WATERWAYS MAINTENANCE AND REHABILITATION MASTERPLAN FOR THE TERRY'S CREEK CATCHMENT

Prepared for Parramatta City Council

By Applied Ecology Pty Ltd

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DISCLAIMER

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1 A VISION FOR THE CATCHMENT

1.1 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. Approximately 300 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.

Four people from the local community attended the meeting, and participated in a vigorous discussion session. Most of the participants indicated that they had not previously taken the opportunity to be involved in a community consultative process. The issues discussed, opportunities identified, and desired outcomes identified are summarised in the following section. This was used to inform the development of the Vision for Terry's Creek Catchment, below.

1.2 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:

- Recommendations for an overall Masterplan for Terry's Creek that includes all relevant councils (Parramatta, Ryde, Hornsby) and Lane Cove National Park
- Management of development to reduce impacts of encroachment, eg Channel 7 development site
- Manage hydraulics to reduce impacts of flooding such as erosion of creek banks and beds, eg non-functioning of detention basin at Brickworks development
- Suggestions include harvesting of stormwater on medium to high density housing developments for reuse on site, reducing peak flows in the catchment
- Changes over time observed in the shape of banks, which used to be gently sloping and lined with trees, but now are steep and incised to clay
- Changes over time observed in the nature of the stream habitat in Terry's Creek, with natural debris flushed out during storm flows
- Importance of Blue Gum High Forest EEC as a vegetation community
- Need to increase public education about the values of local native flora and fauna, eg signage along Terry's Creek Walk, labelling for important plant species, and involvement of local schools in understanding the importance of Terry's Creek
- Masterplan needs to accommodate the different types of usage for various parts of the catchment, eg. People go through Mobbs Lane Reserve and linked reserves on the Terry's Creek Walk, but they go to Edna Hunt Sanctuary to visit that reserve
- Need to provide refuges along the creek as habitat for frogs, fish, water dragons

This formed the basis of the Vision for Terry's Creek Catchment.

1.3 THE VISION FOR TERRY'S CREEK

THE VISION FOR TERRY'S CREEK CATCHMENT

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

provide opportunities for education for casual and regular users of the environment; and

ensure that land uses 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."

2 PURPOSE OF A MASTERPLAN

2.1 GENERAL PURPOSES

Parramatta City Council requires maintenance and rehabilitation masterplans for waterways within its jurisdiction. The Masterplan identifies:

- What the waterways were like in the past
- Their current status
- A vision for the specific waterway corridor
- Future opportunities and current constraints in improving them
- Detailed recommendations of works required (actions)

Actions that are recommended in the masterplan include estimated budgets, areas of responsibility, priority and type of action. Types of action may include:

- Capital works
- Education
- Research
- Strategic Management
- Maintenance

The Action Plan is flexible to allow for annual updates and refinement each year as new information is collected and more detailed investigations are undertaken. Actions will then be implemented either through Council's ongoing services or through targeted projects.

2.2 THE NEED FOR THE TERRY'S CREEK CATCHMENT MASTERPLAN

In order to develop a consistent and agreed maintenance and regeneration program for the Terry's Creek Catchment, a 'Waterways Maintenance and Rehabilitation Master Plan' is required. The Master Plan will be the primary guiding document in the management of the Terry's Creek Catchment in Parramatta LGA, and will provide a framework and foundation for the necessary collaboration between the relevant state and local government authorities for the associated maintenance and rehabilitation planning and works.

The Master Plan considers the whole of the Terry's Creek Catchment in the development of actions and recommendations. These actions and recommendations are primarily for Community Lands within Parramatta LGA that border Terry's Creek and its tributaries. In some cases, specific recommendations may be made with respect to other lands.

This report includes a review of all relevant issues associated with the Terry's Creek Catchment, and seeks to inform the development of the Waterways Maintenance and Rehabilitation Master Plan for the Terry's Creek Catchment.

3 CATCHMENT OVERVIEW

Within Parramatta LGA the Terry's Creek catchment is bound by the Northern Railway Line to the east, the Parramatta City Council boundary to the South (Terry Road), Marsden road to the west and a low ridge to the north. The main creek line running through the catchment is the headwaters of Terry's Creek.

The Terry's Creek Catchment covers an area of 215.5 hectares within the Parramatta LGA, and includes three subcatchment sections. Two smaller tributaries of Terry's Creek are included in the study area and exit the LGA before joining the main tributary of Terry's Creek downstream in the neighbouring LGA of City of Ryde. From here Terry's Creek drains to the Lane Cove River just upstream of its tidal limit. The catchment, creek-lines and selected subcatchments in the Parramatta LGA section are shown in **Error! Reference source not found.** (SMCMA 2012).

The catchment is currently undergoing major residential redevelopment of the brickworks site in the centre of the study area in addition to the old Channel 7 site immediately north on the northern side of Mobbs Lane. Both of these developments have the potential to make a significant impact on the Terry's Creek Catchment.

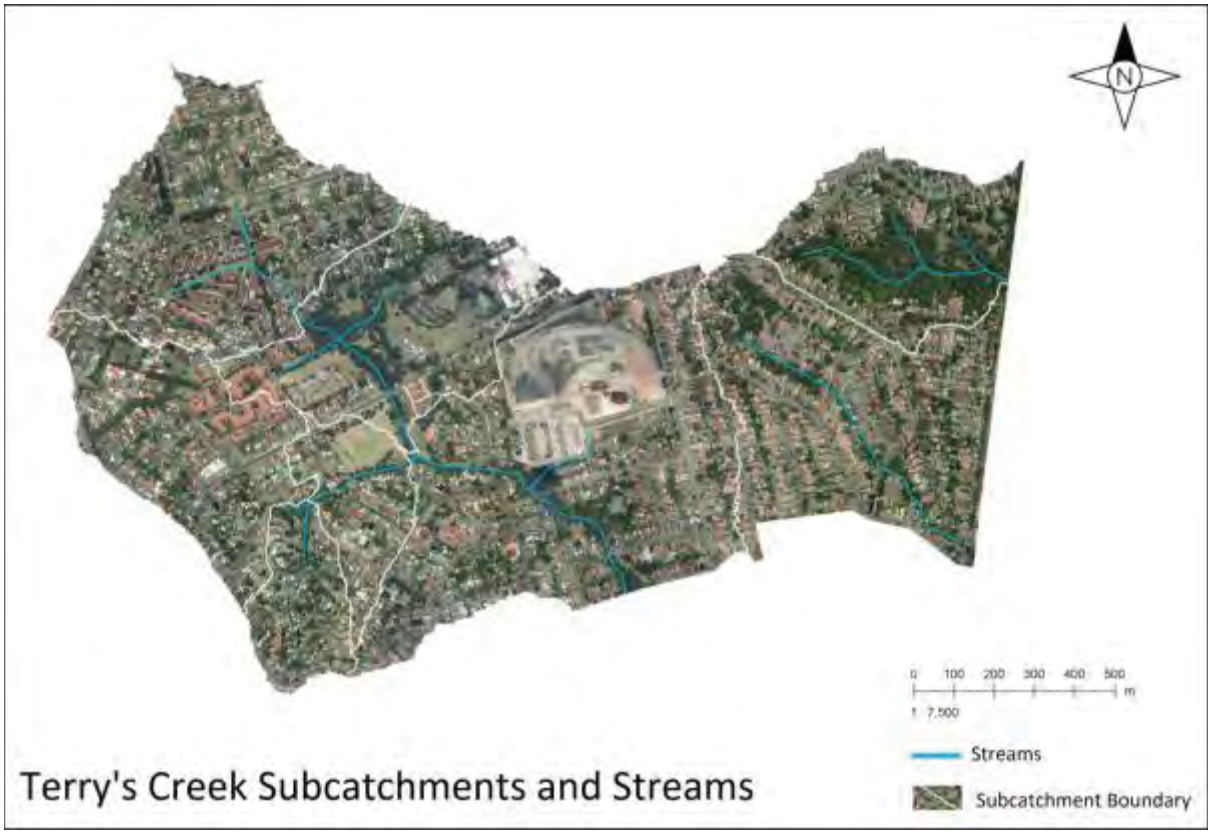


Figure 1 Study Area of Terry's Creek Catchment

The whole of the Terry's Creek Catchment extends from Carlingford to the Lane Cove River, and includes the local government areas of Parramatta City, City of Ryde and Hornsby Shire Councils. The estimated total area of Terry's Creek is approximately 1012 hectares (10.12 square kilometres).

Below the Parramatta council boundary Terry's Creek passes through a series of concrete channels that were constructed in the 1930s as part of stormwater management activities by the Dept of Public Works. The main channel continues beyond the end of the concrete lined channel below Eastwood town centre for approximately 3 kilometres in a northeasterly direction to the Lane Cove River, and then into the Parramatta River estuary.

3.1 LAND USE AND ZONING

Land use in the Terry's Creek catchment is predominantly urban residential as shown in Figure 2 (adapted from SMCMA 2012) and the Parramatta City Council zone map (Figure 3).

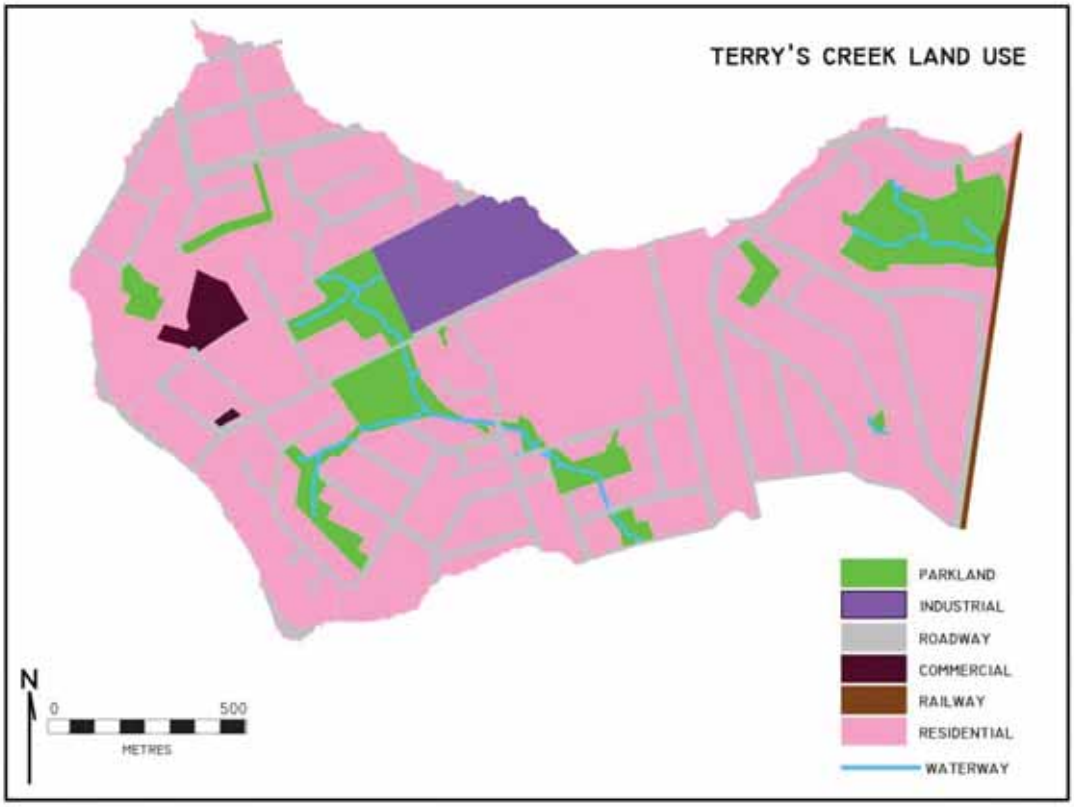


Figure 2 Study Area Land Use

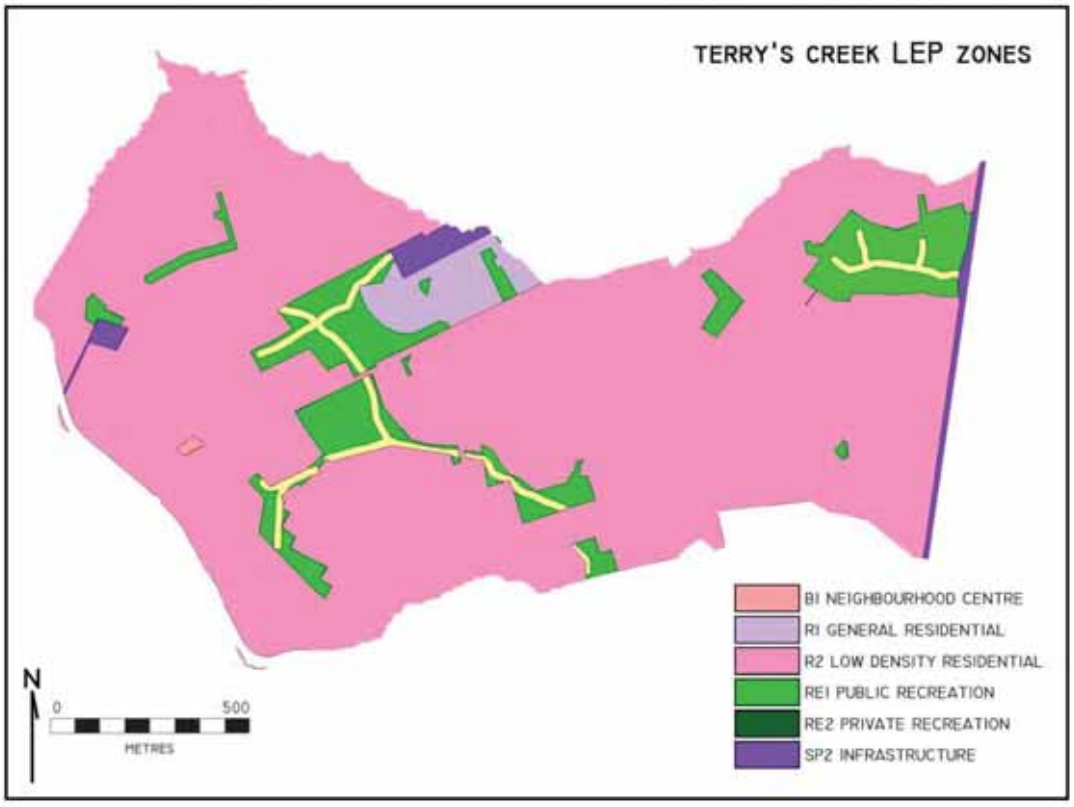


Figure 3 Study Area LEP Zones

A breakdown of the catchment land use for the Terry's Creek catchments as used in the recent Lane Cove River Source Catchments model (SMCMA 2012) is provided in **Error! Reference source not ound.**. The percentage impervious area used to calculate runoff volumes and estimated pollutant loads in this model is in agreement with that used previously for flood studies (PCC 2005) which estimated the total impervious fraction of the 215.5 ha catchment was 50%.

