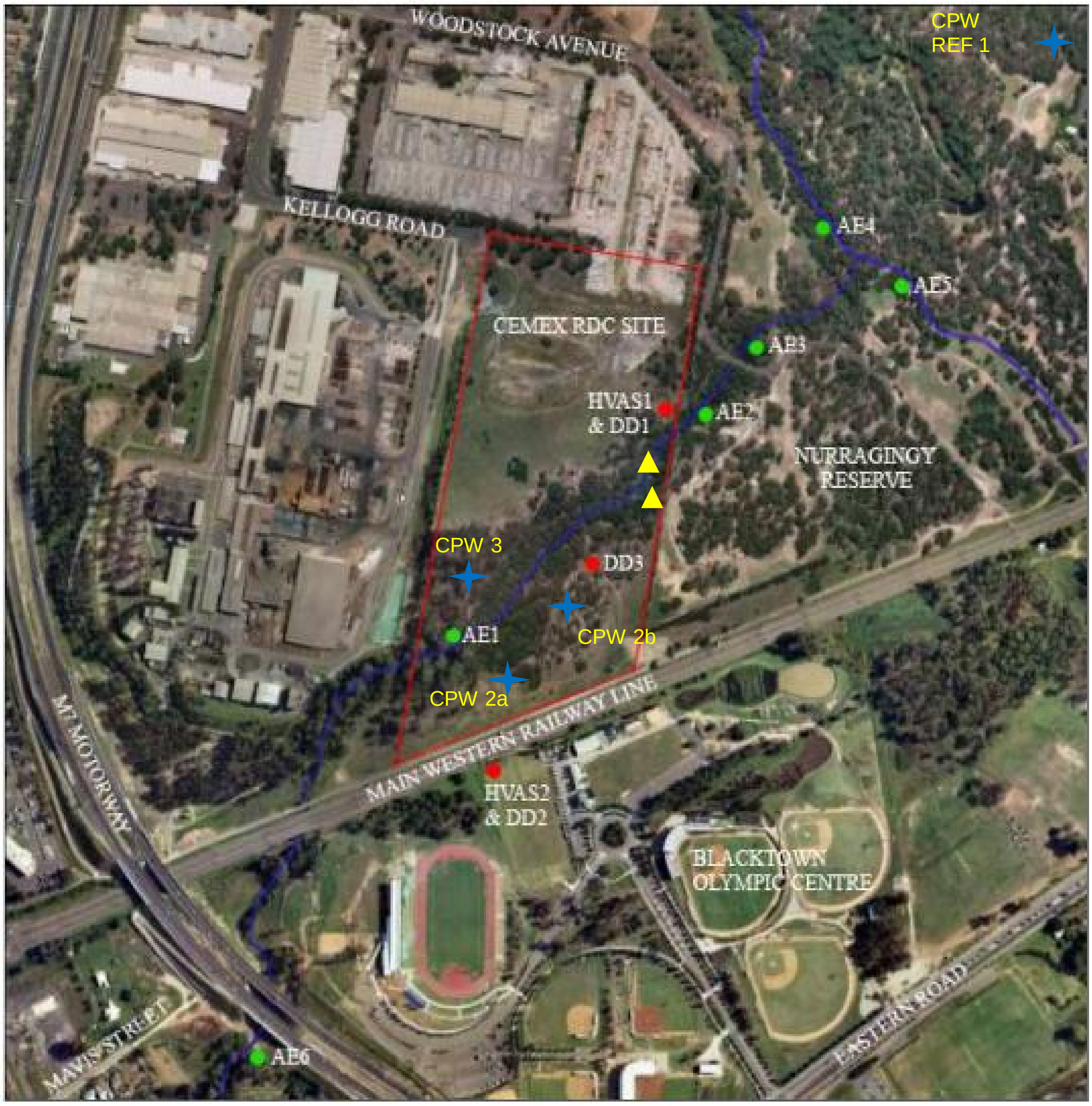
Season	Monitoring date
Spring 2013	11-12 November 2013
Summer 2014	11-12 February 2014
Autumn 2014	20-21 May 2014
Winter 2014	25-26 August 2014

Monitoring locations included the following, which are illustrated in Figure 4-1.

- AE1 - Angus Creek at upstream boundary of Rooty Hill RDC (Holcim site)
- AE2 - Angus Creek at downstream boundary of Rooty Hill RDC (Nurragingy Reserve)
- AE3 - Angus Creek 150 m downstream of Rooty Hill RDC culvert (Nurragingy Reserve)
- AE4 - Eastern Creek downstream of Angus Creek confluence (Nurragingy Reserve)
- AE5 - Eastern Creek upstream of Angus Creek confluence^ (Nurragingy Reserve)
- AE6 - Angus Creek, 500 m upstream Rooty Hill RDC^

(^These sites will be adopted as control sites.)

Figure 4-1 Monitoring locations



Legend:

- Juniper-leaved Grevillea populations - North and South of Angus Creek
- Riparian health assessment - AE1 to AE6
- Cumberland Plain Woodland CEEC- Rooty Hill RDC site and Nurragingy Nature Reserve (CPW 2a, CPW 2b, CPW 3, CPW Ref)

4.3 Monitoring methodology

4.3.1 Juniper-leaved Grevillea

Across the RDC, the Juniper-leaved Grevillea has been recorded in very small densities at two locations either side of Angus Creek. In 2005, Biosis recorded fewer than 4 mature individuals in total across the site, with several additional juveniles successfully recruiting in the location north of Angus Creek.

Pre-construction counts of the species, provide baseline information for the quarterly monitoring required in the Vegetation Management Plan (VMP). The intention of quarterly monitoring is to monitor the health of individuals of the grevillea to ensure works across the site are not having a negative impact on the population.

Once bushland regeneration works commence at the site, quarterly monitoring will also report on the active management of the species. Absolute counts of individuals of the species were undertaken at sites quarterly, as well as an assessment of growth rates, records of vigour, photopoint monitoring and a fixed quadrat assessment of groundcover diversity and abundance.

4.3.2 Riparian health assessment

Riparian health and condition monitoring was conducted at the six established monitoring sites quarterly during dry weather (refer Figure 4-1).

4.3.3 Riparian site value assessments – NSW Biobanking framework

The monitoring program includes assessments for general riparian health and condition using the NSW Biometric vegetation condition as a benchmark and the Biobanking methodology to record condition. These benchmarks are specified for a suite of vegetation and fauna habitat condition variables for each Biometric vegetation type and can be readily used to assess the current and predicted condition of native vegetation.

The riparian environments across the six sampling sites were characteristic of River-flat Eucalypt Forest (RFEF) being a Threatened Ecological Community (TEC) listed as Endangered under the NSW Threatened Species Conservation Act 1995. A Site Value assessment under the NSW Biobanking framework (DECC 2009) was undertaken for each sampling site to quantify the overall condition of the vegetation against established benchmarks for the Biometric vegetation types present in the study area. Survey effort (that is, the number of sites monitored) and monitoring method followed the NSW Biobanking Assessment Methodology (DECC 2009).

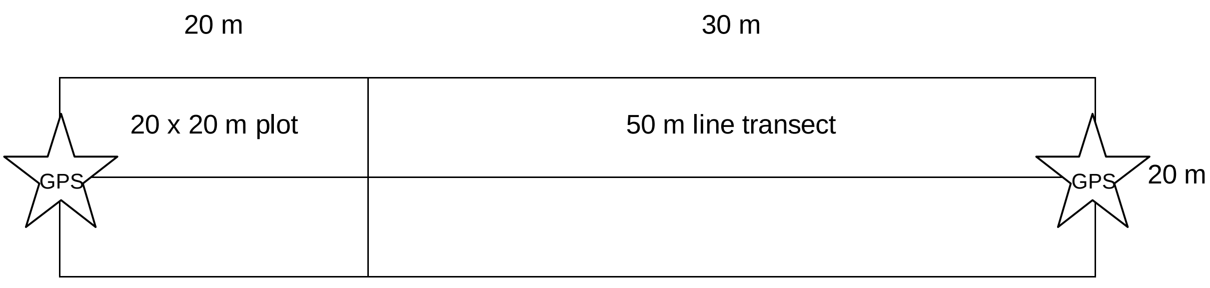
The intention of monitoring these sites prior to construction was to develop a baseline of vegetation condition, from which ongoing monitoring could determine whether the project is having an impact upon the vegetation communities present. The program also includes surveys to monitor change in reference sites of similar vegetation condition situated in close proximity to the property but not subjected to potential impacts from the project. For example, if the study area is subject to a natural event which results in a decline in vegetation condition (such as wildfire, flooding or psyllid infestation), reference sites may also be influenced by this event, demonstrating that any decline in condition is a result of natural events rather than as a result of the project.

The following parameters were recorded at the six sampling sites:

- Native plant species richness
- Native over-storey cover
- Native mid-storey cover
- Native ground cover
- Number of trees with hollows
- Total length of fallen logs
- Exotic plant cover
- Over-storey regeneration

The site value assessment was recorded on BioBanking field data sheets using the recommended BioBanking plot layout which consists of a 20 x 20 m plot (0.04 ha) and a 50 m line transect (Figure 4-2.) Native canopy and mid-storey cover were visually estimated at 10 points along the 50 m line transect and divided by 10 to provide an estimated project foliage cover for the plot. The projected foliage cover (%) of ground covers (native grasses, shrubs, other and exotic species), was calculated by recording their presence/absence at 50 points along the 50 m line transect and dividing the total number of hits by 50.

Figure 4-2 Transect / plot layout



The plot data for each site attribute was compared against the relevant benchmark for the vegetation type, scored and then ranked using the matrix in Seidel and Briggs (2008). The final score for each vegetation plot was then assigned an arbitrary condition rating based on this assessment:

- low = 0 to 16
- low-moderate = 17 to 33
- moderate = 34 to 50
- moderate-high = 51 to 67
- high = 68 to 84
- very high = 85 to 100

Trends in site value for each of the sites AE1 to AE6 across the four seasons is presented in Section 4.4.3.

