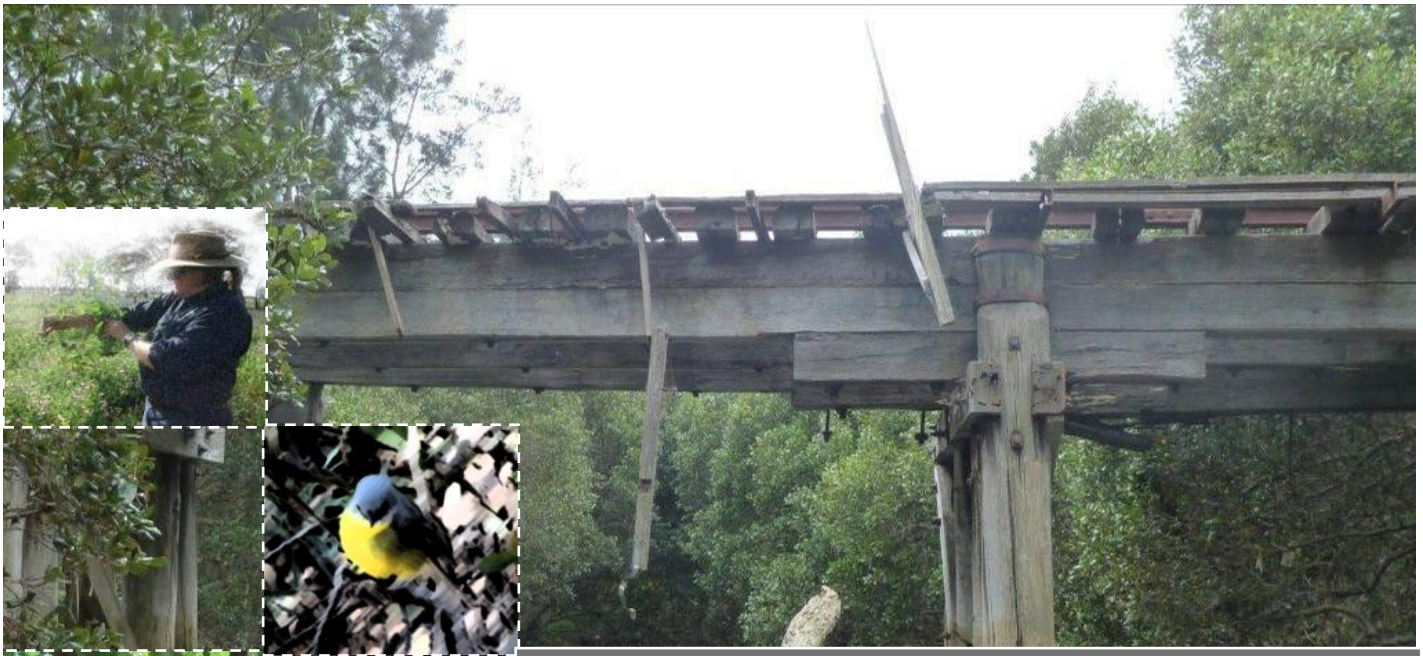

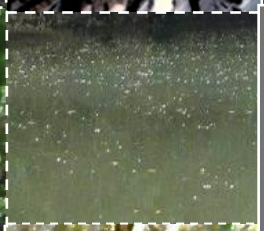

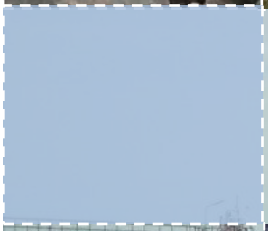

WATERWAYS MAINTENANCE AND REHABILITATION MASTERPLAN FOR THE DUCK RIVER CATCHMENT

Prepared for Parramatta City Council

By Applied Ecology Pty Ltd

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PARRAMATTA CITY COUNCIL

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A VISION FOR THE CATCHMENT

CONSULTATION FRAMEWORK

A range of stakeholders were consulted during the preparation of this Plan of Management. Representation was sought from local government, special interest groups, residents and the broader community. Around 350 people were invited to a public meeting as part of the plan development process. They were provided with alternatives for lodging comments and suggestions through online portals on Parramatta Councils' website, via email or mail.

Around 35 people attended the meeting, and participated in a vigorous brainstorming session. Many of the participants indicated that they had not previously taken the opportunity to be involved in the community consultative process, despite a number of these being held over the last 10 or 15 years. The issues discussed, opportunities identified, and desired outcomes identified are presented in detail in Appendix One, along with responses to a community survey questionnaire.

This was used to inform the development of the Vision for Duck River Catchment, below.

DEFINING THE VISION

Feedback from stakeholders was used to guide preparation of the Masterplan, particularly identifying the actions and their priorities. All of the suggestions were considered during the formulation of the Masterplan, and most were directly incorporated. Key findings from the community survey and consultation process are listed below:

- Need to reserve some areas specifically for nature conservation, with restricted access.
- A need was identified to conserve, maintain and improve the integrity of natural bushland.
- Strategies for managing the huge volume of rubbish in the catchment were discussed, and solutions included public education through specific programs in schools, for local businesses, cultural groups with non-English speaking backgrounds, and appointment of council rangers to specifically target littering and dumping of rubbish
- Manage water pollution including impacts from development and surrounding land use activities; better management of sediment traps and SQIDs
- The need for coordination between Auburn and Parramatta councils was highlighted; also the need to liaise with Bankstown Council to manage inputs from higher in the catchment.
- Programs to involve the local community more in the natural resources of the Upper Duck River Wetlands, increasing awareness of the assets and problems of the catchment through information brochures, signage, guided walks, schools programs, "Adopt a Reach" programs for local factories and corporate identities.
- Need for appropriate development controls to conserve the natural assets of Upper Duck River throughout ongoing urban development and population expansion in the area, including WSUD, BASIX, maintaining setbacks, buffer trees in the urban footprint

This formed the basis of the Vision for Duck River Catchment.

THE VISION FOR DUCK RIVER

A VISION FOR DUCK RIVER CATCHMENT

"is to improve the ecological health and value of the riparian corridor and wetlands ecosystems,

while enhancing a healthy, diverse and productive environment; and

ensuring that landuses within the catchment are developed and managed effectively for conservation of the natural environment and cultural heritage,

for all of its users, now and into the future."

OBJECTIVES OF THE MASTERPLAN

The current condition of significant parts of the Duck River catchment is highly degraded, requiring significant resources of funding and time to achieve good ecological outcomes, in line with the Vision Statement. In recognition of this, the Masterplan proposes that rehabilitation be implemented progressively over a reasonable period time - five to ten years is recommended. The objectives are:

- Protect threatened species
- Rehabilitate endangered ecological communities and improve connectivity
- Improve water quality
- Stabilise sites of geomorphic degradation (bed or bank erosion)
- Protect known Aboriginal and European heritage items, and identify and record new ones
- Improve recreational facilities such as walking trails, rest areas, play areas and signage
- Increase community involvement in environmental management of the corridor, including offering opportunities for learning, and places to develop a connection with the natural environment
- Improve the connections between the Parramatta side of the river and the Auburn side
- Investigate, and if necessary, remediate contaminated land
- Repair important civil structural assets (e.g. stormwater, sewer and weir)
- Ensure all new development has appropriate environmental controls to minimise impact on the receiving ecosystem health

REACH APPORTIONMENT

Streams were divided into reaches based broadly on the method described by Rutherford et al (1999) in the Australian Streambank Rehabilitation Manual, and adapted from "A rapid riparian assessment tool for local council urban creek assessment: Ku-ring-gai Council, Sydney, NSW", (MP Taylor, S Findlay, A Fletcher, 2004. Fourth Australian Stream Management Conference, Launceston, 2004). Determination of reaches was conducted using the following steps:

1. **Division of longitudinal continuity:** Individual reaches are identified as being longitudinally bounded by a confluence or termination of the stream (including entry and exit from pipes).
2. **Division of different land use:** Changes in land use between bushland, urban areas and sporting fields/parks are used to further sub-divide the reaches. Land surface composition, in particular, area of impervious surfaces can greatly impact the quality and quantity of stormwater and thus affects stream condition.
3. **Division by buffer width:** For bushland and parkland stretches, the reaches are further divided according to width of riparian buffer (distance of vegetated zone before urban development). A substantive riparian buffer is in effect a "biophysical highway;" it provides effective filtration by trapping sediments and nutrients, attenuates flood impacts and provides habitat and wildlife corridors. The width of the riparian zone determines biophysical and ecological effectiveness and stream characteristics, an important factor to consider when defining representative reaches. Narrow corridors have greater relative 'edge effects' compared to larger buffers and these effects impact on their effectiveness as a refuge and a filter.

A total of 28 reaches were identified in the catchment, and are examined later in this report.

SHARED MANAGEMENT REACHES

A number of reaches have limited management recommendations because of existing management arrangements, or private ownership, including Sydney Water owned/managed concrete lined drains:

- A'BECKETTS CREEK 1
- DUCK CREEK 1
- DUCK CREEK 2
- DUCK CREEK 2A
- DUCK CREEK 3
- DUCK CREEK 4
- LITTLE DUCK CREEK 3
- LITTLE DUCK CREEK 4
- UNNAMED 4 A'BECKETTS ST
- UNNAMED 8 GUILDFORD RD

Other reaches that have private ownership of riparian lands include:

- DUCK RIVER 8
- DUCK CREEK 5
- SMALLS CREEK 1
- UNNAMED 7 BANKSIA ST

DEVELOPMENT OF A REHABILITATION WORKS PLAN

INTERPRETING THE CURRENT CONDITION OF THE CATCHMENT

A series of condition scores are provided to develop an overall understanding of the ecosystem health for that section of the catchment (Table 1). Each component of the overall condition is scored as indicated, with a maximum possible total of 26 for a reach. Contributing factors to these scores are explained in Table 1.

Table 1. Reach condition scores and how they are calculated

SCORE	CALCULATED FROM
GEOMORPHIC CONDITION (/5)	Geomorphology: score /2.5, deductions for overall extent of modification, erosion, sediment deposition Hydrology: score /2.5, deductions for modifications (eg. weirs, channelized, etc), storm damage, storm debris **Condition score = Geomorphology score + Hydrology score**
RIPARIAN VEGETATION (/5)	**Vegetation score = (Percent riparian vegetation cover) x (percent native species) x 5** eg. (70% cover x 60% native) x 5 = score of 2.1
INSTREAM HABITAT (/10)	Wetlands: score /4 for overall extent and condition of wetlands Habitat: score /4 with points added for complexity and extent of habitat elements present (see Table 18) Fish passage: score /2, deductions for barriers such as weirs, or partial barriers to passage eg. stepping stones weir **Habitat score = Wetlands score + Habitat score + Fish passage score**
SENSITIVITY (/6)	Endangered Ecological Communities: score 1 for each EEC present Threatened Species: score 1 for a species present Indigenous heritage: score 1 for an item present European heritage: score 1 for an item present **Sensitivity score = EEC score + TS score + Indigenous heritage score + European heritage score**
OVERALL SCORE	Overall score = sum of individual scores Maximum possible = 26

The overall score gives a useful ranking of stream condition. In general, higher ranked reaches should be worked first. Primary management objectives are determined from the individual condition scores (Table 2). This reflects the key values for that reach, and underpins targeted management objectives and actions.

A good hydro-geomorphology score is ≥ 3; a good riparian vegetation condition score is ≥ 2.5; a good instream habitat score is > 7; and a high sensitivity score is ≥ 5. Reaches that score in any of these ranges for condition categories need to be managed to maintain and improve these assets. Reaches that do not score in these ranges need to be managed to protect aspects of the downstream environment. In some cases, it is recommended that rehabilitation works target habitat creation or improvement, particularly in areas that have a direct impact on good habitat downstream.

Overall scores recorded ranged from 1.7 (A'Becketts Creek 2) to 22.2 (Duck River 8), providing an indication of the variation in condition of different reaches in the catchment.

Table 2. Individual scores, overall score and priority category for Duck River reaches

REACH NAME	HYDRO-GEOMORPHOLOGY SCORE	RIPARIAN VEGETATION SCORE	INSTREAM HABITAT SCORE	SENSITIVITY SCORE	OVERALL CONDITION SCORE	PRIMARY MANAGEMENT OBJECTIVE(S)
A'BECKETTS CREEK 1	1.5	0.5	1	0	3.0	REDUCE DOWNSTREAM IMPACTS
A'BECKETTS CREEK 2	0.5	0.1875	1	0	1.7	IMPROVE ESTUARY HEALTH
DUCK CREEK 1	1.5	0.0625	1	1	3.6	REDUCE DOWNSTREAM IMPACTS
DUCK CREEK 2	1.5	0.65	1	2	5.2	REDUCE DOWNSTREAM IMPACTS
DUCK CREEK 2a	1.5	0.225	1	0	2.7	REDUCE DOWNSTREAM IMPACTS
DUCK CREEK 3	1	0.4	1	0	2.4	REDUCE DOWNSTREAM IMPACTS
DUCK CREEK 4	1.5	2.1	6	0	9.6	REDUCE DOWNSTREAM IMPACTS
DUCK CREEK 5	4	3.6	7	3	17.6	IMPROVE ESTUARY HEALTH
DUCK RIVER 1A	2.5	1.75	5.2	4	13.5	PROTECT DOWNSTREAM HABITAT
DUCK RIVER 1B	3.5	2.75	5.8	2	14.1	GOOD RIPARIAN HABITAT, GOOD HYDROGEOMORPHOLOGY
DUCK RIVER 2A	2.5	2	7.2	2	13.7	GOOD INSTREAM HABITAT
DUCK RIVER 2B	3	2.6	7.3	6	18.9	HIGH SENSITIVITY, GOOD RIPARIAN HABITAT
DUCK RIVER 3A	4	1.1	7.5	3	15.6	GOOD INSTREAM HABITAT

REACH NAME	HYDRO-GEOMORPHOLOGY SCORE	RIPARIAN VEGETATION SCORE	INSTREAM HABITAT SCORE	SENSITIVITY SCORE	OVERALL CONDITION SCORE	PRIMARY MANAGEMENT OBJECTIVE(S)
DUCK RIVER 3B	4	1.25	7.4	3	15.7	GOOD INSTREAM HABITAT
DUCK RIVER 4A	3	0.75	6	4	13.8	GOOD HYDROGEOMORPHOLOGY
DUCK RIVER 4B	3.5	1.1	7.8	4	16.4	GOOD INSTREAM HABITAT, GOOD HYDROGEOMORPHOLOGY
DUCK RIVER 5A	3.3	1	7.5	4	15.8	GOOD INSTREAM HABITAT, GOOD HYDROGEOMORPHOLOGY
DUCK RIVER 5B	2.5	0.4875	7.8	6	16.8	HIGH SENSITIVITY, GOOD INSTREAM HABITAT
DUCK RIVER 6	3	1.125	7.8	5	16.9	HIGH SENSITIVITY, IMPROVE ESTUARY HEALTH
DUCK RIVER 7	4	2.4375	7.5	4	17.9	IMPROVE ESTUARY HEALTH
DUCK RIVER 8	4.8	3.4	8	6	22.2	HIGH SENSITIVITY, IMPROVE ESTUARY HEALTH
LITTLE DUCK CREEK 1A	3.5	2.475	3.5	0	9.5	GOOD HYDROGEOMORPHOLOGY, POTENTIAL HABITAT EXPANSION
LITTLE DUCK CREEK 1B	2.5	0.225	2	0	4.7	POTENTIAL HABITAT EXPANSION
LITTLE DUCK CREEK 2	2	1.35	3	1	7.4	POTENTIAL HABITAT EXPANSION
LITTLE DUCK CREEK 3	1.5	0.1	1	0	2.6	REDUCE DOWNSTREAM IMPACTS

REACH NAME	HYDRO-GEOMORPHOLOGY SCORE	RIPARIAN VEGETATION SCORE	INSTREAM HABITAT SCORE	SENSITIVITY SCORE	OVERALL CONDITION SCORE	PRIMARY MANAGEMENT OBJECTIVE(S)
LITTLE DUCK CREEK 4	1.5	0.75	1	2	5.3	REDUCE DOWNSTREAM IMPACTS
SMALLS CREEK 1	3.8	2.925	4	5	15.7	HIGH SENSITIVITY, GOOD RIPARIAN HABITAT
SMALLS CREEK 2	2.5	4.75	6	4	17.3	GOOD RIPARIAN HABITAT
UNNAMED 1A WADDANGALI	4	4.25	2	4	14.3	GOOD RIPARIAN HABITAT
UNNAMED 1B CAMPBELL HILL	3	3	6	4	16.0	GOOD RIPARIAN HABITAT
UNNAMED 2A RANDOLPH ST	3.5	1.6875	3	1	9.2	GOOD HYDROGEOMORPHOLOGY
UNNAMED 2B CHISWICK RD	3.5	1.75	5.5	2	12.8	GOOD HYDROGEOMORPHOLOGY
UNNAMED 3 BENNETT RD	3	3.325	7	3	16.3	GOOD RIPARIAN HABITAT, GOOD HYDROGEOMORPHOLOGY
UNNAMED 4 A'BECKETTS ST	1.5	1	1	0	3.5	REDUCE DOWNSTREAM IMPACTS
UNNAMED 5 DIXMUDE ST	3	3.5	2	1	9.5	GOOD RIPARIAN HABITAT
UNNAMED 6 MONS	2.5	2.1375	3	1	8.6	PROTECT DOWNSTREAM HABITAT

REACH NAME	HYDRO-GEOMORPHOLOGY SCORE	RIPARIAN VEGETATION SCORE	INSTREAM HABITAT SCORE	SENSITIVITY SCORE	OVERALL CONDITION SCORE	PRIMARY MANAGEMENT OBJECTIVE(S)
ST						
UNNAMED 7 BANKSIA ST	2.5	0.4	5	2	9.9	PROTECT DOWNSTREAM HABITAT
UNNAMED 8 GUILDFORD RD	1.5	0.1	1	0	2.6	REDUCE DOWNSTREAM IMPACTS
UNNAMED 9 WELLINGTON RD	4	3.5	2	5	14.5	HIGH SENSITIVITY, GOOD RIPARIAN HABITAT

DEVELOPMENT OF A PRIORITISED REHABILITATION PLAN

The prioritisation process

A prioritisation process should aim to

1) maintain and protect areas in good condition, or with specific important assets
2) maintain and improve areas in fair condition
3) reduce the impacts from areas in poor condition

Some broad rules for the prioritisation process are:

- **Rarity** (rare reaches have higher priority than common) and other High Conservation Value criteria
- **General condition** based on assessment of assets and problems (reaches in good condition are easier to fix than those in bad condition)
- **Trajectory** (deteriorating reaches should at least be stabilised before improving reaches that are improving on their own accord)*
- **Ease** (reaches that are easy to improve, before those that are hard)

(* Note: trajectory will also be affected by the condition of reaches immediately upstream)

A combination of field survey data and results from desktop surveys was used to inform decisions about the prioritisation process (Table 3).

Table 3. Deciding which works to do first for restoration activities

RANKING CRITERIA	SURVEY COMPONENT(S)
Rarity	• Threatened species present • EECs present • Migratory species present • Cultural heritage items present
General condition	Determined from the overall score (see previous section and site context drawing sheets)
Trajectory	Stream condition can be improving, remaining stable, or deteriorating. The reach trajectory summarises its probable pathway based on current condition and types of impacts currently operating in that reach. The trajectory was determined for the reach's ecological attributes (including riparian vegetation and instream habitat) and its hydrologic and geomorphic condition (based on presence of erosion, sediment deposition, deposition of storm debris).
Ease	Determined from additional data, including: • "good streams" are easier to fix than "bad streams" • Land tenure (public land is "easier" than private) • Presence of bushcare group (community support for ongoing works) • Accessibility, eg. for machinery for capital works

Identified works were then classified into works categories, based on the size and frequency of the activity, and this was also used to inform the works plans.

Works category

Proposed works fall into one, or occasionally more, of the following categories, depending on the size and frequency of the activity:

a) **Ongoing maintenance:** includes works that require repeating activities over time, such as regular mowing to reduce weed seed sources, monitoring programs, or other regular maintenance activities.
b) **Preservation requirements:** includes works that aim to prevent deterioration of existing assets, such as regular weeding in good bushland to retain its overall good health.
c) **Restoration works:** includes works that aim to improve the overall condition of an area or asset, such as primary weed control, carp control and other feral animal control activities.
d) **Minor capital works:** includes works with a budget <$20K, that provide minor additional infrastructure to improve the overall amenity or condition of the catchment, such as footpaths, seating, signage, minor bank stabilisation activities and small GPTs.
e) **Major capital works:** includes works with a budget >$20K, that provide major additional infrastructure to improve the overall amenity or condition of the catchment, such as major bank stabilisation works, trash racks, and pedestrian footbridges.

Works plans

A complete list of actions is provided in the following tables. Actions are grouped according to their management objective:

- **Biodiversity enhancement** actions aim to improve the overall health of the wetlands and riparian zones by removing or reducing a problem, or improving or expanding an asset
- **Water quality improvement** actions aim to improve the overall health of the wetlands by removing or reducing a problem
- **Erosion control** actions aim to improve the overall condition of riparian zones by stabilising channel banks and beds, and to improve the health of the aquatic environment by reducing the amount of sediment mobilised
- **Community and recreation** actions aim to improve the overall amenity of the wetlands and riparian corridor to encourage positive interactions that increase general awareness of the importance of the Upper Duck River wetlands and riparian corridor

Highest priority has been allocated to protecting, maintaining and restoring areas of high ecological and/or geomorphic resilience. The timetable for implementation is as follows:

- **Urgent priority** to be implemented as soon as possible
- **High priority** to be implemented within three years
- **Medium priority** to be implemented within six years
- **Low priority** to be implemented within ten years
- **Ongoing maintenance** refers to actions that are to be carried out for the duration of the Masterplan

Primary responsibility for implementation of the actions provided in the Masterplan falls to Parramatta City Council.

REHABILITATION WORKS AND ACTIVITIES

TYPES OF WORK

The following table provides a brief outline of the aims of activities that are recommended for restoration and management works (Table 4).

Table 4. A brief outline of the aims and activities included in recommended works

MASTERPLAN WORKS/ACTIVITY	BRIEF DESCRIPTION
Bush regeneration weed control	Removal of weeds in predominantly healthy bushland; also refers to follow-up weeding
Primary weed control of vines	Weed control targeting vines for eradication
Primary weed control	First cut weed control, often targeting woody weeds and noxious weeds; needs to have follow up weed control activities
Local provenance plant propagation	Cultivation of plants for revegetation using seed or propagules derived from local native species where possible
Infill planting for diversity	Supplementary planting for depauperate ecosystems – aims to provide increased habitat resources through increased plant diversity; species should be selected to improve vegetation structure and provide flowering and fruiting throughout the year
Planting for stabilisation	Supplementary planting using specifically selecting deep rooted, fast establishing species for planting in areas susceptible to erosion
Revegetation planting	Higher density supplementary planting to replace weeds that have been removed; select plant species that replicate original vegetation structure, improve habitat resources, maintain bank stability
Riparian buffer expansion planting	Preliminary plantings should be canopy species as these are slowest to establish, and Acacias to improve soil health
Plant fringing vegetation	Aims to provide a vegetative “shield” for sensitive vegetation through establishment of shrub and canopy species
Install jute matting with stabilisation planting	Soft engineering solutions to minor/localised erosion issues, and may include the use of jute matting, jute mesh, coir logs, or sandbags
Control/remove introduced ducks and geese	Aims to reduce impacts from utilisation of habitat resources, and pollution of waterways through defecation

MASTERPLAN WORKS/ACTIVITY	BRIEF DESCRIPTION
Control carp populations	Aims to reduce impacts on water quality and streambank erosion through agitation of sediments by bottom feeding behaviours, reduce competition with native fish species for food and habitat resources
Install end of pipe litter control device	Aims to reduce the volume of litter transported via Duck River in smaller channels at piped outflows
Install trash rack, trap or similar litter control device	Aims to reduce the volume of litter transported via Duck River in larger and smaller open channels
Install sediment trap/basin	Aims to reduce the volume of fine particulate pollution transported via Duck River in smaller channels
Install instream vegetated wetland or bioretention system	Aims to reduce the concentration of nutrients and fine sediments to improve water quality in the receiving environment; generally constructed offline or with a high flow bypass to protect the integrity of the system in peak flow events
Maintain mesh trash traps regularly; prepare and implement an Operations and Maintenance Plan	Aims to ensure ongoing correct functioning of gross pollutant control devices
Remove litter and debris from fringing reeds; consider installation of floating trash trap	Aims for an initial reduction in the volume of storm debris in reedland areas, and proposes an ongoing solution that should be implemented if installation of nets, traps and racks higher in the catchment fail to effectively control the pollutant load
Remove sediment plug and other rubbish/storm debris	Aims to provide an immediate solution to sediment and pollutant loading in a smaller channel; if regular maintenance of traps downstream fails to control future loads then ongoing cleaning will be necessary, and consideration should be given to relocating the traps
Water quality monitoring point	Aims to collect data that will help identify high pollution generating sub-catchments through a process of community involvement)
Toe protection works	eg. root wads, rock lining: aims to control erosion in areas where bank erosion is linked to toe erosion
Bank stabilisation works	eg. terracing, rebattering, geotextile lining, rock lining, retaining wall construction: aims to provide control of bank erosion from a number of possible causes

MASTERPLAN WORKS/ACTIVITY	BRIEF DESCRIPTION
Channel bed stabilisation works	eg. construction of rock riffles and/or rock chutes: aims to prevent further channel bed lowering and sediment mobilisation, leading to further disconnection of the main channel flows from the surrounding floodplain
Outlet protection	Aims to control localised erosion around stormwater discharge points
Install seating	Aims to provide facilities that encourage passive recreation/enjoyment of the natural environment
Install informative signage	Aims to provide facilities that encourage education and enjoyment of the natural environment
Install weather shelters	Aims to provide facilities that encourage passive recreation/enjoyment of the natural environment
Formalise existing path by constructing all weather crushed granite footpath for pedestrian access	Aims to improve access to some areas and improve public safety
Concrete footpath/cycleway to provide linkages with existing road and footpath network	Aims to improve access to some areas and improve public safety
Install pedestrian footbridge across river/wetlands	Aims to improve access to some areas and improve public safety
Manage as grassed open space	Aims to manage facilities that encourage passive recreation/enjoyment of the natural environment

See Appendix Two for a full description of works activities and recommended best practice methods.

WATERWAYS CORRIDOR RESPONSES TO MASTERPLAN WORKS AND ACTIVITIES

See Appendix Two for full description of works and recommended best practice methods.

POTENTIAL RESPONSES TO BIODIVERSITY ENHANCEMENT WORKS

Table 5. Potential geomorphic, hydrological and ecological responses to works activities proposed for biodiversity enhancement

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
Bush regeneration weed control removal of weeds in predominantly healthy bushland; also applies to follow-up weeding	• Potential for minor changes to sediment mobilisation and deposition regimes due to changes in plant cover • More closely aligned with naturally functioning waterway	• Minor localised changes during stabilisation following weed removal • Long term positive benefit in flood behaviour through re-establishment of healthy and resilient forested wetland	• Improvement in overall health of EECs • Improvement in diversity and quantity of habitat resources • Ecological for threatened species and endangered populations
Primary weed control of vines (weed control targeting vines for eradication)	• Potential for increased erosion during initial weed control phase. • Selection of the appropriate control methods and early establishment of native plants to replace vines is important to maintain bank stability during ecosystem transition and recovery phases	• Localised modification of flow behaviour through reduction in flow resistance due to intensive weed removal; this needs to be offset by replacement planting of native species • Long term positive reduction in adverse impacts from flood behaviour through re-establishment of healthy and	• Reduction/removal of ecosystem transforming invasive species (listed as key threatening process) • Potential short term loss of habitat resources (feeding and roosting) due to removal of weeds; this can be offset by using a staged removal process. • Long term improvement in

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
	• Long term reduction in mid and upper bank erosion	resilient forested wetlands	overall health of ecosystems and diversity and quantity of habitat resources
Primary weed control first cut weed control, removing the woody weeds and noxious weeds; needs to have follow up weed control activities	• Potential for increased erosion during initial weed control phase. • Selection of the appropriate control methods and early establishment of native plants to replace weeds removed is important to maintain bank stability during recovery phases • Long term reduction in mid and upper bank erosion	• Localised modification of flow behaviour through reduction in flow resistance due to intensive weed removal; this needs to be offset by replacement planting of native species • Long term positive reduction in adverse impacts from flood behaviour through re-establishment of healthy and resilient forested wetlands	• Reduction/removal of noxious weeds and environmental weeds in line with legislative requirements • Potential short term loss of habitat resources (feeding and roosting) due to removal of weeds; this can be offset by using a staged removal process. • Long term improvement in overall health of ecosystems and diversity and quantity of habitat resources
Local provenance plant propagation cultivation of plants for revegetation using seed or propagules derived from local native species where possible	• None anticipated	• None anticipated	• Improvement in overall health of wetland EECs • Supplementary plants of threatened species and endangered populations • Maintenance of biodiversity resources through active conservation of species and

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
			local genetic makeup
Infill planting for diversity supplementary planting for depauperate ecosystems	• Reduction in mid and upper bank erosion • Reduction in quantity of local sediment supply to stream system	• Potential minor modification in flow behaviour; impacts of increase in riparian planting density balanced through associated reduction in weed infestation • Negligible anticipated change in cross-section averaged flow velocities and associated flood behaviour	• Improvement in overall health of wetland EECs • Ecological for threatened species and endangered populations • Long term improvement in overall health of ecosystems through increases in the diversity and quantity of habitat resources • Maintenance of biodiversity resources through active conservation of species and local genetic makeup
Planting for stabilisation specifically selecting deep rooted, fast establishing species for planting in areas susceptible to erosion	• Resistance to mid and upper bank erosion. • Reduction in quantity of local sediment supply to stream system • Retention of diverse array of streambank habitats	• Localised modification in flow behaviour; impacts of increase in riparian planting density balanced through associated reduction in weed infestation • Negligible anticipated change in cross-section averaged flow velocities and associated flood behaviour	• Improvement in overall health of wetland EECs • Ecological for threatened species and endangered populations • Long term improvement in overall health of ecosystems through increases in the diversity and quantity of habitat resources

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
			• Maintenance of biodiversity resources through active conservation of species and local genetic makeup
Revegetation planting higher density supplementary planting to replace weeds that have been removed; select plant species that replicate original vegetation structure, improve habitat resources, maintain bank stability	• Reduction in mid and upper bank erosion • Reduction in quantity of local sediment supply to stream system	• Potential minor modification in flow behaviour; impacts of increase in riparian planting density balanced through associated reduction in weed infestation • Negligible anticipated change in cross-section averaged flow velocities and associated flood behaviour	• Improvement in ecosystem health of wetland and forested EECs • Ecological support for threatened species and endangered populations • Long term improvement in overall health of ecosystems through increases in the diversity and quantity of habitat resources • Maintenance of biodiversity resources through active conservation of species and local genetic makeup
Riparian buffer expansion planting preliminary plantings should be canopy species as these are slowest to establish, and Acacias to improve soil health	• Improved mid and upper bank stability • Reduction in sediment mobilisation and deposition	• Localised modification in flood flow behaviour only • Negligible anticipated change in cross-section averaged flow velocities and associated flood behaviour	• Protection of EECs through buffer planting • Ecological support for threatened species and endangered populations • Long term improvement in

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
			overall health of ecosystems through increases in the diversity and quantity of habitat resources
Plant fringing vegetation aims to provide a vegetative "shield" for sensitive vegetation through establishment of shrub and canopy species	• Improved mid and upper bank stability • Reduction in sediment mobilisation and deposition	• Localised minor modification in flow behaviour; impacts of increase in planting density generally offset by reduction in weed infestation • Negligible anticipated change in cross-section averaged flow velocities and associated flood behaviour	• Protection of EECs through buffer planting • Ecological support for threatened species and endangered populations • Long term improvement in overall health of ecosystems through increases in the diversity and quantity of habitat resources
Install jute matting with stabilisation planting soft engineering solutions to minor/localised erosion issues	• Resistance to bank erosion in longer term • Reduction in sediment supply to stream system as a result of stable, well protected banks	• Localised modification in flow behaviour; impacts of increase in riparian planting densities balanced through associated reduction in weed infestation • Negligible anticipated change in cross-section averaged flow velocities and associated flood behaviour	• Improvement in ecosystem health of wetland and forested EECs • Long term improvement in overall health of ecosystems through increases in the diversity and quantity of habitat resources • Improved stream ecosystem health through reduction in erosion and sediment

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
			mobilisation
Control/remove introduced ducks and geese reduce impacts from utilisation of habitat resources, and pollution of waterways through defecation	• Improved bank stability through reduction in degradation of bank vegetation by ducks and geese	• Improved water quality through reduction of pollutants from faecal deposition in the water	• Reduced competition with native birds for food and habitat resources • Improved aquatic ecosystem health through reduction in degrading processes
Control carp populations reduce impacts on water quality and streambank erosion through agitation of sediments by bottom feeding behaviours, reduce competition with native fish species for food and habitat resources	• Improved bank stability through reduction in undercutting of bank as a result of feeding behaviour by carp	• Improved water quality through reduction of sediment mobilisation and associated toxic compounds	• Improved aquatic ecosystems through reduction in degrading behaviours by carp • Reduced competition with native fish species for food and habitat resources • Reduction in competitive exclusionary behaviours by carp

POTENTIAL RESPONSES TO WATER QUALITY IMPROVEMENT WORKS

Table 6. Potential geomorphic, hydrological and ecological responses to works activities proposed for water quality improvement

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
Install trash rack aims to reduce the volume of litter transported via Duck River in larger channels	• Some potential changes to bank and channel bed form • Potential for increased erosion or sediment deposition in response to changes to channel form	• Possible flow modification due to in-channel debris buildup • Some reduction in flow velocities due to increased resistance, and associated flood level increases, up to overtopping flow	• Improved aquatic habitat through reduction of storm debris in peak flows • Improved riparian habitat through reduction in deposition of storm transported litter and debris • No net impact on fish passage for appropriately designed and located structures
Install end of pipe litter control device aims to reduce the volume of litter transported via Duck River in smaller channels at piped outflows	• Minor changes to sediment movements in response to changes in flow patterns	• Possible flow modification due to in-channel debris buildup • Some reduction in flow velocities due to increased resistance, up to maximum pipe flows • Possible back flooding higher in the catchment due to reduction in pipe's discharge capacity	• Improved aquatic habitat through reduction of storm debris in peak flows • Improved riparian habitat through reduction in deposition of storm transported litter and debris
Install trash trap or similar litter	• Minor changes to sediment	• Possible flow modification	• Improved aquatic habitat

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
control device aims to reduce the volume of litter transported via Duck River in smaller open channels	movements in response to changes in flow patterns	due to in-channel debris buildup • Some reduction in flow velocities due to increased resistance, and in associated flood level increases, up to overtopping flow • Minimal back flooding higher in the catchment as peak flows overtop the device	through reduction of storm debris in peak flows • Improved riparian habitat through reduction in deposition of storm transported litter and debris
Maintain mesh trash traps regularly; prepare and implement an Operations and Maintenance Plan aims to ensure ongoing correct functioning of gross pollutant control devices	• Reduction in destabilisation of sediments and banks by ensuring ongoing correct operations of gross pollutant traps	• Improvement in water quality by ensuring that devices are functioning correctly	• Improvement in aquatic and riparian habitats through improving bank stability and water quality • Reduced impacts from deposition of storm debris and sediments
Remove litter and debris from fringing reeds; consider installation of floating trash trap aims for an initial reduction in the volume of storm debris in reedland areas, and proposes an ongoing solution that should be implemented if installation of nets, traps and racks	• No net response to removal of litter and debris • Possible minor erosion or sedimentation associated with installation of floating trash trap	• No net response to removal of litter and debris • Possible minor changes in flow associated with installation of floating trash trap, although these are unlikely as the trap will float in response to changes in	• Improvement in aquatic and riparian habitats through reduction in a degrading process as a result of removing deposited storm debris and litter • Reduced impacts from deposition of storm debris

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
higher in the catchment fail to effectively control the pollutant load		flows; suitable for use in larger channels except where it can be a hazard to water craft	and sediments
Remove sediment plug and other rubbish/storm debris aims to provide an immediate solution to sediment and pollutant loading in a smaller channel; if regular maintenance of traps downstream fails to control future loads then ongoing cleaning will be necessary, and consideration should be given to relocating the traps	• Resistance to bed erosion in longer term.	• Localised modification in low flow and bankfull stream behaviour • Reduction in flow velocities for frequent events due to increase in waterway area • Improved flood behaviour for frequent *(up to bankfull)* flood events; negligible fluvial impacts for rarer flood events *(eg. greater than bankfull)*.	• Improved aquatic habitat through strengthening of in-stream and fringing vegetative structure • Improved aquatic habitat through rehabilitation of riparian corridor • Improved riparian and fringing species diversity.
Water quality monitoring point aims to collect data that will help identify high pollution generating sub-catchments through a process of community involvement	• No response expected	• No response expected	• Potential for identifying adverse water quality impacts and addressing them; resulting improvement in overall health of aquatic ecosystems