	Area (km2)	Area (%)
Urban/Residential	1.408	65.5%
Industrial	0.101	4.7%
Commercial	0.026	1.2%
Roadway	0.350	16.3%
Waterway	0.000	0.0%
Rail corridor	0.022	1.0%
Open Space	0.243	11.3%
Total	2.15	100.0%

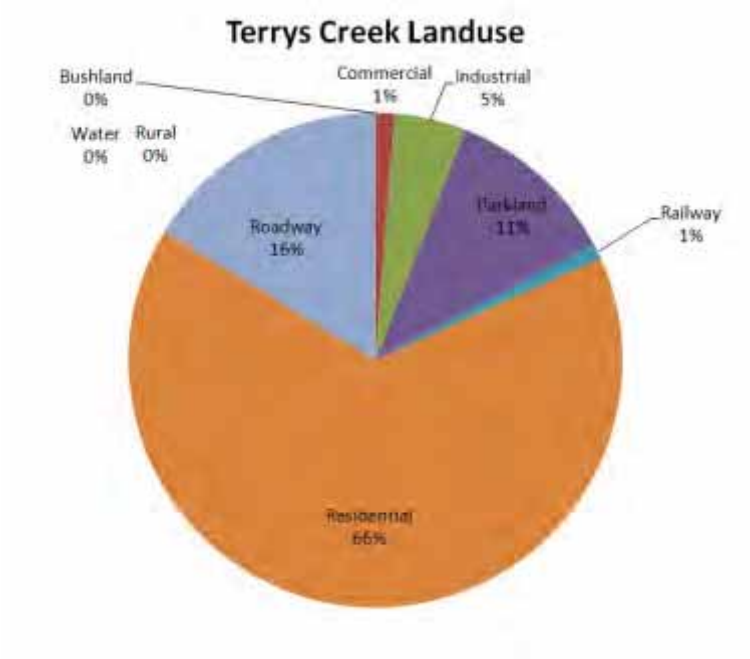


Figure 4 Terry's Creek Landuse

3.2 WHAT IS COMMUNITY LAND?

The Local Government Act 1993, herein referred to as the Act, requires Council to take and maintain an inventory of all land owned by Council. This land was then to be classified as either:

- Community Land, or
- Operational Land

The 1999 Regulation (as amended in 2005) has provided Council's with guidelines to ensure all community land is appropriately categorised and managed in accordance with identified management objectives, described in the Act as core objectives.

Community land must now be categorised as one, or more, of the following:

a) Sportsground
b) Park
c) General Community Use
d) Area of Cultural Significance
e) Natural Area

Natural Areas must be further sub-categorised as:

1. Foreshore
2. Bushland
3. Wetland
4. Escarpment
5. Watercourse

3.3 LEGISLATIVE AND POLICY FRAMEWORK

A summary of the relevant state and federal legislation that is broadly applicable to management and restoration of waterways ecosystems is provided in Appendix One of this report. Any actions that are undertaken that are likely to cause a significant impact on a matter of National Environmental Significance (including threatened species and ecological communities and migratory species) will require a referral to the Federal Minister for consideration.

Under the terms of the NSW TSC Act, Local Government must assess the impacts of any proposed development or activity which might adversely impact on an Endangered Ecological Community, threatened species or populations, including restoration works associated with streambanks and bushland rehabilitation. Where impacts are likely to occur, it must also identify strategies to minimise such impacts. Where a conflict arises, the development proposal must be referred to the NSW Office of Environment & Heritage (OEH) for resolution.

For many communities and species listed under the TSC Act, Threatened Species Recovery Plans have been prepared, while others are addressed more generally in the Priorities Action Statement (PAS). The PAS identifies 36 broad strategies to help threatened plants and animals recover, and it establishes relative priorities to implement these strategies. Each of these strategies has more specific priority actions within them, which cover things like:

- surveys to clarify the distribution of a species
- weed and pest management programs
- guidelines for threatened species issues in development assessments
- research into factors influencing the survival of threatened species
- community education programs to raise awareness of a species or threat in a particular area

Parramatta LGA has a total of 412 priority actions identified to help recover threatened species and tackle threatening processes in the LGA. These priority actions are grouped into 23 recovery

strategies and 1 threat abatement strategy. For the recovery strategies, 140 actions have high priority, 201 actions have medium priority, and 70 actions have low priority.

The PAS also establishes performance indicators to report achievements in implementing recovery and threat abatement strategies and their effectiveness and sets out clear timetables for recovery and threat abatement planning and achievement. A variety of strategies outlined in the PAS can be used to manage a threatening process. One of these strategies is the preparation of a detailed threat abatement plan (TAP) which presents a strategic framework for a targeted threat abatement program. Threat abatement plans have been finalised for a number of key threatening processes, including the following recorded in the Terry's Creek Catchment:

- Predation by *Gambusia holbrooki* (Plague Minnow)
- Predation by the European Red Fox (*Vulpes vulpes*)
- Predation by feral cats

A fourth plan is currently in draft form, open for public comment until May 2013:

- Draft threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi*

4 REVIEW OF LITERATURE: EXISTING PLANS

Several plans of management have been prepared that are relevant for the Terry's Creek Catchment. These cover a range of aspects, from stormwater and flood mitigation to biodiversity management, and have been developed by the three City Councils that manage the main channel of Terry's Creek.

4.1 Terry's Creek Catchment Management Study (Bewsher Consulting, 1991)

This report was prepared for the Sydney Water Board under the Special Environmental Program, and includes the results of a community questionnaire distributed to all residents within the catchment. The report investigates existing flooding and water quality and recommends a strategy for reducing flooding and pollution of the creek. The main recommendations include:

- Basin at Mobbs Lane
- Off-creek flood storage at Austral brickworks site
- Various culvert & stormwater augmentation
- Flood proofing & planning measures in town centre
- Review impact of community building in Hillview Rd
- Minor basin in Eastwood Park (lower field)
- Uniform OSD policy for catchment

This study recommends that the best option to rectify the deficiency of the main trunk channel is through upper catchment retarding basins, particularly utilisation of the Austral Brickworks pit in Midson Road as off-line flood storage. It also notes the generally low standard of the tributary pipe systems and the difficulty of upgrading all drainage systems to even a 5 year capacity.

4.2 Lane Cove Catchment Stormwater Management Plan (Egis Consulting, 1999)

This two volume report looks initially at issues for stormwater management in the Lane Cove River catchment. Terry's Creek is considered one of the main subcatchments in the middle reaches of the River. The Issues Report was been produced to describe the Lane Cove River catchment; identify any gaps in the data provided by stakeholders; prioritise the values of the stakeholders within the catchment; propose objectives for management of stormwater; list the issues arising from stormwater effects; and identify probable causes of the issues identified. The results from this process are summarised in the following table, reproduced here from the Issues Report (Figure 5).

Catchment Value	Value	Objective
Protection of river and bushland environment	High	• To meet recommended Australian water quality guidelines • To protect native species and biodiversity and restore sensitive areas. • To restore more natural flows in sensitive waterways to minimise flooding / erosion.
Maintaining public health and safety	High	• Improve water quality so people can swim and boat without risk to public health. • To restore more natural flows in sensitive waterways to minimise flooding / erosion. • To reduce flood effects in identified sensitive areas. • To ensure public health and safety is maintained and improve the current situation in identified "hot-spots".
Protecting resources from development issues	High	• To ensure new development does not increase degradation and will improve the current quality in some areas
Recreation on waterways or along river foreshore	Med-High	• To at least maintain identified recreation areas while minimising impact of use on other catchment resources.
Maintaining pleasing visual amenity	Med-High	• To meet recommended Australian water quality guidelines • To restore identified sensitive areas of bushland and aquatic habitat • To at least maintain identified recreation areas while minimising impact of use on other catchment resources
Develop and improve costing for management of stormwater issues	High	• To manage using Whole-of-catchment approach allowing for funding disparities • To assign worth to all values for cost/benefit analyses
Improve cooperation and standardisation between stakeholders	Med - High	• Ensure stakeholders stay involved by providing opportunities to participate . • To manage using Whole-of-catchment approach by improving the current cooperation of stakeholders and address and agree to priorities where there may be conflict
Protect commercial resources	Low	• To manage any current commercial uses while not compromising other uses valued by the community.

Figure 5 Prioritised objectives for ranked catchment values (Table 12; LCRSMP Issues Report, Egis 1999)

The second part of the SMP identifies potential management strategies, prioritises structural and non-structural management strategies, identifies alternative sources of funding, and identifies responsibilities and suggests a timeframe for actions. It takes into account possible constraints and cost/benefit analyses.

Cause	Option
Toxic chemicals:	• Encourage organic fertilisers and compost rather than chemicals • Highlight careful use of pesticides/chemicals • Education to read labels and determine what is desirable • Emergency procedures for spills • Audit potential pollution sources and work with stakeholder to produce management plans eg Petrol stations with spill plans • Ensure new development has adequate controls before approval granted • Encourage sweeping/vacuum rather than hosing • Carparks covered, oil arrestors, porous paving • Have monitoring program and reports for pollution sources eg tips • Councils to avoid herbicide use, alternate methods such as steam
Nutrients:	• Work with sports groups, schools, private landowners to suggest improved management. Recognise funding requirements. • Communal car washing spot in high density residential areas with porous pavement • Provide education for fertilising, car washing, keeping pets • Mandatory inspection of sanitary drainage systems on sale of house • Report incidents through CMC or SoE • Keep a buffer defecation zone of 10m to a watercourse. This will be addressed in the proposed Companion Animals Act • Educate about organic litter
Flow issues:	• Use new technology permeable drainage structures where possible • Install storm detention basins • Use grass swales and porous pavement where possible • Encourage or subsidise water re-use • prioritise stormwater system upgrade where there are reported flood problems
Sediment/erosion:	• Consider current guidelines when building roads access/paths • Issue consistent fines after standard warning for erosion control • Educate nursery deliverers so as not to dump loads near gutters and can educate customers. Provision to use mats • On-site detention systems in larger developments • Reduce grades of road construction, increase pervious areas • Plant appropriate vegetation (consider species and diversity) • Assess what storm level is causing erosion in sub-catchments Put in detention where possible • Identify hot-spots through audits, audit from land and water, re-evaluate priorities after actions. • Protect stream banks by stabilisation, gabian walls, rock armour. • Install PCDs.
Waste management:	• Education/awareness • Use community to report dumping then ACT (fines). Be consistent • Advertise waste management, collection days, centres
Species loss:	• Give away native vegetation to plant • Produce list of undesirables plant species and educate through nurseries (maybe make recommendations of species endemic to local area). Provide money for production of publications • Educate about bushfire hazard. Use natural grasses, mulching for fire buffer zone. Work with bush regeneration groups for maintenance of buffers • Set target of no nett vegetation loss • Avoid straight pipe outfall to watercourse, put in controls to decrease scouring. redistribute energy
Sewerage overflows:	• Obtain reports from SWC. Report frequency and volume in catchment SoE report • Install PCDs on overflows. • Request SWC monitor real overflow incidents/amounts and compare to models.

Figure 6 Potential management options for causes of stormwater issues (Table 15, pt 1; Issues Report, Egis 1999)

The SMP is described as an initial document which allows for ongoing revision after examining monitoring results and upgrading hot-spots after audits. It explores in detail the list of potential management options proposed at the end of the Issues Report (Figure 6, Figure 7). These options were designed to address the causes identified for each of the stormwater management issues that have resulted in a reduction in the condition of catchment values.

Cause	Option
Aesthetics:	• Sweep and collect visual pollutants, retain organic litter to use as mulch if appropriate. • Specify zones of non-parking for street cleaning days • Make recommendations of frequency in hot-spots after collecting data • Make recommendations on what packaging is better • Audit location of bins, regularity of emptying, work with centres, provide recycling opportunities • Redesign some garbage bins • Educate householders that organic litter should not collect in street gutters.
Policies:	• Audit hot-spots and re-evaluate priorities • Target industry to look after sections (audit, check erosion, report litter) • Agree on minimum checklist for development approvals • Agree on planning checklist when considering LEPs, note topography, distance to waterways, soils (as per Sustainable Water DCP (HSC) • During development specify staged vegetation removal • Include open space where possible (request in large developments or during extension/renovation applications) • Agree on priorities from risk and community. Establish actions to address disagreements • Define "sensitive" area for all values • Consider catchment funding pool to address Catchment priorities • Decide who collects and distributes revenue source (is it currently possible for Council Admin to collect extra funding by catchment?) • Provide CMC with opportunity to veto development proposals which are inconsistent with SMP.

Figure 7 Potential management options for causes of stormwater issues (Table 15, pt 2; Issues Report, Egis 1999)

Little attempt was made to direct the implementation of these actions on a subcatchment basis, and the report does not describe the prior condition or recommended works for Terry's Creek. It can, however, be used as a template for generic works that remain relevant for stormwater management in Lane Cove River catchment. Many of the remedial actions described in Figure 6 and Figure 7 have been implemented, and many of the strategies are commonly used today because of their ongoing successes.

4.3 PCC Biodiversity Plan (PCC, 2003)

Parramatta Council's Biodiversity Plan was prepared by council staff in 2003, and comprises two volumes. The first volume provides background information for the plan, an overview of the status of biodiversity in Parramatta LGA, a vision, goals and outcomes, and a set of management actions to achieve these aims. The vision for biodiversity management in Parramatta was stated as "Parramatta is a City that values, protects and conserves its locally occurring native plants, animals and other living things, the environment they live in and the way they interact, so that biodiversity is sustained and enhanced." To realise the Vision, the following key outcomes were identified, and management actions were tailored to meet these:

1. Biodiversity is recognised as a core business of Council.
2. Biodiversity principles are reflected across a range of public and private land uses.
3. Biodiversity principles are applied across Council units.
4. Biodiversity values are optimised while providing for adequate recreational, access, safety and cultural heritage opportunities.
5. Planning instruments are effective in protecting biodiversity.
6. The Parramatta LGA has a system of sustainable, natural corridors as well as ecological communities.
7. Populations of native plant and animal species are sustainable.
8. Council is a recognised leader in biodiversity management.
9. The local community is empowered and involved in biodiversity management and values natural areas and things.
10. Council has in place an effective system to manage, monitor and update biodiversity information.

Volume two of the Biodiversity Plan includes a review of the status of biodiversity in Parramatta LGA, including: ecological communities, native flora and conservation status of rare plants, and native fauna and the conservation status of threatened and other significant species. Considerable community input is summarized in this report, including community values and issues associated with biodiversity management, and the outcomes of several workshops.

This plan is currently being rewritten, with a new draft plan to be completed in the near future.