4.3.4 Riparian Channel and Environmental Inventory

The Riparian, Channel and Environmental (RCE) Inventory was developed to provide a consistent framework for assessing biophysical conditions of small streams in modified agricultural landscapes (Petersen and Robert, 1992). It uses rapid assessment parameters to characterise biological structure and function of streams in order to provide a relative value of stream health against established indicators. At each of the six sites in the monitoring program and 50 m upstream and downstream of the site the following parameters were recorded within the stream channel and riparian zone:

- Land-use pattern beyond immediate riparian zone
- Completeness of riparian zone
- Width of riparian zone from stream edge to field
- Aquatic vegetation
- Stream-bank structure
- Riffles and pools or meanders
- Stony substrate; feel and appearance
- Stream bottom
- Retention devices
- Detritus
- Channel sediments
- Bank undercutting
- Channel structure

Vegetation of riparian zone within 10m of channel RCE scores range from 16-36 and are divided into the following categories:

- 4-21 Poor
- 22-38 Fair
- 39-56 Good
- 57-73 Very Good
- 74-90 Excellent

4.3.5 Cumberland Plain Woodland Critically Endangered Ecological Community

Cumberland Plain Woodland (CPW) was monitored as a baseline assessment (pre-Stage 2 construction) of the three zones (or conditions) of the woodland on the Rooty Hill RDC site and an assessment of one external reference CPW site in close proximity to the site (refer Figure 4-1**)**. The field methodology aligns with current industry best practice for describing vegetation condition in relation to biodiversity offsets. This methodology will provide a useful baseline upon which to describe improvements resulting from bushland regeneration efforts that are required at the site as part of the conditions of approval for the project as well as identifying any condition changes as a result of the project.

A site value assessment using the NSW Biobanking framework was undertaken in the woodland at each of the four sites to describe the overall condition of the vegetation against formally established benchmarks for CPW. This methodology follows that described in Section 4.2 for the riparian assessment. These sites are being monitored prior to significant construction works to develop a baseline of condition to demonstrate whether the project is having an impact upon the woodland. The use of control sites on adjacent properties not subject to the potential impacts of the project will assist in determining whether any trend in vegetation condition decline is attributable to the project or natural environmental events. This is particularly important as current infestations of the lace lerp have resulted in the defoliation of Grey Box (*Eucalyptus moluccana*) across the region, although without including a control site in the monitoring program, this defoliation may have been incorrectly attributed to project impacts. Applying the site value assessment of the NSW Biobanking framework will achieve repeatable, comparable monitoring assessments which will provide a valuable framework for determining improvements in vegetation condition once bushland regeneration takes place at the site.

4.4 Results

4.4.1 General condition

Climatic conditions contributed to decreases in vegetation condition at both reference and control sites as a result of low rainfall, which was less than the historic monthly average in all months but November 2013 and August 2014 when total monthly rainfall reached historical highs and caused localised flooding, also temporarily reducing riparian condition.

The physiological stress related to low water availability was evident at Cumberland Plain Woodland sites at the RDC in spring 2013 and summer 2013-14 monitoring rounds, with the regenerative potential of overstorey species declining and sub-adult Eucalyptus amplifolia individuals variously suffering branch dieback or complete senescence at some monitoring locations.

Native Blady Grass (Imperata cylindrica) and Lomandra (Lomandra longifolia), usually robust in places were observed to have completely browned off in the spring 2013 and summer 2013-14 monitoring rounds, and Broad-leaf privet, a weedy shrub that is present at many monitoring sites, suffered substantial leaf-drop.

Evidence of eucalypts previously suffering from psyllid defoliation continued to show signs of rehabilitation via coppicing at Cumberland Plain Woodland monitoring sites. Despite these stressors, seasonal site scores generally remained consistent with sites trending toward recovery as early as the summer 2014 monitoring round. Overall site values for both riparian environments and Cumberland Plain Woodland ecosystems remained stable over the year.

The northern grevillea population also appears relatively stable despite the senescence of mature individuals at the site, with vigorous growth of juveniles in the population and a reasonable proliferation of seedlings this year. The southern grevillea population has been slow to recover from the wildfire in January 2013 which resulted in the death of all individuals at the site. However, in winter 2014 when grasses and other groundcovers were sparse, the number of seedlings observed had doubled from previous surveys suggesting a viable seedbank of sufficient quality to allow natural recolonisation.

4.4.2 Juniper-leaved Grevillea

Southern population

The southern population of the Juniper-leaved Grevillea is the smaller of the two populations at the RDC site originally comprising two mature individuals and more than 10 juveniles. The individuals occupied an area of more than $20m^2$ and generally occurred in small clumps with juveniles usually between one and three metres from mature adults. Seedling germination at the site was low and in the summer of 2013 a wildfire swept through the area that has resulted in 100% loss of individuals from that site. In autumn 2013 monitoring, less than five individuals remained, but by the winter monitoring these had died off completely.

Figure 4.3 illustrates the population dynamic of the southern population highlighting that juvenile plants dominated the population profile. The winter 2013 data point represents the new growth at the site post-fire which represents 5 seedlings observed during that survey. A number of new seedlings were detected in 2014 and more than 50 seedlings recorded from the population in the winter 2014 monitoring round when grasses and groundcover were less dense at the site.

Figure 4.4 illustrates the proportion of the northern and southern grevillea population that has reproductive potential. The reproductive potential of the northern population remains stable due to juvenile individuals exhibiting flowering and fruiting almost all year round. The reproductive potential of the southern population was eliminated from the site in the wildfire in January 2013, and it is anticipated that seedlings in that population will become reproductively mature in two or three years.

Figure 4.3 : Population dynamics of the northern and southern populations of the Juniper-leaved Grevillea since the baseline survey

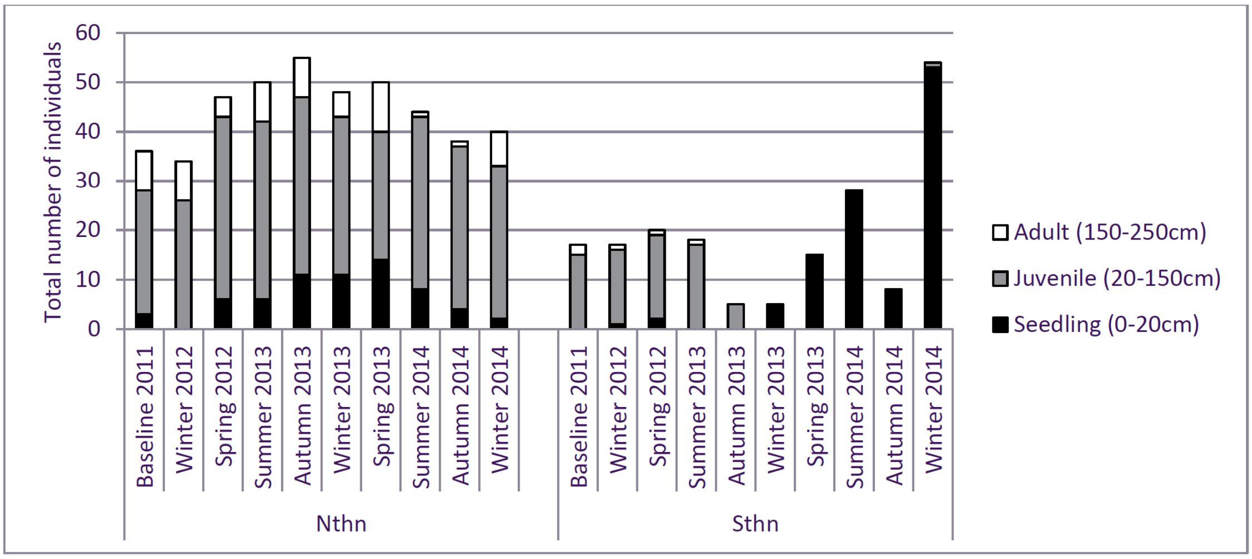
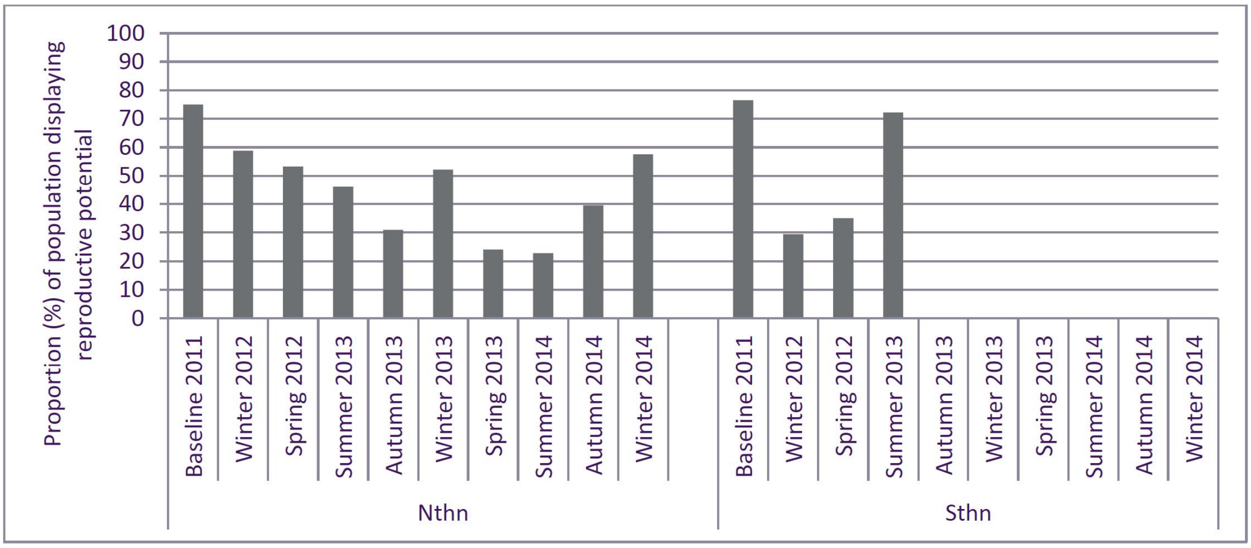


Figure 4.4 : Reproductive potential of each population of the Juniper-leaved Grevillea over four seasons



Northern population

The northern population of the Juniper-leaved Grevillea is the larger of the two populations at the RDC site comprising four mature individuals and more than 20 juveniles at baseline. The population occupies an area of approximately 30 m^2 with juveniles aggregating in small clumps usually between one and three metres from mature adults.

The population remains generally healthy, although four mature individuals have either died or are dying. This does not appear to be as a result of any human-induced disturbance as most juveniles in this area continue to thrive. Figure 4.3 illustrates the population dynamic of the northern population highlighting that juvenile plants dominate the population profile with a healthy cohort of seedlings likely to develop into juveniles in the summer of 2014.

