HOLCIM

Rooty Hill Regional Distribution Centre
Environmental Monitoring
Annual Report 2010-11

August 2011

The ALS Water Sciences Group is part of the Environmental Division of ALS, one of the largest and most geographically diverse environmental testing businesses in the world.

CERTIFICATE OF APPROVAL FOR ISSUE OF DOCUMENTS

Client: HOLCIM
Project Title: Rooty Hill Regional Distribution Centre Environmental Monitoring
Report Title: Holcim Environmental Monitoring Annual Report, August 2011
Document No: CN212179-2011-001
Document Status: **Draft Report**
Comments:

	Position	Name	Signature	Date
Prepared by:	Consultant	Max Best		**July 2011**
Internal Review by:	Principal Consultant	Nimal Chandrasena		August 2011
Peer Review by:				
Approved by:	Principal Consultant	Danielle Baker		

For further information on this report, contact:

Name: Max Best
Title: Consultant
Address: 24a Lemko Place, Penrith NSW 2750

Document Revision Control

Version	Description of Revision	Person Making Issue	Date	Approval
1	Final Draft	Danielle Baker		

Ecowise Australia Pty Ltd trading as ALS Water Resources Group. ABN 94 105 060 320

The photo on the front cover (© ALS Water Resources Group) was taken on-site during ALS project work and is of the vulnerable Grevillea juniperina ssp. juniperina. Grevillea juniperina R. Br. was first collected 11 km NW of Prospect in October 1803 by George Caley and described by Robert Brown in 1810 (NSW OEH, 2011).

Table of Contents

List of Appendices

Table of Figures

List of Tables

1 Introduction

1.1 Background

HOLCIM (formerly CEMEX and Readymix) proposes to build and operate a Regional Distribution Centre (RDC) in Rooty Hill, in Western Sydney, NSW. The RDC would facilitate the logistics of receiving, blending and distributing bulk construction products, such as sand and aggregate. Raw materials would be transported to the site by rail, blended, and then transported in smaller loads, via the existing road network, to the Sydney market (Readymix, 2005).

The Rooty Hill RDC development includes:

- Storage silos for a range of building materials including sand and aggregate
- A concrete batching plant
- A concrete testing laboratory
- A conveyor system linking a rail unloading station with the storage facilities
- Bridges at two locations across Angus Creek
- Workshops, office buildings, weighbridges and truck parking

The proposed development was designated as a 'Major Project' under NSW State Environment Planning Policy, 2005. The development application for the RDC was approved in 2006, with conditions set out to minimise the Centre's impact on the local community and the environment (NSW Department of Planning, 2006).

The construction phase is expected to begin in late 2011 and take approximately 2 years to complete. Once operational, the proposed RDC would have the capacity to handle up to 4 million tonnes of construction materials per annum, and is proposed to operate 24 hours a day, 7 days a week. It is expected that the RDC facility would employ approximately 230 - 270 people at full production (Readymix, 2005).

After consultation and site feasibility inspections with Ecowise Environmental in 2008; the now Australian Laboratory Services (ALS) Water Resources Group was commissioned to conduct baseline monitoring of water quality, aquatic ecology, riparian vegetation and ambient air quality in the lead-up to construction. This report summarises the monitoring data collected to date and provides comment on significant results.

Additional soil investigation work was conducted as part of a university research task and is additional to the original scope of work. Results from this soil investigation are provided in Appendix 1 and may be useful in the preparation of soil and erosion management plans.

1.2 Monitoring Objectives

The objectives of this monitoring program have been to quantify environmental values of the RDC site, prior to the commencement of construction activities. The information gathered prior to construction provides a benchmark condition of key environmental characteristics, which can be used to assess any environmental changes that may occur as the construction and operation of the facility progresses.

The design of the monitoring program is essentially following a BACI approach (Before-After, Control-Impact). Data is currently being collected in the *Before* construction phase, for comparison with data collected *After* construction.

Control sites have also been established at locations upstream of the potential runoff effects of construction, to determine differences between these and the potential *Impact* sites, located downstream of the RDC site.

The information presented in this report can be used to set 'pre-construction', environmental baseline conditions. These can then be statistically compared to the 'construction' and 'post-construction' datasets to examine changes occurring as a result of activities on-site.

2 Methods

2.1 Monitoring Sites and Sampling Regime

Figure 1 illustrates the sampling locations for air quality, water quality and aquatic ecology.

Figure 1 - Air, water and aquatic ecology sample locations map (Source: Google Earth satellite imagery)

Six (6) water quality and aquatic ecology (AE) sites were monitored along local waterways (**Figure 1**). Four (4) of these sites were located on Angus Creek and two (2) were located on Eastern Creek. Sites AE6 and AE5 are located upstream of potential site runoff and can be considered 'control' sites.

Three (3) air quality sites were also monitored (**Figure 1**), two (2) within the proposed RDC site boundary and one (1) within the Blacktown Olympic Park grounds. High Volume Air Samplers (HVAS) collected samples from two (2) of the sites and depositional dust (DD) gauges collected samples from all three (3) sites.

Targeted riparian vegetation assessments were conducted at each of the AE sites in 2009. A broad vegetation assessment was also conducted within the RDC site boundary in 2010.

Table 1 presents site information and the frequency / timing of sample collection for each aquatic monitoring (AE) site.

Site information and sampling frequency for the air quality monitoring sites (HVAS and DD) are presented in **Table 2**.

The proposed number of sampling events per annum is presented, excluding samples missed due to equipment failure. All site location coordinates provided are relevant to the World Geodetic System, 1984.

Table 1 - Site information and sample timing for aquatic monitoring sites

Site Code	Location	Sample Type	Frequency / Timing	Latitude	Longitude
AE6	Angus Creek 500m upstream RDC	Surface Water	Quarterly	33.77207	150.84926
		Aquatic Ecology	Spring 2009 and 2010 Autumn 2009 and 2011		
		Riparian Vegetation	Sept. And Nov. 2009		
AE1	Angus Creek at upstream boundary of RDC	Surface Water	Quarterly	33.76806	150.85173
		Aquatic Ecology	Spring 2009 and 2010 Autumn 2009 and 2011		
		Riparian Vegetation	Sept. And Nov. 2009		
AE2	Angus Creek at downstream boundary of RDC	Surface Water	Quarterly	33.76519	150.85497
		Aquatic Ecology	Spring 2009 and 2010 Autumn 2009 and 2011		
		Riparian Vegetation	Sept. And Nov. 2009		
AE3	Angus Creek 150m-downstream of RDC culvert	Surface Water	Quarterly	33.76490	150.85567
		Aquatic Ecology	Spring 2009 and 2010 Autumn 2009 and 2011		
		Riparian Vegetation	Sept. And Nov. 2009		
AE4	Eastern Creek downstream of Angus Creek confluence	Surface Water	Quarterly	33.76360	150.85655
		Aquatic Ecology	Spring 2009 and 2010 Autumn 2009 and 2011		
		Riparian Vegetation	Sept. And Nov. 2009		
AE5	Eastern Creek upstream of Angus Creek confluence	Surface Water	Quarterly	33.76434	150.85748
		Aquatic Ecology	Spring 2009 and 2010 Autumn 2009 and 2011		
		Riparian Vegetation	Sept. And Nov. 2009		

2.2 Ambient Air Quality Monitoring

Total Suspended Particulate matter (TSP) was monitored at the two HVAS sites (**Table 2**). Depositional dust in the form of Total Insoluble Matter was measured at all three Depositional Dust Gauges (DDGs).

2.2.1 TSP sampling using HVASs

All sampling and analysis for the measurement of TSP was conducted in accordance with the relevant Australian Standards; AS/NZS 3580.9.3 (2003).

HVAS calibration is required every two months and was performed on-time by field staff, to ensure units were operating effectively and conforming to the required flow rate. HVAS - TSP analysis was performed at the ALS Mudgee Laboratory.

Table 2 - Site descriptions and sample regime for air quality monitoring sites

Site Code	Sample Type	Frequency	Ideal # events p.a.	Latitude	Longitude
HVAS1	HVAS – TSP	Every 6 days	61	33.76539	150.85437
DD1	Depositional Dust	Monthly	12		
HVAS2	HVAS – TSP	Every 6 days	61	33.76934	150.76934
DD2	Depositional Dust	Monthly	12		
DD3	Depositional Dust	Monthly	12	33.76793	150.85411

2.2.2 Depositional Dust using DDGs

All sampling and analysis for the measurement of depositional dust, was conducted according to the relevant Australian Standards; AS/NZS 3580.10.1 (2003). Samples were collected as close as possible to the first day of each month.

Any potential contamination of the sample was noted on a field sheet. Common contaminants include insects, bird droppings and vegetation. Depositional dust sample analysis was undertaken at the ALS Mudgee Laboratory.

2.2.3 Air quality assessment guidelines

HVAS and DDG results were evaluated against the air quality goals outlined by the NSW DECCW and against the statement of commitments in the Director Generals Environmental Assessment Report (NSW Department of Planning, 2006). The specific air quality goals are given in **Table 3**.

Table 3 - NSW Department of Planning air quality guidelines

Pollutant	Averaging period	Concentration guideline
TSP - HVAS	Annual	90 µg/m^3
Total insoluble matter - DDG	Annual	4 grams/m^2/month
	max. increase	2 grams/m^2/month

2.3 Water Quality Monitoring

Water quality data was collected *in-situ*, using a fully calibrated water quality multi-probe; and *ex-situ*, through laboratory analysis of water samples. Water sampling was conducted during base flow conditions at all AE sites four times each year.

2.3.1 *In-situ* physical and chemical measurements

A fully calibrated Hydrolab multi-probe water-quality instrument was used to measure the following parameters in-situ at each site. Measurements were taken from just below the water surface in areas where water was flowing (if applicable).

The following parameters were measured in the field:

- pH
- Dissolved oxygen
- Temperature
- Electrical conductivity

2.3.2 Water quality sampling and ex-situ laboratory analysis

All water sampling was conducted in accordance with the Australian/New Zealand standards for water quality sampling (AS/NZS S667:1:1998). Samples were collected in the appropriate bottles and subject to the preservation techniques appropriate for the analysis required.

The following analytes were measured through ex-situ analysis of water samples at Ecowise/ALS laboratories in Canberra, and later, in the local laboratory at Smithfield, Sydney.

- Total Nitrogen (TN)
- Total Phosphorus (TP)
- Total alkalinity
- Turbidity

2.3.3 Water quality assessment guidelines

Water quality data were evaluated against the ANZECC (2000) guidelines for aquatic ecosystems of south-east Australian lowland rivers, depicted in **Table 4** below.

Table 4 - ANZECC (2000) aquatic ecosystem guidelines

Parameter	Abbreviation	Units	ANZECC (2000) guidelines
Electrical Conductivity	EC	µS/cm	125 - 2200
Dissolved Oxygen	DO	% sat	85 - 110
pH	pH	pH units	6.5 - 8.0
Total Nitrogen	TN	mg/L	0.5
Total Phosphorous	TP	mg/L	0.05
Turbidity	Turb.	NTU	50

2.4 Aquatic Macroinvertebrate Sampling

Macroinvertebrate sample collection, processing and habitat assessment was undertaken in strict accordance with the NSW AUSRIVAS Sampling and Processing Manual (Turak et al., 2004). Analyses were performed using both AUSRIVAS and SIGNAL2 (Chessman, 2003) methods.

Freshwater macroinvertebrate samples were collected from 10m of suitable edge habitat at each of the six AE sites, using nets with 250 µm mesh size. Samples were collected during the designated AUSRIVAS sampling seasons of 2009 (spring and autumn), 2010 (spring only), and 2011 (autumn, spring pending).

2.4.1 Macroinvertebrate sample processing

Macroinvertebrate sampling involved 'live' sorting of the collected material for a minimum of 40 minutes by experienced AUSRIVAS accredited aquatic ecologists. Samples were preserved in 100% methylated spirits and clearly labelled with all appropriate information. Samples were transported to the ALS Brisbane and Sydney laboratories for identification to family level using microscopy.

2.4.2 Data analysis

Macroinverebrate data was interpreted using the following two published techniques.

- SIGNAL2 (Stream Invertebrate Grade Number Average Level) - Version 2, unweighted
- AUSRIVAS (Australian River Assessment System) - NSW separated spring and autumn

2.4.3 Macroinvertebrate data interpretation

Interpretation of the macroinvertebrate data requires an understanding of a spectrum of interrelated environmental and ecological variables. As such, the data interpretations outlined below provide an initial perspective of the data, with further detail available through close examination of other aspects of the dataset, including: aquatic habitat, water quality, community composition and hydrology.

The macroinvertebrate data assessment criteria are split between the SIGNAL2 and AUSRIVAS analysis techniques. SIGNAL2 outputs include the SIGNAL2 score and number of macro-invertebrate taxa represented. AUSRIVAS outputs include the OE50 score (Observed to Expected above 50% confidence) and an associated band indicating the level of ecological impairment.

SIGNAL2 outputs are visualised and interpreted using a bi-plot separated into four distinct quadrats, indicating different habitat and water quality conditions. The quadrat boundaries vary with geographic region and habitat type and some intuitive judgement is required to define these for the current investigation. An example of the SIGNAL2 bi-plot is provided in **Figure 2**.

AUSRIVAS outputs can be interpreted using the banding scheme, which is classified by the OE50 outputs. AUSRIVAS band descriptions and the OE50 thresholds used to classify these bands for the NSW-edge-autumn and NSW-edge-spring models are presented in **Table 5**.

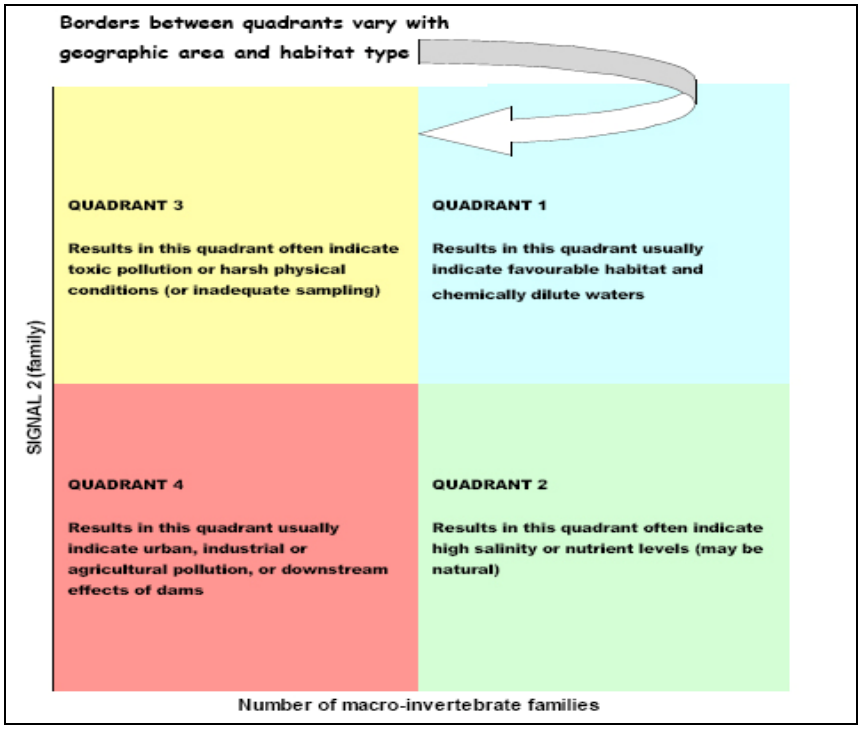


Figure 2 - Example of SIGNAL2 bi-plot for interpreting macroinvertebrate data

Table 5 - AUSRIVAS band descriptions and OE50 thresholds

Band Label	Band Name	OE50 upper limit	Comments
Band X	More biologically diverse than reference sites	Infinity	More taxa found than expected. Potential biodiversity hot-spot. Possible mild organic enrichment.
Band A	Reference condition	1.16	Most/all of the expected families found. Water quality and/or habitat condition roughly equivalent to reference sites. Impact on water quality and habitat condition does not result in a loss of macroinvertebrate diversity.
Band B	Significantly impaired	0.83	Fewer families than expected. Potential impact either on water quality or habitat quality or both, resulting in loss of taxa.
Band C	Severely impaired	0.51	Many fewer families than expected. Loss of macroinvertebrate biodiversity due to substantial impacts on water and/or habitat quality.
Band D	Extremely impaired	0.19	Few of the expected families remain. Extremely poor water and/or habitat quality. Highly degraded.

2.5 Vegetation Assessments

Records of riparian vegetation were collected during 2009 along transects perpendicular to the waterway, both upstream and downstream of all water quality (AE) sites.

In late 2010, a broad vegetation assessment was conducted to map the vegetation community groups present onsite and assign some contextual value to those groups.

The 2010 survey involved traversing the site using a handheld GPS/GIS unit to record significant observations. The traverse route concentrated around the heavily-vegetated 'forested' areas, and avoided the disturbed grassland areas around the centre of the site. The riparian vegetation (within 25 m of the creek) was also not targeted, as this had been previously assessed in 2009.

Point, line and area features were collected to describe the vegetation observed. Line and area features were used to represent obvious community boundaries. Point observations were then used to depict significant observations and individual trees outside the mapped community boundaries.

The majority of vegetation identification was conducted on-site, with some identification made from collected specimens. All GIS information was differentially corrected and edited to produce a map of the significant vegetation within the RDC site.

Vegetation community value was assigned arbitrarily by the perceived ecological and legislative significance of the community.

2.6 Aquatic Habitat Assessments

Specific observations of aquatic and riparian habitat were made during each aquatic ecology sampling event. Summarised descriptions for each creek are provided in **Appendix 2**

Descriptions of sites included visual estimates of streambed composition (percentage of total for each substrate category), amount/type of in-stream organic material, and basic riparian vegetation characteristics.

The width, depth and general geomorphologic characteristics were also recorded at each site. A plan and cross sectional map were drawn at each sample event to identify key habitat and morphological features.

Field sheets containing field data were retained, and can be provided on request.

2.7 Additional Soil Investigations

Local soil landscape information was sourced from Hazelton, Bannerman & Tille (1989), and was overlaid on a base map (**Figure 3**) sourced from Google Earth (2010) to provide an overview of the potential soils that could be expected in the area.

Hazelton, Bannerman & Tille (1989) identified two soil landscapes occurring within the study area: the fluvial *South Creek* soil landscape, occurring in close proximity to existing local water courses; and the residual *Blacktown* soil landscape, overlying Wianamatta Group geology and occurring away from recent fluvial processes.

Investigation of soil at the site was also performed at four locations marked in **Figure 3** below. Information from the in-situ soil investigation and descriptions of the *Blacktown* and *South Creek* soil landscapes, are provided in **Appendix 5**.

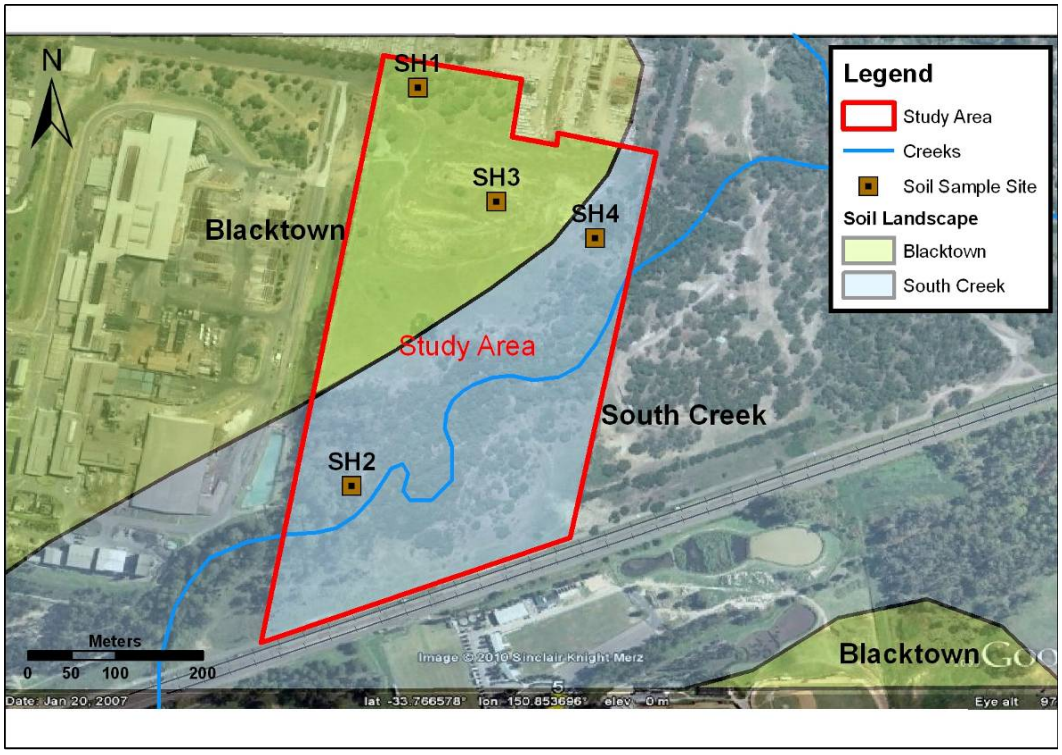


Figure 3 - Soil landscape map (modified from Hazelton, Bannerman & Tille, 1989)

3 Results and Discussion

This section presents results of the environmental monitoring that commenced in February/March 2009. Information on air quality, water quality, aquatic ecology and vegetation is presented and discussed below.

Additional summary information is provided in **Appendix 1** and aquatic habitat information is provided in **Appendix 2**.

3.1 Air quality

Results from High Volume Air Samplers (HVAS) and Depositional Dust (DD) gauges are presented in **Table 6** and **Table 7** below. Tables contain the mean and standard error (indicated in brackets), along with the number of samples.

3.1.1 TSP

All TSP data collected to date are provided in **Table 6**. HVAS2 data are illustrated in **Figure 4**.

Only six (6) valid TSP samples were collected at HVAS1 site in early 2009, before a critical power outage prevented any further sampling at this site. The mean TSP here was 32.5 µg/m^3.

One hundred and thirty nine (139) samples were collected from HVAS2 between February 2009 and June 2011, with a mean of 38.6 µg/m^3 for all data. The 2010 data for HVAS2 represents the only full annual dataset of January 2010 to December 2010, with only one sample missed.

The 2009 data represents all months except January 2009, before sampling began; and the 2011 data represents January to June 2011. All mean values calculated were well below the recommended guideline level of 90 µg/m^3.

Table 6 - Mean Total Suspended Particulates (TSP) at HVAS1 and HVAS2 – 2009 to 2011

Site	Dataset	Mean TSP µg/m3 (and SE)	no. samples
HVAS1	**All data**	**32.5 (±3.6)**	**6**
HVAS2	**All data**	**38.6 (±1.6)**	**139 (of 146)**
HVAS2	2009 only	39.9 (±2.5)	51 (max. 61)
HVAS2	2010 only	35.1 (±2.0)	60 (max. 61)
HVAS2	2011 only	43.9 (±4.5)	28 (max. 61)
Guideline = 90µg/m3 (annual average)			

TSP at HVAS2 varied between a maximum of 117 µg/m^3 (25th of February 2011), and a minimum of 8.7 µg/m^3 (3rd of October 2009), with large variations week to week (**Figure 4**).

The dust storm of September 23rd 2009 was not specifically recorded by HVAS2, as the event occurred over non-sample days (closest samples were on 21st of September and 3rd of October).

Weather and local site specific events are likely to be the main sources for the variability in the dataset.

3.1.2 Depositional dust

All depositional dust results collected to date are provided in **Table 7**.

Data from each of the sites are also illustrated in **Figure 5**, **Figure 6** and **Figure 7**, along with a 12 month rolling average.

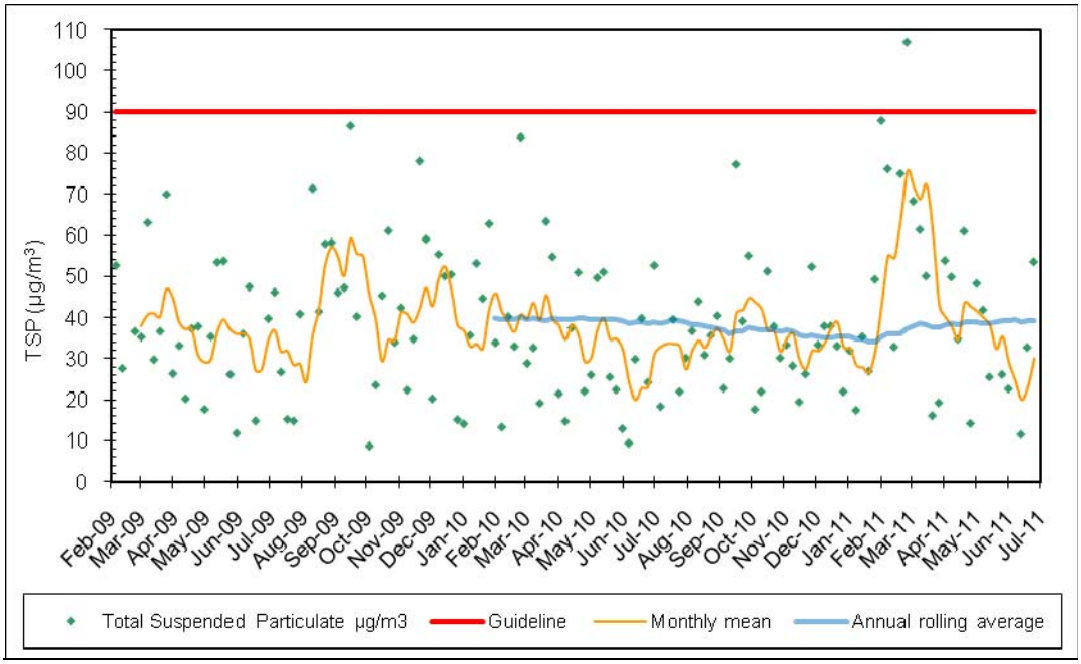


Figure 4 - Total Suspended Particulates (TSP) at HVAS2 site - Feb. 2009 to Jun. 2011

Table 7 - Mean deposited insoluble matter and ash content at all DDGs – 2009 to 2011

Site	Dataset	Total insoluble matter ($g/m^2/mnth$)	Mean ash content (% as decimal)	Samples collected (n)
DD1	**All data**	**1.7** (0.2)	**0.70** (0.02)	**27**
	2009	1.6 (0.4)	0.72 (0.02)	10
	2010	1.8 (0.2)	0.69 (0.04)	12
	2011	1.6 (0.4)	0.68 (0.05)	5
DD2	**All data**	**2.4** (0.3)	**0.65** (0.03)	**28**
	2009	2.2 (0.4)	0.70 (0.02)	10
	2010	2.6 (0.5)	0.63 (0.04)	12
	2011	2.1 (0.5)	0.60 (0.11)	6
DD3	**All data**	**2.2** (0.3)	**0.68** (0.02)	**26**
	2009	2.3 (0.6)	0.70 (0.02)	9
	2010	2.3 (0.3)	0.68 (0.03)	12
	2011	2.0 (0.4)	0.63 (0.05)	5
Guideline = $4g/m^2$/month (annual average), $2g/m^2$/month max. increase				

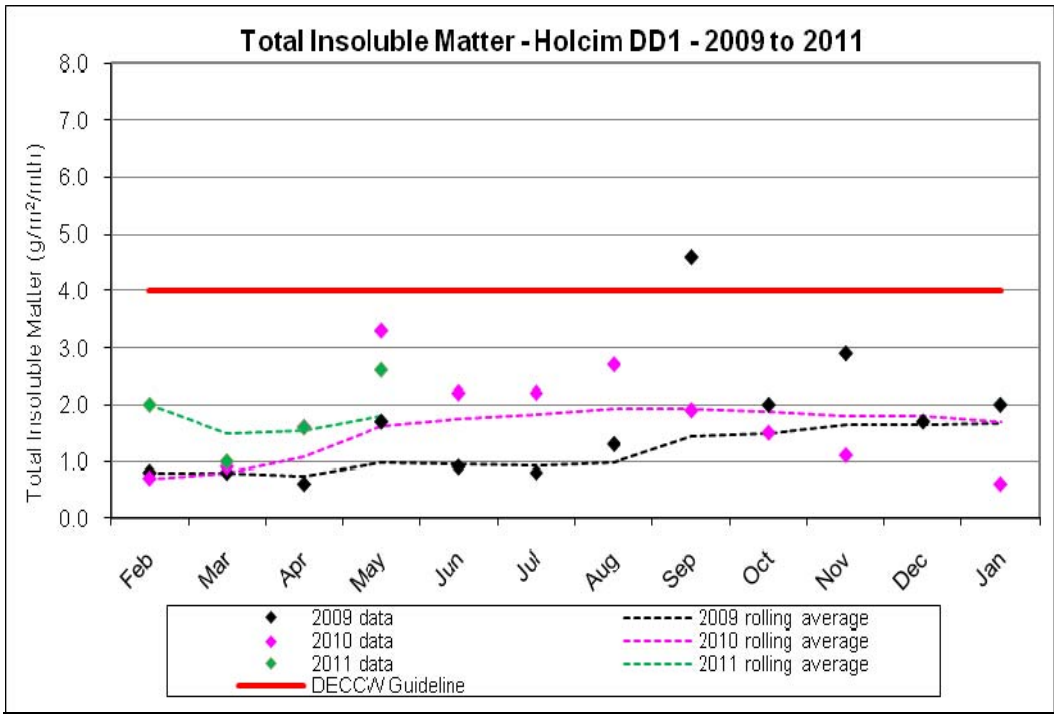


Figure 5 - Total Insoluble Matter DD1

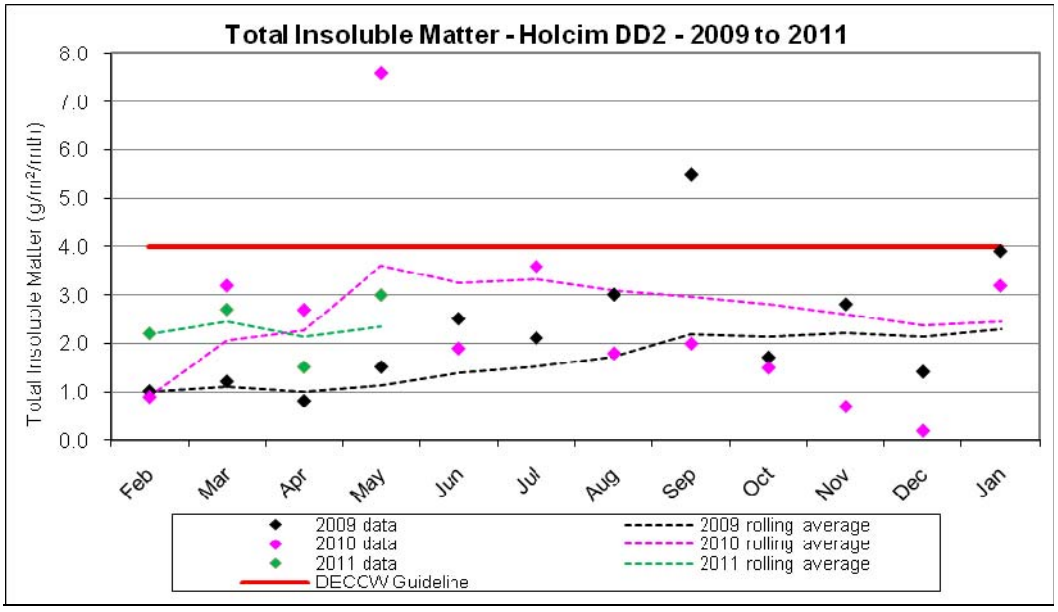


Figure 6 - Total Insoluble Matter DD2

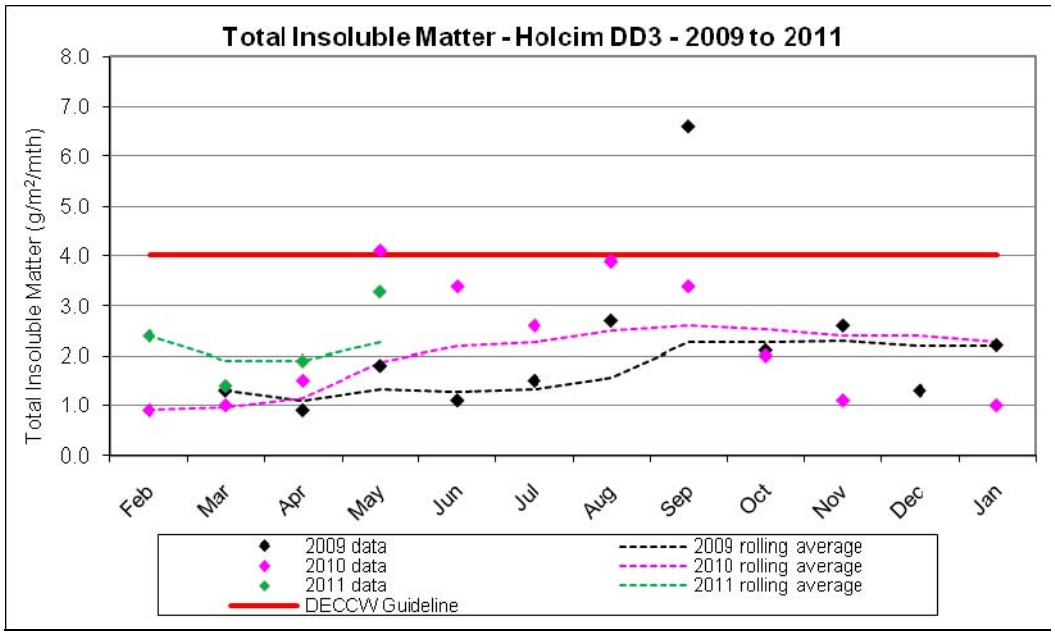


Figure 7 - Total Insoluble Matter DD3

Table 7 shows DD1 with the lowest mean deposited dust results (1.7 g/m²/month). DD3 results (2.2 g/m²/month) were slightly lower than those of DD2 on average (2.4 g/m²/month). The ash content of the samples was similar across the sites, with DD1 recording the highest (70% ash) and DD2 the lowest (65% ash). All mean values calculated were well below the recommended guideline level of 4 g/m²/month.