POTENTIAL RESPONSES TO EROSION CONTROL WORKS

Table 7. Potential geomorphic, hydrological and ecological responses to works activities proposed for erosion control

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
Toe protection works eg. root wads, rock lining: aims to control erosion in areas where bank erosion is linked to toe erosion	• Potential change in flow resistance, depending on previous conformation of bank toe • Reduction in bank slumping through undercutting • Reduction in mid and lower bank erosion	• Lower flow resistance in bank may induce higher velocity flows at bank full levels • Cross-section averaged flow velocities at rarer floods *(ie. higher than bankfull)* balanced through proposed dense riparian understorey and groundcover plantings in upper bank • Short term lower flow resistance may induce higher velocity flows at bankfull levels	• Minor loss of habitat in degrading bank section(s) as a result of implementation • Improved habitat in immediate riparian area through reduction in degrading process, and through habitat creation associated with installation of complex habitat components, eg. rocks, logs, etc • Improved aquatic habitat through reduction in sediment sources • Improved riparian ecosystem health through planting for stability and diversity
Bank stabilisation works eg. terracing, rebattering, geotextile lining, rock lining, retaining wall construction: aims to provide control	• Minimising potential for toe failure and subsequent bank slumping and retreat – reduction in potential for	• Lower flow resistance in bank may induce higher velocity flows at bank full levels	• Minor loss of habitat in degrading bank section(s) as a result of implementation • Improved habitat in

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
of bank erosion from a number of possible causes	sediment loss to stream system • Less resistance to flow, leading to potential for additional bed scour downstream of structure • Resistance to mid and lower bank erosion • Minimising potential for mid-bank failure and bank retreat.	• Cross-section averaged flow velocities at rarer floods *(ie. higher than bankfull)* balanced through proposed dense riparian understorey and groundcover plantings in upper bank • Short term lower flow resistance may induce higher velocity flows at bankfull levels	immediate riparian area through reduction in degrading process, and through habitat creation associated with installation of complex habitat components, eg. rocks, logs, etc • Improved aquatic habitat through reduction in sediment sources • Improved riparian ecosystem health through planting for stability and diversity
Channel bed stabilisation works eg. construction of rock riffles and/or rock chutes: aims to prevent further channel bed lowering and sediment mobilisation, leading to further disconnection of the main channel flows from the surrounding floodplain	• Resistance to prograding bed and bank erosion, reducing bank failure risk • Reduction of sediment supply to stream system • Imitating natural flow regime in limited reach • Structure shape proposed to centralise low flows, reducing bank failure risk	• Localised modification in flow behaviour; reduction in flow velocities for low *(daily average)* flows through local increase in bed resistance • Resultant centralised low flow improves flow behaviour through bridge pier protection works • No anticipated variation in flood level or risk to	• Improved aquatic ecology through water quality enhancement • Enhanced aquatic habitat through addition of habitat complexity components • Structure allows fish migration; no anticipated influence on fish breeding areas

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
		property	
Outlet protection aims to control localised erosion around stormwater discharge points	• Reduction in sediment supply to stream system • Resistance to upper bank erosion through maintaining a more stable surface downstream of outlets	• No response expected	• Improved aquatic ecology through water quality enhancement brought about by reduction in suspended sediments

POTENTIAL RESPONSES TO COMMUNITY AND RECREATION ACTIVITIES

Table 8. Potential geomorphic, hydrological and ecological responses to works activities proposed for community involvement and recreational activities

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
Install seating aims to provide facilities that encourage passive recreation/enjoyment of the natural environment	• No response expected	• No response expected	• Improved connection between users of the riparian corridor and the natural environment
Install informative signage aims to provide facilities that encourage education and enjoyment of the natural environment	• No response expected	• No response expected	• Improved connection between users of the riparian corridor and the natural environment
Install weather shelters	• No response expected	• No response expected	• Improved connection between users of the

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
aims to provide facilities that encourage passive recreation/enjoyment of the natural environment			riparian corridor and the natural environment
Formalise existing path by constructing all weather crushed granite footpath for pedestrian access aims to improve access to some areas and improve public safety	• No response expected	• No response expected	• Improved health of riparian habitat through reduction in creation in informal paths
Concrete footpath/cycleway to provide linkages with existing road and footpath network aims to improve access to some areas and improve public safety	• No response expected	• No response expected	• Improved connection between users of the riparian corridor and the natural environment
Install pedestrian footbridge across river/wetlands aims to improve access to some areas and improve public safety	• No response expected	• No response expected	• Improved connection between users of the riparian corridor and the natural environment
Manage as grassed open space aims to manage facilities that encourage passive	• No response expected	• No response expected	• Reduction in potential impacts from exotic grasses through adequate

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
recreation/enjoyment of the natural environment			management of potential propagules

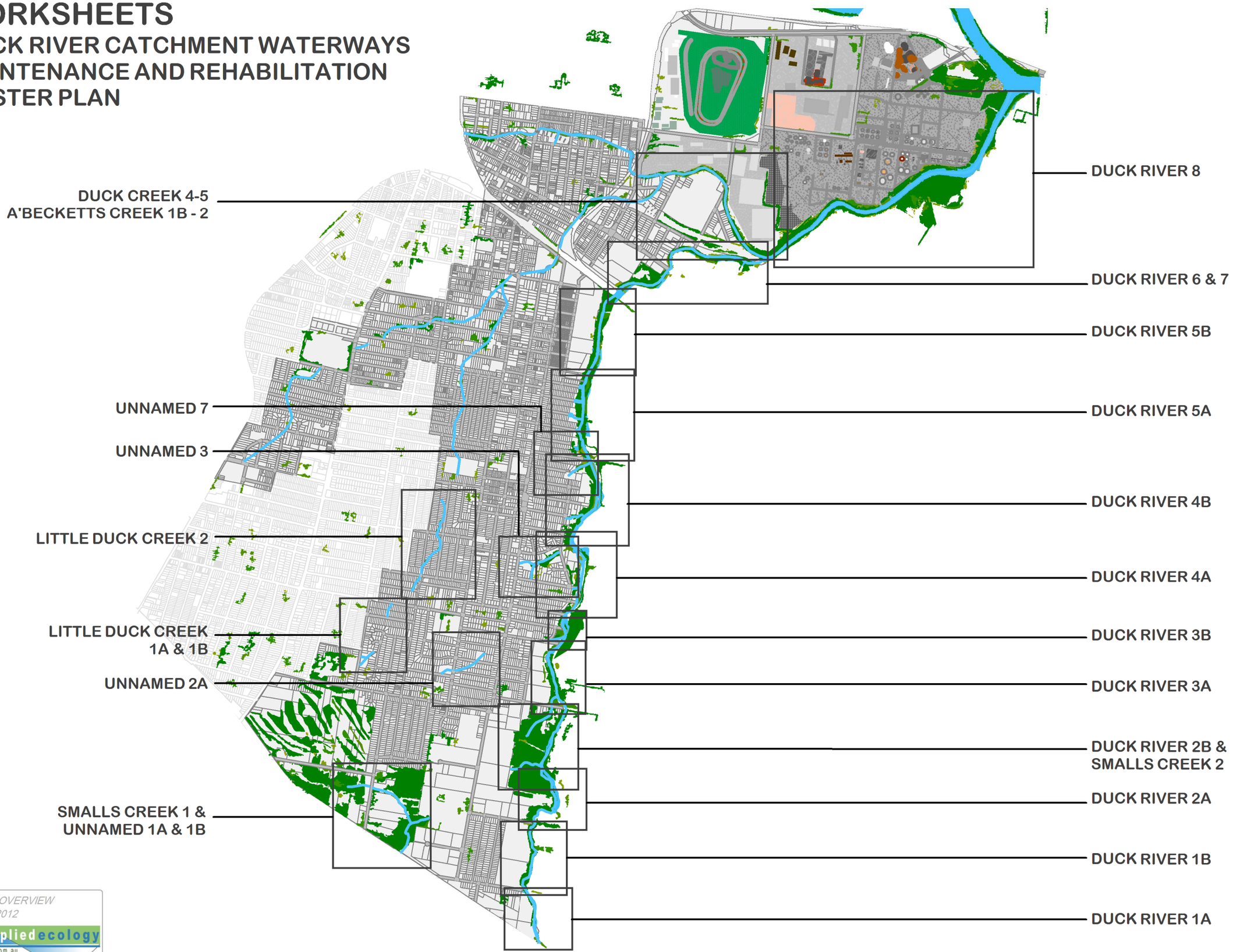
REHABILITATION WORKS AND ACTIVITIES – THE MASTERPLAN

OVERVIEW

See following pages

WORKSHEETS

DUCK RIVER CATCHMENT WATERWAYS MAINTENANCE AND REHABILITATION MASTER PLAN



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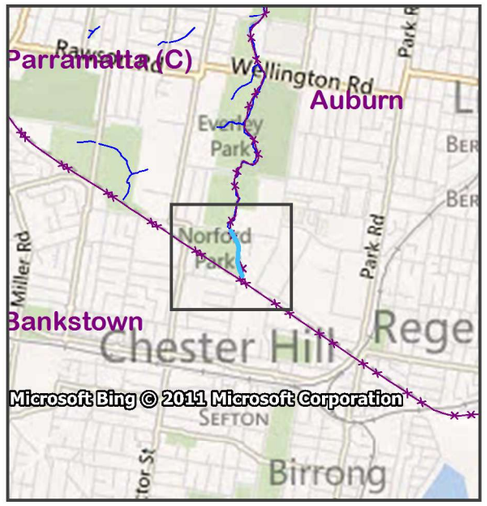
DUCK RIVER 1A

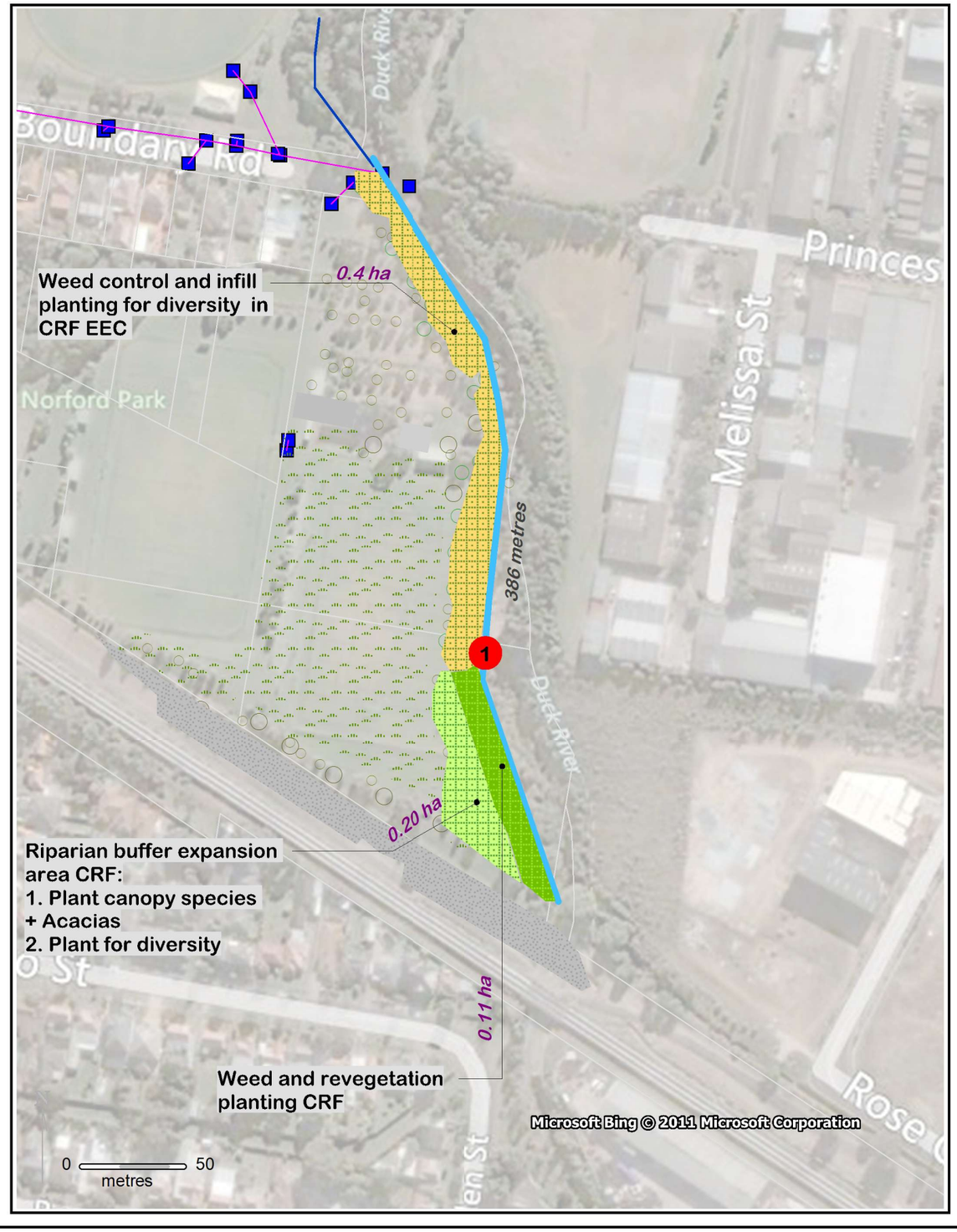
Table 9. Management actions and works required for reach DUCK RIVER 1A

REACH	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
DUCK RIVER 1A (1)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Water quality improvement: install trash rack	Urgent	N/A	$250-500K	$2-5K	PCC/ACC
DUCK RIVER 1A (2)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.40ha	$2-6K	$500-1000	PCC
DUCK RIVER 1A (3)	Biodiversity enhancement: bush regeneration weeding and revegetation planting with Cumberland Riverflat Forest species	High	0.088ha	$1-3K	$500-1000	PCC
DUCK RIVER 1A (4)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control carp	Medium	N/A	$3-5K per event	ongoing	PCC/ACC
DUCK RIVER 1A (5)	Biodiversity enhancement: riparian buffer expansion planting with Cumberland Riverflat Forest species	Low	0.20ha	$4-6K	$500-1000	PCC




REACH: DUCK RIVER 1A



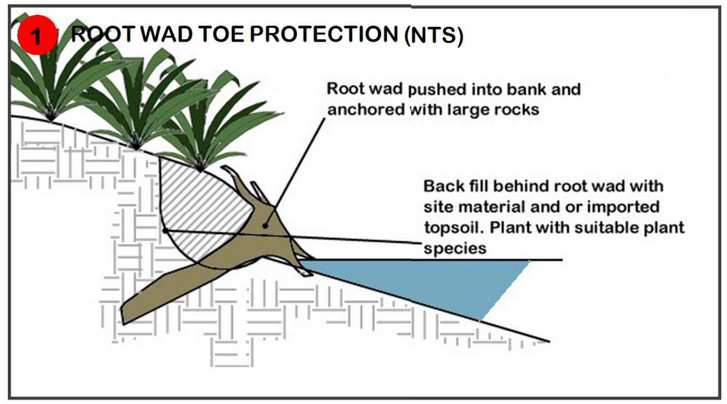


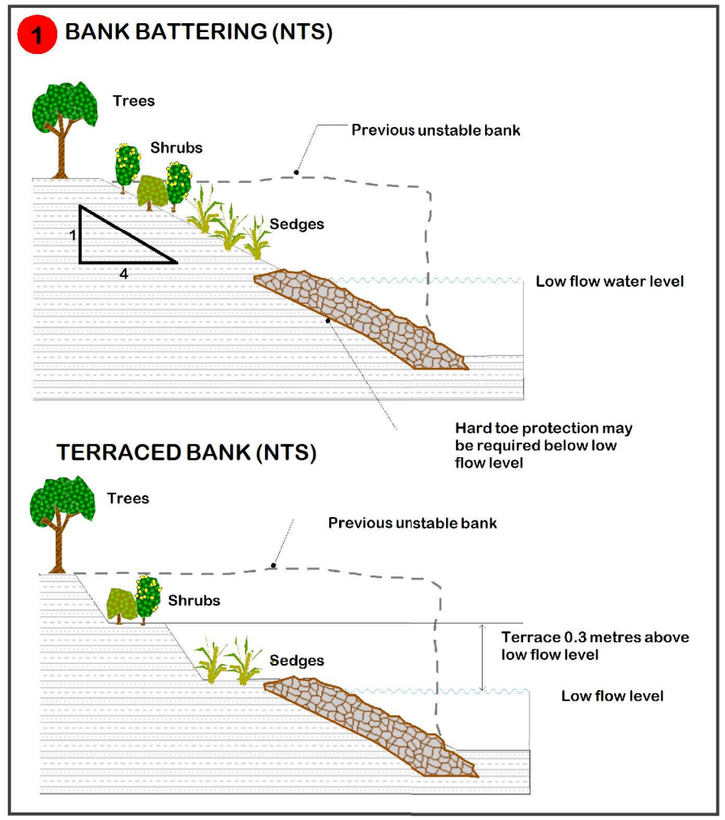
WORKS PLAN

VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)





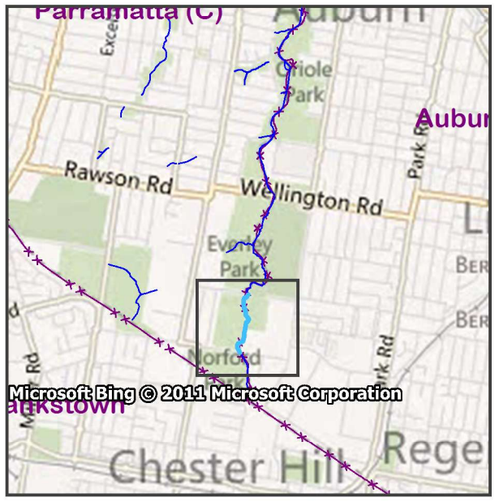
DUCK RIVER 1B

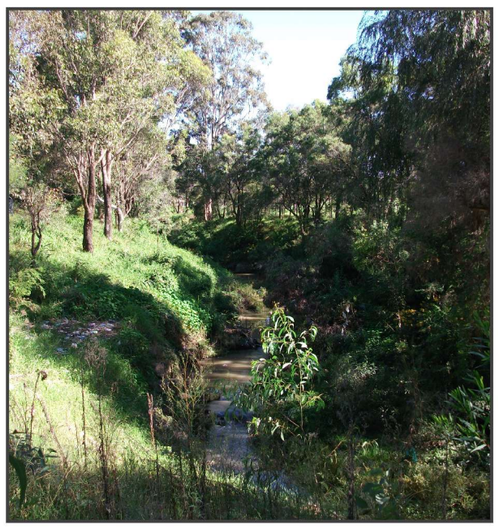
Table 10. Management actions and works required for reach DUCK RIVER 1B

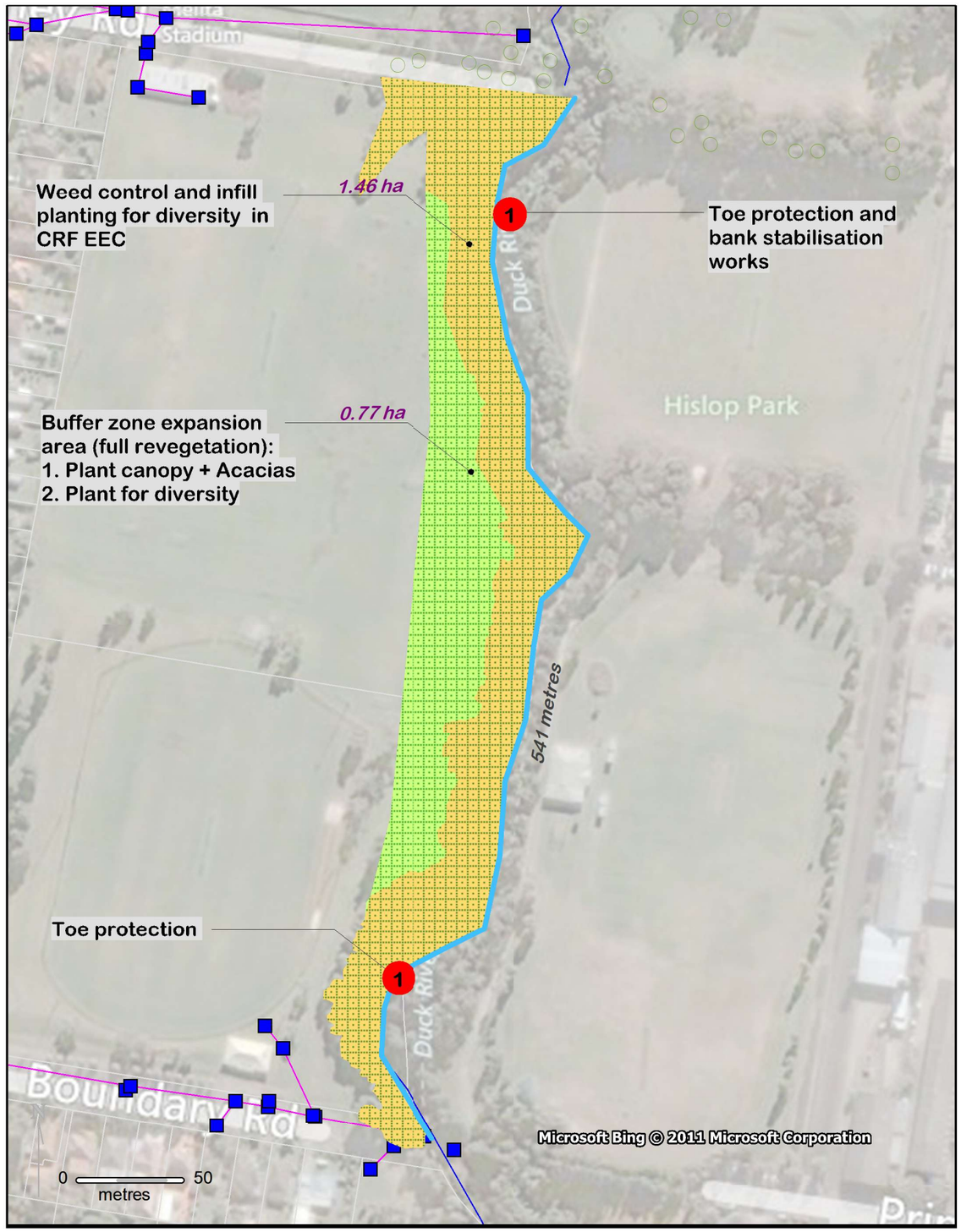
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
DUCK RIVER 1B (1)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Water quality improvement: water quality monitoring point	Urgent/ongoing	N/A	$1-2K	$1-2K	PCC/ACC
DUCK RIVER 1B (2)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	1.46ha	$10-20K	$3-5K	PCC
DUCK RIVER 1B (3)	Erosion control: toe protection works	High	30m	$20-30K	$1-2K	PCC
DUCK RIVER 1B (4)	Biodiversity enhancement: riparian buffer expansion planting with Cumberland Riverflat Forest species	Low	0.77ha	$20-25K	$5-8K	PCC




REACH: DUCK RIVER 1B



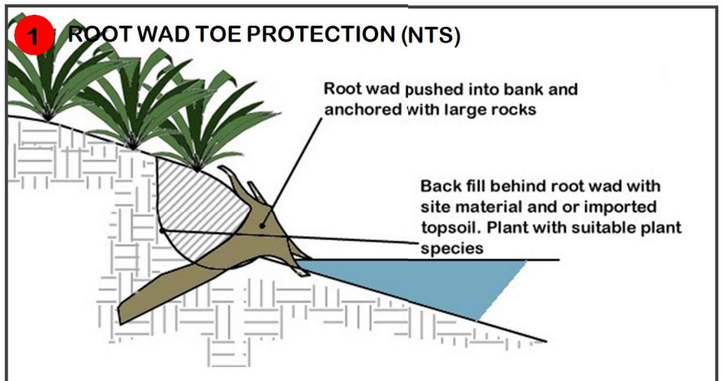


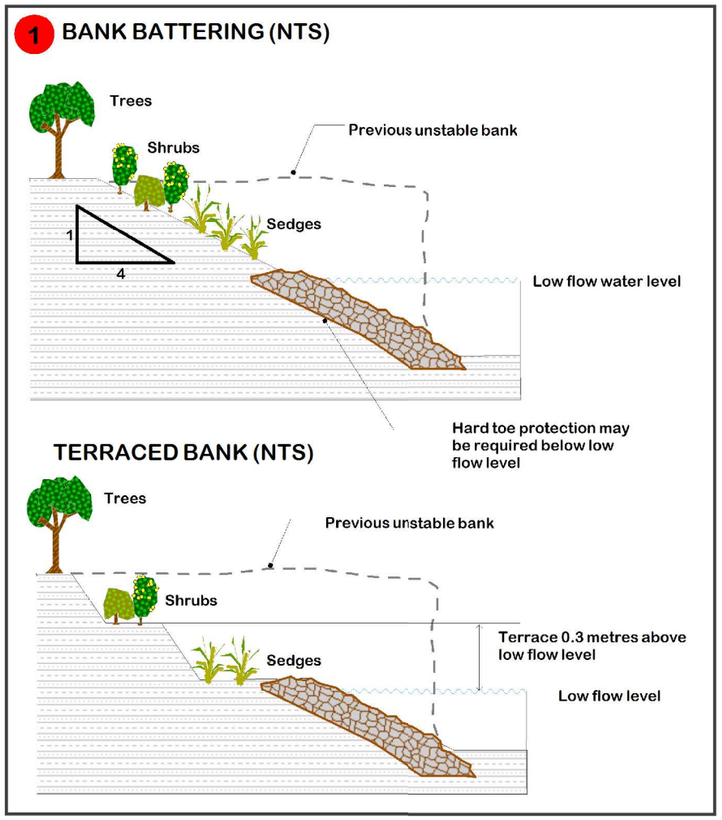


WORKS PLAN

VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)





DUCK RIVER 2A

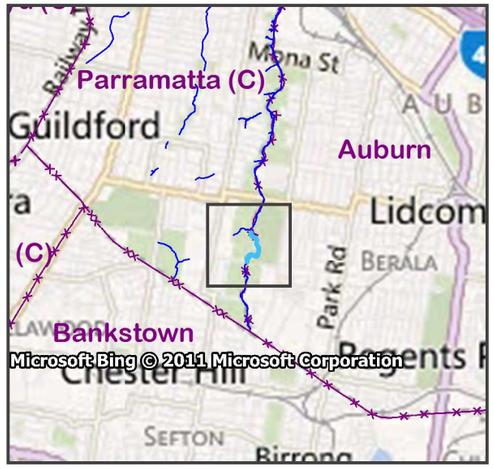
Table 11. Management actions and works required for reach DUCK RIVER 2A

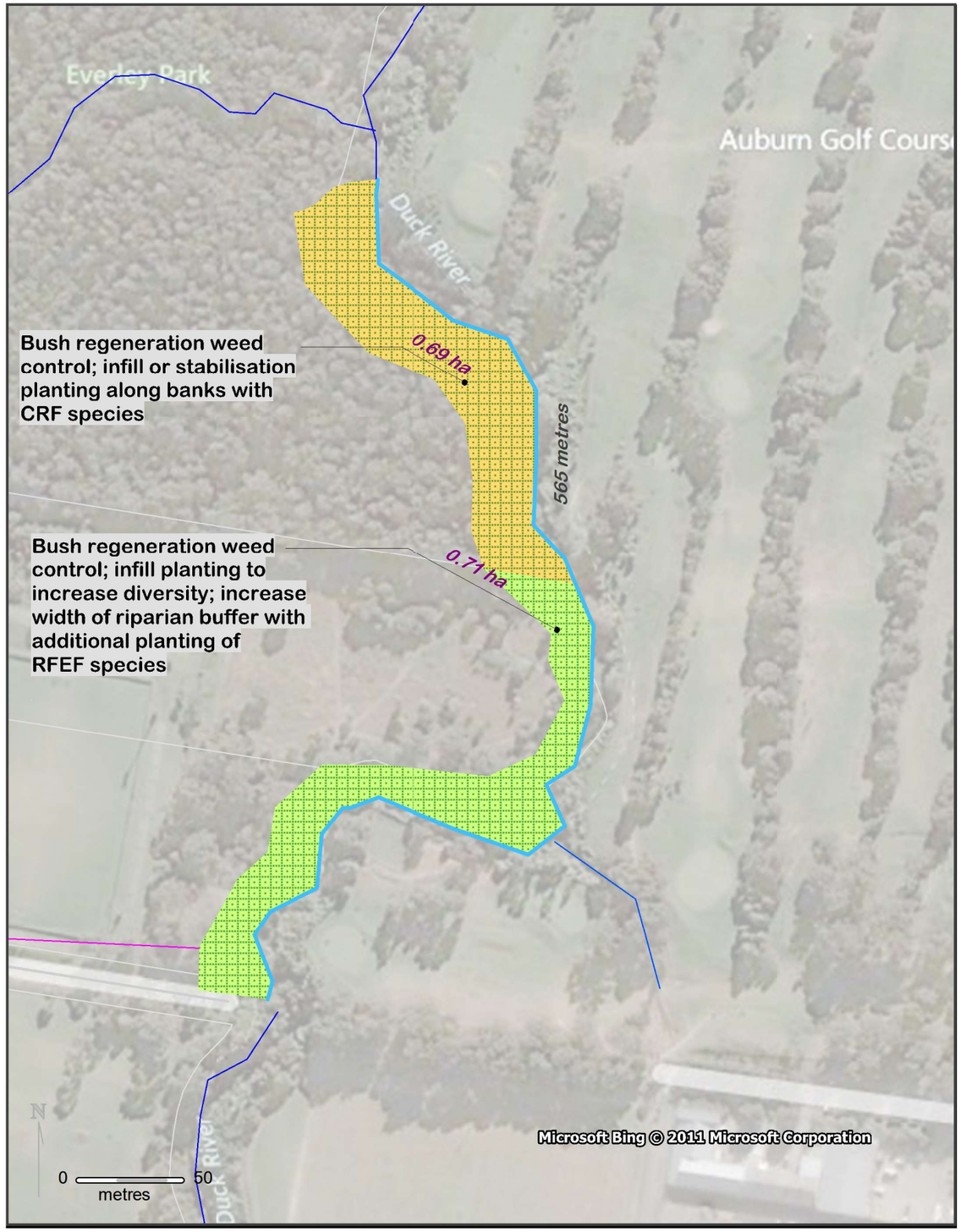
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
DUCK RIVER 2A (1)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.69ha	$5-10K	$1-2K	PCC
DUCK RIVER 2A (2)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.71ha	$5-10K	$500-1000	PCC
DUCK RIVER 2A (3)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	ongoing	PCC/ACC
DUCK RIVER 2A (4)	Biodiversity enhancement: riparian buffer expansion planting with Cumberland Riverflat Forest species	Low	0.71ha	$20-25K	$5-8K	PCC
DUCK RIVER 2A (5)	Erosion control: monitor bank stability and install jute matting with stabilisation planting as required; use Cumberland Riverflat Forest species	Ongoing	560m	$0-15K	$1-2K	PCC




REACH: DUCK RIVER 2A

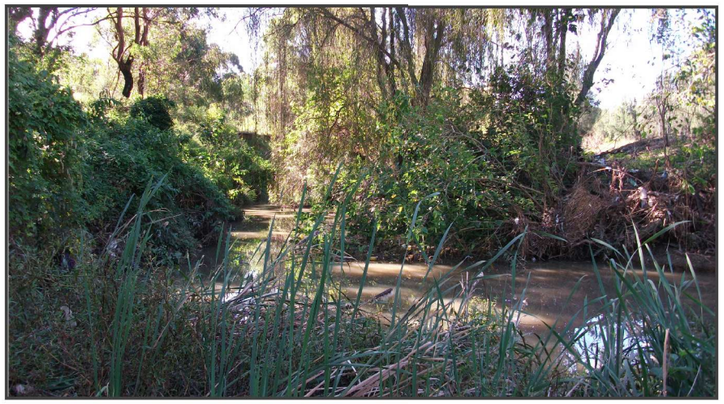
WORKS PLAN

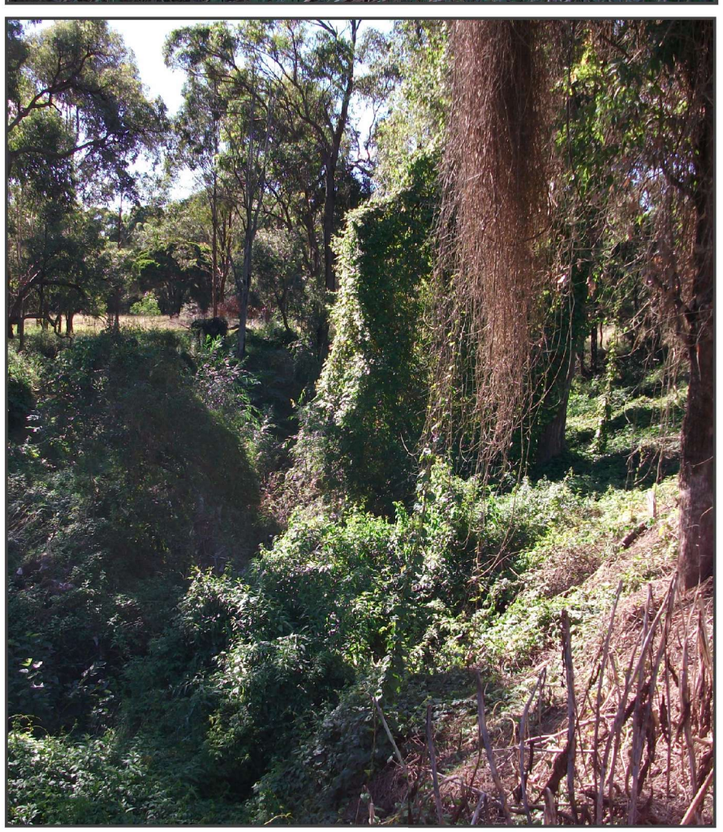




VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)





DUCK RIVER 2B

Table 12. Management actions and works required for reach DUCK RIVER 2B

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
DUCK RIVER 2B (1)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Water quality improvement: water quality monitoring point	Urgent/ongoing	N/A	$1-2K	$1-2K	PCC/ACC
DUCK RIVER 2B (2)	Biodiversity enhancement: bush regeneration weeding and stabilisation planting with Cumberland Riverflat Forest species	High	1.00ha	$10-20K	$1-5K	PCC
DUCK RIVER 2B (3)	Erosion control: monitor bank stability and install jute matting with stabilisation planting as required; use Cumberland Riverflat Forest species	Ongoing	470m	$0-15K	$1-2K	PCC
DUCK RIVER 2B (4)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	ongoing	PCC/ACC

SMALLS CREEK 2

Table 13. Management actions and works required for reach SMALLS CREEK 2

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
SMALLS CREEK 1 (1)	Erosion control: scouring and undercutting protection for outlet control structure	Urgent	N/A	$150-250K	$2-4K	PCC
SMALLS CREEK 1 (2)	Erosion control: creek bank and bed stabilisation works	High	150m	$20-50K	$1-2K	PCC
SMALLS CREEK 1 (3)	Biodiversity enhancement: bush regeneration weeding and infill planting for stabilisation and diversity with Cumberland Riverflat Forest or Cooks River/Castlereagh Ironbark Forest species	High	1.6ha	$5-15K	$1-2K	PCC