4.4.3 Riparian site value and condition assessments

Figure 4-5 illustrates the trend in site value for each riparian site (AE1 to AE6) across the four seasonal survey periods, from spring 2013 to winter 2014. Gaps in the data represent periods of high rainfall where access to monitoring sites was impeded by localised flooding during the spring survey period. Sites generally remained stable in terms of riparian condition across the whole year with the exception being the two sites where spring surveys were able to be conducted (AE4 and AE5).

This temporary decrease in the conditions of the riparian monitoring sites is the result of localised flooding and topsoil removal. AE1 on the Rooty Hill RDC site consistently has the highest site value score; however this is likely because the site has a large number of fallen logs and two trees with hollows, characteristics that are favourably weighted in the site value scores.

Figure 4-5 Site value scores for each riparian monitoring site across 4 seasonal survey periods

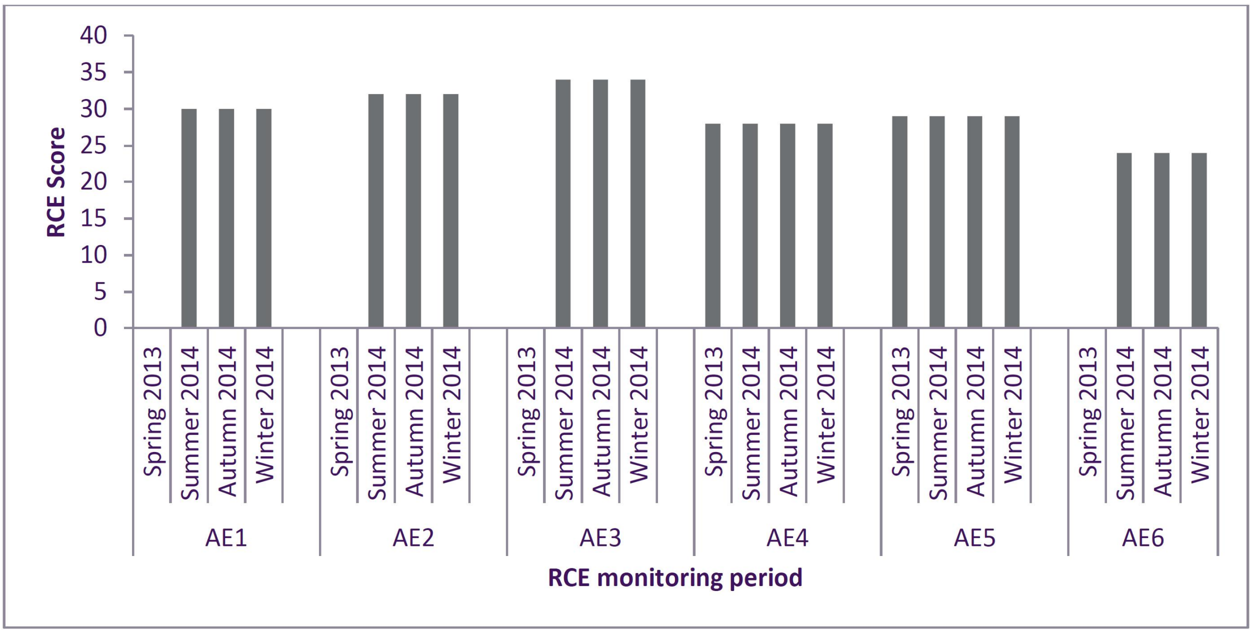
4.4.4 Riparian Channel and Environmental Inventory

Figure 4-6 illustrates the seasonal trends in the riparian channel and environment attributes monitored at AE1 to AE6. All monitoring locations have consistently maintained a Fair condition over the four seasonal survey periods.

These results suggest that major alterations are required to the stability of both Eastern Creek and its tributary both upstream and downstream of the Rooty Hill RDC site. The monitoring site at the RDC (AE1) has remained consistent in its riparian values during the construction phase of the site in the last twelve months.

Riparian health and condition have been previously reported both by ALS in Annual Environment Reports and Biosis in the *Rooty Hill RDC Aquatic Ecology – Environmental Assessment*. Monitoring of riparian health and condition during 2013/2014 concurs with previous assessments that suggest both the aquatic and terrestrial components of the riparian corridor both at the Rooty Hill RDC site and upstream and downstream reference sites are highly modified and representative of streams in peri-urban landscapes. The site value assessment (NSW Biobanking methodology) and the RCE methodology applied in the current monitoring program have allowed for a quantitative evaluation and comparison of the health and condition of development (AE1 Rooty Hill RDC site) and reference (AE5 and AE6) sites as well as determination of the condition of these sites against established benchmarks.

Figure 4-6 Seasonal trends in riparian channel and environment attributes



4.4.5 Cumberland Plain Woodland Critically Endangered Ecological Community

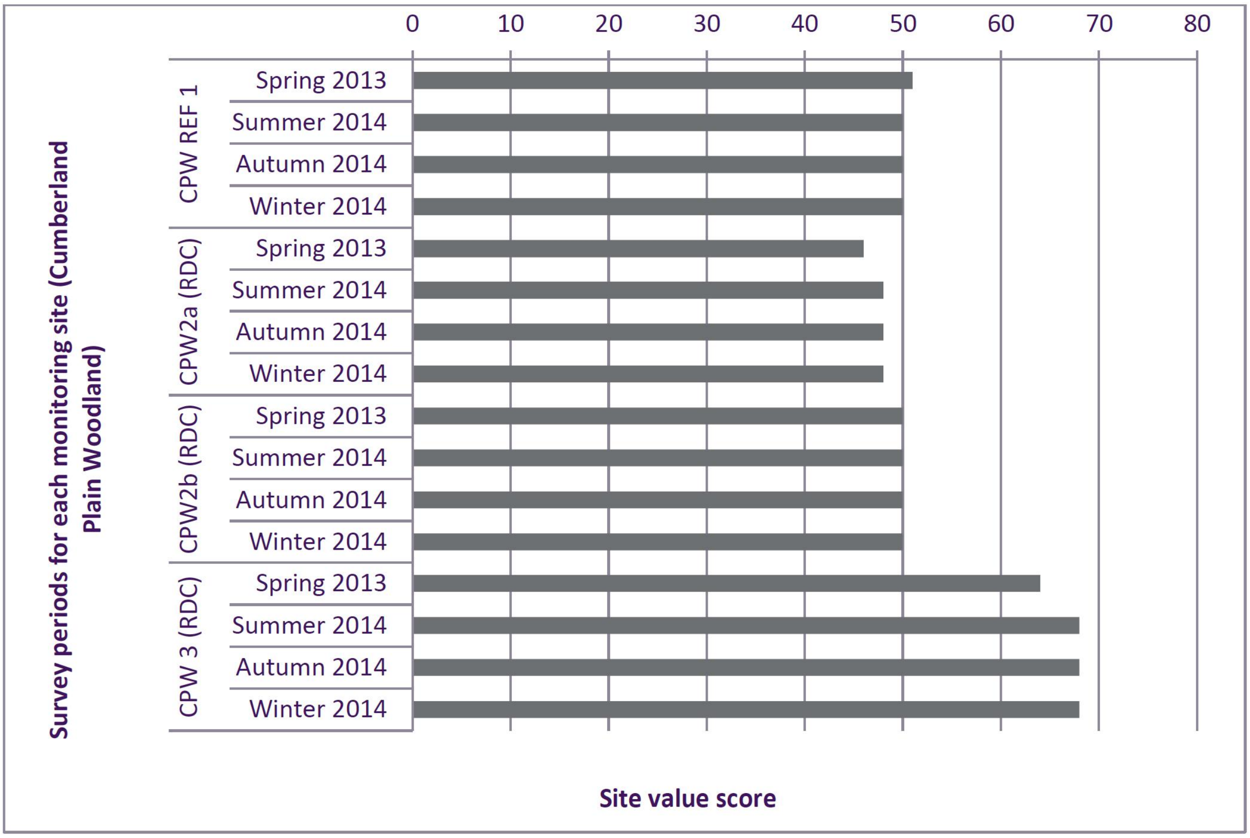
Vegetation condition of Cumberland Plain Woodland (CPW) remained fairly consistent at each site between monitoring events although, between sites, conditions varied between medium and high. Three of the monitoring locations are on the RDC site and the reference site is in Nurragingy Reserve adjacent to the project site.

CPW 3 on the RDC site retains the highest vegetation condition of all woodland monitoring sites and it is also the closest site to the project construction footprint (Figure 4-7).

Small reductions in site values at CPW2a and CPW 3 are likely to be reflective of both the impact of low water stress from a dry year in 2012/13 and the impact of psyllid infestations in eucalypts in the region, where a decrease in canopy cover was observed.

Native plant species richness across all sites was considered moderate and ground cover condition was directly related to density of exotic (weed) species at the sites and where weed density was highest, condition values were lowest. Regenerative potential of overstorey species at all sites was reasonable, and at some sites there is evidence of partial recovery of eucalyptus from psyllid attack with flushes of epicormic regrowth on higher limbs. At all sites, weed infestations persist in the groundcover predominantly as grass weeds.

Figure 4-7 Site value scores for Cumberland Plain Woodland monitoring locations for the four seasonal survey periods



Despite variability in the condition of Cumberland Plain Woodland at the RDC site, resilience is considered to be moderately good across all sites and equivalent to the control site in the adjacent Nurragingy Reserve. Weed infestations persist across all sites including the control site, outcompeting native vegetation particularly in the groundcovers and lessening the condition of each site. Site resilience suggests the sites have good natural regenerative capacity where weeds can be controlled. The most intact remnant of woodland on the RDC site (north of Angus Creek) has maintained its site value despite construction works and is consistently monitored as a higher value than the woodland reference site on Nurragingy Reserve.

5. Water quality

Summary

Water quality indicates that Angus and Eastern Creeks are impaired and representative of a degraded catchment influenced by mixed rural and urban landuses. Poor water quality was mainly due to low flows, high turbidity, low dissolved oxygen and high conductivity. Many of these parameters were often outside the ANZECC/ARMCANZ (2000) water quality guidelines for the protection of lowland river aquatic ecosystems. Oily films and odours were also observed. Such conditions can only sustain the most tolerant aquatic biota. Wet weather increased turbidity and nutrients in the waters, primarily from runoff and continued bank erosion of the clay based sediment.

Sites along both Angus Creek and Eastern Creek showed high nutrient concentrations and occasional algal blooms, in particular AE6 during Year 2. Following the first sampling event, the control site (AE6) became part of an unrelated construction facility which resulted in poor water quality that was noticeably poorer than downstream during dry weather. Shallow, stagnant and muddy pools were observed at site AE6 following the commencement of construction. Historically there has been a consistent trend of decreasing biological impairment (measured through AUSRIVAS bands and OE50 scores) moving downstream from AE6 to AE4, with the best performing site being AE5 above the confluence with Angus Creek.