Figure 5, Figure 6 and **Figure 7** show all depositional data for each site and the 12 month rolling averages. The highest and lowest depositional dust measurements, 7.6 and 0.2 g/m²/month, respectively, were both recorded at the DD2 site.

The dust storm that passed over Sydney in September 2009 corresponds with a peak in depositional dust at all three sites for that month.

Contamination was recorded in the form of insects and vegetation at all sites on numerous occasions. Site DD2 was recorded as being contaminated on the most occasions, with bird droppings also noted on several visits. This and the location of the DD2 site, which is close to the train line and playing field, and next to a large light pole are likely to explain the slightly higher readings at this site.

In contrast, DD1 and DD3 are located in more sheltered, vegetated areas, and accordingly recorded less contamination.

3.2 Rainfall

Rainfall data for the nearby Horsley Park meteorological station is displayed in **Figure 8**, with all water quality and aquatic macroinvertebrate samples collected, recorded with red and green marks.

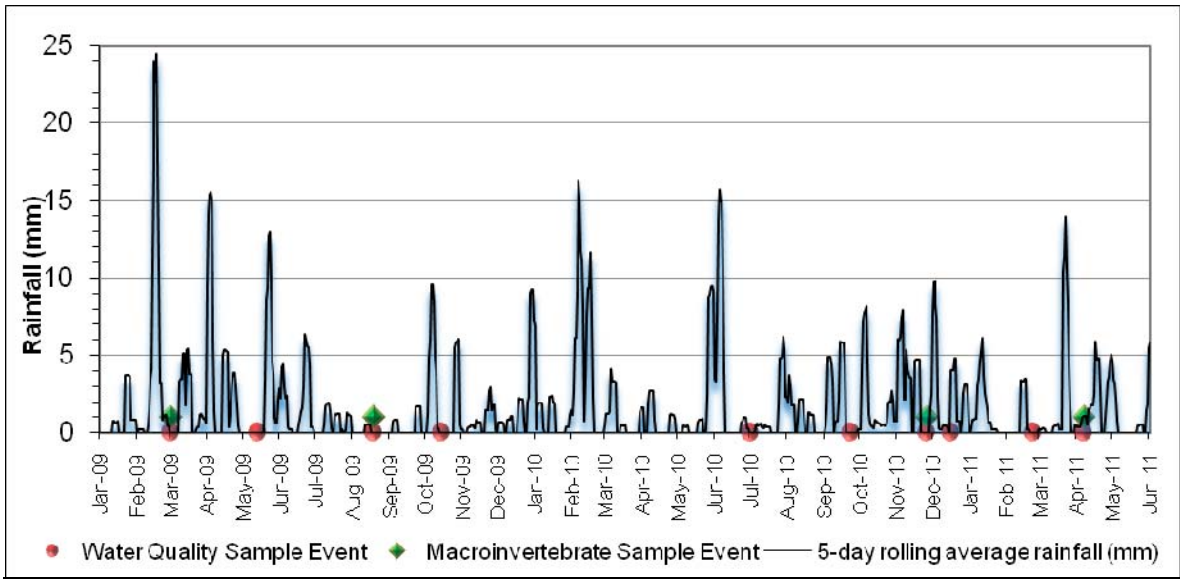


Figure 8 - Rainfall at Horsley Park meteorological station (BOM, 2011), and aquatic sampling events

All water sampling was conducted during low flow periods, as illustrated by the sample times corresponding with low rainfall in **Figure 8**.

Macroinvertebrate and water quality sampling was missed in autumn 2010, although was picked up from July, with macroinvertebrate sampling resuming in late spring 2010.

3.3 Water quality

The mean and standard error for each water quality parameter collected to date at each site are presented in **Appendix 1**.

Data for each individual analyte are illustrated in the 'Box and Whisker plots' in **Figure 9** to **Figure 12** below, and allow comparison of the range of data at each site.

- In these plots, the sites are arranged in downstream order, with Angus Creek sites representing the first four boxes (AE6, AE1, AE2 and AE3) and Eastern Creek the last two (AE5 and AE4).
- The solid box represents 50% of the results (25th and 75th percentile, interquartile range) with the 'whiskers' protruding from the boxes going out to the smallest and largest values.
- Additional data points outside this range are defined as 'outliers', and are indicated as green circles. These points are those that extend more than 1.5 box-lengths from the edge of the box.
- Extreme data points (indicated by red circles) are those that extend more than 3 box lengths from the edge of the box.
- The line inside the rectangle is the Median value.

The alkalinity of Angus Creek is significantly higher at all sites than that of Eastern Creek (**Figure 9**). Some slight decline in alkalinity is apparent moving downstream on Angus Creek. Alkalinity at AE4 (Eastern Creek downstream of the confluence with Angus Creek) is slightly higher and more variable than AE5.

The elevated alkalinity in Angus Creek is likely to occur naturally due to the local soil characteristics. During rainfall and associated soil infiltration, dissolution of carbonate (marine origin soil) produces carbonate ions (CO_3^{-2}), which contribute to the surface water alkalinity.

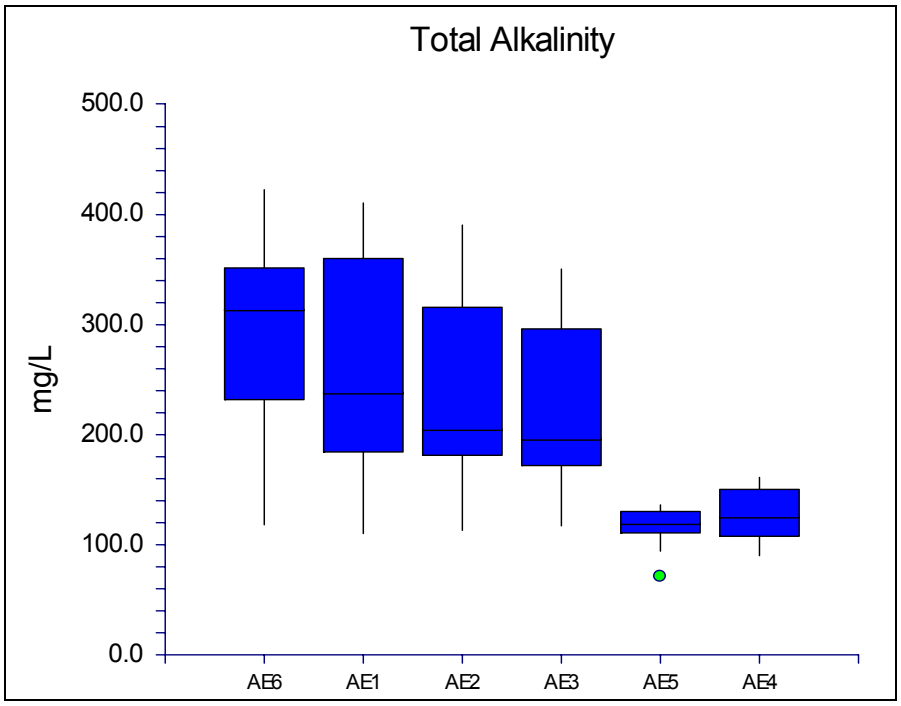


Figure 9 - Box and whisker plot of Total Alkalinity at each site - 2009 to 2011

The pH of both creeks was generally basic (>7 pH units), and within the range of 8 and 6.5 units provided in the ANZECC (2000) guidelines for the protection of aquatic ecosystems (**Table 4**). Basic water and minimal variation in pH throughout the monitoring is likely due to high alkalinity, which provides a capacity to buffer against acidic influences.

Electrical Conductivity (EC) shows a marked decline moving downstream on Angus Creek (**Figure 11**), with site AE6 recording the highest value of 6714 µS/cm on the 14th of May, 2009. This was much higher on average than the EC of Eastern Creek, which fell within the ANZECC (2000) guideline of between 125 and 2200 µS/cm at both sites.

EC is a proxy measure of the ionic constituent concentrations present in the water (the salinity). High EC upstream on Angus Creek may indicate some groundwater influence, with reductions potentially caused by freshwater interflow, and/or the precipitation/utilisation of ionic constituents in transit downstream.

Turbidity was significantly elevated in Eastern Creek (**Figure 12**), with most measurements above the upper ANZECC (2000) guideline of 50 NTU. Angus Creek on the other hand had most values around the lower guideline of 6 NTU, with only one extreme outlier at AE2.

Turbidity provides a measure of the light scattering potential of the water and is indicative of the suspended solids load. High turbidity and suspended solids in Eastern Creek is potentially a result of poor sediment and erosion control practices in development upstream.

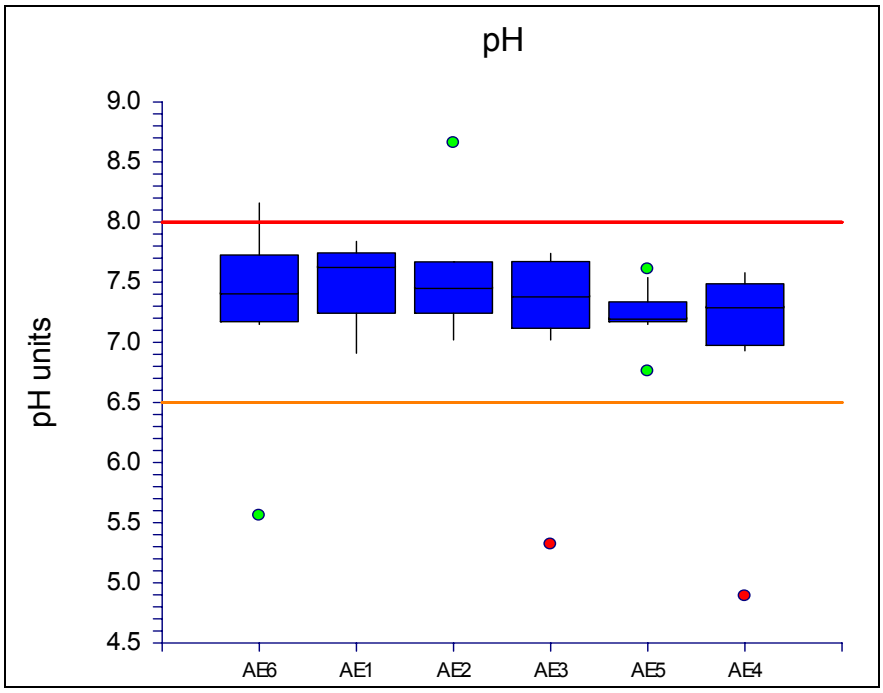


Figure 10 - Box and whisker plot of pH at each site - 2009 to 2011

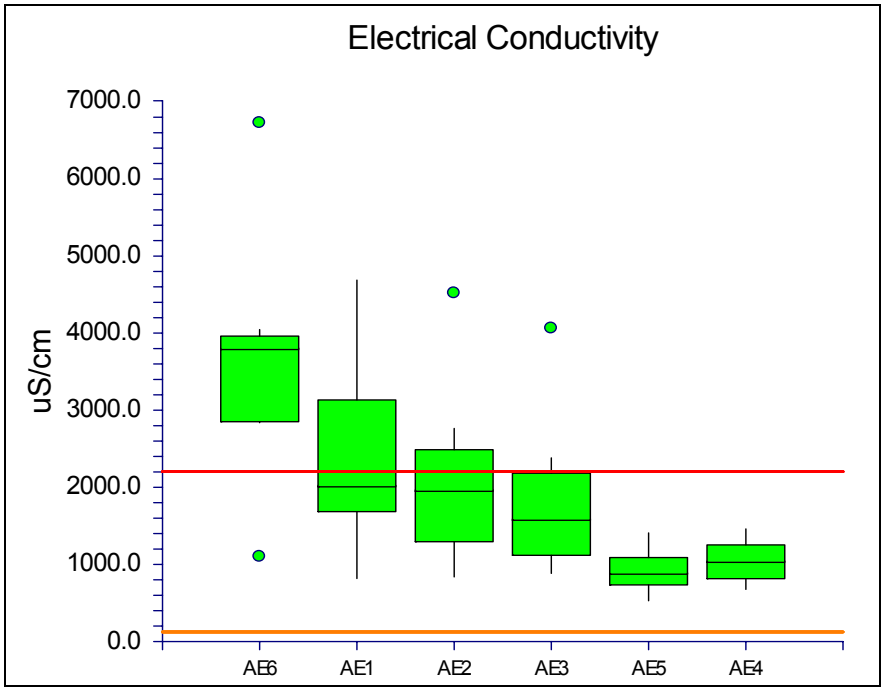


Figure 11 - Box and whisker plot of EC at each site - 2009 to 2011

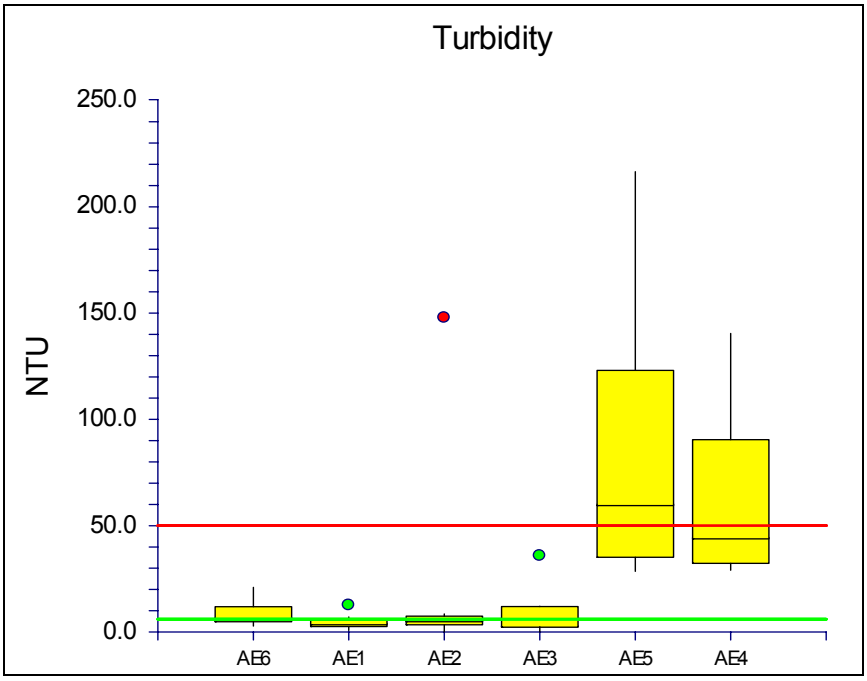


Figure 12 - Box and whisker plot of Turbidity at each site - 2009 to 2011

Dissolved oxygen at all sites along both creeks was below the lower ANZECC (2000) guideline of 85% saturation (**Figure 13**). Site AE6 recorded one supersaturated measurement which may have been related to high algae or aquatic plant photosynthesis. AE6 had a higher density of aquatic plants than other sites and the stream was more exposed to sunlight here than elsewhere along Angus Creek.

Nitrogen levels at all sites were high, with the highest measurements coming from the Eastern Creek sites (**Figure 14**). Total nitrogen concentrations in both creeks exceeded the ANZECC (2000) guideline of 0.5 mg/L for most samples collected at all sites. Total phosphorus was also elevated across all sites and exceeded the ANZECC (2000) guideline of 0.05 mg/L on most occasions (**Figure 15**). Maximum total phosphorus concentrations (1.3 and 1.1 mg/L) were recorded at sites A1 and AE2 on Angus Creek on the 23rd of February 2011.

High nutrient concentrations and low dissolved oxygen were recorded at all sites. A high rate of microbial respiration, fed by excess nutrient loading, leads to the depletion of available dissolved oxygen. These conditions are referred to as eutrophic and are indicative of the heavily urbanised catchment with a high input of pollutants, generally from diffuse sources.

Creek Water Quality Summary

Angus Creek exhibited high alkalinity (>250 mg/L) and electrical conductivity (>3000 µS/cm), which decreased significantly moving downstream and may indicate groundwater influences. The high alkalinity may be explained by local soil characteristics through the dissolution of carbonates. Precipitation and sorption of various ions (Na^{+}, Ca^{2+}, Mg^{2+}) and metals such as aluminium and iron (iron precipitate observed along Angus Creek) is potentially contributing to the reduced electrical conductivity. Relatively fresh water from sub-surface interflow may also be a significant contributor to decreasing electrical conductivity, originating from slow drainage of the soils.

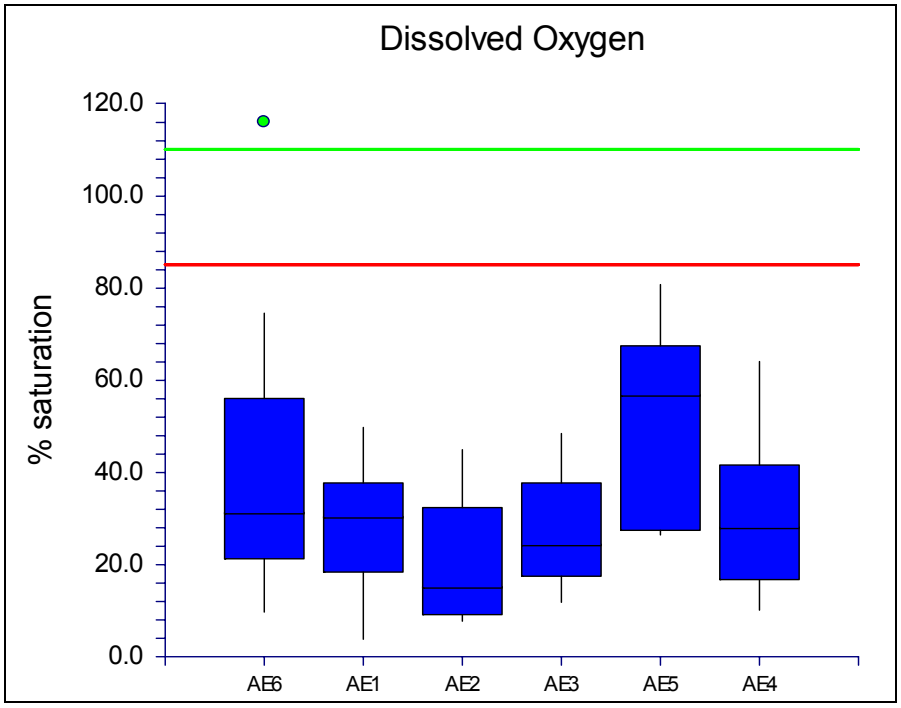


Figure 13 - Box and whisker plot of Dissolved Oxygen at each site - 2009 to 2011

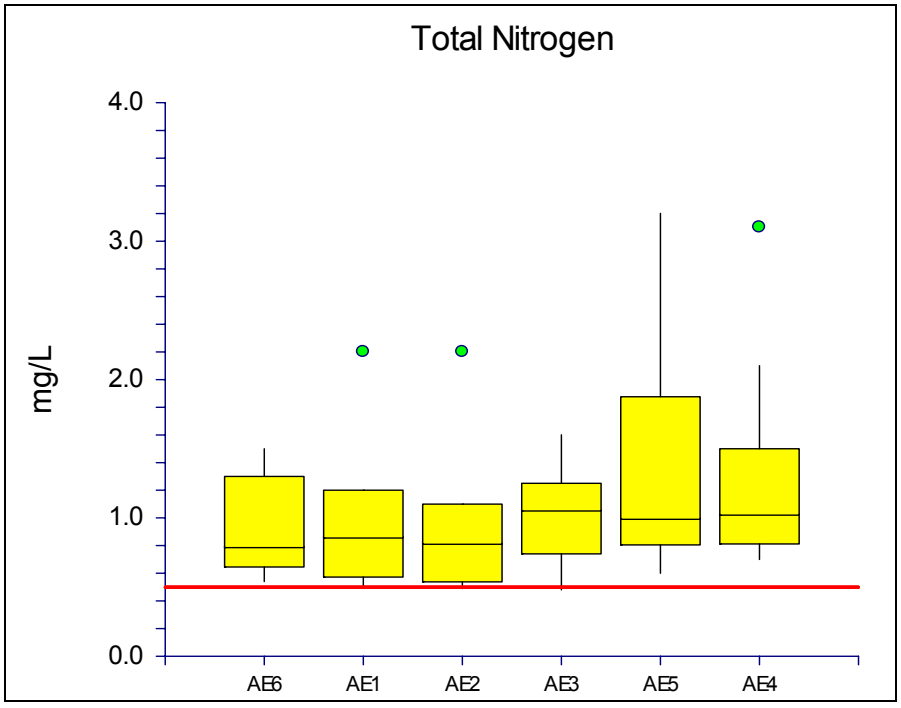


Figure 14 - Box and whisker plot of Total Nitrogen at each site - 2009 to 2011

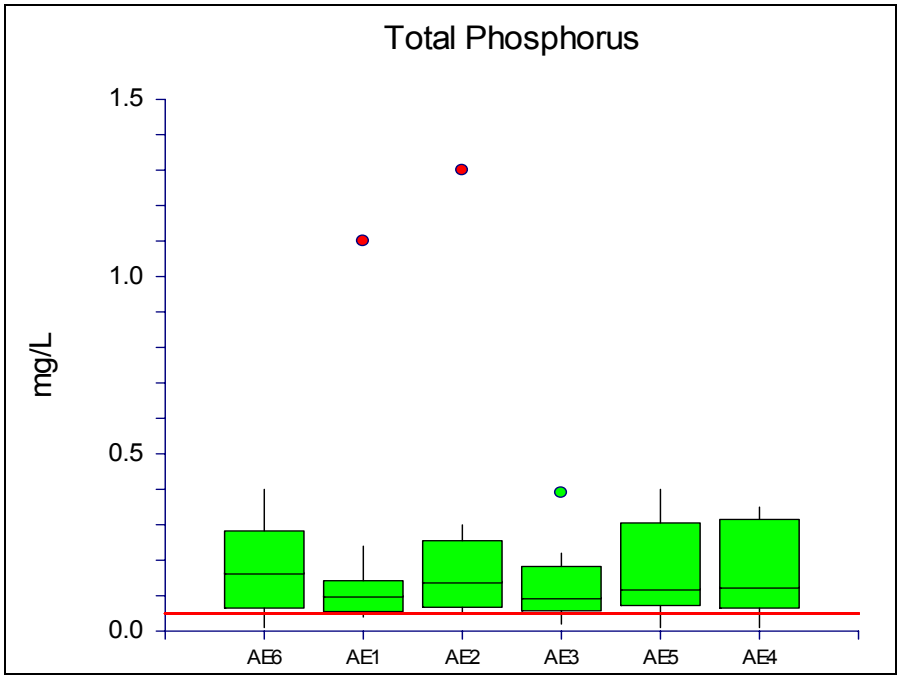


Figure 15 - Box and whisker plot of Total Phosphorus at each site - 2009 to 2011

Eastern Creek had a much higher suspended solids load than Angus Creek, as seen in the higher turbidity (commonly >50 NTU) on all sampling occasions. Most parameters measured at the sites upstream and downstream of the Angus Creek confluence showed only minor differences. This indicates little dilution influence of Eastern Creek during the low flow conditions sampled. Different results are likely to be obtained during rainfall/high flow events, when the majority of discharge and contaminant mass is accounted for.

Photo 1 – Small algae bloom in Angus Creek

Photo 2 – Eastern Creek channel

3.4 Macroinvertebrate Ecology

The macroinvertebrate data collected to date is summarised below in **Figure 16** by the AUSRIVAS OE50 scores and in **Figure 17** by SIGNAL2 scores.

Summary statistics of the AUSRIVAS outputs, SIGNAL2 scores are also presented in **Appendix 1**.

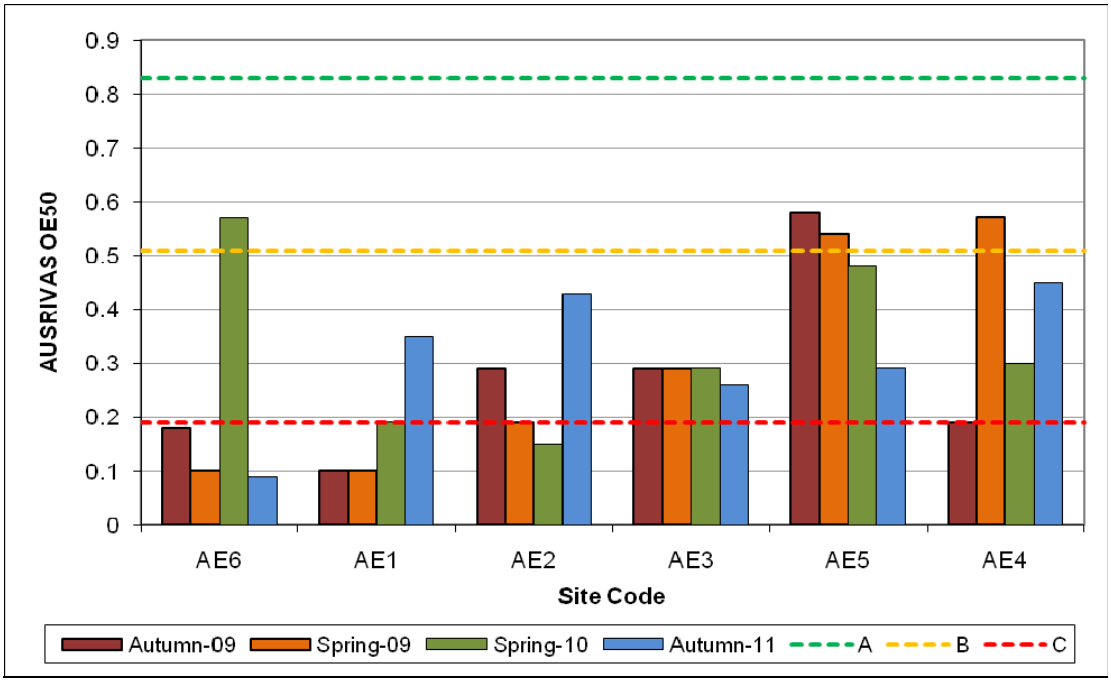


Figure 16 - AUSRIVAS OE50 scores for all sample events at all sites - 2009 to 2011

The sites are again arranged in downstream order in **Figure 16**, with Angus Creek the first four sites (AE6, AE1, AE2 and AE3) and Eastern Creek last two (AE5 and AE4). All samples collected during the monitoring period were well below the *Band A* threshold, indicating less macroinvertebrate taxa observed than expected at an undisturbed site. Most of the samples collected also fall below the thresholds for *Band B* and *Band C*, indicating severe to extreme ecological impairment.

The aquatic macroinvertebrate community appears healthier at the Eastern Creek sites than at the Angus Creek sites at first glance (**Figure 16**). This observation is confirmed by the mean AUSRIVAS OE50 scores for each site, which are provided in **Appendix 1**. Site AE5 (upstream Eastern Creek) scored the highest overall OE50 score (0.47 – *Band C*), while site AE1 on Angus Creek (upstream boundary of RDC site) scored the lowest (0.19 – *Band D*).

Aquatic habitat characteristics are important for interpreting the AUSRIVAS outputs, as the OE50 scores are indicative of the number of taxa predicted to occur under certain habitat conditions. Alkalinity, substrate and stream length, were the habitat variables used for the AUSRIVAS model, which differed most between the sites.

In the case of alkalinity, some values recorded for Angus Creek were outside the experience of the AUSRIVAS model and were reduced to produce outputs. This issue adds increased uncertainty to the outputs, and needs to be considered in future comparisons with the dataset.

Poor water quality, altered flow regimes and aquatic habitat characteristics are likely to be the main drivers of stream health degradation seen in both Angus Creek and Eastern Creek.

Both waterways have heavily urbanised catchments which contribute to the poor aquatic health and this is generally communicated through the model outputs.

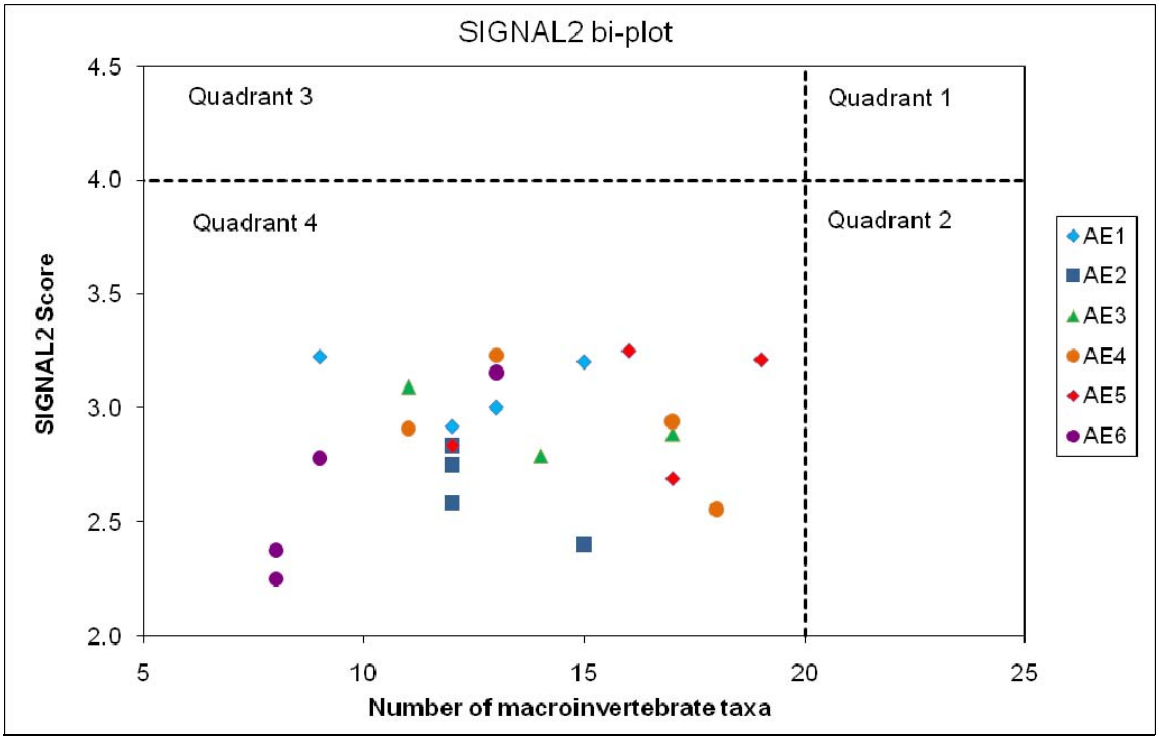


Figure 17 – Bi-plot of SIGNAL2 scores and taxa found for all sample events and sites - 2009 to 2011

SIGNAL2 scores are calculated through a measure of the pollution sensitivity of the organisms collected in each sample. The bi-plot diagram (**Figure 17**) allows visualisation of the SIGNAL2 scores alongside a measure of macroinvertebrate diversity, indicated by the number of taxa on the horizontal axis.

SIGNAL2 scores for all sites were scattered across quadrant 4, which is indicative of significant water pollution at all sites (Chessman, 2003). Differences between the sites are not immediately obvious, although the more extreme points at the bottom-left and top-right corners indicate some grouping.

The poorest scoring site was AE6 on Angus Creek, with fewest macroinvertebrate taxa generally observed and SIGNAL2 scores often below 2.5. The highest scoring site for both SIGNAL2 scores and taxa diversity was AE5 on Eastern Creek (**Figure 17**).

Low dissolved oxygen and high nitrogen and phosphorus across all sample sites (**Section 3.3**), are indicative of the eutrophic and highly polluted nature of both creeks. These, and a range of other water quality characteristics, are causing the absence of pollution sensitive organisms, and in turn, affect the SIGNAL2 scores characterising each site.

The differences in water quality between the two creeks, in terms of alkalinity, EC and turbidity, may explain the marginal differences between the sites observed in the bi-plot (**Figure 17**).

Different aquatic habitat, water quality and hydraulic regimes will also affect macroinvertebrate diversity, and this also is represented in the range of macroinvertebrate taxa observed. Eastern Creek prevailed with this indicator with over 60% of samples obtaining >15 SIGNAL2 taxa, as opposed Angus Creek with less than 10%.

Pollution sensitive taxa such as Ephemeroptera (Mayflies) and Tricoptera (Caddisflies) were found in the eastern creek samples much more regularly than in the Angus Creek samples. These organisms have a higher SIGNAL2 value and increase the score given to the site in which they are found.

3.5 Aquatic Habitat

Full aquatic habitat descriptions are provided in **Appendix 2**, with a summary of the key characteristics of each creek provided below.

- The **Angus Creek** aquatic habitat was relatively simplistic, with homogenous silt and some small pebbles constituting the substrate. Few detritus retaining woody snags were present, with the impacts of high flow velocities evident from soured stream banks. Average stream width was about 1 metre and centre depths ranged from very shallow to over 1 metre in the deeper pools. Banks were generally steep and around 1-2 m high, mostly covered with dense weeds to within a short distance from the water's edge.
- The **Eastern Creek** aquatic habitat was also impacted by the heavy urbanisation of the upstream catchment. Heavy silt plumes were indicative of the fine substrate coating the streambed. The in-stream habitat contained a higher proportion of woody debris than Angus Creek, and areas of outcropping boulders on the stream bends also differentiated the Eastern Creek habitat. The stream width was about 10 m at the sites sampled, with bank height and stream depth also greater than that of Angus Creek.