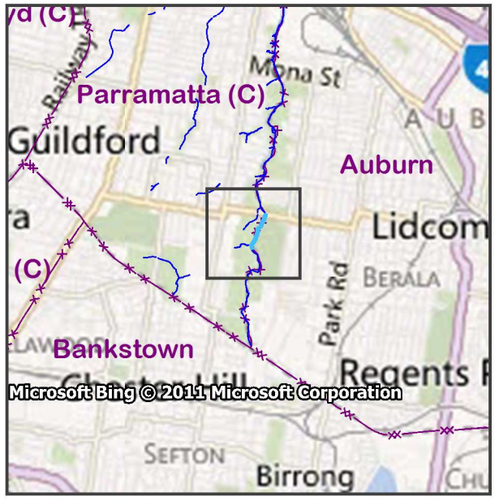
UNNAMED 9 WELLINGTON RD

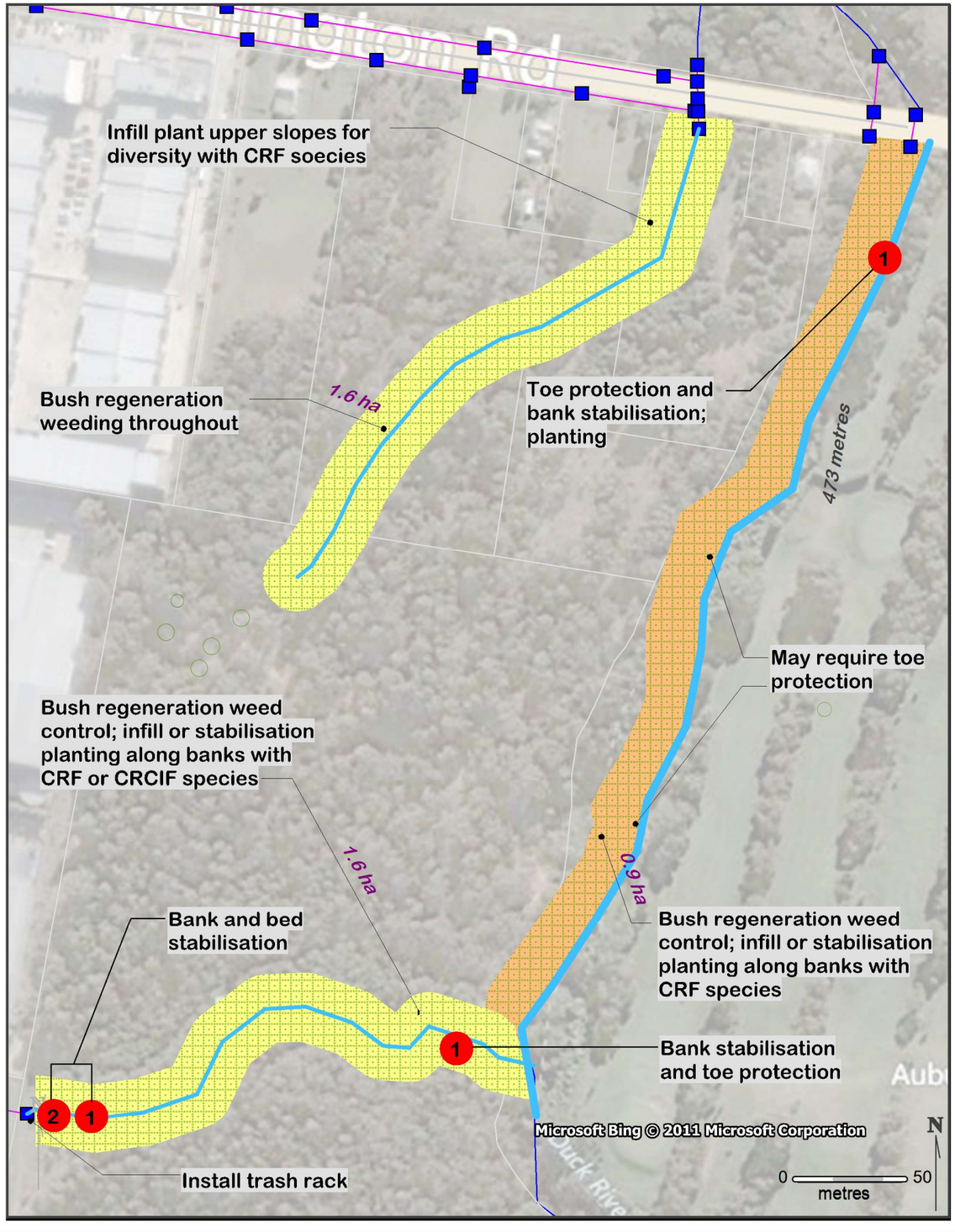
Table 14. Management actions and works required for reach UNNAMED 9 WELLINGTON RD

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
UNNAMED 9 (1)	Biodiversity enhancement: Bush regeneration weed control	High	1.6ha	$10-15K	manage with DUCK RIVER 2B	PCC
UNNAMED 9 (2)	Biodiversity enhancement: Infill planting along upper slopes for diversity with Cooks River/Castlereagh Ironbark Forest or Cumberland Riverflat Forest species	Medium	0.8ha	$5-10K	manage with DUCK RIVER 2B	PCC
UNNAMED 9 (3)	Biodiversity enhancement: Infill planting for stability with Cumberland Riverflat Forest species	Medium	0.4ha	$2-5K	manage with DUCK RIVER 3A	PCC




REACH: DUCK RIVER 2B & SMALLS CREEK 1





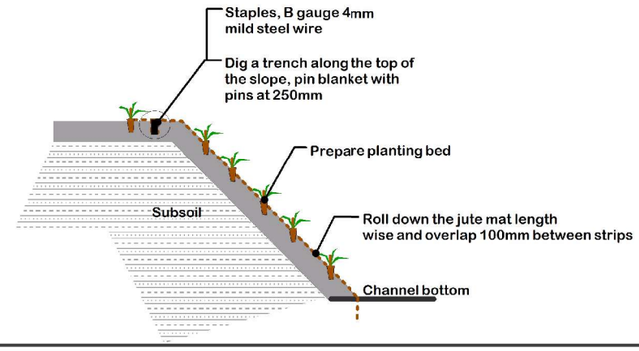
WORKS PLAN

VEGETATION COMMUNITIES

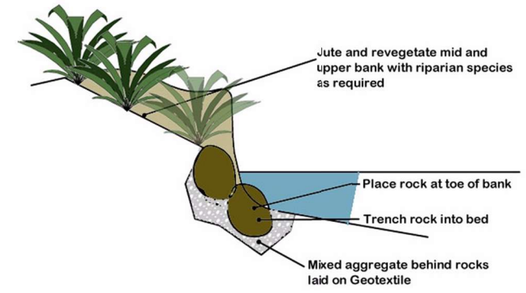
Cumberland Riverflat Forest (CRF)

Cooks river Castlereagh Ironbark Forest (CRCIF)

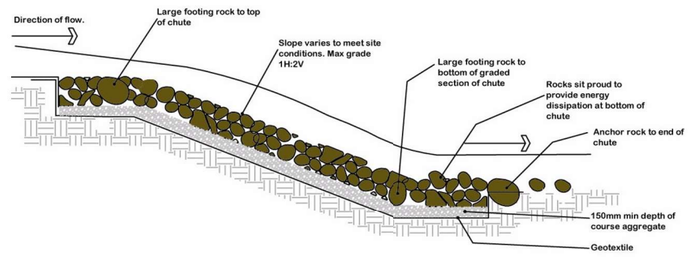
1 JUTE MAT BANK TREATMENT (NTS)



1 ROCK TOE PROTECTION (NTS)



2 ROCK CHUTE (NTS)



DUCK RIVER 3A

Table 15. Management actions and works required for reach DUCK RIVER 3A

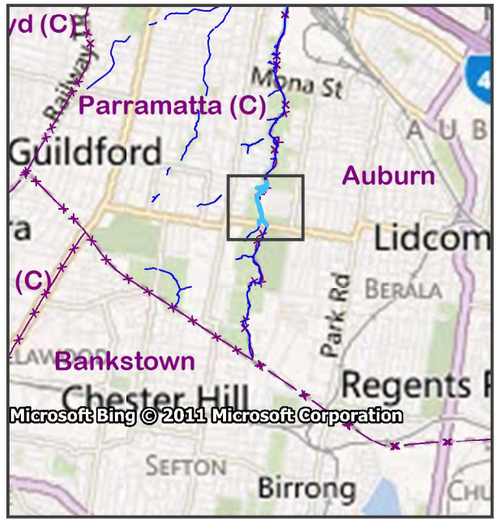
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
DUCK RIVER 3A (1)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Community and recreation: install pedestrian footbridge across river/wetlands	High	N/A	$20-40K	$5-10K	PCC/ACC
DUCK RIVER 3A (2)	Biodiversity enhancement: primary weed control, revegetation for stabilisation with Cumberland Riverflat Forest species	High	0.19ha	$10-15K	$2-5K	PCC
DUCK RIVER 3A (3)	Biodiversity enhancement: primary weed control, revegetation for stabilisation and diversity with Cumberland Riverflat Forest species	High	0.52ha	$20-25K	$1-2K	PCC
DUCK RIVER 3A (4)	Community and recreation: install seating, informative signage and weather shelters	High	N/A	$15-30K	$500	PCC
DUCK RIVER 3A (5)	Community and recreation: formalise existing path by constructing all weather crushed granite footpath for pedestrian access	High	450m	$5-10K	$500	PCC
DUCK RIVER 3A (6)	Community and recreation: install informative signage	High	N/A	$2-5K	$500	PCC
DUCK RIVER 3A (7)	Biodiversity enhancement: primary weed control of vines	High	0.72ha	$30-40K	$5-10K	PCC
DUCK RIVER 3A (8)	Biodiversity enhancement: primary weed control of vines	High	0.24ha	$10-15K	$2-5K	PCC
DUCK RIVER 3A (9)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.68ha	$10-20K	$2-5K	PCC
DUCK RIVER 3A (10)	Biodiversity enhancement: bush regeneration weed control	High	0.41ha	$5-10K	$1-2K	PCC
DUCK RIVER 3A (11)	Biodiversity enhancement: primary weed control and revegetation with Cumberland Riverflat Forest species	Medium	0.24ha	$10-15K	$2-5K	PCC
DUCK RIVER 3A (12)	Biodiversity enhancement: primary weed control and revegetation with Cumberland Riverflat Forest species	Medium	0.72ha	$40-50K	$5-10K	PCC
DUCK RIVER 3A (13)	Biodiversity enhancement: riparian buffer expansion planting with Cumberland Riverflat Forest species	Low	0.37ha	$10-12K	$2-3K one year only	PCC
DUCK RIVER 3A (14)	Erosion control: monitor bank stability and install jute matting with stabilisation planting as required; use Cumberland Riverflat Forest species	Ongoing	350m	$0-15K	$1-2K	PCC

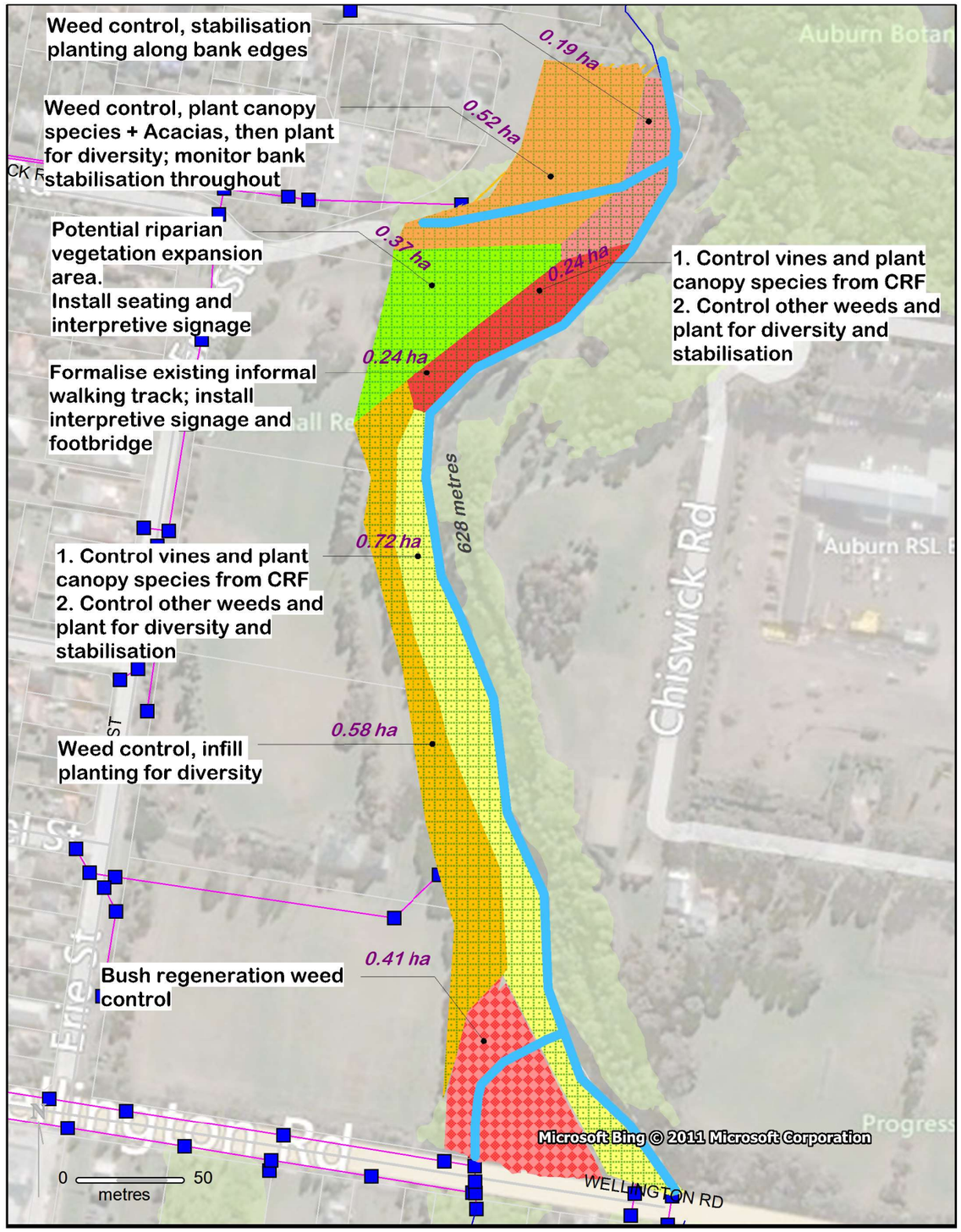
UNNAMED 2B CHISWICK ST

Table 16. Management actions and works required for reach UNNAMED 2B CHISWICK ST

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
UNNAMED 2B (1)	Erosion control: monitor bank stability – do not over clear. Stabilise steep slopes as required, eg. Jute mat and plant, rock line channel or toe	High	40m	$0-5k	manage with DUCK RIVER 3A	PCC
UNNAMED 2B (2)	Biodiversity enhancement: primary weed control, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.4ha	$15-20K	manage with DUCK RIVER 3A	PCC
UNNAMED 2B (3)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Swamp Oak Riparian Forest species	Medium	0.4ha	$2-5K	manage with DUCK RIVER 3A	PCC

REACH: DUCK RIVER 3A



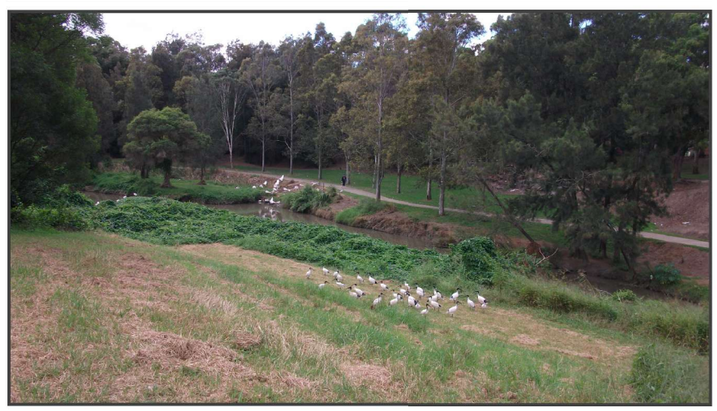


WORKS PLAN

VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)



DUCK RIVER 3B

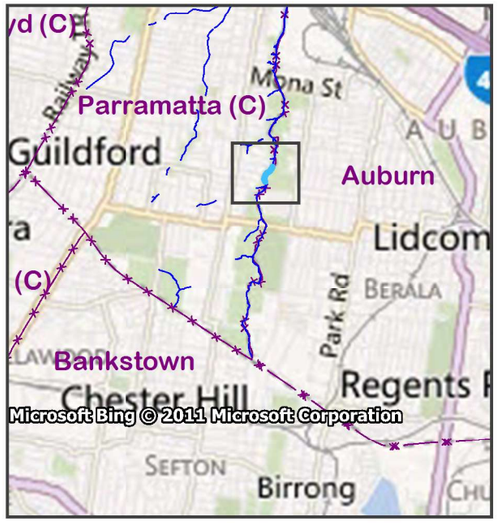
Table 17. Management actions and works required for reach DUCK RIVER 3B

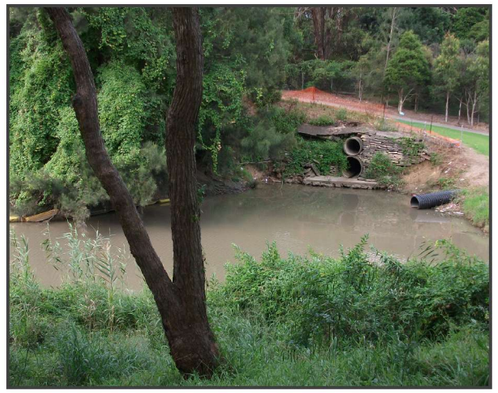
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
DUCK RIVER 3B (1)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.68ha	$8-12K	$1-2K	PCC
DUCK RIVER 3B (2)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	ongoing	PCC/ACC
DUCK RIVER 3B (3)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	ongoing	PCC/ACC
DUCK RIVER 3B (4)	Erosion control: monitor bank stability and install jute matting with stabilisation planting as required; use Cumberland Riverflat Forest species	Ongoing	130m	$0-10K	$1-2K	PCC

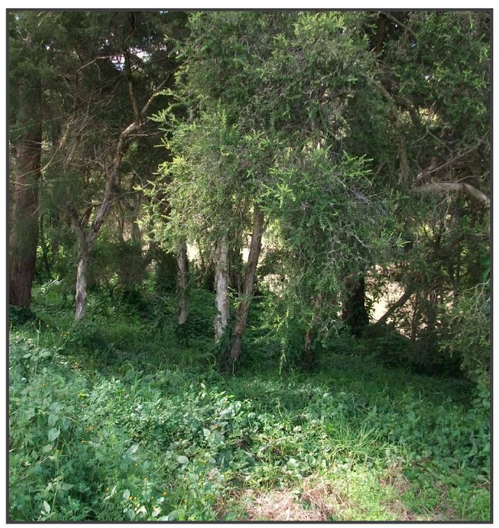


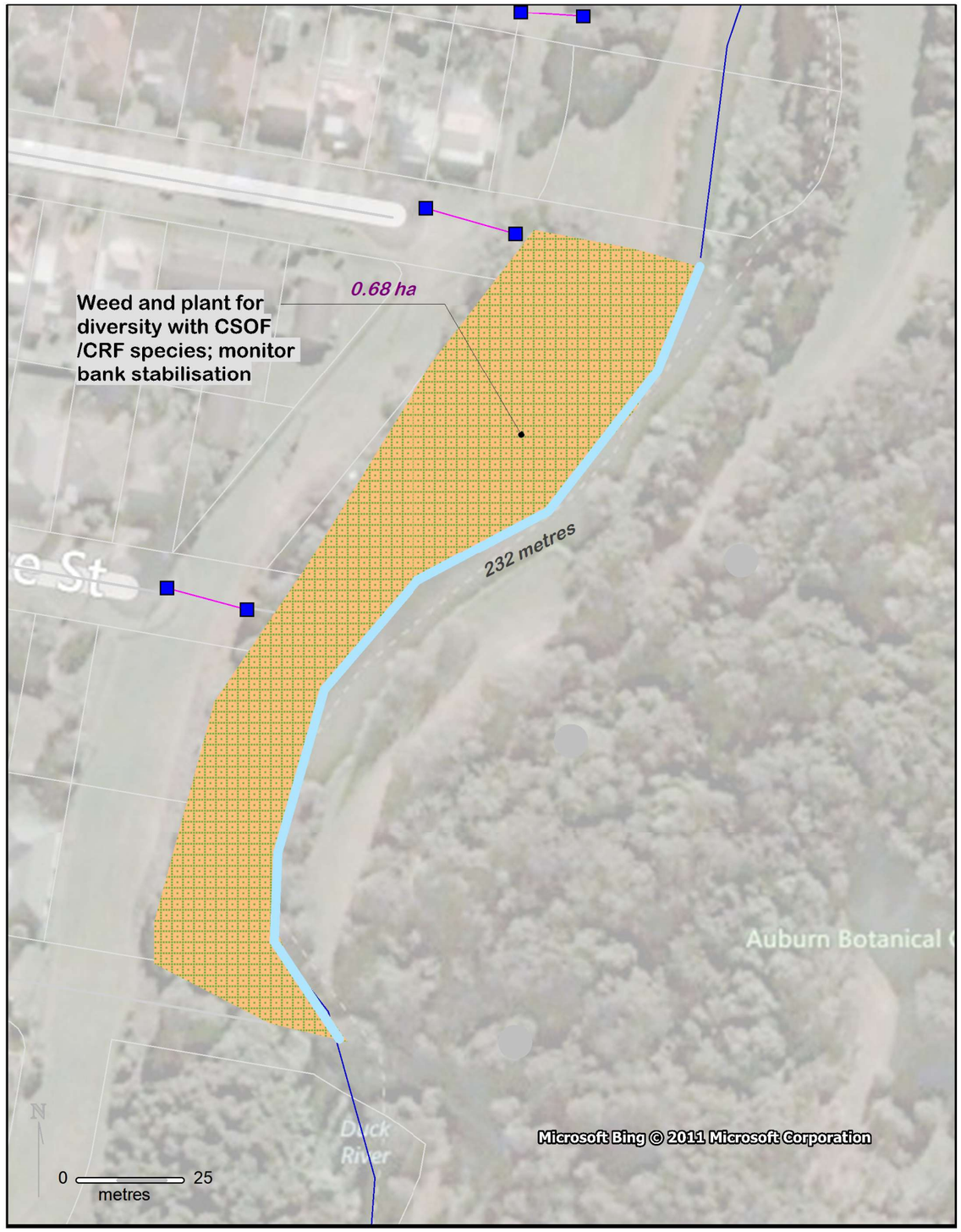

REACH: DUCK RIVER 3B

WORKS PLAN





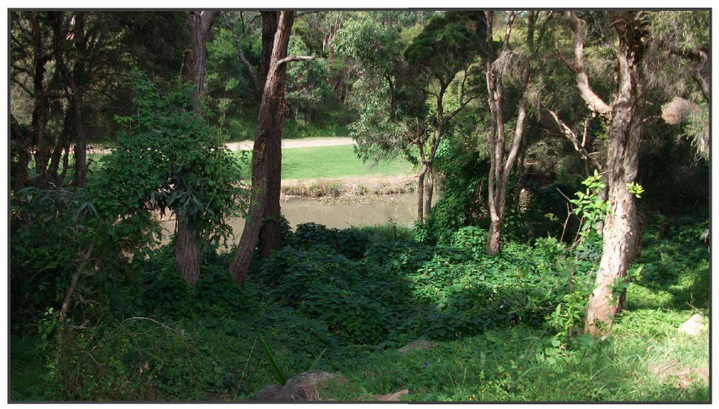




VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)



DUCK RIVER 4A

Table 18. Management actions and works required for reach DUCK RIVER 4A

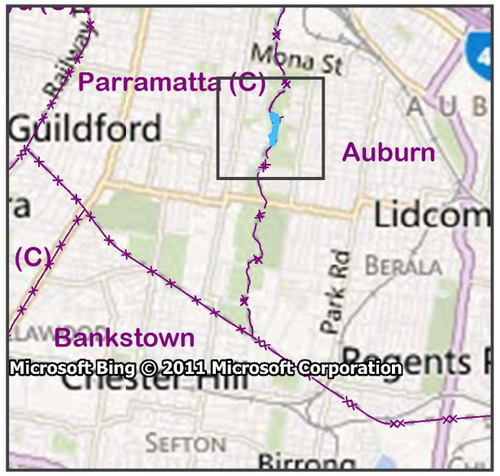
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
DUCK RIVER 4A (1)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Community and recreation: improve safety at causeway crossing (stepping stones weir)	Urgent	N/A	$2-5K	$1-2K	PCC/ACC
DUCK RIVER 4A (2)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.23ha	$5-10K	$500-1000	PCC
DUCK RIVER 4A (3)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.73ha	$10-15K	$3-5K	PCC
DUCK RIVER 4A (4)	Water quality improvement: remove litter and debris from fringing reeds; consider installation of floating trash trap	High	N/A	$5-10K	$3-5K	PCC
DUCK RIVER 4A (5)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control carp populations (LOCATION 1)	Medium	N/A	$3-5K/event	ongoing	PCC/ACC
DUCK RIVER 4A (6)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control carp populations (LOCATION 2)	Medium	N/A	$3-5K/event	ongoing	PCC/ACC
DUCK RIVER 4A (7)	Community and recreation: manage as grassed open space	Ongoing	N/A	$2-5K/year	ongoing	PCC
DUCK RIVER 4A (8)	Community and recreation: maintain existing seating and signage	Ongoing	N/A	$2-5K/year	ongoing	PCC
DUCK RIVER 4A (9)	Community and recreation: manage as grassed open space	Ongoing	N/A	$2-5K/year	ongoing	PCC

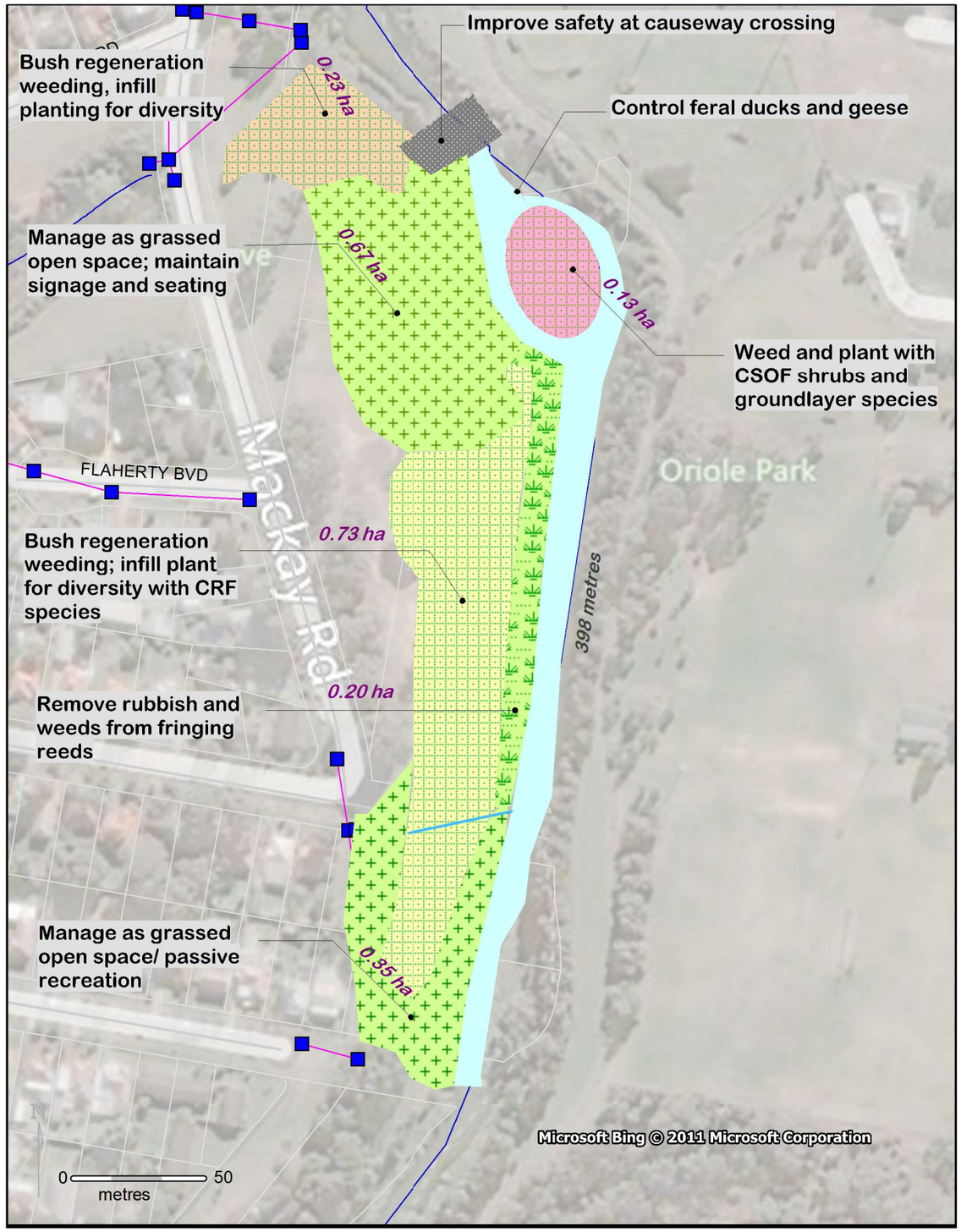




REACH: DUCK RIVER 4A

WORKS PLAN



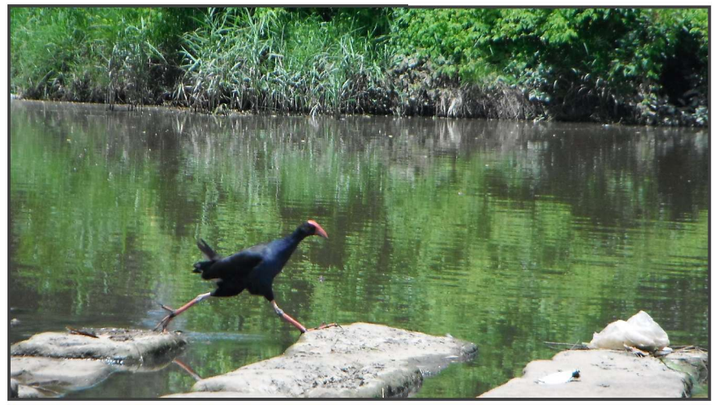


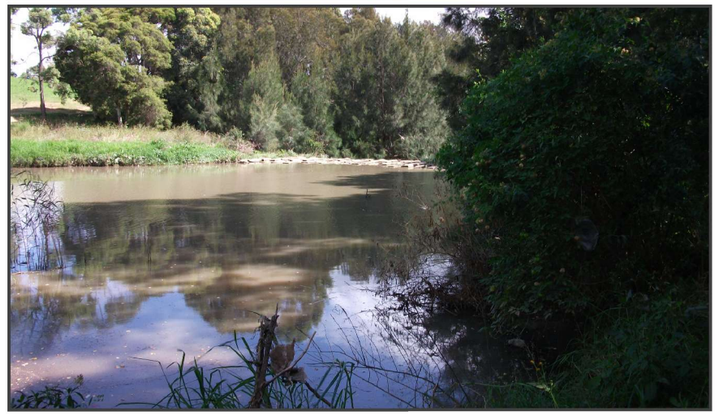
VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Coastal Freshwater Reedlands





UNNAMED 3 CLYDE/BENNETT STS

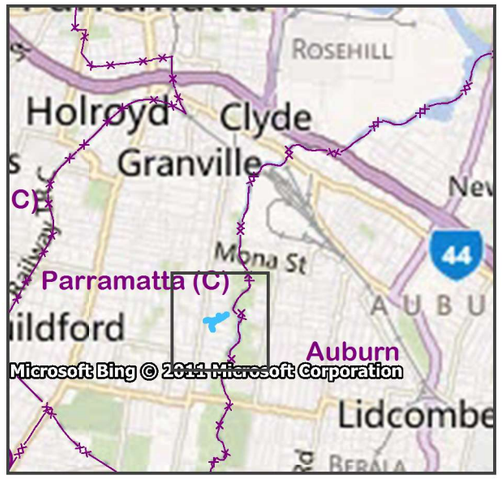
Table 19. Management actions and works required for reach UNNAMED 3 CLYDE/BENNETT STS

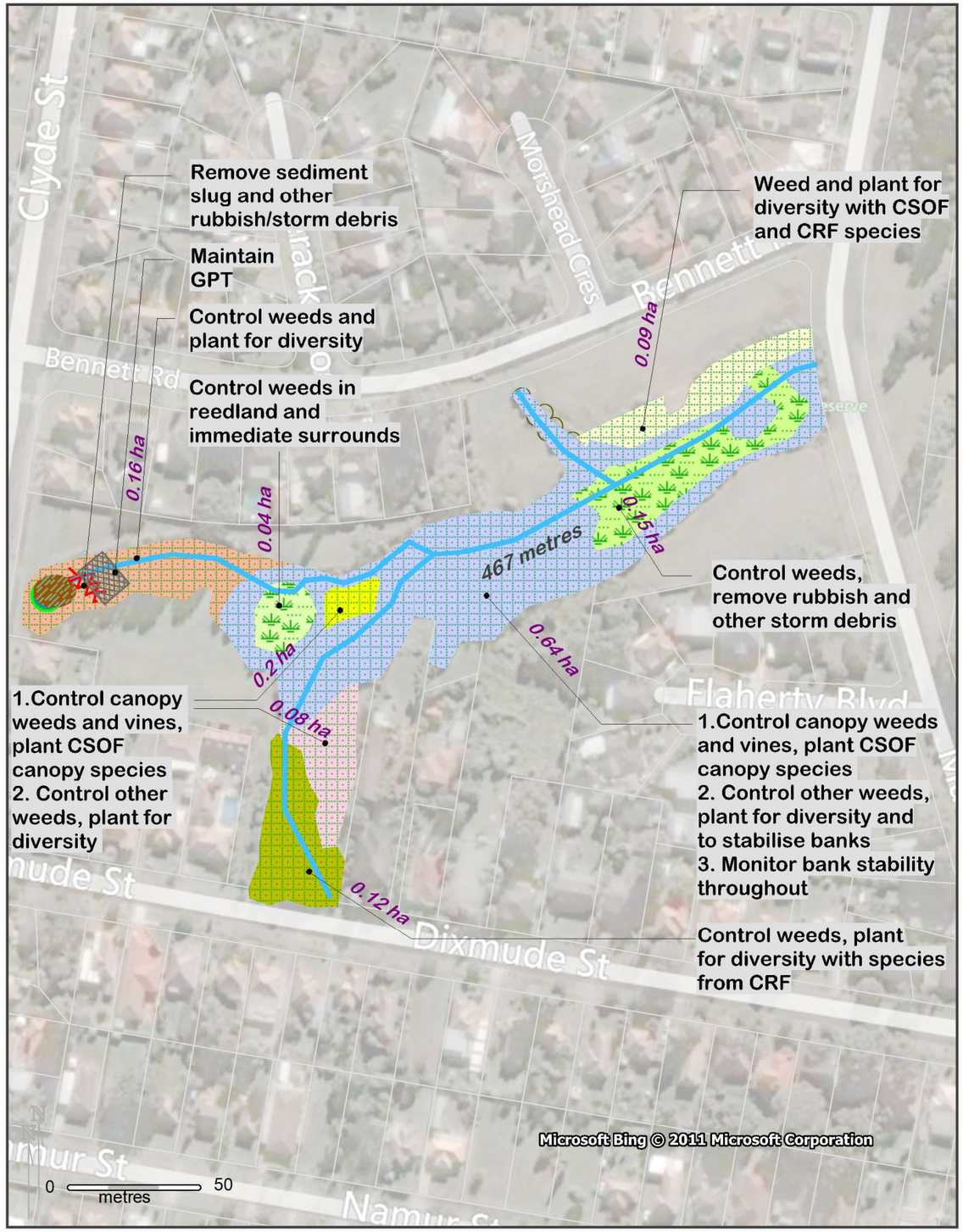
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
UNNAMED 3 (1)	Water quality improvement: remove litter and debris from fringing reeds	Urgent	N/A	$1-2K	event based	PCC
UNNAMED 3 (2)	Water quality improvement: remove sediment plug and other rubbish/storm debris	High	N/A	$3-5K	event based	PCC
UNNAMED 3 (3)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Swamp Oak Riparian Forest species	High	0.16ha	$10-15K	$1-2K	PCC
UNNAMED 3 (4)	Biodiversity enhancement: bush regeneration weeding and fringing planting for diversity with Cumberland Swamp Oak Riparian Forest species	High	0.04ha	$3-5K	$500-1000	PCC
UNNAMED 3 (5)	Biodiversity enhancement: primary weed control, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.28ha	$15-20K	$2-4K	PCC
UNNAMED 3 (6)	Biodiversity enhancement: primary weed control, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.12ha	$10-15K	$1-2K	PCC
UNNAMED 3 (7)	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.64ha	$25-35K	$3-5K	PCC
UNNAMED 3 (8)	Biodiversity enhancement: primary weed control of vines and other weeds	High	0.15ha	$10-15K	$1-2K	PCC
UNNAMED 3 (9)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.09ha	$8-10K	$500-1000	PCC
UNNAMED 3 (10)	Biodiversity enhancement: secondary weed control, revegetation by infill planting with Cumberland Swamp Oak Riparian Forest species	Medium	0.28ha	$15-20K	$1-2K	PCC
UNNAMED 3 (11)	Biodiversity enhancement: secondary weed control, revegetation by infill planting with Cumberland Swamp Oak Riparian Forest species	Medium	0.12ha	$10-15K	$1-2K	PCC
UNNAMED 3 (12)	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.64ha	$25-35K	$3-5K	PCC
UNNAMED 3 (13)	Water quality improvement: maintain mesh trash traps regularly; prepare and implement an Operations and Maintenance Plan	Ongoing	N/A	$2-5K/year	ongoing	PCC
UNNAMED 3 (14)	Monitor bank stability and install jute matting with stabilisation planting as required; use Cumberland Swamp Oak Riparian Forest species	Ongoing	0.64ha	$0-15K	N/A	PCC




REACH: UNNAMED 3 BENNETT STREET

WORKS PLAN



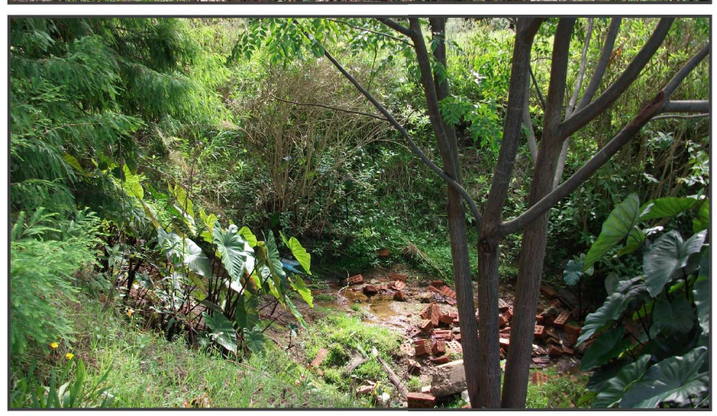


VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Coastal Freshwater Reedlands



