



Windale Creek Restoration Plan

Prepared for
Masters

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Project Number	14NEWECO-0057
Project Manager	Gordon Patrick (02) 4910 3407 Suites 28 & 29, Level 7 19 Bolton St Newcastle NSW 2300
Prepared by	Gordon Patrick
Reviewed by	Antony von Chrismar
Project Director	Robert Humphries
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Abbreviations

Abbreviation	Description
DA	Development Approval
ELA	Eco Logical Australia
GPS	Global Positioning System
LMCC	Lake Macquarie City Council

1 Introduction

Eco Logical Australia (ELA) was engaged to prepare a creek rehabilitation / restoration plan for the watercourse within the study area, which is adjacent to the proposed Masters development at 4a South Street, Windale. The location of the study area is shown in Error! Reference source not found..

The plan was prepared at the request of Lake Macquarie City Council (LMCC) as part of the DA approval process for the Masters development on the adjacent land to the north of the study area. The unnamed watercourse is located within Tulootaba Reserve, is a tributary of Crokers Creek and flows directly in to Jewells Wetland. Given the creek is within Tulootaba Reserve and is connected to Jewells Wetland, the approval conditions included rehabilitation / restoration works to help control weeds, stabilise the existing scoured banks and revegetate bare areas. The plan focuses on the rehabilitation of an area within 20 m from the top of the bank on both sides of the watercourse.

The majority of the study area is vegetated, with approximately 60% remnant native vegetation and the other portion comprises either weed dominated or some bare and exposed areas. The watercourse remains in its original flow path in the central and southern portions, although there is evidence of moderate to severe scouring in the central section. The western section of the watercourse has been modified and appears to have been straightened, presumably due to increased water flows during storm events.

For the purposes of this rehabilitation plan the study area has been divided into three separate work Zones:

- Zone 1 applies to the north-western section
- Zone 2 applies to the central scoured section
- Zone 3 applies to the southern and relatively intact section

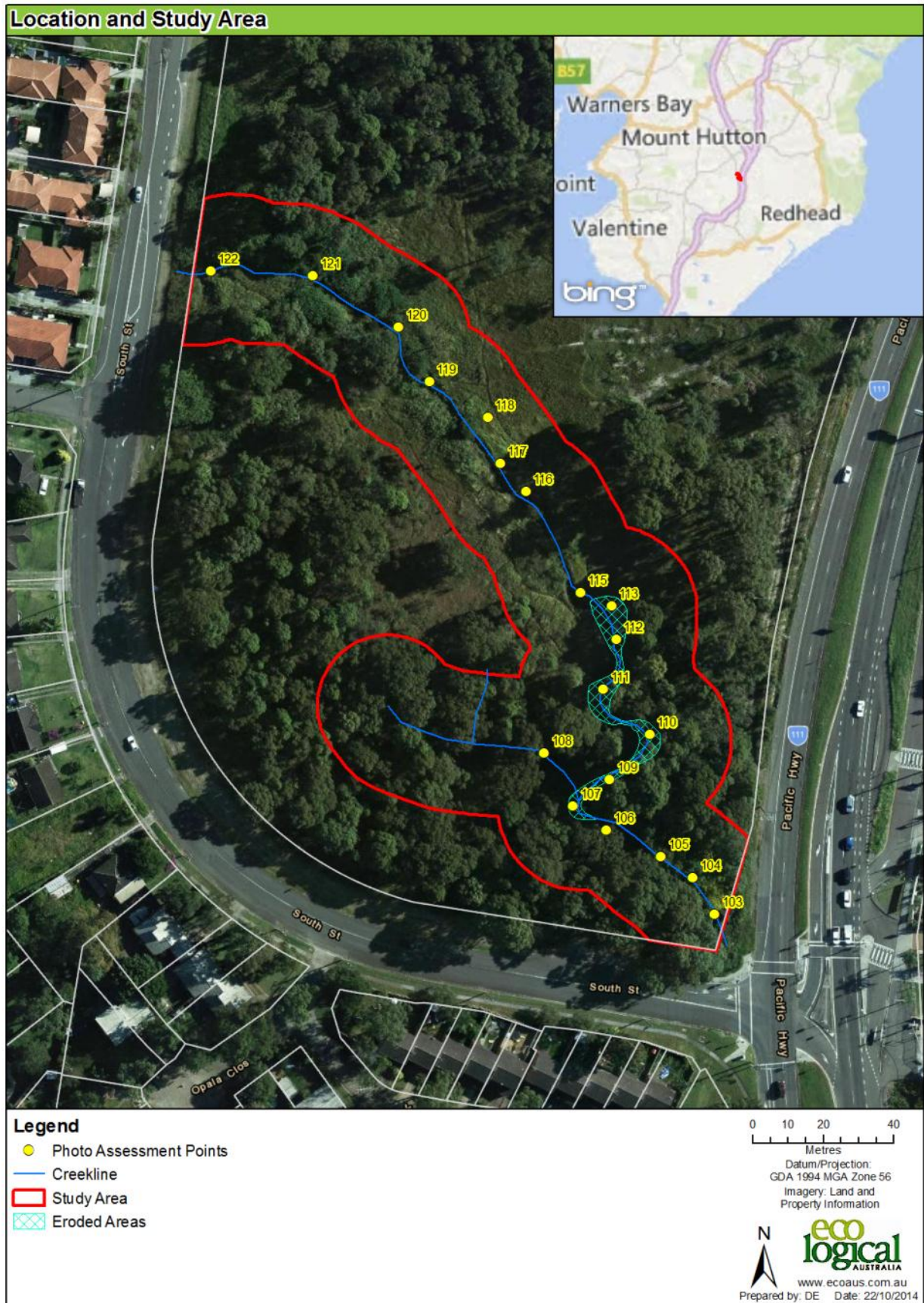


Figure 1 Location and study area

1.1 Vegetation communities

The vegetation communities of the study area have been mapped in detail as part of previous ecological assessments for the survey area (Ecotone 2009; Travers 2011, ELA 2012). This vegetation mapping (**Figure 2**), along with native vegetation community mapping (LHCCREMS 2003) was reviewed to assess the study area.

Two native vegetation communities and areas of modified land occur within the watercourse study area, as follows.

1.1.1 Scribbly Gum – Red Bloodwood heathy woodland on the coastal plains of the Central Coast, Sydney Basin

Remnants of this community are located in the western and central portions of the study area and are in various states of condition. The community generally has an open forest to woodland canopy of 10 m - 18 m and comprised of a understorey mosaic with sections being open grassy with few shrubs to areas of dense (often heath like) shrub cover. The portions of understorey generally dominated by grasses appear to relate to the sections of the site that have had a higher influence from the effects of frequent fire. In Zone 1 this community has been influenced by past clearing works as a result of the creek realignment works. This has allowed for an increase in weed species via various processes, including dispersal from the watercourse, clearing of native vegetation, high frequency fire events and by dumping of garden waste.

The canopy is primarily dominated by *Eucalyptus haemastoma* (Broad-leaved Scribbly Gum) and *Corymbia gummifera* (Red Bloodwood) and to a lesser extent *Angophora costata* (Smooth-barked Apple), *Eucalyptus capitellata* (Brown Stringybark) and *Eucalyptus acmenoides* (White Mahogany).

A sub-canopy of 6 – 8 m, comprising similar species to the canopy was also represented. Other dominant species include *Allocasuarina littoralis* (Black She-oak) and *Melaleuca nodosa* (Ball Honeymyrtle).

Shrub cover within the vegetation type varied considerably (as mentioned above) with representative species including *Banksia spinulosa* var. *collina* (Hair-pin Banksia), *Dodonaea triquetra* (Large-leaved Hopbush), *Acacia longifolia* subsp. *longifolia* (Sydney Golden Wattle), *Leptospermum trinervium* (Paperbark Tea-tree), *Pultenaea villosa* (Bush Pea) and *Lambertia formosa* (Mountain Devil).

Groundcover was variable, with indicative species such as *Themeda australis* (Kangaroo Grass), *Entolasia stricta* (Wiry Panic), *Imperata cylindrica* var. *major* (Bladey Grass), *Pteridium esculentum* (Bracken) and *Dianella caerulea* var. *producta* (Blue Flax Lily).

A low density of climbers and vines were present including *Glycine clandestina* (A Love Creeper), *Billardiera scandens* (Apple Dumplings), *Hardenbergia violacea* (False Sarsaparilla) and *Polymeria calycina* (Swamp Bindweed).

1.1.2 Spotted Gum - Grey Ironbark open forest on the foothills of the Central Coast, Sydney Basin

Relatively intact remnants of this community are present surrounding Zone 2 and within Zone 3. This vegetation community appears to be resilient and contains some moderate weed invasion. This community has a preference for the clay influenced soils located in this section of the study area in association with a slightly more southerly aspect and moist conditions.