3.6 Vegetation

Several endangered communities and an associated vulnerable species were recorded within the site and will require appropriate investigation, management and rehabilitation in accordance with relevant statutory legislation, this being the *Commonwealth EPBC Act, 1999*, and the *NSW TSC Act, 1995*. A newly published **Cumberland Plains Recovery Plan** should be used to guide rehabilitation, a summary of which is provided in **Appendix 3**).

The vegetation community characteristics of the site, surveyed in 2010, are illustrated in **Figure 18**, with an ecological value assigned to provide context to the findings.

Notes on key observations of the survey are provided below, with numbers corresponding to those on the map (**Figure 18, pg. 25)**. Significant plant species found during the vegetation assessments conducted to date are given in **Table 8**.

1. The critically Endangered Ecological Community (EEC) - **Cumberland Plains Woodland** exists on the site in the areas marked with a **1.** The community consists of a tree cover of predominantly, *Eucalyptus amplifolia*, *E. moluccana* and other unidentified *Eucalyptus* spp. closer to the riparian boundary. The native tree Kurrajong, *Brachychiton populneus*, was also noted to occur sparsely in the canopy.

The understorey consists predominantly of *Bursaria spinosa* with *Acacia parramattensis* and *Acacia decurrens* also prominent in the shrub layer. The ground cover consists of a variety of grasses, herbs and small shrubs, including *Themeda australis*, *Dichondra repens*, *Lissanthe strigosa*, *Wurmbea dioica* and *Dichopogon fimbriatus*.

This vegetation community contains high quality habitat for native fauna, with many large hollow bearing trees present. A wide range of native mammalian fauna also inhabit the canopy vegetation within this community including numerous species of microbat (Threlfall et al., 2010).

Various birds, reptiles and invertebrates have also been noted on the site within this vegetation assemblage during the ongoing monitoring. Several introduced mammals were noted during field visits, most significantly the European Red Fox (*Vulpes vulpes*) which appeared to have a den complex to the southwest of the HVAS1 site.

The Cumberland Plains Woodland Community is degraded by various woody, perennial and annual weeds including: *Freesia* sp., *Ligustrum lucidum* and *L. sinense*, *Jasmine polyanthum*, *Asparagus asparagoides*, *Sida rhombifolia* and numerous other species to a lesser extent.

Photo 3 – Cumberland Plain Woodland observed on the northwest of Angus Creek

Photo 4 - Carcass of a White Ibis (*Threskiornis molucca*) with European Red Fox (*Vulpes vulpes*) scat

2. Fifteen (15) individuals of *Grevillea juniperina* ssp. *juniperina* were observed on the north side of the creek (indicated by red stars on the map), and seven (7) individuals were observed on the south side of the creek. Most plants were juveniles, clustered around one and several mature plants (south and north respectively). These plants are listed as **vulnerable** under the NSW Threatened Species Act (1995). The *G. juniperina* on the north side of the creek are close to the current location of the HVAS1 and DD1 dust monitors. The plants of the south side are clustered around the fence line that separates the site from Nurrigingy Reserve.
3. An area of *Eucalyptus amplifolia* woodland also exists on the north western corner of the site in the location marked with a **2**. The vegetation community value of this area was of lesser quality than the main bulk of the Eucalyptus dominated community in the centre of the site. This was due to its disconnection with other woodland vegetation and a weedier understory. The understorey in this area had a high proportion of introduced grasses, mainly *Chloris gayana*. Large mature trees were not present at this location either, indicating more recent regrowth, which provides limited fauna habitat.
4. An area dominated by *Casuarina glauca* exists on the north eastern side of the site, on low ground close to the creek line, indicated with a **3** on the map. This area borders the large patch of *Grevillea juniperina* and should be retained where possible as a buffer for the endangered plant population and as a riparian buffer for the nearby creek. Some minor clearing of his area was performed to provide the power line to the HVAS1 site.
5. Patches of land to the south of the creek (**4**) contain stands of native grasses (primarily *Thermeda australis*), that are of moderate conservation value and should be retained where possible as buffering and potential regrowth area for the existing woodland community. Other small patches of native grasses also exist along the border of the woodland community further to the west, although these were not adequately mapped during the field visit. Generally, the grassland on the north side of the railway line was heavily weed

infested within 20 m of the railway access road and improved towards the woodland community. Swampy ground existed around the **4** mark and in some depressions along the southern boundary of the woodland community. These areas contained a variety of aquatic plants including juvenile *Melaleuca decora*, *Casuarina* sp., *Myriophyllum* sp., *Persicaria decipens* and *Paspalum dilatatum*.

6. The large expanse of grassland around the middle of the site (**Photo 5**), marked with a **5**, contains predominantly introduced annual grasses, including *Chloris gayana*, *Briza minor* and numerous other weeds. This area and the area along the railway corridor were determined to be of low conservation value in its current state.

7. The riparian vegetation along the creek line (**6**) was heavily degraded (**Photo 6**), as noted in the assessments made last year. The community was dominated by a thick canopy of *Ligustrum* spp. and an understory of *Tradescantia fluminensis*. A multitude of other weed species also made up the understorey of this community.

   Some native tree cover was present in the form of scattered specimens of *Melaleuca* spp., *Casuarina* spp. and various *Eucalyptus* spp. Some native understory plants (e.g. *Viola hederacea* and *Lomandra* sp.), and aquatic plants (e.g. *Potomogeton pectinatus*) were also observed at various locations. This riparian vegetation community was considered to be of moderate to high value in terms of its function in bank stabilisation, buffering and as riparian habitat, yet had a reduced ecological value in terms of vegetation diversity.

   The riparian vegetation assemblage observed bears resemblance to the pre-existing and endangered EEC - **River-Flat Eucalypt Forest on NSW Coastal Floodplains**, albeit with a heavily modified, weedy shrub layer and ground cover (**Photo 6**).

Photo 5 – Exotic grasses through the centre of the open land within the RDC site

Photo 6 – Degraded River-Flat Eucalyptus Forest along Angus Creek

Table 8 - Significant plant species found during the 2009 riparian vegetation assessment

Scientific Name	Common Name	Observed	Significance/Comments
Rare/Vulnerable/Endagered Plants[1]			
Grevillia juniperina	Grevillia	see Figure 18	Rare plant Listed by TSC Act[1] as 'Vulnerable'
Declared Plants[2, 3]			
Bryophyllum delagoense	Mother of millions	AE2	Noxious Weed[2] Class 3
Cortaderia selloana	Pampas Grass	AE2	Noxious Weed[2] Class 3
Ageratina adenophora	Croftons Weed	AE5	Noxious Weed[2] Class 4
Olea europea	European Olive	AE5	Noxious Weed[2] Class 4
Opuntia stricta	Prickly Pear	AE2	Noxious Weed[2] Class 4
Ligustrum lucidum	Broadleaf Privet	All AE sites	Noxious Weed[2] Class 4
Ligustrum sinense	Small leaf privet	All AE sites	Noxious Weed[2] Class 4
Rubus fruiticosus	Blackberry	AE2, AE3	Noxious Weed[2] Class 4
Myrsiphyllum asparagoides	Bridal Creeper	All AE sites	Noxious Weed[2] Class 5
Romulea rosea	Onion Grass	AE6	Noxious Weed[2] Class 5
Sonchus oleraceus	Sowthistles	AE6	Noxious Weed[2] Class 5

[1] **NSW Threatened Species Act, 1995**

[2] **NSW Noxious Weed Act, 1993, database query for the Blacktown LGA**

[3] **Weed of National Significance, NSW Noxious Weed Act, 1993**

Figure 18 - Map of site vegetation and ecological values

4 Summary of Significant Results

Significant findings of the environmental assessments conducted to date are outlined below.

4.1 Air Quality

- **HVAS1** has not been operational since 2009. Only six (6) samples were collected with an average TSP of 32.5 µg/m^3, which is well below the guideline level of 90 µg/m^3.
- **HVAS2** has collected 139 samples since site inception in February 2009, with an average TSP of 38.6 µg/m^3. This is also well below the 90 µg/m^3 guideline.
- **DD1** has collected 27 months of depositional dust data, with a mean of 1.7 g/m^2/month.
- **DD2** has collected 28 months of depositional dust data, with a mean of 2.4 g/m^2/month.
- **DD3** has collected 26 months of depositional dust data, with a mean of 2.2 g/m^2/month.
- All depositional dust gauge annual means were below the maximum allowable guideline value of 4 g/m^2/month. The maximum increase in annual mean permitted is 2 g/m^2/month.

4.2 Water Quality

- Elevated alkalinity and electrical conductivity were noted at the upstream Angus Creek sites and generally decreased moving downstream. This may be due to the influence of groundwater and/or water percolation through calcified/reactive soils.
- High turbidity was observed in Eastern Creek, indicative of the high suspended solids load. This may be due to erosion and/or poor sediment control at construction sites upstream.
- Both sites had consistently high nitrogen and phosphorus concentrations and low dissolved oxygen, indicative of eutrophic conditions and their degraded urban catchments.

4.3 Aquatic Ecology

- The **AUSRIVAS** model produced results in Band B, C and D for both creeks, indicating moderate to extreme degradation of the aquatic ecosystem.
- **SIGNAL2** values were also consistently low across all sites sampled. Macroinvertebrate diversity was low, particularly in the Angus Creek samples, where only pollution tolerant taxa remained.
- Angus creek sites generally scored poorly compared to the Eastern Creek sites, despite similarities in habitat characteristics.
- Differences in water quality and hydrology are likely to be the main factors influencing the macroinvertebrate communities observed, with habitat characteristic also playing a role.

4.4 Vegetation

- Ecologically significant vegetation is present on site in the form of the critically Endangered Ecological Community (EEC): **Cumberland Plain Woodland**. This EEC at the site is degraded by various herbaceous weeds in the understorey; yet retains many of the native species described in the assemblage, including the vulnerable *Grevillea juniperina*.
- The riparian vegetation resembles the pre-existing **River-Flat Eucalypt Forest on NSW Coastal Floodplains** community, which is also listed as an EEC), and is covered under the Cumberland Plains Recovery Plan.

4.5 Aquatic Habitat

- The aquatic habitat of both creeks was heavily degraded by the impacts of urbanisation. Abundant quantities of gross pollutants were observed and some degree of bank scouring was noted at both sites. Algae blooms were observed in both creeks on several occasions.

4.6 Soil

Soil investigations were undertaken outside the scope of work for this project and are presented in **Appendix 5**. The following provides a summary of the significant results.

- Two soil landscapes were described within the site by the NSW Soil Conservation Service (Hazelton, Bannerman & Tille, 1989). These include the fluvial South Creek soil landscape, occurring in close proximity to existing local water courses; and the residual Blacktown soil landscape.
- Soil investigations noted characteristics of both soil landscapes, with the South Creek soil characteristics restricted slightly closer to Angus Creek than the inferred boundaries defined on the NSW Soil Conservation Service soil map.
- Development limitations associated with the **Blacktown** soil landscape, covering the majority of the site, include moderately reactive highly plastic subsoil, low soil fertility and poor soil drainage (Bannerman & Hazelton, 1990). Shrink-swell soil was also noted by the movement of the concrete foundation of the HVAS1. Cracking of the upper soil layers was also observed.
- Development limitations associated with the **South Creek** soil landscape include erosion hazard and frequent flooding (Bannerman & Hazelton, 1990).

5 Conclusions and Key Recommendations

Conclusions and key recommendations arising from the monitoring are given below:

Air Quality

- Relocate the HVAS1 site to ensure power supply is not interrupted for future sampling. Guidelines on site selection are available in the Australian Standard guide to siting air monitoring equipment (AS/NZS 3580.1.1:2007). Consultation is recommended on the location and sampling logistics of the new HVAS1 site.
- Consider the implementation of PM10 (particulate matter <10 µm) air quality monitoring to quantify air quality in terms of fine particulate matter. Fine particulate matter is often considered more harmful to human respiration than coarse particles, due to its ability to penetrate further and become lodged in the lungs.
- Control wind erosion through the inclusion of this source of pollution in the soil and erosion control plan. Best management practice should be employed to control dust emission from the site during construction.
- Guideline documents sourced from local councils in the area are provided in **Appendix 4** and provide specific advice on a range of air pollution topics. Contact with Blacktown Council should be made regarding this issue.
- Commission make-up runs for all future HVAS samples that are missed, due to equipment failure. This would result in a more complete and robust air quality dataset.

Water Quality

- Develop and implement a Water Management Plan to assist in the mitigation of further environmental degradation of local waterways that may be caused by the construction and operation of the RDC facility.
- In managing impacts on the local waterways, it would be necessary to adopt the ANZECC (2000) Guidelines for maintenance of waterways and protection of aquatic ecosystems.
- Conduct water sampling during high flow events to categorise the pre-construction stormwater quality, particularly in terms of the suspended solids load. Sampling of this nature would need to be conducted urgently to produce some baseline data, considering the short timeframe before construction is expected to start. Sampling would also depend on the occurrence of rain between now and the start of construction.
- Investigate groundwater characteristics. Baseline data on groundwater is currently limited and requires investigation to quantify both quality and water level. Through this and routine ongoing monitoring, potential changes to local groundwater can be assessed.
- Catchment management action to target pollution sources. Consultation with local catchment management authorities, local government and the local community will increase understanding and emphasis of total catchment management, specifically within the Angus Creek catchment.
- Erosion and spill control measures should be adopted under the Water and Soil Management Plans. Guidelines sourced from local councils have been provided in **Appendix 4** and will assist with water pollution mitigation. Limiting vegetation loss, appropriate revegetation and soil stabilisation measures will assist greatly in this area.

Aquatic and Terrestrial Ecosystems

- Developer licences and National Parks/Office of Environment and Heritage consultation will be required for construction works on site, due to the presence of Endangered Ecological Communities. It is understood that this process is currently taking place.

- As a primary environmental objective, construction should aim to protect and maintain the native vegetation assemblages present on site. Vegetation communities present include the EECs River-flat Eucalypt Forest, and Cumberland Plains Woodland. Both are likely to be adversely impacted, unless mitigation measures are taken.
- If any of the construction work is of the magnitude that it is likely to have any negative impacts or vegetation clearing is required, the impacts should be ameliorated through the production and implementation of a Native Vegetation Management Plan.
- Further vegetation work should focus on developing a full spatial inventory of the flora present on-site, and assessing changes to the vegetation that may result from construction and operation of the RDC facility. This would include targeted vegetation surveys of the areas expected to be cleared or impacted during construction.
- Bush regeneration and rehabilitation work, implemented under an approved plan by a qualified operator who has experience working with the EECs present on the site.
- Any clearing of vegetation will require close consultation with the regulatory agencies and understanding of the current condition of the impacted zones. Further approvals may be sought before undertaking any clearing.
- Minimise habitat fragmentation. The construction of bridges over Angus Creek, fences and other obstacles associated with construction work will lead to fragmentation of aquatic and terrestrial habitat.
- Habitat fragmentation should be limited where possible and regeneration of land to offset losses should be appropriately located. Consideration should also be made for the passage for fauna where fragmentation has occurred.
- Consider feral animal control. The presence of feral animals could be managed through controlled eradication. Baiting for foxes could be investigated to reduce the impact of these on native animals.
- The use of multivariate data analysis techniques on macroinvertebrate data is recommended for future analysis. This will help to identify longer term trends and define variation/similarities between sites.

Soil

- Initiate detailed soil investigations of the site and from this, produce and implement a Soil Management Plan. The Soil Management Plan should consider the spatial distribution of soil landscape characteristics and associated environmental constraints to development.
- Potentially reactive sub-soils may be present and this aspect of the soil could lead to runoff water quality issues if exposed and uncontained.
- Shrink-swell soils where present, will require appropriate foundations to be constructed for any proposed structure.
- High erosion potential along the creek line will need to be mitigated if vegetation removal is proposed.

Other

- Implement a system to record all major developments in the construction and operation phases of the facility. This information will be valuable in interpreting results of the ongoing environmental monitoring.
- Continue the environmental monitoring through the construction and operation phases of the development of the site. Consultation with ALS should be undertaken to identify areas where additional value could be added to the current monitoring. Specific aspects have been identified in the points above.
- Set standards based on the values and range of variation of the baseline monitoring conducted to date. These values could be used as the reference condition on which goals and long term standards can be set.
- At a minimum, the baseline condition of the environment should not be degraded further from the reference values as a result of onsite activities.

6 References

ANZECC, 2000, *Australian and New Zealand Guidelines for fresh and marine water quality*, National Health and Medical Research Council

Bannerman, S.M. and Hazelton, P.A., 1990, *Soil Landscapes of the Penrith 1:100 000 Sheet*, Soil Conservation Service of NSW, Sydney.

Chessman B., 2003, SIGNAL *2 – A Scoring System for Macro-invertebrate ('Water Bugs') in Australian Rivers*, Monitoring River Heath Initiative Technical Report no 31, Commonwealth of Australia, Canberra.

Commonwealth Government, 1999, *Environmental Protection and Biodiversity Conservation Act 1999*

Department of Environment, Climate Change and Water (2008), *NSW Scientific Committee - final determination on the Cumberland Plain woodland - endangered ecological community listing*, Accessed Dec 2010, <http://www.environment.nsw.gov.au/determinations/CumberlandPlainWoodlandEndComListing.htm>

Hazelton, P.A., Bannerman, S.M. and Tille, P.J., 1989, *Penrith 1:100 000 Soil Landscape Sheet 9030*, Soil Conservation Service of NSW, Sydney.

Jones, D.C., and Clark, N.R., (Eds), 1991, *Geology of the Penrith 1:100 000 Sheet*, New South Wales Geological Survey, Sydney.

NSW Department of Planning, 2006, *Major Project Assessment: Regional Distribution Centre, Director General's Environmental Assessment Report*, NSW Department of Planning.NSW Government, 1995, *NSW Threatened Species Conservation Act 1995*

NSW Government, 1995, *New South Wales Threatened Species Act, 1995*

NSW OEH, 2011, Grevillea *juniperina subsp. juniperina (a shrub) - vulnerable species listing*, Accessed July 2011 http://www.environment.nsw.gov.au/determinations/GrevilleaJuniperinaVulSpListing.htm

Readymix, 2005, *Community Newsletter Issue 3, Holcim Australia*, viewed 6 April 2010, <http://www.holcim.com.au/AU/EN/id/1610662241/mod/6/page/holcimweb/page/editorial.html>

Standards Australia, 1998, Australian*/New Zealand standards for water quality sampling (AS/NZS S667:1:1998)*

Standards Australia, 2003, *Australian/New Zealand standards for sampling and analysis of ambient air: suspended particulate matter (AS/NZS 3580.9.3:2003)*

Standards Australia, 2003, *Australian/New Zealand standards for sampling and analysis of ambient air: depositional dust (AS/NZS 3580.10.1:2003)*

Threlfall, C., Law, B., Penman, T. And Banks, P.B. (2010) *Ecological processes in urban landscapes: mechanisms influencing the distribution and activity of insectivorous bats*, Ecography – in press.

Turak, E., Waddell, N., and Johnstone G., 2004, *NSW AUSRIVAS sampling and processing manual*, NSW Department of Environment and Conservation.

Appendix 1 – Summary of Results

Average water quality results (and standard error) for all sites and all years

Analyte	Alkalinity	Mean TN	Mean TP	Mean Temp	Mean pH	Mean EC	Mean DO	DO %	Mean Turb.
Units	**mg/L**	**mg/L**	**mg/L**	**˚C**	**pH units**	**µS/cm**	**mg/L**	**% saturation**	**NTU**
AE6	**297 (±28)**	**0.9 (±0.1)**	**0.18 (±0.09)**	**16.5 (±0.4)**	**7.3 (±0.2)**	**3614 (±443)**	**4.2 (±1.1)**	**41 (±11)**	**9 (±2)**
2009	291 (±31)	0.7 (±0.1)	0.12 (±0.10)	15.2 (±0.6)	7.7 (±0.2)	4163 (±876)	6.2 (±2.4)	60 (±22)	11 (±4)
2010	362 (±26)	1.2 (±0.2)	0.24 (±0.12)	16.5 (±0.8)	7.0 (±0.5)	3889 (±62)	3.0 (±0.6)	28 (±3)	9 (±2)
2011	180 (±62)	1.0 (±0.2)	0.18 (±0.40)	19.1 (±0.1)	7.4 (±0.2)	1966 (±867)	2.2 (±1.3)	24 (±14)	5 (±2)
AE1	**262 (±31)**	**1.0 (±0.2)**	**0.20 (±0.23)**	**15.8 (±0.4)**	**7.5 (±0.1)**	**2380 (±360)**	**2.9 (±0.5)**	**28 (±4)**	**5 (±1)**
2009	291 (±50)	0.9 (±0.2)	0.09 (±0.04)	14.7 (±0.6)	7.6 (±0.1)	2973 (±731)	3.3 (±0.5)	32 (±4)	3 (±1)
2010	291 (±41)	0.8 (±0.2)	0.12 (±0.13)	15.7 (±0.8)	7.5 (±0.2)	2396 (±235)	3.6 (±1.1)	33 (±8)	4 (±1)
2011	147 (±37)	1.5 (±0.6)	0.57 (±0.70)	18.4 (±0.2)	7.4 (±0.3)	1164 (±349)	1.0 (±0.7)	11 (±7)	10 (±3)
AE2	**232 (±28)**	**0.9 (±0.2)**	**0.26 (±0.23)**	**16.0 (±0.4)**	**7.5 (±0.1)**	**2073 (±324)**	**2.1 (±0.5)**	**20 (±4)**	**19 (±14)**
2009	248 (±48)	0.6 (±0.1)	0.10 (±0.07)	14.8 (±0.6)	7.4 (±0.1)	2375 (±727)	1.9 (±0.7)	18 (±6)	4 (±2)
2010	255 (±43)	0.9 (±0.2)	0.17 (±0.14)	15.7 (±0.8)	7.8 (±0.3)	2125 (±311)	3.3 (±1.0)	29 (±7)	5 (±1)
2011	153 (±40)	1.6 (±0.5)	0.74 (±0.65)	19.0 (±0.2)	7.4 (±0.2)	1364 (±526)	0.8 (±0.1)	9 (±1)	78 (±70)
AE3	**219 (±24)**	**1.0 (±0.1)**	**0.13 (±0.10)**	**16.4 (±0.3)**	**7.2 (±0.2)**	**1799 (±290)**	**2.8 (±0.5)**	**27 (±4)**	**8 (±3)**
2009	226 (±41)	1.0 (±0.2)	0.09 (±0.06)	15.4 (±0.6)	7.4 (±0.1)	2009 (±687)	3.2 (±0.7)	31 (±6)	5 (±3)
2010	242 (±40)	1.1 (±0.2)	0.14 (±0.09)	16.3 (±0.7)	6.9 (±0.6)	1830 (±273)	3.1 (±1.1)	28 (±8)	11 (±8)
2011	160 (±43)	1.0 (±0.2)	0.21 (±0.41)	18.8 (±0.2)	7.4 (±0.3)	1319 (±439)	1.7 (±0.5)	18 (±5)	7 (±5)
AE5	**116 (±6)**	**1.4 (±0.2)**	**0.18 (±0.10)**	**16.6 (±0.4)**	**7.2 (±0.1)**	**900 (±82)**	**5.2 (±0.8)**	**51 (±6)**	**81 (±19)**
2009	119 (±9)	2.0 (±0.4)	0.22 (±0.17)	15.0 (±0.7)	7.2 (±0.0)	994 (±140)	5.5 (±1.3)	53 (±11)	103 (±42)
2010	125 (±4)	1.1 (±0.2)	0.19 (±0.16)	17.0 (±0.9)	7.2 (±0.2)	891 (±129)	5.7 (±1.6)	54 (±12)	58 (±15)
2011	94 (±23)	0.8 (±0.2)	0.08 (±0.25)	19.3 (±0.3)	7.4 (±0.2)	732 (±204)	4.0 (±1.7)	43 (±16)	83 (±48)
AE4	**126 (±7)**	**1.3 (±0.2)**	**0.17 (±0.10)**	**16.7 (±0.4)**	**7.1 (±0.3)**	**1061 (±83)**	**3.2 (±0.7)**	**30 (±5)**	**60 (±12)**
2009	123 (±11)	1.8 (±0.4)	0.21 (±0.17)	15.2 (±0.7)	7.3 (±0.1)	1180 (±162)	3.0 (±0.8)	29 (±7)	91 (±23)
2010	140 (±9)	1.0 (±0.1)	0.17 (±0.15)	16.9 (±0.9)	6.7 (±0.6)	1044 (±91)	3.9 (±1.8)	35 (±14)	40 (±6)
2011	107 (±17)	0.8 (±0.1)	0.09 (±0.27)	19.2 (±0.4)	7.2 (±0.2)	855 (±179)	2.5 (±1.0)	26 (±10)	39 (±6)

OE50 AUSRIVAS outputs with mean and standard error for each site

Site	AE6	AE1	AE2	AE3	AE5	AE4
Autumn-09	0.18	0.10	0.29	0.29	0.58	0.19
Spring-09	0.10	0.10	0.19	0.29	0.54	0.57
Spring-10	0.57	0.19	0.15	0.29	0.48	0.30
Autumn-11	0.09	0.35	0.43	0.26	0.29	0.45
MEAN	0.24	0.19	0.27	0.28	0.47	0.38
SE	0.09	0.05	0.05	0.01	0.05	0.06

SIGNAL2 outputs with mean and standard error for each site

Site	AE6	AE1	AE2	AE3	AE5	AE4
Autumn-09	2.78	2.92	2.75	2.79	2.69	3.23
Spring-09	2.25	3.20	2.58	2.79	3.25	2.56
Spring-10	3.15	3.22	2.40	2.88	3.21	2.94
Autumn-11	2.38	3.00	2.83	3.09	2.83	2.91
MEAN	2.64	3.08	2.64	2.89	3.00	2.91
SE	0.16	0.06	0.07	0.06	0.11	0.11

Appendix 2 – Aquatic Habitat Descriptions

Angus Creek

The natural aquatic habitat in Angus Creek (**Photo 7**) was severely restricted by the stresses of a heavily urbanised catchment. Large amounts of gross pollutants occurred within the stream and on riparian vegetation and snags, including general litter, car batteries and vehicle parts. Anoxic sediment odour and the presence of algae blooms indicated poor submerged habitat conditions. Iron precipitate was observed in several areas seeping out of banks, and as build-up in slow moving water.

High peak flows were evident and have removed some in-stream edge habitat and littoral vegetation, with limited detritus and large woody debris available for biological activity. It is highly probable that peak flows are a result of the extent of catchment imperviousness and extensive stormwater interconnectivity, due to the intensive urban land use within the catchment.

Minimal stream bank and trailing vegetation and debris were present at most sites. Some submerged and emergent vegetation was present, although this was generally sparse. A moderate amount of in-stream vegetation was present at site AE6 compared top other sites, possibly due to a lower percentage cover of canopy and overstory vegetation at this site.

The substrate in Angus Creek was primarily silt and clay with limited sand and some areas of pebble and gravel build-up. The banks of the creek were generally steep and around 1-2m high. The width of the creek varied between 0.5-5 m, with a mean width of around 1 m.

Eastern Creek

The aquatic habitat in Eastern Creek was similarly disturbed by the impacts of urbanisation. Large amounts of gross pollutants were observed, as well as significant algae blooms, covering large sections of the waterway. The most obvious difference between the two creeks was the consistently low water visibility due to high suspended solids in Eastern Creek (**Photo 8**), and a larger quantity of large woody debris.

High peak flows and some erosion was evident, with little vegetation present with 1 m of the waterline. Large woody debris generally remained in the channel, as well as a thick layer of Casuarina needles in some areas. No submerged macrophytes were observed in the creek and these were likely to be sparse, because of limited light penetration of the waters surface.

The substrate in Eastern Creek was difficult to observe due to high turbidity, yet high silt/clay content was evident from sediment plumes during macroinvertebrate sampling. Some large boulders were also noted protruding from the water at various places in the channel.

The channel width in this section of the Eastern Creek was about 6-12 m, with an average of approximately 10 m. The banks were higher and steeper than those of Angus Creek, being closer to 4 m high.

Photo 7 - Habitat typical of Angus Creek

Photo 8 - Habitat typical of Eastern Creek

Appendix 3 – Endangered Ecological Community information

Approved Recovery Plan

Cumberland Plain Recovery Plan

January 2011

NSW GOVERNMENT Environment, Climate Change & Water

Australian Government

Department of Environment, Climate Change and Water (NSW)
59–61 Goulburn Street
(PO Box A290)
Sydney South NSW 1232
Phone: (02) 9995 5000 (switchboard)
Phone: 131 555 (information & publications requests)
TTY: (02) 9211 4723
Fax: (02) 9995 5999
Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

Requests for information or comments regarding the recovery program for the Cumberland Plain are best directed to:

Cumberland Plain Recovery Program Coordinator
EPRG Metro Branch
Department of Environment, Climate Change and Water
PO Box 1967
Hurstville
NSW 2220

Cover photo: Jaime Plaza © Botanic Gardens Trust

This plan should be cited as follows:

Department of Environment, Climate Change and Water (NSW) (2010) *Cumberland Plain Recovery Plan*, Department of Environment, Climate Change and Water (NSW), Sydney.

ISBN 978 1 74232 808 9
DECCW 2010/501

Printed on recycled paper

Cumberland Plain Recovery Plan

Foreword

The Cumberland Plain in western Sydney is Australia's fastest growing and most populous region. Many of its unique natural attributes need special effort to maintain their values and ensure their protection. Just 13% of western Sydney's native vegetation remains in highly fragmented patches of varying size and condition. This recovery plan has been designed to provide for the long-term survival and protection of the threatened biodiversity of the Cumberland Plain as the area develops. It constitutes the formal New South Wales recovery plan for 20 threatened species, populations and ecological communities that reside there.

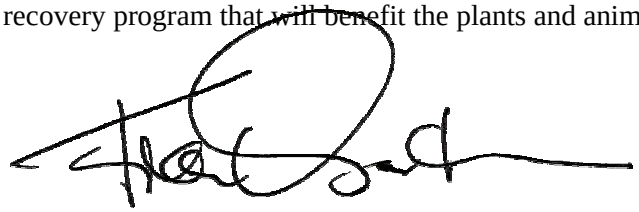
Preparing a multi-entity recovery plan is complex. Successful implementation of the plan will require active management and need co-operation at all levels. All land owners and managers can play an important role in conserving and managing the remaining biodiversity. By 2019 the Cumberland Plain will be home to 2.18 million people – or 44% of Sydney. This will place significant pressure on the region. We need to cater for the population's need for housing and jobs, while at the same time looking after a rapidly disappearing landscape and need for green space. The best way to do this is by taking a proactive and strategic approach by identifying and protecting the biggest, most viable remnants of native vegetation rather than considering it piece by piece and development by development.

The recovery plan takes a multi-pronged approach building on four recovery themes:

- Building the Cumberland Plain protected area network, including both public and private land and concentrating on the identified Priority Conservation Lands
- Delivering best management practices to prevent degradation of remaining bushland
- Enhancing the community's understanding and awareness of the values of the Cumberland Plain, and
- Improving our understanding of, and capacity to manage, the many threats to the biodiversity of the Cumberland Plain.

The recovery plan provides the foundation for future biodiversity protection in western Sydney. The plan is integrated with existing and pending planning, assessment and development initiatives including the Metropolitan Strategy and draft Metropolitan Plan, the Growth Centres Biodiversity Certification and the draft Commonwealth Strategic Assessment for Western Sydney. The $530 million Growth Centres Conservation Fund demonstrates strong investment for realising the building of the protected area network and implementing best-practice management.

We all need to work together to ensure the conservation of these unique species and communities. These actions draw on the expertise of local, state and Australian governments and encourage the participation of community groups and individuals, who are passionate about conserving their local environment, by drawing on their knowledge and enthusiasm. The plan provides guidance for those who are committed to conserving the entities covered by the plan in order to deliver a coordinated, strategic and targeted recovery program that will benefit the plants and animals of the Cumberland Plain for years to come.



FRANK SARTOR
Minister for Climate Change and the Environment

LISA CORBYN
Director General

Executive summary

The NSW Department of Environment Climate Change and Water (DECCW) has prepared this recovery plan to provide for the long-term survival and protection of seven threatened species, four endangered populations and nine threatened ecological communities listed on the NSW *Threatened Species Conservation Act 1995* that are found only on the Cumberland Plain. Seven of these are also listed as threatened under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Conservation of the rich variety of plants, animals and their habitats on the Cumberland Plain in western Sydney is challenging. The remaining native vegetation is highly fragmented and occurs largely on private land. Land values are high and competing land uses and strong population growth is placing extraordinary pressures on remaining bushland. For example, the population of the Cumberland Plain is expected to grow by 510,000 to be home to 2.18 million people by 2019, increasing western Sydney's share of the Metropolitan population to 44%.

Past and continuing land-use pressures have greatly affected the Cumberland Plain. Today only 13% of the region's native vegetation remains as intact bushland and this is scattered across the region in more than 2,400 individual remnants. Eight percent of what is left is protected within national parks and other conservation reserves. Significantly, the 81 largest remnants (over 50 ha) contain 51% of the remaining bushland and many of these large, intact patches occur on public land, including Commonwealth land.

Given the scale and nature of the issues, it is important that prioritisation and investment in the recovery program be guided by sound principles, based upon the best available evidence. Two of these principles are that the protection and management of large, intact remnants is more effective and efficient than for smaller, fragmented remnants, and that recovery efforts need to aim to ensure that a representative sample of all target threatened species, populations and communities is conserved. DECCW has completed an assessment of the remaining bushland based on these principles and other factors, including the distribution and zoning of remnant vegetation, which has resulted in the identification of the priority conservation lands (PCLs), shown in Figure 1.