DUCK RIVER 4B

Table 20. Management actions and works required for reach DUCK RIVER 4B

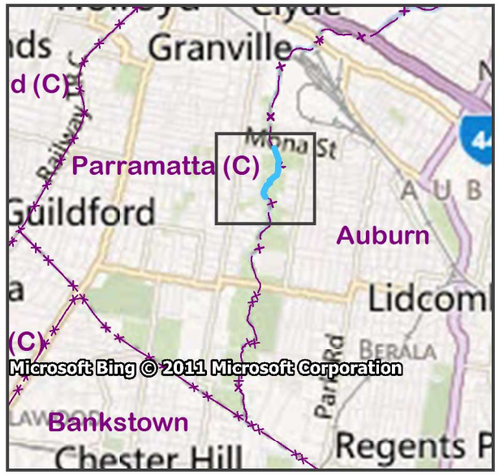
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA / LENGTH	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
DUCK RIVER 4B (1)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control aquatic noxious weeds	Urgent	0.02ha	$5-10K	$500-1000	PCC/ACC
DUCK RIVER 4B (2)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Water quality improvement: water quality monitoring point	Urgent/ongoing	N/A	$1-2K	$1-2K	PCC/ACC
DUCK RIVER 4B (3)	Biodiversity enhancement: fringing buffer planting with Cumberland Swamp Oak Riparian Forest species	High	0.15ha	$3-5K	$500 one year only	PCC
DUCK RIVER 4B (4)	Community and recreation: install concrete footpath/cycleway to provide linkages with existing road and footpath network	High	360m	$30-40K	$500-1000	PCC
DUCK RIVER 4B (5)	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.32ha	$12-15K	$3-5K	PCC
DUCK RIVER 4B (6)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Swamp Oak Riparian Forest species	High	0.60ha	$5-10K	$500-1000	PCC
DUCK RIVER 4B (7)	Biodiversity enhancement: primary weed control of vines	High	0.05ha	$3-5K	$500-1000	PCC
DUCK RIVER 4B (8)	Biodiversity enhancement: primary weed control of vines	High	0.39ha	$15-20K	$5-8K	PCC
DUCK RIVER 4B (9)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	1.47ha	$20-30K	$5-8K	PCC
DUCK RIVER 4B (10)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control carp populations (LOCATION 1)	Medium	N/A	$3-5K/event	ongoing	PCC/ACC
DUCK RIVER 4B (11)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control carp populations (LOCATION 2)	Medium	N/A	$3-5K/event	ongoing	PCC/ACC
DUCK RIVER 4B (12)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control carp populations (LOCATION 3)	Medium	N/A	$3-5K/event	ongoing	PCC/ACC
DUCK RIVER 4B (13)	Biodiversity enhancement: primary weed control and revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.05ha	$3-5K	$500-1000	PCC
DUCK RIVER 4B (14)	Biodiversity enhancement: primary weed control and revegetation with Cumberland Riverflat Forest species	Medium	0.39ha	$15-20K	$3-5K	PCC
DUCK RIVER 4B (15)	Community and recreation: manage as grassed open space	Ongoing	N/A	$2-5K/year	ongoing	PCC

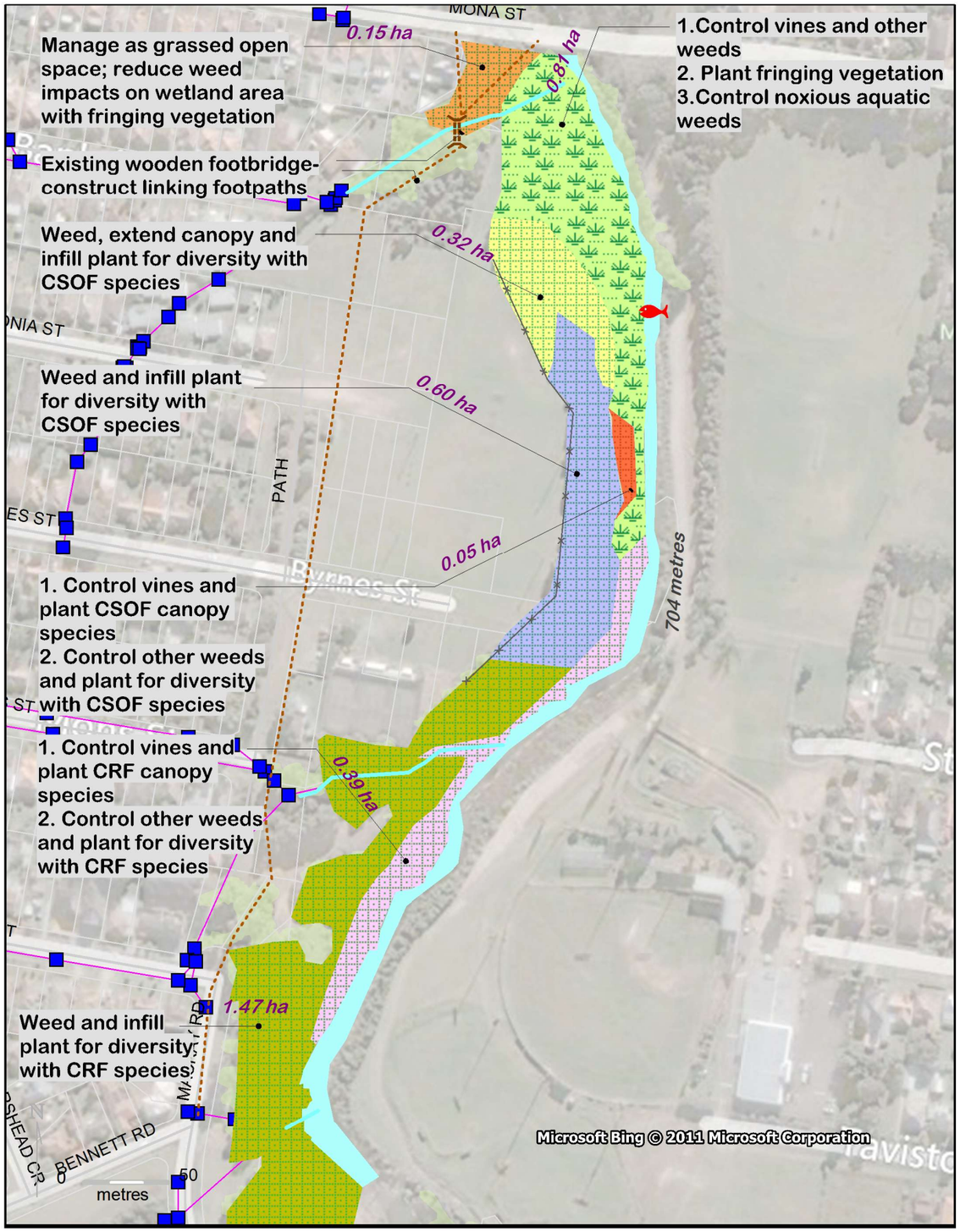




REACH: DUCK RIVER 4B

WORKS PLAN



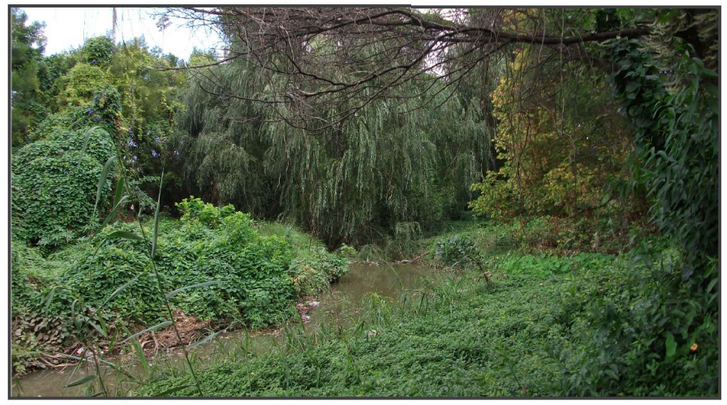


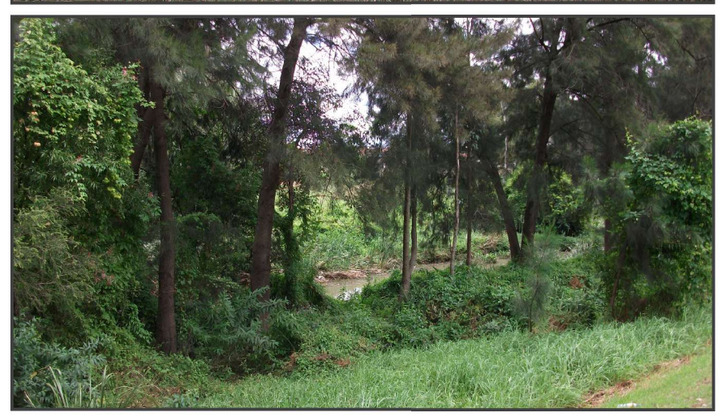
VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Coastal Freshwater Reedlands





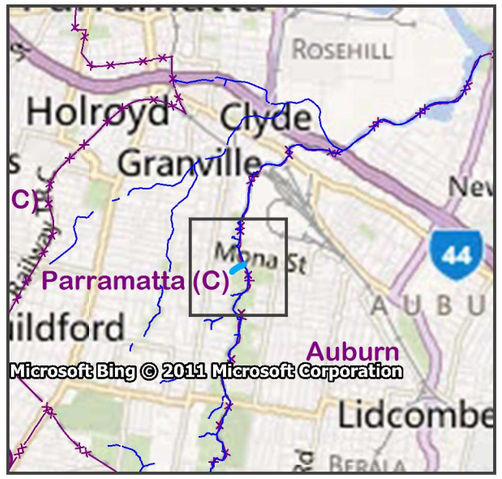
UNNAMED 7 BANKSIA ST

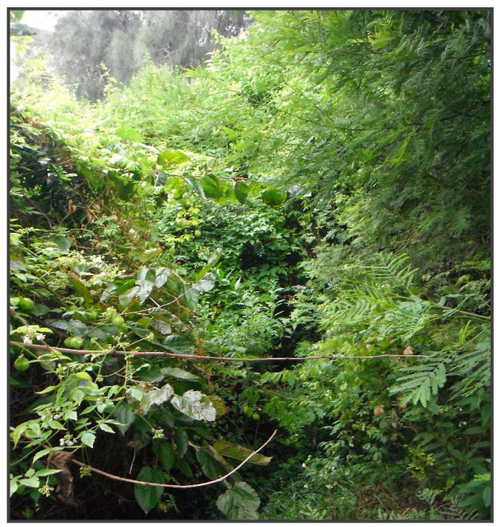
Table 21. Management actions and works required for reach UNNAMED 7 BANKSIA ST

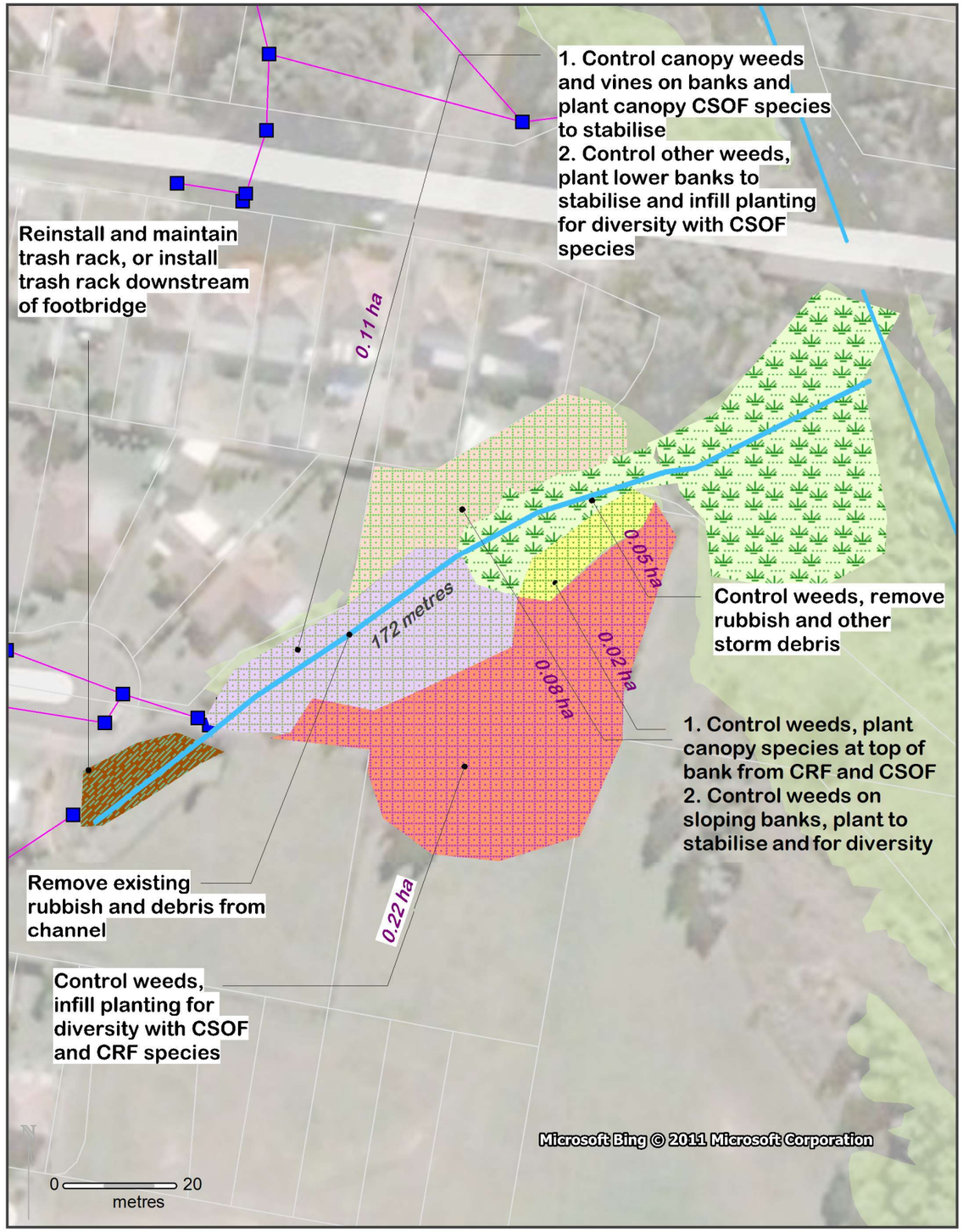
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
UNNAMED 7 (1)	Water quality improvement: liaise with landholder to reinstall and maintain trash rack above detention basin, or install trash rack below footbridge	Urgent	N/A	$4-70K	$2-5K	Private landholder/PCC
UNNAMED 7 (2)	Water quality improvement: remove litter and debris from fringing vegetation upstream of reedlands	Urgent	N/A	$1-2K	manage with DUCK RIVER 4B	PCC
UNNAMED 7 (3)	Water quality improvement: remove litter and debris from fringing reeds	Urgent	N/A	$1-2K	manage with DUCK RIVER 4B	PCC
UNNAMED 7 (4)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Swamp Oak Riparian Forest species	High	0.22ha	$10-15K	manage with DUCK RIVER 4B	PCC
UNNAMED 7 (5)	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.08ha	$5-10K	manage with DUCK RIVER 4B	PCC
UNNAMED 7 (6)	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.11ha	$5-10K	manage with DUCK RIVER 4B	PCC
UNNAMED 7 (7)	Biodiversity enhancement: primary weed control of vines and other weeds	High	0.05ha	$3-5K	manage with DUCK RIVER 4B	PCC
UNNAMED 7 (8)	Community and recreation: install concrete footpath/cycleway to connect between footbridges	High	40m	$3-5K	manage with DUCK RIVER 4B	PCC
UNNAMED 7 (9)	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.11ha	$5-10K	manage with DUCK RIVER 4B	PCC
UNNAMED 7 (10)	Biodiversity enhancement: primary weed control, revegetation for stabilisation with Cumberland Swamp Oak Riparian Forest species	Medium	0.10ha	$5-10K	manage with DUCK RIVER 4B	PCC
UNNAMED 7 (11)	Monitor bank stability and install jute matting with stabilisation planting as required; use Cumberland Swamp Oak Riparian Forest species	Ongoing	0.10ha	$0-5K	manage with DUCK RIVER 4B	PCC

REACH: UNNAMED 7 BANKSIA STREET

WORKS PLAN







VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Coastal Freshwater Reedlands

DUCK RIVER 5A

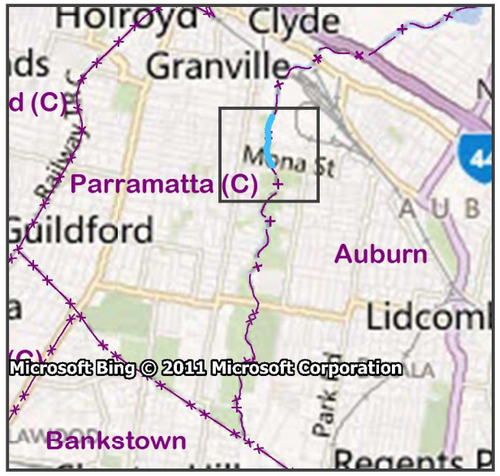
Table 22. Management actions and works required for reach DUCK RIVER 5A

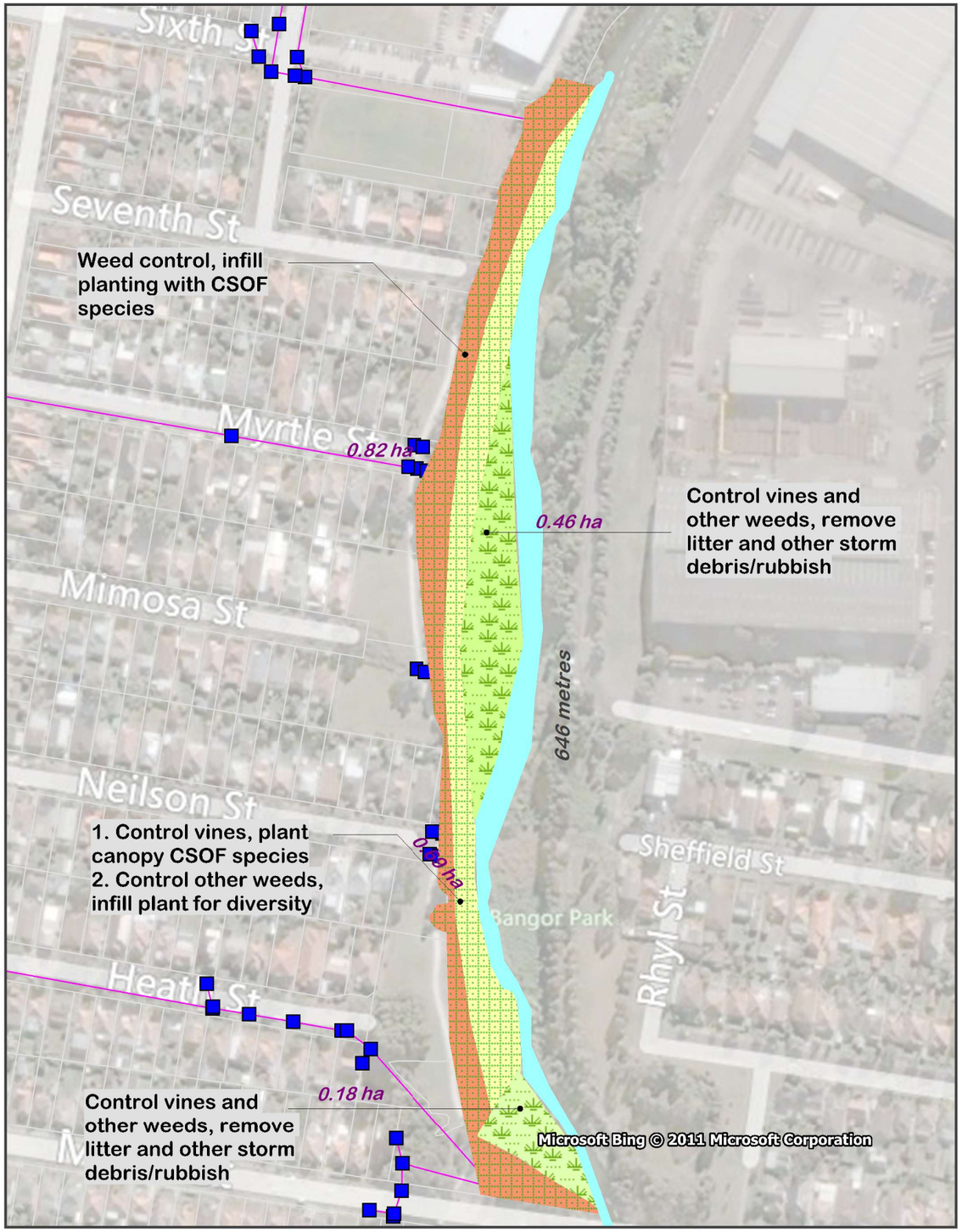
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
DUCK RIVER 5A (1)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Water quality improvement: remove litter and debris from fringing reeds; consider installation of floating trash trap	Urgent	N/A	$5-10K	$1-3K	PCC
DUCK RIVER 5A (2)	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Swamp Oak Riparian Forest species	High	0.82ha	$40-50K	$5-10K	PCC
DUCK RIVER 5A (3)	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.69ha	$30-40K	$5-10K	PCC
DUCK RIVER 5A (4)	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.69ha	$30-40K	$5-10K	PCC
DUCK RIVER 5A (5)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control carp populations (LOCATION 1)	Medium	N/A	$3-5K/event	ongoing	PCC
DUCK RIVER 5A (6)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control carp populations (LOCATION 2)	Medium	N/A	$3-5K/event	ongoing	PCC




REACH: DUCK RIVER 5A

WORKS PLAN



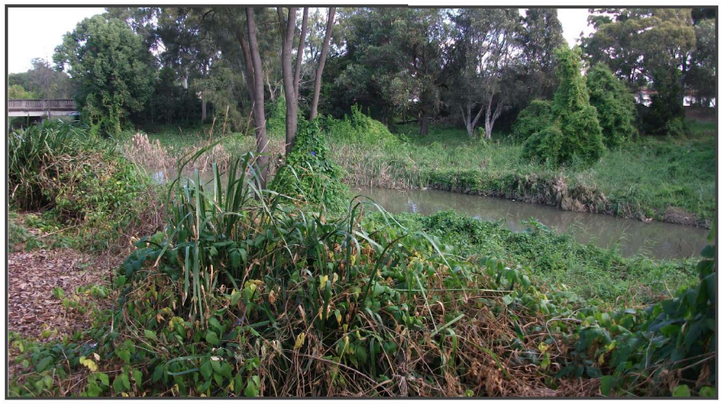


VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Coastal Freshwater Reedlands



DUCK RIVER 5B

Table 23. Management actions and works required for reach DUCK RIVER 5B

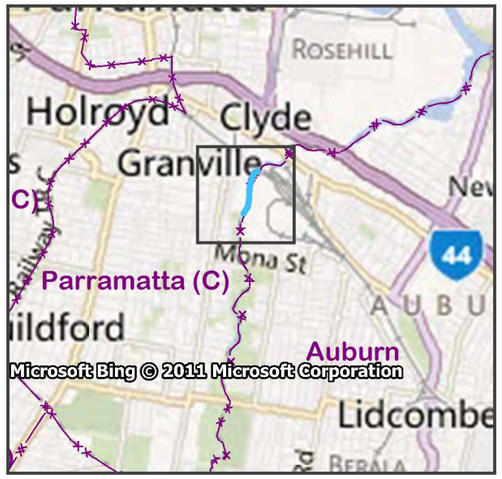
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
DUCK RIVER 5B (1)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Water quality improvement: remove litter and debris from fringing reeds; consider installation of floating trash trap	Urgent	N/A	$5-10K	$1-2K	PCC/ACC
DUCK RIVER 5B (2)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Water quality improvement: water quality monitoring point	Urgent/ongoing	N/A	$1-2K	$1-2K	PCC/ACC
DUCK RIVER 5B (3)	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Riverflat Forest)	High	0.37ha	$20-30K	$5-7K	PCC
DUCK RIVER 5B (4)	Biodiversity enhancement: primary weed control of vines, and plant for diversity with Cumberland Swamp Oak Riparian Forest species	High	0.27ha	$15-20K	$5-7K	PCC
DUCK RIVER 5B (5)	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.54ha	$25-35K	$5-7K	PCC/private landholders
DUCK RIVER 5B (6)	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Riverflat Forest)	High	0.43ha	$25-30K	$5-7K	PCC/private landholders
DUCK RIVER 5B (7)	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.54ha	$25-30K	$5-7K	PCC/private landholders
DUCK RIVER 5B (8)	Biodiversity enhancement: primary weed control, revegetation with Cumberland Riverflat Forest species	Medium	0.43ha	$25-30K	$5-7K	PCC/private landholders
DUCK RIVER 5B (9)	Biodiversity enhancement: primary weed control of vines and other weeds	Medium	0.20ha	$10-15K	$2-5K	PCC/private landholders
DUCK RIVER 5B (10)	Joint actions with Auburn Council recommended in the Upper Duck River Wetlands and Riparian Management Plan: • Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	ongoing	PCC/ACC

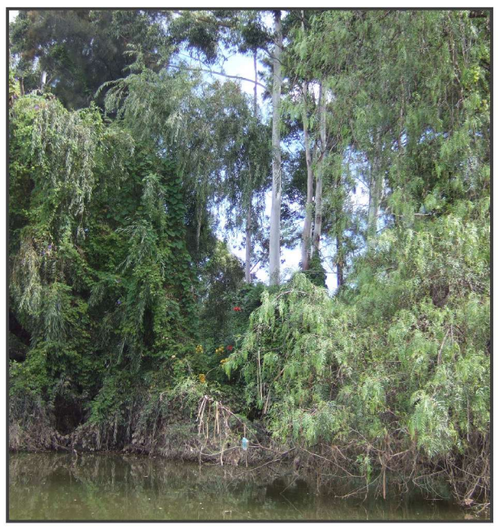


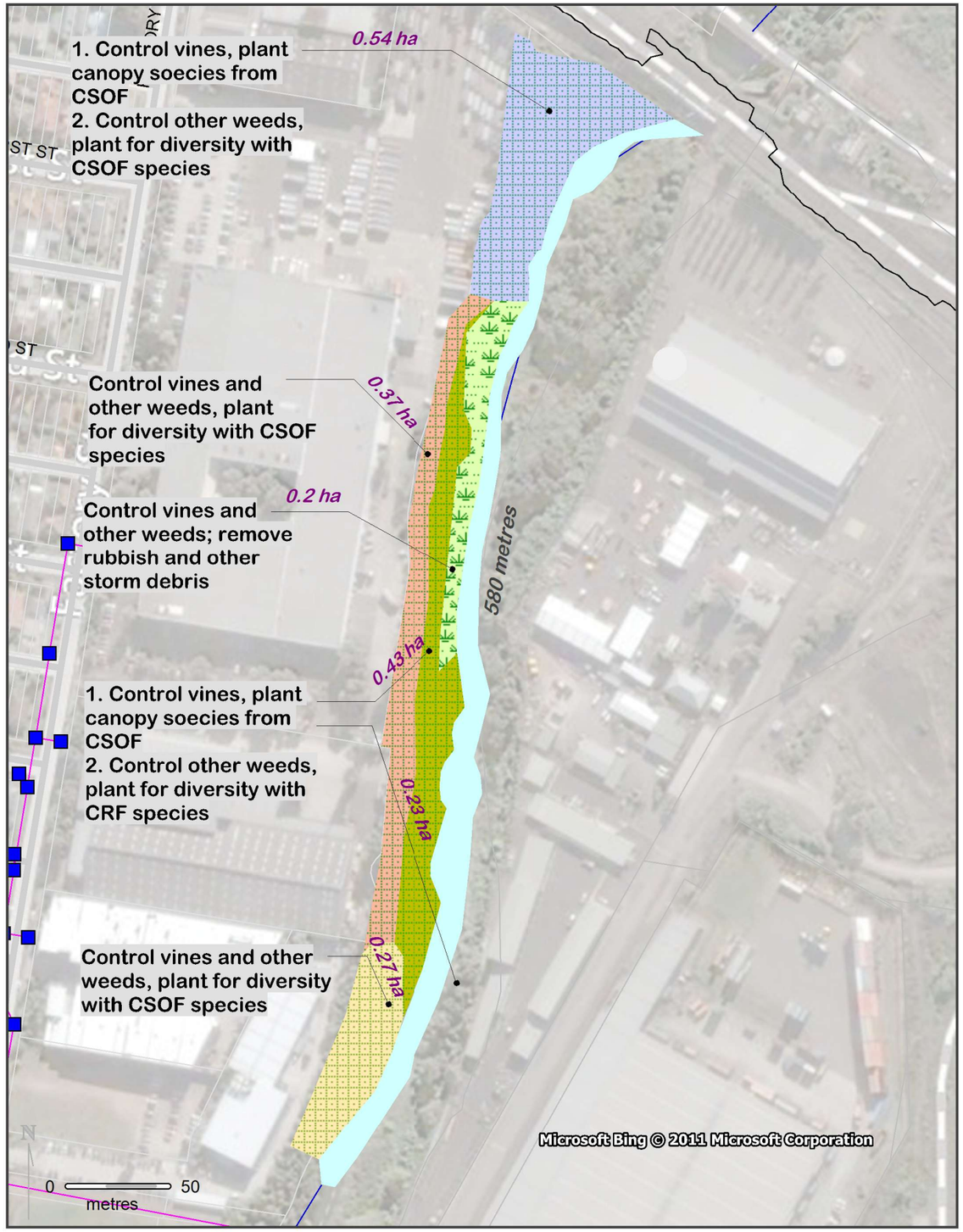


REACH: DUCK RIVER 5B

WORKS PLAN







VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Coastal Freshwater Reedlands

DUCK RIVER 6

Table 24. Management actions and works required for reach DUCK RIVER 6

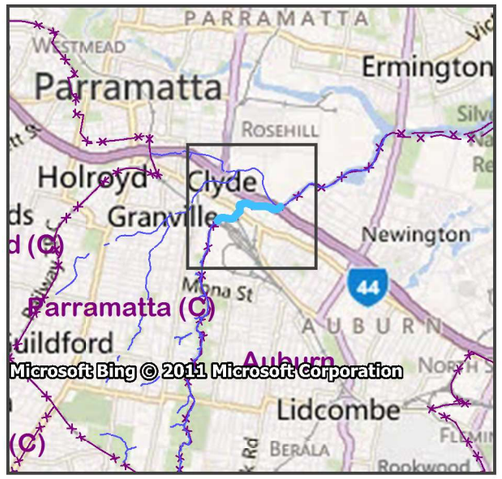
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
DUCK RIVER 6 (1)	Biodiversity enhancement: primary weed control of vines and noxious weeds	High	1.79ha	$40-50K	$5-8K	PCC/private landholders
DUCK RIVER 6 (2)	Biodiversity enhancement: weed control and infill planting for stabilisation and diversity with Cumberland Swamp Oak Riparian Forest or Cumberland Riverflat Forest species	High	1.79ha	$40-50K	$5-8K	PCC/private landholders
DUCK RIVER 6 (3)	Erosion control: monitor bank stability, especially below railways bridges	High	120m	$0-5K	N/A	PCC/private landholders
DUCK RIVER 6 (4)	Biodiversity enhancement: possible riparian buffer expansion area: weed control and infill planting for stabilisation and diversity with Cumberland Swamp Oak Riparian Forest or Cumberland Riverflat Forest species	Medium	0.82ha	$10-15K	$1000-1500	PCC/private landholders

DUCK RIVER 7

Table 25. Management actions and works required for reach DUCK RIVER 7

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
DUCK RIVER 7 (1)	Biodiversity enhancement: primary weed control of vines and noxious weeds	High	1.66ha	$40-50K	$10-15K	PCC/private landholders
DUCK RIVER 7 (2)	Biodiversity enhancement: weed control and infill planting for stabilisation and diversity with Cumberland Swamp Oak Riparian Forest or Cumberland Riverflat Forest species	High	1.66ha	$15-20K	$2-5K	PCC/private landholders
DUCK RIVER 7 (3)	Erosion control: monitor bank stability, especially around Darcy Street	High	130m	$0-10K	N/A	PCC/private landholders

REACH: DUCK RIVER 6 & 7



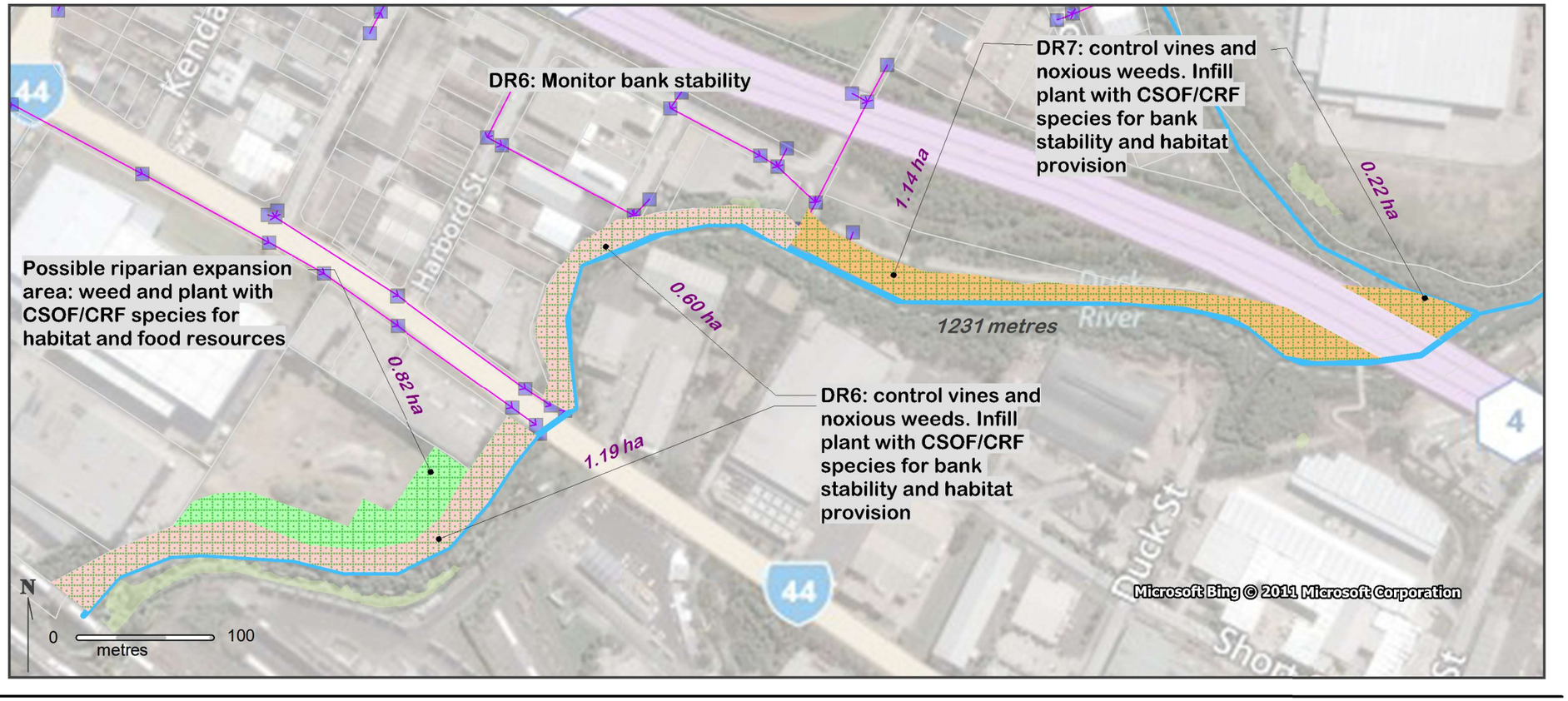
WORKS PLAN

VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Estuarine Mangrove Forest (EMF)



DUCK RIVER 8

Table 26. Management actions and works required for reach DUCK RIVER 8

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
DUCK RIVER 8 (1)	Community involvement Liaise with Shell Refinery to coordinate habitat restoration works	High/ongoing	N/A	N/A	N/A	Private landholders
DUCK RIVER 8 (2)	Biodiversity enhancement: primary weed control of vines and noxious weeds	High	20.6ha 2313m shoreline	$20-30K	$5-8K	PCC/Private landholders
DUCK RIVER 8 (3)	Biodiversity enhancement: bush regeneration weeding and infill planting for stabilisation and diversity with Cumberland Swamp Oak Riparian Forest or Cumberland Riverflat Forest species	Medium	20.6ha 2313m shoreline	$10-20K	$3-5K	PCC/Private landholders