The open forest canopy, which can be at times discontinuous due to human disturbances, is of height ranging from 18 to 22 m. Dominant canopy species are *Corymbia maculata* (Spotted Gum) and

Eucalyptus siderophloia (Grey Ironbark). Other canopy species include *Angophora costata* (Smooth-barked Apple), *Eucalyptus piperita* (Sydney Peppermint) and *Angophora floribunda* (Rough-barked Apple).

A moderately sparse sub-canopy of 8 to 10 m is also present, with representative species including *Allocasuarina littoralis* (Black She-oak), *Glochidion ferdinandi* (Cheese Tree), *Callistemon salignus* (Willow Bottlebrush) and examples of the canopy tree species.

Shrubs were generally sparse throughout the community and comprised few species, *Breynia oblongifolia* (Coffee Bush), *Leucopogon lanceolatus* (Lance Beard-heath), *Maytenus sylvestris* (Orange Bark) and *Gymnostachys anceps* (Settlers Flax).

Groundcover was particularly dense, with a large number of grass species present. Common representative species include *Imperata cylindrica* var. *major* (Bladey Grass), *Entolasia stricta* (Wiry Panic), *Entolasia marginata* (Margined Panic), *Poa labillardieri* (Tussock Grass) and *Pteridium esculentum* (Bracken).

Common climber / twiners include *Smilax australis* (Smilax), *Pandorea pandorana* (Wonga Wonga Vine), *Eustrephus latifolius* (Wombat Berry) and *Hibbertia scandens* (Golden Guinea Flower).



Figure 2 Vegetation communities of the study area and adjacent areas

2 Site evaluation

Brief site inspections were undertaken on foot on the 13 October and 17 October 2014 to photograph, assess and identify the issues within the study area. This involved the establishment of 19 specific assessment points (**Figure 3**). Each point was located and recorded by a hand held GPS and at least one or a series of photographs were taken. Notes were recorded at each location documenting issues such as:

- extent of weed invasion noting the dominant invasive species
- detail of erosion and scouring of the creek banks
- locations of rubbish and other features
- presence and intactness of remnant native vegetation



Figure 3 Photo point locations

3 Proposed works

For reference and ease of interpretation the section of creek within the study area has been divided into three distinct works zones (**Figure 4**). The following sections provide an overview of the issues and management strategies at each Zone with more detail at each specific photo assessment point provided in the Appendices.

3.1 Work zone 1

The site contains the culvert entry point from pipes under South Street. Previously this section of the watercourse appears to have had its alignment straightened, thereby increasing water flow and potential for erosion in downstream areas (particularly work zone 2). Banks appear less stable due to alluvium and no obvious bedrock. Banks at some locations are moderately incised / eroded with several areas within and adjacent to the creek containing large areas of introduced grass and herbaceous species, although some woody weeds are also evident. Some partially intact stands of remnant native woodland are present in the vicinity of Points 120, 121 and 122.

Due to disturbances, emphasis will be placed on erosion and in-stream water flow control works associated, and weed control and revegetation works within the zone and at locations adjacent to the watercourse banks. A brief summary of the tasks required for Zone 1 (**Figure 5**) is presented in **Table 1**. All detailed site information relating to Zone 1 is presented in **Appendix A**.

Table 1: Work Zone 1 summary of tasks

Task	Priority	Comment
Erosion control works	H	Due to past watercourse straightening and realignment, erosion controls and in particular in-stream water flow restrictors will be installed as part of the priority works in this area. It is anticipated that flow and erosion control devices could be installed at up to five locations in this Zone – Points 115, 119, 120, 121 and 122.
Weed control	M	Primary weed control will be carried out in this Zone in combination with the erosion control works in in-stream areas. Additional weed control will be carried out in the areas adjacent to the creek banks targeting herbaceous and grass species, as well as scattered woody weeds. Likely to require a team of four bushland regenerators for an estimated total of three / four days to carry out the primary weed control works with an additional two days for initial follow up.
Revegetation	M	Revegetation is considered an important component for the success of the works in this area and will comprise installation of a number of tubestock (~300 - 500) dependent on the size and scale of the erosion and flow control measures implemented. There is potential for some strategic planting outside the banks of the creek to help in re-establishing adjacent woodland vegetation.
Rubbish Removal	L	General rubbish to be collected and some larger construction items

The works to be carried out in this Zone (as mentioned above) are anticipated to be in the vicinity of eight days for a team of four bushland regenerators. This excludes any work involving actual bank reshaping and earthworks (as

these tasks would be carried out by others), but includes planting and the installation of weed matting / jute mesh.

3.2 Work zone 2

This zone has become extensively and in some cases severely incised across assessment points 109 through to 113. This outcome is primarily due to the high flows created by the straightened upstream areas in Zone 1. Both bank and stream bed erosion is extensive in this area, with the stream bed being eroded from the surrounding vegetated areas to a depth ranging from 1.5 m (Point 109) to 4.5 m (Point 113). Scouring of the banks, particularly on external bends, is extensive with tree roots exposed and obvious evidence of slumping.

This area comprises a highly degraded watercourse that will require a moderate degree of stabilisation and erosion control measures. Weeds are evident within the scoured and eroded areas, but remnant native vegetation is generally intact within the rest of the Zone. As a result, the majority of effort will need to be targeted toward erosion control and stabilisation (incl. revegetation). A brief summary of the tasks required for Zone 2 (**Figure 6**) is presented in **Table 2**. All detailed site information relating to Zone 2 are presented in **Appendix B**.

Table 2: Work Zone 2 summary of tasks

Task	Priority	Comment
Erosion control works	H	Due to past watercourse straightening in Zone 1, erosion control will need to be installed as part of the priority works in this area. It is anticipated that flow and erosion control devices, incorporated with some bank reshaping, could likely need to be installed along the complete length of the watercourse in this Zone.
Weed control	M	Primary weed control will be carried out in this Zone in combination with the erosion control works in in-stream areas. Additional weed control will be carried out in the areas adjacent to the creek banks targeting scattered woody weeds, as well as some patches of herbaceous and grass species. Likely to require a team of four bushland regenerators for an estimated total of two days to carry out the primary weed control works with an additional two days for initial follow up.
Revegetation	H	Revegetation is considered an important component for the success of the works in this area and will comprise installation of a number of tubestock (~800 – 1,200) dependent on the size and scale of the erosion and flow control measures implemented. There is potential for some strategic planting outside the banks of the creek to help in re-establishing adjacent woodland vegetation.
Rubbish Removal	L	General rubbish to be collected and some larger items (e.g. shopping trolleys, vehicle tyres, etc.)

The works to be carried out in this Zone (as mentioned above) are anticipated to be in the vicinity of six to eight days for a team of four bushland regenerators. This excludes any work involving actual bank reshaping and earthworks (as these tasks would be carried out by others), but includes planting and the installation of weed matting / jute mesh.

3.3 Work zone 3

This area comprises generally intact remnant native vegetation and will have an emphasis on weed control works, with only minor consideration to erosion control, revegetation and rubbish removal. A brief summary of the tasks required for Zone 3 (**Figure 7**) is presented in **Table 3**. All detailed site information relating to Zone 3 are presented in **Appendix C**.

Table 3: Work Zone 3 summary of tasks

Task	Priority	Comment
Erosion control works	L	Relatively minor weed control works are anticipated for Point 103 and potentially Point 107. This is expected to include the installation of weed matting and or jute mesh in conjunction with some planting.
Weed control	H	Weed control in this zone is the highest priority and will require a team of four bushland regenerators for an estimated period of four days to carry out the primary weed control works and an additional two days for follow-up. As woody weeds are the primary target in this area, a hand and cut stump and paint method of control (or similar) will be applied, although some spot spraying may be necessary.
Revegetation	L-M	Revegetation is not considered a large component of the works in this area but will comprise installation of some tubestock (~30 -50) in the vicinity of Point 103 and potentially Point 107.
Rubbish Removal	L	General rubbish to be collected

The works to be carried out in this Zone (as mentioned above) are anticipated to be in the vicinity of seven / eight days for a team of four bushland regenerators.

3.4 Assumptions and contingencies

It is anticipated that all weed control, revegetation and minor erosion and bank stabilisation works will be carried out by experienced and qualified Bushland Regenerators. Where any larger stream bank modification or bank reshaping is needed, a suitable contractor will be engaged and work in conjunction with the restoration ecologist and the bushland regenerators.

Maintenance will be required in areas that have been planted (i.e. watering) and where erosion control devices have been installed (i.e. movement during storm events, vandalism, etc.). The estimated times provided for Bushland Regenerators excludes maintenance beyond one follow up watering of tubestock. Dependant on prevailing conditions, additional scheduled watering may be required.