The PCLs have been identified as the lands that represent the best remaining opportunities in the region to secure long-term biodiversity benefits for the lowest possible cost. They contain a total of 11,754 ha of the targeted threatened ecological communities, representing almost 40% of their combined remaining extent, along with 50–100% of the remaining populations of each threatened flora species and endangered population covered by the plan.

The identification of the PCLs as priorities should not be misinterpreted as underrating the significance of other remnant vegetation. While the plan promotes the PCLs as the regional priorities for the Cumberland Plain, areas of local significance (such as corridors and smaller council reserves) will complement and enhance these regional priorities. A comprehensive network of corridors on the Cumberland Plan is being developed and managed by a range of stakeholders, including riparian zones retained within the North West and South West Growth Centres, the establishment of the Western Sydney Parklands, open space corridors on South and Ropes Creek and regional biodiversity corridors within the Hawkesbury–Nepean Catchment Management Authority's Catchment Action Plan.

The third principle of the plan is that active management to best practice standards is needed to prevent the degradation of the remaining bushland in such a fragmented landscape. Without active management, weed invasion, frequent fire, stormwater flooding, grazing, mowing and recreational impacts such as illegal rubbish dumping will continue. This will be complemented by increasing the extent and condition of vegetation on the Cumberland Plain using assisted natural regeneration and revegetation techniques.

The fourth principle on which the plan is based is that where impacts on threatened species, populations and ecological communities cannot be avoided, they should be offset using appropriate means. The principle of offsetting loss of native vegetation that occurs as the result of development already underpins the NSW Government's approach to development of the Growth Centres in western Sydney. While most of the best remaining vegetation within the Growth Centres will be protected over time, some will be lost. To offset this, the Growth Centres Conservation Fund will provide $530 million over the next 30 years to secure the protection and management of high conservation bushland in western Sydney and surrounding areas. This provides unprecedented investment in recovery efforts in the region.

Actions are identified for implementation by local, State and Australian government authorities and are grouped under the following recovery objectives:

1. *To build a protected area network, comprising public and private lands, focused on the priority conservation lands*

Securing public and private land to be actively managed for conservation using a range of secure conservation options will underpin long-term recovery efforts on the Cumberland Plain. The identification of the PCLs is also intended to inform land-use planning decisions and to maximise conservation outcomes for threatened species, populations and ecological communities. This includes identifying where planning protection measures can most effectively be applied to protect the areas of greatest significance, and where buffers, corridors and other links are needed to support these areas.

2. *To deliver best practice management for threatened species, populations and ecological communities across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with conservation*

These actions seek to promote the adoption of best practice standards for bushland management on all tenures across the Cumberland Plain. Particular emphasis is given to the priority conservation lands and public lands where the primary management objectives are compatible with conservation.

3. *To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program*

Actions under this objective seek to improve the capacity of land owners and managers to understand and effectively implement relevant parts of the recovery program. This will involve providing access to information, developing skills and knowledge, and providing support through advice, materials and funding.

4. *To increase knowledge of the threats to the survival of the Cumberland Plain's threatened species, populations and ecological communities, and thereby improve capacity to manage these in a strategic and effective manner*

The data on which the original regional vegetation mapping was based need to be reviewed and updated. This work is also needed to assist monitoring, compliance and enforcement programs to tackle unauthorised land clearing and degradation activities. DECCW will encourage and assist local government authorities to develop biodiversity strategies that are consistent with the priorities identified in the recovery plan.

In addition to the list of actions under the four themes of the recovery strategy, species-specific actions have also been identified for the recovery of two plants, the Sydney Plains Greenhood and the endangered population of *Pomaderris prunifolia*. These actions are required due to the very small number of known sites containing these species.

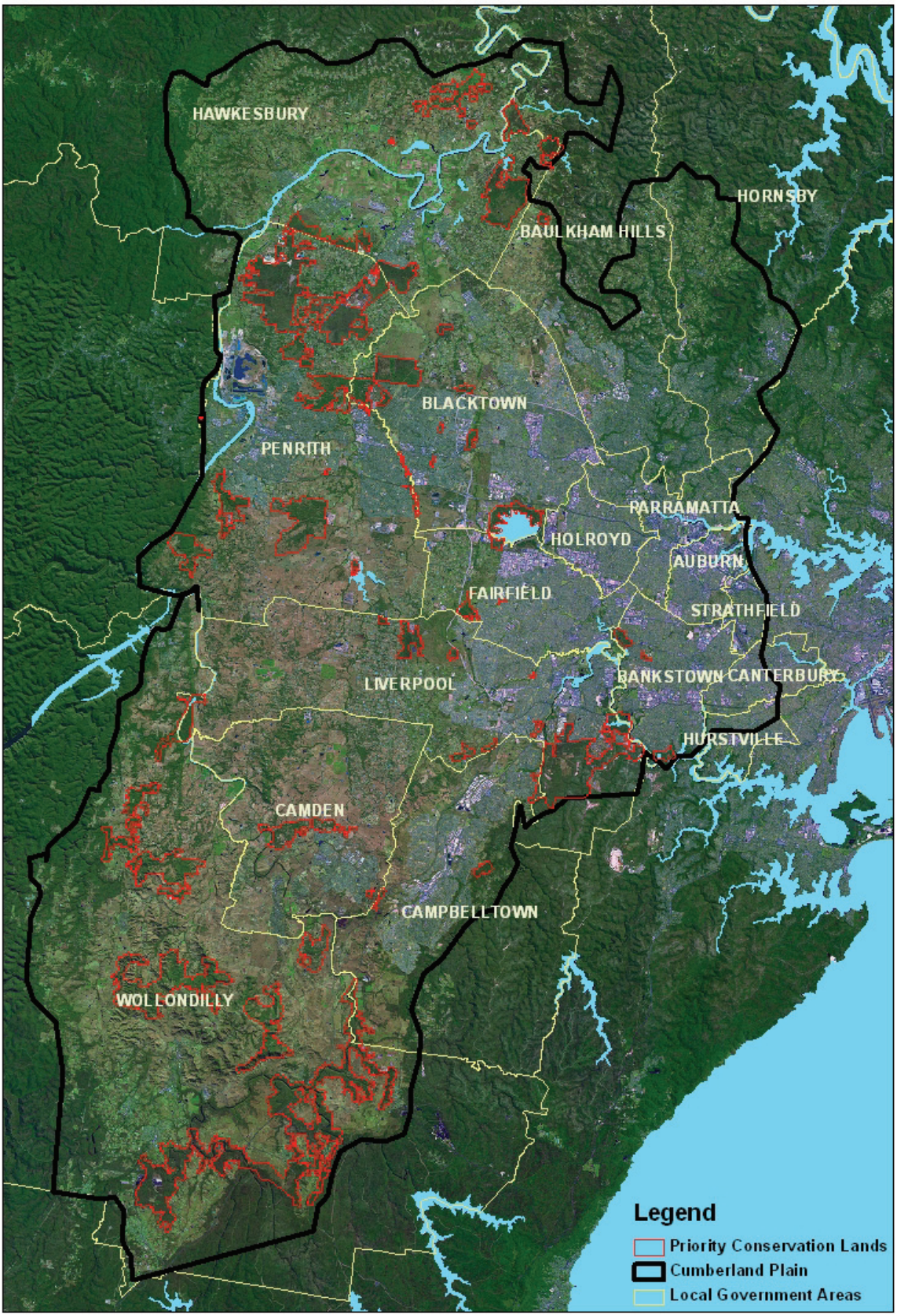


Figure 1. The Cumberland Plain and priority conservation lands[1]

[1] ArcGIS shapefiles of the priority conservation lands are available on the DECCW website at www.maps.environment.nsw.gov.au/.

Table of contents

Figures

Tables

1 Introduction

Conservation of the rich biodiversity of the Cumberland Plain in western Sydney is one of the most challenging issues facing natural resource management in New South Wales (NSW). Extensive loss and fragmentation of vegetation has occurred, land values are high and competing land uses are placing extraordinary pressures on the remaining areas of bushland in the region.

This recovery plan has been prepared under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the NSW *Threatened Species Conservation Act 1995* (TSC Act) to promote the recovery of threatened species, populations and ecological communities on the Cumberland Plain. The plan has been prepared with reference and due consideration of the objects of the EPBC Act and the TSC Act and constitutes the NSW recovery plan for the threatened species, populations and ecological communities that are listed in Table 1. The plan also satisfies the provisions of Part 4 of the TSC Act and Part 13 of the EPBC Act, which specify matters to be included in a recovery plan.

The recovery plan will guide investment in the recovery of the threatened biodiversity of western Sydney, and to inform future urban planning decisions. The plan is an integrated conservation plan for western Sydney that informs and implements key initiatives, including the *NSW State Plan* (NSW Government 2010a), the *Metropolitan Strategy for Sydney* (Department of Planning 2005), the Biodiversity Certification of the North West and South West Growth Centres[2] and the accompanying Australian Government Strategic Assessment of the Sydney Region Growth Centres.

By focusing on a group of threatened entities within a defined landscape or geographical area, the recovery plan will deliver a more coordinated and targeted recovery program than could be achieved through the implementation of a number of single species, population or community plans. This approach has also enabled regional conservation priorities to be clearly identified for the preferential investment of finite resources. Given the magnitude of the threats operating in the region, the successful implementation of the recovery plan will require a broad partnership, involving all levels of government (Australian, State and local), industry and the community.

2 Study area and scope

The area covered by the recovery plan is the broad shale basin of the Cumberland Plain in western Sydney. The parts of the Hornsby Plateau that were mapped in the *Native Vegetation of the Cumberland Plain Final Edition* (NPWS 2002) are intentionally excluded from the scope of this recovery plan. This is because the Hornsby Plateau is a geomorphologically distinct area from the Cumberland Plain and contains different assemblages of species and threats than the Cumberland Plain.

The native vegetation of the Cumberland Plain is diverse, reflecting variations in soil type, landform, and drainage, and differs markedly from that of the surrounding landscape. The Cumberland Plain covers all or part of the following local government areas (Figure 1):

- Auburn Council
- Bankstown City Council
- Blacktown City Council
- Camden Council
- Campbelltown City Council
- Canterbury City Council
- Fairfield City Council
- Hawkesbury City Council
- Holroyd City Council
- Hornsby Shire Council
- Hurstville Council
- Liverpool City Council
- Parramatta City Council
- Penrith City Council
- Strathfield Council
- The Hills Shire Council
- Wollondilly Shire Council.

[2] For more information see www.environment.nsw.gov.au/biocertification/notcert.htm

Ku-ring-gai and Ryde local government areas were excluded from the scope of the recovery plan as none of the threatened species, populations or ecological communities covered by the plan occur in these areas.

The recovery plan focuses on the threatened species, populations and ecological communities that are endemic to the Cumberland Plain or are primarily distributed on the Cumberland Plain (Table 1).

Table 1. Threatened biodiversity addressed in this recovery plan

Flora species	TSC Act status	EPBC Act status
Allocasuarina glareicola	Endangered	Endangered
Dillwynia tenuifolia	Vulnerable	Vulnerable
Juniper-leaved Grevillea (*Grevillea juniperina* subsp. *juniperina*)	Vulnerable	-
Micromyrtus minutiflora	Endangered	Vulnerable
Sydney Plains Greenhood (*Pterostylis saxicola*)	Endangered	Endangered
Pultenaea parviflora	Endangered	Vulnerable
Fauna species		
Cumberland Land Snail (*Meridolum corneovirens*)	Endangered	-
Populations		
Dillwynia tenuifolia population in the Baulkham Hills LGA	Endangered	-
Dillwynia tenuifolia population at Kemps Creek	Endangered	-
Marsdenia viridiflora R. Br subsp. *viridiflora* population in the Bankstown, Blacktown, Camden, Fairfield, Holroyd, Liverpool and Penrith LGAs	Endangered	-
Pomaderris prunifolia (a shrub) population in the Parramatta, Auburn, Strathfield and Bankstown LGAs	Endangered	-
Ecological communities		
Agnes Banks Woodland	Endangered	-
Castlereagh Swamp Woodland	Endangered	-
Cooks River/Castlereagh Ironbark Forest	Endangered	-
Cumberland Plain Woodland (listed on EPBC Act as Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest)	Critically Endangered	Critically Endangered
Moist Shale Woodland	Endangered	-
Shale Gravel Transition Forest (listed on EPBC Act as Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest)	Endangered	Critically Endangered
Shale Sandstone Transition Forest	Endangered	Endangered
River-flat Eucalypt Forest (previously Sydney Coastal River Flat Forest)	Endangered	-
Western Sydney Dry Rainforest	Endangered	-

The following threatened ecological communities are not specifically addressed in the recovery plan, as only a small proportion of their distribution occurs within the study area, or a recovery plan already exists:

- Blue Gum High Forest
- Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions
- Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions
- Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregions
- Sydney Turpentine Ironbark Forest.

Elderslie Banksia Scrub Forest will also be excluded from consideration in this recovery plan as the future of the remaining area of this threatened ecological community at Spring Farm, Camden has already been determined through the land-use planning system.

The following threatened species and populations are not specifically addressed in this recovery plan, as only a small proportion of their distribution occurs within the study area or a recovery plan already exists:

- Downy Wattle (*Acacia pubescens*)
- *Hibbertia superans*
- Matted Bush-pea (*Pultenaea pedunculata*)
- Nodding Geebung (*Persoonia nutans*)
- *Pimelea curviflora* var. *curviflora*
- Spiked Rice-flower (*Pimelea spicata*).

The Tadgell's Bluebell (*Wahlenbergia multicaulis*) population in the Auburn, Bankstown, Baulkham Hills, Canterbury, Hornsby, Parramatta and Strathfield LGAs is not considered in this plan as a separate recovery plan for this endangered population has been sent to the relevant public authorities for statutory endorsement prior to public exhibition.

Threatened entities that are not covered by this plan are addressed in the Department of Environment, Climate Change and Water's (DECCW) Priorities Action Statement (PAS)[3]. Additionally, all threatened and native biodiversity is covered by existing legislation, including application of the NSW *National Parks and Wildlife Act 1974*, *Environmental Planning and Assessment Act 1979* (EP&A Act), and the TSC Act, as well as the Commonwealth EPBC Act.

Descriptive profiles for each of the threatened entities in Table 1 are available on the NSW Threatened Species Website at www.threatenedspecies.environment.nsw.gov.au and the Australian government Species Profile and Threats Database at http://environment.gov.au/cgi-bin/sprat/public/sprat.pl. Detailed descriptions of each of the threatened ecological communities (TECs) are also provided in NPWS (2002) and Tozer (2003). There are definitional differences between TSC Act and EPBC Act listed TECs. The main difference in descriptions relates to the use of condition classes under the EPBC Act (see Section 3).

Recovery actions identified within the recovery plan will also potentially benefit a number of other listed species under the TSC and EPBC Acts, such as the Barking Owl (*Ninox connivens*), Black-chinned Honeyeater (*Melithreptus gularis gularis*), Brown Treecreeper (*Climacteris picumnus victoriae*), Diamond Firetail (*Stagonopleura guttata*), Eastern Bent-wing Bbat (*Miniopterus schreibersii oceanensis*), Gang-gang Cockatoo (*Callocephalon fimbriatum*), Glossy Black-Cockatoo (*Calyptorhynchus lathami*), Green and Golden Bell Frog (*Litoria aurea*), Grey-headed Flying-fox (*Pteropus poliocephalus*), Koala (*Phascolarctos cinereus*), Large-footed Myotis (*Myotis macropus*), Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*), Regent Honeyeater (*Anthochaera phyrgia*), Speckled Warbler (*Pyrrholaemus saggitatus*), Spotted-tailed Quoll (*Dasyurus maculatus*), Square-tailed Kite (*Lophoictinia isura*), Squirrel Glider (*Petaurus norfolcensis*), Swift Parrot (*Lathamus discolour*), Yellow-bellied Glider (*Petaurus australis*) and Yellow-bellied Sheath-tailed Bat (*Saccolaimus flaviventris*) (DEC 2005b).

At the time of publication of this recovery plan it is acknowledged that the NSW Scientific Committee has made a preliminary determination to list the Castlereagh Scribbly Gum Woodland in the Sydney

[3] For further information see www.threatenedspecies.environment.nsw.gov.au/tsprofile/home_PAS_new.aspx.

Basin Bioregion as a vulnerable ecological community under the TSC Act and that Sydney Sand Flats Dry Sclerophyll Forest has been nominated as a threatened community under the EPBC Act.

3 History of land use on the Cumberland Plain

The past – Aboriginal occupation, European settlement and land use

At the time of European settlement, the Cumberland Plain would have been immensely productive for Aboriginal people and would have supported abundant native fauna. Many hundreds of Aboriginal sites have been recorded across the Sydney region, indicating the significance of the whole landscape and its resources to Aboriginal people, in its material, social and spiritual dimensions.

Extensive grassy woodlands were present, as well as tall ironbark and turpentine forests, dry rainforests, and floodplain communities. Mammals such as echidnas, quolls, phascogales, bandicoots, koalas, possums, gliders, bettongs, wallabies and kangaroos would have all been common, along with emus and a vast array of woodland birds such as the Hooded Robin (*Melanodryas cucullata cucullata*), Brown Treecreeper, Speckled Warbler and Diamond Firetail.

The gentle slopes and fertile soils of the region made it an early focus for agriculture following European settlement. Agricultural development was underway as early as 1792 and by the middle of the 19th century most of the region was either being grazed or was cultivated (DEC 2005a). Clearing for agriculture was later supplemented by clearing for residential, commercial and industrial purposes.

The present – a legacy of past land-use pressures

Past and continuing land-use pressures have taken a major toll on the biodiversity of the Cumberland Plain. Only 13% of the pre-1750 extent of the region's vegetation remains as intact bushland, with an additional 12% occurring as scattered trees in disturbed areas (NPWS 2002). Consequently, much of the region's biodiversity is listed as threatened under State and/or Commonwealth legislation.

The vast majority (76%) of the Cumberland Plain's remaining bushland is privately owned, and only 8% is protected within the formal reserve system. The region's bushland is also highly fragmented, comprising 2,446 individual remnants (DECCW 2010). Significantly, however, the 81 largest remnants (i.e. >50 ha) contain 51% of the remaining bushland and many of these large, intact remnants occupy public land.

While some flora and fauna species will persist in small remnants with active management, evidence clearly suggests that larger remnants have a better prospect for long-term survival. Larger remnants are usually more diverse and resilient than smaller remnants, and are less susceptible to 'edge effects', catastrophic events, and the expected impacts of climate change. Research also suggests that biodiversity loss caused by habitat fragmentation significantly increases once clearing levels exceed 70% of the landscape (Freudenberger *et al.* 1997; WALGA 2004). This threshold has already been passed on the Cumberland Plain.

Clearing and fragmentation have had a profound effect on the fauna of the Cumberland Plain. Many mammal species declined to extinction in the decades after settlement. While many mammals persist in a small number of larger remnants, few exist in any number in western Sydney, such as the Eastern Grey Kangaroo (*Macropus giganteus*), Common Brushtail Possum (*Trichosurus vulpecular*), Grey-headed Flying-fox and a number of microchiropteran bat species such as the Lesser Long-eared Bat (*Nyctophilus geoffroyi*), Gould's Wattled Bat (*Chalinolobus gouldii*) and Gould's Long-eared Bat (*Nyctophilus gouldi*).

Many bird species were relatively common until the 1950s when declines commenced. They persisted longer than many mammal species but populations collapsed across most of western Sydney in the 1970s and are no longer commonly seen. However, not all bird species were equally affected. Clearing and under-scrubbing have created suitable habitat for a number of aggressive native species including the Sulphur-crested Cockatoo (*Cacatua galerita*), Australian Magpie (*Gymnorhina tibicen*) and Noisy Miner

(*Manorina melanocephala*). These species have all increased in western Sydney and now out-compete smaller woodland bird species in areas of fragmented vegetation.

While the general pattern has been one of fragmentation, habitat loss and species decline, some animals, including threatened woodland birds such as the Brown Treecreeper and Hooded Robin have persisted in the larger, better connected remnants. These remnants are not dominated by aggressive bird species and retain the characteristic habitat requirements for woodland bird fauna. Similarly, a number of mammal species have been recorded from the larger connected remnants. The vulnerable Squirrel Glider was feared to be extinct in western Sydney but was found in the Castlereagh area in the region's largest remaining patch of vegetation (DEC 2005b). This and other species such as wombats, echidnas and the Common Wallaroo (*Macropus robustus*) are not generally found in the smaller, degraded and isolated patches due to the severity of the threats and the absence of opportunities to recolonise areas of remnant vegetation after fire or other disturbance events.

The consequences for flora have been similar, although not as dramatic. While many flora species are now at risk of extinction, populations have persisted in small and sometimes degraded remnants. There is evidence to support the view that small remnants remain important for flora species at least in the short to medium term (Tozer 2003). The future of small remnants must be considered in the context of increasing urbanisation and the expected impacts of climate change, which will place additional stresses on these remnants, further reducing their habitat value and viability.

Table 2 shows the current and pre-1750 extent of the threatened ecological communities addressed in the recovery plan, and their current levels of formal protection. While some of these communities have fared slightly better than others, all have suffered a marked reduction in extent and condition. NPWS (2002) used condition classes for native vegetation on the Cumberland Plain to distinguish good and poor quality vegetation. The main condition classes include 'A', 'B', 'C', 'TX' and 'TXR'. Condition classes A, B and C contain areas with a relatively intact native tree canopy. These condition classes are most likely to contain high levels of floristic diversity (Tozer 2003). Condition classes TX and TXR contain areas of scattered native canopy (NPWS 2002) and may have either high or low levels of floristic diversity (Tozer 2003).

Only a small proportion of TX and TXR areas are likely meet the definition of a TSC Act listed community as defined in the NSW Scientific Committee determination (NSW Scientific Committee 2009). To be considered part of the EPBC Act listed Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest community, patches must be in an A, B or C condition class and meet other condition thresholds relating to patch size, understorey integrity and the presence of tree hollows.

Along with the loss of native vegetation, there has been significant loss of areas of Aboriginal cultural heritage significance. This includes many hundreds of archaeological sites. In spite of this, many areas of Aboriginal heritage values remain on the Cumberland Plain and there is often a clear overlap with areas of biodiversity conservation value. Many Aboriginal communities in western Sydney retain an interest in seeing the land and its biodiversity protected and managed.

The future – an enduring natural landscape amid urban development

There is no doubt that Sydney's natural environment is highly valued by the community. In the community forums that informed the preparation of the Metropolitan Strategy, people talked passionately about protecting Sydney's natural areas, and the natural environment was identified as Sydney's greatest asset (Department of Planning 2005). In western Sydney, many community groups have been working over a long period of time to identify and protect the biodiversity values of the Cumberland Plain.

The population of the Sydney Metropolitan Area is projected to increase from 4.3 million in 2006 to 6 million by 2036, passing the 5 million mark in 2019. The highest growth subregions are South West, North West and West Central (Department of Planning 2008a). The Cumberland Plain will be home to 2.18 million people by 2019 (i.e. an extra 510,000 people), increasing the region's share of the metropolitan population to 44% (WSROC 2005).

Table 2. Status of the threatened ecological communities addressed in the recovery plan

Extent[4]	Pre-1750 (ha)	Current area total (ha)			Current area total (% of pre-1750)	Current area on DECCW estate (ha)	Current area on DECCW estate (%)	Pre-1750 area on DECCW estate (%)
Condition classes[5]	n/a	A, B and C	TX and TXR	EBPC Act	A, B and C	A, B and C	A, B and C	A, B and C
Threatened Ecological Community								
Agnes Banks Woodland	627	88	86		14	38	43	7
Castlereagh Swamp Woodland	1,006	609	42		61	115	19	2
Cooks River/Castlereagh Ironbark Forest	12,211	976	407		8	336	34	<1
Cumberland Plain Woodland	125,449	10,612	13,918	10,726[6]	8	967	9	<1
Moist Shale Woodland	2,034	603	543		30	6	1	<1
River-flat Eucalypt Forest[7]	39,118	5,313	3,916		14	112	2	<1
Shale Gravel Transition Forest	5,427	1,670	1,242	10,726[6]	31	229	14	<1
Shale Sandstone Transition Forest	45,355	9,642	7,933	9,642	21	420	4	<1
Western Sydney Dry Rainforest	1,282	335	232		26	<1	<1	<1
Total	**232,509**	**29,848**	**28,319**	**20,368**	**13**	**2,242**	**8**	**<1**

The *Metropolitan Strategy for Sydney* (Department of Planning 2005) provides the key directions for managing Sydney's population growth until 2030. The strategy emphasises the need to minimise the urban footprint and concentrate future growth in identified centres and corridors, thereby minimising loss and disturbance to regionally and state-significant habitats. It contains environmental targets to 'maintain or improve regional biodiversity values across the region' and 'ensure 60–70% of future growth occurs within the existing urban footprint'[8]. It also requires that land release be focused in the North West and South West Growth Centres[9]. The *Metropolitan Strategy for Sydney* (Department of Planning 2005) provides strong support for addressing biodiversity issues at the strategic planning stage, linking to reforms of threatened species legislation such as biodiversity certification and Biobanking.

The NSW Government's five-year review of the *Metropolitan Strategy for Sydney* is due in late 2010. The new Metropolitan Plan will integrate infrastructure and planning into one document and will cover the next 25 years to 2036.

To secure the protection and management of high conservation value bushland in western Sydney and surrounding areas, the Growth Centres Conservation Fund, established by the Biodiversity Certification of the North West and South West Growth Centres, will provide $530 million over the next 30 years to

[4] Within the NPWS (2002) study area. Some communities extend beyond the study area and so have a greater total extent.
[5] As mapped by NPWS (2002) and Tozer (2003). Figures for 'A', 'B' and 'C' condition classes include mapping by the NSW Scientific Committee and Simpson (2008) for Cumberland Plain Woodland plus addition mapping performed for the other TECs.
[6] This figure includes both Cumberland Plain Woodland and Shale Gravel Transition Forest TECs, as these communities are listed as one entity (Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest) under the EPBC Act.
[7] The figures given may include small areas of the Swamp Oak Floodplain Forest TEC.
[8] E2.2 and E3.1 in Table 5 (Department of Planning 2005).
[9] E4.2 (Department of Planning 2005).

offset the impacts on biodiversity that will occur as the Growth Centres are developed. The fund will be used to voluntarily purchase land for addition to the public reserve system and to establish perpetual conservation agreements, including Biobanking agreements, both within and outside the Growth Centres. Consequently, it provides an unprecedented opportunity to support recovery efforts in the region by securing the long-term future of some the most significant remaining bushland areas in western Sydney and surrounding areas.

In response to the Biodiversity Certification of the North West and South West Growth Centres, a *Sydney Growth Centres Strategic Assessment Draft Program Report* (NSW Government 2010b) and the *Draft EPBC Act Strategic Assessment Report for the Sydney Growth Centres Program*[10] (NSW Government 2010c) have been developed to assesses the potential impacts of urban development on matters of National Environmental Significance protected under the EPBC Act. These draft documents were placed on public exhibition from the 24 May 2010 to 25 June 2010. If endorsed by the Commonwealth Minister for the Environment, the Strategic Assessment will ensure that matters of national environmental significance have been identified, considered and addressed early in the planning process. Commitments made for the protection of biodiversity assets under the Strategic Assessment will ensure that government, the development industry and the community have a clear understanding of how these key environmental issues will be managed in the Growth Centres.

4 Threatening processes

The principal threat to the biodiversity of the Cumberland Plain is the further loss and fragmentation of habitat. Clearing for rural and residential developments, industry, and agricultural land uses has led to increasingly isolated small remnants which are more susceptible to degradation, provide less habitat values and support fewer species.

The plant communities of the Cumberland Plain are particularly vulnerable to weed invasion due to their grassy understorey, relatively fertile soils and past agricultural uses. Weeds such as African Olive (*Olea europea* subsp. *cuspidata*), African Lovegrass (*Eragrostis curvula*) and Bridal Creeper (*Myrsiphyllum asparagoides*) have established themselves widely, displacing native plants and affecting the regeneration of communities (Benson 1992). *Invasion of Native Plant Communities by African Olive* was listed as a Key Threatening Process on the TSC Act on 1 October 2010 (NSW Scientific Committee 2010).

Due to its urban setting, frequent fire from arson is a major problem in the bushland remnants of western Sydney. This has resulted in a significant change to the bush, which has evolved over thousands of years to be dependant on a certain fire regime. Guidance on the appropriate fire regimes for Cumberland Plain vegetation is provided in Appendix 3.

Urban run-off from impermeable surfaces such as roads and house blocks can escape drainage systems and end up in bushland. This water often carries high nutrient and sediment loads, which can encourage weed invasion in addition to the soil erosion caused by the run-off. Other threats include recreational impacts, grazing and mowing, altered hydrology, sedimentation, erosion, salinity and the expected impacts of climate change. More detailed descriptions of these threats are provided in *Recovering bushland on the Cumberland Plain: Best practice guidelines for the management and restoration of bushland* (DEC 2005a). The actions contained in this recovery plan are aimed at addressing these threats in a strategic and cost-effective manner.

5 The recovery strategy – constraints, principles and themes

Given the extent of existing disturbance and the ongoing land-use pressures on the Cumberland Plain, a tailored approach is required to achieve the long-term survival of the threatened biodiversity of the region.

The main constraints to the effective implementation of recovery efforts on the Cumberland Plain are:

- highly fragmented, and in many cases, poor condition vegetation

[10] For more information see www.growthcentres.nsw.gov.au/strategicassessment-94.html.

- a lack of active management, which will result in many bushland remnants degrading through weed invasion, inappropriate use and other 'edge effects'
- the high proportion of privately owned bushland
- the largely voluntary participation of private landowners in the recovery program
- high land values
- limited funding and resources, which are nonetheless significant
- the unavoidable impact of urban growth on some bushland remnants.

It is important that prioritisation and investment in the recovery program be guided by sound principles. These principles, based upon the best available ecological evidence, are that:

- the protection and management of large, intact remnants is more effective and efficient than for smaller, fragmented remnants
- recovery efforts need to aim to ensure that a representative sample of biodiversity is conserved
- active management to best practice standards is needed to prevent the degradation of bushland in a fragmented landscape
- where impacts on biodiversity cannot be avoided, they should be offset using appropriate means.

This Cumberland Plain Recovery Plan seeks to focus recovery efforts on those lands which represent the best opportunities to secure viable, long-term conservation outcomes in the region. These lands, hereafter referred to as the priority conservation lands, have been identified by DECCW (2010) and are described in the following section.

Following these principles, a suite of recovery actions has been developed for implementation by Australian, State and local governments. The actions are grouped into the following themes:

- Building the protected area network
- Delivering best practice management
- Promoting awareness, education and engagement
- Enhancing information, monitoring and enforcement.

6 Priority conservation lands

An assessment has been undertaken using the best available information on biodiversity and threatening processes to identify the lands on the Cumberland Plain that can contribute most to the long-term recovery and maintenance of threatened biodiversity (DECCW 2010). The priority conservation lands (PCLs) (Figure 1) represent the best remaining opportunities in the region to maximise long-term biodiversity benefits for the lowest possible cost, including the least likelihood of restricting land supply. DECCW considers these lands, which cover approximately 25,566 ha, to be the highest priority for future efforts to conserve the threatened biodiversity of the region.

The method used in the identification of these lands is described in the *Report on the Methodology for Identifying Priority Conservation Lands* (DECCW 2010). Consistent with the principles outlined in Section 5, considerations included size, shape, condition, and the landscape context of individual vegetation remnants, as well as the presence of endemic threatened species, populations and communities. A target to include at least 15% of the remaining area of each of the threatened ecological communities addressed in this recovery plan was applied and exceeded for all communities (Table 3). This minimum target was in recognition of the region's high land values, fragmentation levels and land-use pressures. A total of 11,754 ha of the targeted threatened ecological communities are included in the priority conservation lands.

Table 3. Area of threatened ecological communities in the priority conservation lands

Threatened Ecological Community	Total extant area (ha)[11]		TEC in priority lands (ha)		% of extant TEC in priority lands
	TSC Act	EPBC Act	TSC Act	EPBC Act	TSC Act
Agnes Banks Woodland	88		73		83
Castlereagh Swamp Woodland	609		557		91
Cooks River/Castlereagh Ironbark Forest	976		708		73
Cumberland Plain Woodland	10,612	10,726[12]	4,171	5,045[14]	39
Moist Shale Woodland	603		478		79
River-flat Eucalypt Forest	5,313		1,339		25
Shale Gravel Transition Forest	1,670	10,726[14]	1,077	5,045[14]	64
Shale Sandstone Transition Forest	9,642	9,642	3,145	3,145	33
Western Sydney Dry Rainforest	335		206		61
Total	**29,848**	**20,368**	**11,754**	**8,190**	**39**

The threatened flora and endangered populations covered by the plan were given individual percentage targets (Table 4). All of the threatened flora and endangered populations met their representation targets within the PCLs, with the exception of the *Pomaderris prunifolia* endangered population. No specific target was applied for the Cumberland Land Snail as potential habitat for this species was included in the targets for Cumberland Plain Woodland, Castlereagh Swamp Woodland and River-flat Eucalypt Forest.