Following wet weather, water quality appeared poorer at the impact sites downstream from AE6; however, deterioration could not be directly attributed to the Holcim site. Water quality of Angus Creek shows no noticeable deterioration downstream of the Holcim Compound (AE1). It would appear therefore that while there are significant localised land use disturbances, the Holcim site *per se* is not a major contributor to poor water quality in these waterways.

5.1 Sampling methodology

Surface water quality was monitored on a quarterly basis in six locations. Sampling was undertaken on:

- Dry Weather- 14-16 Oct 2013
- Wet Weather - 17 February 2014
- Dry Weather- 10-11 April 2014
- Dry Weather -1 July 2014*

*Only one wet weather event met the rainfall thresholds, thus an additional dry weather trip was conducted in July 2014. Sampling locations are summarised in Table 5-1.

Table 5-1 Site Location

Site Code	Location
AE6	Angus Creek, 500m upstream RDC^
AE1	Angus Creek at upstream boundary of RDC
AE2	Angus Creek at downstream boundary of RDC
AE3	Angus Creek 150m downstream of RDC culvert
AE4	Eastern Creek downstream of Angus Creek confluence
AE5	Eastern Creek upstream of Angus Creek confluence^

^These sites will be adopted as control sites (MCoA 2.28A)

Water quality sampling was undertaken both *in situ* and via grab samples. In situ sampling was undertaken using a calibrated Hydrolab Quanta Water Quality Probe. The following indicators were measured:

- pH (pH Units)
- Turbidity (NTU)
- Temperature (°C)
- Dissolved Oxygen (% saturation and mg/L)
- Electrical conductivity (µS/cm and ms/cm).

Three replicate readings of each indicator were taken within a 50m radius from approximately 30cm below the surface at each site. Readings were recorded onto a field data sheet together with additional information including: site code, site name, location and coordinates, date and time of sampling, details of team members collecting samples, weather conditions, water surface conditions, presence of nuisance organisms, presence of oily films, odour etc.

Grab samples were collected concurrently with *in situ* water monitoring at each site for analysis of total nitrogen and total phosphorus concentrations. Sampling was conducted in accordance with the Australian/New Zealand standards for water quality sampling (AS/NZS 5667.1:1998). Samples were collected in the appropriate bottles and stored on ice as per the preservation techniques appropriate for analysis. Samples were then transported to Envirolab in Chatswood for ex-situ analysis.

Water quality results have been compared to default trigger values in the ANZECC/ARMCANZ (2000) guideline for protection of lowland river aquatic ecosystems. These trigger values are provided in Table 5.2.

Table 5.2 : ANZECC/ARMCANZ (2000) Guidelines

Water quality Indicator	Default Trigger Values
Temp (°C)	N/A
Turbidity (NTU)	6-50
DO (% sat)	85-110
Electrical Conductivity (µS/cm)	125-2200
TDS (g/L)	N/A
pH	6.5-8.5
Total Nitrogen (mg/L)	0.5
Total Phosphorus (mg/L)	0.05

5.2 Sampling results

Water quality results for each site during both dry and wet weather are presented in Table 5-3 together with the ANZECC/ARMCANZ (2000) default trigger values. Highlighted text indicates values that are outside the water quality guidelines.

The sites are displayed in a downstream order with AE6, AE1, AE2 and AE3 located on Angus Creek, AE6 being the most upstream. AE5 and AE4 are on Eastern Creek. All sites are located upstream of wastewater treatment plant discharges and are representative of mixed rural and urban land uses.

Overall, water quality was poor across the study area. During dry weather sampling, water levels were low at all sites with little or no flow. All sites presented oily films and odours which are a reflection of low flow. During wet weather sampling, flow increased with highly turbid waters due to the scouring of banks and underlying geology which was largely clay based.

Table 5-3 Average dry and wet weather water quality results (2012/13)

Site	Dry/Wet	Temp (°C)	Turbidity (NTU)	DO (% sat)	Conductivity (µS/cm)	TDS (g/L)	pH	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
AE6	Dry	14.88	106.40	41.90	2867.78	1.48	8.84	9.90	1.20
	Wet	21.22	307.67	71.80	701.00	0.34	8.36	2.30	0.30
AE1	Dry	13.86	30.64	29.10	2411	1.23	8.53	5.53	0.49
	Wet	20.89	231.00	68.77	527.33	0.25	8.71	1.60	0.20
AE2	Dry	15.15	40.11	35.93	2531.67	1.31	8.37	5.60	0.31
	Wet	21.08	263.00	69.17	1145.67	0.56	8.42	1.40	0.10
AE3	Dry	14.67	41.47	31.33	2219.67	1.13	8.42	4.00	0.14
	Wet	21.08	262.00	66.07	464.33	0.22	8.60	1.90	0.20
AE4	Dry	14.46	85.77	40.32	1111.56	0.56	8.28	1.70	0.14
	Wet	21.62	62.53	52.87	417.67	0.20	8.57	1.00	0.10
AE5	Dry	14.67	100.71	40.17	1023.78	0.50	8.33	2.17	0.07
	Wet	21.73	36.67	51.73	494.00	0.24	8.56	1.60	0.10
ANZECC/ARMCANZ Guidelines		**N/A**	**6-50**	**85-110**	**125-2200**	**N/A**	**6.5-8.5**	**0.5**	**0.05**

Shaded cells exceed ANZECC/ARMCANZ (2000) Guidelines

Turbidity within Angus Creek exceeded the guidelines at the upstream control AE6, largely due to unrelated construction works, which dammed the creek and releases water weekly. This resulted in a shallow stagnant and muddy pool, which at times exhibited algal growth.

Turbidity in Eastern Creek was elevated in dry weather and exceeded the guidelines at AE4 and AE5. Following wet weather, turbidity levels exceeded the guidelines at all sites in Angus and Eastern Creeks with the exception of the upstream Eastern Creek Site AE5. Generally, the increased turbidity during wet weather is likely due to the addition of suspended solids from runoff and channel erosion.

Dissolved oxygen levels were low at all sites, particularly during dry weather when mean concentrations were less than half the minimum level for protection of aquatic ecosystems. These levels were likely attributable to the stagnant and low flow conditions across all sites. Following wet weather, dissolved oxygen levels increased as a result of aeration due to increased water flow, however levels still fell below the lower guideline limit of 85% saturation.

Angus Creek demonstrated elevated electrical conductivity during dry weather, which exceeds the recommended upper limit. These saline conditions are likely a result of low flow conditions during dry weather and the discharge of saline groundwater. Following wet weather, increased flow provided dilution of salts and therefore conductivity levels fell within the recommended range of 125 to 2200µS/cm. In Eastern Creek, conductivity complied during both dry and wet weather, and similar to Angus Creek, electrical conductivity was lower during wet weather.

pH levels increased throughout the study area in 2013-14. Mean pH levels exceeded the guidelines for the protection of lowland river aquatic ecosystems (6.5-8.5 mg/L) at AE6, AE1, AE4 and AE5. During wet weather, pH levels were generally higher due to runoff from the surrounding catchment which may contain fertilizers and detergents that are known to increase pH.

Nutrient concentrations were elevated in both Angus and Eastern Creeks, with mean total phosphorus (TP) and mean total nitrogen (TN) exceeding the recommended guidelines at all sites. The mean TN concentration was very high at the control site AE6 during dry ($\bar{x}$9.90mg/L) and wet ($\bar{x}$ 2.3mg/L) weather. TN concentrations decreased further downstream and were much lower within Eastern Creek.

The elevated TN concentrations at AE6 are likely attributable to the other local construction activities near the monitoring site. In high concentrations these nutrients can result in the algal blooms which were evident during dry weather at AE4, AE5 and AE6.

6. Air quality

Summary

Ambient dust sampling included PM10, TSP (calculated based on PM10) and depositional dust. A single PM10 sampling unit was employed until May 2014, at which time a second unit was installed adjacent to the Holcim site office. Annual limits for PM10 and TSP were met over the reporting period.

The 24-hour limit for PM10 was exceeded on one occasion. However this occurred when wind was from the opposite direction and unlikely to be attributable to activities under Holcim's control.

Depositional dust was sampled from September 2013 to August 2014. Results demonstrate depositional dust levels were less than the annual limit, though some elevated levels were recorded particularly in September.

6.1 Sampling methodology

Air quality monitoring included the measurement of depositional dust and particulate matter (PM) at locations within and outside the RDC boundary.

PM10 (Particulate Matter smaller than 10 micrometres), was monitored in two locations using a High Volume Air Sampler (HVAS) with size selective head, as listed in Table 6-1. Until May 2014, only a single HVAS was in use (PM10-2). The second (PM10-1) was installed once power was available. Total Suspended Particulate (TSP) was initially measured directly but the HVAS was switched to the size selective head in December 2012 and this parameter is now conservatively estimated at 2.5 times the measured PM_{10} level.