Actual design and the materials to be used in the control of erosion and to reduce water flow within the watercourse are not specified in this report.

3.5 Cost estimates

Following is a cost estimate for the works proposed and described in this document with the exclusion of large plant and machinery based works such as bank reshaping and in-stream earth works. **Table 4** provides an indicative cost to carry out the Bushland Regeneration works including weed control (both

primary and initial follow-up works until LMCC resumes maintenance of site), minor in-stream erosion control works, planting and supply of native tubestock.

Table 4: Cost estimates to carry out proposed works

Task	Comment	Cost estimate (ex. GST)
Primary works	This component includes: • Primary weed control (includes herbicide costs) • Planting (up to 1,750 tubestock) and initial watering • Minor in-stream and bank erosion works (e.g. jute mesh and coir log installation) • General rubbish removal A team of bushland regenerators consists of four (including a supervisor) working an 8hr day @ \$ 1,650 per team day. Estimated 16 team days @ \$ 1,650 per team day.	\$26,400
Follow-up works	This component includes: • Initial follow-up weed control (includes herbicide costs) • Planting follow-up watering • Minor maintenance on in-stream and bank erosion works Estimated 8 team days @ \$1,650 per team day.	\$13,200
Plant supply	A total of up to 1,750 native tubestock are anticipated to be incorporated into the project to help in stabilisation within the stream bank areas and revegetation in the adjacent areas. Tubestock costs are based on an average cost of \$2.10 per unit. Note: Tubestock should be ordered at the earliest opportunity to ensure availability for planting. Actual planting costs are included in bushland regeneration costs. Tree guards are not warranted on this site.	\$3,675
General costs	General costs include: • Rubbish and plant disposal costs (\$250) • Jute mesh / Jute matting and metal pegs (\$1,500) • coir logs and wooden pegs (25 x 3 m @ \$105 each) = \$2,700 Note: Plant disposal will only be in regard to specific seeds and plant parts that need to be removed from site, the majority of plant material will be retained on site. Costs for native mulch have not been included.	\$4,450
Reporting / monitoring	Initial reporting and monitoring on the works (Bushland Regenerator / Restoration ecologist)	\$3,500
Total estimated costs		\$51,225