Table 4. Threatened flora species and endangered flora populations in the priority conservation lands

Threatened flora species	Populations on the Cumberland Plain	Populations within the priority lands	Actual proportion	Target proportion
Allocasuarina glairecola	5	5	100%	100%
Dillwynia tenuifolia	28	20	71%	60%
Juniper-leaved Grevillea (*Grevillea juniperina* subsp. *juniperina*)	27	17	63%	60%
Micromyrtus minutiflora	11	10	91%	80%
Sydney Plains Greenhood (*Pterostylis saxicola*)	6	6	100%	100%
Pultenaea parviflora	30	19	63%	60%
Endangered flora populations	**Populations on the Cumberland Plain**	**Populations within the priority lands**	**Actual proportion**	**Target proportion**
Dillwynia tenuifolia (Kemps Creek)	1	1	100%	100%
Dillwynia tenuifolia[13] (Baulkham Hills)	1	1	100%	100%
Marsdenia viridiflora	10	8	80%	80%
Pomaderris prunifolia[14]	2	1	50%	100%

[11] As mapped by NPWS (2002), Tozer (2003) and NSW Scientific Committee and Simpson (2008) for Cumberland Plain Woodland and addition mapping performed for the other TECs. Excludes all TX condition classes.
[12] This figure includes both Cumberland Plain Woodland and Shale Gravel Transition Forest TECs, as these communities are listed as one entity (Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest) under the EPBC Act.
[13] An additional site for this endangered population on Wisemans Ferry Rd occurs outside the study area and so was not included in this assessment.
[16] A translocation recipient site for this species in Rookwood Cemetery was not included in the assessment as it is not naturally occurring.

The priority conservation lands also contain 'other vegetation' and areas with no mapped vegetation. These non threatened vegetation types were included when they occurred at a site that was selected to meet a threatened flora target, or when they were part of a remnant that was selected to meet a threatened ecological community target. Also included were areas with no mapped vegetation. Roads, rivers, and scattered trees or derived native grasslands[15] were included in order to enhance the management viability of the PCLs. Non-vegetated areas were also included if they were part of the existing DECCW estate or were needed to establish practical management boundaries.

The priority conservation lands contain habitat for a far broader suite of threatened and regionally significant species and ecological communities than those addressed in the recovery plan. Additional threatened fauna species may include the Barking Owl, Black-chinned Honeyeater, Brown Treecreeper, Diamond Firetail, Eastern Bent-winged Bat, Gang-gang Cockatoo, Glossy Black-Cockatoo, Green and Golden Bell Frog, Grey-headed Flying-fox, Koala, Large-footed Myotis, Masked Owl, Powerful Owl, Regent Honeyeater, Speckled Warbler, Spotted-tailed Quoll, Square-tailed Kite, Squirrel Glider, Swift Parrot, Yellow-bellied Glider and Yellow-bellied Sheath-tailed Bat (DEC 2005b). Additional threatened flora species include those with distributions that extend beyond the Cumberland Plain, or for which a recovery plan has already been drafted. Conservation activities focused on the priority conservation lands will therefore have greater biodiversity benefits than just for the threatened biodiversity addressed in the recovery plan.

In identifying the priority conservation lands, the largest intact bushland remnants were targeted in the first instance. Many of these 'jewels in the crown' for conservation management are public landholdings. Key examples include the Department of Defence sites at Orchard Hills and Holsworthy, and the Air Services Australia site at Shanes Park.

The priority conservation lands are integrated with existing land-use planning strategies. About 58% of the priority conservation lands are freehold, and these are primarily rural-zoned lands on Sydney's fringes (Table 5). Areas that are zoned for residential and industrial purposes were excluded from consideration in the assessment, as were areas that have been identified for future urban growth (i.e. the certified areas of the North West and South West Growth Centres). Residential and industrial zones attract higher land values and stronger development pressures than other zones. Historically, rezoning residential and industrial zones has been a very difficult outcome to achieve for remnant vegetation and land owners may require compensation if their land is rezoned, which would disallow certain developments to proceed.

The vast majority of the priority conservation lands are located within the first preference investment areas for the Growth Centres Biodiversity Offset Program. The program will receive ¾ of the $530 million (in 2005–06 dollar values) Growth Centres conservation fund to voluntarily acquire lands for reservation or establish conservation agreements in priority areas outside the Growth Centres. The remaining ¼ of the Growth Centres conservation fund will be spent by the Department of Planning in acquiring identified conservation lands within the Growth Centres. The majority of the priority conservation lands are also mapped as Regional Biodiversity Corridors in the Hawkesbury–Nepean Catchment Action Plan (HNCMA 2006).

The priority conservation lands have been identified as regional priorities for the implementation of recovery actions. The mapping does not, in itself, imply or guarantee conservation outcomes. Such outcomes are dependent on the primary purpose of the land, future land-use planning decisions and the ability and desire of land managers to implement recovery actions. As a result, Figure 1 cannot be static through time, but must be able to be reviewed and amended in response to the effects of existing or emerging threats, the development of more up-to-date mapping of vegetation extent and condition, or changes in legislative listing or the definition of biodiversity. An action has been identified in this plan for DECCW to review the methodology and the identified areas of priority conservation lands within 5 years of the approval of this plan.

[15] Derived native grasslands are grasslands that were once grassy woodlands where the tree or shrub cover has been removed.

Table 5. Summary statistics for the priority conservation lands

Tenure	Estimated area (ha)	Percentage of total (%)
Freehold	14,887	58
National Park	3,973	16
Commonwealth land	3,602	14
Australian government land (reserve, leased, licensed, other)	1,732	7
State government land (non-Crown)	1,130	4
Council	242	<1
Zoning		
Rural	11,715	46
Special Uses	4,627	18
National Park	3,474	14
Environmental Protection	2,333	9
Open Space	2,060	8
Subject to condition 12 of GCBCO[16]	1,089	4
Other[17]	268	<1
Total	**25,566**	

The local government areas that contain priority conservation lands include:

- Bankstown City Council
- Camden Council
- Fairfield City Council
- Liverpool City Council
- The Hills Shire Council
- Blacktown City Council
- Campbelltown City Council
- Hawkesbury City Council
- Penrith City Council
- Wollondilly Shire Council.

While the priority conservation lands are considered to represent the regional conservation priorities for the Cumberland Plain, it is recognised that areas of local conservation significance (such as council reserves) complement and enhance these regional conservation priorities. Areas of local conservation significance will include buffers, corridors and ecological linkages for the priority conservation lands. The implementation of best practice management on these and other areas of local conservation significance will contribute to the long-term viability of biodiversity on the Cumberland Plain.

The targets applied in the identification of the PCLs do not represent thresholds which, if passed, indicate 'recovery' of the threatened entities. The targets were applied to assist in identifying the best remaining opportunities to secure long-term biodiversity benefits in the region and, in doing so, provide a practical and realistic focus for recovery efforts.

7 The importance of corridors and small remnants

The PCLs were chosen based on the reserve design principles of size, condition and representativeness. The PCLs are the largest, most intact remnants and are the highest priority for future recovery efforts for the threatened biodiversity of the Cumberland Plain. They represent the full suite of threatened entities in Table 1 and are arguably more viable than smaller, more fragmented remnants. DECCW recognises that smaller remnants and corridors outside the PCLs are important and may play a role in linking the PCLs

[16] Land marked with red hatching on the maps accompanying the Growth Centres Biodiversity Certification Order (GCBCO) where the native vegetation will be retained pursuant to condition 12 of the order.
[17] Includes rivers, roads and other unzoned areas, as well as proposed roads and lands reserved for other purposes, including open space.

and/or supporting biodiversity in the priority conservation lands. They may also contain biodiversity that is otherwise significant and play a role in assisting species' movement in the face of climate change.

The identification of regional conservation priorities within this Plan should not be misinterpreted as underrating the significance of remnant vegetation outside the priority conservation lands. This plan simply attempts to provide a practical, realistic conservation focus for DECCW and others. While resources at a regional level should be strategically focused on the PCLs, implementation of best-practice management on areas of local conservation significance will contribute to the long-term viability of biodiversity and will continue to be encouraged by DECCW. Important work is being undertaken by other agencies, local governments and communities to protect and restore land outside the PCLs that is of local conservation significance. This work, in coordination with appropriate planning controls, will provide a valuable complement to the PCLs and will assist in conserving biodiversity more generally.

A comprehensive network of corridors on the Cumberland Plan is being developed and managed by a range of stakeholders. Within the North West and South West Growth Centres, many riparian zones have been identified as protected land in the Biodiversity Certification Order for the Growth Centres State Environmental Planning Policy (NSW Government 2007). These flood-prone lands are important creek and riparian corridors and have been afforded special protection in the Certification Order. The zoning of these lands will not change but development controls protect existing native vegetation within these areas. This will provide protection of approximately 4,050 ha of land, of which almost 760 ha are classified as high-quality vegetation (Growth Centres Commission 2007), and these areas may act as wildlife corridors.

The establishment of the Western Sydney Parklands is another example of a regional scale habitat corridor being established in western Sydney. The parklands link the protected lands of the North West Growth Centre with those of the South West Growth Centre. They also contain five areas that are identified as priority conservation lands. A biodiversity restoration strategy for the parklands has been prepared and is being implemented by the Western Sydney Parklands Trust (Department of Planning 2008b).

A biodiversity strategy for the regional open space corridors on South and Ropes Creek, which also contain identified priority conservation lands, has been prepared by the Department of Planning (Department of Planning 2008c).

The Hawkesbury–Nepean Catchment Management Authority's Catchment Action Plan (HNCMA 2006) also supports conservation corridors and linkages and has identified regional biodiversity corridors within and outside of western Sydney. The corridors aim to provide for contiguous native vegetation at a regional scale and connect major landscape features.

It is beyond the scope of this recovery plan to identify areas that are of local conservation significance as this is more effectively done at the local government scale. An action has been identified in this plan for DECCW to encourage local government authorities to develop biodiversity strategies that are consistent with the recovery plan and that guide protection, management and strategic investment in biodiversity, both within and outside the PCLs.

8 Species-specific actions

The overall objective of the recovery plan is to provide for the long-term survival of the threatened biodiversity of the Cumberland Plain. The actions listed under the four recovery themes of the recovery program have been tailored for the management and protection all the threatened species, populations and ecological communities listed in Table 1 (with the exception the Sydney Plains Greenhood (*Pterostylis saxicola*) and the endangered population of *Pomaderris prunifolia*). All of the TECs, threatened flora and endangered populations covered under the four recovery themes have met their representation targets within the PCLs and will be equally targeted for management.

Species-specific actions were identified as necessary for the recovery of two plant species, the Sydney Plains Greenhood and the endangered population of *Pomaderris prunifolia*, following a targeted

threatened flora survey in late 2007. These actions (5.1 through to 5.7) are required due to the very small number of known sites containing these species.

9 Previous recovery actions

Programs undertaken by a number of public authorities, organisations and individuals over many years have contributed significantly to the conservation of threatened biodiversity on the Cumberland Plain. Examples of these programs include:

- *Council projects and council reserves*: Local councils have developed management plans and carry out restoration and rehabilitation works in many council reserves containing threatened biodiversity. Similarly, many councils have developed education campaigns for specific threatened entities that occur in their council reserves.
- *Cumberland Plain best practice management demonstration sites*: Four demonstration sites have been developed to provide land managers with practical on-ground examples of many of the restoration techniques outlined in the best practice management guidelines (DEC 2005a), www.environment.nsw.gov.au/threatenedspecies/CumberlandPlainManagementGuidelines.htm.
- *Conservation Incentives Program:* A project involving the Department of Environment and Climate Change and Hawkesbury–Nepean and Sydney Metropolitan Catchment Management Authorities (CMAs) targeted the on-ground implementation of priority actions for threatened entities on private property on the Cumberland Plain (DECC 2009).
- *Threatened Species Demonstration Sites Project:* The Department of Environment and Climate Change and Sydney Metropolitan CMA developed the Threatened Species Demonstration Sites Project to provide guidance to community volunteers and land managers by demonstrating best practice management of threatened species and ecological communities. One of the sites dealt with protecting and restoring the Cumberland Plain Woodland community at Campbell Hill West Reserve, Chester Hill, www.environment.nsw.gov.au/resources/threatenedspecies/08639cumbplnwl.pdf.
- *Catchment Action Plans*: Targets and programs which focus on a number of the issues affecting Cumberland Plain vegetation are included in the Catchment Action Plans of both the Hawkesbury–Nepean and Sydney Metropolitan CMAs.
- *Greening Western Sydney:* Since 1992, the Department of Planning has been involved in Sydney's largest ongoing vegetation restoration project, *Greening Western Sydney*. In association with project partners Greening Australia, the project has seen 800,000 trees and shrubs established in Western Sydney, 700,000 of which are planted within the Western Sydney Parklands area, www.greeningaustralia.org.au/index.php?nodeId=86.
- *NSW Seedbank collection of the Sydney Plains Greenhood:* From 2004 to 2006, Mount Annan Botanic Garden obtained Sydney Plains Greenhood seed by hand-pollinating potted specimens. This seed was used to isolate the mycorrhizal fungus required for germination, conduct experimental work on encapsulation of the seed and fungus (Sommerville et al. 2008), test the feasibility of storing soil samples for later fungal isolation (Sommerville et al. 2009), and generate a larger collection of adult plants. As a result, Mount Annan Botanic Garden now holds collections of seed and mycorrhizal fungi for the Sydney Plains Greenhood and also maintains a collection of potted plants.

10 Proposed recovery objectives, actions and performance criteria

The overall objective of this recovery plan is to provide for the long-term survival and protection of the threatened biodiversity of the Cumberland Plain. The specific recovery objectives are:

1. To build a protected area network, comprising public and private lands, focused on the priority conservation lands
2. To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation
3. To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program

4. To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner.

Under Section 59 of the TSC Act, a recovery plan must state the actions that are to be carried out and identify the public authorities that are responsible for implementing recovery actions. A measure must not be included in a recovery plan for implementation by a public authority unless the Chief Executive Officer responsible for the public authority approves of the inclusion of that measure. Public authorities that endorsed the actions in this recovery plan before it was published are listed as responsible for their implementation under 'responsibility'. DECCW will continue to liaise with and promote the recovery plan to all relevant government authorities and organisations involved in the Cumberland Plain. The 'responsibility' lists below should not limit the implementation of actions by community groups, private individuals or public authorities not listed at the time of publication.

Recovery Objective 1: To build a protected area network, comprising public and private lands, focused on the priority conservation lands

Securing land to be actively managed for conservation purposes will underpin long-term recovery efforts on the Cumberland Plain. Actions under this objective seek to build a protected area network, focused on the priority conservation lands, that is viable and sustainable into the future.

A protected area network can include both public and private lands, provided that secure agreements are in place to achieve biodiversity conservation. The acquisition of land for the formal reserve system provides the highest level of security but can also involve high costs for purchase and significant ongoing management costs. In recognition of this, and the fact that not all landholders will be willing to enter perpetual agreements, the recovery plan will seek to use a range of mechanisms to secure biodiversity outcomes within the priority lands (Table 6).

The voluntary acquisition of private land and the establishment of conservation covenants in the PCLs will be strongly supported by the investment of the Growth Centres conservation fund, in accordance with the biodiversity certification order. The recovery plan also establishes the priority lands as being 'first preference' locations for proponents seeking to offset unavoidable biodiversity impacts in the region for other developments which are not associated with the Growth Centres.

Table 6. Potential mechanisms for including land within the protected area network

Type of land	Conservation mechanism	
	Preferred	**Other**
Freehold	• Voluntary acquisition (reservation) • Biobanking agreements • Conservation covenants	• Voluntary acquisition (open space) • Environmental protection zoning • Property vegetation plan under the *Native Vegetation Act 2003* (Wollondilly LGA only)
Australian government land	• Reservation • Biobanking agreements • Conservation covenants	• Environmental protection zoning • Memorandum of Understanding
Local government land	• Biobanking agreements • Conservation covenants	• Local open space classified as 'natural area' • Environmental protection zoning • Joint Management Agreement • Memorandum of Understanding
Other public land	• Biobanking agreements • Conservation covenants • Crown reserves dedicated for environmental protection	• Environmental protection zoning • Joint Management Agreement • Memorandum of Understanding

Future planning decisions concerning the scale and location of urban development in western Sydney, and the identification of environmental protection and open space areas, will influence the success of efforts

to build the protected area network. The identification of priority conservation lands in this recovery plan is intended to inform land-use planning decisions and to maximise conservation outcomes for threatened biodiversity. Specifically, the spatial identification of regional conservation priorities will assist strategic planners in determining:

- Where planning protection measures can most effectively be applied to conserve the areas that are of greatest significance for threatened biodiversity in the region
- Where buffers, corridors and other ecological linkages (such as stepping-stone reserves) are needed to support these areas[18].

Recovery actions: Building the protected area network

Action 1.1 DECCW will negotiate with the relevant Australian Government authorities to seek the highest level of protection for priority conservation lands managed by the Australian government, via options such as conservation agreements or the transfer of lands into the formal reserve system

Responsibility: **DECCW**

Action 1.2 DECCW will seek and encourage investment for the protection of the threatened biodiversity in Table 1, including via voluntary acquisition or conservation agreements, to be preferentially targeted to the priority conservation lands

Responsibility: **DECCW**

Action 1.3 DECCW will negotiate with other public authorities regarding the options for including the priority conservation lands that are under their care, control and management in the protected area network

Responsibility: **DECCW**

Action 1.4 Local councils will have regard to the priority conservation lands in identifying areas for inclusion in environment protection and regional open space zones

Responsibility: **Bankstown City Council, Blacktown City Council, Camden Council, Campbelltown City Council, Hawkesbury City Council, The Hills Shire Council, Liverpool City Council, Penrith City Council, Wollondilly Shire Council**

Action 1.5 In circumstances where impacts on the threatened biodiversity listed in Table 1 are unavoidable, as part of any consent, approval or license that is issued, ensure that offset measures are undertaken within the priority conservation lands where practicable (Note that offsets for impacts within the Growth Centres will continue to be provided in accordance with the Growth Centres Biodiversity Certification Order.)

Responsibility: **DECCW, Department of Planning, The Hills Shire Council, Liverpool City Council, RailCorp, NSW Roads and Traffic Authority, Sydney Water, TransGrid**

Action 1.6 DECCW will review the priority conservation lands and assessment methodology within five years of the date of approval of the plan

Responsibility: **DECCW**

Key performance targets: Building the protected area network

Five years from the date of approval of the recovery plan:

Target 1.1 The area of the priority conservation lands that is the subject to conservation mechanisms (see Table 6) will have increased

Target 1.2 The priority conservation lands and assessment methodology will have been reviewed

[18] ArcGIS shapefiles of the priority conservation lands are available on the DECCW website at www.maps.environment.nsw.gov.au/.

Recovery Objective 2: To deliver best practice management for threatened biodiversity across the Cumberland Plain, with a specific focus on the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation

Efforts to improve the extent and condition of native vegetation on the Cumberland Plain using assisted natural regeneration and revegetation techniques have been progressing for many years. These efforts have focused on individual sites, as well as identified local and regional corridors. Significant public funding has been invested in this work, as well as related programs including those identified in Section 8.

Actions under this objective seek to promote the adoption of best practice standards for bushland management (Appendix 2) on all tenures across the Cumberland Plain. However, particular emphasis is given to the priority conservation lands and public lands where the primary management objectives are compatible with biodiversity conservation.

These actions also seek to ensure that public funding for activities associated with the management of the threatened biodiversity addressed in this recovery plan is preferentially invested in the priority conservation lands. Having been identified as the 'regional priorities' for recovery efforts, it is appropriate that these lands be afforded the highest priority when allocating finite resources.

The funding and the implementation of best practice management may not be limited to the priority conservation lands. The importance of efforts to improve the extent and condition of native vegetation outside these areas, or to establish buffers, corridors and other ecological linkages between these is also recognised. Such work will potentially provide a valuable complement to the priority conservation lands and assist in conserving biodiversity more generally.

Recovery actions: Delivering best practice management

Action 2.1 Preferentially target any future investment associated with the management of the threatened biodiversity listed in Table 1 to the priority conservation lands where practicable

Responsibility: **Bankstown City Council, Campbelltown City Council, DECCW, Hawkesbury–Nepean CMA, The Hills Shire Council, Liverpool City Council, Sydney Metropolitan CMA**

Action 2.2 Support and promote the adoption of best practice standards for bushland management and restoration (as specified in Appendix 2) on public and private lands within the Cumberland Plain

Responsibility: **Bankstown City Council, Campbelltown City Council, City of Canterbury, DECCW, Fairfield City Council, Hawkesbury–Nepean CMA, The Hills Shire Council, Hornsby Shire Council, Liverpool City Council, Penrith City Council, Strathfield Council, Sydney Metropolitan CMA**

Action 2.3 State and Australian Government agencies will manage, to best practice standards (as specified in Appendix 2), any lands which are under their ownership or for which they have care control and management, which:

- contain any of the threatened biodiversity listed in Table 1
- are located within the priority conservation lands or, if located outside these lands, have conservation as a primary management objective

Responsibility: **DECCW, Department of Industry and Investment, RailCorp, NSW Roads and Traffic Authority, Sydney Catchment Authority, Sydney Water, TransGrid, University of Western Sydney, Western Sydney Parklands Trust**

Action 2.4 Promote the inclusion of measures to protect and restore remnant vegetation, consistent with the best practice management guidelines, in the environmental management plans for schools in the study area

Responsibility: **Department of Education and Training**

Action 2.5 Local government will manage to best practice standards (as specified in Appendix 2) any lands which are under their ownership or for which they have care, control and management, which:

- contain any of the threatened biodiversity listed in Table 1
- are located within the priority conservation lands or, if located outside these lands, have conservation as a primary management objective

Responsibility: **Bankstown City Council, Blacktown City Council, Camden Council, City of Canterbury, Fairfield City Council, Hawkesbury City Council, The Hills Shire Council, Holroyd City Council, Hornsby Shire Council, Parramatta City Council, Penrith City Council, Strathfield Council, Wollondilly Shire Council**

Action 2.6 DECCW will develop and promote a landscape-scale response to African Olive invasion on public and private lands within the Cumberland Plain

Responsibility: **DECCW**

Action 2.7 DECCW will coordinate a Cumberland Plain land managers technical group to refine and promote best practice standards for bushland management and restoration on public and private lands within the Cumberland Plain

Responsibility: **DECCW**

Key performance targets: Delivering best practice management

From the date of approval of the recovery plan:

Target 2.1 Investment in conservation activities associated with the threatened biodiversity listed in Table 1 will be preferentially directed towards the priority conservation lands, and will be reported on through the Priorities Action Statement

Target 2.2 Relevant funding agreements and consent, approval and licence conditions will include reference to the best practice bushland management standards endorsed in the recovery plan

Five years from the date of approval of the recovery plan:

Target 2.3 Public authorities endorsing the actions in this plan will have adopted management plans or management approaches for the priority conservation lands consistent with the best practice standards for bushland management described in Appendix 2

Target 2.4 Public authorities endorsing the actions in this plan will have adopted management plans or management approaches consistent with best practice standards for bushland management described in Appendix 2 for lands outside the priority conservation lands that are under their care, control and management and for which conservation is compatible with the primary management objective

Target 2.5 A landscape-scale response to African Olive invasion on public and private lands within the Cumberland Plain will have been developed and promoted

Target 2.6 A land managers technical group will have been formed to refine and promote best practice standards on public lands within the Cumberland Plain

Recovery Objective 3: To develop an understanding and enhanced awareness in the community of the Cumberland Plain's threatened biodiversity, the best practice standards for its management, and the recovery program

Actions under this objective seek to improve the capacity of stakeholders to understand and effectively implement relevant parts of the recovery program. This will involve providing access to information, developing skills and knowledge, and providing support through advice, materials and funding.

DECCW will contact private landholders within the priority conservation lands who may be interested in voluntarily selling their land or entering into a conservation agreement. Other initiatives that will be developed or supported through the recovery program within and outside the priority conservation lands include:

- ongoing provision of information on threatened biodiversity through the DECCW website (e.g. recovery plans, threatened species, populations and community profiles, management guidelines, vegetation maps etc)
- guidance on urban stormwater management
- establishment and promotion of best practice demonstration sites, showcasing both rehabilitation projects and reference sites
- development of interpretive programs for key reserves
- promotion of key events in the implementation of the recovery plan.

DECCW will also work collaboratively with local government authorities to communicate the recovery plan's messages to local communities.

Recovery actions: Promoting awareness, education and engagement

Action 3.1 DECCW will work with state and local government authorities on implementation of the NSW Diffuse Water Pollution Strategy and other programs to promote actions that reduce the impacts of stormwater on sensitive receiving environments, such as remnant bushland.

Responsibility: **DECCW**

Action 3.2 DECCW will provide access to information resources associated with the recovery program (such as the recovery plan, vegetation maps, best practice management guidelines, threatened species, populations and community profiles) through the DECCW website

Responsibility: **DECCW**

Action 3.3 DECCW will negotiate with willing landholders within the priority conservation lands to achieve improved conservation arrangements, including through the establishment of conservation agreements or the voluntary acquisition of land for reservation where cost effective

Responsibility: **DECCW**

Action 3.4 Work collaboratively with local government authorities and other organisations to inform communities about the value and role of remnant vegetation on the Cumberland Plain, the best practice standards for its management, and any opportunities to participate in the recovery program

Responsibility: **Bankstown City Council, Blacktown City Council, Camden Council, Campbelltown City Council, City of Canterbury, DECCW, Fairfield City Council, Hawkesbury City Council, The Hills Shire Council, Holroyd City Council, Hornsby Shire Council, Liverpool City Council, Parramatta City Council, Penrith City Council, Strathfield Council, Wollondilly Shire Council**

Action 3.5 Work with Aboriginal communities, landowners, community groups, and students to deliver best practice management in the priority conservation lands, and to identify other opportunities for involvement in the recovery program

Responsibility: **Bankstown City Council, Blacktown City Council, Camden Council, Campbelltown City Council, City of Canterbury, DECCW, Hawkesbury City Council, Hawkesbury–Nepean CMA, The Hills Shire Council, Holroyd City Council, Hornsby Shire Council, Liverpool City Council, Parramatta City Council, Penrith City Council, Strathfield Council, Sydney Metropolitan CMA, Wollondilly Shire Council**

Action 3.6 Establish and promote best practice management demonstration sites for the threatened biodiversity listed in Table 1

Responsibility: **City of Canterbury, DECCW, Hawkesbury–Nepean CMA, The Hills Shire Council, Hornsby Shire Council, Liverpool City Council, Strathfield Council, Sydney Metropolitan CMA**

Action 3.7 Develop interpretive programs for key local reserves that contain examples of the threatened biodiversity addressed in the recovery plan

Responsibility: **Bankstown City Council, Blacktown City Council, Camden Council, Campbelltown City Council, City of Canterbury, DECCW, Hawkesbury City Council, The Hills Shire Council, Holroyd City Council, Hornsby Shire Council, Liverpool City Council, Parramatta City Council, Penrith City Council, Strathfield Council, Wollondilly Shire Council**

Key performance targets: Promoting awareness, education and engagement

Five years from the date of approval of the recovery plan:

Target 3.1 Urban stormwater management guidelines will have been promoted to key stakeholders in the region

Target 3.2 Key information resources associated with the recovery program will be accessible on the DECCW website

Target 3.3 A strategy for improving conservation arrangements for land within the priority conservation lands will be developed and implemented with willing landholders

Target 3.4 Local government authorities will be implementing communication strategies associated with the recovery plan

Target 3.5 Demonstration sites for threatened biodiversity will be established and promoted

Recovery Objective 4: To increase knowledge of the threats to the survival of the Cumberland Plain's threatened biodiversity, and thereby improve capacity to manage these in a strategic and effective manner

The biodiversity of the Cumberland Plain has been the focus of considerable research and survey effort. The existing information on the region's biodiversity, particularly regional native vegetation mapping, has served its purpose well by providing clear evidence of the extent of vegetation loss, the level of fragmentation, and by highlighting conservation significance. This information has had a major influence on decision-making processes and has provided a common basis for directing community action and on-ground restoration programs.

The data on which much of the original regional vegetation mapping was based are now over ten years old. To remain relevant to future decision-making, this mapping needs to be reviewed and updated. In general, updates can largely be completed remotely with the use of contemporary, high quality aerial photography, although some site survey may be required, for example, at sites that were affected by fire during previous surveys or whose vegetation remains 'unclassified'.

Verification and updating of the regional vegetation maps are also needed to enhance monitoring, as well as compliance and enforcement programs to tackle unauthorised land clearing and degradation activities.

DECCW will encourage and assist local government authorities to develop biodiversity strategies that are consistent with the priorities identified in the recovery plan. This would involve the identification of buffers, corridors and ecological linkages that would support the priority conservation lands and identification of other areas of local conservation significance.

The actions under this objective also promote research and monitoring priorities that are relevant to the management of the threatened biodiversity of the Cumberland Plain.

Recovery actions: Enhancing information, monitoring and enforcement

Action 4.1 Review the adequacy of the existing regional vegetation mapping, including information on the extent, condition and classification of the vegetation, to determine what requires updating and identify the gaps where further information is required

Responsibility: **DECCW**

Action 4.2 DECCW will seek resources to update the existing vegetation maps for the Cumberland Plain, and to provide for more ongoing monitoring and updates every 5 to 10 years

Responsibility: **DECCW**

Action 4.3 DECCW will encourage local councils to prepare or review biodiversity strategies to be consistent with the recovery plan that guide protection, management and strategic investment in threatened biodiversity, both within and outside of the priority conservation lands

Responsibility: **Bankstown City Council, Blacktown City Council, Camden Council, Campbelltown City Council, City of Canterbury, DECCW, Fairfield City Council, Hawkesbury City Council, The Hills Shire Council, Holroyd City Council, Hornsby Shire Council, Liverpool City Council, Parramatta City Council, Penrith City Council, Strathfield Council, Wollondilly Shire Council**

Action 4.4 DECCW will work collaboratively with local councils to enhance the compliance and enforcement program with regard to the unauthorised clearing of bushland on the Cumberland Plain

Responsibility: **Bankstown City Council, Blacktown City Council, Camden Council, Campbelltown City Council, City of Canterbury, DECCW, Fairfield City Council, Hawkesbury City Council, The Hills Shire Council, Holroyd City Council, Hornsby Shire Council, Liverpool City Council, Parramatta City Council, Penrith City Council, Strathfield Council, Wollondilly Shire Council**

Action 4.5 DECCW will work with the Department of Planning to establish a statutory framework that enables DECCW to be notified when development activity under the EP&A Act occurs within and adjacent to priority conservation lands

Responsibility: **DECCW, Department of Planning**

Action 4.6 DECCW will support, promote and, where feasible, undertake research and monitoring that will assist future management decisions regarding the threatened biodiversity listed in Table 1, in accordance with the research priorities detailed in Appendix 4

Responsibility: **DECCW**

Key performance targets: Enhancing information, monitoring and enforcement

Five years from the date of approval of the recovery plan:

Target 4.1 The regional native vegetation mapping will have been updated using recent aerial photography

Target 4.2 Local government authorities will be actively implementing biodiversity strategies which adopt an approach consistent with that of the recovery plan

Target 4.3 Enhanced compliance and enforcement programs will be established utilising updated vegetation mapping and remote sensing technologies where feasible

Target 4.4 Collaborative research and monitoring programs on the threatened biodiversity of the Cumberland Plain will be established to inform on-ground management decisions

Additional species-specific actions for the endangered population of *Pomaderris prunifolia* and Sydney Plains Greenhood

The overall strategy of the recovery plan is to provide for the long-term survival of the threatened biodiversity of the Cumberland Plain, including the threatened species, populations and ecological communities listed in Table 1. In addition to the list of actions under the four themes of the recovery strategy, species-specific actions have also been identified for the recovery of two plants, the Sydney Plains Greenhood and the endangered population of *Pomaderris prunifolia*. These actions are required due to the very small number of known sites containing these species.

Recovery actions: Species-specific actions

Pomaderris prunifolia (a shrub) population in the Parramatta, Auburn, Strathfield and Bankstown LGAs

Action 5.1 Using propagative material sourced from the Rydalmere site, seek to establish a viable self sustaining population of *Pomaderris prunifolia* in nearby habitat that is under secure tenure

Responsibility: **Parramatta City Council**

Action 5.2 Prepare a translocation proposal for the *Pomaderris prunifolia* at the Rydalmere site to guide the implementation of these works and the long-term monitoring outcomes

Responsibility: **Parramatta City Council**

Action 5.3 Ensure that the Rydalmere *Pomaderris prunifolia* work is consistent with the *Guidelines for Translocation of Threatened Plants in Australia* (Vallee et al. 2004)

Responsibility: **Parramatta City Council**

Action 5.4 Implement an ecological burn of the *Pomaderris prunifolia* population at the Bankstown Crest Reserve site within 2 years of approval of the recovery plan to encourage seedling recruitment of this species

Responsibility: **Bankstown City Council**

Sydney Plains Greenhood

Action 5.5 Coordinate the implementation of a monitoring program for the Sydney Plains Greenhood in consultation with landholders to monitor population dynamics and response to management

Responsibility: **DECCW**

Action 5.6 Conduct additional targeted surveys for the Sydney Plains Greenhood in the Holsworthy and Wilton areas

Responsibility: **DECCW**

Action 5.7 Investigate flasking or seed banking of existing populations of the Sydney Plains Greenhood

Responsibility: **DECCW**

Key performance targets: Species-specific actions

Five years from the date of approval of the recovery plan:

Target 5.1 Propagative material sourced from the Rydalmere site will have been used to establish a population of *Pomaderris prunifolia* in nearby habitat under secure tenure

Target 5.2 A translocation proposal for the *Pomaderris prunifolia* at the Rydalmere site will have been prepared

Target 5.3 Works at the Rydalmere *Pomaderris prunifolia* site will be consistent with the *Guidelines for Translocation of Threatened Plants in Australia* (Vallee et al. 2004)

Target 5.4 An ecological burn will have been implemented at the Bankstown Crest Reserve site within 2 years of approval of the recovery plan to encourage seedling recruitment of this species

Target 5.5 Implementation of monitoring program for the Sydney Plains Greenhood will be coordinated in consultation with landholders

Target 5.6 Targeted surveys will have been completed for the Sydney Plains Greenhood in Holsworthy and Wilton areas

Target 5.7 Symbiotic culture and seed banking for existing collections of the Sydney Plains Greenhood will have been investigated, and seed collected and stored from wild populations

11 Consideration of Aboriginal interests

With over 30,000 people, the greater Sydney region contains one of the largest Aboriginal populations in Australia (Attenbrow 2002). Local Aboriginal Land Councils (LALCs) are significant landowners of native vegetation on the Cumberland Plain. They are required to protect the interests of Aboriginal persons in this area in relation to the acquisition, management, use, control and disposal of its land. There are three LALC with responsibility for areas in the Cumberland Plain: Deerubbin, Gandangara and Tharawal. LALCs and other groups representing Aboriginal people from the Cumberland Plain have been contacted during the writing of this recovery plan, and consultation with these groups is ongoing.