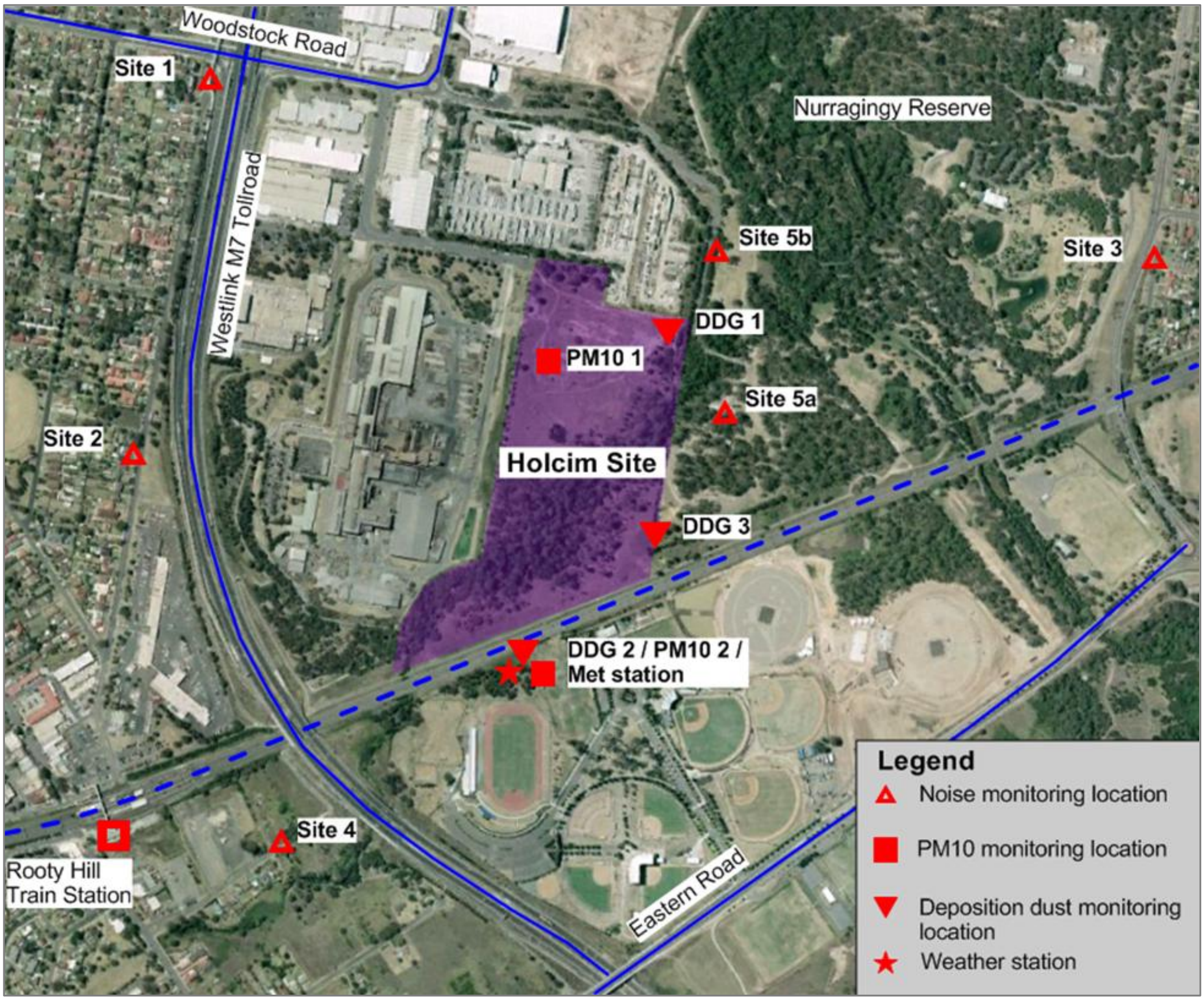
The HVAS was operated one-day-in-six in accordance with AS/NZS 3580.9.6:2003 *Methods for sampling and analysis or ambient air, Method 9.6: Determination of suspended particulate matter (PM10) – High volume sampler with size selective inlet - Gravimetric method*. Calibration of the unit is checked on a monthly basis, in accordance with operating instructions for the unit and AS/NZS 3580.9.6:2003.

Depositional dust monitoring consisted of three depositional dust gauges (DDGs), which are collected and sample bottles replaced approximately every 30 days in accordance with AS/NZS 3580.10.1:2003 *Methods for sampling and analysis of ambient air Method 10.1: Determination of particulate matter – Deposited matter – Gravimetric method* and are analysed for total insoluble solids. The depositional dust monitoring locations listed in Table 6-1 have been selected to be representative of sensitive receptors. Figure 6-1 shows the monitoring locations.

Table 6-1 Dust monitoring locations

Reference	Description	Type of dust measured	
		Depositional dust	TSP / PM_{10}
PM10-1	Blacktown International Sportspark		✓
PM10-2	Holcim site offices		✓
DDG1	Adjacent to eastern boundary in northern section of construction site, abutting Nurragingy Reserve	✓	
DDG2	Adjacent to southern boundary abutting Blacktown Olympic Centre	✓	
DDG3	Adjacent to south eastern boundary abutting Nurragingy Reserve	✓	

Figure 6-1 Air quality monitoring locations



6.2 Dust guidelines

Air quality (dust) criteria within the Project Conditions of Approval and the CDMP mirror those in the NSW EPA document A*pproved methods for the modelling and assessment of air pollutants in New South Wales* (DEC 2005). The air quality assessment criteria are outlined in Table 6-2, which apply cumulatively (that is, due to all sources of emissions and not just the contribution from the project).

Table 6-2 Dust concentration guidelines

Pollutant	Averaging period	Concentration
TSP	Annual	90 µg/m^3
PM10	24 hours	50 µg/m^3
	Annual	30 µg/m^3
Deposited dust	Annual	4 g/m^2/month

6.3 Results

6.3.1 PM_{10} and TSP

Ambient concentrations of PM_{10} and TSP are summarised graphically for each monitoring location in Figure 6-2 and Figure 6-3.

PM_{10} concentrations are generally within the 24-hour limit of 50 µg/m^3, with the exception of one sample period in November 2013, where a minor exceedance of the limit was observed for PM10-2 (Sports Park). However during work hours on this day, wind was calm and any light breeze was from the south east more than 90% of the time. Given that the work site is north of this monitoring location, it is unlikely that the recorded dust originated on the Holcim site. It is possible that lawn mowing of the adjacent soccer fields or other activities at the Blacktown Sports Centre may have affected this measurement.

Annual PM_{10} dust concentrations were 23 µg/m^3 and 24 µg/m^3 for PM10-1 and PM10-2 respectively, below the limit of 30 µg/m^3.

The annual average of calculated (2.5 x PM_{10} concentration) TSP concentrations was 59µg/m^3 at both monitoring locations. This value is well below the annual limit of 90 µg/m^3 despite several outstanding results. These higher results align with the higher measured PM_{10} events including the elevated level in November and several elevated events in June 2014. The results for June are indicative of construction dust impacts on the Blacktown Sports Park with north westerly winds of around 3 m/s.

Figure 6-2 Measured PM_{10} concentrations: PM10-1 (top) and PM10-2 (bottom)