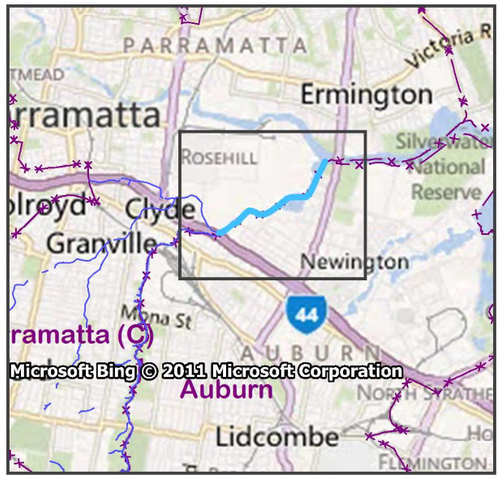


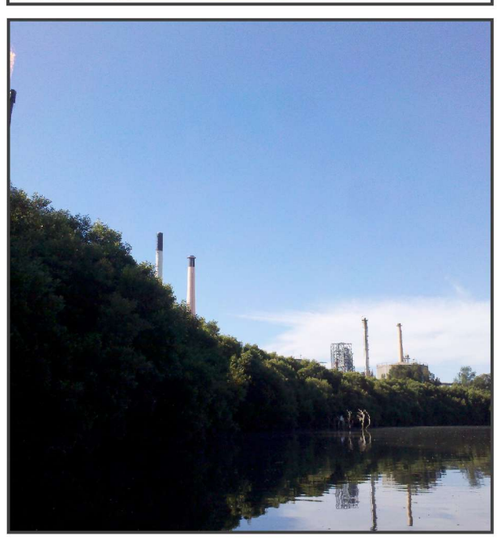


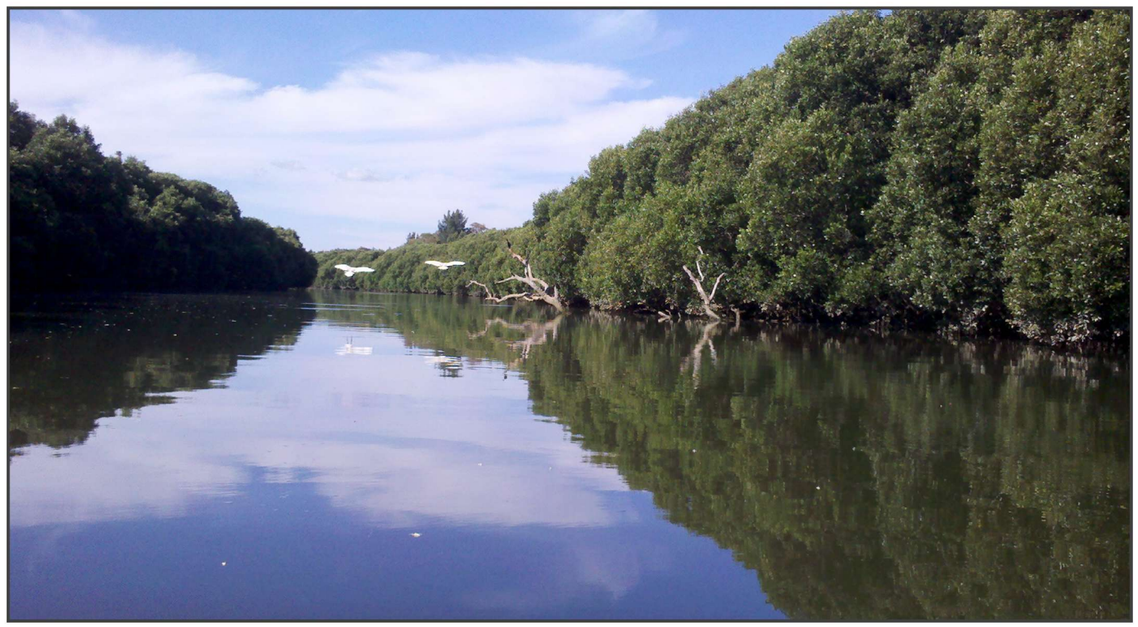



REACH: DUCK RIVER 8

WORKS PLAN





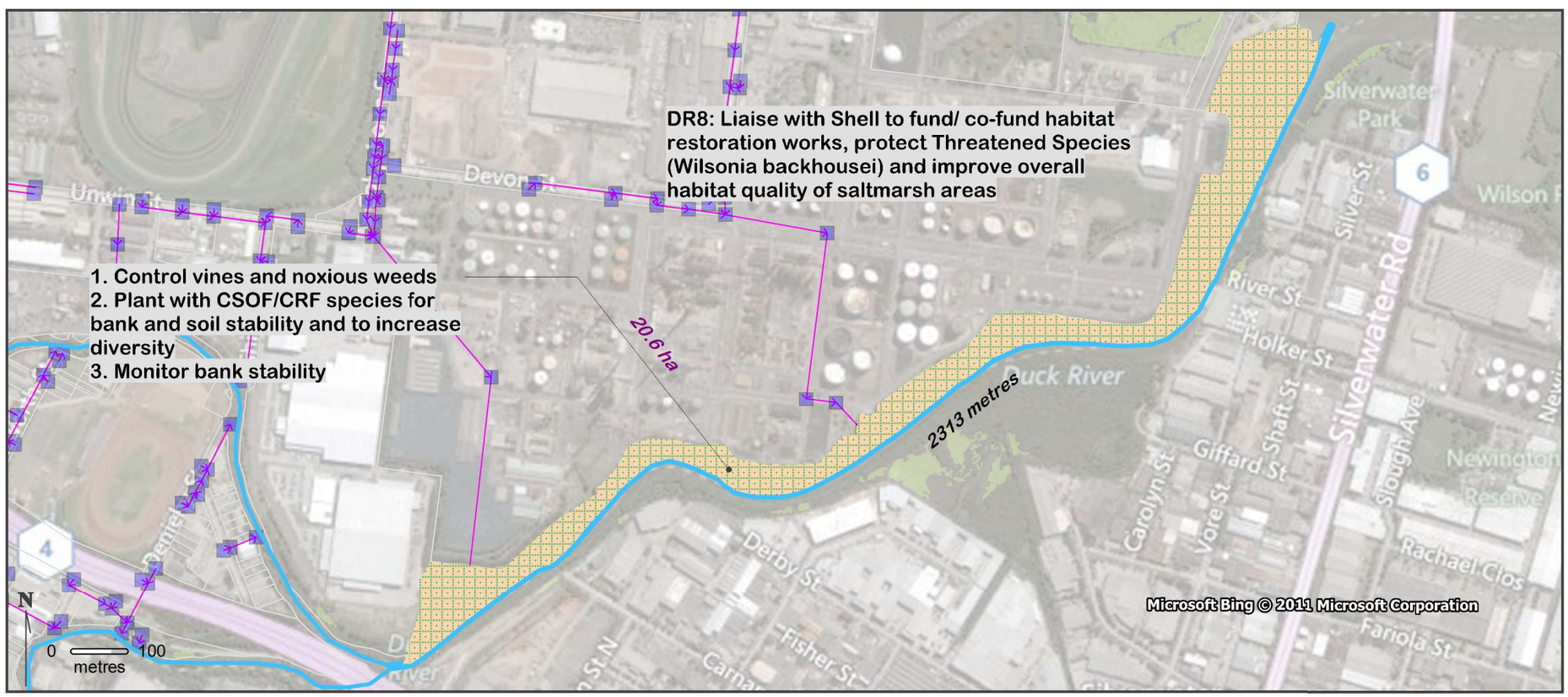


VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Estuarine Mangrove Forest (EMF)



DUCK CREEK 4

Table 27. Management actions and works required for reach DUCK CREEK 4

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
DUCK CREEK 4 (1)	Biodiversity enhancement: primary weed control of vines and noxious weeds	High	1.3ha	$40-50K	$10-20K	PCC
DUCK CREEK 4 (2)	Biodiversity enhancement: stabilise steep slopes as required, eg. Jute mat and plant	High	300m	$0-10K	N/A	PCC
DUCK CREEK 4 (3)	Biodiversity enhancement: bush regeneration weeding and infill planting for stabilisation and diversity with Cumberland Swamp Oak Riparian Forest or Cumberland Riverflat Forest species	HIgh	1.3ha	$10-20K	$2-5K	PCC

DUCK CREEK 5

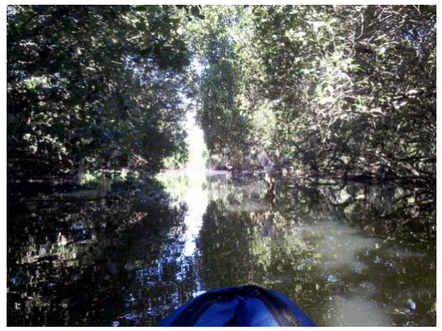
Table 28. Management actions and works required for reach DUCK CREEK 5

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
DUCK CREEK 5 (1)	Biodiversity enhancement: primary weed control of vines and noxious weeds	High	7.6ha	$40-50K	$10-20K	PCC
DUCK CREEK 5 (2)	Biodiversity enhancement: stabilise steep slopes as required, eg. Jute mat and plant, rock walls, rock groynes	High	1000m	$0-10K	N/A	PCC
DUCK CREEK 5 (3)	Biodiversity enhancement: bush regeneration weeding and infill planting for stabilisation and diversity with Cumberland Swamp Oak Riparian Forest or Cumberland Riverflat Forest species	High	7.6ha	$10-20K	$5-8K	PCC
DUCK CREEK 5 (4)	Community involvement: Liaise with local landholders to coordinate weed control; provide ongoing support as required	Medium/ongoing	N/A	N/A	N/A	Private landholders

A'BECKETTS CREEK 1 & 2

Table 29. Management actions and works required for reaches A'BECKETTS CREEK 1 & 2

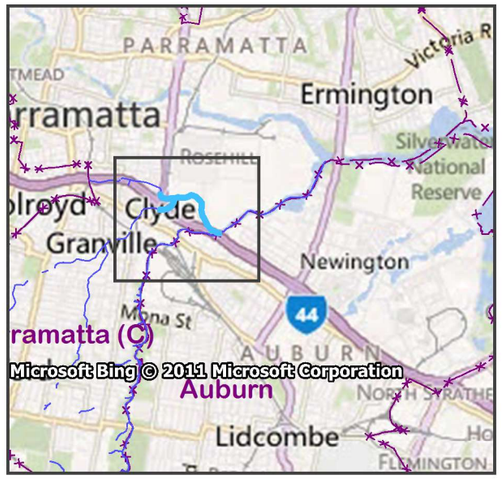
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
A'BECKETTS CREEK 1&2 (1)	Biodiversity enhancement: primary weed control of vines and noxious weeds	High	0.75ha	$30-40K	$4-6K	PCC/Sydney Water
A'BECKETTS CREEK 1&2 (2)	Biodiversity enhancement: stabilise steep slopes as required, eg. Jute mat and plant	High	150m	$5-7K	$500-1000	PCC/Sydney Water
A'BECKETTS CREEK 1&2 (3)	Biodiversity enhancement: bush regeneration weeding and infill planting for stabilisation and diversity with Cumberland Swamp Oak Riparian Forest or Cumberland Riverflat Forest species	Medium	0.75ha	$5-10K	$500-1000	PCC/Sydney Water

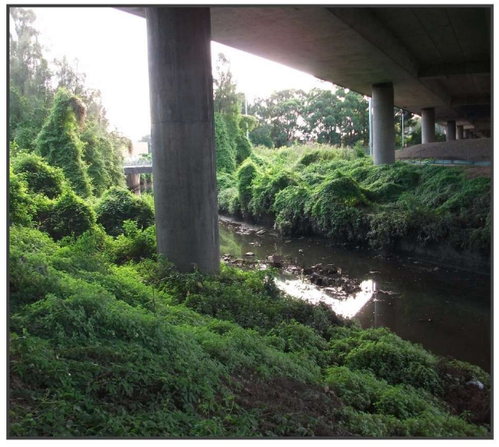


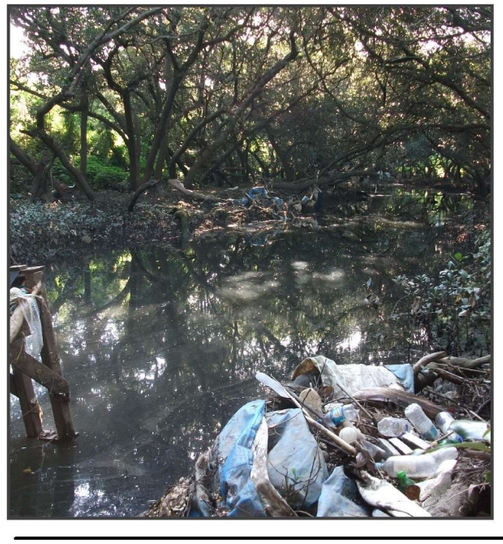


REACH: DUCK CREEK 4-5, A'BECKETTS CREEK 1B-2

WORKS PLAN



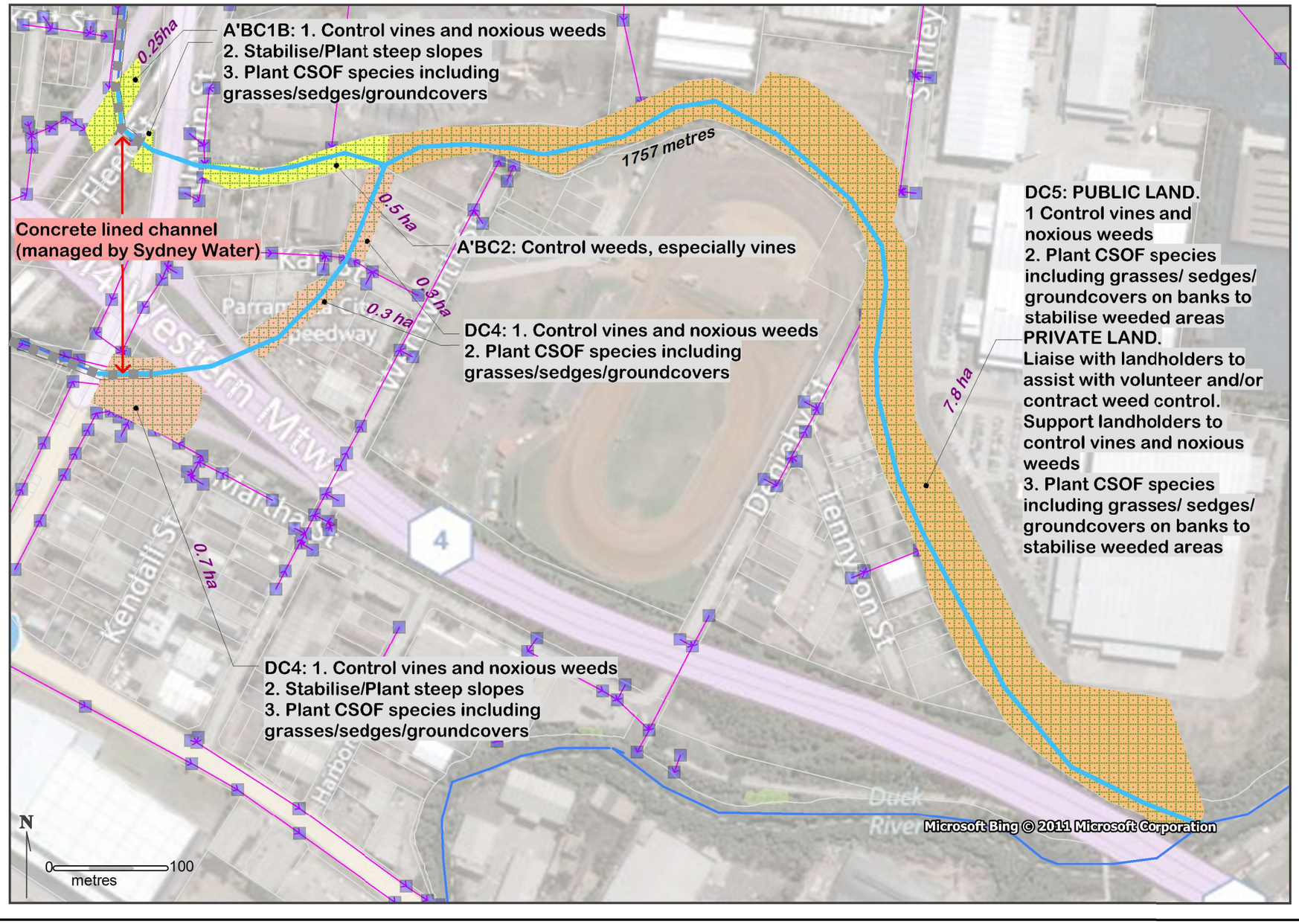




VEGETATION COMMUNITIES

Cumberland Swamp Oak Forest (CSOF)

Estuarine Mangrove Forest (EMF)



LITTLE DUCK CREEK 1A

Table 30. Management actions and works required for reach DUCK CREEK 1A

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
LITTLE DUCK CREEK 1A (1)	Erosion control: Rebatter banks where necessary in conjunction with weed removal	High	80m	$10-20K	$1-2K	PCC
DUCK LITTLE CREEK 1A (2)	Biodiversity enhancement: primary weed control of noxious and woody weeds in channel	High	0.3ha	$10-15K	$1-2K	PCC
DUCK LITTLE CREEK 1A (3)	Biodiversity enhancement: plant for stabilisation and habitat diversity with Cumberland Swamp Oak Riparian Forest or Cumberland Riverflat Forest species; target species that improve habitat resources for Grey-headed Flying Foxes	High	0.3ha	$5-10K	$1-2K	PCC
DUCK LITTLE CREEK 1A (4)	Biodiversity enhancement: riparian buffer expansion, targeting species for planting that improve resources for Grey-headed Flying Foxes	Medium	0.07ha	$2-5K	$500-1000	PCC

LITTLE DUCK CREEK 1B

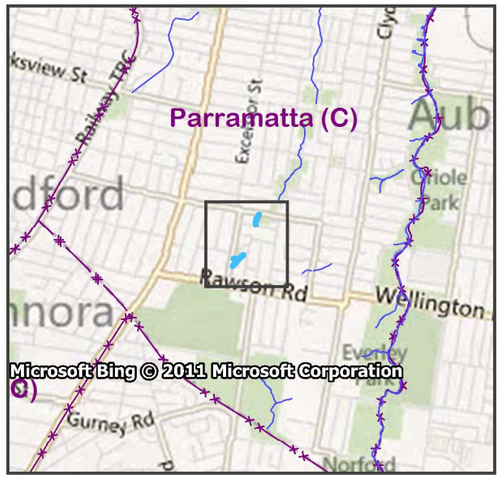
Table 31. Management actions and works required for reach DUCK CREEK 1B

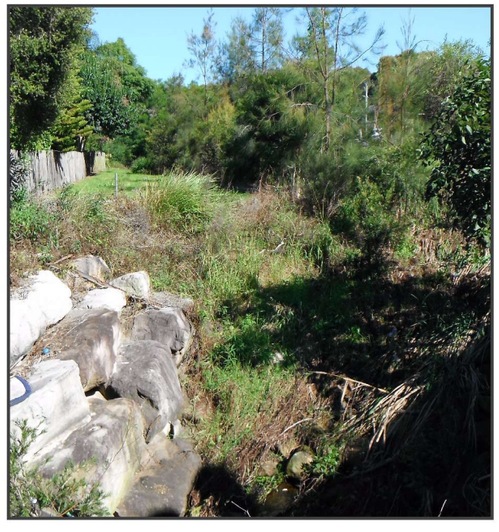
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
LITTLE DUCK CREEK 1B (1)	Water quality improvement: install gross pollutant traps (channel nets or similar) on each channel inlet; monitor for illegal dumping	Urgent/ongoing	N/A	$20-50K	$1-2K	PCC
DUCK LITTLE CREEK 1B (2)	Biodiversity enhancement: primary weed control of noxious and woody weeds in channel	High	0.5ha	$20-25K	$5-7K	PCC
DUCK LITTLE CREEK 1B (3)	Biodiversity enhancement: plant for stabilisation and habitat diversity with Cumberland Swamp Oak Riparian Forest or Cumberland Riverflat Forest species; target species that improve habitat resources for Grey-headed Flying Foxes	High	0.5ha	$5-10K	$1-2K	PCC
DUCK LITTLE CREEK 1B (4)	Biodiversity enhancement: riparian buffer expansion, targeting species for planting that improve resources for Grey-headed Flying Foxes	Medium	0.14ha	$2-5K	$500-1000	PCC

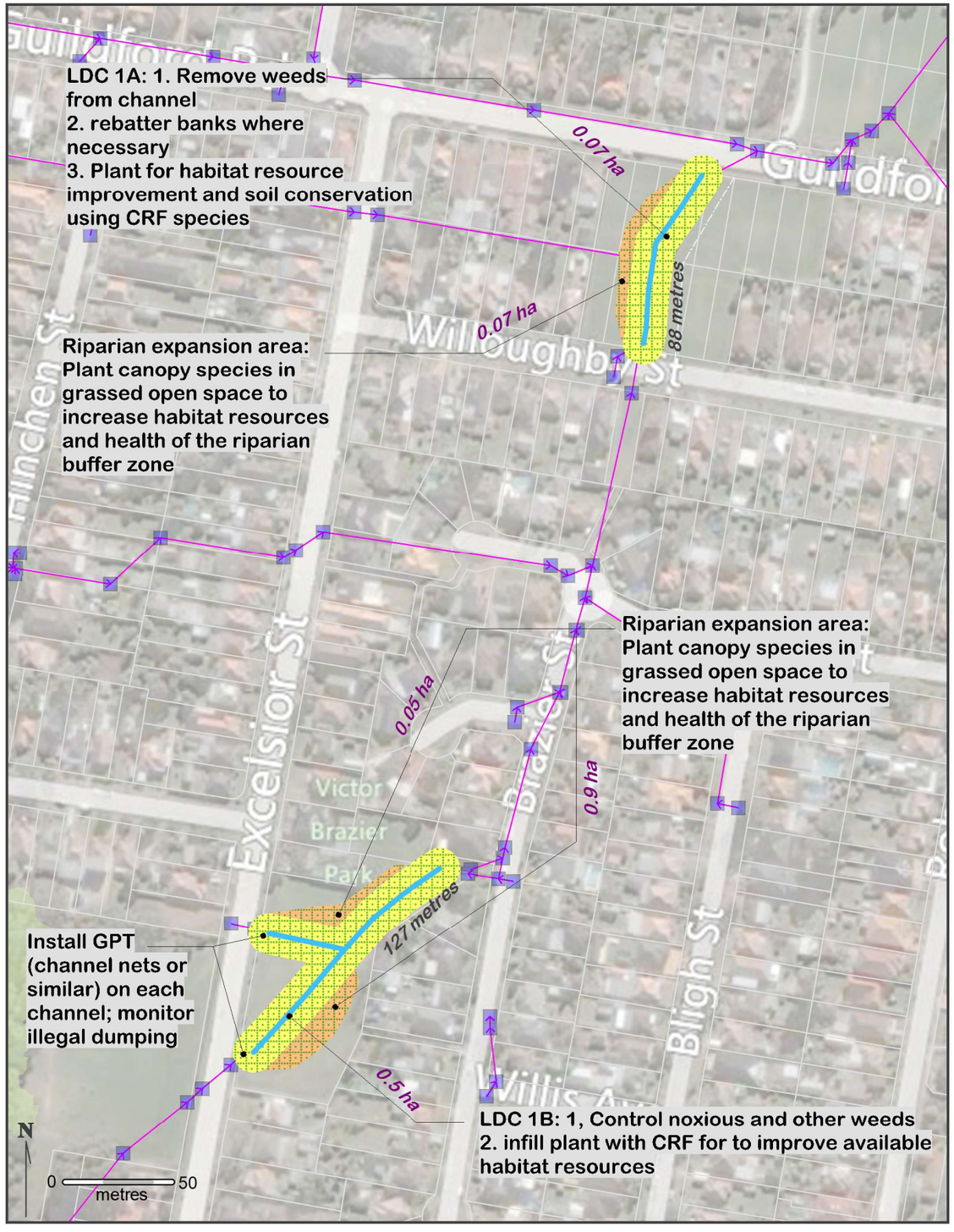




REACH: LITTLE DUCK CREEK 1A & 1B







WORKS PLAN

VEGETATION COMMUNITIES

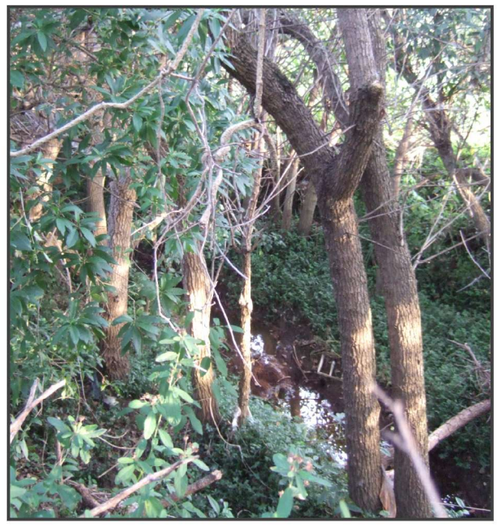
Cumberland Riverflat Forest (CRF)

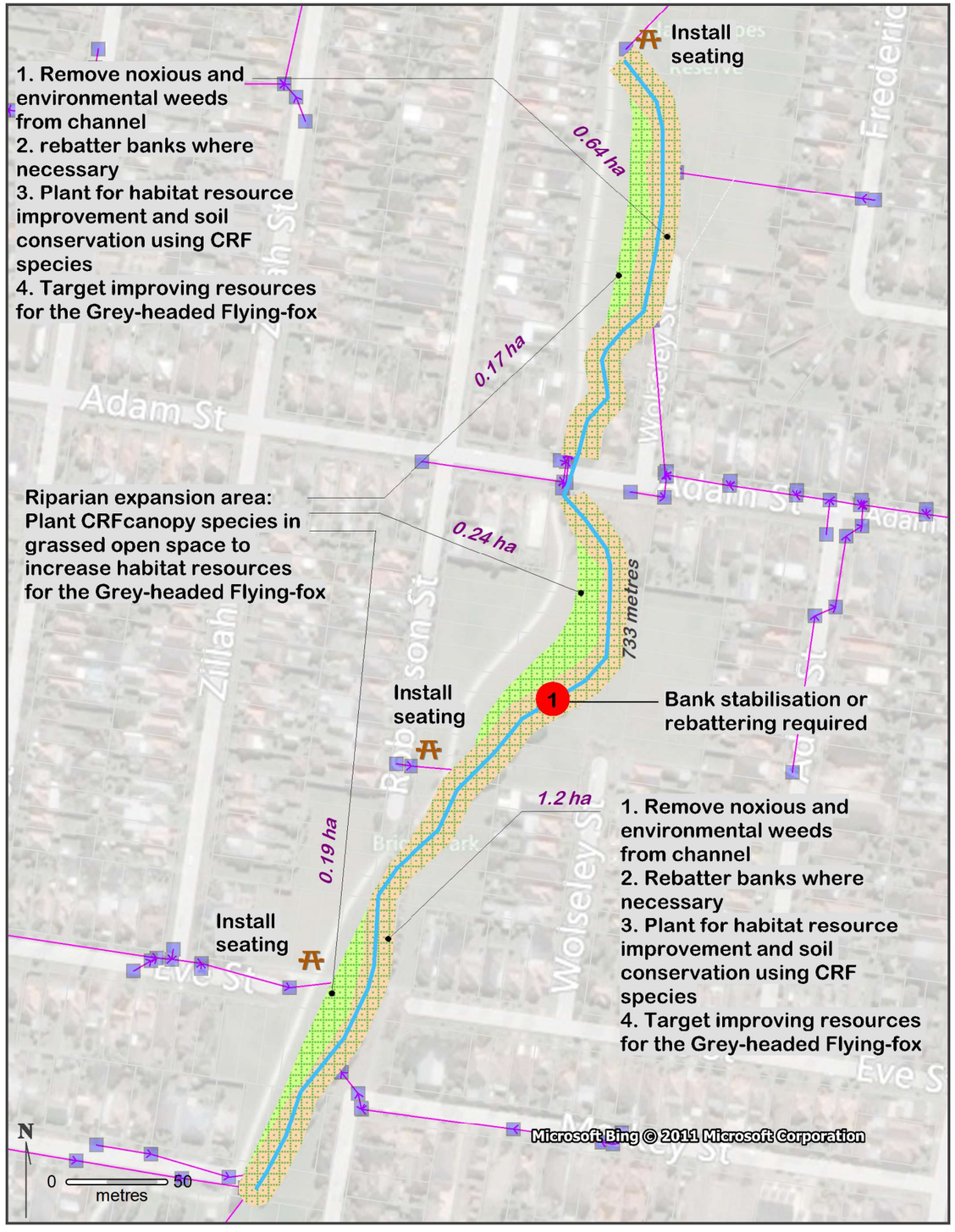
LITTLE DUCK CREEK 2

Table 32. Management actions and works required for reach DUCK CREEK 2

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
DUCK LITTLE CREEK 2 (1)	Erosion control: Rebatter banks where necessary in conjunction with weed removal	Urgent	100m	$20-50K	$0-2K	
LITTLE DUCK CREEK 2 (2)	Biodiversity enhancement: primary weed control of noxious and woody weeds in channel	High	1.84ha	$60-75K	$5-10K	
DUCK LITTLE CREEK 2 (3)	Biodiversity enhancement: plant for stabilisation and habitat diversity with Cumberland Swamp Oak Riparian Forest or Cumberland Riverflat Forest species; target species that improve habitat resources for Grey-headed Flying Foxes	High	1.84ha	$40-50K	$5-10K one year only	
DUCK LITTLE CREEK 2 (4)	Biodiversity enhancement: riparian buffer expansion, targeting species for planting that improve resources for Grey-headed Flying Foxes	Medium	0.60ha	$10-15K	$1-3K one year only	

REACH: LITTLE DUCK CREEK 2

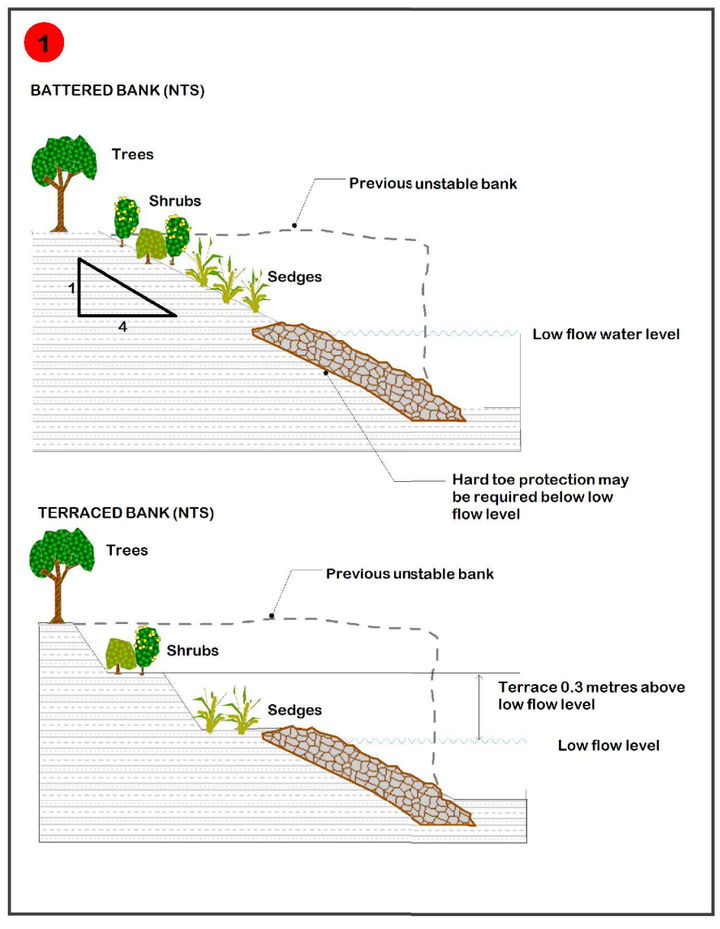




WORKS PLAN

VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)



SMALLS CREEK 1

Table 33. Management actions and works required for reach SMALLS CREEK 1

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
SMALLS CREEK 1 (1)	Biodiversity enhancement: primary weed control of vines and noxious weeds	High	1.74ha	$40-50K	$5-10K	PCC
SMALLS CREEK 1 (2)	Biodiversity enhancement: bush regeneration weeding and infill planting for stabilisation and diversity with Cumberland Riverflat Forest species	High	1.74ha	$5-10K	$1-2K	PCC
SMALLS CREEK 1 (3)	Erosion control: monitor bank stability – do not over clear. Stabilise steep slopes as required, eg. Jute mat and plant, rock line channel or toe	High	200m	$0-10K	N/A	PCC
SMALLS CREEK 1 (4)	Biodiversity enhancement: control environmental weeds and infill planting as required with Cumberland Riverflat Forest species	Medium	0.7ha	$5-10K	$1-2K	PCC

UNNAMED 1A CAMPBELL HILL

Table 34. Management actions and works required for reach UNNAMED 1A CAMPBELL HILL

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
UNNAMED 1A (1)	Water quality improvement: install trash rack or trash trap at inflow next to Campbell Hill Rd	Urgent	N/A	$20-25K	$1-2K	PCC
UNNAMED 1A (2)	Biodiversity enhancement: bush regeneration weeding and infill planting for stabilisation and diversity with Cumberland Plain Woodland species	High	1.35ha	$5-10K	$500-1000	PCC
UNNAMED 1A (3)	Erosion control: Monitor bank stability around new steps; increase planting density in this area; use stabilising plants from Cumberland Plain Woodland	High	0.1ha	$1-3K	$500	PCC
UNNAMED 1A (4)	Biodiversity enhancement: plant canopy species in grassed open space as a buffer for reed lined channel, use Shale Gravel Transition Forest species	Medium	0.25ha	$5-7K	$1000-1500 one year only	PCC

UNNAMED 1B WADDANGALI

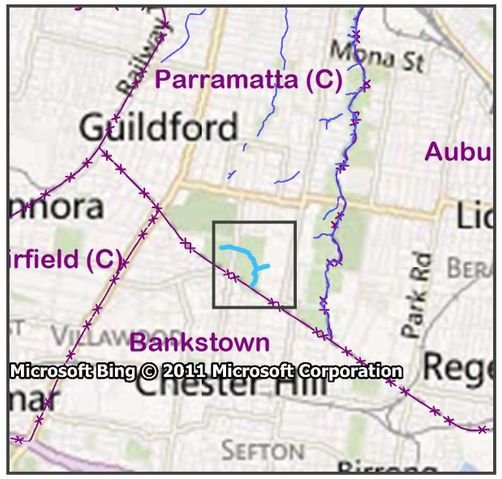
Table 35. Management actions and works required for reach UNNAMED 1B WADDANGALI

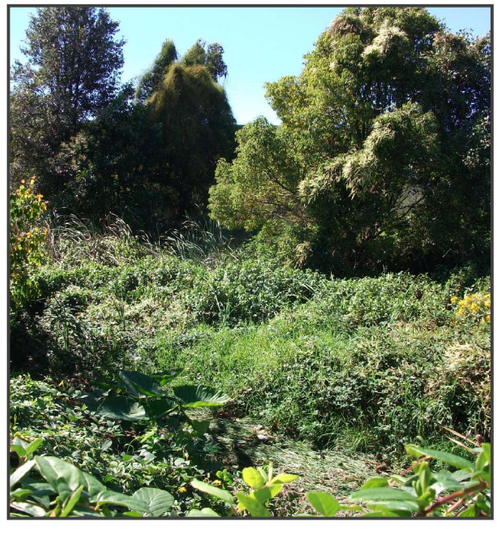
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
UNNAMED 1B (1)	Biodiversity enhancement: bush regeneration weeding and infill planting for stabilisation and diversity with Cumberland Plain Woodland species	High	1.11ha	$5-7K	$500-1000	PCC
UNNAMED 1B (2)	Biodiversity enhancement: develop whole of reserve management plan with staged removal of noxious and other weeds in swampy areas, and incorporate habitat replacement using Cumberland Plain Woodland species	High	N/A	$8-12K	N/A	PCC