DECCW recognises that the LALCs have social, cultural and economic interests for their lands that both compete and complement the biodiversity values. DECCW proposes to work closely with LALCs to identify opportunities for multiple outcomes across these areas. Opportunities may exist through DECCW's *Land Alive* program to engage with LALCs regarding biodiversity issues. *Land Alive* gives Aboriginal landowners a chance to balance economic objectives with land stewardship responsibilities through managing land for conservation under the Biobanking scheme[19].

Biobanking enables land owners to derive an annual income to manage land for biodiversity conservation and provides a streamlined offset mechanism for development impacts on biodiversity. In this regard the scheme has benefits for Aboriginal land owners in both conservation and development contexts, which is highly relevant for Aboriginal land owners in a metropolitan setting. *Land Alive* assists Aboriginal land owners to participate successfully in the Biobanking scheme by developing knowledge of biodiversity values on Aboriginal owned land, increasing the skills of Aboriginal land owners to manage land for conservation and providing support to Aboriginal land owners to test the Biobanking scheme.

Land Alive has engaged with two of the three LALCs in the Cumberland Plain area and has an on-going relationship with the NSW Aboriginal Land Council (NSWALC) to develop strategies to identify and address policy and legislative concerns from the Land Council perspective.

12 Critical habitat

Critical habitat has not been declared for any of the threatened entities addressed by this recovery plan under the TSC Act. The declaration of critical habitat under the TSC Act is not considered to be a priority, as other measures will be employed through the implementation of this plan that will seek to increase the security of the regional conservation priorities.

Under the EPBC Act, a recovery plan must identify the habitats that are critical to the survival of the species or communities covered by the plan. 'Habitat critical to the survival' differs from 'critical habitat' under the EPBC Act, which has not been declared for any of the threatened entities addressed in this plan. For the threatened entities in Table 1 that are listed under the EBPC Act, the Priority Conservation Lands are considered to contain the habitats critical to their survival. It should be noted that the Priority Conservation Lands will be reviewed within 5 years of the approval of this plan, in accordance with Action 1.6.

13 Social and economic consequences of taking action

Implementation of the recovery plan will deliver a range of socio-economic benefits including:

- the long-term survival of viable areas of conservation value for threatened biodiversity that are also the most cost effective for ongoing management
- the most effective and efficient use of available resources, ensuring that each available conservation dollar delivers the maximum investment return
- the delivery of ecological and human services, such as air and water quality, regulation of local climatic conditions, noise abatement, amenity and recreation

[19] For more information visit the DECCW website at www.environment.nsw.gov.au/landalive/index.htm.

- meeting community expectations for the protection of biodiversity
- supporting provision of a safety net for the biodiversity impacts of climate change
- streamlined planning processes and potential economic gains for private landowners protecting and managing biodiversity under new schemes such as Biobanking.

The recovery program has been designed to align with existing programs and commitments where possible. These include:

- the Growth Centres conservation fund which will strongly support actions to build the protected area network on the Cumberland Plain, consistent with the biodiversity certification order (NSW Government 2007)
- land-use planning commitments under the *Metropolitan Strategy for* Sydney (Department of Planning 2005) and standard local planning practice requirements
- current land-use zoning (i.e. avoiding areas that are zoned for urban development)
- existing requirements for the preparation of management plans, either by State or local government authorities responsible for land management
- existing programs to manage and control environmental weed and pest animal species
- restoration and rehabilitation projects being delivered through the Hawkesbury–Nepean and Sydney Metropolitan CMAs, the Greening Western Sydney program, and local Landcare and Bushcare groups
- existing programs to establish best practice demonstration sites and develop educational and promotional material
- existing corridors identified in western Sydney.

New or supplementary resources are required in some action areas, including:

- verification and updating of the native vegetation maps of the Cumberland Plain and ongoing monitoring of the extent and condition of native vegetation
- the enhancement of compliance and enforcement programs targeting unauthorised clearing
- reviewing *Recovering bushland on the Cumberland Plain: Best practice guidelines for the management and restoration of bushland* (DEC 2005a)
- developing a landscape-scale response to African Olive invasion on the Cumberland Plain (as per completion of action 2.6).

This recovery plan does not require that additional planning protections be placed over the priority conservation lands. What the recovery plan does do is inform land-use planning decisions by clearly identifying the priority conservation lands as being regional priorities for the conservation of threatened biodiversity. The socio-economic implications of future rezoning or development proposals in the priority conservation lands will be addressed via the existing assessment processes of the EP&A Act.

Similarly, the actions in the *Metropolitan Strategy for* Sydney (Department of Planning 2005) provide clear direction regarding the NSW Government's commitment to the protection of Sydney's biodiversity values. The recovery program directly reflects these commitments and in that context does not in itself generate any new socio-economic impacts that have not already been contemplated by the NSW Government.

14 Preparation details and review date

This recovery plan has been prepared by the NSW Department of Environment, Climate Change and Water with financial assistance from the Australian Government. It has been developed in consultation with the NSW Scientific Committee (Appendix 5) and other technical and scientific experts both within and external to DECCW. The information in this recovery plan was accurate to the best available knowledge on the date it was approved.

This recovery plan will be reviewed five years from the date of its approval by the Minister for Climate Change and the Environment.

15 References

Attenbrow V. (2002) *Sydney's Aboriginal Past*. UNSW Press, Sydney

Benson D.H. (1992) The natural vegetation of the Penrith 1:100,000 map sheet. *Cunninghamia* 2, 4:541–96

Department of Environment and Conservation (2005a) *Recovering bushland on the Cumberland Plain: Best practice guidelines for the management and restoration of bushland*. NSW Department of Environment and Conservation, Sydney

Department of Environment and Conservation (2005b) *Candidate Areas Fauna Reports*. Prepared as part of the rapid fauna assessment of high priority remnant vegetation in western Sydney. Unpublished Report

Department of Environment and Climate Change (2009) *Conservation Incentives Program Final Report*. Unpublished report, Department of Environment and Climate Change, Hurstville

Department of Environment, Climate Change and Water (2010) *Report on the Methodology for Identifying Priority Conservation Lands on the Cumberland Plain*. NSW Department of Environment and Climate Change, Hurstville

Department of Planning (2005) *Metropolitan Strategy for Sydney*. NSW Department of Planning, Sydney

Department of Planning (2008a) *State and Regional Population Projections: 2008 Release*. Available at: www.planning.nsw.gov.au/Programsservices/Populationandhousingprojections/tabid/124/language/en-US/Default.aspx

Department of Planning (2008b) *Biodiversity Restoration Strategy – Western Sydney Parklands*. Department of Planning, Sydney

Department of Planning (2008c) *Biodiversity Restoration Strategy – South and Ropes Creeks*. Department of Planning, Sydney

Freudenberger D., Noble J. and Morton S. (1997) *A Comprehensive, Adequate and Representative Reserve System for the Southern Mallee of NSW: Principles and Benchmarks*. A consultancy report prepared for the NSW Department of Land and Water Conservation and the Southern Mallee Regional Planning Committee

Growth Centres Commission (2007) *Growth Centres Conservation Plan Exhibition Draft*. Growth Centres Commission, Parramatta

Hawkesbury–Nepean Catchment Management Authority (2006) *Hawkesbury–Nepean Catchment Action Plan*. Hawkesbury–Nepean Catchment Management Authority, Sydney

Hughes N.K., Burley A.L., King SA. and Downey P.O. (2009) *Monitoring manual for bitou bush control and native plant recovery*. Department of Environment, Climate Change and Water, Sydney

National Parks and Wildlife Service (2002) *The Native Vegetation of the Cumberland Plain Final Edition*. NSW National Parks and Wildlife Service, Hurstville

National Parks and Wildlife Service (2003) *Guidelines for Ecologically Sustainable Fire Management*. *NSW Biodiversity Strategy*. Unpublished Report

NSW Government (2007) *Order to confer biodiversity certification on the State Environmental Planning Policy (Sydney Region Growth Centres) 2006*. Available at: www.environment.nsw.gov.au/resources/nature/biocertordwsgcentres.pdf

NSW Government (2010a) *NSW State Plan*. Available at: www.nsw.gov.au/stateplan

NSW Government (2010b) *Sydney Growth Centres Strategic Assessment Draft Program Report*. Available at: www.growthcentres.nsw.gov.au/strategicassessment-94.html

NSW Government (2010c) *Draft EPBC Act Strategic Assessment Report for the Sydney Growth Centres Program*. Available at: www.growthcentres.nsw.gov.au/strategicassessment-94.html

NSW Scientific Committee (2010). *African Olive* Olea europaea L. subsp. cuspidata *(Wall ex G.Don Ciferri) – key threatening process listing, final determination*. Available at http://www.environment.nsw.gov.au/determinations/africanoliveFD.htm

NSW Scientific Committee (2009) *Cumberland Plain Woodland in the Sydney Basin Bioregion – critically endangered ecological community listing.* Available at http://www.environment.nsw.gov.au/determinations/cumberlandwoodlandsFD.htm

NSW Scientific Committee and Simpson, C.C. (2008) *Change in the distribution of Cumberland Plain Woodland*. Unpublished Report

Sommerville K.D., Siemon J.P., Wood C.B. and Offord C.A. (2008) Simultaneous encapsulation of seed and mycorrhizal fungi for long-term storage and propagation of terrestrial orchids. *Australian Journal of Botany*, vol. 56, pp. 609–615

Sommerville K.D., Heslewood M.M., Siemon J.P. and Offord C.A. (2009) Banking site soil for the germination of terrestrial orchid seed collections. *Seed Sci. & Technol.*, vol. 37, pp. 222–228

Tozer M. (2003) The native vegetation of the Cumberland Plain, western Sydney: systematic classification and field identification of communities. *Cunninghamia* 8(1): 2003

Vallee L., Hogbin T., Monks L., Makinson B., Matthes M. and Rossetto M. (2004) *Guidelines for the Translocation of Threatened Plants in Australia, second edition.* Australian Network for Plant Conservation, Canberra

West Australian Local Government Association (2004) *Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Region.* West Australian Local Government Association, Perth

Western Sydney Regional Organisation of Councils (2005) *FutureWest – Final report*. Sydney, WSROC

Watson P. J. (2005) *Fire frequencies for Western Sydney's woodlands: indications from vegetation dynamics.* PhD thesis, University of Western Sydney

Appendix 1: Cost and implementation details

Action no	Action title	Priority [22]	Cost estimate ($/year)					Total cost ($)	Funding sources[23]	Responsible party[24]
			Year 1	Year 2	Year 3	Year 4	Year 5			
Building the protected area network										
1.1	DECCW will negotiate with the relevant Australian government authorities to seek the highest level of protection for priority conservation lands managed by the Australian government, via options such as conservation agreements or the transfer of lands into the formal reserve system	1	2,000	2,000	2,000	1,000	1,000	8,000	In kind	DECCW
1.2	DECCW will seek and encourage investment for the protection of the threatened biodiversity in Table 1, including via voluntary acquisition or conservation agreements, to be preferentially targeted to the priority conservation lands	1	2,000	2,000	2,000	2,000	2,000	10,000	In kind	DECCW
1.3	DECCW will negotiate with other public authorities regarding the options for including the priority conservation lands that are under their care, control and management in the protected area network	1	2,000	2,000	2,000	2,000	2,000	10,000	In kind	DECCW
1.4	Local councils will have regard to the priority conservation lands in identifying areas for inclusion in environment protection and regional open space zones	1						Not costed	In kind	BnksCC, BlaCC, CC, CCC, HillsSC, LCC, PCC, WSC
1.5	In circumstances where impacts on the threatened biodiversity listed in Table 1 are unavoidable, as part of any consent, approval or license that is issued, ensure that offset measures are undertaken within the priority conservation lands where practicable (Note that offsets for impacts within the Growth Centres will continue to be provided in accordance with the Growth Centres Biodiversity Certification Order)	1						Not costed	Unsecured	DECCW, DoP, HillsSC, LCC, RailCorp, RTA, SW, TransGrid
1.6	DECCW will review the priority conservation lands and assessment methodology within five years of the date of approval of the plan	3				5,000	5,000	10,000	Unsecured and in kind	DECCW
Delivering best practice management										
2.1	Preferentially target any future investment associated with the management of the threatened biodiversity listed in Table 1 to the priority conservation land where practicable	1						Not costed	Unsecured	BnksCC, CCC, DECCW, HNCMA, HillsSC, LCC
2.2	Support and promote the adoption of best practice standards for bushland management and restoration (as specified in Appendix 2) on public and private lands within the Cumberland Plain	2						Not costed	Unsecured	BnksCC, CCC, CoC, DECCW, FCC, HNCMA, HillsSC, HbySC, LCC,

Action no	Action title	Priority [22]	Cost estimate ($/year)					Total cost ($)	Funding sources[23]	Responsible party[24]
			Year 1	Year 2	Year 3	Year 4	Year 5			
										PenCC, SC, SMCMA
2.3	State and Australian government agencies will manage, to best practice standards (as specified in Appendix 2), any lands which are under their ownership or for which they have care, control and management and: - contain any of the threatened biodiversity listed in Table 1 - are located within the priority conservation lands or, if located outside these lands, have conservation as a primary management objective	1						Not costed	Unsecured	DECCW, I&I, RailCorp, RTA, SCA, SW, TransGrid, UoWS, WSPT
2.4	Promote the inclusion of measures to protect and restore remnant vegetation, consistent with the best practice management guidelines in the environmental management plans for schools in the study area	3							Not costed	DET
2.5	Local government will manage to best practice standards (as specified in Appendix 2), any lands which are under their ownership or for which they have care control and management, which: - contain any of the threatened biodiversity listed in Table 1 - are located within the priority conservation lands or, if located outside these lands, have conservation as a primary management objective	1							Not costed	BnksCC, BlaCC, CC, CoC, FCC, HillsSC, HolCC, HbySC, ParaCC, PenCC, SC, WSC
2.6	DECCW will develop and promote a landscape-scale response to African Olive invasion on public and private lands within the Cumberland Plain	2	1,600	1,600	1,600	1,600	1,600	8,000	In kind	DECCW
2.7	DECCW will coordinate a Cumberland Plain land managers technical group to refine and promote best practice standards for bushland management and restoration on public lands within the Cumberland Plain	3	1,600	1,600	1,600	1,600	1,600	8,000	In kind	DECCW
Promoting awareness, education and engagement										
3.1	DECCW will work with state and local government authorities on implementation of the NSW Diffuse Water Pollution Strategy and other programs to promote actions that reduce the impacts of stormwater on sensitive receiving environments, such as remnant bushland.	2	2,000	2,000	1,000	1,000	1,000	7,000	In kind	DECCW
3.2	DECCW will provide access to information resources associated with the recovery program (such as the recovery plan, vegetation maps, best practice guidelines, threatened species, populations and community profiles) through the DECCW website	2	500	500	500	500	500	2,500	In kind	DECCW
3.3	DECCW will negotiate with willing landholders within the priority conservation lands to achieve improved conservation arrangements, including through the establishment of conservation agreements or the voluntary acquisition of land for reservation where cost effective	2	220,000	140,000	70,000	70,000	70,000	570,000	Secured[25]	DECCW
3.4	Work collaboratively with local government authorities and other organisations to inform communities about the value and role of remnant vegetation on the	2						Not costed	In kind	BnksCC, BlaCC, CC,

Action no	Action title	Priority [22]	Cost estimate ($/year)					Total cost ($)	Funding sources[23]	Responsible party[24]
			Year 1	Year 2	Year 3	Year 4	Year 5			
	Cumberland Plain, the best practice standards for its management, and any opportunities to participate in the recovery program									CCC, CoC, DECCW, FCC, HillsSC, HolCC, HbySC, LCC, ParaCC, PenCC, SC, WSC
3.5	Work with Aboriginal communities, landowners, community groups, and students to deliver best practice management in the priority conservation lands, and to identify other opportunities for involvement in the recovery program	2						Not costed	Unsecured	BnksCC, BlaCC, CC, CCC, CoC, DECCW, FCC, HNCMA, HillsSC, HolCC, HbySC, LCC, ParaCC, PenCC, SC, SMCMA, WSC
3.6	Establish and promote best practice demonstration sites for the biodiversity listed in Table 1	2	30,000	30,000	30,000	10,000	10,000	110,000	Unsecured and in kind	CoC, DECCW, HNCMA, HillsSC, HbySC, LCC, SC, SMCMA
3.7	Develop interpretive programs for key local reserves that contain examples of the threatened biodiversity addressed in the recovery plan	2	3,000	3,000	3,000	3,000	3,000	15,000	Unsecured and in kind	BnksCC, BlaCC, CC, CCC, CoC, DECCW, HillsSC, HolCC, HbySC, LCC, ParaCC, PenCC, SC, WSC
Enhancing information, monitoring and enforcement										
4.1	Review the adequacy of the existing regional vegetation mapping, including information on the extent, condition and classification of the vegetation, to determine what requires updating and identify the gaps where further	2	1,600	1,600	1,600	1,600	1,600	8,000	In kind	DECCW

Action no	Action title	Priority [22]	Cost estimate ($/year)					Total cost ($)	Funding sources[23]	Responsible party[24]
			Year 1	Year 2	Year 3	Year 4	Year 5			
	information is required									
4.2	DECCW will seek resources to update the existing vegetation maps for the Cumberland Plain, and to provide for more regular ongoing monitoring and updates	3						Subject to action 4.1, not costed	Unsecured	DECCW
4.3	DECCW will encourage local councils to prepare or review biodiversity strategies to be consistent with the recovery plan and that guide protection, management and strategic investment in threatened biodiversity, both within and outside of the priority conservation lands	1						Not costed	Unsecured and in kind	BnksCC, BlaCC, CC, CCC, CoC, DECCW, FCC, HillsSC, HolCC, HbySC, LCC, ParaCC, PenCC, SC, WSC
4.4	DECCW will work collaboratively with local councils to enhance the compliance and enforcement program with regard to the unauthorised clearing of bushland on the Cumberland Plain	2						Not costed	Unsecured and in kind	BnksCC, BlaCC, CC, CCC, CoC, DECCW, FCC, HillsSC, HolCC, HbySC, LCC, ParaCC, PenCC, SC, WSC
4.5	DECCW will work with the Department of Planning to establish a statutory framework that enables DECCW to be notified when development activity under the EP&A Act occurs within and adjacent to priority conservation lands	1	2,000	2,000	2,000	2,000	2,000	10,000	In kind	DECCW, DoP
4.6	DECCW will support, promote and, where feasible, undertake research and monitoring that will assist future management decisions regarding the threatened biodiversity listed in Table 1, in accordance with the research and monitoring priorities detailed in Appendix 4	3						Not costed	Unsecured and in kind	DECCW
Additional species-specific actions are proposed for the *Pomaderris prunifolia* endangered population and Sydney Plains Greenhood (*Pterostylis saxicola*)										
***Pomaderris prunifolia* endangered population**										
5.1	Using propagative material sourced from the Rydalmere site, seek to establish a viable self sustaining population of *Pomaderris prunifolia* in nearby habitat that is under secure tenure	2							Unsecured	ParraCC
5.2	Prepare a translocation proposal for the *Pomaderris prunifolia* population at the	2	2,000	2,000	2,000	2,000	2,000	10,000	Unsecured	ParraCC

Action no	Action title	Priority [22]	Cost estimate ($/year)					Total cost ($)	Funding sources[23]	Responsible party[24]
			Year 1	Year 2	Year 3	Year 4	Year 5			
	Rydalmere site to guide the implementation of these works and the long-term monitoring outcomes									
5.3	Ensure that the Rydalmere *Pomaderris prunifolia* work is consistent with the *Guidelines for Translocation of Threatened Plants in Australia* (Vallee et al. 2004)	2	1,600	1,600					Unsecured and in kind	DECCW, ParraCC
5.4	Implement an ecological burn of the *Pomaderris prunifolia* population at the Bankstown Crest Reserve site within 2 years of approval of the recovery plan to encourage seedling recruitment of this species.	2							Unsecured	BnksCC
Sydney Plains Greenhood										
5.5	Coordinate the implementation of a monitoring program for the Sydney Plains Greenhood in consultation with landholders to monitor population dynamics and response to management	3	4,000	4,000	4,000	4,000	4,000	20,000	Unsecured and in kind	DECCW
5.6	Conduct additional targeted surveys for the Sydney Plains Greenhood in the Holsworthy and Wilton areas	3	4,000	4,000	4,000	4,000	4,000	20,000	Unsecured and in kind	DECCW
5.7	Investigate flasking or seed banking of existing populations of the Sydney Plains Greenhood	3	4,000	4,000	4,000	4,000	4,000	20,000	Unsecured	DECCW

[22] Priority ratings are: 1 - action critical to meeting plan objectives, 2 - action contributing to meeting plan objectives, 3 - desirable but not essential action.
[23] 'In kind' funds represent a salary component of permanent staff and current resources.
[24] Abbreviations: BnksCC = Bankstown City Council, BlaCC = Blacktown City Council, CC = Camden Council, CoC = City of Canterbury, CCC = Campbelltown City Council, DECCW = Department of Environment, Climate Change and Water, DET = Department of Education and Training, I&I = Department of Industry and Investment, DoP = Department of Planning, FCC = Fairfield City Council, HNCMA = Hawkesbury–Nepean Catchment Management Authority, HillsSC = The Hills Shire Council, HolCC = Holroyd City Council, HbySC = Hornsby Shire Council, LCC = Liverpool City Council, ParraCC = Parramatta City Council, PCC = Penrith City Council, RTA = NSW Roads and Traffic Authority, SC = Strathfield Council, SCA = Sydney Catchment Authority, SMCMA = Sydney Metro Catchment Management Authority, SW = Sydney Water, UoWS = University of Western Sydney, WSPT = Western Sydney Parklands Trust, WSC = Wollondilly Shire Council.
[25] These funds are dependent on the certification order for the Growth Centres being maintained in its current form.

Appendix 2: Best practice standards for bushland management

For the purposes of this recovery plan, DECCW has defined best practice standards for bushland with various management objectives. Below are the requirements for lands to meet best practice standards for management.

1. Bushland on **public lands within or outside the priority conservation lands which have conservation as a primary management objective** requires:
   - an adopted plan of management, management system or biodiversity strategy (or similar planning document), which addresses management of threatened biodiversity and is consistent with the recovery plan
   - the implementation of the plan, system or strategy is funded such that its objectives are met
   - details of the implementation of the plan, system or strategy are publicly reported
   - monitoring to be undertaken periodically to determine the status of threatened entities, or to assess the effectiveness of threat abatement measures being implemented (for guidance see the *Monitoring manual for bitou bush control and native plant recovery* (Hughes et al. 2009) at www.environment.nsw.gov.au/bitouTAP/monitoring.htm)
   - management to be consistent with the following documents, and any additional best practice documents that DECCW may promote at a later date:
     - *Recovering bushland on the Cumberland Plain – Best practice guidelines for the management and restoration of bushland* (DEC 2005a)
     - the recommended fire regimes in the Appendix 3
     - a landscape-scale response to African Olive invasion on the Cumberland Plain (as per completion of action 2.6)

2. Bushland on **public lands outside the priority conservation lands where conservation is not a primary management objective but is compatible with the primary management objective** requires:
   - an adopted management system or policy (or similar planning document) which addresses management of threatened biodiversity and is consistent with the recovery plan
   - the land to be managed such that the objectives of the management system or policy are met
   - monitoring to be undertaken periodically to determine the status of threatened entities, or to assess the effectiveness of threat abatement measures being implemented (for guidance see the *Monitoring manual for bitou bush control and native plant recovery* (Hughes et al. 2009) at www.environment.nsw.gov.au/bitouTAP/monitoring.htm)
   - management is consistent with the following documents, and any additional best practice documents that DECCW may promote at a later date:
     - *Recovering bushland on the Cumberland Plain – Best practice guidelines for the management and restoration of bushland* (DEC 2005a)
     - the recommended fire regimes in the Appendix 3
     - a landscape-scale response to African Olive invasion on the Cumberland Plain (as per completion of action 2.6)

3. Bushland on **private lands** requires:
   - a site action or management plan to be prepared which addresses the management of threatened biodiversity and is consistent with the recovery plan
   - the land to be managed in accordance with the site action or management plan
   - management to be consistent with the following documents, and any other best practice documents that DECCW may promote at a later date:
     - *Recovering bushland on the Cumberland Plain – Best practice guidelines for the management and restoration of bushland* (DEC 2005a)
     - the recommended fire regimes in Appendix 3

Appendix 3: Recommended fire regimes for threatened biodiversity of the Cumberland Plain

Inappropriate fire regimes can alter the species composition and the structure of ecological communities. The key factors in fire regimes are the fire's frequency, intensity and season of occurrence. High fire frequency leads to a reduction in shrub diversity and abundance, particularly legumes (e.g. *Dillwynia* and *Pultenaea* species). However, low fire frequency often leads to dominance of one shrub species, such as Blackthorn (*Bursaria spinosa*) or Prickly Leaved Paperbark (*Melaleuca nodosa*). Given the fragmented nature of Cumberland Plain remnants, an inappropriate fire regime can lead to local extinctions of species because recolonisation or perpetuation of the population elsewhere in the landscape may not be possible.

The recommended fire intervals (i.e. fire frequencies) for Cumberland Plain ecological communities will vary depending on their structure, with the grassy woodlands requiring a higher fire frequency than the shrubby woodlands to maintain their structure. There is need for further investigation of fire intervals for the Cumberland Plain to determine more conclusively the required fire regimes for various ecological communities (Appendix 4).

The current recommended fire intervals (Table 7 and 8) are largely based upon fire interval guidelines for broad vegetation types (NPWS 2003) and the NSW Rural Fire Service's Threatened Species Hazard Reduction List[26], amended to include information based upon studies carried out specifically within Cumberland Plain ecological communities (Watson 2005).

It is important to note that when applying inter-fire intervals in planning, actual intervals, seasonality and fire intensity experienced at a site should be variable to ensure the greatest species diversity.

The figures in Table 7 and 8 are indicative and their implementation should be accompanied by ongoing monitoring of the effects on species richness and community structure. Site-specific plans should be adopted that take into consideration the overall management aims and the use of fire in the local context.

Table 7. General fire regimes for threatened ecological communities of the Cumberland Plain[27]

Threatened Ecological Community	Suggested min fire interval (years)	Suggested max fire interval (years)
Agnes Banks Woodland	7	30
Castlereagh Swamp Woodland	7	30
Cooks River/Castlereagh Ironbark Forest	5	18
Cumberland Plain Woodland	5	12
Elderslie Banksia Scrub Forest	7	30
Moist Shale Woodland	Burning not recommended	Burning not recommended
Shale Gravel Transition Forest	5	15
Shale Sandstone Transition Forest	7	30
Sydney Coastal River-flat Forest	7	35
Western Sydney Dry Rainforest	Burning not recommended	Burning not recommended

[26] For more information see www.rfs.nsw.gov.au/dsp_content.cfm?CAT_ID=536.

[27] Fire intervals are based upon fire interval guidelines for broad vegetation types (NPWS 2003) and the NSW Rural Fire Service's Threatened Species Hazard Reduction List, amended to include information from Watson (2005). Fire intensity and season of occurrence should also be considered when undertaking ecological burns.

Table 8. General fire regimes for threatened species and populations of the Cumberland Plain[28]

Species	Suggested min fire interval (years)	Suggested max fire interval (years)
Allocasuarina glairecola	7	25
Dillwynia tenuifolia	7	15
Juniper-leaved Grevillea (*Grevillea juniperina*)	7	25
Marsdenia viridiflora endangered population	7	25
Micromyrtus minutiflora	7	15
Pomaderris prunifolia endangered population	7	15
Sydney Plains Greenhood (*Pterostylis saxicola*)	7	15
Pultenaea parviflora	7	15

[28] Fire intervals are based upon fire interval guidelines for broad vegetation types (NPWS 2003) and the NSW Rural Fire Service's Threatened Species Hazard Reduction List, amended to include information from Watson (2005). Fire intensity and season of occurrence should also be considered when undertaking ecological burns.

Appendix 4: Research priorities for the threatened biodiversity of the Cumberland Plain

DECCW will liaise with research institutions to facilitate research relevant to the recovery of Cumberland Plain threatened biodiversity. Research priorities include:

Identifying impacts and management responses

Investigating impacts on the threatened species, populations and communities and management responses required to manage:

- invasive weed species, especially African Olive
- climate change
- salinity
- elevated soil nutrient levels
- fire regimes.

Investigating ecological restoration

- developing and refining revegetation techniques appropriate to Cumberland Plain threatened ecological communities that re-establish understorey diversity and structure
- determining the role of pollination vectors in habitat restoration
- undertaking trials to establish the propagation requirements for key Cumberland Plain species (including threatened species, populations and communities) to assist with restoration
- researching the seed storage requirements of key Cumberland Plain species (including threatened species, populations and communities)
- researching ecosystem dynamics, particularly in response to disturbance and the role of soil seed banks
- identifying key species with tolerance to salinity for revegetation in riparian areas and affected areas
- investigating the benefits or otherwise of introducing new genetic material into fragmented remnants through enhancement plantings.

Increasing our understanding of threatened species, populations and communities

- gathering information on the distribution and ecology of threatened species and regionally rare species on the Cumberland Plain to improve management
- establishing the relationship between remnant size and ecological value
- understanding habitat requirements for sustainable fauna populations in the Cumberland Plain, including the bushland corridor requirements necessary to facilitate movement of fauna
- developing a system of target species/bioindicators to assess vegetation condition and ecological resilience of Cumberland Plain threatened ecological communities and remnants
- investigating the impact of fire on the fauna values
  - For example, determining an appropriate fire frequency for Cumberland Land Snail
- establishing long-term monitoring sites to assess the long-term change in vegetation structure and required management regimes
  - for example, impact of dense, large shrub regrowth upon the long-term viability of specific threatened species within the Cumberland Plain (e.g. *Dillwynia tenuifolia* and *Pultenaea parvilflora*).

Improving management practices and responses

- developing and refining revegetation techniques appropriate to Cumberland Plain threatened ecological communities that re-establish understorey diversity and structure
- identifying domestic grazing management practices that allow the regeneration of threatened ecological communities and maintenance of biodiversity values
- further refining appropriate fire management regimes to maintain ecological integrity of Cumberland Plain threatened ecological community remnants
- investigating the relationship between fire frequency and exotic weeds in Cumberland Plain.

Appendix 5: Summary of advice from the NSW Scientific Committee

Under Section 66A of the *Threatened Species Conservation Act 1995*, recovery plans must include a summary of any advice given by the NSW Scientific Committee, details of any amendments made to the plan to take account of that advice and a statement of reasons for any departure from that advice. The NSW Scientific Committee's comments on the *Draft Cumberland Plain Recovery Plan* and details of the amendments made are tabled below.

Section of draft	Comment	DECCW response
General comment	The plan must prioritise all remaining pockets of remnant vegetation on the Cumberland Plain and provide a plan for their restoration.	Recovery Objective 1 of the plan aims to build a protected area network focused on the priority conservation lands. The significant funding and resources available for implementation of conservation efforts on the Cumberland Plain are only a fraction of that required to protect and restore all remnants. Therefore the scope of the *Report on the Methodology for Identifying Priority Conservation Lands* (DECCW 2010) was to identify the lands that are most suitable for investment in conservation activities, rather than the identification of all lands in the region with conservation value. The identification of priority areas for future conservation management within the plan should not be misinterpreted as underrating the significance of remnant vegetation outside the identified priority areas. The plan attempts to provide a practical, realistic conservation focus for DECCW and others, but agrees that there are additional areas of conservation value outside the PCLs, including smaller remnants. The plan includes many actions that aim to support and promote protection, management and restoration across the wider Cumberland Plain on lands that contain the threatened entities covered by the plan. These actions are to be implemented within and outside the PCLs. For example, under Recovery Objective 2, which aims to deliver best-practice management, Actions 2.2, 2.3, 2.4 and 2.5 relate to lands within and outside of the PCLs, including small remnants. Similarly, Actions 3.4, 3.5 and 3.7 can all be implemented on, or in relation to, small remnants. Finally, Actions 4.4, 4.5 and 4.7 all encourage protection, management, compliance and research for threatened biodiversity both within and outside of the PCLs regardless of the size of remnants. DECCW has amended the plan to emphasise the importance of small remnants and corridors at a local scale.
General comment	There should be more funded actions that are focused on on-ground actions, not secondary actions like public awareness campaigns or consultation or liaison activities.	The plan clearly states that the aim of building a protected area network is to secure land to be *actively managed* for conservation purposes (page 11) through the implementation of Actions 1.1, 1.2, 1.3 and 1.5. Funds for this are provided through the Growth Centres Conservation Fund (up to $530 million over 30 years). The preferred mechanisms listed in Table 5 of the plan all require long-term, detailed plans of management to be developed and implemented, which identify conservation values and on-ground management actions required to improve or maintain values in perpetuity. Furthermore, Actions 2.2, 2.3, 2.4 and 2.5 under Recovery Objective 2, on pages 12 and 13 of the plan, seek the implementation of best practice standards for bushland management on all tenures across the study area. These actions aim to improve the extent and condition of native vegetation on the Cumberland Plain using assisted natural regeneration and revegetation techniques. Public awareness campaigns and community consultation and liaison activities play a hugely important role in the conservation of biodiversity. Without an understanding of the remaining biodiversity values and the threats they face, the potential for the large human populations of western Sydney to engage with active on-ground management through Bushcare or other initiatives will be curtailed. These activities are especially relevant for the Cumberland Plain as 76% of all bushland on the Cumberland Plain occurs on private land (DEC 2005) and the threatened species, populations and communities listed in Table 1 of the plan occur on both public and private land. No change.