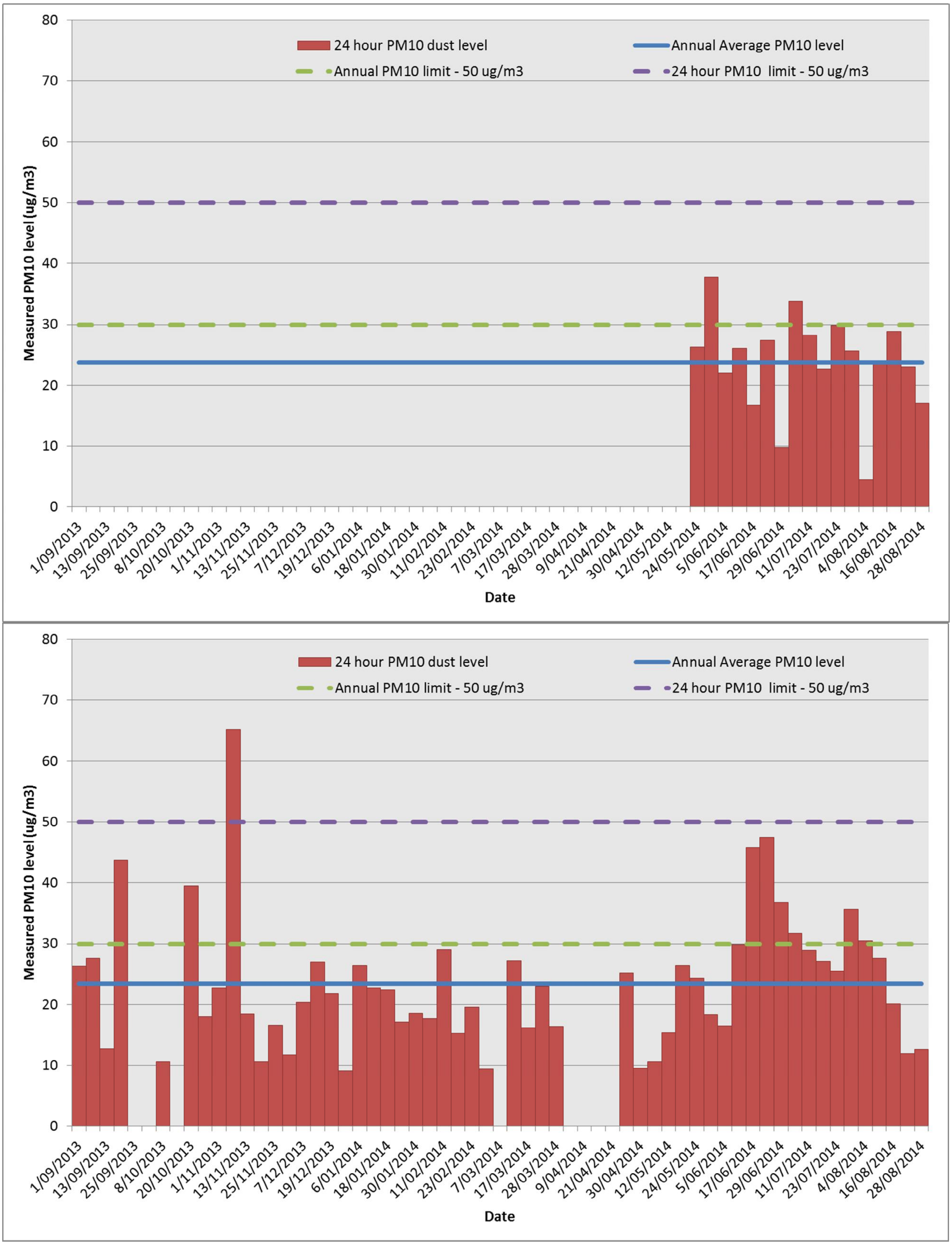
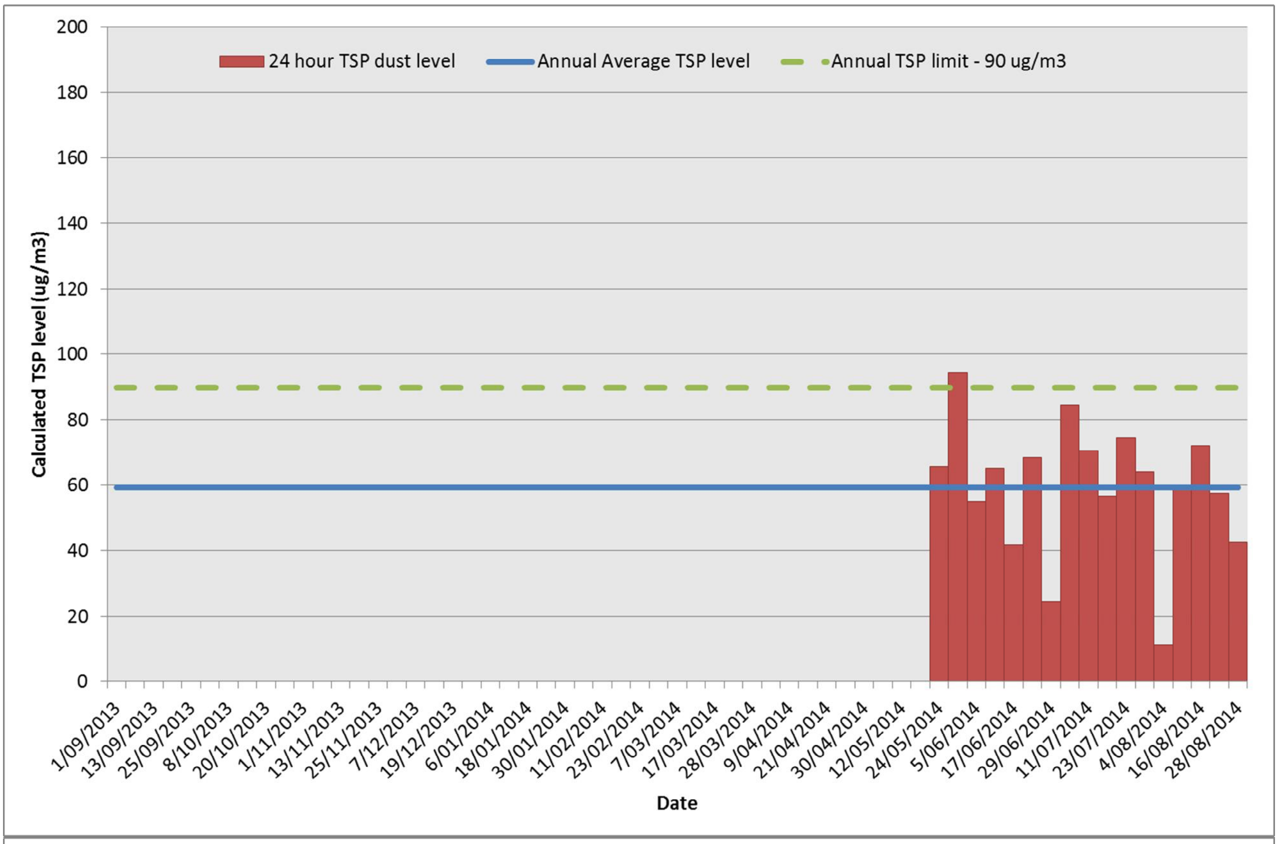
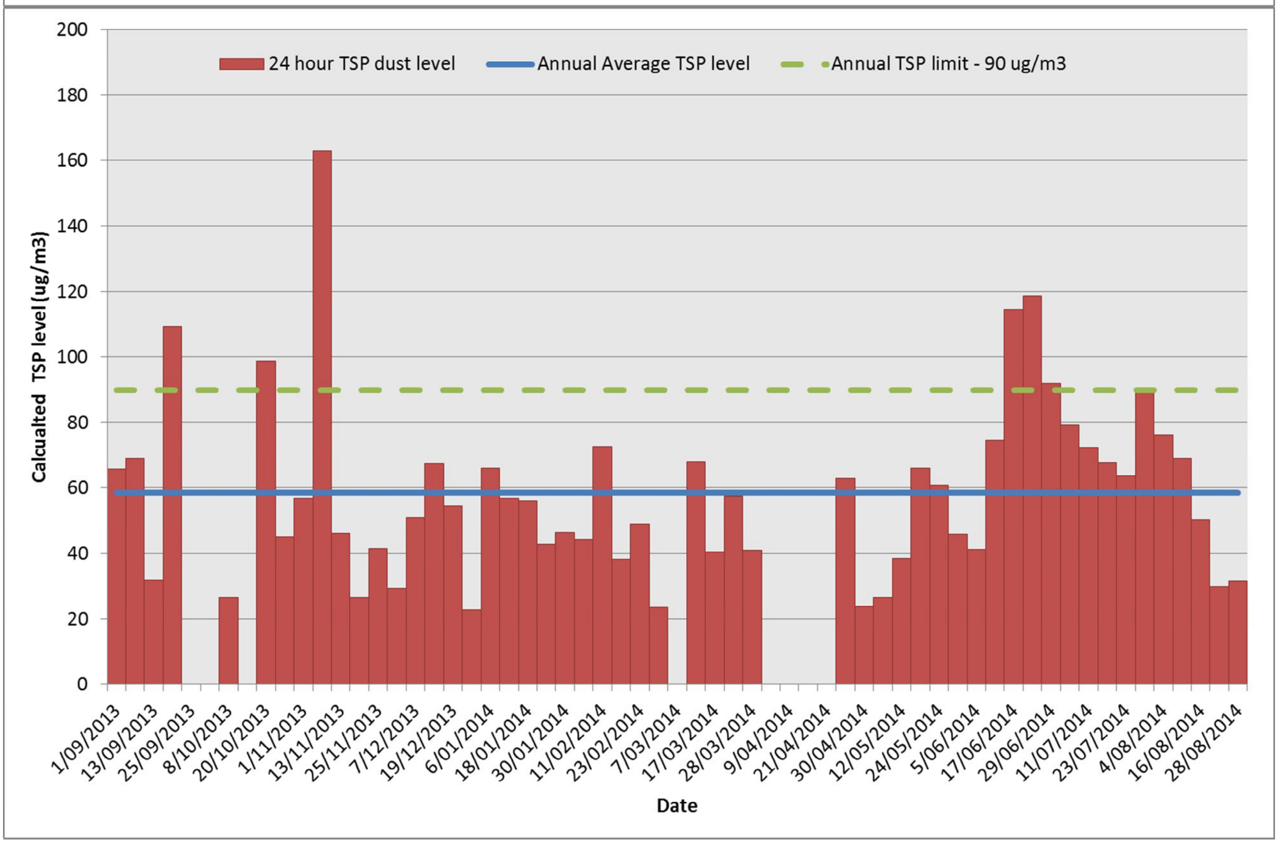


Figure 6-3 Calculated TSP concentrations: PM10-1 (top) and PM10-2 (bottom)





6.3.2 Depositional dust

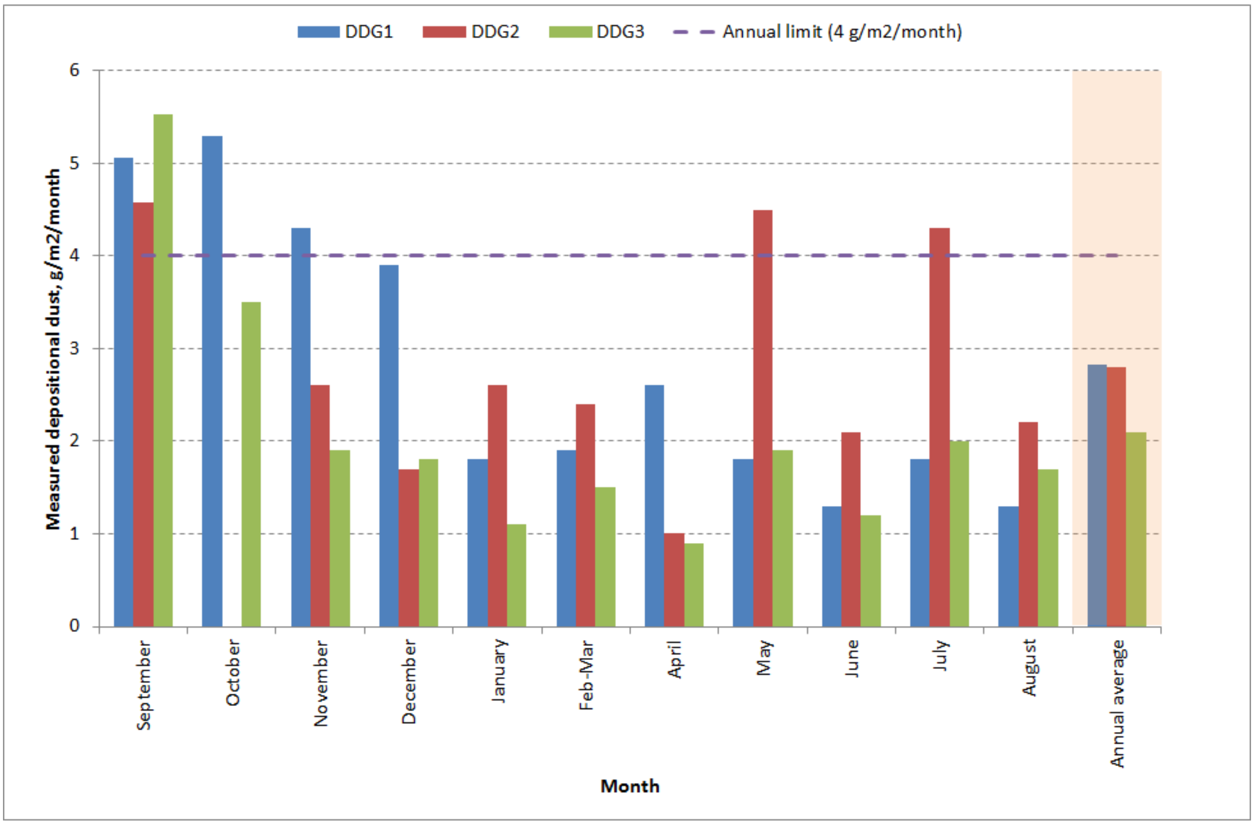
Results for monthly depositional dust sampling are summarised graphically in Figure 6-4. It is evident that the annual average values for each of the three monitoring locations are less than the annual limit of 4 g/m^2/month.

All locations recorded steadily declining dust concentrations from September to April. DDG1 is in the northern section of the site where the site was progressively stabilised and paved. Early elevated levels gave way to steadily low measured levels.

DDG2 and DDG3 are in the southern section of the site where construction was more concentrated, with DDG3 closest to the construction works. Levels for DDG3 also decreased from higher levels in September to less than half the annual limit between November and August.

DDG2 recorded the highest concentrations of depositional dust between May and July 2014, trending to increased levels by the end of the annual monitoring period.

Figure 6-4 Depositional dust results



7. Noise

Summary

Noise was measured in six locations around the construction site from September 2013 to August 2014. Monthly monitoring indicated that noise from RDC construction at the nearest residential receivers was generally inaudible, with traffic noise making up the majority of noise at any single location.