4.4 PCC Open Space Plan (PCC, 2003)

Parramatta Council's Open Space Plan is underpinned by the following vision statement: "From the smallest park to the river foreshore, the City of Parramatta's open space network, will offer its residents, workers and visitors an appealing, accessible and sustainable resource; one that conserves and reflects the landscape's significant natural qualities, offers recreational opportunities for all and builds on the City's rich heritage." Open space establishes a sense of place for the community and is an important contributor to the character of the area.

The principal purpose of the Open Space Plan is to provide a framework to guide the planning, development and management of Parramatta's open space system in the short and long term in line with Council's Strategic Outcomes. This includes ensuring that open space quality is maintained, the availability fits projected population demographics, complies with all the required legislation, and conforms with changing community values and cultural diversity. More importantly it recognises the need to provide adequate resources to ensure best practice planning and management of open space. The provision of ongoing maintenance is vital to the long term success of any natural area restoration program.

The Open Space Plan discusses the importance of Parramatta's natural heritage and biodiversity and the opportunities for improvement. Issues identified include the lack of awareness in sections of the community of the significance and value of this natural heritage. Public safety and pressure from the urban environment were also highlighted as major issues for natural areas. The Open Space Plan links its recommended management actions with the Parramatta Biodiversity Plan 2003 (currently under review), Parramatta Planting Strategy 2002 and the Parramatta Street Tree Masterplan 2011.

4.5 Lane Cove River Estuary Management Plan (Patterson Britton, 2004)

This plan was prepared between 2000 and 2004, and is the culmination of the Lane Cove River Data Compilation Study (1997), Lane Cove River Estuary Processes Study (2000) and the Lane Cove River Estuary Management Study (2002). Key issues affecting sustainable management of Lane Cove River were identified as:

1) Development and human impacts – expansion of urban development
2) Water quality – stormwater, landfill leachate and sewer overflows
3) Education – the need to raise community awareness
4) Estuary sedimentation
5) Riparian vegetation – needs to be preserved in an urban environment
6) Aquatic flora and fauna
7) Bank erosion and scouring of tributary creeks
8) Recreation
9) Navigation
10) Channelization of creeks and estuary shoreline, with alteration to riparian zone vegetation and subsequent potential for loss of habitat

A number of short term strategies (within 3 years) and longer term strategies (within 5 years) were recommended. While most of these fall outside the subject catchment, a number of the issues addressed are particularly relevant to the management of Terry's Creek.

4.6 Terry's Creek sub-catchment management plan: summary and final report (Cardno & Willing, 2005)

This planning report is the most recent flood study of the Terry's Creek catchment area, contained wholly within Parramatta LGA. It provides a review of the current situation for flooding potential, stormwater trunk drainage, and water quality conditions in the catchment.

Based on the issues identified, a series of management options are reviewed and a shortlist of recommendations provided. For water quality management, the following recommendations are made in Parramatta LGA:

- Sediment basin and water quality control pond (wetland) upstream of Mobbs Lane
- GPT in Skenes Avenue Reserve, near Spencer St
- GPT on corner of Mulyan Avenue and Mobbs Lane
- Streambank restoration of unlined creek sections (to reduce erosion)

Flood control options recommended for locations in Parramatta LGA included:

- Detention basin upstream of Mobbs Lane
- Culvert amplification at Valley Rd, Holway St and Terry Rd
- Restoration of earth channels

Amplification of pipe diameters is recommended for areas in the upper sections of the catchment to facilitate rapid dewatering during localized flooding. To date, the culvert amplification has been constructed at Terry Rd, and a stormwater detention basin constructed as part of the Brickworks

redevelopment plan. The current status of this basin suggests that it may not be functioning in an optimal manner (Figure 8).

Figure 8 The Brickworks detention pond has numerous PVC pipes assisting with dewatering following a recent storm

4.7 PCC Sport and Recreation Plan (Stratcorp, 2005)

The main purpose of the Plan was to develop a set of guiding principles and strategies that will provide the basis and direction to Council and other stakeholders for the future development of sport and recreation resources within the Parramatta Local Government Area (LGA). Recently, recreation participation has also been linked to the prevention and treatment of other physical and mental illnesses, and as a useful intervention strategy in reducing anti-social behaviour. Further, parks and nature have enormous untapped health potential as they provide an opportunity for people to re-establish and maintain their health in a holistic manner. Most sports reserves have at least one sport being played on them each season, which is maximising the usage and multipurpose nature of the grounds. One sports oval is located in Fred Spurway Park, on the Terry's Creek open space corridor.

Key issues identified for open space management included improved personal security in open space areas, which is an issue for residents (e.g. lighting, appropriate planting schedules, location and lighting of car parks). Residents highly value their access to well maintained and well located parks. Emerging importance noted for accommodating the needs of dog owners in relation to the provision of off leash zones that are accessible and strategically located. Sustainable turf management and maintenance practices will become increasingly more important for Council and clubs. Many of these issues have direct impacts for the management of parts of the Terry's Creek riparian buffer.

4.8 PCC Natural Areas Plan of Management (PCC, 2006)

The Natural Areas Plan of Management complied with changes to the Local Government Act 1993, and established directions for planning, resource management and maintenance of community land, with the community actively involved in decisions affecting management and use. The Plan relates to all community land within the Parramatta City Council LGA categorised as Natural Area (Bushland and Watercourse), with the exception of those that have their own individual Plan of Management. It addresses Natural Areas in their current condition and established clear directions for future management and conservation of this important public resource.

Aspects of community values for Natural Areas include

- Ecological and environmental values, including functional diversity and species richness, capacity to improve water quality, lower air temperatures and improve air quality, especially through the removal of carbon dioxide during photosynthesis.
- Educational and scientific values, including opportunities for education and research in areas such as environmental awareness, monitoring processes, bush skills, species lifecycles and ecosystem functions.
- Health values, including increased physical activity and relaxation, leading to improved overall health and wellbeing. Regular participation in these activities allows individuals to improve their overall health and wellbeing through development of mental alertness, stress management, coordination, balance and other functions
- Heritage and cultural values, particularly Aboriginal culture through significant places such as carving trees, shell middens, rock art and campsites. Parramatta LGA was one of the earliest European settlements, and historic structures are often preserved partially intact in natural areas.
- Recreational values, including the health and wellbeing benefits of recreation activities such as walking, fishing, photography, painting, birdwatching and picnicking. Linking Natural Areas greatly increases their recreational value to the community.
- Social values. The outdoors has long been part of the Australian culture, with open space areas highly valued as social venues. These areas are becoming increasingly important to the community, particularly in the city, where increasing urbanisation is leading to the replacement of the traditional 'backyard' with community open space.

All of these core community values for open space and natural areas need to be considered in the preparation of management plans for the Terry's Creek Catchment.

4.9 Eastwood & Terry's Creek Floodplain Risk Management Study & Plan (Bewsher Consulting, 2009)

The creek and catchment has a history of flooding, with the worst flood experienced in November 1984. Over 70 houses and commercial properties were estimated to have been inundated above floor level in this flood. Most flooding problems were experienced throughout the City of Ryde, including the Eastwood town centre where some 50 commercial premises were estimated to have been inundated. Other floods are reported to have occurred in 1967 and 1989.

Bewsher Consulting was commissioned by the City of Ryde in May 2006 to prepare a Floodplain Risk Management Study and Plan for Eastwood and Terry's Creek (downstream of Terry Road). The first

step of the project was to establish a computer model to simulate flood behaviour throughout the study area. The model was calibrated to the November 1984 flood and used to determine flood behaviour for a range of design floods under existing conditions. The Eastwood and Terry's Creek Floodplain Management Committee oversaw the study. This committee included Councillors and staff from the City of Ryde, and staff from Parramatta City Council, Hornsby Shire Council, Department of Environment, Climate Change and Water (DECCW), Sydney Water Corporation and the State Emergency Service (SES). A number of community representatives were also represented on the Committee.

In broad terms, this Floodplain Risk Management Study investigated what can be done to minimise the effects of flooding in the Eastwood & Terry's Creek Catchment and has recommended a strategy in the form of a draft Floodplain Risk Management Plan. A total of 12 options were identified by the floodplain management committee for analysis (Figure 9). These options were initially assessed using performance in the 100 year flood and consideration of environmental and other factors. A short list of 6 options was identified for further economic assessment.

Flood Mitigation Options Investigated

Option No.	Description	Committee Recommendation
1	Long Tunnel (Terry Rd to Forrester Park)	High costs & environmental concerns
2	Short Tunnel (Terry Rd to Eastwood Park)	Further consideration
3	Basin in Glen Reserve	Minimal impact on flood behaviour
4	Basin at Mobbs Lane	Further consideration
5	Enlarge Railway Culvert	High costs and practical difficulties
6	Basin in Eastwood Park	Minimal impact on flood behaviour
7	Upgrade Terry Road Culvert	Further consideration
8	Abuklea Road and Millner Park drainage	Further consideration
9	Debris control structures	Further consideration
10	Wood Street drainage upgrade	Has been upgraded since last flood
11	Divert flows to Parramatta River	High costs and practical difficulties
12	First Avenue Drainage Works (final stage)	Further consideration
13	Eastwood Town Centre Drainage Augmentation	Subsequently considered

Figure 9 Flood mitigation options investigated for Terry's Creek Catchment

The basin at Mobbs Lane and the culvert upgrade at Terry Road are two options that were proposed in a report prepared for Parramatta City Council. Both options were reviewed due to their potential impact on flood behaviour through the current study area. The basin was considered likely to reduce flood levels whilst the culvert upgrade could potentially increase flood levels. Model results indicate a reduction in flood levels of 0.1 to 0.2m through Eastwood in a 100 year flood due to the combined measures, but an increase of around 0.1m in more frequent floods (5 year and 10 year events). This is due to the basin becoming less effective in smaller floods whilst the impact of the culvert upgrade became more pronounced. It was recommended that a basin at Mobbs Lane be pursued with Parramatta City Council, with possible cost sharing arrangements between both Councils and the DECCW. Amplification of the Terry Road culvert was not recommended without further consideration of the impacts in smaller floods. To date there has been no progress on either proposal.

4.10 Bushcare Case Study: About our Terry's Creek Bushcare sites (Hornsby Shire Council, 2010)

Terry's Creek divides the Ryde and Hornsby local government areas where it passes between Epping and North Epping. In the Hornsby LGA it runs from just past Blaxland Road and into the Lane Cove River at Browns Waterhole. Hornsby Shire Council manages the western side of Terry's Creek from Vimiera Park north to Lane Cove National Park.

Today there are 12 Bushcare project sites within the Hornsby LGA section of the Terry's Creek Catchment. Through Council's training and support the volunteers have a good understanding of how to assist with natural bush regeneration and get good results. Council and volunteers have been restoring the vegetation growing along the creekline for decades. Together, with additional funding through grants and sponsorships, they have been able to work on significant projects for the benefit of the whole community.

- 2007-2010 A Catchment Connections Grant was awarded through NSW Environment Trust. This grant has assisted with bushland restoration by funding contracts for bush regeneration works. Volunteer Bushcare groups also received funding for training and the purchase of materials.
- 2008-2010 A grant was awarded through Greenspace to assist with walking track upgrades and the installation of directional and interpretative signs.
- 2002-2004 A $20,000 EnviroFund grant was used to employ bush regeneration contractors to target noxious weeds and run education programs.
- 2000-2002 A four-year grant of more than $118, 000 (with Council contributions) was used to restore the degraded creekline near Vimiera Park. Epping Rotary Club assisted with the project.

5 REVIEW OF STUDY AREA: CATCHMENT CHARACTERISTICS AND CONDITIONS

5.1 Geology and soils

5.1.1 Soil Landscapes

The Terry's Creek study area lies predominantly on Wianamatta Shales that have been cut in some areas to reveal the underlying Narrabeen Group sandstones. The soil groups in the study area have been described as follows:

Glenorie Soils: This is the dominant soil type in the study area.

Disturbed Areas: The landform along the waterways has been altered through progressive infill for land reclamation. These areas of infill are referred to as disturbed soil areas and typically comprise variable, unidentified fill materials. Significant disturbed areas exist adjacent to Mobbs Lane Reserve and Fred Spurway Park, and downstream near the Old Brickworks redevelopment site.

Characteristics of each soil landscape are described in Table 1 (DLWC 1:100 000 Soil Landscape Map, 1989).

Table 1 Soil landscape characteristics for soils mapped in the Terry's Creek catchment

SOIL LANDSCAPE	SOIL DEPTH	EROSION HAZARD		URBAN CAPABILITY
		CONCENTRATED FLOWS	NON-CONCENTRATED FLOWS	
Glenorie	<100cm	High	Moderate to Very High	Low to Moderate
Disturbed	40-60cm	Low to High	Low to Extreme	Capable with restrictive conditions

5.1.2 Acid Sulphate Soils

Acid Sulphate Soils (ASS) means naturally occurring sediments and soils containing iron sulphides (principally pyrite) or their precursors or oxidation products, whose exposure to oxygen leads to the generation of sulphuric acid, for example by drainage or excavation. ASS potential within the study area is shown in Figure 10.

There is a low probability of ASS 1 to 3m below ground surface adjacent to all waterways, predominantly towards the downstream section of each waterway.