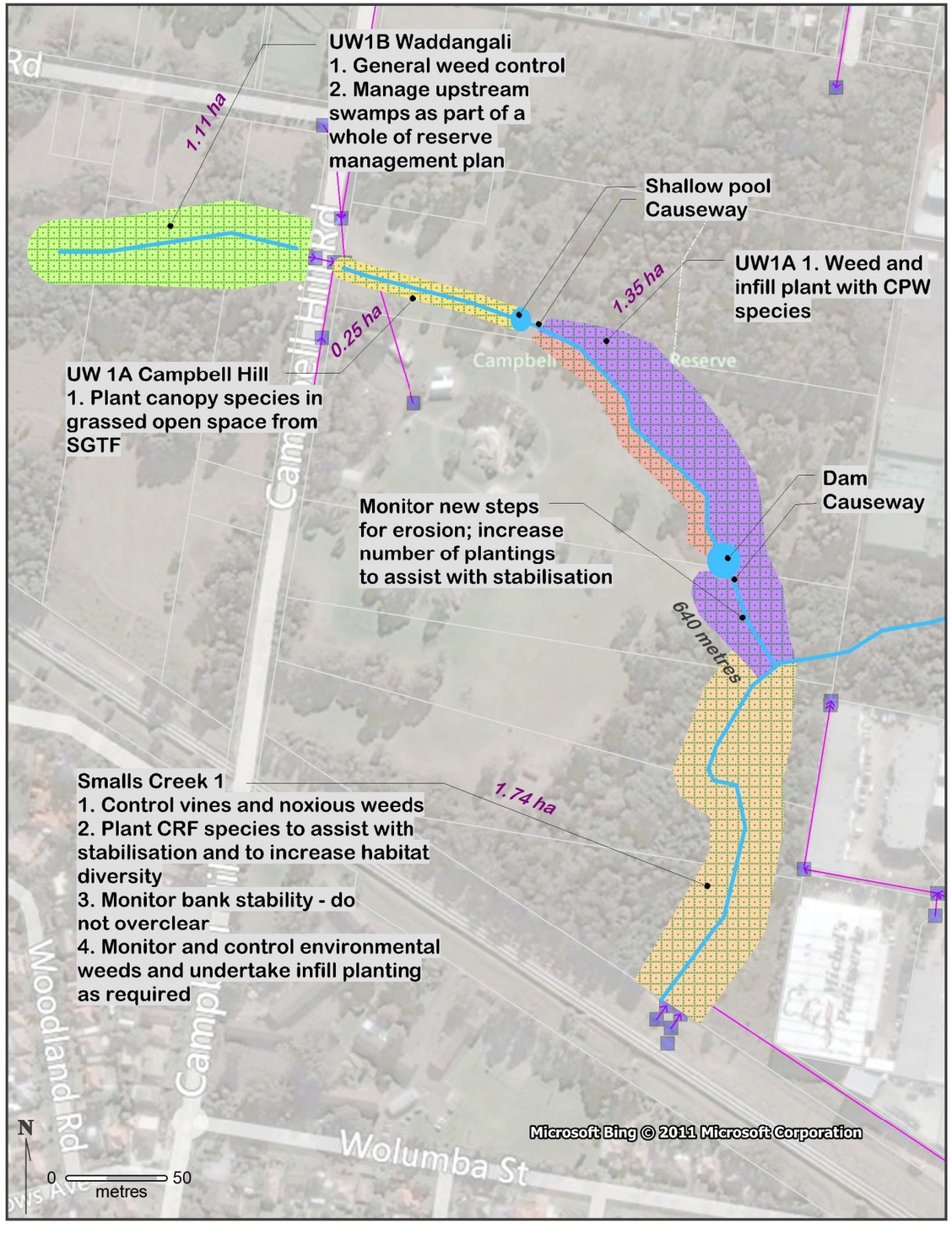




REACH: SMALLS CREEK, UNNAMED 1A & 1B







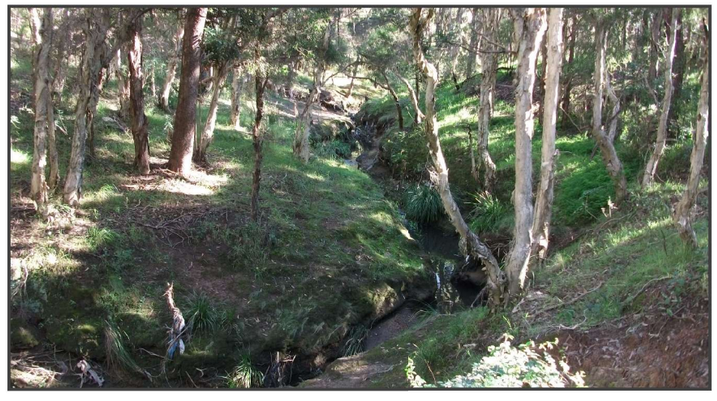
WORKS PLAN

VEGETATION COMMUNITIES

Cumberland Plain Woodland (CPW)

Cumberland Riverflat Forest (CRF)

Shale-gravel Transition Forest (SGTF)



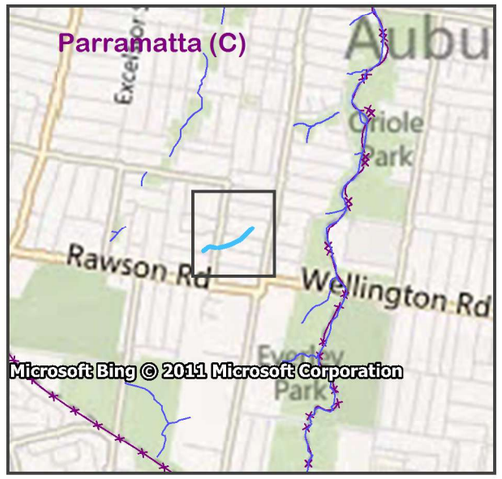
UNNAMED 2A RANDOLPH ST

Table 36. Management actions and works required for reach UNNAMED 2A RANDOLPH ST

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
UNNAMED 2A (1)	Biodiversity enhancement: primary weed control of noxious and woody weeds	High	0.77ha	$10-15K	$1-2K	PCC
UNNAMED 2A (2)	Biodiversity enhancement: bush regeneration weeding and infill planting for stabilisation and diversity with Cumberland Swamp Oak Riparian Forest or Cumberland Riverflat Forest species	Medium	0.77ha	$2-5K	$500-1000	PCC
UNNAMED 2A (3)	Biodiversity enhancement: possible riparian buffer expansion area: weed control and infill planting for stabilisation and diversity with Cumberland Swamp Oak Riparian Forest or Cumberland Riverflat Forest species; target species that improve resources for Grey-headed Flying Foxes	Medium	0.16ha	$2-5K	$500 one year only	PCC

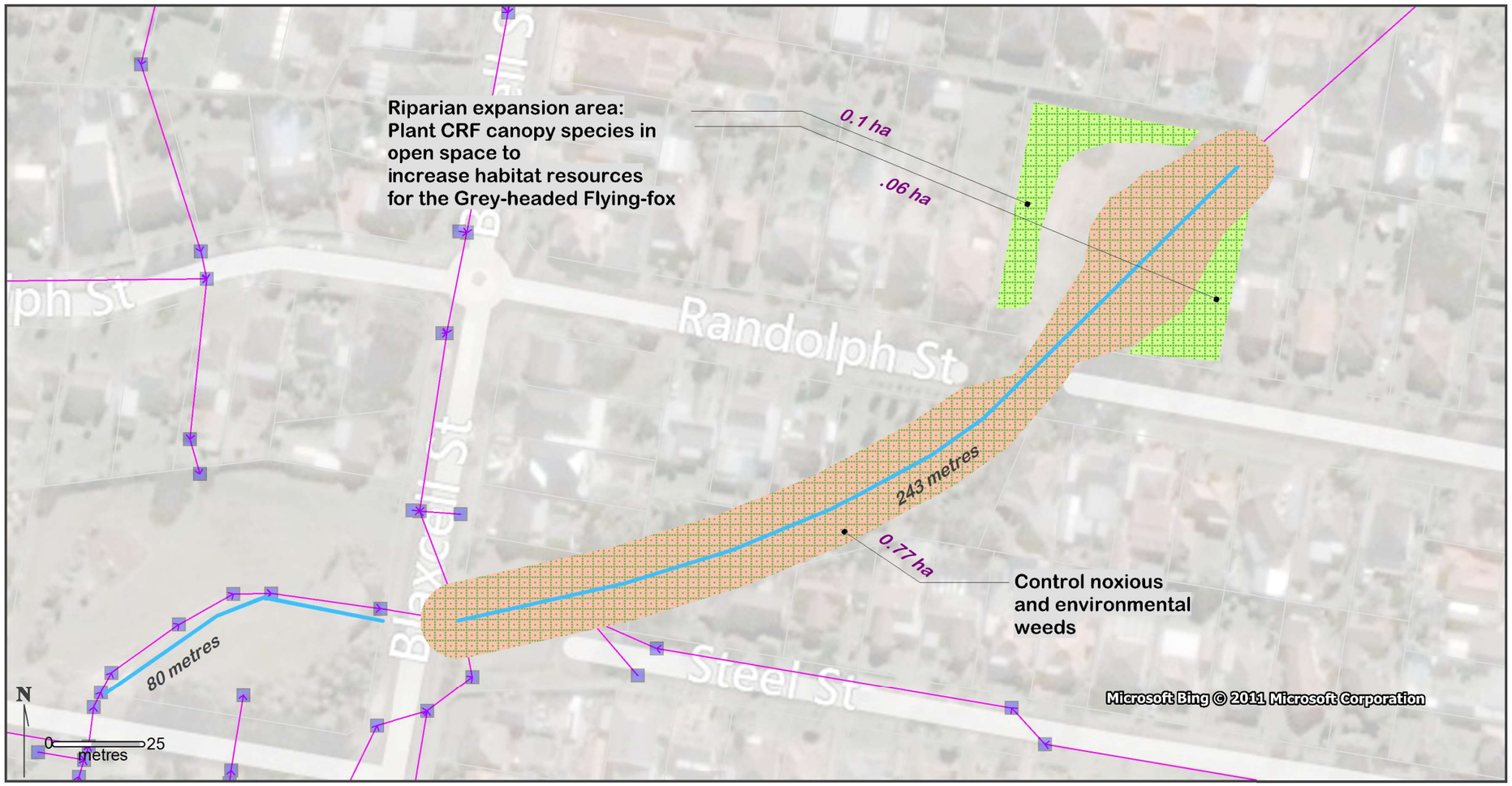
REACH: UNNAMED 2A

WORKS PLAN



VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)



REVIEW OF SETBACKS AND BUFFERS FOR NEW DEVELOPMENT

REQUIREMENTS FOR FLOOD PROTECTION

Molino Stewart (2011) estimated overfloor flooding for properties in the Duck River catchment. Floor levels were estimated from the height of the building floor above ground level and obtaining the ground level from the aerial laser survey provided by PCC. Floor height for non-residential properties (mainly industrial and large commercial premises in the lower part of the Duck River and Duck Creek catchments) was assumed to be 0.5m. Overfloor flooding of properties was estimated for probable maximum flooding events (PMF), and a series of flood average recurrence intervals (ARIs) ranging from 5 to 100 years (Table 37).

Table 37. Estimated overfloor flooding for properties in the Duck River catchment (from Molino Stewart, 2011)

SUB-CATCHMENT	PMF	100y ARI	50y ARI	20y ARI	5y ARI
Duck River	217	0	0	0	0
Duck Creek	906	93	63	35	6
Little Duck Creek	377	78	54	38	8
Commercial/ Industrial	220	39	28	17	7
TOTAL	1720	210	145	90	21

Key areas affected by flooding, even at shorter ARIs, are in Duck Creek, Little Duck Creek and the commercial and industrial areas in the lower part of Duck River. Residential properties affected by overfloor flooding in a 5 or 20 year event should be considered for voluntary buyback by PCC in areas where the channel is not under Sydney Water management. This will create opportunities for localised enhancement of biodiversity resources in these areas, as well as mitigating flood impacts.

BIOPHYSICAL REQUIREMENTS

The following vegetated riparian buffer requirements have been noted:

- Minimum distances to manage water quality processes in the riparian zone vary with rainfall intensity, soil type and land use characteristics. Connecticut River Joint Commission (1998) suggest a range of 38-46m for nutrient removal in forests with medium density groundcover on moderate slopes
- Ideal buffer widths for fauna habitat and movement are difficult to estimate, but a basic corridor linkage is recommended to improve the creek's value

- Minimum distances to attenuate overland flows for a catchment with gentle to moderate slope and medium to high groundcover are recommended to be 15m to 30m (MWH Australia P/L, 2003)
- LWA (2000) recommend a minimum width for riparian vegetation of 20m as being suitable for most situations, but needing to be wider where pollutant loads and slopes are greater

Based on this, an optimum width of 30m vegetated buffer – ideally with local native species from the appropriate vegetation community – is recommended, with a minimum of 20m to be enforced for all future developments.

The riparian zone may include existing developed areas – such as sporting fields, ovals, fences and even small buildings. In effect, these are part of the functional riparian zone, even though they are unnatural. From a land use management perspective, we suggest that the designation should not affect existing use rights, but that community education and landholder co-operation could be used by Council to actively support and encourage better management (such as joint rehabilitation projects and control of polluted runoff).

ZONING AND SETBACKS

The specific reference to provision of buffers in design principles in the Parramatta LEP 2011 refers to Clause 6.7 Foreshore Building Line and Clause 6.5 Water Protection. Consideration of the foreshore building alignment generally applies to foreshore downstream of the M4 motorway crossing. There is no specific reference to buffers or setbacks under Clause 6.5, Water Protection that may otherwise suggest a specific buffer distance or setback to riparian land and waterways.

Biodiversity design principles for development of land abutting land zones E2 and W1 in the LEP (2011) also recognise the need for "the requirement for provision of a buffer zone on the abutting land to protect the bushland area" although a specific distance/width is not specified. Molino Stewart (2011) suggests a riparian zone of between 20m and 40m on both sides of the Duck River based on the need for three specific zones:

1. Core riparian zone – land in and adjacent to the channel;
2. Vegetated buffer to protect the integrity of the core riparian zone; and
3. An asset protection zone for protection against bushfire damage.

Part 6 of LEP 2011 includes several sub-clauses that provide additional protection for lands in the riparian corridor. Part 6.4 Biodiversity protection aims to maintain terrestrial and aquatic biodiversity, and applies to a small parcel of land immediately downstream of Seventh Ave, Granville, and an unpiped section of Smalls Creek between factories.

Part 6.5 Water protection aims to maintain the hydrological functions of riparian land, waterways and aquifers, and applies to a small parcel of land immediately downstream of Seventh Ave, Granville, and small portions of residential blocks adjoining UNNAMED 3 CLYDE/BENNETT STS.

The recommended setbacks are congruent with the requirements under each relevant section of Parramatta LEP 2011.

TIMEFRAME FOR REVIEW

Review of the Masterplan should be conducted in two ways over different timeframes:

- Review of progress of works allowing for financial and environmental considerations
- Revision/rewriting of the Masterplan

REVIEW OF PROGRESS OF WORKS

Rate of progress of environmental restoration works are affected by a range of variables that are generally beyond the control of implementing authorities, including:

- Availability of funding
- Seasonal variables
- Rainfall regime
- Bushfire
- Vandalism
- Availability of local provenance tubestock suitably matured for planting

In the normal course of a rehabilitation program, works follow a sequential path, with each taking a period of time that may be affected by any of these variables. Thus the rehabilitation program is effectively a dynamic strategy, changing as works are completed, additional works are required, or new issues arise. Regular review should be conducted annually at a minimum to determine progress. An annual review will allow for modification of the implementation program as required.

REVISION/REWRITING OF THE MASTERPLAN

The Masterplan is considered current for a minimum period of 5 years. Annual review will extend the relevant lifespan of the plan, and retain a works focus on appropriate objectives and issues. The Masterplan should be updated as required, or within 3 years from completion or the last review.

Revision of the Masterplan should consider the following aspects:

- Results of bushland rehabilitation activities
- Results of water quality monitoring
- Whether short and medium term management objectives have been completed
- Whether any new issues arise that have not been previously addressed
- Whether existing management objectives are still current and appropriate

The Masterplan should be revised earlier if any of the following occurs:

- a significant change occurs in the catchment due to fire, flood or other catastrophic event
- additional information becomes available that changes the objectives or desired outcomes of management
- new issues are raised which require immediate attention
- additional funding for works becomes available
- data becomes available that indicates that the objections are not able to be achieved

APPENDIX ONE: COMMUNITY CONSULTATION

COMMUNITY WORKSHOP

Issues identified

Participants at the community consultation workshop identified the following issues:

- Pioneer reserve on a Sunday afternoon – terrible rubbish.
- Granville bridge on The Avenue...lots of rubbish.
- Community education on rubbish for people with a non English speaking background.
- Need to keep/maintain /improve the integrity of the natural bushland.
- Are the schools involved in Streamwatch?
- How do we engage culturally – other ethnic groups want to know.
- Water pollution from poor development and management.
- Verges that have been sprayed and eroded.
- We don't want a cycleway through the Duck River bushland.
- People in the football season – the football tape is all over the park.
- We don't really want to have people fishing....
- Maintenance of the sediment traps are supposed to be on a monthly cycle – some have not (ponds) been done in 9 months.
- Sediments very very poor quality – especially on the bed and banks.
- Mowing areas with alligator weeds = spread it.
- High turnover of parks grounds management staff, so they are not familiar with local issues
- Engaging community and industry – how do we achieve this?
- Purchase the land – department of housing owns some land? Identify areas for voluntary buyback.
- OHS concerns for self guided walks. Some raised walkways – some of it got burned up and removed.
- Bike jumps – cutting down trees for bikes jumps and bike paths. Need somewhere else to construct the ramps for the bikes.
- Dead end streets – people go up and dump in them.
- Fruit trees – tree nets. Fruit net in urban areas – have to look into the regulations.
- Trees that are cut down – on private land.
- Scar trees – important for indigenous heritage – an extra 60 trees that council does not know about.
- Planted out the island – and planted it out which was a significant aboriginal site. Japanese gardens built over a burial site where there was a massacre.

Opportunities identified

Participants at the community consultation workshop identified the following opportunities:

- Rangers for the rubbish. ??
- Education in schools.
- Contact local takeaways – educate about rubbish. Business products are all around the area. Put a bit of pressure on them.

- Maybe there needs to be something like cleanup Australia type day/s to clean up the rubbish.
- Start with schools and adopt some bushland. Pride in peoples kids and pride in the bushland.
- Five schools in the catchment doing environmental programs on the Duck River throughout the year.
- Need to have a plan that says that these are the places for nature and these are the places for mixed – the rest is urban.
- Fine the football clubs if they don't clean up their rubbish!
- Council does compliance – they do the surveys around shopping centres, not in areas. Rubbish is recyclable – it needs to be captured and recycled.
- Some guided walks in the Duck River bushland .
- Adopt a river section and linking it to pride – positive advertising when they look good.
- Auburn council – ":natural area coordinator" – got some new candidates and staff coming on. Mainly for the Duck River.
- Large community comes into the catchment every day - some corporate people are desperate to do something in the community – corporate responsibility every day volunteering in their work plan – large workforce available to get them in? "Cause some of the grief and does not stay". Massive workforce - companies come and wear their shirts - the whole thing is coordination – it costs a lot to coordinate.

Desired outcomes

Participants at the community consultation workshop identified the following as desired outcomes:

- Some areas for nature and not just universal access.
- Signage around the parks for litter.
- So little bushland – so little left. So precious – we just want to keep it nice!
- Protect the sacred sites and then educate other groups about the cultural law . i.e this is a women's birthing site etc.
- Building sites that have been managed properly.
- Better coordination between councils. One bit of work on one side but not the other. Council should know that if they start something they need to have a 10year commitment.
- Significant reduction in rubbish and resulting storm debris; fines for non compliance
- Sediment basins are emptied twice a year or as required.
- An education strategy or information booklet that targets parks services. Clearly identify areas that are managed as natural heritage and those that are mixed use.
- Catchment management programs – supporting programs that Council is doing – put the emphasis back on council to be systematic about how it is implemented. Need to know what all the peripheral plans say too. The masterplan needs to be the primary document.
- Council/businesses – sign off on an MOU?? Get some signatory agreement to assist with the management.
- River rewards scheme to highlight something positive.
- Sydney water plan – CMA catchment Action Plan – catchment wide targets etc. Important that the longer term goals in the broader strategies they need to be referred to.
- A Duck River Steering Committee for implementing the actions – constant feedback.

- The bushland is too small – we want to get into the urban footprint. They should be using street trees – local species etc – very rarely enforced. Eg factory developments. – peoples yards.
- Developments next to sensitive areas need to be triple checked and incorporate WSUD and any potential changes to the development. Population will increase in Parramatta. Feed into Councillors through a steering committee??

COMMUNITY SURVEY QUESTIONNAIRE

Community responses to questionnaires

A number of stakeholders completed the Community Consultation Survey Questionnaire. The responses from these questionnaires were collected to determine the key values and issues for the catchment. The following were identified as important for a vision for Duck River Catchment:

- Conserves natural qualities 15 responses
- Appealing, accessible and sustainable 13 responses
- Offers recreational opportunities (passive) 10 responses
- Improve water quality and waste management 8 responses
- Conserves heritage values 8 responses
- Important contribution to the character of the area 6 responses
- A sense of place for the community 4 responses
- Improve habitat 3 responses

APPENDIX TWO: FLORA FOR REVEGETATION

Cumberland Swamp Oak Riparian Forest, S_FoW07 (SMCMA, 2010)

The distinguishing feature is the prominent stands of swamp oak (*Casuarina glauca*) found along or near streams. Often these are relatively young trees, swarming amongst a mix of old and young eucalypts such as rough barked apple (*Angophora floribunda*), forest red gum (*Eucalyptus tereticornis*) and grey box (*Eucalyptus molucanna*). The understorey is typical of the open grassy and herbaceous characteristics of other riverflat forests.

Cumberland Swamp Oak Riparian Forest is a component of River Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions, and is listed as an Endangered Ecological Community under the NSW Threatened Species Conservation Act 1995 (TSC Act).

Table A 1. Species recommended for revegetation in Cumberland Swamp Oak Riparian Forest

CORE SPECIES	ADDITIONAL SPECIES
TREES & SHRUBS	
Acacia decurrens	*Angophora floribunda*
Bursaria spinosa	*Breynia oblongifolia*
Casuarina glauca	*Eucalyptus baueriana*
Eucalyptus moluccana	*Eucalyptus crebra*
Maytenus silvestris	*Eucalyptus tereticornis*
Melaleuca decora	*Jacksonia scoparia*
Melaleuca nodosa	*Melaleuca styphelioides*
Ozothamnus diosmifolius	*Polyscias sambucifolia*
VINES & GROUNDCOVERS	
Alisma plantago-aquatica	*Adiantum aethiopicum*
Brunoniella australis	*Alternanthera denticulata*
Commelina cyanea	*Arthropodium milleflorum*
Damasonium minus	*Billardiera scandens*
Dichondra repens	*Carex appressa*
Echinopogon ovatus	*Centella asiatica*
Eclipta platyglossa	*Cheilanthes sieberi subsp. Sieberi*
Einadia hastate	*Clematis glycinoides var. glycinoides*
Eleocharis cylindrostachys	*Dianella longifolia*
Entolasia marginata	*Dianella revoluta var. revoluta*

CORE SPECIES	ADDITIONAL SPECIES
Glycine tabacina	*Dichelachne micrantha*
Pratia purpurascens	*Eragrostis leptostachya*
Senecio hispidulus	*Glycine microphylla*
Veronica plebeia	*Gonocarpus tetragynus*
Wahlenbergia gracilis	*Goodenia ovata*
	Hibbertia diffusa
	Juncus usitatus
	Lomandra longifolia
	Microlaena stipoides var. stipoides
	Oplismenus aemulus
	Oxalis exilis
	Oxalis perennans
	Persicaria decipiens
	Plantago debilis
	Poa labillardierei
	Poranthera microphylla
	Pseuderanthemum variabile
	Setaria distans
	Solanum prinophyllum
	Tetragonia tetragonioides

Coastal Freshwater Reedland, S_FrW03 (SMCMA, 2010)

Coastal Freshwater Reedland is found on poorly drained alluvial flats and sand depressions across the NSW east coast. These swamps are predominantly freshwater communities although some swamps may be brackish. The reedlands are tall sometimes reaching over 3 metres in height and are dominated by one or two species, predominantly common reed (*Phragmites australis*) and cumbungi (*Typha orientalis*). Other tall reeds include *Elaeocharis sphacelata*. The continous cover of reedlands may include a sparse cover of swamp oak (*Casuarina glauca*) or swamp paperbark (*Melaleuca ericifolia*) on the drier margins of the swamp.

Many of these remaining swamps in the SMCMA area are situated amongst intense urban landuses. In these environments drainage patterns have been altered and weeds are prolific at many sites. Where these swamps occur on muds, sands, silts and loams associated with coastal floodplains they forma component of Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney

Basin and South East Corner bioregions an Endangered Ecological Community listed under Schedule1 of the NSW Threatened Species Act, 1995.

Table A 2. Species recommended for revegetation in Coastal Freshwater Reedlands

CORE SPECIES	ADDITIONAL SPECIES
TREES & SHRUBS	
Melaleuca ericifolia	*Casuarina glauca*
	Melaleuca decora
	Melaleuca linariifolia
VINES & GROUNDCOVERS	
Blechnum indicum	*Baumea juncea*
Eleocharis sphacelata	*Bolboschoenus fluviatilis*
Hemarthria uncinata var. uncinata	*Carex appressa*
Hydrocotyle verticillata	*Gleichenia dicarpa*
Hypolepis muelleri	*Juncus continuus*
Isachne globosa	*Juncus planifolius*
Juncus kraussii	*Parsonsia straminea*
Phragmites australis	*Philydrum lanuginosum*
Typha orientalis	

Cumberland Riverflat Forest, S_FoW06 (SMCMA, 2010)

Cumberland Riverflat Forest is an open eucalypt forest that forms narrower ribbons alongside streams and creeks that drain the Cumberland Plain. Typically the canopy includes one of the rough-barked apple (*Angophora floribunda*) or broad-leaved apple (*Angophora subvelutina*) and one or both of forest red gum (*Eucalyptus tereticornis*) and cabbage gum (*Eucalyptus amplifolia*). However there are a wide variety of other interesting eucalypts that are highly localised.

Cumberland Riverflat Forest is a component of River Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions and is listed as an Endangered Ecological Community under the NSW Threatened Species Conservation Act 1995 (TSC Act).

Table A 3. Species recommended for revegetation in Cumberland Riverflat Forest

CORE SPECIES	ADDITIONAL SPECIES
TREES & SHRUBS	
Acacia decurrens	*Eucalyptus amplifolia*
Angophora floribunda	*Eucalyptus saligna*

CORE SPECIES	ADDITIONAL SPECIES
Bursaria spinosa	*Exocarpos cupressiformis*
Eucalyptus baueriana	*Grevillea robusta*
Eucalyptus tereticornis	*Leucopogon juniperinus*
Hibiscus heterophyllus	*Persoonia linearis*
Ozothamnus diosmifolius	*Pittosporum undulatum*
	Trema tomentosa
VINES & GROUNDCOVERS	
Brunoniella australis	*Adiantum aethiopicum*
Cheilanthes sieberi subsp. Sieberi	*Cyperus laevis*
Commelina cyanea	*Dianella longifolia*
Clematis glycinoides var. glycinoides	*Echinopogon caespitosus var. caespitosus*
Desmodium varians	*Einadia trigonos*
Dichondra repens	*Eragrostis leptostachya*
Digitaria parviflora	*Microlaena stipoides var. stipoides*
Echinopogon ovatus	*Pratia purpurascens*
Einadia hastata	*Wahlenbergia gracilis*
Entolasia marginata	*Veronica plebeia*
Glycine clandestina	
Glycine microphylla	
Glycine tabacina	
Marsilea hirsuta	
Oplismenus aemulus	
Oxalis perennans	
Solanum prinophyllum	

Cooks River/Castlereagh Ironbark Forest S_DSF01 (includes Cooks River Clay Plain Scrub Forest) (SMCMA, 2010)

Castlereagh Ironbark Forest is associated with clay soils derived from Tertiary alluvial deposits. The structure ranges from a moderately tall open eucalypt forest or woodland to a low dense thicket of paperbarks with low emergent eucalypts. The latter is prevalent across the catchment of the Cooks River and is recognised in other classifications as Cooks River Clay Plain Scrub.

Broad-leaved ironbark (*Eucalyptus fibrosa*) is the most commonly recorded eucalypt although at some sites it may be absent. Other species such as woollybutt (*Eucalyptus longifolia*) is a more regular associate although sites often have a diverse canopy composition which reflects subtle grades between substrates sourced from tertiary sand, sandstone bedrock, shale and ironstone gravels. A prominent small tree layer of *Melaleuca decora* features above dense cover of shrubs that include *Melaleuca nodosa*, blackthorn (*Bursaria spinosa*) and peach heath (*Lissanthe strigosa*).

Castlereagh Ironbark Forest is a component of Cooks River/Castlereagh Ironbark Forest in the Sydney Basin an Endangered Ecological Community listed under Schedule 1 of the NSW Threatened Species Conservation Act 1995.

Table A 4. Species recommended for revegetation in Cooks River/Castlereagh Ironbark Forest

CORE SPECIES	ADDITIONAL SPECIES
TREES & SHRUBS	
Acacia decurrens	*Acacia falcata*
Acacia pubescens	*Acacia parramattensis*
Bursaria spinosa	*Daviesia ulicifolia*
Eucalyptus crebra	*Dillwynia parvifolia*
Eucalyptus fibrosa	*Dillwynia sieberi*
Leucopogon juniperinus	*Eucalyptus eugenioides*
Lissanthe strigosa	*Eucalyptus longifolia*
Melaleuca decora	*Eucalyptus tereticornis*
Melaleuca nodosa	*Exocarpos cupressiformis*
Pultenaea villosa	*Maytenus silvestris*
	Notelaea longifolia
	Ozothamnus diosmifolius
	Persoonia linearis
	Polyscias sambucifolia
VINES & GROUNDCOVERS	
Aristida vagans	*Austrostipa rudis*
Austrodanthonia tenuior	*Billardiera scandens*
Brunoniella australis	*Bossiaea prostrata*
Cheilanthes sieberi subsp. sieberi	*Calotis cuneifolia*
Desmodium varians	*Cymbopogon refractus*
Dianella revoluta var. revolute	*Dianella longifolia*

CORE SPECIES	ADDITIONAL SPECIES
Dichelachne micrantha	*Einadia hastate*
Dichondra repens	*Entolasia marginata*
Echinopogon caespitosus var. caespitosus	*Entolasia stricta*
Echinopogon ovatus	*Euchiton sphaericus*
Glycine clandestina	*Glycine tabacina*
Glycine microphylla	*Gonocarpus tetragynus*
Goodenia hederacea subsp. hederacea	*Hibbertia pedunculata*
Hardenbergia violacea	*Hypericum gramineum*
Hibbertia aspera subsp. aspera	*Lagenophora stipitata*
Lomandra filiformis	*Laxmannia gracilis*
Lomandra multiflora	*Lepidosperma laterale*
Opercularia diphylla	*Microlaena stipoides var. stipoides*
Oxalis perennans	*Olearia microphylla*
Panicum simile	*Poa labillardierei*
Poranthera microphylla	*Polymeria calycina*
Pratia purpurascens	*Pomax umbellata*
Setaria distans	*Veronica plebeia*
Themeda australis	
Vernonia cinerea var. cinerea	
Wahlenbergia gracilis	

Cumberland Shale Plains Woodland (S_GW03)

The gentle topography associated with the shale plains of Western Sydney carries an open grassy woodland dominated by grey box (*Eucalyptus moluccana*), forest red gum (*Eucalyptus tereticornis*) and ironbark (*Eucalyptus crebra/Eucalyptus fibrosa*). Localised patches of spotted gum (*Corymbia maculata*) may occur. Cumberland Shale Plains Woodland is the second of the grassy woodlands that comprise the Cumberland Plain Woodland endangered ecological community listed under the NSW Threatened Species Conservation Act, 1995. Like the related community Cumberland Shale Hills Woodland it is typified by a sparse to moderate cover of shrubs and a high cover of grasses and forbs.

Research has defined the primary habitat for the community as occurring at elevations less than 150 meters above sea level with some sites occurring at higher elevations where the landscape remains gently inclined. Rainfall is restricted to a narrow band between 750-950 millimetres per annum.

Table A 5. Species recommended for revegetation in Cumberland Shale Plains Woodland

CORE SPECIES	ADDITIONAL SPECIES
TREES & SHRUBS	
Bursaria spinosa	*Acacia decurrens*
Eucalyptus moluccana	*Acacia implexa*
Eucalyptus tereticornis	*Breynia oblongifolia*
	Daviesia ulicifolia
	Dillwynia sieberi
	Eucalyptus crebra
	Ozothamnus diosmifolius
VINES & GROUNDCOVERS	
Aristida vagans	*Austrostipa rudis*
Aristida ramosa	*Arthropodium milleflorum*
Brunoniella australis	*Asperula conferta*
Cheilanthes sieberi subsp. Sieberi	*Austrodanthonia racemosa var. racemosa*
Chloris ventricosa	*Austrodanthonia tenuior*
Cymbopogon refractus	*Dianella revoluta var. revoluta*
Desmodium varians	*Echinopogon caespitosus var. caespitosus*
Dianella longifolia	*Echinopogon ovatus*
Dichelachne micrantha	*Einadia hastata*
Dichondra repens	*Entolasia marginata*
Eragrostis leptostachya	*Eremophila debilis*
Euchiton sphaericus	*Fimbristylis dichotoma*
Glycine clandestina	*Goodenia hederacea subsp. hederacea*
Glycine microphylla	*Hypericum gramineum*
Glycine tabacina	*Hypoxis hygrometrica*
Hardenbergia violacea	*Juncus usitatus*
Lomandra filiformis	*Lachnagrostis filiformis*
Microlaena stipoides var. stipoides	*Lomandra multiflora*
Opercularia diphylla	*Panicum effusum*
Oxalis perennans	*Panicum simile*

CORE SPECIES	ADDITIONAL SPECIES
Setaria distans	*Phyllanthus virgatus*
Stackhousia viminea	*Plantago debilis*
Themeda australis	*Poa labillardierei*
Tricoryne elatior	*Poranthera microphylla*
Wahlenbergia gracilis	*Pratia purpurascens*
	Solanum prinophyllum
	Sporobolus creber
	Vernonia cinerea var. cinerea
	Veronica plebeia

Castlereagh Shale-Gravel Transition Forest (S_DSF02)

Castlereagh Shale-Gravel Transition Forest is recognised as a community associated with shale influenced sandy soils that support a component of ironstone gravels. The location of these soils can occur in remarkably different locations. Some are associated are with low lying tertiary alluvium overlying shale soils in the Bankstown area, whereas others occur on the northern Woronora Plateau where residual shale caps lie above bands of ironstone laterite and sandstone bedrock. The combination of the parent material produces a soil of relatively low fertility compared to the deeper Wianamatta Shale soils of the Cumberland Plain.

Together with a relatively low mean annual rainfall (800-900 millimetres) these conditions produce an open eucalypt forest with an understorey that may vary between dense shrubs to a low sparse shrub cover with an abundant groundcover of grasses.

Typically the canopy includes broad-leaved ironbark (Eucalyptus fibrosa) along with a wide variety of other eucalypts depending on location. The taller paperbark Melaleuca decora may be prominent above a lower open shrub layer of blackthorn (Bursaria spinosa) and gorse bitter pea (Daviesia ulicifolia). The ground cover is a mix of grasses, sedges and herbs. This community can be difficult to distinguish from the closely related Castlereagh Ironbark Forest on the basis of floristic composition alone. Within the SMCMA, mean species diversity for this community tends to be lower although this may be influenced by disturbance.

Table A 6. Species recommended for revegetation in Castlereagh Shale-Gravel Transition Forest

CORE SPECIES	ADDITIONAL SPECIES
TREES & SHRUBS	
Acacia falcata	*Acacia decurrens*
Bursaria spinosa	*Amyema gaudichaudii*
Daviesia ulicifolia	*Eucalyptus crebra*

CORE SPECIES	ADDITIONAL SPECIES
Eucalyptus fibrosa	*Eucalyptus globoidea*
Eucalyptus moluccana	*Melaleuca nodosa*
Eucalyptus tereticornis	*Ozothamnus diosmifolius*
Lissanthe strigosa	*Pultenaea villosa*
Melaleuca decora	
VINES & GROUNDCOVERS	
Aristida vagans	*Austrostipa rudis*
Atriplex semibaccata	*Bossiaea prostrata*
Brunoniella australis	*Brunoniella pumilio*
Cheilanthes sieberi subsp. sieberi	*Dianella longifolia*
Dianella revoluta var. revolute	*Echinopogon caespitosus var. caespitosus*
Dichelachne micrantha	*Echinopogon ovatus*
Dichondra repens	*Einadia hastata*
Glycine clandestina	*Entolasia stricta*
Glycine tabacina	*Eragrostis leptostachya*
Hardenbergia violacea	*Goodenia hederacea subsp. hederacea*
Lomandra filiformis	*Imperata cylindrica*
Lomandra multiflora	*Lepidosperma laterale*
Opercularia diphylla	*Microlaena stipoides var. stipoides*
Panicum simile	*Pimelea linifolia*
Themeda australis	*Pomax umbellata*
	Pratia purpurascens

APPENDIX THREE:

Best Practice guidelines for the following works activities are described in detail in Appendix Four.