In the adjacent Nurragingy Reserve, noise from construction was audible, with comments noting the contribution of construction noise as being less than, or on a few isolated occasions, equal to the noise management level (NML).

It is unlikely that construction noise is having a significant impact on nearby sensitive receivers.

7.1 Monitoring methodology

Monthly noise monitoring has been undertaken by a qualified acoustic consultant in six locations between September 2013 and August 2014. Monitoring was conducted for a minimum of 15 minutes in each location and in accordance with the requirements set out in the EPA (2000) *Industrial Noise Policy* and the DECC (2009) *Interim Construction Noise Guidelines*.

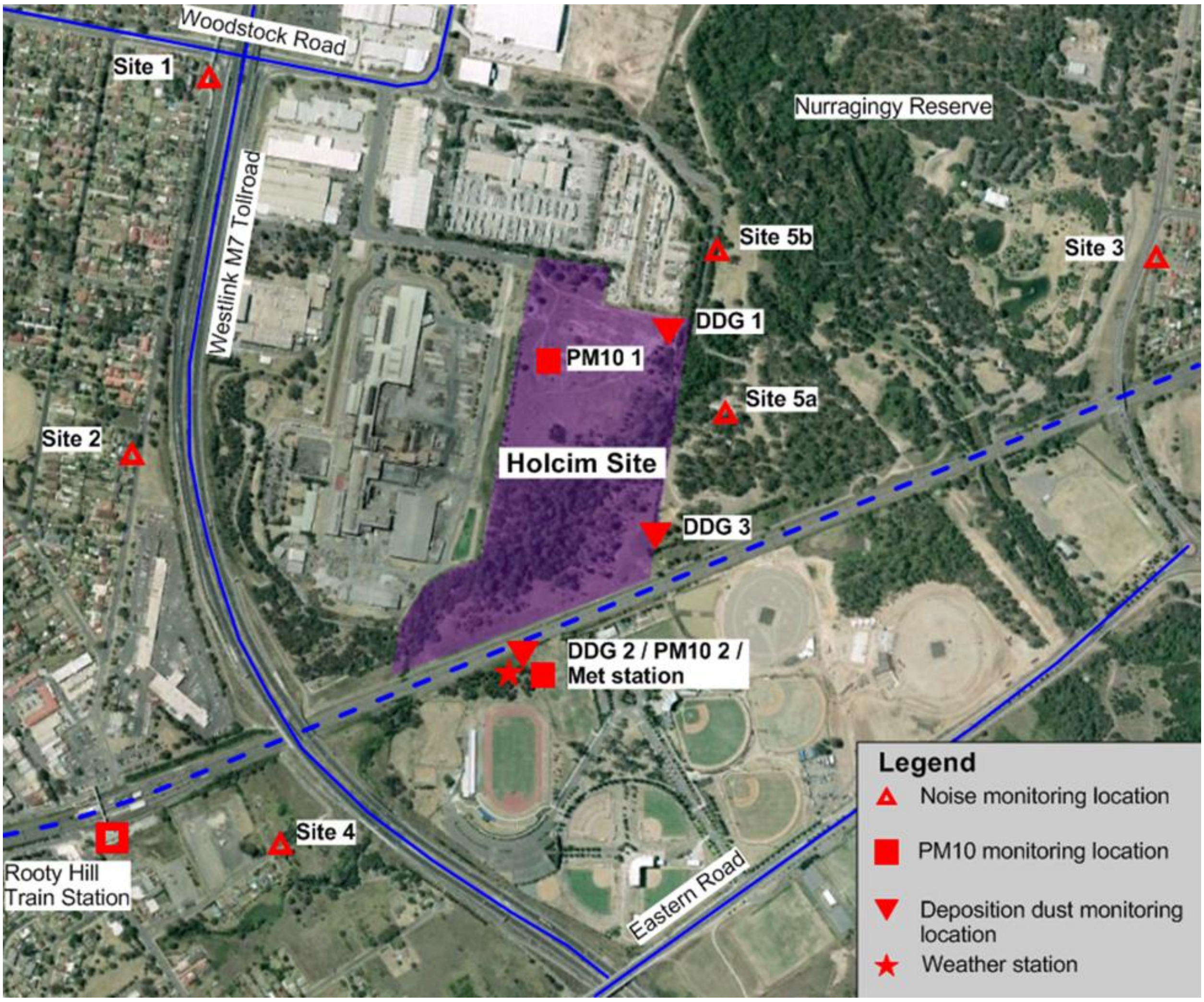
Monitoring was carried out using a SVAN 858 Type 1 Sound Level Meter by appropriately qualified personnel. Calibration of the unit was checked before and after each monitoring period, and the drift was less than 0.5dB.

Monitoring locations are listed in Table 7-1 and are illustrated in Figure 7-1. The monitoring locations are sufficient to demonstrate compliance with noise criteria in all locations.

Table 7-1 Monitoring locations and assessment criteria

Receiver		Receiver Type	Approximate Distance and Orientation from RDC boundary	NML LAeq,15min
1	132 Station Street	Residential	650m west	58
2	54 Station Street	Residential	650m west	58
3	63 Coghlan Street	Residential	850m east	58
4	16 Mavis Street	Residential	650m west	63
5a	Lomandra Shelter Shed (Nurragingy Reserve)	Recreational	<100m east	60
5b	Boronia Shelter Shed (Nurragingy Reserve)	Recreational	<100m east	60

Figure 7-1 Noise monitoring locations



7.2 Monitoring results

Monitoring results for each location are summarised individually from Table 7-1 to Table 7-7.

Results and observations recorded for each monitoring period demonstrate that construction noise was rarely audible and did not contribute substantially to total noise levels measured at sensitive receiver locations. The existing environment is relatively noisy, with the M7 Motorway and other busy roads generating the majority of noise in the area.

At locations 1 – 4, construction noise was consistently noted as inaudible.

At locations 5a and 5b in Nurragingy Reserve construction noise was audible with sound pressure levels equal to or below the noise criterion. Though audible, construction noise levels in the reserve were not observed to exceed the criterion of 60 dB(A).

Based on observations and recorded noise levels, traffic noise is the dominant noise source in the area and construction of the RDC is unlikely to result in adverse impacts on sensitive receivers.

Table 7-2 Summary of monthly monitoring – Location 1

Month	$L_{Aeq(15min)}$ sound pressure level, dB(A)			Observations
	NML	L_{Aeq}	L_{A90}	
September	58	57	52	Holcim inaudible, M7 (constant 55-65), Woodstock avenue traffic (freq 55-60), birds
October		54	48	Holcim inaudible, M7 (constant 50-65), Woodstock avenue traffic (freq 35-40)
November		53	47	Holcim inaudible, M7 (constant 50-60), cicadas, birds
December		54	47	Holcim inaudible, M7 (constant 50-60), birds
January		59	53	Holcim inaudible, M7 (constant 60-70), Woodstock avenue (55-65)
February		53	51	Holcim inaudible, M7 (constant 60-70), Woodstock avenue (55-65), birds, aeroplane
March		55	55	Holcim inaudible, M7 (constant 60-65), birds
April		56	52	Holcim inaudible, M7 (constant 60-65), birds, pedestrians
May		55	51	Holcim inaudible, M7 (constant 60-65), birds, pedestrians
June		56	50	Holcim inaudible, M7 (constant 55-60), birds, pedestrians
July		55	49	Holcim inaudible, M7 (constant 50-60), birds
August		63	54	Holcim inaudible, M7 traffic [60-66 dB(A)] traffic/braking along Woodstock Street [60-71 dB(A)].

Table 7-3 Summary of monthly monitoring – Location 2

Month	$L_{Aeq(15min)}$ sound pressure level, dB(A)			Observations
	NML	L_{Aeq}	L_{A90}	
September	58	57	52	Holcim inaudible, M7 (constant 55-60), local traffic (55-65), breeze, birds
October		54	49	Holcim inaudible, M7 (constant 55-60), local traffic (55-65), breeze, cicadas, birds
November		51	50	Holcim inaudible, M7 (constant 50-60), local traffic (60-65), birds
December		54	50	Holcim inaudible, M7 (constant 55-65), local traffic (50-60), birds
January		62	53	Holcim inaudible, M7 (constant 55-60), local traffic (65-70), birds
February		55	54	Holcim inaudible, M7 (constant 55-60), local traffic (55 - 60), birds, residential noise
March		57	57	Holcim inaudible, M7 (constant 55-60), local traffic (55 - 65), birds
April		57	52	Holcim inaudible, M7 (constant 55-60), local traffic (55 - 65), birds,
May		58	54	Holcim inaudible, M7 (constant 55-60), local traffic (55 - 65), birds
June		57	52	Holcim inaudible, M7 (constant 55-60), local traffic (55 - 70), birds
July		59	51	Holcim inaudible, M7 (constant 50-55), local traffic (60-65), birds
August		55	50	Holcim inaudible. M7 traffic [53-55 dB(A)], local traffic [56-75 dB(A)] and birds [63-66 dB(A)].

Table 7-4 Summary of monthly monitoring – Location 3

Month	$L_{Aeq(15min)}$ sound pressure level, dB(A)			Observations
	NML	L_{Aeq}	L_{A90}	
September	58	54	52	Holcim inaudible, M7 (constant 55-60), birds
October		57	50	Holcim inaudible, M7 (constant 45-65), cicadas, birds
November		56	46	Holcim inaudible, Knox Rd traffic (constant 45-55), plane
December		57	50	Holcim inaudible, Knox Rd traffic (constant 55-65), birds
January		61	52	Holcim inaudible, Knox Rd traffic (constant 55-65), birds, nearby roadworks
February		48	48	Holcim inaudible, train, Knox Rd traffic (constant 50-65)
March		54	53	Holcim inaudible, train, Knox Rd traffic (constant 55)
April		58	50	Holcim inaudible, trains, Knox Rd traffic (constant 55-65)
May		57	50	Holcim inaudible, other construction nearby, lawn mowing (60 - 70), Knox Rd traffic (55-65)
June		58	48	Holcim inaudible, Knox Rd traffic (constant 55-65), birds
July		59	50	Holcim inaudible, Knox Rd traffic (constant 55-65), garbage collection adjacent street (45-50)
August		62	51	Holcim inaudible. Knox Road [54-64 dB(A) LV's, 67-74 dB(A) HV's].