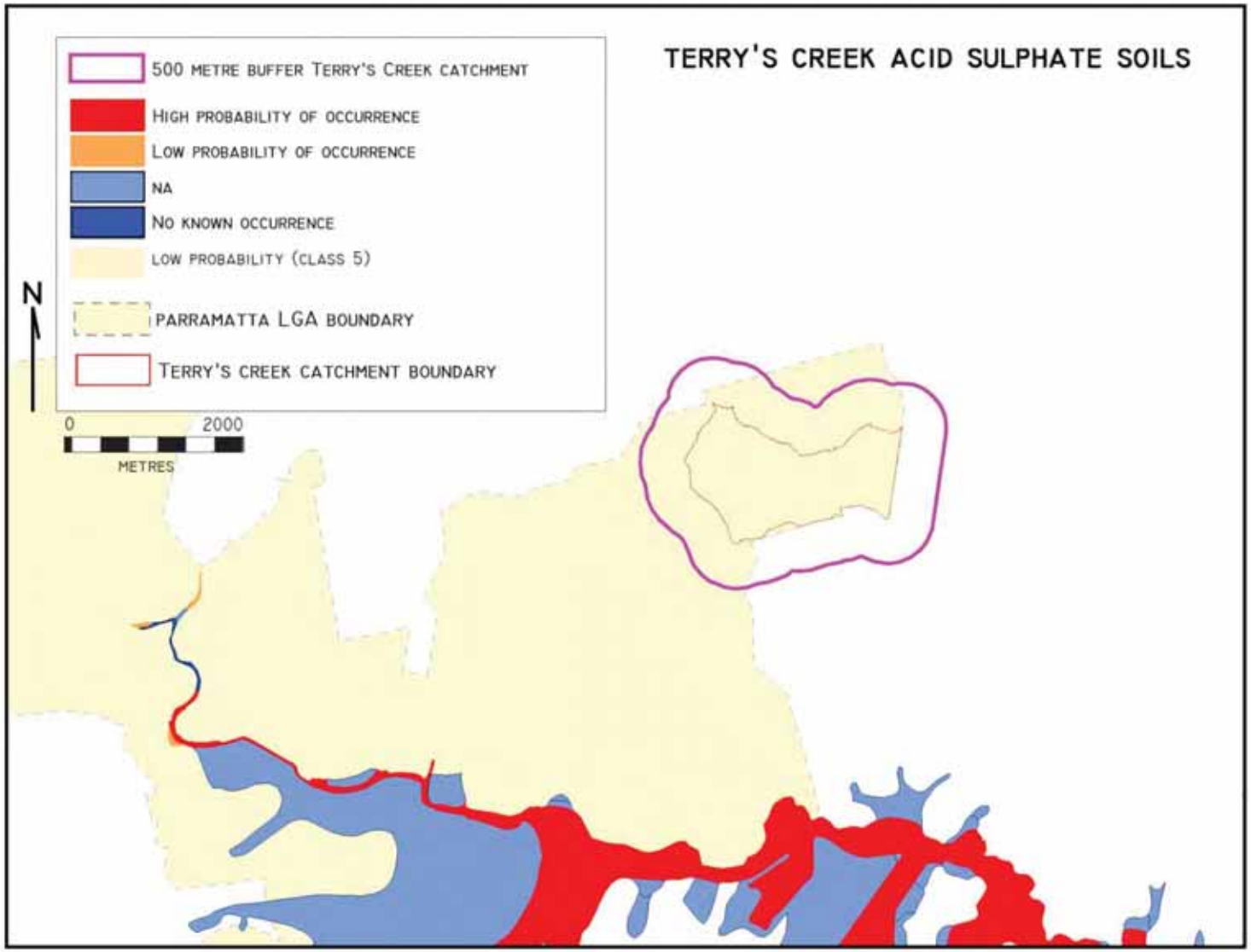


Figure 10. Acid Sulphate Soils probability mapping for Terry's Creek catchment

5.2 Flora, fauna and vegetation communities

A number of recent surveys have been conducted in the Parramatta section of the Terry's Creek Catchment riparian corridor. These include fauna surveys conducted by Applied Ecology P/L at a number of reserves during 2011/12. These lists are indicative of catchment condition, rather than exhaustive.

5.2.1 Fauna

In recent surveys Applied Ecology staff recorded 17 species of birds in reserves in the Terry's Creek catchment (**Error! Reference source not found.**; Applied Ecology, 2012). This included 2 species of ntroduced birds, and 1 threatened species. Distribution across the catchment was not consistent, with more birds recorded at Edna Hunt Sanctuary (14 species) and at Mobbs Lane Reserve (11 species). Avian diversity was considerably lower in all other reserves surveyed.

In addition, 2 species of frog were recorded, 2 lizards, 4 bats (including 2 threatened species), and 3 introduced mammals were recorded (Table 2; Applied Ecology, 2012). Once again, areas of higher diversity were concentrated in the two larger bushland reserves, and considerably lower in all other reserves surveyed.

Table 2 Summary of fauna survey records during 2012 for reserves in the Terry's Creek catchment

Fauna Group (no of species)	Mobbs Lane Reserve	Fred Spurway Park	James Hoskin Reserve	Skenes Ave Reserve	David Hamilton Reserve	Terry's Creek Walk	Edna Hunt Sanctuary
Birds (17)	11	5	7	5	4	4	14
Threatened							1
Introduced		1		1	1	1	1
Frogs & Reptiles (2)	2	2	2	2	1	1	4
Threatened							
Mammals (6)	5	4	2	2	0	0	8
Threatened							2
Introduced	1	2	2	1			2

5.2.2 Threatened Fauna

Five species of threatened fauna have been recorded from the Terry's Creek Catchment, including:

Barking Owl (*Ninox connivens*)

The Barking Owl is a medium-sized hawk-owl. Hawk-owls lack the definite heart-shaped face of the tyto-owls (which include the Barn Owl, *Tyto alba*). Adult Barking Owls are grey-brown above, with white spots on the wings, and whitish below, heavily streaked with grey-brown. The head is almost entirely grey-brown, and the eyes are large and yellow. Young Barking Owls have less streaking on the underparts and are mottled white and grey-brown on the rear of the neck. Barking Owls are nocturnal birds, although they may sometimes be seen hunting during the day.

Barking Owls are found in open woodlands and the edges of forests, often adjacent to farmland. They are less likely to use the interior of forested habitat. They are usually found in habitats that are

dominated by eucalyptus species, particularly red gum, and, in the tropics, paperbark species. They prefer woodlands and forests with a high density of large trees and particularly sites with hollows that are used by the owls as well as their prey. Roost sites are often located near waterways or wetlands.

Habitat loss and degradation is a major threat to the survival of the Barking Owl. Loss of hollow-bearing trees and firewood harvesting impacts on the species by removing nesting and roost sites as well as habitat for hollow-dependent prey such as gliders, possums and parrots. Competition from feral honeybees for roost sites has been named a key threatening process for this species in NSW. Competition with foxes and feral cats, as well as predation by foxes is also thought to be a reason for their decline. Barking Owl mortality has also been recorded due to secondary agricultural poisoning, barbed wire fences and vehicle collisions. There are two recorded observation of this species, one based on a call heard in the vicinity of Mobbs Lane in 1990, and more recently a sighting in 1996 in the same area.

Powerful Owl *(Ninox strenua)*

The Powerful Owl is a large owl with a relatively small head and a rounded tail. It is dark grey to dark grey-brown above, with white barring, and off-white below, with distinctive dark v-shaped chevrons. The eyes are yellow, set in a dark grey/brown facial mask. The legs are feathered and the yellow to orange feet are massive, with sharp talons. The sexes are alike but the female is smaller, with a narrower head. Juvenile birds are downy white on the head and underparts, the underparts are sparsely streaked, and they have much shorter tails than the adults. Powerful Owls are the largest of the Australian nocturnal birds.

The Powerful Owl is endemic to eastern and south-eastern Australia, mainly on the eastern side of the Great Dividing Range, from south-eastern Queensland to Victoria. It is found in open forests and woodlands, as well as along sheltered gullies in wet forests with dense understoreys, especially along watercourses. It will sometimes be found in open areas near forests such as farmland, parks and suburban areas, as well as in remnant bushland patches. The Powerful Owl needs old growth trees and the associated large hollows for nesting.

The Powerful Owl is adversely affected by land clearing, but can live in fragmented habitats such as farms or suburban areas. The species is sometimes killed by collision with cars, and young birds are sometimes killed by foxes, cats and dogs. The species was recorded at Edna Hunt Sanctuary in 2012 by Applied Ecology P/L.

Grey-headed Flying Fox (*Pteropus poliocephalus*)

The Grey-headed Flying-fox is the largest Australian bat, with a head and body length of 23 - 29 cm. It has dark grey fur on the body, lighter grey fur on the head and a russet collar encircling the neck. The wing membranes are black and the wingspan can be up to 1 m. It can be distinguished from other flying-foxes by the leg fur, which extends to the ankle.

This species occurs in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in

vegetation with a dense canopy. Individual camps may have tens of thousands of animals and are used for mating, birthing and the rearing of young.

Main threats for this species include loss of foraging habitat; disturbance of roosting sites; unregulated shooting; and electrocution on powerlines. There are numerous observations of this species, which is frequently recorded throughout the area.

Eastern Bentwing Bat (*Miniopterus schreibersii oceanensis*)

The Eastern Bent-wing Bat has chocolate to reddish-brown fur on its back and slightly lighter coloured fur on its belly. It has a short snout and a high 'domed' head with short round ears. The wing membranes attach to the ankle, not to the base of the toe. The last bone of the third finger is much longer than the other finger-bones giving the "bent wing" appearance.

Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures. Form discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young. Breeding or roosting colonies can number from 100 to 150,000 individuals, and the species hunts in forested areas, catching moths and other flying insects above the tree tops.

Main threats for this species include damage to or disturbance of roosting caves, particularly during winter or breeding; loss of foraging habitat; application of pesticides in or adjacent to foraging areas; and predation by feral cats and foxes. The species was recorded at Edna Hunt Sanctuary in 2012 by Applied Ecology P/L.

Eastern False Pipistrelle *(Falsistrellus tasmaniensis)*

The Eastern False Pipistrelle is relatively large with a head-body length of about 65 mm. It weighs up to 28 grams. It is dark to reddish-brown above and paler grey on its underside. It has long slender ears set well back on the head and some sparse hair on the nose. The Eastern False Pipistrelle is found on the south-east coast and ranges of Australia, from southern Queensland to Victoria and Tasmania.

The Eastern False Pipistrelle prefers moist habitats, with trees taller than 20 m. It generally roosts in eucalypt hollows, but has also been found under loose bark on trees or in buildings. It hunts beetles, moths, weevils and other flying insects above or just below the tree canopy. Like many similar species, this bat hibernates in winter and females become pregnant in late spring to early summer.

This species was recorded at Edna Hunt Sanctuary in 2012 by Applied Ecology P/L.

5.2.3 Threatened Flora

One species of threatened flora (*Acacia pubescens*) was recorded along the Terry's Creek riparian corridor:

Acacia pubescens **(Downy Wattle)**

A spreading shrub, 1 - 5 m high with brilliant yellow flowers, bipinnate leaves (divided twice pinnately) and conspicuously hairy branchlets. Occurs on alluviums, shales and at the intergrade between shales and sandstones. The soils are characteristically gravely soils, often with ironstone.

Occurs in open woodland and forest, in a variety of plant communities, including Cooks River/ Castlereagh Ironbark Forest, Shale/ Gravel Transition Forest and Cumberland Plain Woodland. Main threats for this species include habitat loss; habitat degradation (through weed invasion, mechanical damage, rubbish dumping, illegal track creation, and inappropriate fire regimes); disease; and hybridisation. This species was recorded in Edna Hunt Sanctuary.

5.2.4 Vegetation communities

Vegetation communities in the Terry's Creek catchment have been mapped recently by SMCMA as part of the draft Native Vegetation of the Sydney Metropolitan Catchment Management Authority Area (2010). The native vegetation community identified has been listed as an Endangered Ecological Community (Figure 11), and is described in the following section.

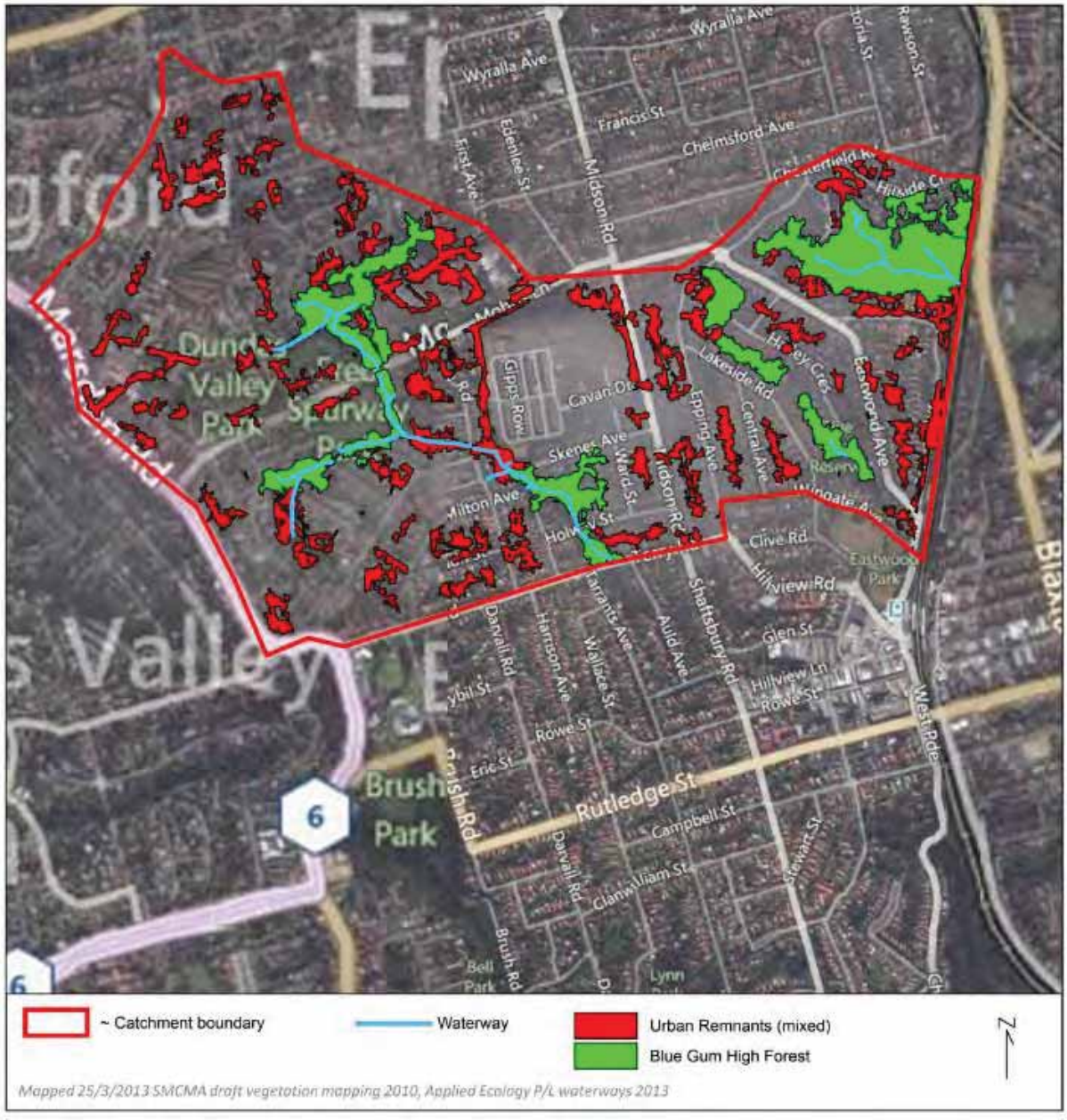


Figure 11 Vegetation in Terry's Creek catchment is predominantly urban remnants, with areas of Blue Gum High Forest EEC in poor to good condition

Additional vegetation has been described as Mixed Urban remnants, which are dominated by introduced species. This ranges from a highly degraded form of native vegetation that retains limited representation of the original species, often with only canopy species remaining, to a community where local native species may be completely absent, a condition which is much harder to rehabilitate.