Figure 4 Work Zones overview

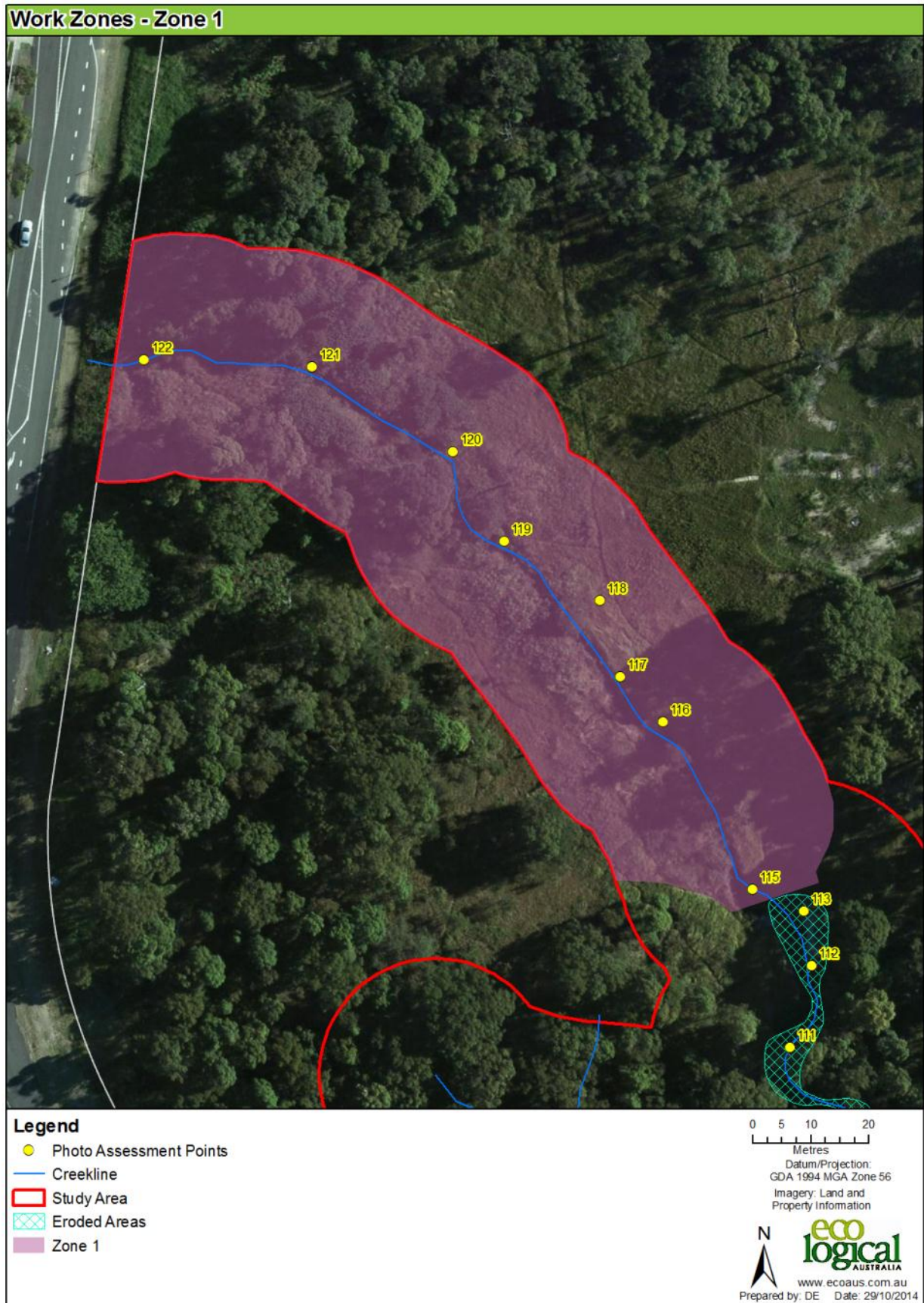


Figure 5 Location of Work Zone 1



Figure 6 Location of Work Zone 2

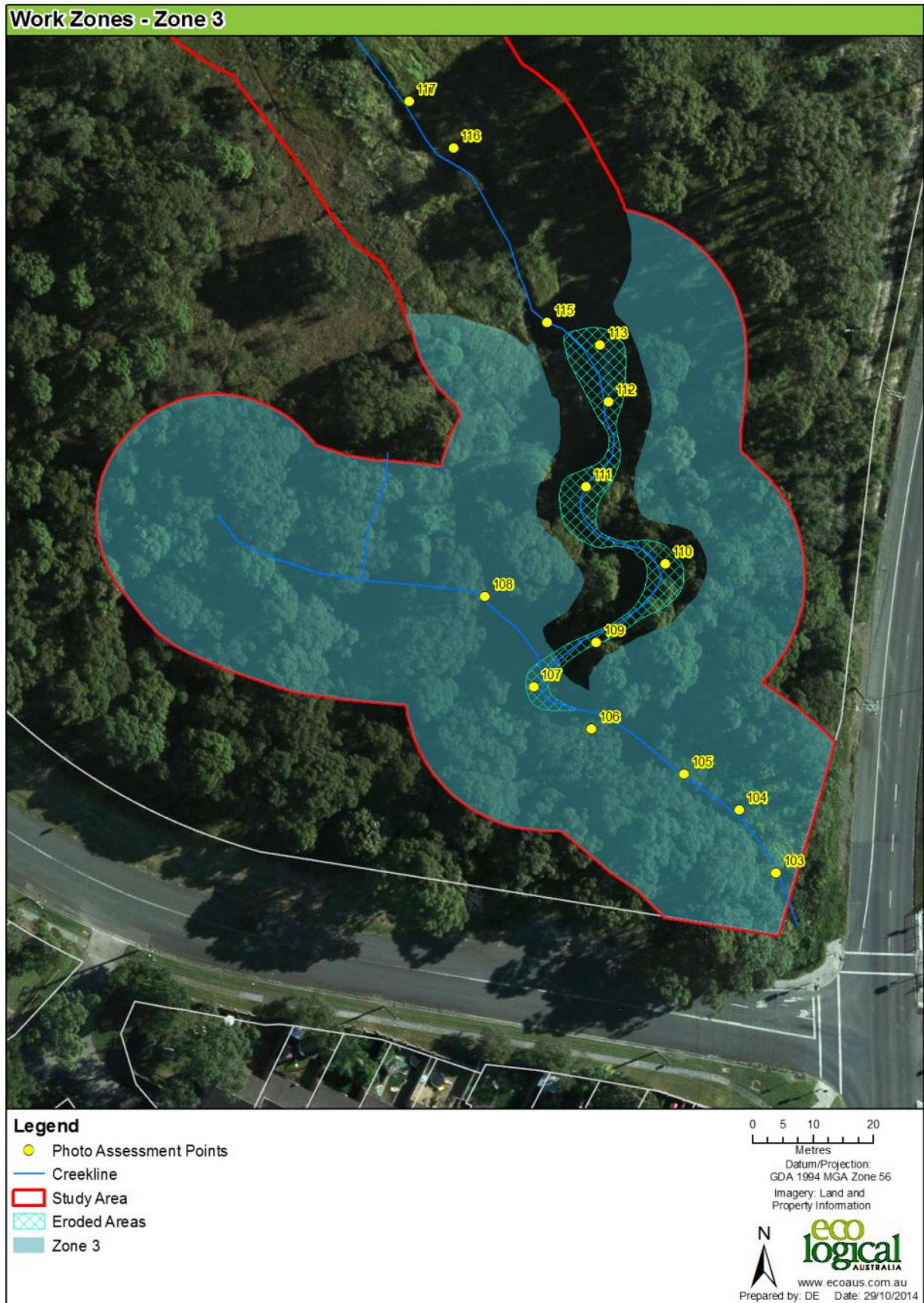


Figure 7 Location of Work Zone 3

4 Reporting and monitoring

As part of this initial phase of the creek / stream rehabilitation project monitoring points will be set up with baseline information collected. Any future monitoring is to be provided by others, as the site is owned by LMCC and will be managed by council.

Monitoring is anticipated to be carried out at a minimum of six strategic points along the watercourse and adjacent areas, with the suggested locations being in the vicinity of assessment points 103, 107, 111, 113, 119 and 122. The monitoring will include the use of permanently set up photo points to monitor visual change over time.

Aspects to be monitored in addition to the photographs will include (but not limited to):

- Extent of weed invasion / weed cover and species
- Presence and type of rubbish
- Evidence of vandalism or human impact
- Extent of erosion and success of erosion control methods
- Success of planting and weed control

A brief monitoring report will be prepared by a suitable contractor at nominated intervals during the works / construction phase of the creek rehabilitation project. The report will include:

- A summary of revegetation works carried out within the period.
- Photos from each of the photo monitoring points in each work Zone.
- A brief discussion on any changes in vegetation health observed between photo monitoring periods.
- A brief discussion on the state of the revegetation works and general ecological conditions at the site.
- A description of any problems or issues encountered and recommendations to overcome these.

References

Ecotone (2009) *Flora and Fauna Constraints Assessment Addressing Land at 6A Pacific Highway, Bennetts Green*. Prepared for Lake Macquarie City Council.

Eco Logical Australia (ELA) 2012. *Species Impact Statement: Retail Development, 4 B South Street, Windale*. Prepared for Hydrox.

Lower Hunter Central Coast Regional Environmental Management Strategy (LHCCREMS) (2003) *Extant Vegetation Map*. LHCCREMS, New South Wales

Travers (2011) *Flora and Fauna Report: Due Diligence Assessment for Proposed Hardware Facility and Retail Tenancy Buildings at Lot 10 DP 1013486 6A Pacific Highway Bennetts Green*. Prepared for PTC Projects Pty Ltd.

Appendix A Work zone 1 photo assessment points

Point 115



Site Issue	Priority	Works needed
Erosion	H	The section is moderately incised (~1.0 m) but appears quite stable due to the surrounding native vegetation, although where vegetation may be removed by weed control works some stabilisation such as jute matting or coir logs may need to be incorporated. Due to the location just upstream from the deeply eroded section (Point 113) it is recommended that the section require some woody debris to be implanted into and across the stream bed to help naturally reduce water flow and trap sediment. This in conjunction with other such methods further upstream in zone 1 to reduce flow rates will help stabilise the existing stream banks.
Weed control	M	The area has moderate to dense infestations of weed species in the creek and on the upper banks and surrounding areas that will require removal and control. Main dominant weed species at this location include: Cockspur Coral Tree, Crofton Weed, Small-leaved Privet and Camphor Laurel. Kikuyu and Buffalo Grass. Other common weedy species are primarily herbaceous and grass species including <i>Briza</i> spp., Cobblers Pegs, Purple Top, Fleabane and Vacy Grass.
Revegetation	L	Some supplementary planting of suitable native species at this location after weed control has been carried out would be advisable to help in stabilisation of the upper bank. Suitable species would include: <i>Lomandra longifolia</i>, <i>Carex appressa</i>, <i>Gahnia clarkei</i>, <i>Dianella caerulea</i>, <i>Melaleuca styphelioides</i>, <i>Melaleuca lineariifolia</i> and <i>Glochidion ferdinandi</i>.
Rubbish	L	Rubbish comprises scattered general litter only.

Point 116



Site Issue	Priority	Works needed
Erosion	M	As for adjacent areas the section is moderately incised (~1.0 m) but appears quite stable due to the surrounding native vegetation, although where vegetation may be removed by weed control works some stabilisation such as jute matting or coir logs may need to be incorporated.
Weed control	M	This section contains a high percentage of native cover within the creek and adjacent areas. The area has moderate infestations of weed species in the creek and on adjacent banks and surrounding areas that will require removal and control. Main dominant weed species at this location include: Crofton Weed, Pennywort Cobblers Pegs, Purple Top, Fleabane and Vetch. Other common weedy species are primarily herbaceous and grass species including Spear Thistle and Watsonia.
Revegetation	L - M	Some supplementary planting of suitable native species at this location after weed control has been carried out would be advisable to help in stabilisation of the upper bank. Suitable species would include: <i>Lomandra longifolia</i> , <i>Carex appressa</i> , <i>Gahnia clarkei</i> , <i>Dianella caerulea</i> , <i>Melaleuca styphelioides</i> , <i>Melaleuca lineariifolia</i> and <i>Glochidion ferdinandi</i> . In adjacent areas <i>Corymbia maculata</i> , <i>Eucalyptus siderophloia</i> , as well as <i>Angophora costata</i> , <i>Angophora floribunda</i> and <i>Eucalyptus piperita</i> . Additional species for revegetation are present in Schedule 1.
Rubbish	L	No rubbish observed.

Point 117



Site Issue	Priority	Works needed
Erosion	H	The section is moderately incised (~1.0 m) but appears quite stable due to the surrounding native vegetation, although where vegetation may be removed by weed control works some stabilisation such as jute matting or coir logs may need to be incorporated.
Weed control	M	The area has dense infestations of weed species in the creek and on the upper banks and moderate infestations in surrounding areas that will require removal and control. Main dominant weed species at this location include: Cockspur Coral Tree, Crofton Weed and <i>Crotalaria lunata</i> . Other common weedy species are primarily herbaceous and grass species including <i>Briza</i> spp., Cobblers Pegs, Purple Top and Fleabane.
Revegetation	L	Some supplementary planting of suitable native species at this location after weed control has been carried out would be advisable to help in stabilisation of the upper bank. Suitable species would include: <i>Lomandra longifolia</i> , <i>Carex appressa</i> , <i>Gahnia clarkei</i> , <i>Dianella caerulea</i> , <i>Melaleuca styphelioides</i> , <i>Melaleuca lineariifolia</i> and <i>Glochidion ferdinandi</i> . In adjacent areas <i>Corymbia maculata</i> , <i>Eucalyptus siderophloia</i> , as well as <i>Angophora costata</i> , <i>Angophora floribunda</i> and <i>Eucalyptus piperita</i> . Additional species for revegetation are present in Schedule 1.
Rubbish	L	Rubbish comprises scattered general litter only.

Point 118 – dense introduced grassland area adjacent to creek



Site Issue	Priority	Works needed
Erosion	L	This area is located adjacent to the creek and contains a large proportion of introduced grass species. No erosion issues.
Weed control	M	The area is dominated by modified grassland of primarily weed species. The predominant species are Coolatai Grass and Watsonia which cover an area of over 500 m ² . The area will require weed removal and control. Other common weed species at this location include: Blackberry Nightshade, Purple Top, Cobblers Pegs and Veined Verbena.
Revegetation	L - M	Some supplementary planting of suitable native species at this location after weed control has been carried out and would be advisable to help in reestablishment of native vegetation. Suitable species would include: <i>Lomandra longifolia</i> , <i>Carex appressa</i> , <i>Gahnia clarkei</i> , <i>Dianella caerulea</i> , <i>Melaleuca styphelioides</i> , <i>Melaleuca lineariifolia</i> , <i>Corymbia maculata</i> , <i>Eucalyptus siderophloia</i> , <i>Angophora costata</i> , <i>Glochidion ferdinandi</i> . <i>Angophora floribunda</i> and <i>Eucalyptus piperita</i> . Additional species for revegetation are present in Schedule 1.
Rubbish	L	Rubbish comprises scattered general litter only.