Table 7-5 Summary of monthly monitoring – Location 4

Month	$L_{Aeq(15min)}$ sound pressure level, dB(A)			Observations
	NML	L_{Aeq}	L_{A90}	
September	63	59	53	Holcim inaudible, Knox Rd traffic (constant 50-60), train (60-70)
October		54	46	Holcim inaudible, Knox Rd traffic (constant 50-65), birds
November		53	48	Holcim inaudible, M7 (constant 55-65), trains, birds
December		56	51	Holcim inaudible, M7 (constant 55-65), birds
January		58	53	Holcim inaudible, M7 (constant 55-60), birds / insects
February		46	45	Holcim inaudible, M7 (constant 50-60), residential noise, birds / insects, aeroplane
March		50	49	Holcim inaudible, M7 (constant 55-60), birds / insects, aeroplane, trains
April		54	48	Holcim inaudible, M7 (constant 55-60), birds, aeroplane, trains
May		57	52	Holcim inaudible, M7 (constant 55-60), birds, trains
June		54	50	Holcim inaudible, M7 (constant 55-60), local traffic (55 - 70), birds, trains
July		55	49	Holcim inaudible, M7 (constant 50-60), birds, train, aeroplane
August		56	52	Holcim inaudible. M7 [51-53 dB(A) LV's, 54-61 dB(A) HV's], birds, train.

Table 7-6 Summary of monthly monitoring – Location 5a

Month	$L_{Aeq(15min)}$ sound pressure level, dB(A)			Observations
	NML	L_{Aeq}	L_{A90}	
September	60	57	53	Holcim (constant 50-60, trucks, dozer tracks, horns, beepers), cicadas (57), local traffic (55-60)
October		52	49	Holcim (constant 40-45, trucks, dozer tracks, beepers), cicadas, birds, M7 (40 constant)
November		48	44	Holcim (infrequent bangs <35), cicadas, birds, M7 (<35 constant)
December		50	41	Holcim (excavator, occasional <35), planes / trains, local traffic (60-70), cicadas
January		51	48	Holcim (backhoe 50-55 for 1-2 minute period only), train, birds / insects
February		52	51	Holcim (banging 53, reverse alarms 51, engines 56), construction in reserve (65-70), birds
March		56	55	Holcim (Crane operating close to monitoring location 55-60, occasional trucks 60), local traffic
April		56	55	Holcim (occasional reversing alarms and trucks 55), birds, local traffic, aeroplane, train
May		56	51	Holcim (equipment near rail line, occasional reversing alarms and bangs 55), birds, train
June		54	50	Holcim (drilling, trucks, excavator, occasional reversing alarms), birds, trains, local traffic
July		54	48	Holcim (drilling, ratchet gun, bangs from northern earthworks), birds, trains, local traffic
August		55	52	Holcim rail works (saw cutting at track, haulage trucks and unloading, rollers) at 55-58 dB(A).

Table 7-7 Summary of monthly monitoring – Location 5b

Month	$L_{Aeq(15min)}$ sound pressure level, dB(A)			Observations
	NML	L_{Aeq}	L_{A90}	
September	60	56	49	Holcim (constant 40-50, dozer tracks, bangs, truck engines, beepers), traffic (65), birds (50-60)
October		59	54	Holcim (constant 50, excavator, trucks. Frequent bangs (75)), cicadas, birds
November		45	42	Holcim inaudible, industrial area (<35), distant traffic (Knox Road <40), cicadas, birds
December		46	42	Holcim IA, Knox Rd (<40), cicadas, birds
January		53	47	Holcim IA, Hume industrial area (45-55)
February		60	60	Holcim (trucks 55, hammering 66), construction in reserve (65-70), birds
March		48	48	Holcim (occasional trucks 50, bucket bangs 55), birds, local traffic
April		57	52	Holcim (occasional light vehicles and banging 55-65, constant engine noise 45-50), local traffic
May		48	44	Possibly Holcim or nearby industrial area (unable to identfy 40), birds, local traffic
June		48	44	Holcim (trucks and machinery occasionally audible 54), birds, local traffic, aeroplane
July		49	43	Holcim (excavator - constant 35-40), work at Hume site, birds, local traffic, park users
August		53	47	Holcim inaudible except short metal on metal noise [50 dB(A)]; nearby industry, birds, traffic.

8. Groundwater

Summary

Data collected as part of the September 2014 groundwater monitoring round indicated that, with the exception of water quality at GW02, the parameters assessed remain consistent with pre-construction baseline data collected by SKM (now Jacobs) in September 2012.

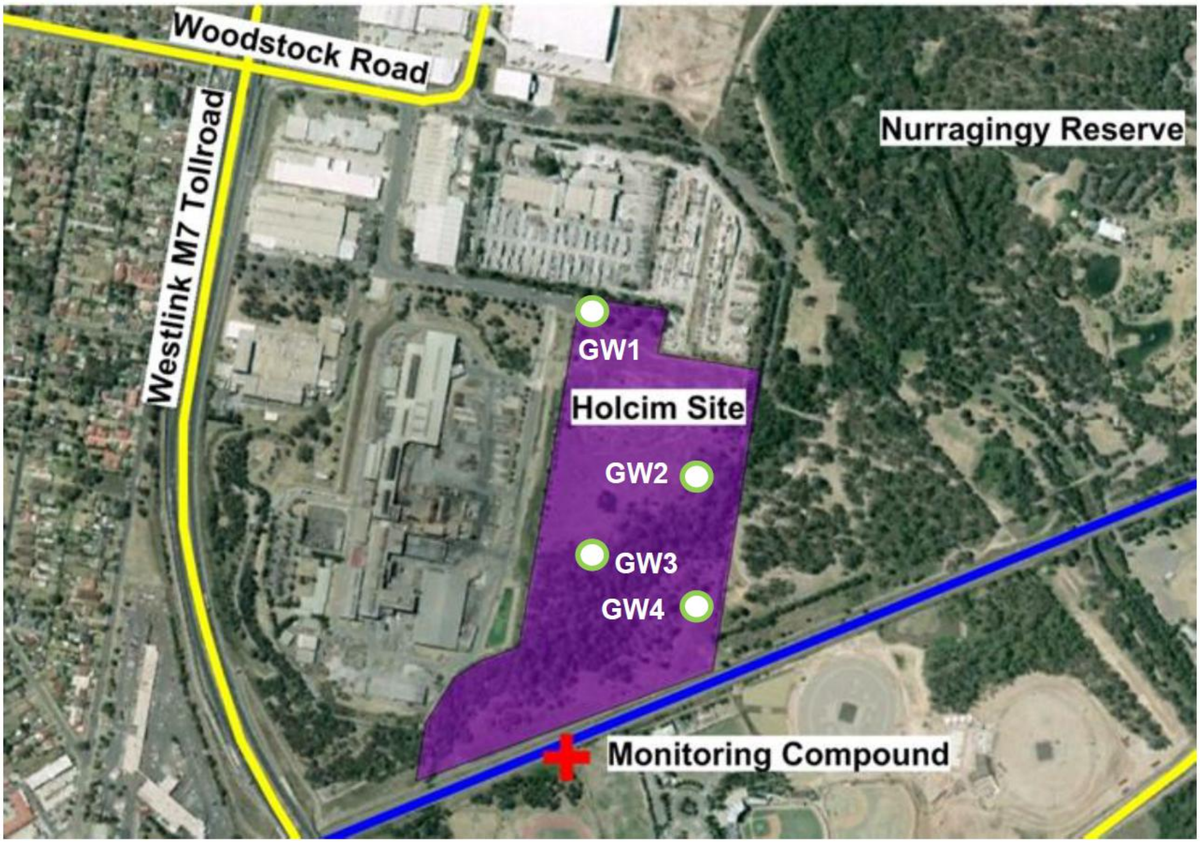
Results for EC, salinity and TDS at GW02 were significantly lower than previous monitoring rounds (by up to 50%). A sudden increase or decrease in conductivity maybe indicative of pollution, however, no odours, staining or visual signs of contamination (such as oily residue on the interface probe or bailer) were noted during the monitoring of GW02, therefore it is considered unlikely that contamination is the cause for the decrease in EC, salinity and TDS at GW02.

It is noted that GW02 is located within 3m (down gradient) of a sediment retention pond. The September 2014 monitoring event was the first monitoring round where the retention pond was observed to be completely dry. It is possible the water quality and recharge within GW02 was influenced by the retention pond given the proximity of the well to the pond.

8.1 Methodology

Two rounds of the six-monthly groundwater monitoring were completed in September 2013 and March 2014 at four groundwater monitoring locations, GW1 - GW4, as illustrated in Figure 8-1.

Figure 8-1 Groundwater monitoring locations



The depth to water and total well depth were measured using a decontaminated multi-phase probe to record water levels and the presence of any Non-aqueous phase liquids (NAPLs). No measurable indications of NAPL were recorded within any of the groundwater monitoring wells.

Monitoring wells were purged and sampled using dedicated disposable bailers. A Quanta Hydrolab water quality meter was used to measure the physico-chemical water quality parameters *in situ* including:

- dissolved oxygen,
- total dissolved solids,
- conductivity,
- pH,
- redox,
- temperature
- pH

8.2 Results

In situ water quality parameters are summarised in Table 8-1.

- **Table 8-1 - Summary of intrinsic groundwater quality**

Location	Date	Depth to Water (m)	Well Depth (m)	Dissolved Oxygen (% sat)	Electric Conductivity (µS/cm)	Total dissolved solids (TDS)	Redox Potential (mV)	pH	Temp. (^{0}C)
GW01	19/03/14	6.24	9.59	68.8	25600	17.5	182	6.48	23.7
	30/09/14	6.33	9.50	62.6	27000	18.4	120	6.7	19.1
GW02	19/03/14	3.34	6.00	34	23000	15.6	141	6.55	21.5
	30/09/14	4.22	5.92	30.8	10350	7.0	108	6.9	17.7
GW03	19/03/14	3.78	8.13	32	25600	17.3	130	6.42	22.2
	30/09/14	3.50	9.10	39.6	27100	18.5	108	6.71	18
GW04	19/03/14	3.35	7.66	66	27350	17.3	133	6.44	21.8
	30/09/14	3.17	7.67	54.6	22500	15.3	79	6.7	18.1

It is evident that there were no dramatic changes in groundwater depth between measurement periods, with the exception of GW02 which dropped by around 1 metre. GW02 displayed a reduction in salinity and TDS from one sampling period to the next. GW02 is located within 3m (down gradient) of a sediment retention pond. The September 2014 monitoring event was the first monitoring round where the retention pond was observed to be completely dry. It is possible the water quality and recharge within GW02 was influenced by the retention pond given the proximity of the well to the pond.