WORKS ACTIVITIES FOR BIODIVERSITY ENHANCEMENT

Table A 7. Works activities recommended for biodiversity enhancement, with works category, guidelines and comments

SPECIFIC WORKS REQUIRED	WORKS CATEGORY	GUIDELINES AND COMMENTS
Bush regeneration weed control	Preservation requirements	Applies to bushland areas where there is existing native canopy with some native understorey and some native groundcover. These areas usually require removal of weeds to improve their overall condition; planting should not be required.
Primary weed control	Restoration works	Applies to bushland areas where there are considerable weed impacts in the canopy, midstorey and groundlayers. A staged removal of weeds is recommended, generally starting with woody weeds and shrubs, then groundlayer weeds. NOTE: noxious weeds should be treated as the first priority. In many cases, supplementary planting will be required (see below). A primary weed control program must include secondary and subsequent (followup) weed control activities. Most weeds are not effectively controlled by one treatment. Target weed species and floristic groups that have been identified as key threatening processes (NSW Dept Environment & Heritage): • Invasion and establishment of exotic vines and scramblers • Invasion and establishment of Scotch Broom • Invasion, establishment and spread of Lantana • Invasion of native plant communities by exotic perennial grasses

SPECIFIC WORKS REQUIRED	WORKS CATEGORY	GUIDELINES AND COMMENTS
Primary weed control of vines	Restoration works	Applies to bushland areas where there is significant impacts from exotic vines. NOTE: Invasion of exotic vines and scramblers is listed as a key threatening process. Control of vines should be followed by a reassessment of the ecological condition of the bushland. Generally, further primary weed control will be required. Vines must be controlled before any planting is commenced, as young plants can quickly become smothered. Ongoing control of vines should be implemented.
Local provenance plant propagation	Preservation requirements Restoration works	Local provenance species should be used for replanting where possible. When estimating the number of species, allowance should be made for replacement planting and on-going maintenance. A list of flora species for revegetation in each of the identified vegetation communities is provided in Appendix C.
Planting guidelines	Restoration works Ongoing maintenance	Undertake weed control activities first. Soil must be properly prepared before planting. Dig a hole that is big enough to loosen the soil around where the plant will go. Use native plant food and water retention crystals in the hole. Water in well and mulch or use a weed suppression mat. See section #
Infill planting for diversity	Restoration works	Dense weed infestations can suppress local native plant diversity. In areas where there are dense infestations over a large area, with little good bushland nearby, there is limited opportunities for improving floristic diversity by natural regeneration. Consider which vegetation layers need supplementing, and whether this can be achieved by direct seeding. Choose species from the appropriate vegetation communities provided in Appendix C.
Planting for stabilisation	Restoration works	Removal of a dense weed infestation can create bare areas. The best way to stabilise these areas is to establish a good vegetation cover as quickly as possible using local native species. Consider a combination of brush matting and tubestock planting. Brush

SPECIFIC WORKS REQUIRED	WORKS CATEGORY	GUIDELINES AND COMMENTS
		matting with native plant material that includes fruiting or seeding structures is a method of direct seeding that also provides temporary cover for potential erosion points. Brush matting should be installed to a depth of 0.5m. Monitor for compaction, erosion and vandalism. Choose nearby bushland areas as a source for the brush, and never over-harvest. A maximum of 10% of the whole plant should be harvested at any time. Do not reharvest for brush matting from the same plant for 5 years. Choose species from the appropriate vegetation communities provided in Appendix C. Give priority to species that develop deep roots quickly, or provide good groundcover – a mixture of these is best.
Revegetation planting	Restoration works	Applies to areas that have little or no native species present. These areas are generally targeted to improve connectivity between adjoining areas of better bushland. See comments for stabilisation planting and infill planting for diversity (above). Consider a staged planting program (see riparian buffer expansion planting). Choose species from the appropriate vegetation communities provided in Appendix C.
Riparian buffer expansion planting	Restoration works	Applies to areas where there is potential to expand the existing riparian buffer. Generally this buffer is currently narrow, and provides limited benefits to the wetlands. Riparian buffer expansion planting involves the complete recreation of native bushland. A staged planting program will achieve the best results. Plant colonising species first, along with canopy species. Generally accepted density for revegetation with trees is one per 5m2. These can be evenly distributed or clumped together; however, clumping can provide protection against wind and storms during the first five years of growth. Colonising species such as acacias help to promote soil heath which improves the establishment of eucalypts and other tree species. Faster growing shrubs also provide some protection for saplings. Once these plants are well established, infill plant with additional shrubs and groundcover species to improve the diversity of the buffer area.

SPECIFIC WORKS REQUIRED	WORKS CATEGORY	GUIDELINES AND COMMENTS
Plant fringing vegetation	Restoration works	Applies to areas with multiple use demands to be managed. Protection of wetland areas is best managed through the establishment of a fringing buffer of native vegetation. This is the normal condition for these wetlands. Width of this fringing buffer is determined by the availability of land for planting around the wetland perimeter.
Monitor bank stability and install jute matting with stabilisation planting	Restoration works Ongoing maintenance	Applies to areas with very steep banks. Weed control activities can create bare areas. In steeper areas, brush matting and tubestock planting may not be enough. Additional stabilisation can be achieved by installing jute mesh or jute matting, and planting into this at regular intervals (minimum 4 plants per m2). Where minor erosion points are apparent, consider the use of brush check dams and/or coir logs to provide temporary stabilisation during plant establishment. For more serious erosion, further consultation is recommended; these may require hard engineered solutions.
Control/remove introduced ducks and geese	Restoration works	This may require some community liaison before implementation. A number of local residents feed the ducks and geese as part of their regular activities. Contact a pest bird control company for removal of pest waterbird species. Engage the community in ongoing monitoring to ensure they do not become re-established in the area.
Control carp populations	Restoration works	A carp control program should be developed. This can include considerable community input, and may provide an effective way of engaging and educating additional members of the community. See section # for details.

WORKS ACTIVITIES FOR WATER QUALITY IMPROVEMENT

Table A 8. Works activities recommended for water quality improvement, with works category, guidelines and comments

WORKS REQUIRED	WORKS CATEGORY	GUIDELINES AND COMMENTS
Install trash rack, use appropriate height to accommodate flood flows	Major capital works	This needs to be properly sized and installed. Preparation and implementation of an operations and maintenance plan is a major component of the success of this type of structure. See section # for examples.
Install end of pipe litter control device	Minor capital works	This needs to be properly sized and installed. Preparation and implementation of an operations and maintenance plan is a major component of the success of this type of structure. See section # for examples.
Install trash trap or similar litter control device	Minor capital works	This needs to be properly sized and installed. Preparation and implementation of an operations and maintenance plan is a major component of the success of this type of structure. See section # for examples.
Maintain mesh trash traps regularly; prepare and implement an Operations and Maintenance Plan	Ongoing maintenance Preservation requirements	Prepare an Operations and Maintenance Manual and schedule for all GPTs and other SQIDs in the Upper Duck River catchment, and ensure the recommendations are implemented
Remove litter and debris from fringing reeds; consider installation of floating trash trap	Preservation requirements Major capital works	Use of booms to control litter in Duck River has proved unsuccessful. Netting, dragging and hand collection of litter/storm debris around wetlands can be conducted by boat. This will provide an initial clean up of the area; however, this needs to be maintained
Remove sediment plug and other rubbish/storm debris	Ongoing maintenance	Must be conducted by suitably qualified and experienced earthworks operator – type of machinery should be determined during a preliminary site inspection
Water quality monitoring	Preservation requirements	Liaise with local primary and high schools to implement a Streamwatch monitoring

WORKS REQUIRED	WORKS CATEGORY	GUIDELINES AND COMMENTS
point	Ongoing maintenance	program at a number of points along the main channel of Duck River. This will help to identify what the main pollution loadings are, and where they are coming from. Results of these monitoring programs can then be used to inform a targeted water quality improvement program.

WORKS ACTIVITIES FOR EROSION CONTROL

Table A 9. Works activities recommended for erosion control, with works category, guidelines and comments

WORKS REQUIRED	WORKS CATEGORY	GUIDELINES AND COMMENTS
Toe protection works	Minor capital works or Major capital works	This needs to be properly sized and installed. See individual works plans for examples.
Bank stabilisation works	Major capital works	This needs to be properly sized and installed. See individual works plans for examples.
Outlet protection	Minor capital works or Major capital works	This needs to be properly sized and installed. See individual works plans for examples.

WORKS ACTIVITIES FOR COMMUNITY AND RECREATION

Table A 10. Works activities recommended for community involvement and recreation, with works category, guidelines and comments

WORKS REQUIRED	WORKS CATEGORY	GUIDELINES AND COMMENTS
Install seating	Minor capital works	Must comply with relevant design standards and guidelines for urban infrastructure
Install informative signage	Minor capital works	Must comply with relevant design standards and guidelines for urban infrastructure
Install weather shelters	Minor capital works	Must comply with relevant design standards and guidelines for urban infrastructure
Formalise existing path by constructing all weather crushed granite footpath for pedestrian access	Minor capital works	Must comply with relevant design standards and guidelines for urban infrastructure
Concrete footpath/cycleway to provide linkages with existing road and footpath network	Minor capital works or Major capital works	Must comply with relevant design standards and guidelines for urban infrastructure
Install pedestrian footbridge across river/wetlands	Major capital works	Must comply with relevant design standards and guidelines for urban infrastructure
Manage as grassed open space	Ongoing maintenance	Create a clear delineation between grassed open space zones and bushland management zones. Use timber edging or similar method. Prevent the spread of exotic grasses and other environmental weeds to adjoining bushland. Avoid use of fertilizers and herbicides that may affect bushland health or water quality in nearby waterways.

APPENDIX FOUR: ADDITIONAL INFORMATION FOR GUIDELINES

These revegetation guidelines are designed to specify the processes, techniques and standards required for effective restoration of landscapes for biodiversity conservation. The emphasis is deliberately on restoration. They are designed to assist people and organisations planning revegetation at the landscape-scale as part of an integrated program of protection and repair of existing native vegetation.

WEED CONTROL TECHNIQUES

Cut and paint

This is suitable for coppicing and suckering weeds such as Camphor and Privet, or any weeds which are too large for hand-pulling or have long taproots such as Ochna. This method provides for no soil disturbance and weed eradication is successful.

1. Cut the stem/s 1-2 cm above (a cut stump or stem protruding above the ground can be dangerous to work around and the seed's ability to re-shoot is reduced), ground level using either secateurs, loppers, a pruning saw or a chainsaw, depending on the thickness and toughness of the stem.
2. Immediately apply glyphosate™ (generally 1:1 or 1:1.5 or 100%) to the cut surface of the stem or, with medium and large trees, to the outside edges of the cut surface. (Herbicides need to be applied immediately after the cut is made because the ability of the plant to transport fluids ceases as soon as the tissues are severed.))
3. Search through the leaf litter to locate any exposed stem or root surface. Scrape the exposed stem or root surface slightly with a knife until you can see a light green coloured layer. (Do not scrape too deeply.) Apply the herbicide to the scraped sections, either with a brush, injector or spray bottle.
4. Follow up as required.

Stem injection – Drill & frill

Drilling

A rechargeable drill with a 5mm drill bit, is used to drill holes in the tree. The battery life of the drill will not last very long, so make sure you have charged them up properly. 100mm deep holes are drilled into the sapwood at a downward sloping angle, drilling 1 to 2 holes at a time, then immediately (within 10 seconds) filling the holes with a glyphosate mix dependent on tree type. The holes are drilled approx. 15cm apart in a circular pattern around each and every multi-branch.The holes are easily filled using a drench gun. These are available from the Rural Co-op and Farmcare for approx. $110.00, and are easy to use. The drill method is good in difficult to get to spots (eg. multi-stemmed tree).

Frilling

Use a small axe to cut into the sapwood at a downward angle. Three rows of cuts are made in a brick pattern around all multi-branches, low to the ground. 1 to 3 cuts are made before immediately filling the cuts with a glyphosate mix dependent on tree type. The cuts need to be filled slowly to avoid chemical spills. The axe is easy to use in readily accessible spots. Note: The cordless drill and the axe

could be used together. The axe for the easily accessible trunks and the drill for the hard to get at multi-stems. This way the battery lasts a lot longer.

Scrape and paint

This is a variation of the cut, scrape and paint technique described above, the difference being the plant is not cut but left intact and scraped. This technique is suitable for Madeira Vine, Kudzu, saplings of Camphor Laurel and Privet as it ensures the translocation of the herbicide throughout the entire plant.

1. Scrape several sections of the stem along one side only, in lengths of at least 30 cm. The stem needs to be scraped firmly, exposing the fibres and/or light green coloured layer. Be careful not to sever the stem completely.
2. Each scraped section is immediately painted, prior to scraping the next section, with the recommended diluted glyphosate for the particular weed.

Crown grasses and herbs

Crowning: This technique is useful for weeds such as grasses and asparagus fern, which have their growing points below the surface of the soil. (corms, rhizomes or tufted fibrous root systems).

1. Grasp the leaves or stems of the plant and hold them firmly so that the base of the plant is visible. Any weeds with sharp leaves or stems should be cut back first.
2. Insert a knife close to the base of the plant at an angle, with the tip well under the root system.
3. Cut through the roots close to the base of the plant. Make sure that the hard crown or base of the plant where the roots begin is completely removed. It may require several cuts.
4. Hang the crowned plant matter up off the ground.
5. Follow up on a regular basis.

Manual removal (hand pulling)

Hand pulling: This requires holding the plant stem as close as possible to the base of the plant. Gently tug the plant. This will loosen the soil and allow the plant to come free. The plant may be hung up off the ground or piled in a heap.

Winding up: This process is suitable for plants with surface or climbing runners such as Morning glory.

1. You need to locate a runner, gently pull it along the ground towards you. Roll the runners up for easy removal. Continue doing this until all the runners have been rolled up. Small fibrous roots growing from the runners can be cut with a knife.
2. You should locate the main root system whilst removing the runners. When you do, remove it manually.
3. Do not leave any bits of stem or large roots, as these may reshoot.
4. Bag or compost the runners/roots.
5. Follow up on a regular basis.

Spray

Foliar spraying is a complementary or alternative method to some hand removal techniques. It is used in large areas of weed infestations that have a small native component or small dense areas of weeds with no natives. There are three different spraying techniques.

Spot spray

Spot spraying: is useful in areas with native seedlings present. In circumstances where solitary natives are scattered throughout a weed infestation, the individual trees may be covered or marked with a piece of bright coloured flagging tape. An area of about 10- 50 cm around the base of each native or clump of natives should be hand weeded. Spray units with adjustable nozzles should be set to produce a fine spray, at low to medium pressure. The weed clumps are sprayed with appropriate herbicide at the recommended strength plus a tracer dye. If a native is inadvertently sprayed, remove the affected leaves or immediately rinse off the herbicide with water.

Blanket or Area spray

Selective blanket spraying is used in areas with few or no native seedlings, where weeds have either formed a dense bed or have a large leaf size. Herbicides and concentration varies depending on the weed species, it is a good idea to use a Tracer dye so you can see where you have sprayed. Make sure you thoroughly check the area for natives prior to spraying. Any weeds close to natives should be removed by hand before starting to spray. Alternatively, young natives can be covered with cardboard prior to spraying. Spray units with adjustable nozzles should be set to produce a fine spray, at low to medium pressure

Splatter guns

The splatter gun (or gas gun) control technique involves the low volume, high concentration application of herbicide to the foliage of lantana, bitou bush and similar weeds using a specialised spray device.

This technique is particularly useful in areas of difficult access or sensitive vegetation because the tool is easily portable and causes limited off target damage. Like all management techniques, the splatter gun has limitations, but in general it provides a cheap and efficient method of managing dense infestations in places that are difficult to access, and that can be used as part of an integrated management program.

Herbicide use and requirements

Safety Gear

When using herbicides, it is essential to equip yourself with appropriate safety clothing.

Key items are rubber gloves, overalls, shoes or boots, eye goggles and a hat. An agricultural respirator is required for moderately and highly toxic herbicides. Avoid any parts of your skin being in contact with any herbicide. Immediately wash any parts of your body which come into contact with any herbicide, particularly your hands before eating.

Training, Certification

Weed control should be undertaken by appropriately qualified and experienced professional bush regenerators, or by volunteers under the direct supervision of a appropriately qualified and

experienced professional bush regenerator. Selecting the appropriate technique can be a matter of experience, both with local conditions, and the weed species being targeted.

Labels, Permits, MSDS

When using herbicides it is essential that you read the label on the container and follow the manufacturers' instructions. The label describes how the herbicide should be used (method and concentration, plus additives) for best results to control particular weeds. The permit describes the conditions under which the herbicide can be used in NSW. The MSDS describes a range of information about the chemical constituents in the herbicide, the most important of which is the safety measures required for use and first aid/medical treatment required following exposure.

Herbicides and additives

Glyphosate

Glyphosate is a systemic chemical which is inactivated upon contact with the soil. Roundup Bioactive™ and Weedmanster 360™ are products with improved surfactants, making them safer to use near waterways. Do not use Glyphosate within 6 hours of rainfall and where there is likelihood of rain within 24 hours.

LI 700®

LI 700® is a penetrant , which facilitates the transfer of the herbicide through the surface tissue and is often used for plants with waxy leaves, such as Madeira Vine and Wandering Jew. (Oils are also used for this purpose.) Manufacturer's instructions should be followed when using any penetrant.

This will help the chemical stick to the leaves, is rain-fast within minutes and helps spread the chemical evenly over the plant.

Tracer Dyes

Tracer Dyes are used with herbicides to improve efficiency and safety. The tracer allows areas/plants that have been treated to be identified. The tracer alerts anyone entering the treated area that a herbicide has been used for a short period of time. It also helps to ensure that the target plants are treated and non-target plants avoided.

Commonly used tracer is a red fluorescent dye such as Spraymate Marker Dye®. Manufacturer's instructions should be followed.

Metsulphuron Methyl

Metsulfuron is a non-residual herbicide, which is the active ingredient in Brushkiller® and Brushoff®.

Weed control – alternative methods

Repeated sprays with a knockdown herbicide (such as glyphosate) are effective in that they exhaust the soil weed seedbank, resulting in less weeds germinating after the planting. Residual herbicides prevent the weed seeds in the soil from germinating until the effect of the herbicide diminishes over time. Care should be used in the selection of herbicides: consider factors such as the development of herbicide resistance, residue in the soil, impacts on native plants and waterways. Alternatives to herbicides should always be considered.

Scalping (removing some of the surface soil) removes the majority of weed seeds and is very effective in a range of soils, although it may expose subsoils that are prone to cracking as they dry. Non-chemical methods include mulching with newspaper, straw, sawdust or similar; flaming; repeated cultivation and hand-chipping. Mowing reduces the vigour of the competing plants but is not as effective as complete removal. Many direct seeding machines have a built in scalping blade or disc to do weed control in a single pass. Most sites will still benefit from two-years of weed control prior to direct seeding.

Great care should be taken before exposing highly-erodible soils. Weed control should be in strips approximately one metre wide with a grassy strip retained between rows, or in spots one metre in diameter around each planting location.

Weed control and assessment

Weed control is usually the single most important factor in the success or failure of tree plantings. It is just as critical after planting as before and should be continued for at least one full growing season after planting and preferably for 2 years. A weed-free area of 1m diameter should be maintained around each plant for this period.

Weeds should be controlled when they are actively growing, before they set seed and before they begin to compete with your newly established plants. Different weeds will germinate at different times of the year so you will need to monitor your site regularly. Look at your site each month after planting and schedule weed control when you see actively growing weeds. It is much easier to control weeds before they get too big and before they set seed. If you have an annual program of revegetation planned, it pays to keep records of which weeds occur and when they emerge, as well as effective techniques for their control.

The Florabank website can help to identify weeds. It contains an interactive tool which enables you to select your area and look through a list of weed species known to occur in a particular region, with pictures and information about them. The Weeds CRC produced a range of weed management guidelines that may be helpful to tackle specific problem weed species. Another useful publication is 'Stop Bushland Weeds' by Meg Robertson. This publication also contains a table which shows the most effective times of year to control particular weeds.

Non-chemical methods such as hand weeding, mowing or mulching can also be used. For example, or weedy grass species, mowing when the exotic grasses flower, but before the native grasses do, gives the native grasses an advantage. If repeated over successive years, this method has been shown to increase the cover of native grasses and reduce the area of exotic grasses.

PLANTING

Local Provenance

It is generally accepted that for revegetation for conservation purposes, it is best to choose species that occur locally. Such species are well adapted to the environmental conditions of the site, and their pollinators, predators, symbionts and dependent wildlife are present. There are likely to be sources of seed available locally. Local provenance is principally about getting material that is adapted to local conditions, but also arises out of concerns about genetic pollution.

Florabank now recommends that provenance be considered in the following manner when collecting seed for revegetation:

Get the taxonomy right first

- Make sure you are dealing with the same species/subsp/variety or cultivar

Get the physical and genetic quality right

- Collect from 20-100 plants.
- Collect from plants at least 3 plant-heights apart

Only collect from large populations or pool multiple collections from smaller populations

Store seed under best conditions from collection right through to use

Match the site conditions

- Soil (texture and origin)
- Altitude
- Aspect
- Slope position
- Latitude (use bioregions as the boundary)

Then worry about proximity between collection and revegetation sites. Having said that, where possible, all revegetation works are to be conducted in accordance with current best practices. These include:

1) Collection of seed

a) Must be by appropriately qualified and licenced personnel
b) Must be local provenance seed stock (refer Florabank Guideline No.10)
c) Must be collected in a manner that maximises genetic quality of seeds (refer Florabank Guideline No.5)
d) No more than 20% of the fruit or 10% of plant material should be removed from one plant

2) Determining local provenance

a) Environmental conditions at the collection site should match the existing or desired environmental conditions at the proposed planting site
b) Consider the method is pollination and seed dispersal for the species concerned before deciding on local provenance boundaries (Figure 24).
c) While it is best to collect seed as locally as possible, care must be taken to maximise the genetic diversity of available seed stock to avoid problems associated with inbreeding

Collection Range

Factors	Narrow		Intermediate		Regional
Pollination	self-pollinated	wind-pollinated	insect-pollinated	bird-pollinated	bat-pollinated
Seed dispersal	gravity			wind or water	bats and birds
Longevity	short-lived				long-lived
Extent	small number and small area				large number and large area
Density	low		medium		high
Fragmentation	low		medium		high

Figure 30. Collection ranges for determining local provenance areas (adapted from Florabank Guideline No.10).

3) Storage of seed

a) Seed must be stored appropriately (refer Florabank Guideline No.1)
b) Seed should be tested for viability before storage (refer Florabank Guideline No.8)

4) Propagation of plants

a) Plants should be propagated so that seedlings will be large enough to transplant onto site
b) Care should be taken that unexpected delays in construction do not cause seedlings to become root-bound
c) Propagation should be conducted in accordance with current best practices

5) References for plant propagation information:

- Wrigley, J.W. & Fagg, M. (1993) 'Bottlebrushes, paperbarks & tea trees: and all other
- plants in the Leptospermum alliance'. Angus & Robertson, Sydney. 352 pp.
- Wrigley, J.W. & Fagg, M. (1996) 'Australian native plants: propagation, cultivation &
- use in landscaping'. 4th ed. Reed. 696 pp
- Ralph, M. (1994) 'Germination of local native plant seed: for revegetation, tree
- planting & direct seeding projects'. Murray Ralph, Fitzroy, Vic. 42 pp.
- Ralph, M. (1997) 'Growing Australian native plants from seed'. Murray Ralph, Fitzroy,
- Vic. 156 pp.
- Ralph, M. (1994) 'Seed collection of Australian native plants for revegetation, tree
- planting and direct seeding'. Murray Ralph, Fitzroy, Vic. 121 pp.

Revegetation techniques

There are three techniques that are commonly used for revegetation: tubestock planting, direct seeding and natural or assisted regeneration.

DIRECT SEEDING	TUBESTOCK PLANTING	NATURAL REGENERATION
(+) Lower establishment costs	(+) More reliable	(+)Plants are well-adapted to the site
(+) Natural look and more diversely structured	(+) Uniform	(+)Establishes healthiest plants
(+) Establishes healthier plants	(+) Revegetation is visible to passers by	(-)May have to wait for a long time for results
(-) Long establishment times may lead to more maintenance such as weed control.	(-) Often results in unnatural looking rows	(-)Needs an adjacent or nearby seed source
(-) Ants have been known to take seed	(-) Higher establishment costs	(+)Lowest establishment costs
(-) Uses lots of seed	(+) Uses small quantities of seed	(-) Long establishment times may lead to more maintenance such as weed control.

Natural Regeneration

Natural regeneration is the term used to describe the growth of plants from seed naturally distributed to the site. Natural regeneration relies on existing seed sources, such as soil or canopy stored seed, or seed transported to the site by water, wind or animals in the area to be revegetated. This method of re-establishing vegetation is especially worthwhile for individuals and groups with limited resources. Natural regeneration is a good first choice, because native plants that grow from this method are likely to be well adapted to the site. If there is a good source of seed, natural regeneration can result in high species diversity, representing the original range of plant species.

Although the process of regeneration itself is 'passive', natural regeneration still usually requires facilitation and management. The areas to be revegetated are usually fenced to exclude stock and allowed to regenerate naturally. Some form of pre-treatment, such as a burn or herbicide treatment, may be applied to the site. If the regeneration fails or is poor, direct seeding or planting seedlings can be considered. As with other methods, implementation of a long-term weed management strategy is important.

Direct Seeding

Direct seeding involves sowing seed directly into prepared ground. Direct seeding generally is more efficient in terms of time, cost and labour, compared to tubestock planting. It also allows for a more diverse seed mix, leading to greater plant diversity. The main limitation with direct seeding is usually the availability of seed. Establishment of plants from direct seeding can be patchy and can take

several years, especially for hard-seeded species, but the plants that do establish are often robust and have developed a good root system. There are two main methods of direct seeding:

Hand Sowing: this method is useful for small areas or in inaccessible country. Handfuls of seed mixed with a bulking agent are thrown onto the prepared seed bed. Another method of hand-seeding uses cut stems of a plant with ripe fruit present, laid across a prepared site.

Mechanical direct seeding: this method involves the use of specialised direct seeding equipment, which is calibrated for different seed sizes and planting depths. Large areas can be seeded quickly using this method - up to 50 hectares in one day using one direct seeder.

As with other revegetation methods, ground preparation and weed control is critical. Because germinating seeds must compete with weed seeds that may be in the soil, a weed control program ideally should begin two years before direct seeding. The top layer of soil can also be scalped to remove weed seeds. Control of seed and shoot predators such as ants and red-legged earth mites is also important.

Tubestock Planting

'Tubestock' is the term for seedlings that have been raised in small nursery tubes, for transport to the planting site. Propagation of seedlings can be by seed, by cuttings, or through division. Seedlings can be planted by hand or with a mechanical seedling planter at the prepared site. As with direct seeding, site preparation is essential and will involve weed control and fencing.

Even though tubestock planting is more expensive and requires more labour than direct seeding and natural regeneration, it is a widely used method of revegetation. Results are reliable and immediate, and plant placement is controllable. Because of the labour-intensive nature of tubestock planting (both in propagation and planting), fewer species tend to be planted than with direct seeding.

General planting notes

Plants

Large healthy root systems, with no evidence of root curl, restriction or damage. Plants should be vigorous, well established, and free from disease and pests, of good form consistent with the species or variety. Before planting, plants should be hardened off, not soft or forced, and suitable for planting in the natural climatic conditions prevailing at the site.

General considerations

Replace damaged or failed plants with plants of the same type and size. Supply plants in weed-free containers of the required size. Label at least one plant of each species or variety in a batch with a durable, readable tag.

Deliver plant material to the site on a day to day basis, and plant immediately after delivery. Give notice of proposed changes to plant locations and spacing, for example, to avoid service lines, or to cover the area uniformly. Do not plant in unsuitable weather conditions such as extreme heat, cold, wind or rain. In other than sandy soils, suspend excavation when the soil is wet, or during frost periods.

Placement

Wherever possible, different species should be placed adjacent to each other. Trees and shrubs are to be planted to maximise the diversity of the upper canopy as much as possible.

Remove the plant from the container with minimum disturbance to the root ball, ensure that the root ball is moist and place it in its final position, in the centre of the hole and plumb, and with the top soil level of the plant root ball level with the finished surface of the surrounding soil.

Fertilising and water crystals

Slow release fertiliser pellets should be placed into the plant hole immediately before planting. Install water crystals with the fertiliser according to the manufacturer's recommendations. Best results are obtained if water crystals are soaked in water first.

Backfilling

Backfill holes after planting using topsoil. Lightly tamp down and water to eliminate air pockets. Ensure that topsoil is not placed over the rootball so that the plant stem remains the same height in the ground as it was in the container.

MANAGING THE SPREAD OF PHYTOPHTHORA

Phytophthora cinnamomi

Phytophthora cinnamomi is not visible to the naked eye. Under a microscope, its main body, the mycelium, looks like white hair-like threads. Sporangia (spore sacs) are produced on the mycelium in moist and aerobic conditions and at temperatures of 22-28ºC. In each sporangium 30-40 zoospores are formed and released. Zoospores are motile by way of two flagella, which enables Phytopthora to infect new and healthy root tips. Zoospores survive up to four days. When conditions for growth become less favourable, generally when the soil dries out, mycelium may form another type of spore, known as a chlamydospore. This resting spore has a thick cell wall and is able to survive in the soil or host tissue for many years, waiting for growth conditions to become suitable again. The mycelium can also survive on plant debris on or in the soil.

The most critical interaction in disease development is the simultaneous presence of Phytopthora zoospores and susceptible host plants. A range of factors determines the severity of the disease and its rate of spread. These include temperature, rainfall, soil type and characteristics, and microbial soil populations. Phytopthora is generally found in areas where:

- average annual rainfall is greater than 500 mm (20 inches)
- soils are acid to neutral with low amounts of nutrients and organic matter
- have few micro-organisms
- have poor drainage

Hot bushfires may destroy Phytopthora to a depth of 15 cm below the soil surface. However, the fire also lowers surface soil organic matter and microbial populations, making it more favourable for its growth.

Symptoms of disease

The roots and stems of plants affected by Phytophthora decay with root-rot and then disintegrate, destroying their ability to extract water and nutrients. An infected plant is then subject to water stress which is also known as 'internal drought'. The first visual symptoms of infection are generally shown as yellowing of the foliage (chlorosis) followed by dieback of the entire plant. Depending on local site and environmental conditions, this can occur in a matter of weeks for small shrubs or even several years for large shrubs or trees.

Symptoms vary between different plant species. Xanthorrhoea species for example, die rapidly and may collapse. Acacia species may die quickly but symptoms can be masked by other dieback causes such as general drought conditions. Leaves of Banksia species and Eucalyptus species show slower signs of dieback on their branch tips but may temporarily re-shoot. The Fabaceae, Acacia, Leptospermum and some Epacridaceae become yellow and die back in warm moist periods during spring and autumn. They may recover and form new growth during dry periods in summer or cold periods in midwinter. The cycle continues with dieback occurring again in spring and autumn.

Dieback may also be caused by factors other than Phytophthora. These may include chemicals, old age, fire, mechanical damage, insects, and environmental factors including drought, waterlogging, salt, frost and hail.

How the disease is spread

The single most important cause in the spread of Phytophthora appears to be through the transport of infested gravel, soil and plant material, which adheres to vehicles and heavy machinery. Such machinery is usually used in logging, firefighting, road construction and maintenance of roads and powerlines. A vehicle not cleaned after working in an infested area could easily spread the disease to another site many kilometres away. Phytopthora can also be spread in the following ways:

- through transport of soil and plant material adhering to bicycles, footwear, tools and camping equipment
- through water (as drain off, irrigation or moving ground water). Phytopthora will spread quickly downhill in surface and sub-surface water flows. If found along a watercourse, then surface water will most likely carry Phytopthora downstream into the catchment
- by transfer of infested gravel, soil, water or any other raw material
- from plant to plant through natural sub-surface root contact. The spread uphill and on flat ground is slower (approximately 1 metre per year) as it is confined to root contact from plant to plant
- by transferring infested plants to other sites
- by animals, particularly those with cloven hooves

Prevention of spread: Maintenance of vehicles and machinery

To prevent the spread of Phytopthora vehicles and machinery should be kept hygienically clean of soils which may be infected. A visual inspection should confirm that vehicles and machinery are free of clods of soil, slurry (water and soil mixture) and plant material. The cleaning procedure consists of two steps:

1. Dry brushing

- Remove all soil and plant material with a hard brush or tool. Pay particular attention to wheels, mudflaps and undercarriage.

2. Disinfection

- Disinfect vehicles (wheels, mudflaps and undercarriage in particular) and machinery with water containing a disinfectant until any remaining soil and mud is saturated.
- Allow disinfectant to penetrate for 10 minutes.
- Avoid recontaminating vehicles and machinery! The following disinfectants can be used:

A fungicide, such as Phytoclean®. Dilute 1 part in 50 parts water. Sodium hypochlorite (pool chlorine). Dilute 1 part in 1500 parts water.

Points to remember:

- Clean down on a hard, well-drained surface (such as an unsealed road) in high risk areas.
- Do not wash down with water only, as this will create a more suitable environment for infestation. Always use a disinfectant!
- Phytoclean® is preferred above sodium hypochlorite as it is a more effective disinfectant, as well as being biodegradable and noncorrosive.
- The use of a pressurised spray unit is preferred, as this will minimise the amount of water used.
- Do not drive through wash-down effluent.
- Do not allow mud and wash-down effluent to drain into bushland and surface waters such as rivers, creeks, reservoirs and dams.

Cleaning Footwear and Hand Tools

The fundamental hygiene principle to minimise the spread of Phytopthora is to keep footwear and hand tools hygienically clean and therefore free of Phytopthora. A hygiene kit should contain:

- hard brush
- bottle of disinfectant, such as methylated spirit (undiluted) or household bleach (dilute 1 part in 4 parts water)
- spray bottle

The cleaning procedure consists of two steps:

1. Dry brushing

Remove all soil and plant material from footwear and tools with the hard brush.

2. Disinfection

- Disinfect the entire sole of your footwear and tools using the spray bottle containing the disinfectant
- Allow the sole of the boot to dry for at least one minute
- Step forward to avoid recontamination of footwear
- Disinfect the hard brush!

Points to remember:

- Clean down on a hard, well-drained surface (such as an unsealed road) in high risk areas.
- Do not wash down with water only, as this will create a more suitable environment for infestation. Always use a disinfectant!
- Hand tools can also be disinfected by soaking for a few minutes in the bleach solution, then rinsing with distilled water and wiping dry with a clean paper towel. Clean down on a hard, well-drained surface.

Safety, Health and Welfare

Wear Personal Protective Equipment when handling or using disinfectants, wear, including gloves and safety goggles. All disinfectants are toxic to water organisms and extreme care must be taken in the use and disposal of undiluted, diluted and exhausted solutions.

Remember to:

- re-use containers where possible. Undiluted disinfectants and used containers must be disposed of in an approved refuse disposal site. Triple rinse and crush used containers before dispersal.
- dilute exhausted and diluted solutions an extra five times and spread over the ground a minimum of 50 metres away from surface waters. They may also be inactivated in a pit by addition of organic matter, such as sawdust, absorbing clay or paper.

CONTROL PROGRAMS FOR CARP

Carp are considered a pest species because it degrades the water quality of the ponds and limits the opportunity for native fish populations to become established. It is a prolific breeder and reduces the survival chances for native fish. Carp feed from the bottom of the pond, sucking in substrate (or material at the bottom of the pond) and water in search for aquatic organisms. This decreases water quality by increasing turbidity, consequently preventing light penetration into the water. Less light penetration affects plant growth, which is a valuable food source for native fish, and contributes to erosion of the banks of the ponds.

Although there is wide agreement that carp numbers should be reduced, control efforts are being hampered by a lack of information. Nonetheless, there are several options for reducing carp, and each has its benefits, disadvantages and costs.

Effective control of carp will require the application of a combination of techniques which include:

- **Environmental Rehabilitation** - This includes taking actions that will increase the numbers of native fish, such as creating fishways, and revegetating river banks, re-snagging rivers and looking at ways to release warmer water from dams. These are viewed as a necessary part of river management, but their direct effects on carp are unknown.
- **Physical Removal** - Catching large number of carp is already under way on a small scale and more licences are being issued. To be effective, at least 98% of carp must be removed, which may be very expensive, or impossible to achieve. Methods include netting and electrofishing.
- **Reduce Carp Reproduction** - This strategy involves reducing the numbers of carp eggs that have been laid in shallow habitats such as billabongs and wetlands where most spawning

activity occurs. This technique involves lowering the level of water by 45-60 cm to expose and dry out the carp eggs. The technique is being researched and could work well in wetland and billabong habitats.

- **Chemical Poisoning**: - While this is possibly an effective method, poisoning is very expensive and may only work in small or closed bodies of water. In addition, chemical poisoning would not be acceptable for the general environment, and would only be able to be used in habitats such as irrigation channels where the water quality is poor and the environment is no good.
- **Biological Techniques** - These include pathogens (usually viruses), immuno-contraception (interfering with reproduction) and interfering with the genetic make-up of the carp. None of these techniques are currently being used, but they are currently the subject of research and management studies.

Of the above control measures, the most suitable one for Upper Duck River Wetlands and Riparian Corridor is physical removal. The Centennial Park and Moore Park Trust (Trust) has an ongoing Carp eradication program aimed at eliminating carp from the Parklands' pond system, and to encourage native fish stocks to develop. This program has resulted in the removal of over 10 tonnes of carp from the pond system since 1998 – the largest fish weighing a record 24 kilograms.