Point 119 (creek crossing site)



Site Issue	Priority	Works needed
Erosion	H	As for adjacent areas the section is moderately incised (~1.0 m), but appears quite stable due to the surrounding native vegetation, although where vegetation may be removed by weed control works some stabilisation such as jute matting or coir logs may need to be incorporated. This location would also be a potential area for the installation of in stream flow controls to reduce the impacts further downstream. This section may require some woody debris or rocky structures (e.g. rock armour) to be implanted into and across the stream bed to help naturally reduce water flow and trap sediment. This in conjunction with other such methods further upstream to reduce flow rates will help stabilise the existing stream banks.
Weed control	M	The area has dense infestations of weed species on the creek banks and moderate infestations in surrounding areas that will require removal and control. Main dominant weed species at this location include: Cockspur Coral Tree, Crofton Weed and <i>Crotalaria lunata</i>. Other common weedy species are primarily herbaceous and grass species including <i>Briza</i> spp., Cobblers Pegs, Purple Top and Fleabane.
Revegetation	L	Some supplementary planting after weed control, of suitable native species at this location should be carried out to help in stabilisation of the upper bank where Privet and <i>Crotalaria</i> have been removed. Suitable species would include: <i>Lomandra longifolia</i>, <i>Carex appressa</i>, <i>Gahnia clarkei</i>, <i>Dianella caerulea</i>, <i>Ficus coronata</i>, <i>Melaleuca styphelioides</i>, <i>Melaleuca lineariifolia</i> and <i>Glochidion ferdinandi</i>. In adjacent areas <i>Corymbia maculata</i>, <i>Eucalyptus siderophloia</i>, as well as <i>Angophora costata</i>, <i>Angophora floribunda</i> and <i>Eucalyptus piperita</i>. Additional species for revegetation are present in Schedule 1.
Rubbish	L	Rubbish comprises scattered general litter, as well as building waste (fencing) as this is currently an existing makeshift bridge / creek crossing.

Point 120



Site Issue	Priority	Works needed
Erosion	H	This area is moderately incised to a depth of ~1.5 m with banks that appear to contain less compact sediments (possibly dumped on the top of the southern bank of the watercourse during a past sediment removal practice, likely undertaken by machinery). As a result this section will require the installation of erosion controls, such as jute matting and / or coir logs, for stabilisation purposes along the upper banks once the primarily weed dominated adjacent vegetation is removed. Due to previous disturbances at this location, it would also be a potential area for the installation of in stream flow controls to reduce the impacts further downstream. This section may require some woody debris or rocky structures (e.g. rock armour) to be implanted into and across the stream bed to help naturally reduce water flow and trap sediment. This in conjunction with other such devices further upstream to reduce flow rates will help stabilise the existing stream.
Weed control	M	The area has dense infestations of weed species on both creek banks and in surrounding areas that will require removal and control. Clear removal of existing weed dominated vegetation, installation of weed matting and planting is recommended for a large proportion this location. Main dominant weed species at this location include: Small-leaf Privet, Lantana, Crofton Weed and <i>Crotalaria lunata</i>. Other common weedy species are primarily herbaceous and grass species including Guinea Grass, Cobblers Pegs, Purple Top and Fleabane. Spraying weed dominated grassy areas (away from the stream) with herbicide will likely be necessary.
Revegetation	M-H	Moderate to extensive planting of suitable native species after weed control, should be carried out to help in stabilisation of the upper bank and adjacent areas where Privet and <i>Crotalaria</i> have been removed



		as well as areas covered in dense grassy and herbaceous weeds. Suitable species would include: <i>Lomandra longifolia</i> , <i>Themeda australis</i> , <i>Pratia purpurescens</i> , <i>Cymbopogon refractus</i> , <i>Carex appressa</i> , <i>Gahnia clarkei</i> , <i>Dianella caerulea</i> , <i>Ficus coronata</i> , <i>Melaleuca styphelioides</i> , <i>Melaleuca lineariifolia</i> and <i>Glochidion ferdinandi</i> . In adjacent areas <i>Corymbia maculata</i> , <i>Eucalyptus siderophloia</i> , as well as <i>Angophora costata</i> , <i>Angophora floribunda</i> and <i>Eucalyptus piperita</i> . Additional species for revegetation are present in Schedule 1.
Rubbish	L	Rubbish comprises scattered general litter only.

Point 121



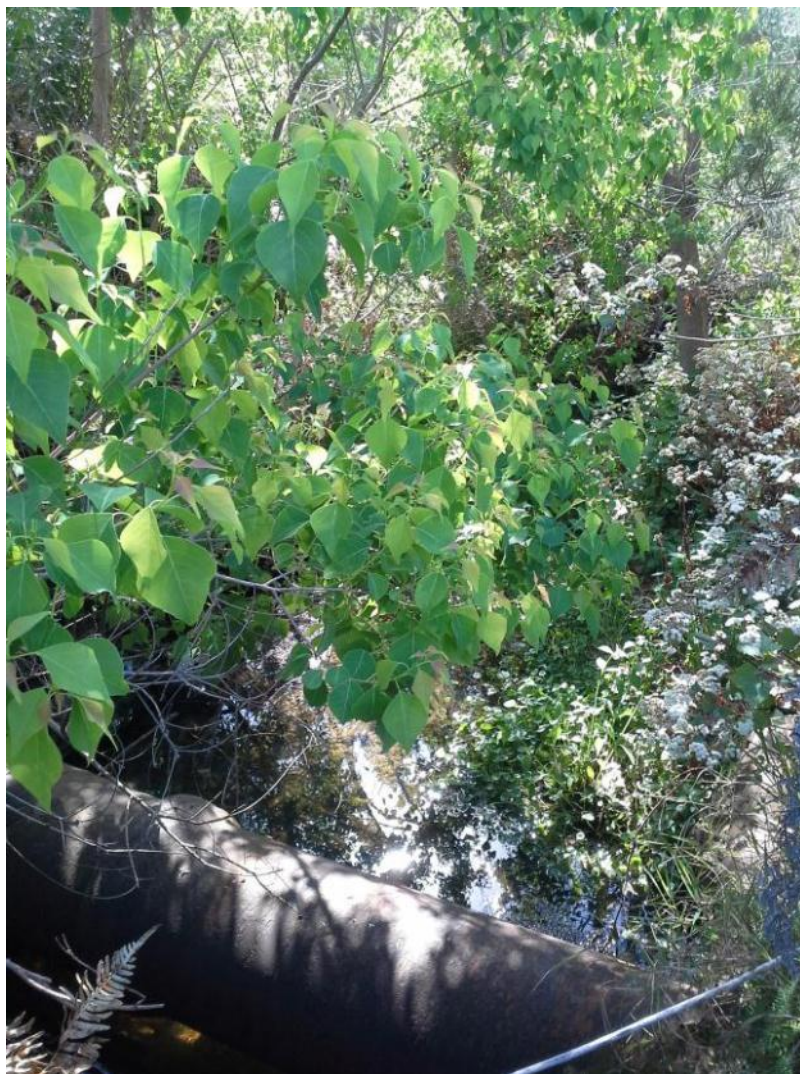
This section is similar in most respects to Point 120

Site Issue	Priority	Works needed
Erosion	H	This area is moderately incised to a depth of ~1.2 m with banks that appear to contain less compact sediments (possibly dumped on the top of the southern bank of the watercourse during a past sediment removal practice, likely undertaken by machinery). As a result this section will require the installation of erosion controls, such as jute matting and / or coir logs, for stabilisation purposes along the upper banks once the primarily weed dominated vegetation is removed. Due to previous disturbances at this location, it would also be a potential area for the installation of in stream flow controls in conjunction with the works at Point 120 to reduce erosion impacts further downstream. This section may require some woody debris or rocky structures (e.g. rock armour, gabions, etc.) to be implanted into and across the stream bed to help naturally reduce water flow and trap sediment. This in conjunction with other such devices further upstream to reduce flow rates will help stabilise the existing stream and improved areas.
Weed control	M	The area has dense infestations of weed species on both creek banks and in surrounding areas that will require removal and control. The process would involve detailed removal of existing weed dominated vegetation; installation of weed matting; planting is recommended for a large proportion this location. Dominant weed species at this location include: Camphor Laurel, Small-leaf Privet, Lantana, Crofton Weed and <i>Crotalaria lunata</i>. Other common weedy species are primarily herbaceous and grass species including Guinea Grass, Cobblers Pegs, Purple Top and Fleabane. Spraying weed dominated grassy areas (away from the stream) with herbicide will likely be necessary.