5.2.5 Endangered Ecological Communities

One Endangered Ecological Communities (EEC) – the Blue Gum High Forest EEC has been recorded from the Terry's Creek catchment (Figure 12).

Blue Gum High Forest in the Sydney Basin Bioregion, a Critically Endangered Ecological Community

A moist, tall open forest community, with dominant canopy trees of Sydney Blue Gum (*Eucalyptus saligna*) and Blackbutt (*E. pilularis*). Forest Oak (*Allocasuarina torulosa*) and Sydney Red Gum (*Angophora costata*) also occur. Species adapted to moist habitat such as Lilly Pilly (*Acmena smithii*), Sandpaper Fig (*Ficus coronata*), Rainbow Fern (*Calochleana dubia*) and Common Maidenhair (*Adiantum aethiopicum*) may also occur, although the community contains many more species. Originally restricted to the ridgelines in Sydney's north from Crows Nest to Hornsby, and extending west along the ridges between Castle Hill and Eastwood. In 2000 there was less than 200 hectares remaining (about 4.5% of its original extent). It only occurs in small remnants of which the largest is less than 20 hectares. The remnants mainly occur in the Lane Cove, Willoughby, Ku-ring-gai, Hornsby, Baulkham Hills, Ryde and Parramatta local government areas.

This community occurs only in areas where rainfall is high (above 1100 millimetres per year) and the soils are relatively fertile and derived from Wianamatta shale. In lower rainfall areas, it grades into Sydney Turpentine-Ironbark Forest. The rainforest understorey species rely on birds and mammals to disperse their seeds and are vulnerable to fire. Along the drier ridgelines, fire would have been more frequent and an important factor in maintaining understorey diversity. The community also occurs on soils associated with localised volcanic intrusions (diatremes).

Main threats for this community include:

- The main threat is further clearing for urban development, and the subsequent impacts from fragmentation.
- Habitat degradation from inappropriate access and disturbance from people, horses, trail bikes and other vehicles.
- Urban run-off, which leads to increased nutrients and sedimentation.
- Weed invasion, including listed weeds such as Lantana, exotic vines and scramblers, and exotic perennial grasses.
- Inappropriate fire regimes have altered the appropriate floristic and structural diversity.
- Loss of community structure particularly understorey species from understorey scrubbing, landscaping and continual mowing.

Figure 12 Blue Gum High Forest EEC in fair to good condition is conserved at Edna Hunt Sanctuary

5.3 CATCHMENT RUNOFF AND WATER QUALITY

5.3.1 Hydrology

The Terry's Creek Catchment receives approximately 1100mm of rainfall per year (1950 to present) and evaporation of approximately 1400mm/year (SILO, 2010). Rainfall can vary significantly from year to year, but generally ranges between 600 and 1700mm/year (Figure 13).

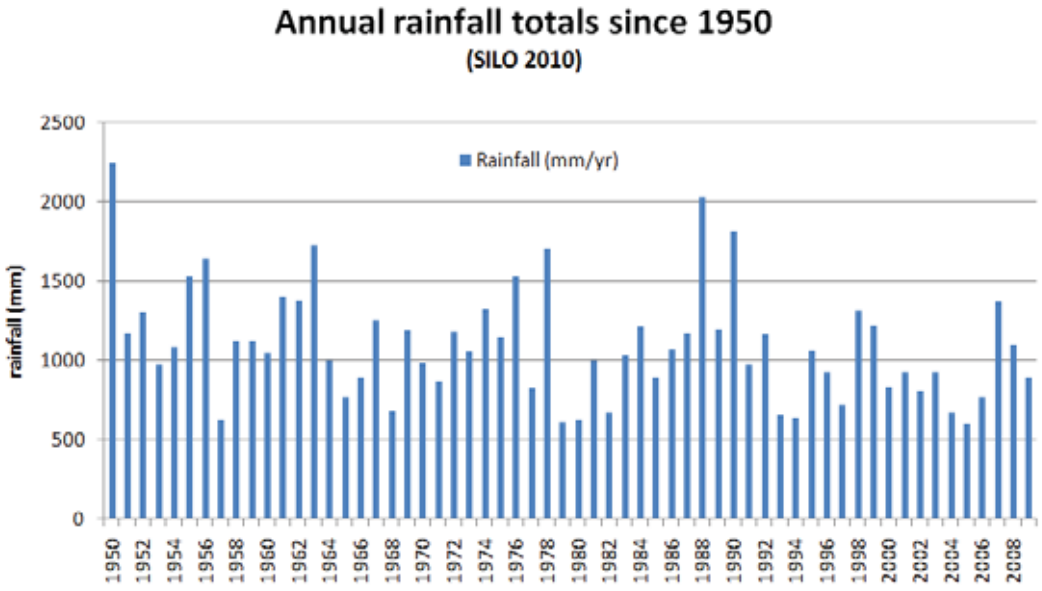


Figure 13 Terry's Creek Catchment Annual Rainfall (SILO 2010)

Catchment runoff is not systematically monitored on Terry's Creek. In the absence of stream flow records, recent catchment modeling studies have been reviewed (Table 3) to provide insight to the Terry's Creek hydrology including:

- 1991 AUSQUAL modelling (White and Cattell 1992) as part of a catchment management study;
- 2005 MUSIC modelling (Wong et al 2001) as part of a Terry's Creek flood study; and
- 2012 Source Catchments modelling (SMCMA 2012) undertaken to model the flows and pollutant loads in catchments draining to the Lane Cove River.

Table 3 Terry's Creek Runoff Studies

	Area (km2)	Runoff ML/yr	Runoff (mm/yr)
AUSQUAL (1991) **Based on 1210 mm rainfall/yr**	3.58	2383	666
MUSIC (2005) **Hourly time step modelling 1998-2000. rainfall 965mm/yr**	5.38	2510	467
Source Catchments (2012) **Whole of Lane Cove Catchment, 2003-2010.**	95.3	48744	511
Average			548 mm/yr

This modeling generally covers only relatively short time periods of a few years or less and cannot be interpreted as being indicative of the entire range of conditions in Terry's Creek. Nevertheless, this modeling provides insight to the responsiveness of the catchment to rainfall and volume of runoff generated from rainfall in this highly urbanised catchment.

The three reviewed modeling studies are largely in agreement in terms of mean annual runoff (mm/yr) estimates when taking into account the years modeled. The AUSQUAL modeling assumed rainfall close to or slightly higher than mean annual rainfall for the catchment whereas the MUSIC and Source Catchments modeling covered drier periods in the rainfall record resulting in less runoff. Taking rainfall periods into account, the modeling suggests that the catchment has a runoff coefficient of approximately 50%. This figure indicates that the catchment is likely to be highly responsive to rainfall and that even small, frequent rainfall events (<5mm rainfall) are likely to result in runoff being generated from the impervious surfaces in the catchment.

5.3.2 Water quality

Several studies have included collection of water quality data in the Terry's Creek Catchment:

1) **Hornsby Shire Council Water Quality Monitoring Program Annual Report 2011–12**

Hornsby Shire Council has conducted ongoing sampling at numerous sites across the LGA, including Site 46 which is located on an unnamed tributary of Terry's Creek on a track from the eastern end of Somerset St, North Epping. This tributary flows into Terry's Creek well below the Parramatta LGA boundary, and has no relevance for the current study.

2) **Biological Survey of Parramatta Waterways – Aquatic Ecology Report (Cardno Ecology Lab, 2010)**

Biological surveys were undertaken during spring 2009 and autumn 2010 at 20 representative sites distributed across four major catchments in the Parramatta Local Government Area (LGA). The primary objective of these surveys was to determine the biological health of each waterway as indicated by water quality, the condition of aquatic habitats and their associated fauna and flora. The secondary objective was to determine whether the biological health of each waterway was related to the level of effective imperviousness (the proportion of the catchment that consists of impervious surfaces connected directly to streams by stormwater pipes).

One of these sites was on Terry's Creek, located in the Unnamed Reserve off Valley Road. The site was described as a second order stream with "a highly modified, narrow, shallow channel located within a densely populated residential area. There was minimal shading over the reach and a moderate, young, intermittent riparian vegetation corridor that contained a public walking track along the northern edge of the creek. Short sections of the stream bank were supported by boulder retaining walls and major bank stabilization/plant regeneration works had recently been completed at the downstream extent of the study reach. The site was broken up into pool sections (gravel and sand dominated substratum) by a long riffle section characterized by pebbles, gravel and sand. Bank stabilized stormwater tributaries entered the creek near the middle of the study site and at the downstream extent".

Results of surveys conducted at TRWP04 monitoring site on Terry's Creek are summarised in Table 4.

Table 4 Summary of field sampling results from biological surveys conducted in Terry's Creek (Cardno 2010)

PARAMETER	SPRING 2009	AUTUMN 2010
Diatoms	28 species	36 species
Macrophytes	10 species, including 7 native and 3 introduced	13 species, including 7 native and 6 introduced
Macroinvertebrates: riffle	18 species	15 species
Macroinvertebrates: edge	17 species	19 species
SIGNAL2 score: riffle	3.00	3.27
SIGNAL2 score: edge	3.30	3.19
Analysis of macroinvertebrate results	Above average diversity and SIGNAL2 score	Above average diversity and SIGNAL2 score
Fish	2 species, 5 captures	3 species, 3 captures

The results of an overall analysis indicated that the site was subject to moderate disturbance at that time, and was in better condition than many of the other sites surveyed. The Terry's Creek site scored poorly during spring 2009 surveys for water quality, diatom abundance, SIGNAL2 scores for riffle fauna, and fish diversity; and during autumn 2010 surveys for macroinvertebrate diversity in riffles and SIGNAL2 scores for riffle fauna.

When biological indicator results were correlated with % effective imperviousness of the subcatchment, the study found overall a positive relationship with diatom and fish diversity, suggesting these fauna are dependent on water quantity more than quality, although diatoms typically respond quite quickly to changes in water quality. The absence of other significant relationships was attributed to the range of potential environmental disturbances resulting from urbanisation of the catchment, including "clearance of riparian vegetation, channel modification, dumping of rubbish, inputs of nutrients, and changes in flow regime resulting from the construction of weirs and barrages."

3) Other studies

Recent water quality data specific to the Parramatta section of the Terry's Creek Catchment appears to be limited, however the studies undertaken for the 1991 catchment and flood study (SPCC 1991) include:

- A review of previous Water Board sampling on Terry's Creek;
- Results from wet weather and baseflow sampling undertaken for the SPCC 1991 study; and
- Results of sediment analysis (metals concentrations)

In addition to these studies, Ryde City Council has collected water quality data in Terry's Creek, however this sampling site is located approximately 3km downstream of the study catchment. The locations of sampling sites are listed in Table 5, and shown in Figure 14. Note that Site 3 and Site 8 are effectively in the same location but relate to studies done over different time periods.

Table 5 Site locations, dates of surveys and sources of data for water quality records relevant to PCC's section of Terry's Creek

SITE LOCATION	SURVEY DATES	DATA REFERENCE
Site 1 City of Ryde	2004-2011	CoR 2012
Site 2 Pembroke Street	1989-1990	SPCC 1991
Site 3 Somerville Park	1989-1990	SPCC 1991
Site 4 Lane Cove River Confluence	1989-1990	SPCC 1991
Site 5 Valley Road	1991	SPCC 1991
Site 6 Terry Road	1991	SPCC 1991
Site 7 May Street	1991	SPCC 1991
Site 8 Cassia Place/Somerville Park	1991	SPCC 1991

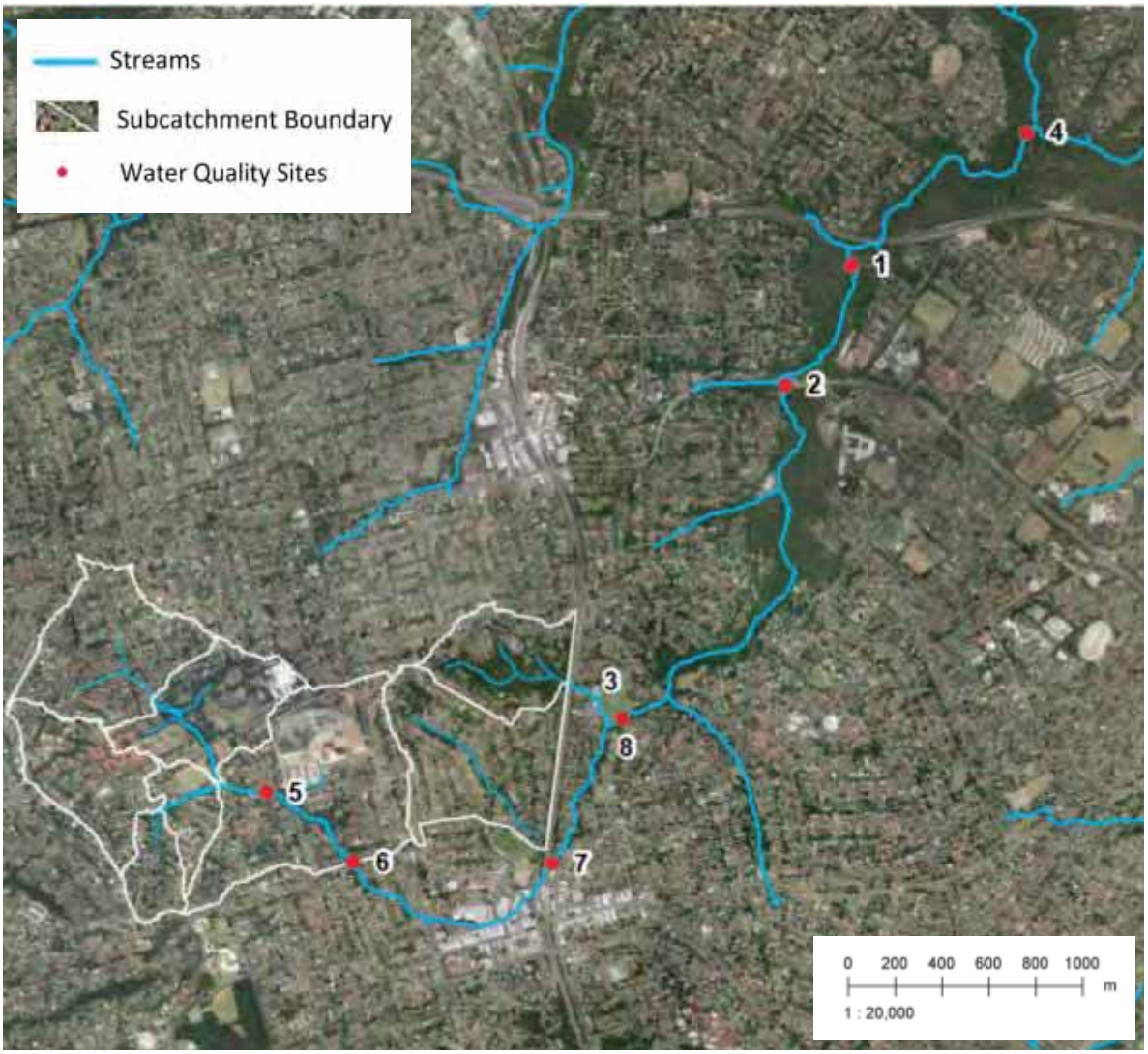


Figure 14 Terry's Creek Water Quality Sites:

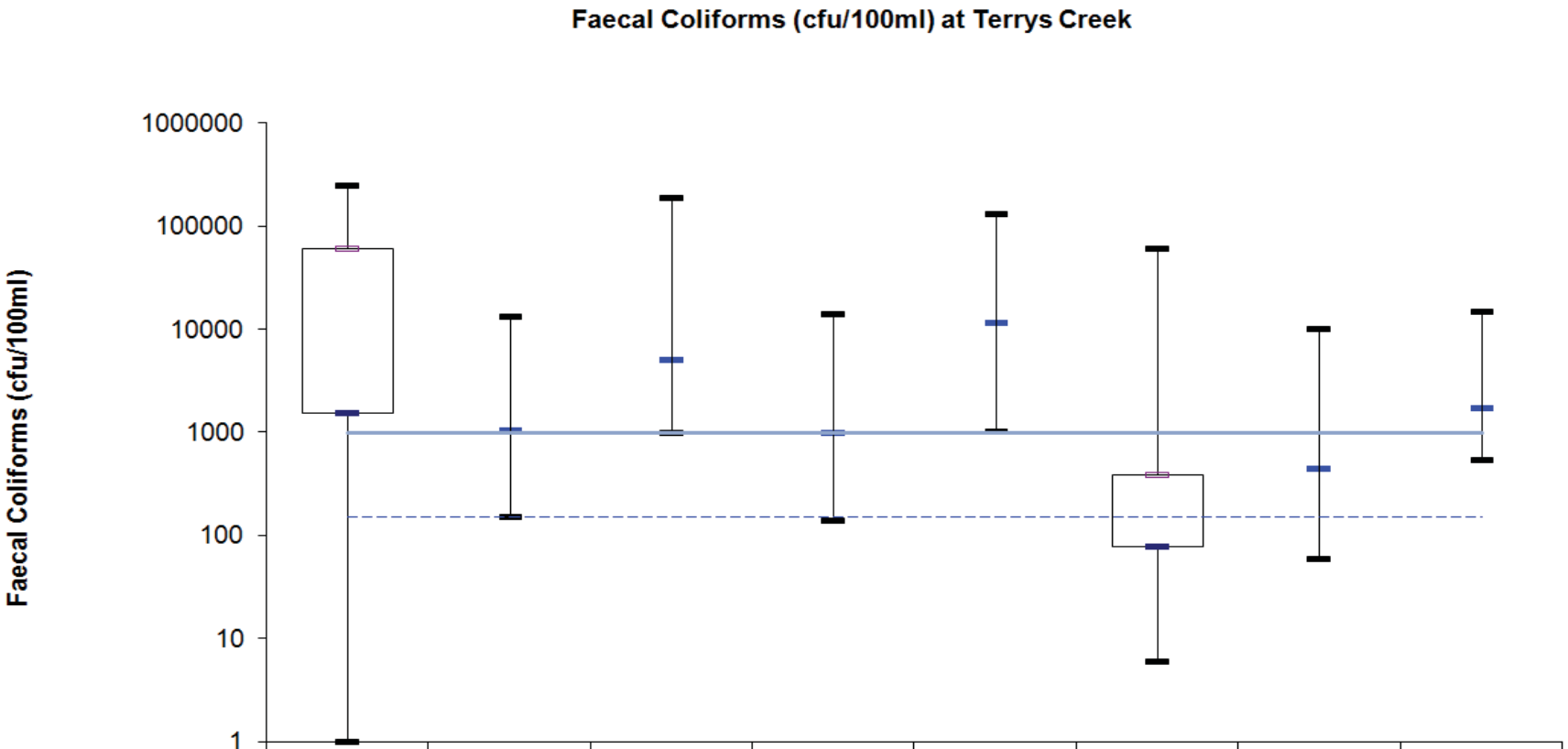
5.3.3 Water Quality: Microbiology

The studies reviewed contained faecal coliform data to represent microbiological water quality (Figure 16 overleaf). This data showed:

- Historically, the median faecal coliform levels in Terry's Creek are near or above guideline levels (for example, in Unnamed Reserve Valley Rd, Figure 15);
- Wet weather sampling events show higher counts of faecal coliforms; and
- There may be a slight trend to lower faecal coliform levels as you travel further downstream.

The high historic bacteriological levels in Terry's Creek had previously been partially attributed to sewer overflows (SPCC 1991) and indeed, 1 sewer overflow event just outside this study boundary at Shaftsbury Road was observed and sampled during the 1991 study.

Figure 15 Poor water quality can be evident by the growth of algae and bacterial sludge, seen on a high flow bench in Unnamed Reserve, Valley Rd



	sites 5-8. 1991 study (combined)	Site 3 Somerville Park (dry)	site 3 Somerville Park (wet)	Site 2 Pembroke street Dry	Site 2 Pembroke street (wet)	Site 1 Ryde site	Site 4 US LCR confluence dry	Site 4 US LCR confluence wet
20th percentile	1548					77		
minimum	1	150	1000	140	1020	6	60	540
Median	21000	1060	5000	1000	11500	155	450	1700
maximum	250000	13200	190000	14000	130000	60000	10000	15000
80th percentile	60000					390		
Guideline Primary Contact	150	150	150	150	150	150	150	150
Guideline Secondary Contact	1000	1000	1000	1000	1000	1000	1000	1000

Figure 16 Microbiological Water Quality

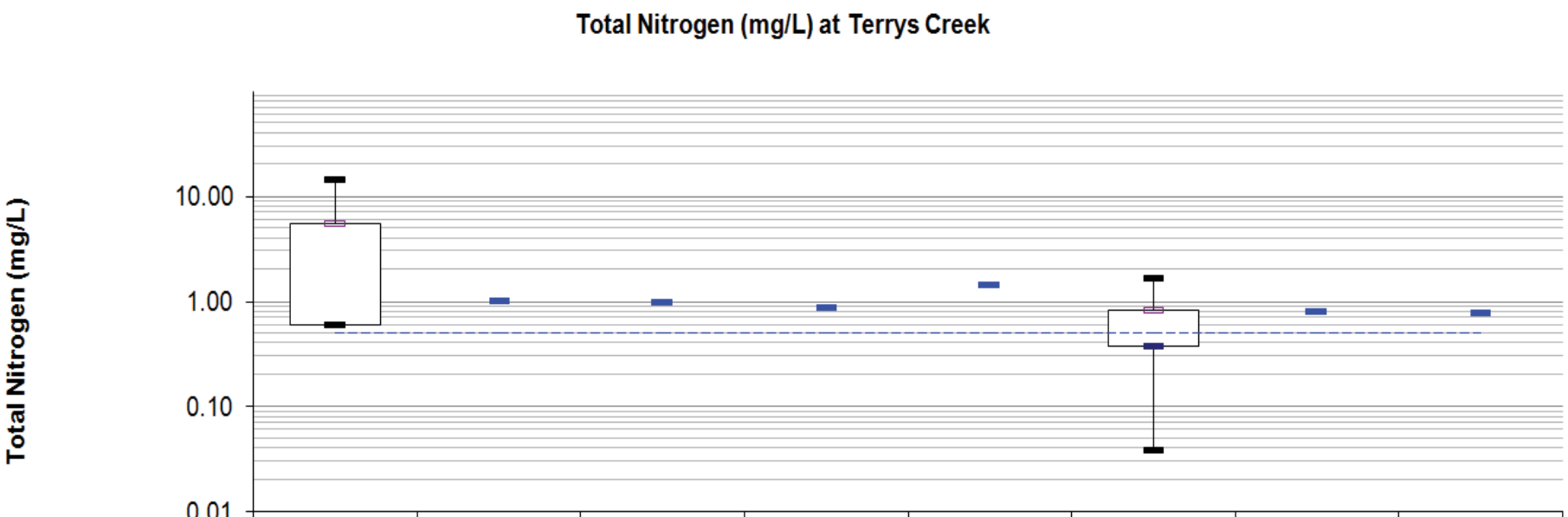
5.3.4 Water Quality: Nutrients

The nutrient data specifically collected in the 1991 study (Figure 18 overleaf; SPCC 1001) showed relatively high nutrient loads compared to older SPCC data reviewed in this study and data from further downstream in Terry's Creek collected by Ryde Council. The relatively high nutrient levels observed in the 1991 study are indicative of concentrations typically found in highly urbanised catchments, particularly during storm events. The data shows:

- Historic (pre 2000) TN data shows median values exceed default Aquatic Ecosystem trigger values (Figure 18 overleaf; ANZECC 2000);
- Historic (pre 2000) TP data shows median values don't exceed default Aquatic Ecosystem trigger values (ANZECC 2000) with the exception of upper catchment data (Figure 19 overleaf); and
- Recent data from Ryde City Council for lower Terry's Creek shows median nutrient values near or below trigger values (Figure 18; Figure 19).

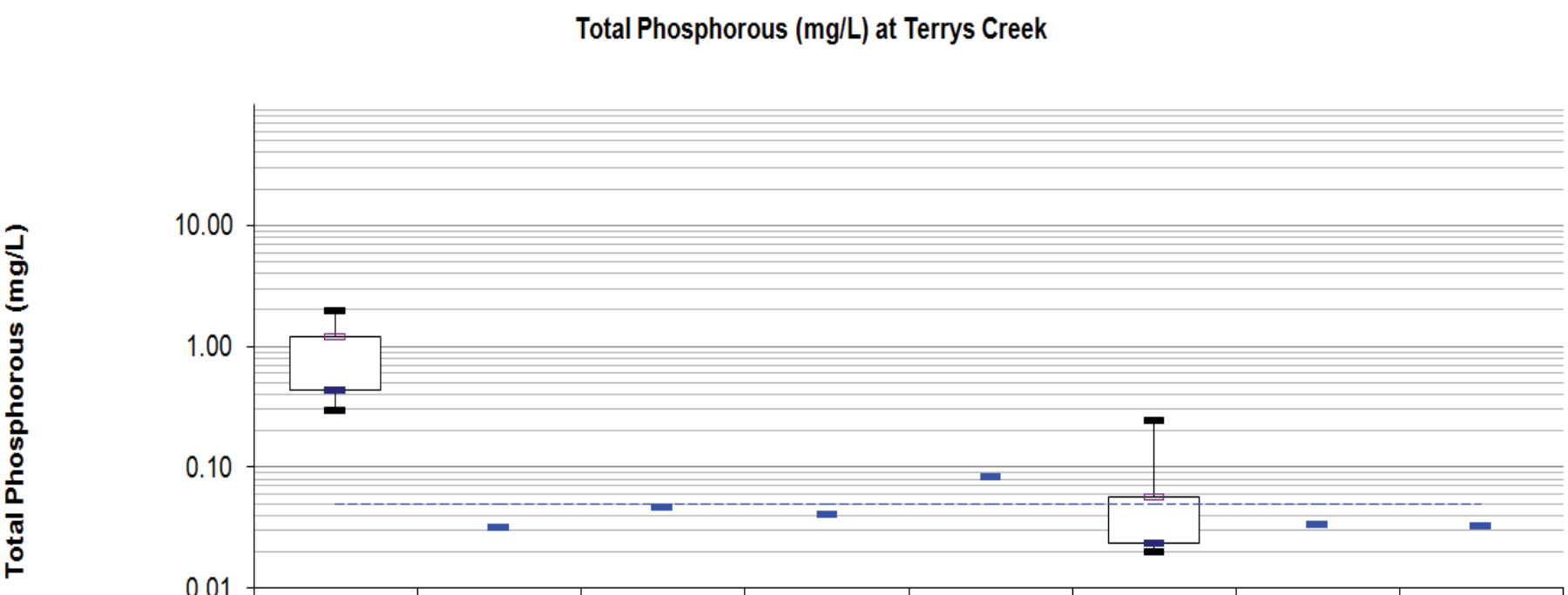
It is worth noting that the trigger values are generally not applicable to urbanised systems such as Terry's Creek. Nevertheless they do provide both an aspiration target for at least median water quality values and an indication of historically poor water quality in the upper catchment (Figure 17).

Figure 17 Elevated nutrient levels (TN and TP) promote channel choking weeds, seen at Fred Spurway Park



	sites 5-8. 1991 study (combined)	Site 3 Somerville Park (dry)	site 3 Somerville Park (wet)	Site 2 Pembroke street Dry	Site 2 Pembroke street (wet)	Site 1 Ryde site	Site 4 US LCR confluence dry	Site 4 US LCR confluence wet
20th percentile	0.6					0.38		
minimum	0.6					0.04		
Median	1.2	1.01	0.98	0.88	1.44	0.58	1	1
maximum	14.3					1.68		
80th percentile	5.5					0.83		
Guideline trigger value lowland River	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Figure 18 Terry's Creek Total Nitrogen data



	sites 5-8. 1991 study (combined)	Site 3 Somerville Park (dry)	site 3 Somerville Park (wet)	Site 2 Pembroke street Dry	Site 2 Pembroke street (wet)	Site 1 Ryde site	Site 4 US LCR confluence dry	Site 4 US LCR confluence wet
20th percentile	0.440					0.023		
minimum	0.300					0.020		
Median	0.600	0.03	0.05	0.04	0.08	0.03	0.03	0.03
maximum	2.000					0.243		
80th percentile	1.200					0.056		
Guideline trigger value lowland River	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Figure 19 Terry's Creek Total Phosphorus data

5.3.5 Water Quality: Suspended Sediments

Recent suspended solids data specific to the catchment is not available, however historic data from the 1991 study (Figure 21 overleaf; SPCC 1991) captured some baseflow samples and 2 storm event samples in the catchment and showed:

- Data collected during baseflow and small stormflow conditions was associated with relatively low TSS levels (<50mg/L);
- The large storm event captured was associated with much higher TSS loads and was attributed to the Brickworks site (now an urban development) undertaking dewatering activities during this large rainfall event.

The increase in TSS loads to Terry's Creek due to inflow at the brickworks site is likely to still be occurring today and was observed during site inspection on the 9th March 2013 (Figure 20). The large sedimentation basin constructed on the old brickworks site was discharging to Terry's Creek and resulted in noticeable increases in turbidity downstream.