9	The first Specific Recovery Objective mixes objective and mechanism. The objective should not be constrained by the mechanism.	The reference to the PCLs in the objective is warranted as it clearly identifies the priorities of the plan. No change.
9	Specific Recovery Objective 3 for management of private land should be strengthened to facilitate active management.	This objective is targeted wholly towards education. Active management is the focus of Specific Recovery Objective 2. No change.
9	An additional Specific Recovery Objective should be included: "To prevent further clearing of threatened ecological communities", and this should be accompanied by a corresponding action.	The recovery plan is integrated with existing land-use planning strategies to provide the highest possible degree of awareness, acceptance and uptake by planning authorities. However, the unavoidable impact of urban growth on some bushland remnants is a real constraint. DECCW does not have a statutory role in making environmental planning instruments or approving or determining developments or activities, providing advice only to consent and determining authorities. It must also be noted that under Section 60 of the TSC Act, a measure must not be included for implementation by a public authority unless the chief executive officer of the public authority approves of the inclusion of the measure. The plan also acknowledges that there is not unlimited funding available in the context of that required to comprehensively protect and restore all patches of threatened remnant vegetation. The Growth Centres Conservation Fund provides an unprecedented opportunity to support recovery efforts in the region with up to $530 million to be spent in western Sydney and surrounding areas over the next 30 years. As a result, the plan advocates the prioritisation of investment in the PCLs, which represent the best remaining opportunities in the region to maximise long-term biodiversity benefits for the lowest possible cost. No change.
1	The plan should recognise the relationship between recovery plans and the *Threatened Species Conservation Act 1995.*	Amended
2	Table 1 needs updating to reflect recent changes to the conservation status of TECs	Amended
2	The map should include all remnant native vegetation and overlay the PCLs. Identify remnants and include tenure and other details in a table	Map amended. Summary statistics of tenure of PCLs shown in Table 5.
3	Bat species should be mentioned by name	Amended
3	Wording and examples of aggressive native species needs clarificaton.	Amended
3	Examples of remnants that support threatened vertebrates would be helpful, to enable populations to be monitored.	Monitoring threatened fauna populations will be a component of site management plans developed and implemented in accordance with Actions 2.2, 2.3 and 2.5 and the *Best Practice Standards for Bushland Management* (Appendix 2). Action 4.7 also aims to support stakeholders in monitoring threatened entities covered by the plan. No change.
3	The Plan understates the importance of small remnants.	Recovery Objective 1 of the plan aims to build a protected area network focused on the priority conservation lands. The draft refers to the assessment methodology used to identify these lands, which is described in the *Report on the Methodology for Identifying Priority Conservation Lands* (DECCW 2010). The significant funding and resources available for implementation of conservation efforts on the Cumberland Plain are only a fraction of that required to protect and restore all remnants. Therefore the scope of the methodology report was to identify the lands that are most suitable for investment in conservation activities, rather than the identification of all lands in the region with conservation value. The identification of priority areas for future conservation management within the plan should not be misinterpreted as underrating the significance of remnant vegetation outside the identified priority areas. The plan attempts to provide a practical, realistic conservation focus for DECCW and others,

		but agrees that there are additional areas of conservation value outside the PCLs, including smaller remnants. The plan has been amended to strengthen this with a new section: Section 7 *The important role of corridors and small remnants.*
3	The figures of current extent of TECs in Table 2 need updating.	Amended
6	The minimum target of 15% protection of remaining extent of TECs is too small.	The principles on which the PCLs were defined (comprehensive, adequate, representative) were modified for western Sydney in recognition of the region's high land values, fragmentation levels and land-use pressures. The identification of the PCLs as the basis for a protected area network in western Sydney significantly exceeds this target. Between 25 and 91% of the extant distribution of the threatened ecological communities are represented in the PCLs, and six of the nine communities have greater than 60% of their remaining area within the PCLs. No change.
6	It is misleading to include land (e.g. rivers and roads) that is not part of a TEC in the summary statistics of the PCLs.	The draft plan states on page 8 that: "The priority conservation lands also contain 'other vegetation' and areas with no mapped vegetation. These vegetation types were included when they occurred at a site that was selected to meet a threatened flora target, or when they were part of a larger remnant that was selected to meet a threatened ecological community target. Also included were areas with no mapped vegetation. These include roads, rivers and derived native grasslands. Non-vegetated areas were also included if they were part of the existing DECCW estate or were needed to establish practical management boundaries." No change.
6	More information is required on reasons why particular vegetation patches were selected for inclusion in the PCLs.	DECCW will release the *Report on the Methodology for Identifying Priority Conservation Lands* (DECCW 2010), which provides information on reasons for including land within the PCLs. No change.
6	The plan is flawed by exclusion from assessment as PCLs of all lands zoned residential, commercial or for the NW and SW Growth Centres.	The *Report on the Methodology for Identifying the Priority Conservation Lands* (2010), which will be released along with the final plan, excluded these lands on the basis of capability. The capability assessment focussed on identifying lands with the greatest potential to deliver long-term conservation outcomes for threatened biodiversity. Conservation outcomes for lands zoned for residential and industrial purposes are much harder to achieve in the context of a recovery program as they attract higher land values and stronger development pressures than other zones. Historically, rezoning from residential to environmental protection has been a very difficult outcome to achieve for remnant vegetation and land owners may require compensation if their land is rezoned. As a result these are too expensive to purchase or reserve under other conservation mechanisms. No change.
6	The Plan needs actions for protecting biodiversity in non-PCLs. There should be some discussion of compliance	The plan includes many actions that aim to support and promote protection, management and restoration across the wider Cumberland Plain., Actions 2.2, 2.3, 2.4 and 2.5 aim to deliver best-practice management to lands within and outside of the PCLs, including small remnants. Similarly, Actions 3.4, 3.5 and 3.7 can all be implemented on, or in relation to, small remnants. Finally, Actions 4.4, 4.5 and 4.7 all encourage protection, management, compliance and research for threatened biodiversity both within and outside of the PCLs. DECCW believes that the implementation of Actions 4.3 and 4.5 will effectively address compliance issues. No change.
7	Inadequate attention has been given to threatened species with specific actions for only 2 species.	The presence of individual threatened species and populations played a core role in the identification of the PCLs. Additional targets were applied for the inclusion of the recovery plan's threatened flora species and endangered populations and areas of 'other vegetation' were included when they occurred at a site that was selected to meet a threatened flora target. The plan has been amended to include the targets for individual threatened flora species and populations that were used to derive the PCLs.
Recovery	Key performance targets are too	The operating context of western Sydney is influenced by many factors

objective 1	vague to be useful.	and is exceedingly complex. The high and extremely variable land values between zonings and across the broad geographic area of the Cumberland Plain preclude any reasonable or realistic area-based targets for inclusion of lands in the protected area network. In light of these issues the timeframes for achieving targets of any magnitude are far too uncertain to predict. No change.
Recovery objective 4	Education, monitoring and compliance actions should be extended to landholders and neighbours of all TECs, not just those within or adjacent to PCLs.	All of the actions under recovery objective 4 (except 4.6) relate to the wider Cumberland Plain, not just the PCLs. No change.
Appendix 1	Cost details are missing and some are incorrect.	Amended

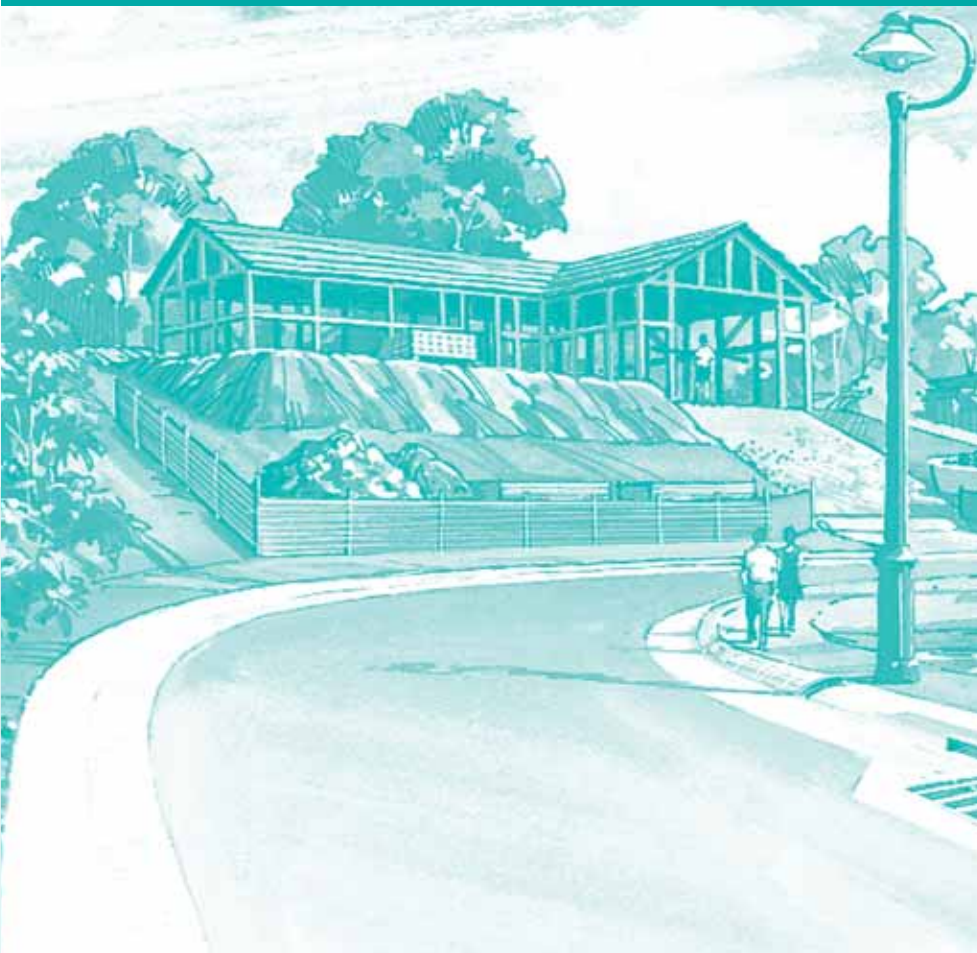
Environment,
Climate Change
& Water

PO Box 1967
Hurstville NSW 2220

Appendix 4 – Sediment and Dust Control Information

CITY OF SYDNEY

GUIDELINES FOR EROSION AND SEDIMENT CONTROL ON BUILDING SITES



city of villages

Guidelines for erosion and sediment control on building sites

INDEX

This booklet has been prepared to provide information relevant at the time of publishing. It is not a regulatory document. For more information regarding legal obligations consult a lawyer, the legislation, the NSW Department of Environment and Conservation (DEC) or the City of Sydney.

Guidelines for erosion and sediment control on building sites

INTRODUCTION

This handbook provides a practical guide for best practice to reduce stormwater pollution from building sites. These guidelines will help you to comply with your statutory environmental obligations. This document does not override advice issued to you by City of Sydney staff.

Construction disturbs soil and creates dust and debris. Run-off from a building site travels down gutters, drains and canals and eventually ends up in a river or the sea.

Polluting stormwater is an offence that can result in on-the-spot fines or legal proceedings.

Although a single building site may seem insignificant, if you consider all the building sites in the City of Sydney area, erosion has a huge effect on water quality. Studies by the NSW Department of Environment and Conservation (DEC) show that one building site can lose up to four truckloads of soil in a single storm.

It is important to keep the soil on the site.

Everyone on site is responsible. Preventing site erosion saves money for you and your client and protects you from prosecution.

Be sure that all your employees and contractors understand what they need to do.

If you need printed material in a different language call the DEC Pollution Line on 131 555

THE LAW AND YOU

There are many laws, regulations, policies and guidelines to help protect the environment in NSW. These laws give guidance to business and industry. In some cases, if you break these laws it is an offence that can carry serious penalties and in most instances the prosecutor does not need to prove that you intended to cause the incident. Even accidents can result in prosecution. You and others in your business should be aware of these laws and penalties and take all reasonable care not to harm the environment.

The ***Protection of the Environment Operations Act*** **(POEO)** came into effect in 1997 and has consolidated the following earlier Acts:

- *Clean Air Act* 1961
- *Clean Waters Act* 1970
- *Pollution Control Act* 1970
- *Noise Control Act* 1975
- *Environmental Offences and Penalties Act* 1989
- Regulatory sections of *the Waste Minimisation and Management Act* 1995

All owners, managers and operators should ensure that they know about environmental laws and their responsibilities.

The POEO Act focuses on environmental management and gives local councils increased powers in relation to environmental management in their local area.

These changes mean that owner-builders, builders and landscapers are directly responsible for preventing sediment and construction wastewater leaving a building site. While the DEC monitored builders' actions in the past, councils now have the power and responsibility to monitor the industry and issue penalty infringement notices.

Under the POEO Act, **on-the-spot fines of $1,500 may be imposed on builders, owner/occupiers or landscapers** of land where pollution has the potential to, or has entered gutters, drains and waterways. On top of this fine you may also be charged a $320 administration fee.

Supervisors need to take reasonable and practical steps to ensure that workers under their control on the site (e.g. sub-contractors) do not breach environmental laws.

The law does not recognise:

- Whether or not the site is difficult
- Problems that might be encountered in implementing the erosion and sediment plan
- Whether or not you are familiar with good soil and water standards

Note that workers who become aware of significant environmental harm in association with their work, e.g. a major loss of sediment from their site, have a legal duty under the POEO Act to notify their employer.

The City of Sydney may issue the following notices:

- Clean Up Notices
- Prevention Notices
- Penalty Infringement Notices
- Compliance Cost Notices
- Noise Control Notices
- Noise Abatement Directions

PLANS

Erosion and Sediment Control Plans or Soil and Water Management Plans are the key to managing erosion and sediment on construction sites and subdivision. These plans are submitted to council at the Development Application (DA) stage. It is the size of works that dictates which of the two kinds of plans will be used. Both plans are principal management tools used during works.

EROSION AND SEDIMENT CONTROL PLANS (ESCP)

ESCP identify the erosion and sediment control for relatively small sites between 250 and 2,500 square metres in size.

SOIL AND WATER MANAGEMENT PLANS (SWMP)

SWMP identify soil and erosion controls (including whether a sediment retention basin is required) for "green field" or "urban renewal or infill" developments in excess of 2,500 square metres of actual developed area.

Where circumstances change during construction, the City of Sydney may require erosion and sediment control measures in addition to those measures specified in the plan.

Other contractors, such as landscapers should check any relevant SWMP or ESCP and make sure any DA conditions do not affect their work.

For more details please refer to the section "Plan Preparation" in the publication *Managing Urban Stormwater – Soil and Construction* (4th Edition 2004) – commonly known as the *Blue Book.*

SUGGESTED EROSION AND SEDIMENT CONTROLS FOR A TYPICAL DEVELOPMENT SITE

- Minimise area to be cleared and leave as much vegetation as possible. Install temporary fences to define 'no go' areas that are not to be disturbed.
- Install sediment fence(s) along the low side of the site before work begins.
- Divert water around the work site and stabilise channels, but ensure that you do not flood the neighbouring property.
- Establish a single stabilised entry/exit point. Clearly mark the access point on an access map that has a delivery point indicated for all supplies.
- Leave or lay a kerb-side turf strip (for example, the nature strip) to slow the speed of water flows and to trap sediment.
- Check the erosion and sediment controls every day and keep them in good working condition.
- Where topsoil is stockpiled, ensure it is within the sediment controlled zone.
- Always be aware of the weather forecast.
- Stabilise exposed earth banks (eg vegetation, erosion control mats).
- Fill in and compact all trenches immediately after services have been laid.
- Install site waste receptacles (mini-skip, bins, windproof litter receptors).
- Sweep the road and footpath every day and put soil behind the sediment controls. Hosing down roads and footpaths is unacceptable.
- Connect downpipes from the guttering to on site detention or the stormwater drain as soon as the roof is installed.
- Revegetate the site as soon as possible. The erosion and sediment control devices must be kept in place until 70% of the site has been revegetated.

FACT SHEET 1

SITE – PLANNING

The overall principle is to stop both erosion and sediment leaving your site. However, this requires careful planning and forethought. The way you run your building site can have a large impact on the amount of pollution in stormwater run off.

When planning the site layout, building location and earthworks, it is possible to make sure control devices don't interfere with the building process.

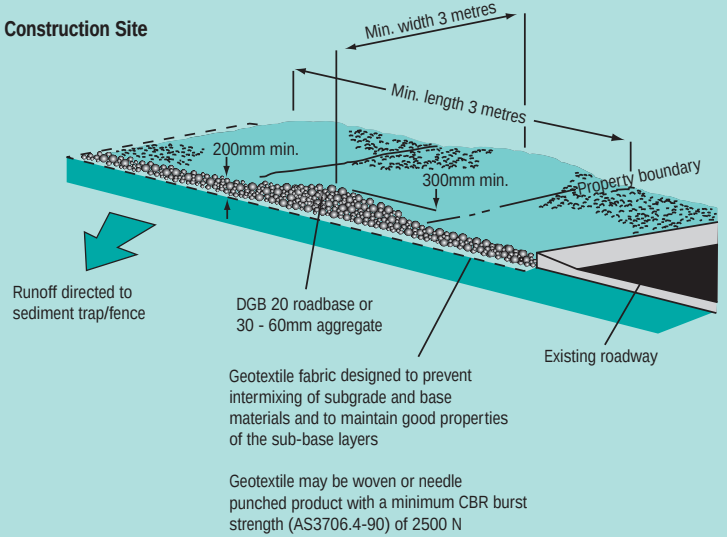
- Avoid stripping and excavating until ready to build.
- Minimise the reshaping, and fill needs to be well compacted.
- Allow stormwater to flow around the building area and any disturbed areas.
- In large developments, temporary revegetation may be required.
- Allow room for a sediment barrier (eg sediment fence) to be located along the lower end of the disturbance.
- Ensure that stockpiles are stored within the sediment fence.
- Avoid long, steep, unstable driveways.
- Limit the amount of material on site to what is required at any one time.
- Ensure all material is immediately removed from the site at the completion of work.
- Instruct site workers on the need to prevent materials from washing or blowing into the stormwater system.
- Ensure all materials are immediately removed from the site when work is completed.

FACT SHEET 2

STABILISED ENTRY/EXIT POINT

Where possible, the entry/exit point of the site should be managed so sediment is not tracked off the site and it should be restricted to one stabilised location. Note that an appropriate location for the construction entrance may not be the location of the permanent driveway.

The recommended construction method for stabilising the access point is 200mm of aggregate at 30-60mm in size (note: crushed sandstone is not suitable). The access should be a minimum of 3 metres wide and 3 metres long, or to the building alignment for all residential or sub-division sites. Where possible, the entry/exit area should extend from the kerb to the building footprint. Remember that a large truck must be able to gain access to this site without leaving the stabilised access.



Where the entry/exit area slopes toward the road, a diversion hump should be installed across the stabilised area to direct stormwater run-off to the side where it can be filtered by a sediment fence.

Stabilised access points only require periodic maintenance with the topping up of the rock. Street sweeping on adjacent roads may still be required.

Advantages. Restricting vehicular movement allows the entire site to be more stable and durable during wet weather. After wet weather, work can begin on the site more quickly due to the area being stable. This prevents the most heavily travelled routes from becoming a source of sediment and reduces the likelihood of vehicles bogging on site.

Remember that extra crushed rock or recycled concrete needs to be added to maintain its effectiveness.

Construction Notes

1. Strip at least 150mm of topsoil, level area and stockpile on site if space available.
2. Compact sub-grade.
3. Cover area with needle-punched geotextile.
4. Construct a 200mm thick pad over geotextile using aggregate at least 40mm in size. Minimum length 3 metres or to building alignment. Minimum width 3 metres.
5. Construct a diversion hump immediately within boundary to divert water to a sediment fence or other sediment trap.

FACT SHEET 3

SEDIMENT FENCING

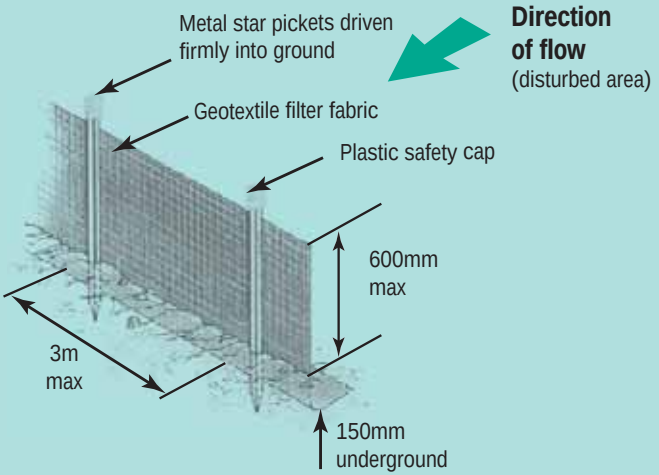
The most efficient and widely accepted sediment barrier for construction sites is a specially manufactured geotextile sediment fence. Sediment fences act like dams – trapping the sediment while allowing water to leave the site. They are effective in retaining suspended solids coarser than 0.02mm. They are simple to construct, relatively inexpensive and easily moved as development proceeds.

When using a sediment fence, keep in mind that it will be effective within the following parameters:

- It is generally not designed to filter concentrated flows and therefore needs to be placed following the contours whenever possible.
- It should last for up to six months but requires regular maintenance and weekly checks. The performance of a sediment fence diminishes considerably when crushed by delivery of building materials. It must remain vertical and keyed into the soil.
- Whenever the sediment fence is not installed correctly water will inevitably flow through the point of least resistance. Damaged fences must be repaired promptly.
- Sediment fences need to be trenched in at least 150mm and buried so the water flows through and not underneath.
- Soil on both sides of the fence must be compacted to avoid seepage under the barrier.

On a typical residential building block (approx. 700m^2), a sediment fence should work well providing it is situated on the low side of the block. If there needs to be a break in the fence for any reason (e.g. an access point) a contour bank/diversion bank or bund needs to be constructed to direct water back to the fence. The sediment fence must have uphill returns at either end to prevent sediment flowing around it.

Advantages. It is a simple strategy that is easily installed, shifted or removed. Sediment fences work well and, if maintained, will last for the duration of the construction stage.



Construction Notes

1. Construct sediment fences as close as possible to follow the contours of the site.
2. Drive 1.5 metre long posts into ground, maximum 3 metres apart.
3. Staple to 40mm square hardwood posts or wire tied to steel posts.
4. Dig a 150mm deep trench along the up-slope line of the fence for the bottom of the fabric to be entrenched.
5. Backfill trench over base of fabric and compact on both sides.

FACT SHEET 4

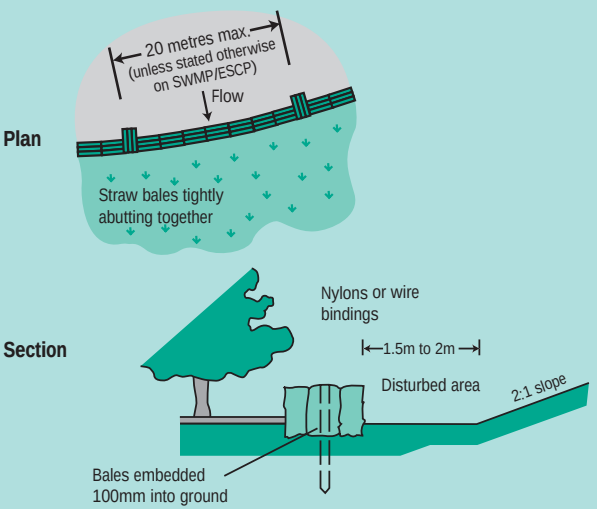
STRAW BALE FILTER

Straw bales are suitable for low flows of water. It is only recommended that these are used in limited applications such as reducing the flow velocity.

The return of straw bales every 20 metres is recommended to ensure some stability for this type of barrier. Please note that they need to be embedded in the ground and held firmly in place with star pickets.

The minimum number of bales to be used is four. If only two bales are used during a storm, the water will simply hit the bales and flow around, increasing erosion. They must dam the run off and allow the sediment to settle behind the bales.

Please note straw bales do not filter sediment-laden waters. They will only hold back water if installed correctly.



FACT SHEET 5

DIVERSION OF UP-SLOPE WATER

Where practical, or where stormwater run off is more than 0.5 hectare, up-slope water should be diverted around the site. Stormwater can be diverted with the use of small turn or geotextile lined catch drains, or with the use of diversion banks.

Diverted stormwater should be discharged onto stable areas and should not be diverted into neighbouring properties unless written permission is obtained from the land owner(s). Avoid directing stormwater towards the site's entry/exit point.

Advantages. There is a reduction in the amount of water that must be treated. The site is kept drier during wet periods.

Remember on steep sites, depending on duration of works and expected water flows, it may be necessary to line the earth drain with turf or a geotextile fabric to avoid unnecessary soil erosion.

FACT SHEET 6

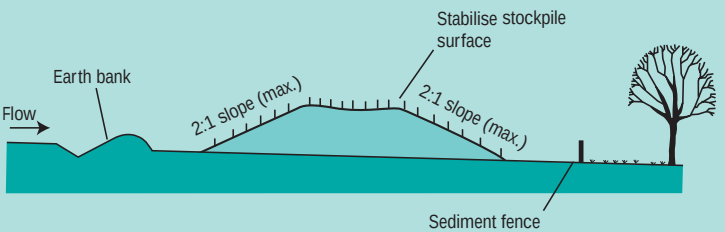
STOCKPILES AND STORAGE OF MATERIALS

Stockpiles and building materials are not to be stored on the footpath or within the road reserve. Where necessary, stockpile losses can be minimised with the use of covers.

All stockpiles and building materials should be located behind the sediment controls. Stockpiles should be protected from run off water by placing diversion banks up-slope and with sediment control structures placed immediately down-slope.

The location of all stockpiles on site should be at least 2 metres (preferably 5 metres) from hazard areas, especially likely areas of concentrated or high velocity flows such as waterways, kerb inlet pits, paved areas and driveways. The height of the stockpile should be less than 2 metres. The incorrect storage of stockpiles is a major source of stormwater pollution.

All site workers, subcontractors and delivery drivers need to be advised of their responsibilities to minimise soil erosion and pollution. The delivery driver must be given a designated location to deliver materials on site. This practice will also keep stockpiles away from site access and consequently keep sediment from being discharged to the stormwater system.



FACT SHEET 7

GRASS FILTER STRIPS

Strips of vegetation left or planted down-slope from earthworks provide a simple method of trapping coarse sediment.

The flatter and wider the filter strips area, the more effective they become. Grass filter strips have little effect in a storm, but form an important part of a sediment control program.

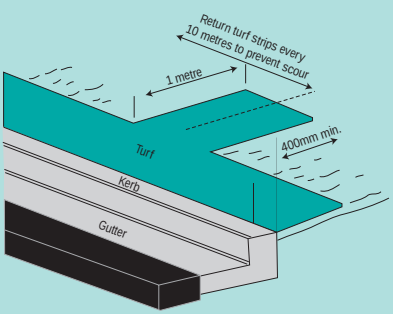
A 400mm wide grass strip can be installed next to a kerb to stabilise the area between the kerb and footpath. It is also valuable for trapping sediment in very small storm events.

For best results it is advised that the whole footpath is planted.

Grass strips will stabilise a disturbed site quickly and easily act as an excellent erosion and sediment control device.

Advantages. Grass filter strips can be very effective in removing coarse sediment upstream from detention basins or infiltration structures. They prevent sediment travelling from bare soil areas towards the formal drainage system.

Remember that grass filter strips are only suitable on low grades.



Construction Notes

1. Install minimum 400mm wide roll of turf on the footpath adjacent to the kerb and at the same level as the top of the kerb.
2. Lay 1.5 metre long turf strips (at 90 degrees) every 10 metres.
3. Rehabilitate disturbed soil behind the turf strip in accordance with the Erosion and Sediment Control Plan, or Soil and Water Management Plan.

FACT SHEET 8

LITTER AND BUILDING WASTE

All hard waste should be stored on site in a way that prevents material loss caused by wind or water.

Smaller materials such as litter should be contained in covered bins or litter traps formed on three sides by geotextile as a windbreak.

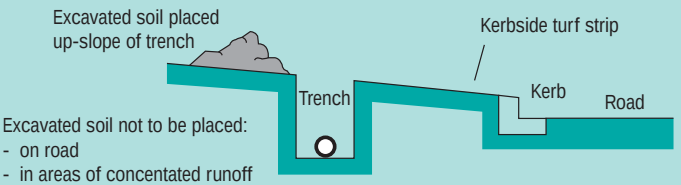
Tipping fees can be reduced by separating building waste products into separate litter traps, so this material can be recycled.

FACT SHEET 9

SERVICE TRENCHES

Where possible, coordinate the various service connections so that a single trench can be used. Avoid trenching in areas where water flow is likely to concentrate. Alternatively, try to schedule work to periods when rainfall is low.

When Excavating Trenches:



Excavated soil not to be placed:
- on road
- in areas of concentated runoff
- within 1 metre of kerb

Try to limit the time trenches are open to fewer than three days and avoid opening them whenever the risk of storms is high. Remove and store vegetated topsoil (sod) so that it can be used to provide immediate erosion protection after backfilling.

Place the soil on the uphill side of trenches to divert water flow away from the trench line, provided this practice meets your Occupational Health and Safety policy requirements. Alternatively, use temporary bunds for similar effect. Backfill subsoil and compact to 95% Standard Proctor. Then replace topsoil and any sod to match surrounding ground levels.

Construction Notes

1. Do not open any trenches unless it is likely to be closed in three days.
2. Place excavated material up-slope of trench.
3. Divert run off from the trenchline with diversions.
4. Revegetate.

FACT SHEET 10

EARLY ROOF DOWNPIPE CONNECTION

Temporary or permanent downpipes should be installed at the same time as the roof is installed. The early connection of downpipes to on site detention (for re-use) or the stormwater system will reduce site drainage problems.

This will reduce downtime following storms. Connecting roof downpipes is a vital process to keep the water off the site and "Keep the Soil on the Site".

MAINTENANCE OF CONTROL MEASURES

Proper maintenance of erosion and sediment controls is vital to their success. After a storm event the effectiveness of the established controls can be assessed. The site manager should check the operation of all erosion and sediment controls each day and initiate repairs or maintenance as required.

An effective maintenance program should include ongoing modification to plans as development progresses. These plans are usually based on a specific landform, but as development proceeds changes occur in slope, gradients and drainage paths.

Best practice includes anticipating potential risks as well as being prepared for abnormal circumstances and emergencies. This could include storing extra sediment fence fabric and posts on site to facilitate emergency repairs, or ensuring that the sediment control contractor's phone number is available on site.

To ensure good practice:

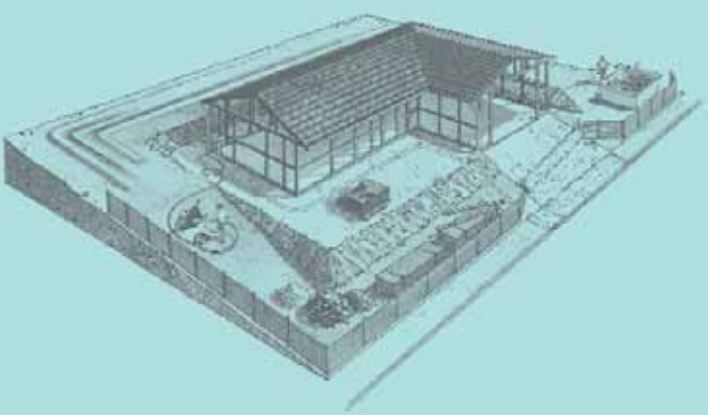
- The entry/exit pad will require reapplication of aggregate if excessive sediment build up occurs.
- Clean any catch drains as required.
- Erosion in drainage channels should be repaired with rock, turf or erosion control matting.
- Sediment fences should be replaced if the fabric is ripped or otherwise damaged. Retrenching may also be needed. Sediment fences work well if they are maintained on a weekly basis and/or after every storm.
- Keep an eye on the weather.

SITE CLEAN-UP AND REHABILITATION

Accidental spills of soil or other materials onto the road or gutter should be removed at the end of the day's work. Materials should be swept from the road, not washed down the gutter. Following storms, the roadway and sediment controls should be inspected and all excessive sediment residues removed.

All areas disturbed by construction should be promptly stabilised (e.g. revegetated) so that they can no longer act as a source of sediment.

If the site has not been rehabilitated and is handed over to a new homeowner, they need to understand their legal obligation associated with erosion and sediment control, especially if a sub-contractor is employed to complete landscaping works. Sediment control devices must be left in place until 70% revegetation cover has been established, or other measures installed in accordance with City of Sydney requirements.