Revegetation	M-H	Moderate to extensive planting of suitable native species after weed control, should be carried out to help in stabilisation of the upper bank and adjacent areas where Privet and Crotalaria have been removed, as well as areas covered in dense grassy and herbaceous weeds. Suitable species would include: <i>Lomandra longifolia</i> , <i>Themeda australis</i> , <i>Pratia purpurescens</i> , <i>Cymbopogon refractus</i> , <i>Carex appressa</i> , <i>Gahnia clarkei</i> , <i>Dianella caerulea</i> , <i>Ficus coronata</i> , <i>Melaleuca styphelioides</i> , <i>Melaleuca lineariifolia</i> and <i>Glochidion ferdinandi</i> . In adjacent areas <i>Corymbia maculata</i> , <i>Eucalyptus siderophloia</i> , as well as <i>Angophora costata</i> , <i>Angophora floribunda</i> and <i>Eucalyptus piperita</i> . Additional species for revegetation are present in Schedule 1.
Rubbish	L	Rubbish comprises scattered general litter only.

Point 122 – Stormwater entry



Site issue	Priority	Works needed
Erosion	H	This area contains the piped stormwater feed for the creek which crosses South Street from the west. The section contains a concrete sill below the pipe, beyond the concrete sill there is little by way of water flow reduction structures. This stormwater entry area would be an ideal location to commence the creek water flow reduction by the installation of dissipaters and / or a retention basin. In addition to the water flow controls this section will require the installation of bank erosion controls, such as jute matting and / or coir logs, for stabilisation purposes along the upper banks once the primarily weed dominated adjacent vegetation is removed.
Weed control	M	The area has dense infestations of weed species on both creek banks and in surrounding areas that will require removal and control. The process would involve detailed removal of existing weed dominated vegetation; installation of weed matting; planting is recommended for a large proportion this location. Main dominant weed species at this location include: Chinese Tallow, Lantana, Crofton Weed and <i>Crotalaria lunata</i>. Other common weedy species are primarily herbaceous and grass species including Guinea Grass, Cobblers Pegs, Purple Top and Fleabane. Spraying weed dominated grassy areas (away from the stream) with herbicide will likely be necessary.
Revegetation	M-H	Moderate to extensive planting of suitable native species after weed control, should be carried out to help in stabilisation of the upper bank and adjacent areas where a variety of weed species have been removed in addition to areas of dense grassy and herbaceous weeds. Suitable species would include: <i>Lomandra longifolia</i>, <i>Themeda australis</i>, <i>Pratia purpurescens</i>, <i>Cymbopogon refractus</i>, <i>Carex appressa</i>, <i>Gahnia clarkei</i>, <i>Dianella caerulea</i>, <i>Ficus coronata</i>,

		<i>Melaleuca styphelioides</i> , <i>Melaleuca lineariifolia</i> and <i>Glochidion ferdinandi</i> . In adjacent areas <i>Corymbia maculata</i> , <i>Eucalyptus siderophloia</i> , <i>Eucalyptus capitellata</i> , as well as <i>Angophora costata</i> , <i>Angophora floribunda</i> and <i>Eucalyptus piperita</i> . Additional species for revegetation are present in Schedule 1.
Rubbish	L	Rubbish comprises scattered general litter only.

Appendix B Work zone 2 photo assessment points

Point 109



Site Issue	Priority	Works needed
Erosion	H	The section is deeply incised (~1.5 m) but appears quite stable due to the surrounding native vegetation, in particular the trees <i>Corymbia maculata</i> (Spotted Gum). The lower bank and stream bed are considered stable due to the presence of sandstone bedrock. This section may require some woody debris to be implanted into and across the stream bed to help naturally reduce water flow and trap sediment. This in conjunction with other such methods further upstream to reduce flow rates will help stabilise the existing stream banks.
Weed control	M	The area has some minor to moderate infestations of weed species on the upper banks and surrounding areas that will require removal and control. Main weed species at this location include: Crofton Weed, Kikuyu and Buffalo Grass. Other scattered species include Lantana, Small-leaf Privet and Senna. Other herbaceous and grassy weed species are common at this location.
Revegetation	L	Some supplementary planting of suitable native species at this location after weed control has been carried out would be advisable to help in stabilisation of the creek. Suitable species would include: <i>Lomandra longifolia</i>, <i>Carex appressa</i>, <i>Gahnia clarkei</i>, <i>Dianella caerulea</i>, <i>Ficus coronata</i>, <i>Breynia oblongifolia</i>, <i>Melaleuca styphelioides</i>, <i>Melaleuca lineariifolia</i> and <i>Glochidion ferdinandi</i>.
Rubbish	L	Rubbish comprises scattered general litter only.

Point 110



Site Issue	Priority	Works needed
Erosion	H	The section is located on a bend and is deeply eroded and incised (~1.5 to 1.8 m) via bank scour. The internal bend appears to be stable although the external bend is quite unstable with obvious recent erosion of siltstone material and exposed tree roots. This area is likely to erode further without works at this location. The adjacent native vegetation is relatively intact and keeping these areas stable. The extreme lower bank and stream bed are considered stable due to the presence of sandstone bedrock. This section may require some woody debris or rocky structures (e.g. rock armour) to be implanted into and across the stream bed to help naturally reduce water flow and trap sediment. This in conjunction with other such methods further upstream to reduce flow rates will help stabilise the existing stream banks.
Weed control	L	With the exception of the large Pampas Grass clump in the creek bed, weed control is limited to a few small patches of Crofton Weed and Lantana, as well as other common herbaceous and grassy weed species.
Revegetation	M	Some supplementary planting of suitable native species at this location would be warranted after construction of any creek stabilisation structures to help in stabilisation of the creek. Suitable species for in and near stream would include: <i>Lomandra longifolia</i>, <i>Carex appressa</i>, <i>Gahnia clarkei</i>, <i>Dianella caerulea</i>, <i>Ficus coronata</i>, <i>Breynia oblongifolia</i>, <i>Melaleuca styphelioides</i>, <i>Melaleuca lineariifolia</i> and <i>Glochidion ferdinandi</i>. In adjacent areas <i>Corymbia maculata</i>, <i>Eucalyptus siderophloia</i>, as well as <i>Angophora costata</i>, <i>Angophora floribunda</i> and <i>Eucalyptus piperita</i>. Additional species for revegetation are present in Schedule 1.
Rubbish	L	Rubbish comprises scattered general litter only.

Point 111



Site Issue	Priority	Works needed
Erosion	H	The section is located on a bend and is severely eroded and undercut up to 2.5 m via bank scour. Both the internal and external bend appear to be unstable with obvious recent erosion of siltstone material and exposed tree roots. This area is likely to erode further without works at this location. The adjacent native vegetation is relatively intact and keeping these areas stable. The extreme lower bank and stream bed are considered stable due to the presence of larger rocky material and sandstone bedrock. This section may require some woody debris or rocky structures (e.g. rock armour) to be implanted into and across the stream bed to help naturally reduce water flow and trap sediment. This in conjunction with other such methods further upstream to reduce flow rates will help stabilise the existing stream banks.
Weed control	L - M	The area comprises a high density of herbaceous species such as Crofton Weed and Purple Top.
Revegetation	M	Some supplementary planting of suitable native species at this location would be warranted after construction of any creek stabilisation structures to help stabilise the creek. Suitable species for in and near stream would include: <i>Lomandra longifolia</i> , <i>Carex appressa</i> , <i>Gahnia clarkei</i> , <i>Dianella caerulea</i> , <i>Ficus coronata</i> , <i>Breynia oblongifolia</i> , <i>Melaleuca styphelioides</i> , <i>Melaleuca lineariifolia</i> and <i>Glochidion ferdinandi</i> . In adjacent areas <i>Corymbia maculata</i> , <i>Eucalyptus siderophloia</i> , as well as <i>Angophora costata</i> , <i>Angophora floribunda</i> and <i>Eucalyptus piperita</i> . Additional species for revegetation are present in Schedule 1.
Rubbish	L	Rubbish comprises primarily scattered general litter only and a few bulky items (e.g. vehicle tyres)