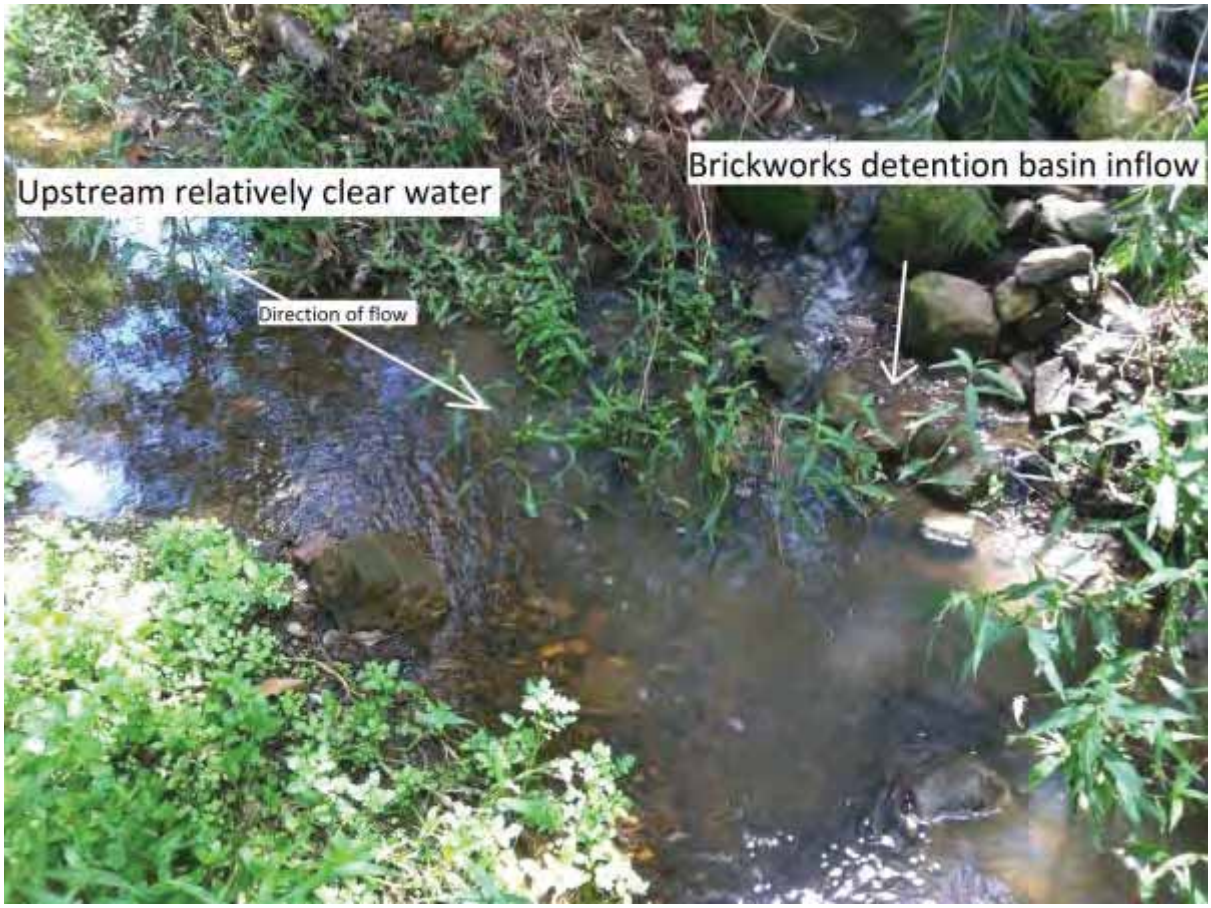
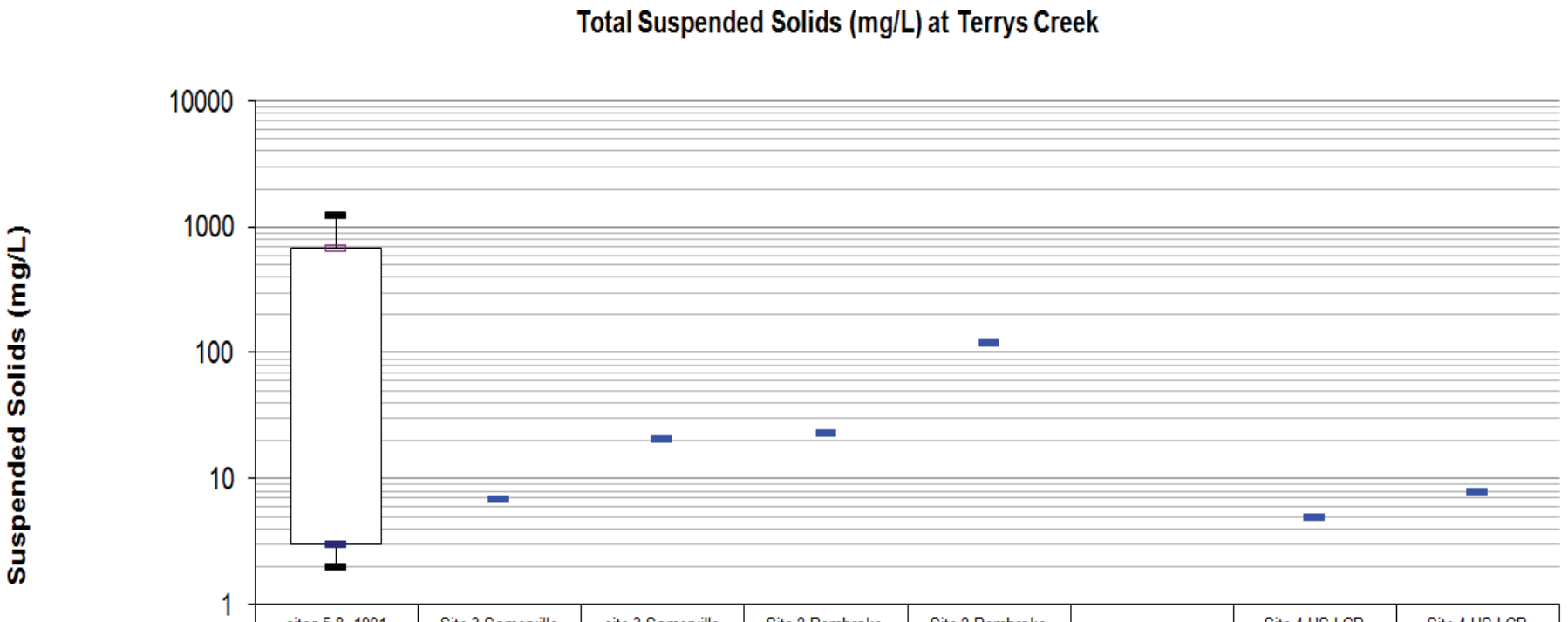


Figure 20 Terry's Creek. Brickworks Sedimentation Basin Inflow during dry conditions (9th March 2013)

It appears that the increased turbidity is associated with post rainfall event dewatering of the sediment basin, and that inadequate efforts have been made to remove sediments from the water column prior to discharge.



	sites 5-8. 1991 study (combined)	Site 3 Somerville Park (dry)	site 3 Somerville Park (wet)	Site 2 Pembroke street Dry	Site 2 Pembroke street (wet)	Site 1 Ryde site	Site 4 US LCR confluence dry	Site 4 US LCR confluence wet
20th percentile	3.0							
minimum	2.0							
Median	20.0	7.0	21.0	23.0	122.0	no data available	5.0	8.0
maximum	1245.0							
80th percentile	677.0							

Figure 21 Terry's Creek Suspended Sediment Data

As part of this investigation, two site inspections were undertaken. The first was under dry conditions on the 9th of March 2013 and the second was on the 12th of March during wet conditions (rainfall 3-5mm). Figure 22 shows the change to inflow and water clarity downstream of Skenes Avenue and Brickworks site. The small amount of rainfall in the catchment has clearly resulted in increased surface runoff compared to dry conditions and has also resulted in increased turbidity. This qualitative information supports earlier findings that:

- Runoff in the catchment is regular and is generated even from small storms;
- Event based runoff is generally associated with higher sediment loads; and
- the Brickworks site is still a contributor to increased sediment loads in the catchment despite attempts to mitigate the impacts of development through the construction of a large sedimentation basin.

Figure 22 Changes in Terry's Creek flow and water clarity (left: dry conditions, right: 0-5mm of rainfall)

5.3.6 Sediment Quality: Metals

The 1991 SPCC study included 1 occasion of in-stream sediment sampling and analysis for metals. The data collected is from sites 5-8 in Figure 14 and is reproduced in Table 6 in addition the sediment quality trigger values. Values that fall between the low and high trigger values (ANZECC 2000) are highlighted in blue and those that exceed the high trigger value are highlighted in red.

The data in Table 6 shows that a number of sites exceed the high trigger value for Lead and one site exceeds the high trigger value for Zinc. The May street site (just outside the study area) also shows Copper and Chromium to be over the low trigger value.

Although the sediment quality data is very limited in both the number of samples analysed and the spatial coverage, it does show that sediment quality may be an issue for any future rehabilitation

efforts and further inquiry may be justified should significant rehabilitation works be undertaken in the catchment.

Table 6 Terry's Creek 1991 Sediment Quality (ug/g). Note: Values that fall between the low and high trigger values (ANZECC 2000) are highlighted in blue and those that exceed the high trigger value are highlighted in red

Site	Pb	Fe	Cu	Cr	Mn	Zn
5. Valley Road	182	3200	18	2.2	267	133
6. Terry Road	45	2130	11	19	203	71
7. May Street	381	6880	111	92	141	737
8. Cassia Place	374	5310	34	5.4	252	408
Low trigger value(1)	50	-	65	80	-	200
High trigger value (1)	220	-	270	370	-	410

5.3.7 Water Quality Modelling

As the above review shows, recent water quality monitoring data in the Parramatta section of Terry's Creek is not available for this study, however the three runoff modeling studies reviewed above have all calculated pollutant loading rates of key constituents, total suspended sediments, total nitrogen and total phosphorous. Similar to the runoff studies, the water quality modeling covers only a relatively short time periods of a few years or less. The results of mean annual pollutant export are provided in Table 7 and reflect typical values for similar urban land uses (Bartley and Spiers 2010).

Table 7 Terry's Creek Water Quality Modelling Results

	AUSQUAL	MUSIC	Source Catchments
Total Suspended Solids (kg/ha/yr)	844	900	843
Total Nitrogen (kg/ha/yr)	9.5	13.4	12.2
Total Phosphorous (kg/ha/yr)	1.34	1.85	1.40

5.4 STREAM AND CHANNEL MORPHOLOGY, FLOODING AND CLIMATE CHANGE

5.4.1 Geomorphic Features and Stream Behaviour

Reaches of the Terry's Creek, including sub branches that run through Edna Hunt Reserve have been visually assessed during two field visits on the 9th March 2013 and the 13th March and broadly characterised into dominant stream processing character and channel stability. The assessment process was undertaken via visual inspection and key stream character attributes were:

1. Stream bed and bank stability; and
2. Stream processing zones.

Stream bed and bank stability was assessed visually by walking between 50 and 250m channel segments and assigning appropriate ratings and a score based upon these ratings. The rating elements and example photographs are provided in Figure 23.

For detailed mapping of stormwater pits and pipes networks, including pipe diameters, see Appendix Four. This mapping was completed by PCC's Catchment Management Team in 2010.

Figure 23 Stream bed and bank stability examples

Stream bed and bank characteristic	Photograph of example from the catchment
Concrete Lined: **Score = 0** **Example: Drain behind Harley Crescent**	
Stable: **Few or no signs of bed and bank erosion, vegetated floodplain** **Score = 1** **Example: Upper Edna Hunt Reserve**	
Minor Erosion: **Irregular bank undercutting and pinch points** **Score = 1 to 2** **Example: Johnson to Fred Spurway reserve**	

Moderately Eroding: **Stream is incised and contained, regular bank undercutting and evidence of scour** **Score = 3** **Example: Lexington to Johnson**	
Highly Eroding: **Stream is deeply incised, generally earth/rock lined with regular pinch points. High degree of bank erosion and scour** **Score = 4 to 5** **Example: Upstream of Terry Road**	
Aggregating: **Weirs or impoundments assist in trapping the movement of sediment leading to buildup**	Not applicable in this catchment
Tidal: Stream is under tidal influence	Not applicable in this catchment

Stream processing zones were assessed in a similar fashion to the stream bed and bank stability. Each reach was assigned a dominant zone, or zones to indicate the major stream processing. Processing zones were divided up into the following general zones:

- Ephemeral;
- Vegetated;
- Riffle;
- Glide;
- Pool;
- Impoundment;
- Tidal; and
- Concrete lined channel.

A total of 22 stream reaches were assessed for geomorphic condition during field inspection. Several minor tributaries with short (<10m) unpiped sections were not independently assessed, but incorporated into scoring for the reach it joins with. A detailed description of reach apportionment

can be found in Section 9.1 of this document. The catchment, pipe network and reach based bed and bank stability scores for the 22 reaches assessed for geomorphic condition are shown in Figure 24.

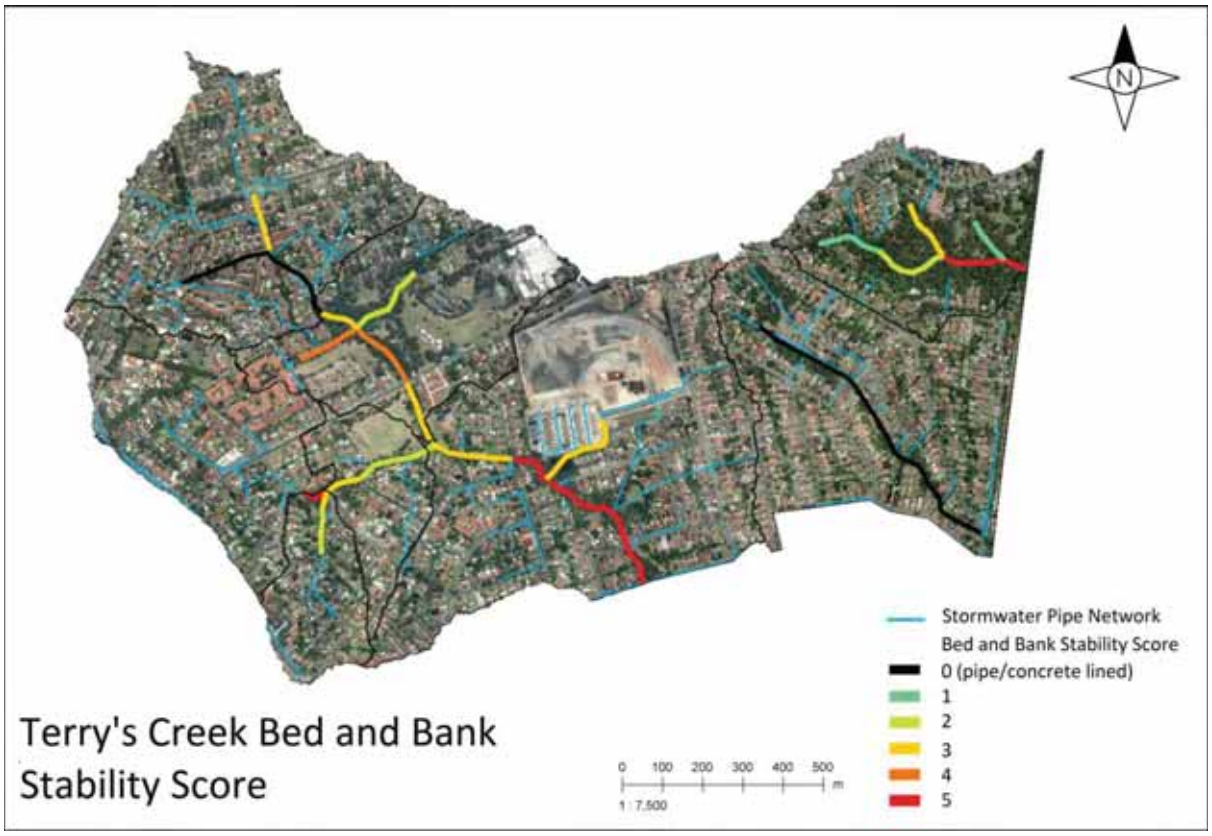


Figure 24 Terry's Creek Catchment bed and bank stability scores

These scores were used to determine a geomorphic condition trajectory for each reach as part of the scoring process and to inform the restoration prioritisation process.