Several activities under this program include:

- Electro-fishing program: a licensed procedure that stuns the fish which are then netted and removed from the ponds. The fish that are removed from the ponds are processed to make an organic liquid fertiliser.
- Line fishing: a dedicated volunteer-led program to selectively remove carp from the ponds using traditional fishing methods. Following removal from the ponds, the fish are then euthanased and used as bait for commercial fishing.
- Australian bass release: a system of gradually introducing Australian bass (Macquaria novemaculeata) - a native fish species - into the pond ecosystem to reduce carp numbers. 15,000 Australian Bass have been released into the Parklands ponds since 2005.

Key conditions of the Centennial Parklands' carp management program:

- Only the use of manufactured and purpose made barbless hooks is permitted. Barbless hooks are used to prevent any unnecessary suffering to Carp and will readily fall out if on the rare occasion a non-target species is hooked. Volunteers are supplied with approved hooks. No stainless steel hooks permitted.
- Fishing is only allowed in the designated area and at no time trampling of vegetation is allowed. One rod per person and rod is always to be held – no rod is to be left unattended nor is a rod holder permitted.
- Induction of all participants is provided as a prerequisite to participation. This induction prioritises the importance of protecting any non carp species from any action which might result in injury.
- A Fishing Coordinator has been recruited from the Australian National Sports Fishing Association a recognised leading industry body, to supervise all fishing activity undertaken in the Parklands to ensure effective quality control of the program.

- All volunteers are required to meet OHS requirements and are fully inducted on these requirements prior to participation.

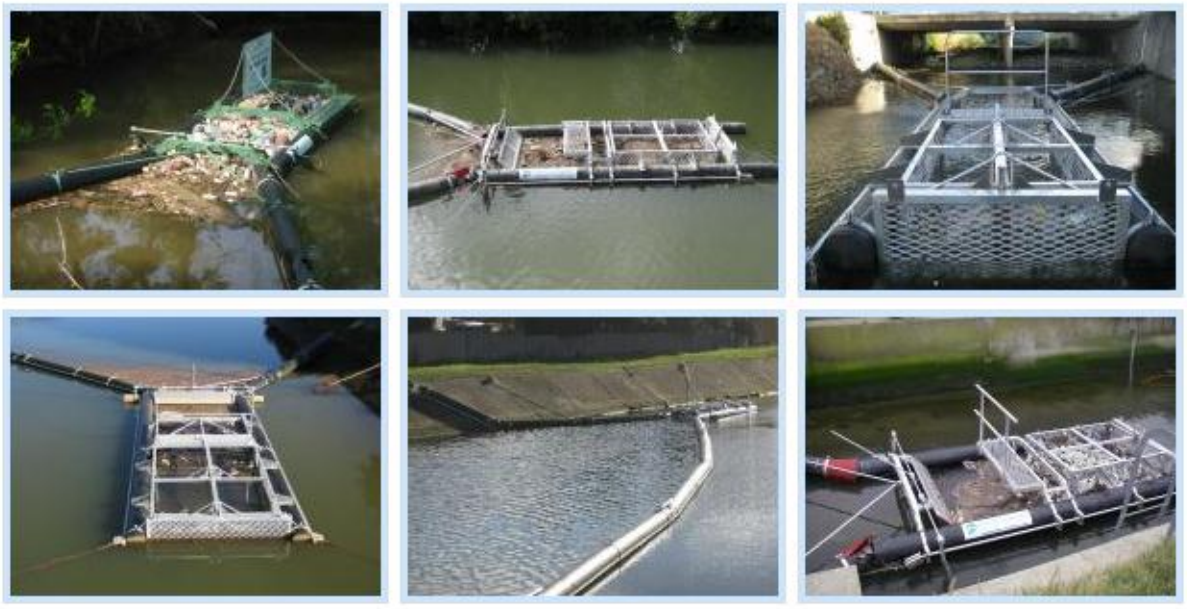
EXAMPLES OF LITTER CONTROL DEVICES

Trash rack

End of pipe control device

Trash trap

Floating trash trap

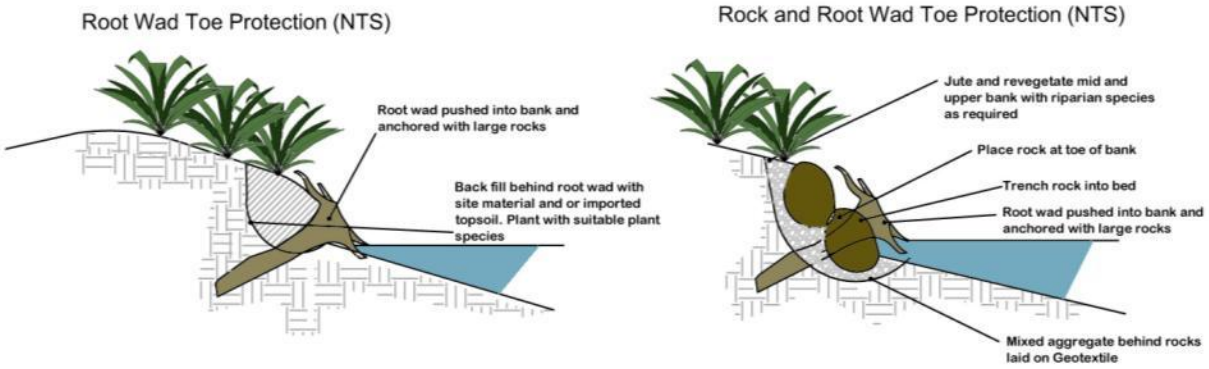


http://www.bandalong.com.au/products-and-services/bandalong-litter-trap/

http://wsud.melbournewater.com.au/content/treatment_measures/litter_traps/litter_trap_types.asp#floatingdebris

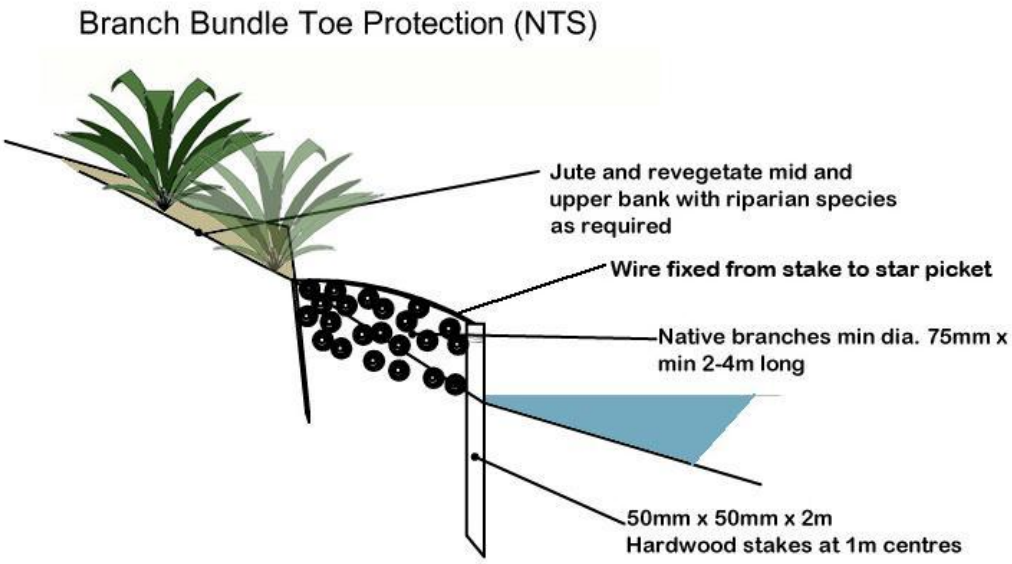
EXAMPLES OF EROSION CONTROL WORKS

Toe protection using root wads



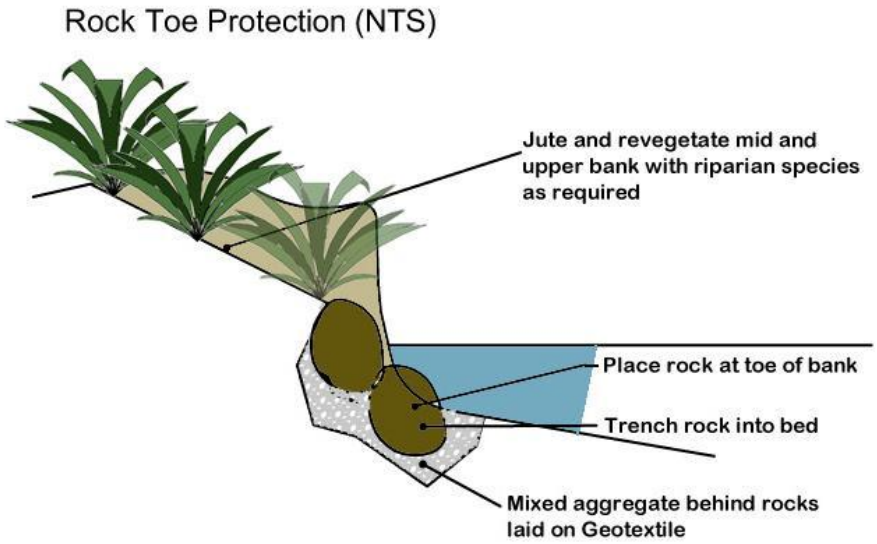
(Source: Sutherland Shire Waterways Prioritised Rehabilitation Plan, Applied Ecology 2012)

Branch bundle toe protection



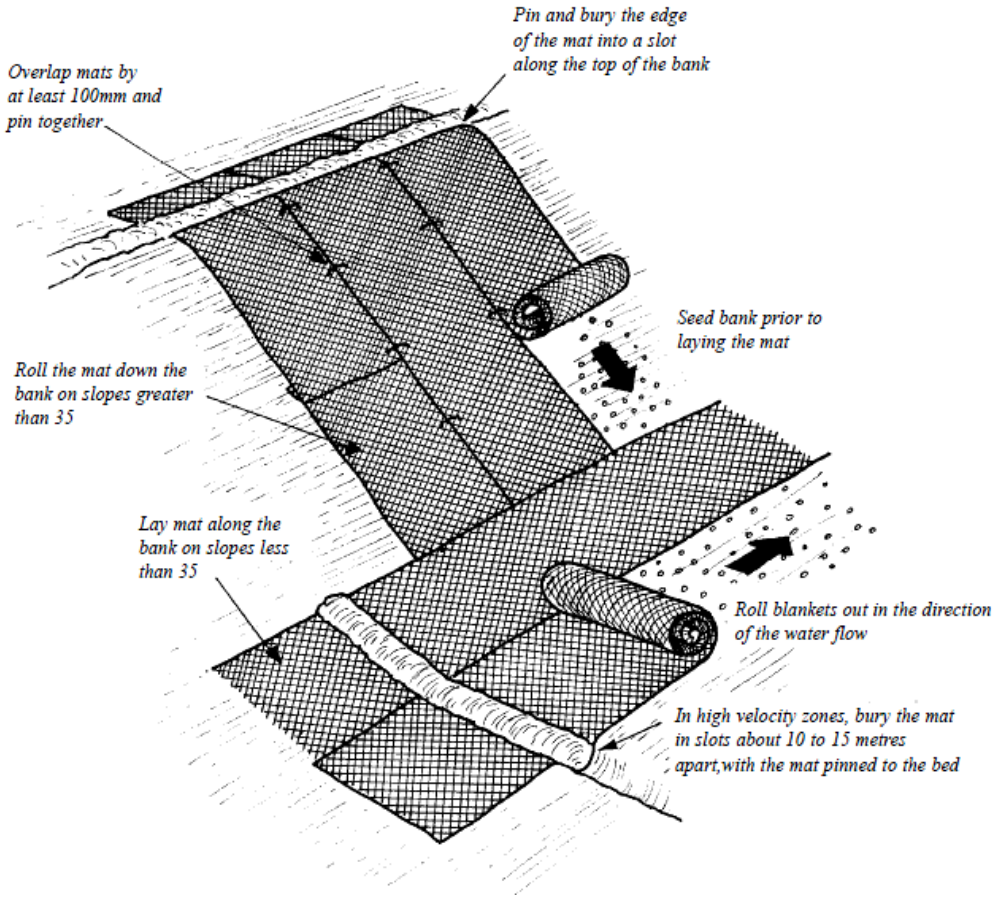
(Source: Sutherland Shire Waterways Prioritised Rehabilitation Plan, Applied Ecology 2012)

Rock toe protection

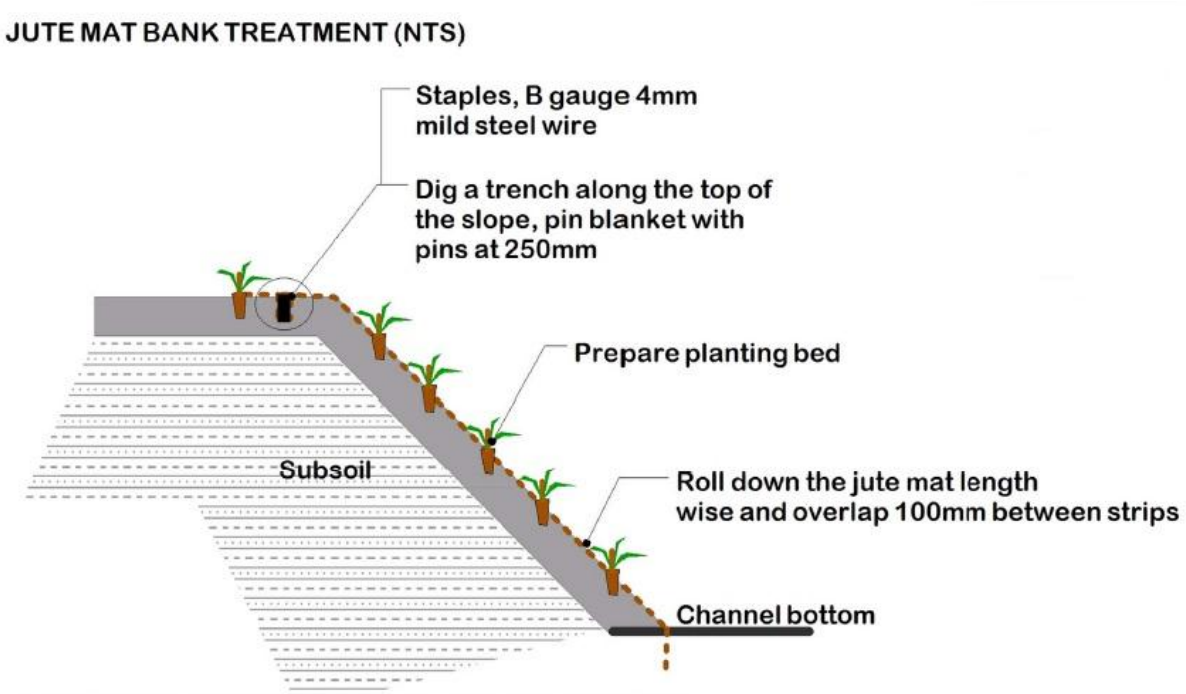


(Source: Sutherland Shire Waterways Prioritised Rehabilitation Plan, Applied Ecology 2012)

Jute matting bank stabilisation treatment



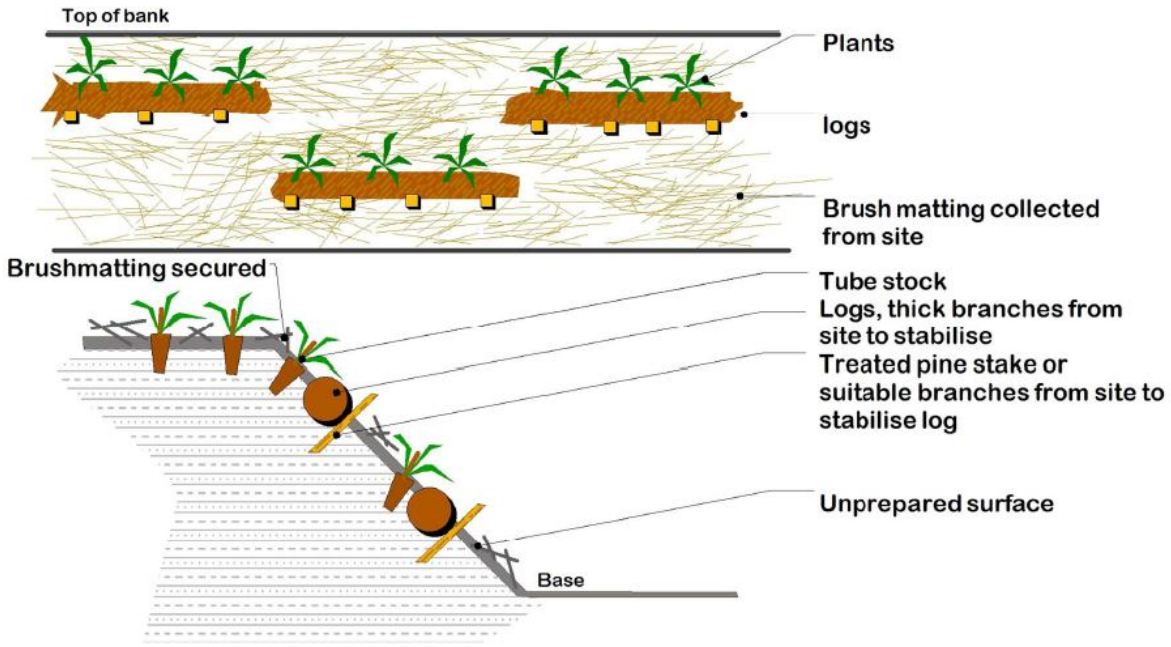
Jute matting bank stabilisation with planting



(Source: Sutherland Shire Waterways Prioritised Rehabilitation Plan, Applied Ecology 2012)

Bank stabilisation using brush matting with logs and stakes

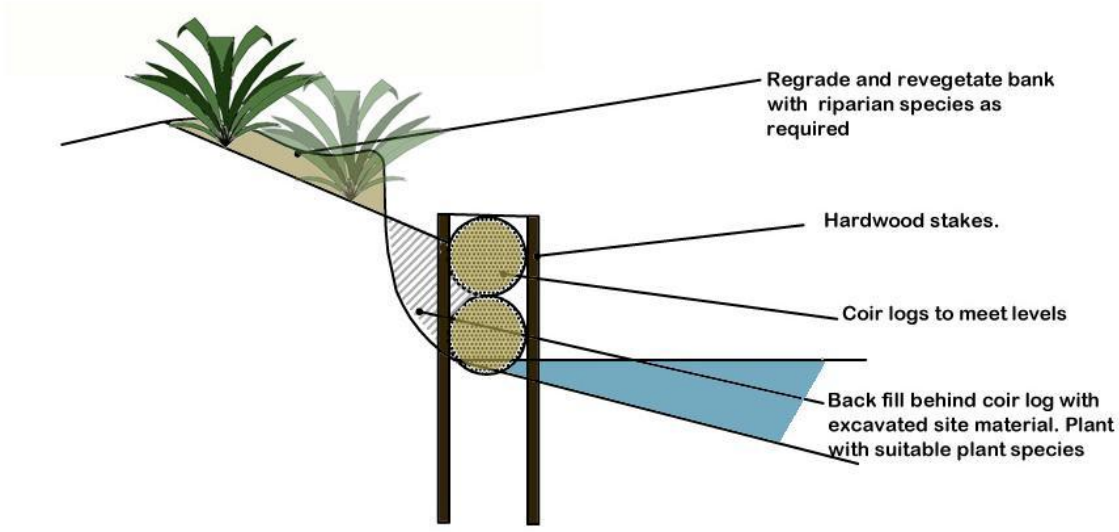
BANK TREATMENT USING LOGS AND STAKES (NTS)



(Source: Sutherland Shire Waterways Prioritised Rehabilitation Plan, Applied Ecology 2012)

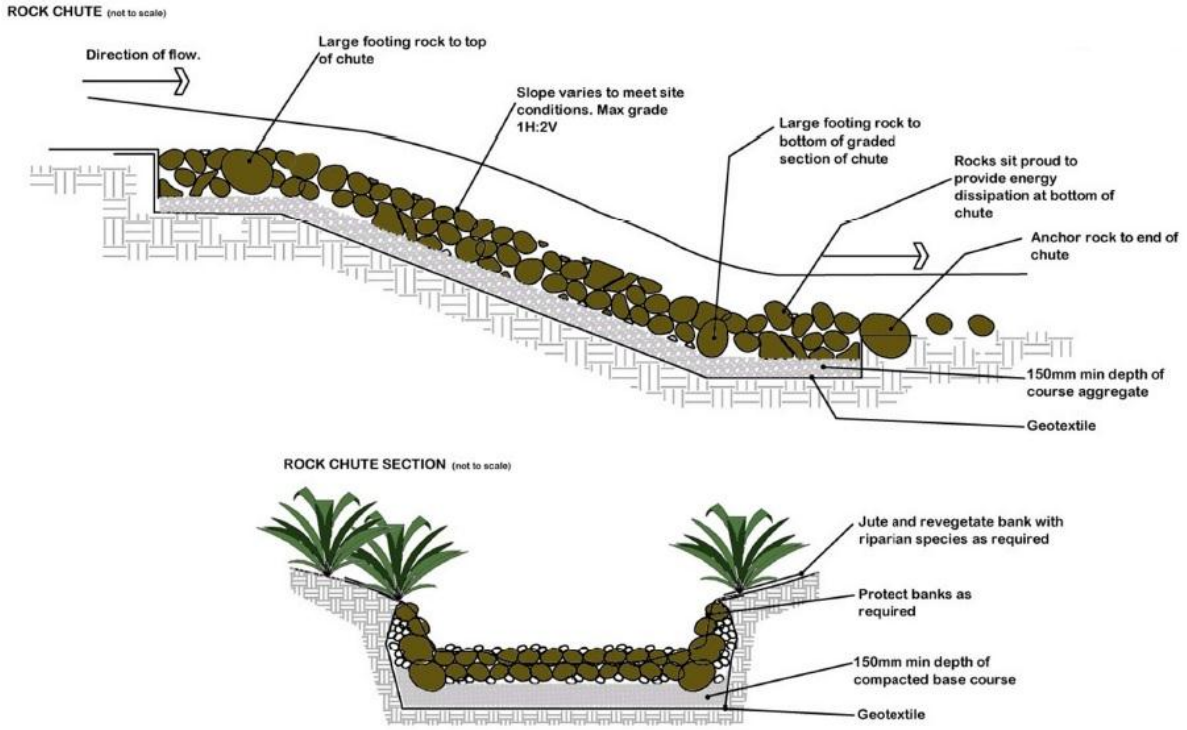
Coir log bank protection

Coir Log Bank Protection (NTS)



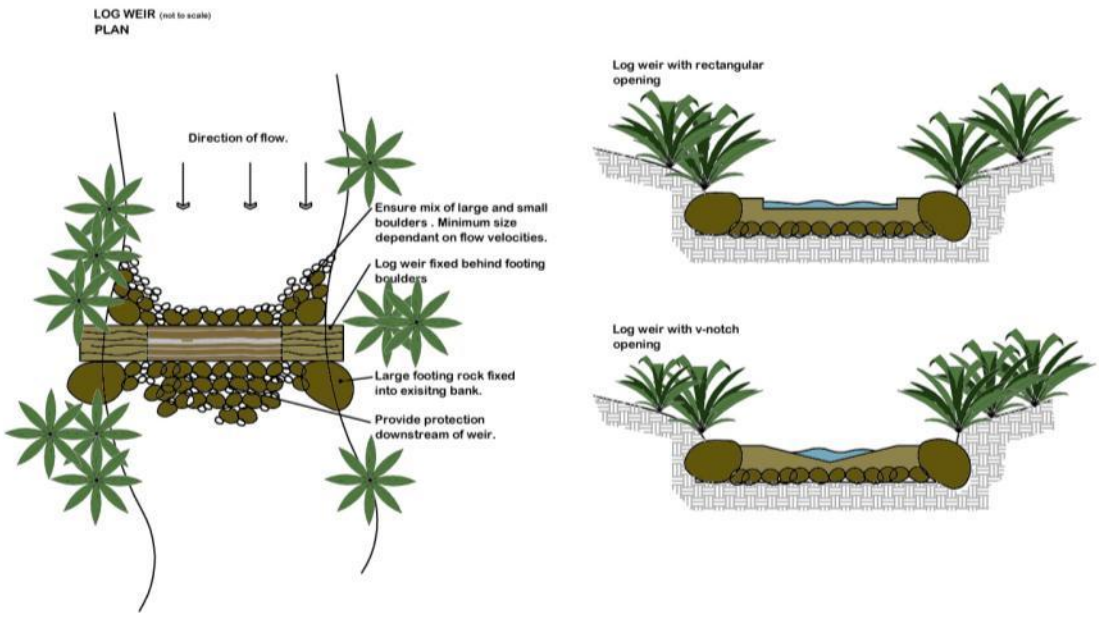
(Source: Sutherland Shire Waterways Prioritised Rehabilitation Plan, Applied Ecology 2012)

Rock chutes for channel bed stabilisation



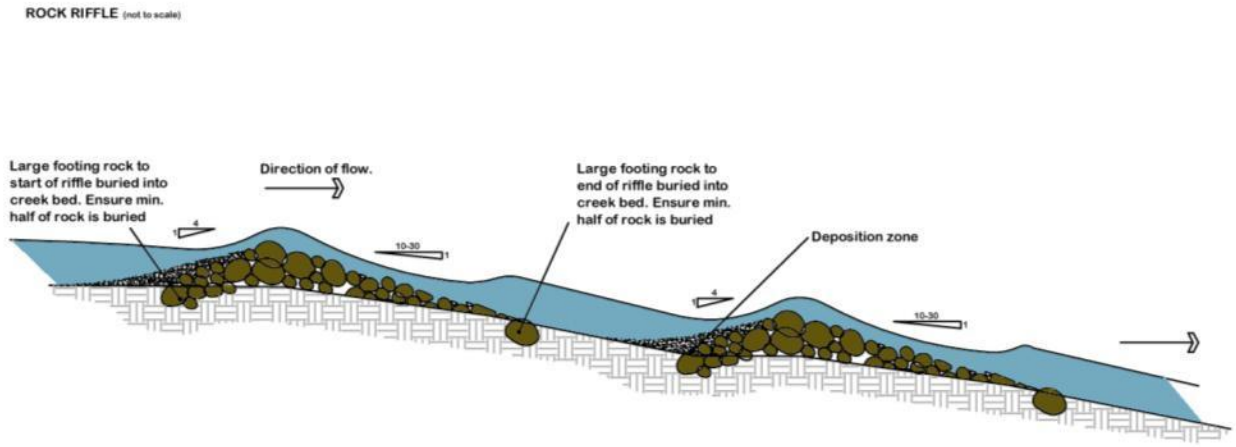
(Source: Sutherland Shire Waterways Prioritised Rehabilitation Plan, Applied Ecology 2012)

Log weirs for channel bed stabilisation



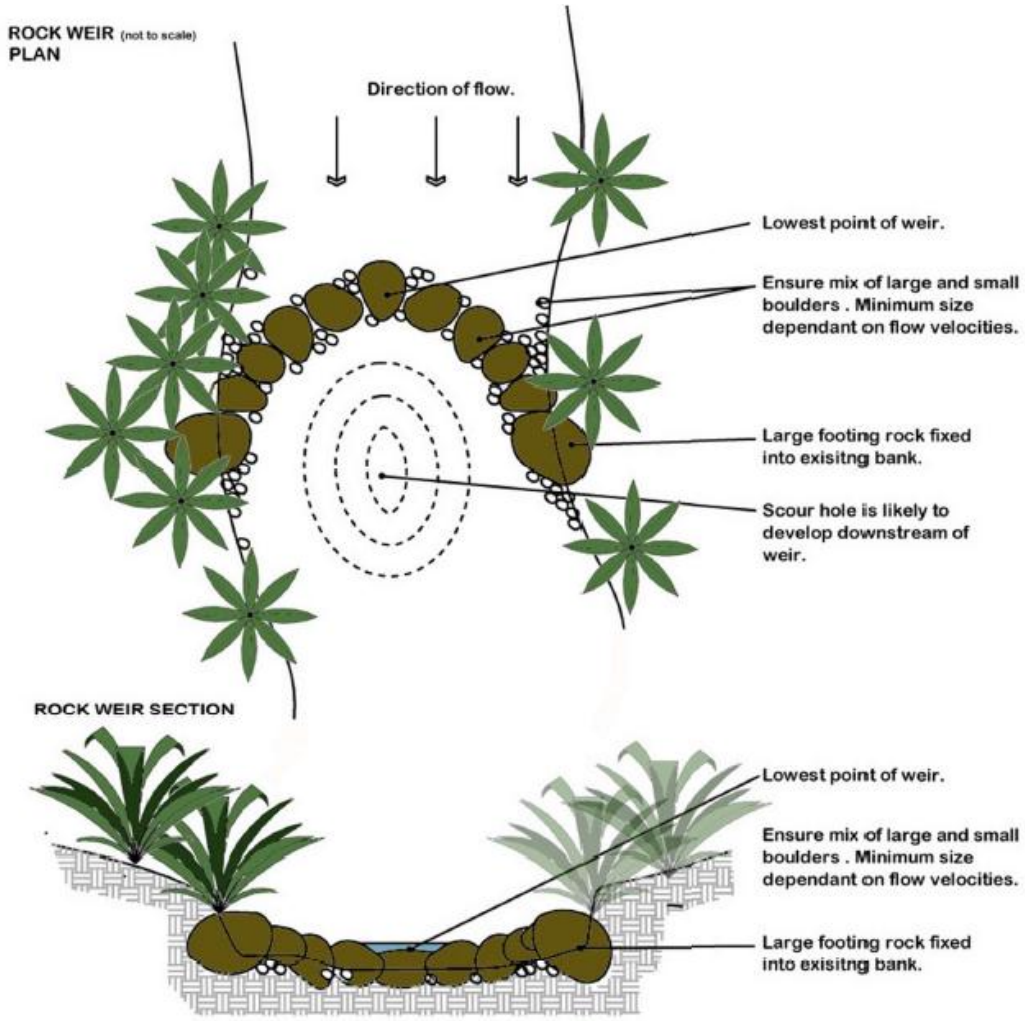
(Source: Sutherland Shire Waterways Prioritised Rehabilitation Plan, Applied Ecology 2012)

Rock riffles for channel bed stabilisation



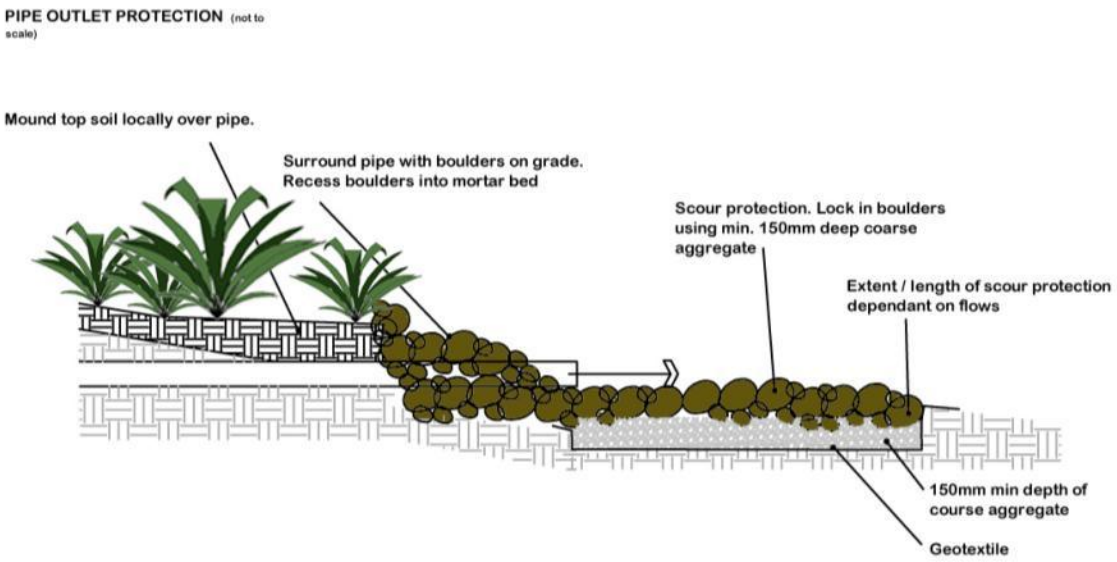
(Source: Sutherland Shire Waterways Prioritised Rehabilitation Plan, Applied Ecology 2012)

Rock weirs for channel bed stabilisation



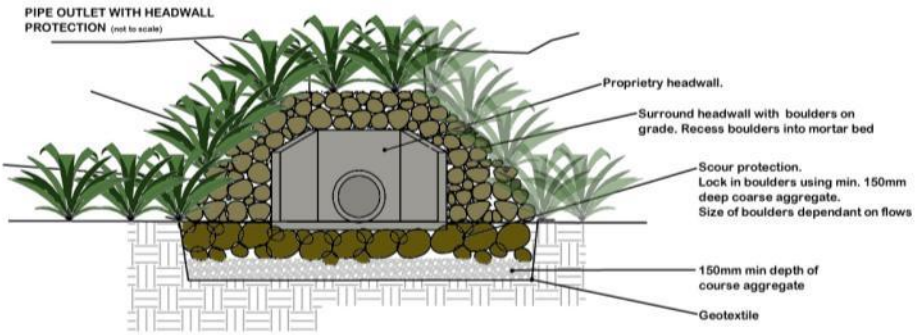
(Source: Sutherland Shire Waterways Prioritised Rehabilitation Plan, Applied Ecology 2012)

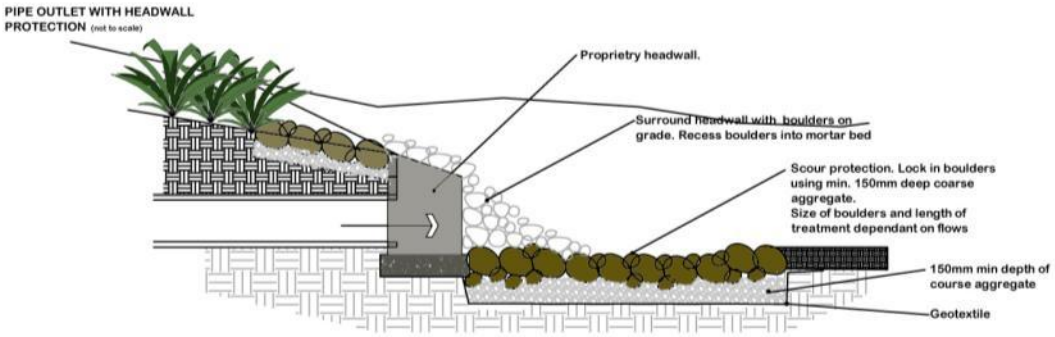
Pipe outlet protection



(Source: Sutherland Shire Waterways Prioritised Rehabilitation Plan, Applied Ecology 2012)

Headwall and outlet protection





(Source: Sutherland Shire Waterways Prioritised Rehabilitation Plan, Applied Ecology 2012)

DESIGN GUIDELINES FOR STREET FURNITURE

Elements of street furniture need to be co-ordinated with each other and with their surroundings. Designers should check the master plan, design guidelines and other planning documents relevant to the site for any requirements for street furniture styles, colours and finishes. Street and park furniture needs to:

- exhibit high resistance to vandalism
- be durable against weathering and deterioration
- be suitable for use by people with a wide range of needs including children, the aged and people with disabilities
- have a low whole-of-life cost.

Paint finishes should be selected on the basis of superior resistance to fading, vandal resistance and appropriateness for the surface they are coating. Graffiti coatings should be considered for surfaces likely to be affected by graffiti. Within these requirements, park furniture should be selected to enhance the unique design character of the space.

Park furniture positioning and selection should respond to the demands of the public and the physical location. The number of furniture items is a direct response to the requirements of the particular space. Park furniture should be positioned to focus on an activity or a view and take advantage of seasonal change, especially winter sun and summer shade. Where possible designers should site furniture in ways that provide shelter from the rain and other local weather patterns such as winter winds.

Seating is a major component in spaces that are created primarily for relaxing or resting. Seating in these spaces should be designed for longer duration sitting. Aggregations or multiples of seating may be required in central locations where they can be placed to encourage conversation or to generate a sense of place. This form of seating is normally inwardly facing, should be visible but not intrusive and sited in a manner that does not obstruct a view, activity or desire lines. Seats in secluded areas should be sited near or directly under street lighting. Avoid locating seats in grass where maintenance of the grass around and beneath the seat will be difficult. Also avoid placing seats around trees where they collect leaf litter and require increased maintenance.

Seats with an all metal framework, durable finish, armrests, slats perpendicular to the length of the seat are preferred. Seating surfaces should have ample space between slats; this type of surface tends to dry more quickly after rain. Seats should be designed to avoid entrapment hazards (see Australian Standard AS 1924.2 for head entrapment and Design Standard 15 Playgrounds and Playground Equipment for finger entrapment). Armrests and slats perpendicular to the length of the seat help to reduce vandalism; especially the danger and damage caused by in-line skaters and skateboard riders.