PRODUCTS AND SERVICES

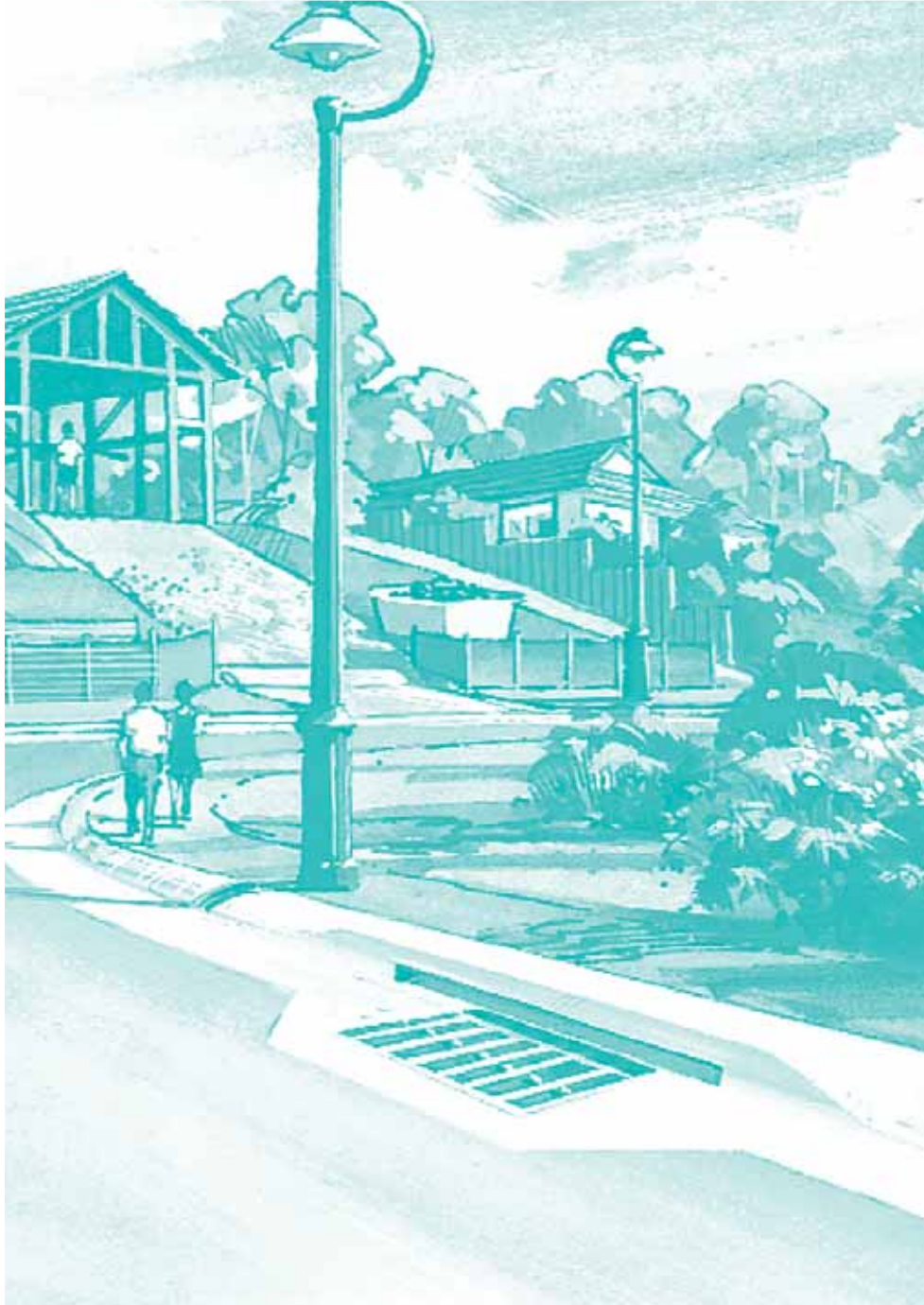
Look under the following headings in the Yellow Pages www.yellowpages.com.au for suppliers of products and services:

- Erosion Control and Soil Stabilisation
- Oil & Chemical Spill Recovery or Dispersal
- Cleaning Contractors--Steam, Pressure, Chemical Etc
- Brick &/Or Brick Wall Cleaning

IMPORTANT NUMBERS

City of Sydney	1300 651 301
DEC Pollution Line	13 1555
Dial Before You Dig	1100
Emergency Services - AGL Gas	13 1909
Emergency Services - Energy Australia	13 1388
Emergency Services - Integral Energy	13 1003
Emergency Services - Sydney Water	13 2090
Housing Industry Association	8878 0400
Master Builders' Association	8586 3555
Master Plumbers and Mechanical Contractors Association	8789 7000
Office of Fair Trading	13 3220
Poisons Information Centre	13 1126
Standards Australia	1300 654 646
WorkCover NSW	13 1050

NOTES:



Guidelines for Controlling Dust from Construction Sites

NSW EPA

our environment it's a living thing
NSW GOVERNMENT PROGRAM

PARRAMATTA CITY COUNCIL


NO DUST
NO FUSS

Contents

Introduction

Sydney suburbs now extend over an area of approximately 2000 square kilometres and a wide range of development types exist, from city centre commercial development to residential dwellings. High levels of dust can be generated by the construction of these developments, which can cause reductions in air quality, health problems, environmental degradation and loss of amenity for residents and businesses.

The aim of this guide is to outline methods that can be implemented to reduce dust levels on construction sites.

Who is this guide for?

This guide has been developed for construction companies, owner-builders, Local Council officers and anyone involved in the land development or approval process. The Australian Bureau of Statistics (ABS 1997) estimates that there are 194,300 businesses operating in the construction industry, employing close to half a million people. Of these businesses, 94% employ less than five staff and fewer than 1% employ more than 20 staff. Given the ratio of smaller businesses, this guide focuses on inexpensive, cost-effective measures to help reduce the impacts of dust.

Why has this guide been developed?

This guide has been developed as part of the New South Wales Government's Clean Air Fund to improve local air quality through the reduction of dust emissions from construction sites.

DID YOU KNOW?

Construction in residential areas makes up about 39% of all construction, with engineering construction at 36% and non-residential construction at 25% (ABS 2003). This highlights the potential for dust to cause problems in residential areas.

What are the benefits of effective dust control?

There are a number of benefits associated with effective dust control on your construction site, including:

To the Builder:

_ Enhanced business reputation
_ Better working conditions for staff
_ Better working relationships with clients and the community
_ Improvements in relations with regulatory authorities, eg. Local Government

To the Owner:

_ Reduced risk of damage to property
_ Improved relationships with future neighbours
_ Knowledge of contribution to environment protection
_ More attractive environment

To the Neighbours and Community:

_ Fewer disruptions to everyday living
_ Reduction of health risks resulting from air pollution
_ Reduced risk of damage to property and belongings
_ Less cleaning!

To the Environment:

_ Reduction in air pollution
_ Reduction in water pollution
_ Fewer disturbances to existing flora and fauna habitats

Community Viewpoint

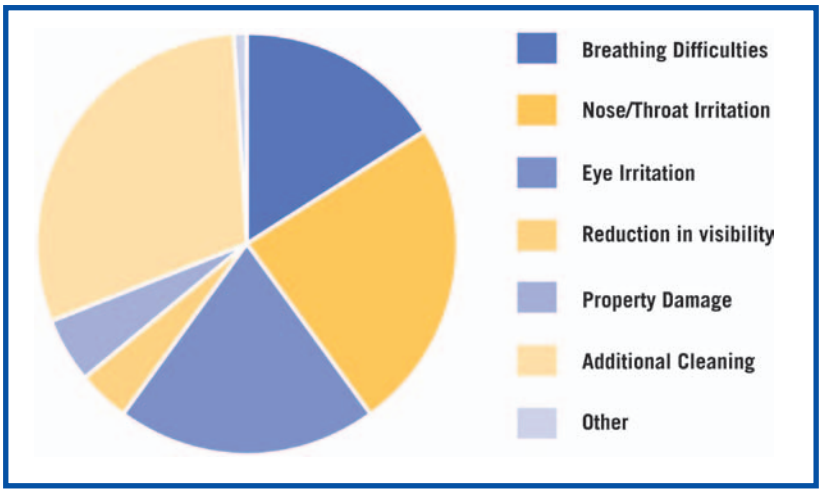
How does the community view dust from construction sites?

To gauge the impact of construction dust on nearby residents, Parramatta City Council conducted surveys near construction sites within the Parramatta Local Government Area. The construction sites ranged from single dwellings to industrial developments.

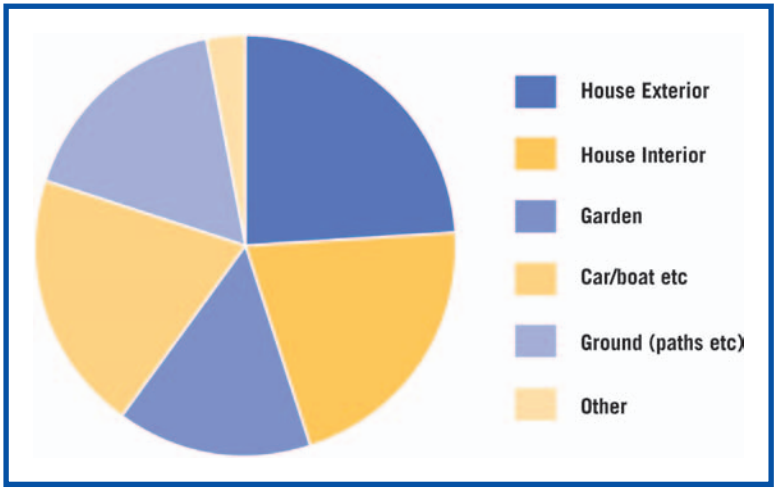
Overall, resident responses indicated that the level of problems experienced were influenced by:

- weather
- the size and scale of the development
- topography and location
- the actions of site workers

The main problems experienced were:



The residents were also asked to nominate where they felt the dust caused the most problems:



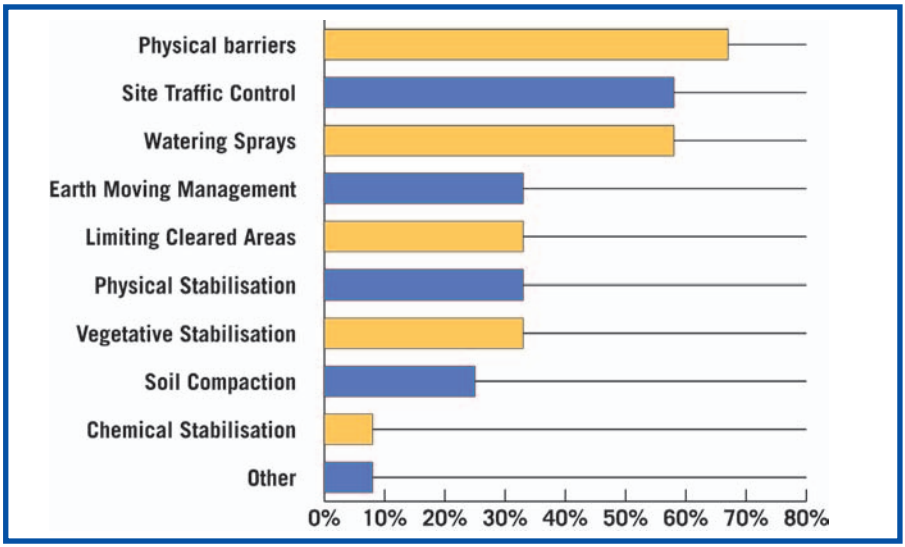
It is recognised that Sydney has recently experienced extremely dry weather conditions, which may have worsened dust problems overall.
However, many residents were able to directly attribute certain dust problems to the nearby construction sites.

Industry Viewpoint

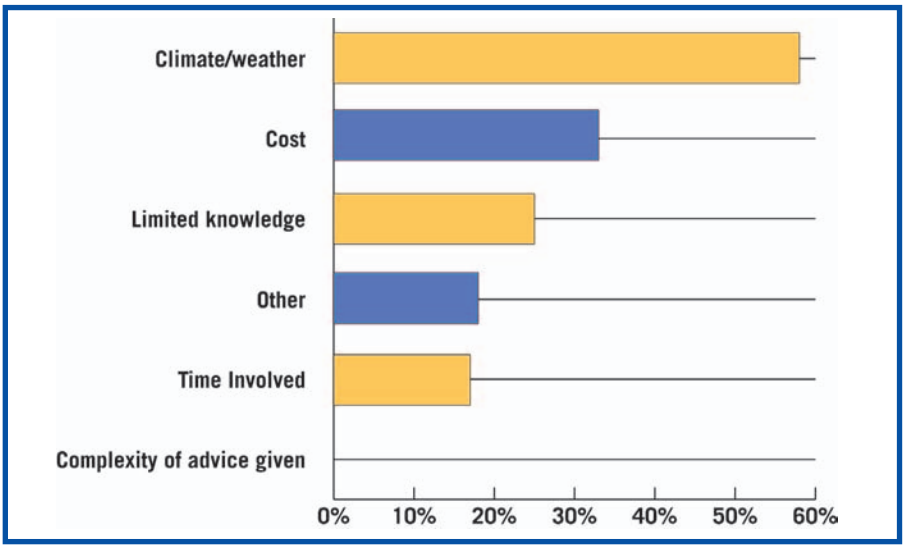
How does the industry view dust from construction sites?

Parramatta City Council also conducted a survey of various construction companies, ranging from large corporations to sole operators. The survey focussed on the main dust control measures adopted by companies and the constraints involved in implementing various control measures.

Dust control measures used include:



Constraints to effective dust control were seen as:



Dust Issues

Why is dust a problem?

Airborne dust from construction sites is a problem for a number of reasons. It can:

- create health problems, particularly for those with respiratory problems
- cause environmental degradation, including air and water pollution
- create problems with visibility
- damage or dirty property and belongings
- create unsafe working conditions
- increase costs associated with the loss of materials or additional work involved

How is it caused?

Dust can become airborne when soil is exposed or left uncovered. Wind then picks up the exposed soil and carries it off-site.

The most common ways that soil is exposed include:

- Demolition activities
- Site preparation activities
- Construction activities
- Vehicle movement
- Uncovered stockpiles

The Law and You

Companies and property owners are legally bound to control dust emissions from construction sites under the Protection of the Environment Operations Act (POEO) 1999, Sections 124 – 126 and 128. Any actions undertaken on site must not contribute to environmental degradation and pollution. Air impurity levels must not exceed the standards. Conditions of Approval on Development Applications relating to dust control as set down by the local council must also be observed.

Dust control measures must be left in place until at least 70% vegetative cover, or other coverage in accordance with council's requirements, has been established. If the site is not rehabilitated before the owners take possession, they need to be made aware that the legal obligations associated with the site now rest with them.

Source: DLWC (2001)

Other Issues

Although not a legal requirement, it is a good idea to let surrounding residents know of the works that are about to take place. A short letter informing them of the date of commencement, the company name and a contact number for any problems will improve neighbourhood relationships. It may also ensure prompt action is taken should any problems or emergencies occur, particularly if the site is unattended.

A sample letter is shown below:

To the Home-owner

ABC Constructions
1 Jones Street
SYDNEY NSW 2000
Ph: 9999 1111
Mob: 0414 111 000

Dear Sir/Madam,

Our company, ABC constructions, is soon to commence construction work at 1 Smith Street, Sydney. We anticipate work will be completed by 1 May 2003.

We will make every effort to ensure that you are not disturbed or inconvenienced during this period. However, if an issue does arise, please contact me as soon as possible so that we can take immediate action.

Yours sincerely,

Gary Brown
Site manager
ABC Constructions

Source: Buildersnet (2002)

Constraints to Dust Control

Climate:

As shown by the previous chart, climate poses an obvious problem for construction companies. This is particularly evident during periods of dry, windy weather when the likelihood of dust being picked up and blown about is increased.

While climate cannot be controlled, three things can be done to minimise climate-generated dust problems:

1. Check weather reports daily; closely observe weather patterns to enable action to be taken immediately if conditions change
2. Implement control measures that ensure dust problems do not occur while the site is unattended, eg. at night or weekends
3. Adopt a site 'shut down and cover up' policy during periods of extreme weather conditions, eg. high winds and low humidity. All site operations should cease and all exposed areas covered or treated to ensure dust does not become airborne

Cost:

Cost was seen as the second major constraint to effective dust control. While some specialised dust control applications can involve substantial costs, the majority of dust control measures require minimal financial outlay (as shown in the following Dust Control Fact Sheets).

Know-how:

Limited knowledge of the measures available was also cited as a constraint and this guide will address this problem by providing simple, easy to follow information and guidelines.

Dust Control Measures

The following control measures have been placed roughly in order of operation. Some may need to be used throughout the entire project, however, the order of operations should follow this outline as far as possible.

Pre-construction Measures	
Fact Sheet 1:	Dust Management Plan
Site Measures	
Fact Sheet 2:	Limit Cleared Areas
Fact Sheet 3:	Physical Barriers
Fact Sheet 4:	Site Traffic Control
Fact Sheet 5:	Earth Moving Management
Fact Sheet 6:	Watering Sprays
Fact Sheet 7:	Soil Compaction
Fact Sheet 8:	Vegetative Stabilisation
Fact Sheet 9:	Chemical Stabilisation
Fact Sheet 10	Site Completion
Storage Piles/General Material Storage	
Fact Sheet 11:	Pile Configuration (also refer to Fact Sheets 3, 6 & 8)
Hauled Materials	
Fact Sheet 12:	Hauled Material Management (also refer to Fact Sheet 6)
Paved Road Trackout	
Fact Sheet 13:	Site Access/Exit Controls (also refer to Fact Sheets 4 & 7)

Typical Site Layout

The following pictures depict a typical construction site before and after dust control methods are in place.

Source: BMCC (2002)

Further Information

Contact Parramatta City Council for further information on dust control within your construction site on:

Parramatta City Council
PO Box 32
PARRAMATTA NSW 2124
Ph: (02) 9806 5000
Fax: 9806 5917
Email: council@parracity.nsw.gov.au
Website: http://www.parracity.nsw.gov.au

Other websites with information relating to dust control include:

- Local Council websites
- http://www.dipnr.nsw.gov.au
  – Department of infrastructure, Planning and Natural Resources
- http://www.epa.nsw.gov.au
  – Department of Environment and Conservation
- http://www.sscc.nsw.gov.au/images/upload/2.Dust%20control.pdf
  - South Sydney Council
- http://www.buildersnet.com.au/ - Builders Net
- http://www.buildingonline.com.au/ - Housing Industry Association Ltd
- http://www.masterbuilders.com.au – Masters Builders Australia Inc.
- http://www.scapca.org/dust.html – Spokane County Public Works
- http://www.leg.wa.gov/wac/index – Washington Department of Ecology

N.B. The authors do not necessarily endorse these products or services.

References

ABS (2003) Construction: *Trends in construction activity. No. 1301.0-2003*. Australian Bureau of Statistics, Canberra.
http://www.abs.gov.au/Ausstats/abs@.nsf/Lookup/1752DF9AE279EE47CA256CAE0015F64A]

ABS (1997) *Private Sector Construction Industry, Australia. No. 8772.0*. Australian Bureau of Statistics, Canberra.
http://www.abs.gov.au/Ausstats/abs%40.nsf/e8ae5488b598839cca25682000131612/02c980c509048eacca2568a9001393d0!OpenDocument

Blue Mountains City Council (2002) *Better Living DCP - Site Management*. BMCC, Blue Mountains.

Communication and Educational Technology Services, *Compaction*. University of Minnesota Extension Service - http://www.extension.umn.edu/distribution/cropsystems/components/7400_02.html

DLWC (2001) *Guidelines for Erosion and Sediment Control on Building Sites*. Department of Land and Water Conservation, Windsor.

Holmes Air Sciences (1998) cited in *National Pollutant Inventory Emission Estimation Technique Manual for Mining*. Version 2.3, Environment Australia, Canberra.
-http://www.npi.gov.au/handbooks/approved_handbooks/pubs/mining2-3.pdf]. Viewed 05/12/02.

Nehasil, M. J. (2002) *Ecosystem Restoration*. Montana State University, Montana.
http://ecorestoration.montana.edu

NSW Environmental Protection Authority (2002) *Model EMP: Environmental Management Plan for Landscaping Works*. NSW EPA, Sydney. Available at: www.epa.nsw.gov.au

NSW Department of Housing (1998) *Managing Urban Stormwater: soils and construction*. NSW Department of Housing, Sydney.

Roa-Espinosa, A., Urban Conservationist, *An Introduction to Soil Compaction and the Subsoiling Practice*. Dane County Land Conservation Department, 1 Fen Oak Court, Madison, Wisconsin, 53718, USA

Soil Compaction. Department of Primary Industries, QLD Government
http://www.dpi.qld.gov.au/fieldcrops/9424.html

PCC8591

Appendix 5 – Soil Landscape and Geology

Soil Landscapes

The *Blacktown* and *South Creek* soil landscapes are described in the flowing paragraphs by Bannerman & Hazelton (1990), along with general limitations for these groups.

Blacktown

Landscape – Gently undulating land on Wianamatta Group shales. Local relief to 30m, slopes usually <5%. Broad rounded crests and ridges with gently inclined slopes. Cleared eucalypt woodland and tall open forest (dry sclerophyll).

Soils – Shallow to moderately deep (<100cm) hardsetting mottled texture contrast soils, *red and brown podzolic soils (Dr3.21, Dr3.31, Db2.11, Db2.21)* on crests grading to *yellow podzolic soils (Dy2.11, Dy3.11)* on lower slopes and drainage lines.

Limitations – moderately reactive highly plastic subsoil, low soil fertility, poor soil drainage.

South Creek

Landscape – Floodplains, valley flats and drainage depressions of the channels on the Cumberland Plain. Usually flat with incised channels; mainly cleared.

Soils – Often very deep layered sediments over bedrock or relict soils. Where pedogenesis has occurred structured plastic clays (Uf6.13) or structured loams (Um6.1) in and immediately adjacent to drainage lines; red and yellow podzolic soils (Dr5.11 Dy2.41 Dr2.21) are most common on terraces with small areas of structured grey clays (Gn4.54), leached clay (Uf4.42) and yellow solodic soils (Dy4.42 Dy5.23).

Limitations – Erosion hazard, frequent flooding.

The soils of the study area are a reflection of the underlying geology and recent fluvial processes. Local geological information was sourced from Jones & Clark (1991) and includes descriptions of the Wianamatta Group by Bembrick, Herbert and Clark (p. 17), which underlies much of the Sydney Basin and is one of the parent materials responsible for the formation of the fluvial soils in the local region.

The Wianamatta Group is thought to have formed in the middle to late Triassic period, during a time when the Sydney Basin was inundated by the ocean. Over time, sediment deposition may have caused the buildup of a barrier system, isolating the west of the basin from the sea and forming a lagoon, into which sediment from the upper catchment was deposited.

The Wianamatta Group shows evidence of this sequence of events: with the deeper layers of Ashfield Shale thought to have been laid down in a brackish marine setting; Minchinbury sandstone following this has the character of a shoreline sand; and on top, the alluvial sediment of the Bringelly Shale.

Clark & Jones (1991) note the underlying geology of the study area as Bringelly Shale, which is composed primarily of laminite, sandstone, siltstone and claystone in increasing order of volumetric significance. In the area closer to the creek lines, Clark & Jones (1991) describe the lithology as Quaternary fine grained sand, silt and clay, which overlays the Bringelly Shale, having been deposited much more recently due to fluvial processes.

Brownlow, *et al.* (pg. 57) in Jones & Clark (1991) also describe several volcanic units in the local area. This includes the Prospect Picrite intrusion, to the east of the current Prospect Reservoir; and several confirmed and suspected volcanic intrusions throughout the region. The closest of these intrusions to the study area are a suspected volcanic dyke on the southern side of Angus Creek and a volcanic breccia neck at the Minchinbury Quarry, near the source of Angus Creek. The predominant material of these volcanic intrusions has been determined to be breccia and basalt (Brownlow, *et al.* from Jones & Clark, 1991).

Landform

Although the site is severely disturbed, it still maintains characteristics of the natural landform that would have been present before European settlement. The main topographic feature of the site is the Angus Creek channel, flanked on both banks by relatively flat and low lying ground, particularly to the south towards Eastern Creek. Native riparian and terrestrial vegetation of the Sydney Basin exists along both banks of the creek at various stages of degradation and invasion by alien species.

Photo 9 – View of the site from high ground (north) to the creek line (south west)

Photo 10 – Evidence of dumping around the central northwest of the site

Gentle hills slope upward to the highest point on the site in the northwest corner (**Photo 9**). Small hills are present between here and the creek line with some minor depressions between these harbouring aquatic macrophytes (*Juncus* sp.) clinging to pooling zones. These hills and depressions appear to be partly natural and partly due to historical earthworks and/or dumping. Extensive evidence of dumping of earth and bulk solid waste material is present around the site (**Photo 10**) apparently having been transported there during the construction of the adjacent One Steel 'mini mill' (NSW Department of Planning, 2006).

A visual inspection of the dumped material indicated that the majority consisted of rubble what appeared to be clean fill. No specific evidence of contaminants were observed (vegetation dieback or gross pollutant materials), although further investigations would be required to confirm this observation.

For several weeks after rain, swampy ground exists on the eastern side of the site on both sides of Angus Creek. This has been noted on many occasions around the DD1 air quality site and on the southern side of the creek, close to the boarder of the Nurragingy Reserve. This would indicate poor drainage or may be indicative of sub-surface flows rising to the surface after slow drainage from elsewhere within the site and/or the local area.

On the southern side of the creek, the land is much flatter, although is more heavily modified by the railway corridor and Blacktown Olympic Centre. Downstream of the site, to the east, Angus Creek converges with Eastern Creek within Nurragingy Reserve, where remnants of Cumberland Plain Woodland can be found.

The geomorphology and vegetation of Eastern Creek within the Reserve differs somewhat to that of Angus Creek, having much higher banks and a riparian canopy consisting primarily of *Melaleuca* sp.

Geology

No large outcrops are present on the site, although some loose surface rock was located on the small hill near SH3. The majority of material present here was grey siltstone (**Photo 11**) and basalt (**Photo 12**). Numerous other small pebbles were also present, including orange and reddish brown rock, which appeared to be of a sedimentary nature. These findings support the existence of underlying Wianamatta Group geology, particularly that of the Bringelly Shale (Clark & Jones, 1991)

Photo 11 – Clay/Siltstone from near Soil Hole 3

Photo 12 – Basalt from near Soil Hole 3

Soil

Soil investigation was undertaken at four locations across the site (**Figure** 3). Two investigative holes were dug close to the creek line (SH2 and SH4) and two were dug on higher ground to the north of the creek (SH1 and SH3). Descriptions of the soil encountered in each of the four locations, along with photos (**Photo 13**, **Photo 14**, **Photo 15** and **Photo 16**) are presented below.

Photo 13 – Soil Hole 1, near the north western boundary

Soil Hole 1 (SH1)

Elevation: 40 m (approx)

Total hole depth: 30 cm.

Location: Northwest of the site, approximately 40 m from the western gate and 40 m from the north fence.

Overlying vegetation: Eucalyptus woodland (probably regrowth as max. GBH <1.5 m) with some *Acacia* sp. and *Bursaria spinosa* in shrub layer. A dense exotic grass understorey consisting mostly of *Chloris gayana* and *Eragrostis curvolva*.

Soil Hole 1 (SH1) description

O Horizon (0 - 1 cm): Organic matter (sticks and leaves). Sharp, even boundary to A Horizon.

A Horizon (1 - 5 cm): Very dry clay with some silt and corse material also present. Pale yellow to pale brown colour. Weakly structured. Some organic matter present, including tree roots, worms and ants present to 15cm. Clear boundary to B Horizon.

B Horizon (5 - 30+ cm): Slightly moist clay with some silt and limited corse particles present (more homogenous than A Horizon). Red to orange colour, becoming darker with depth. Some yellow, brown and grey streaks. Relatively high plasticity. Boundary to C Horizon not reached.

Structure – Weakly structured in the A Horizon. Compact and difficult to dig through, particularly in the deeper layers.

Photo 14 – Soil Hole 2, near Angus Creek to the west of the site

Soil Hole 2 (SH2)

Elevation: 30 m (approx)

Total hole depth: 40 cm.

Location: Approximately 10 m from the north bank of Eastern Creek and approximately 100 m from the western boundary of the site.

Overlying Vegetation: Dense Privet (*Ligustrum* spp.) canopy and Trad (*Tradescantia fluminensis*) understorey with *Casuarina* sp., *Eucalyptus* sp. *Melaleuca* sp. also present.

Soil Hole 2 (SH2) description

O Horizon (0 - 1 cm): Organic matter (mostly privet leaves) on top 1cm. Sharp even boundary to A Horizon.

A Horizon (1cm - 30 cm): Moist silt and clay with some fine sand, yet no corse material observed. Light brown colour with yellow/orange tinge, becoming more yellow/orange with depth. Top 1 - 5 cm slightly darker than below. Organic matter present (tree roots). Clear boundary to B Horizon.

B Horizon (30 - 40+ cm): Moist silt and clay with higher proportion of silt/sand than A Horizon (wet soil feels rougher between fingers). Brown colour and much darker than A Horizon. Boundary to C Horizon not reached.

Structure: Loose and weakly structured. Somewhat compact in the B Horizon, but not as dense as in SH1. Relatively easy to dig through.

Other: Soil has an earthy smell and was generally moister than at SH1.

Soil Hole 3 (SH3) description

O Horizon (0 - 0.5 cm): Limited organic matter. Lots of small pebbles present. Sharp even boundary to A Horizon.

A Horizon (1cm - 20 cm): Dry clay with some silt and corse material present. Pale grey to light brown colour. Weakly structured. Some organic matter present, mostly grass roots. Clear boundary to B Horizon

B Horizon (20 - 25+ cm): Slightly moist clay with some silt and corse particles present. Brown with patches of grey, orange, red and black patches. Relatively high plasticity. Boundary to C Horizon not reached.

Photo 15 – Soil Hole 3

Soil Hole 3 (SH3)

Elevation: 38 m (approx)

Total hole depth: 25 cm.

Location: High ground near the centre of the disturbed land on the northern side of the site.

Overlying vegetation: No trees within approximately 100m. Dense exotic grass understorey consisting mostly of *Chloris gayana*. Some other unidentified grasses and weeds nearby.

Structure: Weakly structured in the A Horizon. Compact and very difficult to dig through, particularly in the B Horizon.

Other: Some piles of rubble nearby. No obvious signs of soil disturbance at this soil site. Obvious historical deforestation and more numerous pebbles and larger rocks on the surface compared with some other areas of the site.

Photo 16 – Soil Hole 4

Soil Hole 4 (SH4)

Elevation: 30 m (approx)

Total hole depth: 20 cm.

Location: Low ground to the east of the site near the DD1 air sampler, on the north side of Angus Creek.

Overlying vegetation: *Casuarina* sp. canopy to the north. Regrowth Eucalyptus Woodland to the south. Upper riparian aquatic macrophyte spp. present in the vicinity. Exotic and native grasses present around hole.

Soil Hole 4 (SH4) description

O Horizon (0 - 1 cm): Organic matter (dried grass and Casuarina needles). Sharp even boundary to A Horizon.

A Horizon (1cm - 5 cm): Dry clay with some silt and some fine sand. Corse material present. Light brown colour with some red and orange mottles. Weakly structured. Some organic matter present (grass roots and tree roots). Clear boundary to B Horizon

B Horizon (5 - 20+ cm): Moist clay with little silt/sand present (wet soil smooth between fingers). Colour brown, red and grey with clumping of coloured clays containing significant streaks and mottles. Some corse material present. Relatively high plasticity. Some organic matter present. Boundary to C Horizon not reached.

Structure: Weakly structured in the A Horizon. Compact and very difficult to dig through, particularly in the B Horizon.

Other: Some piles of rubble nearby. No obvious signs of soil disturbance at this soil site. Obvious deforestation and more numerous pebbles and larger rocks on the surface compared with some other areas of the site.

Discussion

The soil at the SH2 site appeared different to that of the other three sites and could be described as a loam, being more heterogeneous in particle size. The softness of the soil at site SH2 allowed for much easier digging and the soil also smelled richer and appeared to contain more organic matter. Two soil landscapes are described by Bannerman & Hazelton (1990), with differences attributed to fluvial processes. From the investigation it would appear that the SH2 site is within the fluvial influence zone, while other soil sample sites are not.

Soil from the SH1 site was apparently similar to that of the sites further from the stream, although it was within the *South Creek* soil landscape boundary defined by Hazelton and Bannerman (1989). The soil from this site displayed the characteristics of intermittent wetting and drying, having distinct mottling.

This observation fits with the observation of boggy ground around this site for long periods after rain and cracking of the soil in this area during dry periods (**Photo 18**). This site may close to the boundary of the soil classifications described by Hazelton and Bannerman (1989), yet displaying more of the characteristics of the *Blacktown* soil landscape described by these authors, which show properties such as shrink/swell.

Shrinking and swelling of the soil around the SH1 site was observed as large cracks in the soil (**Photo 18**) and the discontinuous subsidence of the small concrete slab positioned nearby. The slab was originally flat and a High Volume Air Sampler was bolted to this to collect ongoing air samples. Over time, with continued wetting and drying, the slab has become displaced and has resulted in an obvious lean to the unit (**Photo 17**).

Potentially reactive subsoil in the form of acid sulphate soil may be present, as defined by Bannerman & Hazelton (1990). The fact that soil is of estuarine origin, formation is relatively recent (Quaternary in the case of the South Creek landscape) and the presence of yellow material in some soil holes (**Photo 13** and **Photo 14**) may be indicative of acid sulphate soil. This observation would need to be confirmed by analysis of soil samples.

Soil characteristics from the SH3 site resembled that of the SH1 site, although the A Horizon of the SH3 site extended much deeper (20 cm) than the SH1 site (5 cm) and the B Horizon was much redder in the SH1 site. This observation is indicative of better drainage at the SH3 site, as would be expected to some extent due to its location on a small hill.

This investigation was limited in spatial scale and should not be used to infer actual soil landscape distribution and boundaries. Further investigation should be initiated for this and other important land management issues.

Photo 17 – Shrink/swell at the DD1 site

Photo 18 – Cracking soil near SH4