Point 112



Site Issue	Priority	Works needed
Erosion	H	The section is located on a bend and is severely eroded and undercut up to 3 m via bank scour and evidence of some slumping. Both the internal and external bend appear to be unstable with obvious recent erosion of siltstone material and exposed tree roots. This area is likely to erode further without works at this location. The adjacent native vegetation is relatively intact and keeping these areas stable. The extreme lower bank and stream bed are considered stable due to the presence of larger rocky material and sandstone bedrock. This section will require some woody debris or rocky structures (e.g. rock armour) to be implanted into and across the stream bed to help naturally reduce water flow and trap sediment. This in conjunction with other such methods further upstream to reduce flow rates will help stabilise the existing stream banks. Bank stabilisation may also require the use of jute or other erosion control matting as well as installation of coir logs or similar.
Weed control	L - M	The area comprises a high density of herbaceous species including as Crofton Weed, various grasses and Purple Top. Woody weeds such as Lantana and <i>Crotalaria lunata</i> are also present as scattered clumps or individuals.
Revegetation	M	Some supplementary planting of suitable native species at this location would be warranted after construction of any creek stabilisation structures to help stabilise the creek. Suitable species for in and near stream would include: <i>Lomandra longifolia</i>, <i>Carex appressa</i>, <i>Gahnia clarkei</i>, <i>Dianella caerulea</i>, <i>Ficus coronata</i>, <i>Breynia oblongifolia</i>, <i>Melaleuca styphelioides</i>, <i>Melaleuca lineariifolia</i> and <i>Glochidion ferdinandi</i>. In adjacent areas <i>Corymbia maculata</i>, <i>Eucalyptus siderophloia</i>, as well as <i>Angophora costata</i>, <i>Angophora floribunda</i> and <i>Eucalyptus piperita</i>. Additional species

		for revegetation are present in Schedule 1.
Rubbish	L	Rubbish comprises primarily scattered general litter only and a few bulky items (e.g. shopping trolley, vehicle tyres)

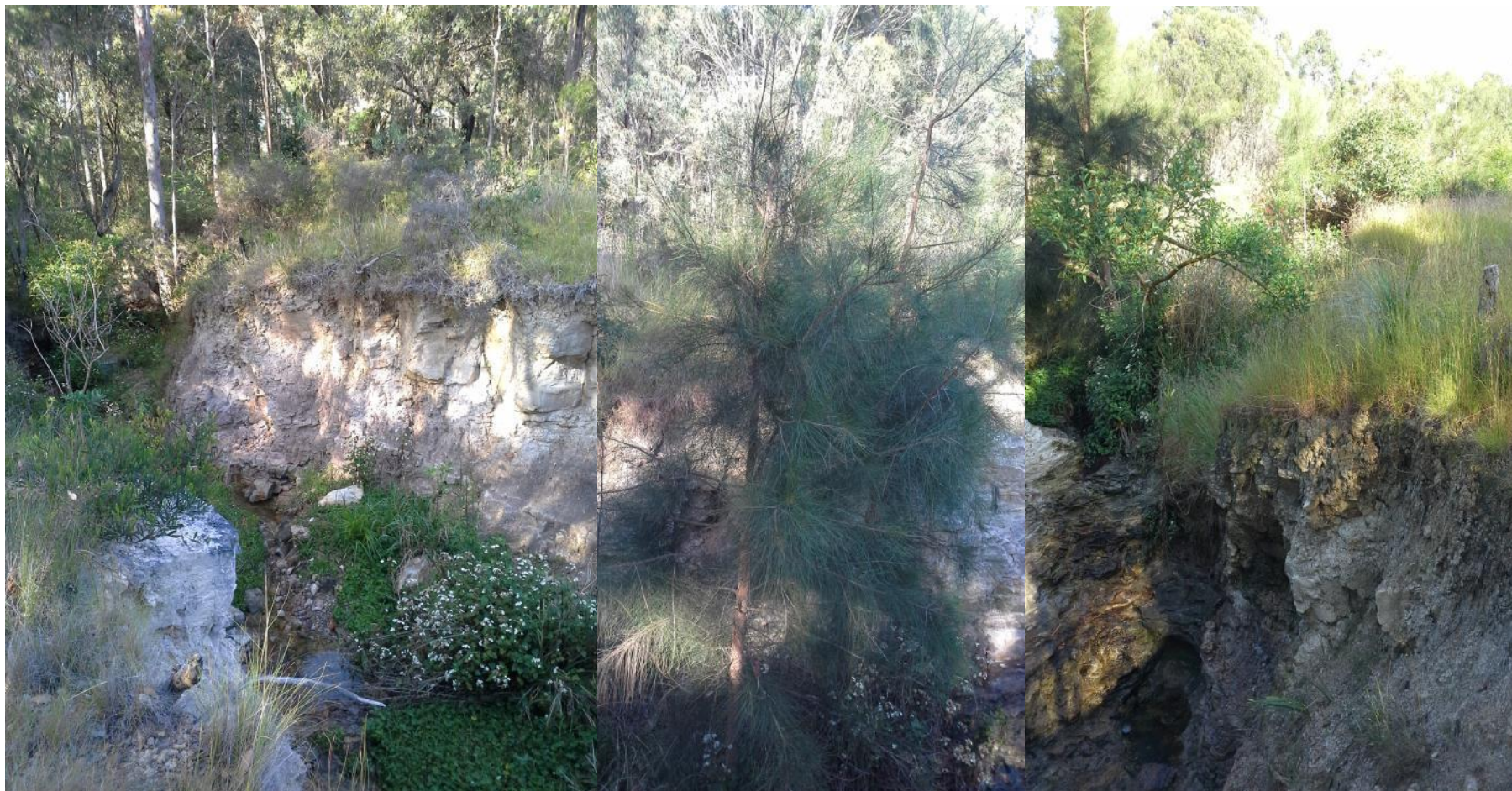
Point 112 (cont.)

Point 113



Site Issue	Priority	Works needed
Erosion	H	This section consists of the most severe erosion along the creek with undercutting of exposed banks up to 4.5 m high. Bank scour and slumping is evident. Both the internal and external bend appear to be unstable with obvious recent erosion of siltstone material and exposed tree roots. This area is likely to erode further without works at this location. The adjacent native vegetation is relatively intact and keeping these areas stable. The extreme lower bank and stream bed are considered stable due to the presence of larger rocky material and sandstone bedrock. This area will require significant work to stabilise the section, including the potential creation of a retention basin, rock wall armour, gabion installation, woody debris or rocky structures be implanted into and across the stream bed or a combination. This in conjunction with other such methods further upstream to reduce flow rates will help stabilise the existing stream banks. Bank stabilisation will also require the use of jute or other erosion control matting as well as installation of coir logs or similar.
Weed control	L - M	The area is highly scoured and has large sections of exposed earth and as such has limited weed cover, although some aggregations of herbaceous species including as Crofton Weed, various grasses and Purple Top are present.
Revegetation	M - H	Supplementary planting of suitable native species at this location will be required after construction of any creek and bank stabilisation structures. Suitable species for in and near stream would include: <i>Lomandra longifolia</i>, <i>Carex appressa</i>, <i>Gahnia clarkei</i>, <i>Dianella caerulea</i>, <i>Ficus coronata</i>, <i>Breynia oblongifolia</i>, <i>Melaleuca styphelioides</i>, <i>Melaleuca lineariifolia</i> and <i>Glochidion ferdinandi</i>. In adjacent areas <i>Corymbia maculata</i>, <i>Eucalyptus siderophloia</i>, as well as <i>Angophora costata</i>, <i>Angophora floribunda</i> and <i>Eucalyptus piperita</i>. Additional species for revegetation are present in Schedule 1.

Rubbish	L	Rubbish comprises primarily scattered general litter only
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Point 113 (cont.)

Appendix C Work zone 3 photo assessment points

Point 103 - Southern exit point for the watercourse



Site Issue	Priority	Works needed
Erosion	M	Very minor at this location. There is a constructed rock reinforced stream bank section which extends for approximately 3 m in this location upstream from the Pacific Highway drainage culvert. The rock reinforcement will need to be maintained and will likely need additional / extra rock material.
Weed control	H	The area is covered extensively with weed species and will require removal and control. Main weed species at this location include: Lantana, Crofton Weed, Purple Top, Small-leaf Privet, Wild Watsonia, Senna and Spear Thistle. Other herbaceous and grassy weed species are common at this location.
Revegetation	M	Some supplementary planting of suitable native species at this location after weed control has been carried out would be advisable to help in stabilisation of the creek. Suitable species would include: <i>Lomandra longifolia</i> , <i>Carex appressa</i> , <i>Gahnia clarkei</i> , <i>Dianella caerulea</i> , <i>Ficus coronata</i> , <i>Breynia oblongifolia</i> , <i>Melaleuca styphelioides</i> , <i>Melaleuca lineariifolia</i> and <i>Glochidion ferdinandi</i> .
Rubbish	L	Rubbish comprises scattered general litter only.

Point 104



Site Issue	Priority	Works needed
Erosion	L	Very minor at this location. No works are anticipated at this time
Weed control	H	The area is covered extensively with weed species and will require removal and control. Main weed species at this location include: Lantana, Crofton Weed, Small-leaf Privet and Senna. Other herbaceous and grassy weed species are moderately common at this location.
Revegetation	L	Not necessary at this location.
Rubbish	L	Rubbish comprises scattered general litter only.

Point 105



Site Issue	Priority	Works needed
Erosion	L	Minor at this location. No works are anticipated at this time. Existing logs and debris to be retained.
Weed control	H	The area is covered extensively with weed species and will require removal and control. Main weed species at this location include: Mulberry, Small-leaf Privet, Lantana, Crofton Weed and Senna. Other herbaceous weed species are moderately common at this location. Introduced grasses are common and dense on the southern bank at this location, particularly Guinea Grass, Rye Grass and Buffalo Grass.
Revegetation	L	Not necessary at this location.
Rubbish	M	Rubbish comprises a combination of scattered general litter, but also contains larger items such as a shopping trolley and road barriers.

Point 106



Site Issue	Priority	Works needed
Erosion	L	The section of creek bank is relatively stable at this location due to the presence of large in-stream debris (i.e. large log) and the presence of a semi-permanent pool.
Weed control	H	The area is covered extensively with weed species and will require their removal and control. Main weed species at this location include woody species to the north such as Lantana, Senna and Small-leaf Privet. On the southern bank primarily herbaceous weed species are present such as Wild Watsonia, Purple Top, Spear Thistle and Crofton Weed, Other herbaceous and grassy weed species are also common at this location.
Revegetation	L	Supplementary planting is not considered as being necessary. Although some planting may be considered once weed control is completed if warranted, to ensure bank stabilisation.
Rubbish	L	Rubbish comprises scattered general litter only.

Point 107



Site Issue	Priority	Works needed
Erosion	L	The section of creek bank is relatively stable at this location.
Weed control	H	The area is covered extensively with weed species and will require their removal and control. Main weed species at this location include woody species such as Lantana, Senna and Small-leaf Privet. Additional weed species such as Crofton Weed are particularly common at this location. Other herbaceous and grassy weed species are also moderately common at this location.
Revegetation	M	Supplementary planting is not considered as being necessary. Although some planting may be considered once weed control is completed if warranted, to ensure bank stabilisation.
Rubbish	L	Rubbish comprises scattered general litter only.

Point 108 – small tributary watercourses to the west



Site Issue	Priority	Works needed
Erosion	L	This tributary section is stable and will not require any erosion control works.
Weed control	M - H	The area has a low coverage of scattered weeds that will require removal. The most common weeds are individuals or clumps of Pampas Grass and Lantana.
Revegetation	M	Supplementary planting is not considered as being necessary.
Rubbish	L	No rubbish present at time of inspection

Appendix D Schedule 1 Plant species recommended for on-site revegetation purposes.

Schedule 1: Windale plant species for creek and adjacent area revegetation			
Family	Species	Common name	Planting location
APOCYNACEAE	<i>Parsonsia straminea</i>	Common Silkpod	M / U
BIGNONIACEAE	<i>Pandorea pandorana</i>	Wonga Wonga Vine	U
CASUARINACEAE	<i>Allocasuarina littoralis</i>	Black She-oak	U
	<i>Casuarina glauca</i>	Swamp Oak	L / M
CYPERACEAE	<i>Carex appressa</i>	Carex	L / M
	<i>Gahnia sieberiana</i>	Saw Sedge	L / M
DILLENIACEAE	<i>Hibbertia scandens</i>	Golden Guinea Flower	M / U
FABACEAE – FABOIDEAE	<i>Bossiaea stephensonii</i>	-	U
	<i>Hardenbergia violacea</i>	False Sarsaparilla	M / U
	<i>Kennedia rubicunda</i>	Dusky Coral Pea	M / U
	<i>Mirbelia rubioides</i>	-	U
	<i>Pultenaea villosa</i>	Bush Pea	M / U
FABACEAE – MIMOSOIDEAE	<i>Acacia irrorata</i> subsp. <i>irrorata</i>	Green Wattle	M / U
	<i>Acacia longifolia</i>	Sydney Golden Wattle	M / U
	<i>Acacia myrtifolia</i>		U
GOODENIACEAE	<i>Goodenia ovata</i>	Hop-leaved Goodenia	L / M
LOMANDRACEAE	<i>Lomandra longifolia</i>	Spiny-headed Mat-rush	L / M / U
MORACEAE	<i>Ficus coronata</i>	Sandpaper Fig	L / M
MYRTACEAE	<i>Angophora costata</i>	Smooth-barked Apple	U
	<i>Angophora floribunda</i>	Rough-barked Apple	M / U
	<i>Callistemon salignus</i>	Willow Bottlebrush	L / M

Schedule 1: Windale plant species for creek and adjacent area revegetation			
Family	Species	Common name	Planting location
	<i>Corymbia maculata</i>	Spotted Gum	U
	<i>Eucalyptus acmenoides</i>	White Mahogany	U
	<i>Eucalyptus capitellata</i>	Brown Stringybark	U
	<i>Eucalyptus piperita</i>	Sydney Peppermint	U
	<i>Eucalyptus siderophloia</i>	Grey Ironbark	U
	<i>Leptospermum polygalifolium</i>	Tantoon	M / U
	<i>Leptospermum trinervium</i>	Paperbark Tea Tree	U
	<i>Melaleuca linariifolia</i>	Snow-in-summer	L / M / U
	<i>Melaleuca nodosa</i>	Prickly-leaved Paperbark	M / U
	<i>Melaleuca sieberi</i>	Sieber's Paperbark	L / M
	<i>Melaleuca styphelioides</i>	Prickly-leaved Tea Tree	L / M
PHORMIACEAE	<i>Dianella caerulea</i>	Blue Flax-lily	L / M / U
PHYLLANTHACEAE	<i>Breynia oblongifolia</i>	Coffee Bush	M / U
	<i>Glochidion ferdinandi</i>	Cheese Tree	M / U
POACEAE	<i>Cymbopogon refractus</i>	Barbed Wire Grass	U
	<i>Entolasia marginata</i>	Margined Panic	M / U
	<i>Entolasia stricta</i>	Wiry Panic	U
	<i>Microlaena stipoides</i> var. <i>stipoides</i>	Weeping Grass	M / U
	<i>Poa labillardierei</i>	Tussock Grass	M / U
	<i>Themeda australis</i>	Kangaroo Grass	M / U
SAPINDACEAE	<i>Dodonaea triquetra</i>	Large-leaved Hopbush	M / U
SMILACEAE	<i>Smilax australis</i>	Smilax	M / U

Key for planting location: L – lower bank / in-stream; M – Mid-bank; U – upper-bank and adjacent areas.

Note: Where applicable, revegetation species should be chosen in line with the species for each of the two identified vegetation communities from site.

**HEAD OFFICE**

Suite 4, Level 1
2-4 Merton Street
Sutherland NSW 2232
T 02 8536 8600
F 02 9542 5622

CANBERRA

Level 2
11 London Circuit
Canberra ACT 2601
T 02 6103 0145
F 02 6103 0148

COFFS HARBOUR

35 Orlando Street
Coffs Harbour Jetty NSW 2450
T 02 6651 5484
F 02 6651 6890

PERTH

Suite 1 & 2
49 Ord Street
West Perth WA 6005
T 08 9227 1070
F 08 9322 1358

DARWIN

16/56 Marina Boulevard
Cullen Bay NT 0820
T 08 8989 5601
F 08 8941 1220

SYDNEY

Level 6
299 Sussex Street
Sydney NSW 2000
T 02 8536 8650
F 02 9264 0717

NEWCASTLE

Suites 28 & 29, Level 7
19 Bolton Street
Newcastle NSW 2300
T 02 4910 0125
F 02 4910 0126

ARMIDALE

92 Taylor Street
Armidale NSW 2350
T 02 8081 2681
F 02 6772 1279

WOLLONGONG

Suite 204, Level 2
62 Moore Street
Austinmer NSW 2515
T 02 4201 2200
F 02 4268 4361

BRISBANE

Suite 1 Level 3
471 Adelaide Street
Brisbane QLD 4000
T 07 3503 7191
F 07 3854 0310

ST GEORGES BASIN

8/128 Island Point Road
St Georges Basin NSW 2540
T 02 4443 5555
F 02 4443 6655

NAROOMA

5/20 Canty Street
Narooma NSW 2546
T 02 4476 1151
F 02 4476 1161

MUDGEES

Unit 1, Level 1
79 Market Street
Mudgee NSW 2850
T 02 4302 1230
F 02 6372 9230

GOSFORD

Suite 5, Baker One
1-5 Baker Street
Gosford NSW 2250
T 02 4302 1220
F 02 4322 2897

1300 646 131
www.ecoaus.com.au