The bed and bank stability scores generally increase (indicating deteriorating conditions) from upstream to downstream. This is to be expected, given that flow volumes that the channel must accommodate are greater in the lower reaches compared to the upper reaches. Stream processing characteristics were generally ephemeral in the upper reaches to pool and riffle zones in the lower reaches before entering the concrete lined drainage channels. Notably, during field inspections the following general features were observed:

- Creek junctions and location where stormwater drains discharged to the main channel appeared to be associated with high levels of bed and bank erosion;
- Rock armouring of some channel sections has been undertaken, however these are generally short (10-30m) sections of channel;
- The discharge from the detention basin on the Brickworks development has undercut and/or bypassed the undersized channel and armouring and is resulting in erosion; and
- During site inspections, little or no sediment and erosion control measures were observed at the Channel 7 development site to prevent sediment from moving directly into Terry's Creek.

5.4.2 Changes in the catchment since European settlement

The Terry's Creek catchment has undergone significant changes since European settlement including:

- Extensive urbanisation and industrialisation resulting in catchment hardening/imperviousness;
- Land clearing;
- Channelisation and lining of sections of the Terry's Creek and side creeks resulting in hydraulically efficient drainage system; and
- Introduction of additional pollutant sources such as agriculture, and now urbanisation and sewage infrastructure.

The study area is situated on the Glenorie soil landscape. These soils typically have moderate fertility, high available water capacity and moderate erodibility (Chapman & Murphy 1989). Prior to European settlement the catchment area would have been well vegetated with woodlands and forest, predominantly Sydney Blue Gum Forest. Sydney Sandstone Gully Forest would have commonly occurred in the steeper gullies of the catchment.

Aerial photographs provide an objective means of gauging more recent catchment change, particularly vegetation and urbanisation. A selection of photographs from 2011 and 1943 showing the same parts of the catchment are shown in Figure 25 to Figure 27. The photographs show that by 1943, much of the Terry's Creek catchment had either undergone urbanisation or was in the process of doing so. Large sections of the upper catchment remained rural with some stands of trees still present. The lower section of Terry's Creek has already been converted to a concrete channel. Crops and/or open paddocks accounted for much of the land use in the upper catchment, however, there is not a substantial change in urban density in the lower catchment between 1943 and 2011.

Figure 25 1943 and 2011 spatial imagery, Mobbs Lane area. Source: LPI NSW, Spatial Information Exchange.

Figure 26 1943 and 2011 spatial imagery, Valley Road area. Source: LPI NSW, Spatial Information Exchange.

Figure 27 1943 and 2011 spatial imagery, Shaftesbury Road area. Source: LPI NSW, Spatial Information Exchange.

The changes in the catchment since European Settlement are likely to have resulted in:

- Larger runoff volumes, higher peak flow rates and higher frequency of surface runoff;
- Increased channel erosion and incision and sedimentation in dead zones/pools;
- Higher nutrient loads and more sunlight; and
- Lower water tables delivering subsurface flows and baseflows to the stream.

These impacts are typical of urban developments in Eastern Australia. These changes typically would have begun following land settlement and are not necessarily very recent changes. Closer aerial photograph inspection of selected Terry's Creek sections indicate an overall increase in vegetation and bush reserves, particularly adjacent to the creek. Two major construction sites on Mobbs Lane dominate the landscape in 2011 with large areas of exposed soil.

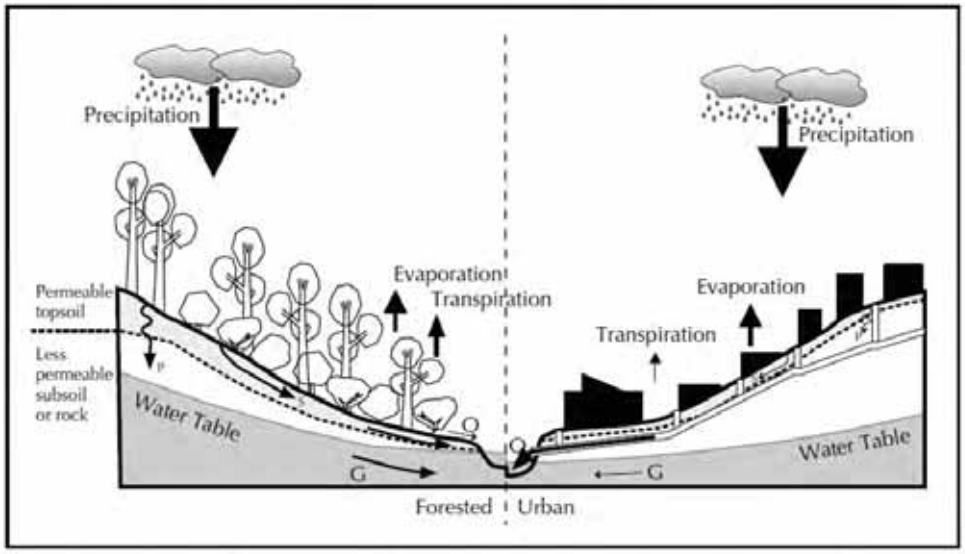


Figure 2. The water cycle in a forested catchment and in an urbanized catchment with a conventional stormwater drainage system (not considering imports of water supply or export of wastewater). The size of arrows indicates qualitative differences in the relative size of annual water volumes through each pathway in a typical south-eastern Australian coastal catchment. Water that falls on the catchment and is not evaporated or transpired may reach the stream by three possible paths: overland flow (O: almost all of which is transmitted to the stream by stormwater pipes in the urban catchment), subsurface flow through permeable topsoil (S), or percolation (P) into groundwater flow (G). (Partly adapted from Dunne & Leopold, 1978.)

Figure 28. Water cycle changes for pre and post catchment urbanization

Pre and post urbanisation conceptual models of catchment responses to rainfall and channel morphology are provided in Figure 28 and Figure 29 (extracted from Walsh et al 2004). Pre and post development of the highly urbanised Terry's Creek catchment are likely to exhibit many of the features shown in these conceptual models.

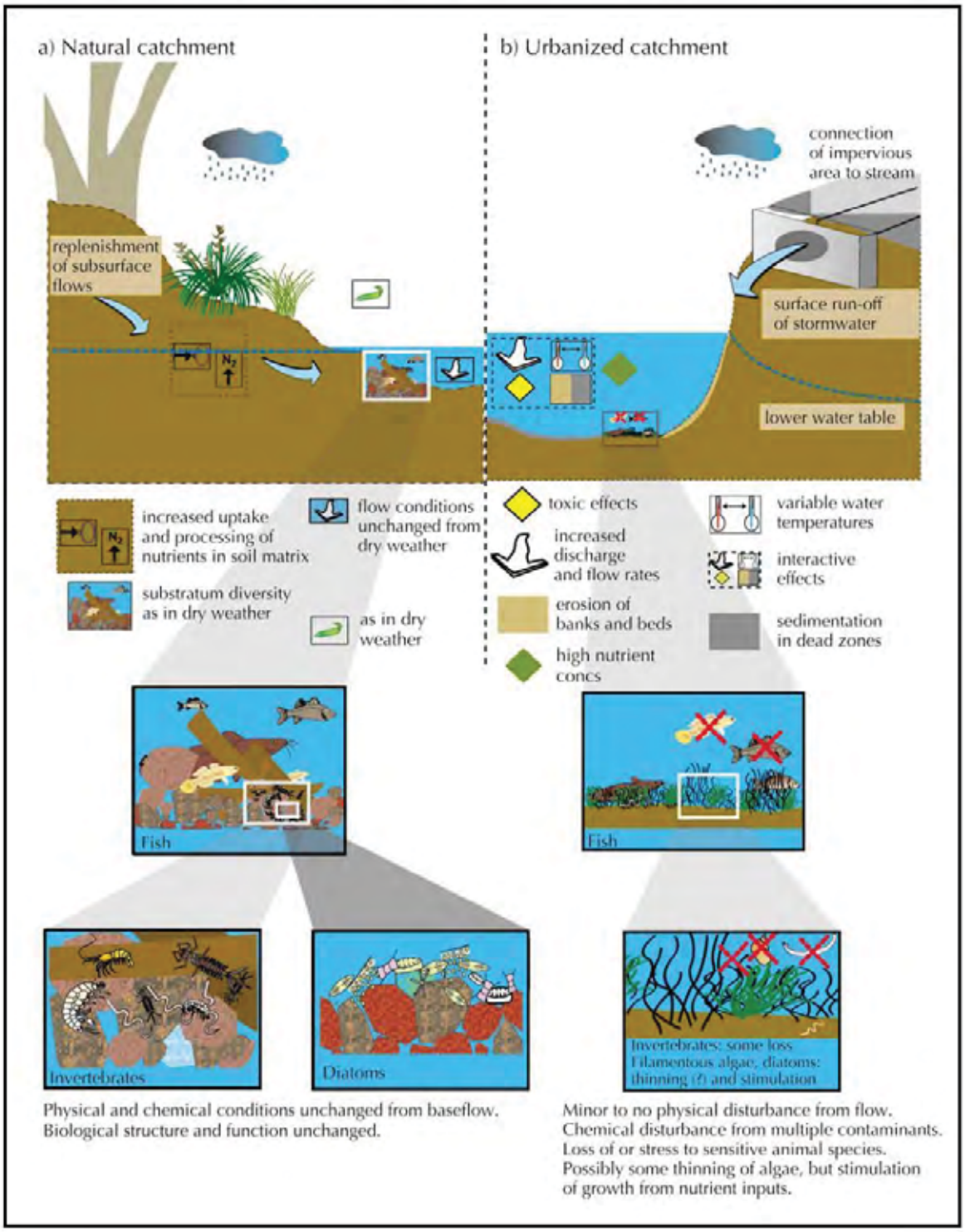


Figure 29. Conceptual processes in natural and urbanised streams following moderate rainfall events (Walsh et al 2004).

5.4.3 Terry's Creek Rehabilitation, Maintenance and Restoration Activities

The management and maintenance of the Terry's Creek corridor is primarily guided by principles outlined in the Parramatta City Council Natural Areas Plan of Management (2006). This document only contains general actions to be undertaken or encouraged across all open space areas in the LGA and does not contain specific management actions for the Terry's Creek corridor. Nevertheless, this plan can be used as a guide for the present study to confirm the identified areas of importance for rehabilitation and maintenance.

In recent years a number of activities have been directed towards improving the health of aquatic ecosystems in Terry's Creek, including on-ground projects and programs aimed at maintaining, restoring and enhancing the health of vegetation:

Terry's Creek Catchment Bushland Restoration (2011-2012) covered three project sites:

1. **Skenes Avenue Reserve** – An area of predominantly creek line vegetation containing planted rainforest species. Maintenance works (4000m^2) with a weed density of 10-30%.
   Site strategies included hand weeding and spot spraying around native species, targeting vines, pruning vegetation around paths, monitoring of water quality (turbidity), and planting with local native species
2. **Mobbs Lane Reserve** – An area of predominantly creek line vegetation requiring maintenance throughout (6000m^2), with a remaining area of secondary (1000m2) in the northwest to protect and promote ecological burn regeneration.
   Site strategies included hand weeding and spot spraying around native species, thinning of invasive woody seedlings, localised translocation of natives, and removal of Asparagus Fern.
3. **Fred Spurway Reserve** - A former National Tree day site. Work consists of maintenance works (approx.8000m^2) with a weed density of 5-10%.
   Site strategies included harvesting and direct seeding from local native species, tubestock planting, spot spraying around existing plantings, weeding around paths and transplanting of local natives.

Mapping showing extent of reserves, Bushcare sites and Bush regeneration contract sites is provided in Appendix Four.

Additional works to improve the health and water quality in the catchment include installation of a range of gross pollutant traps at key points in the catchment, summarised in Figure 30. Detailed mapping of GPTs in relation to the stormwater pipe network is provided in Appendix Four.

Figure 30 Stormwater treatment and management devices and structures in Terry's Creek Catchment

5.4.4 Flooding

The channel is described as a natural earthen channel system upstream of Terry Rd – essentially 1.1km of natural creek (Bewsher, 1991). Below this point it flows through City of Ryde LGA, and becomes and brick and concrete lined channel which was constructed during the 1930s by Dept Public Works. Bewsher (1991) noted that there were two sites on Terry's Creek within the Parramatta LGA that were not fully developed –the Brickworks site and Channel 7 land near Mobbs Lane. Development of these sites is currently under way, and was anticipated to "have the potential to significantly alter the existing runoff regime" (p.10).

The most recent flood study undertaken in Terry's Creek is that by Cardno (PCC 2005) and included plots of the 1% Annual Exceedance Probability (AEP). This plot is reproduced in Figure 31 and shows:

- A number of properties along Terry's Creek may be subject to flooding during a 1% AEP event; and
- Flooding risk to property increases further downstream of Terry Road.

Recommended options to reduce localised flooding risk in the upper catchment include a detention basin upstream of Mobbs Lane and culvert amplification at the Valley Road Culvert.

The Eastwood-Terry's Creek catchment management plan (Bewsher, 2009) also assessed options to improve stormwater quality and shortlisted two options in the upstream section of Terry's Creek including:

- A sedimentation basin/water quality control pond upstream of Mobbs Lane; and
- A Gross Pollutant Trap on Terry's Creek near Skenes Avenue to trap sediment and litter.

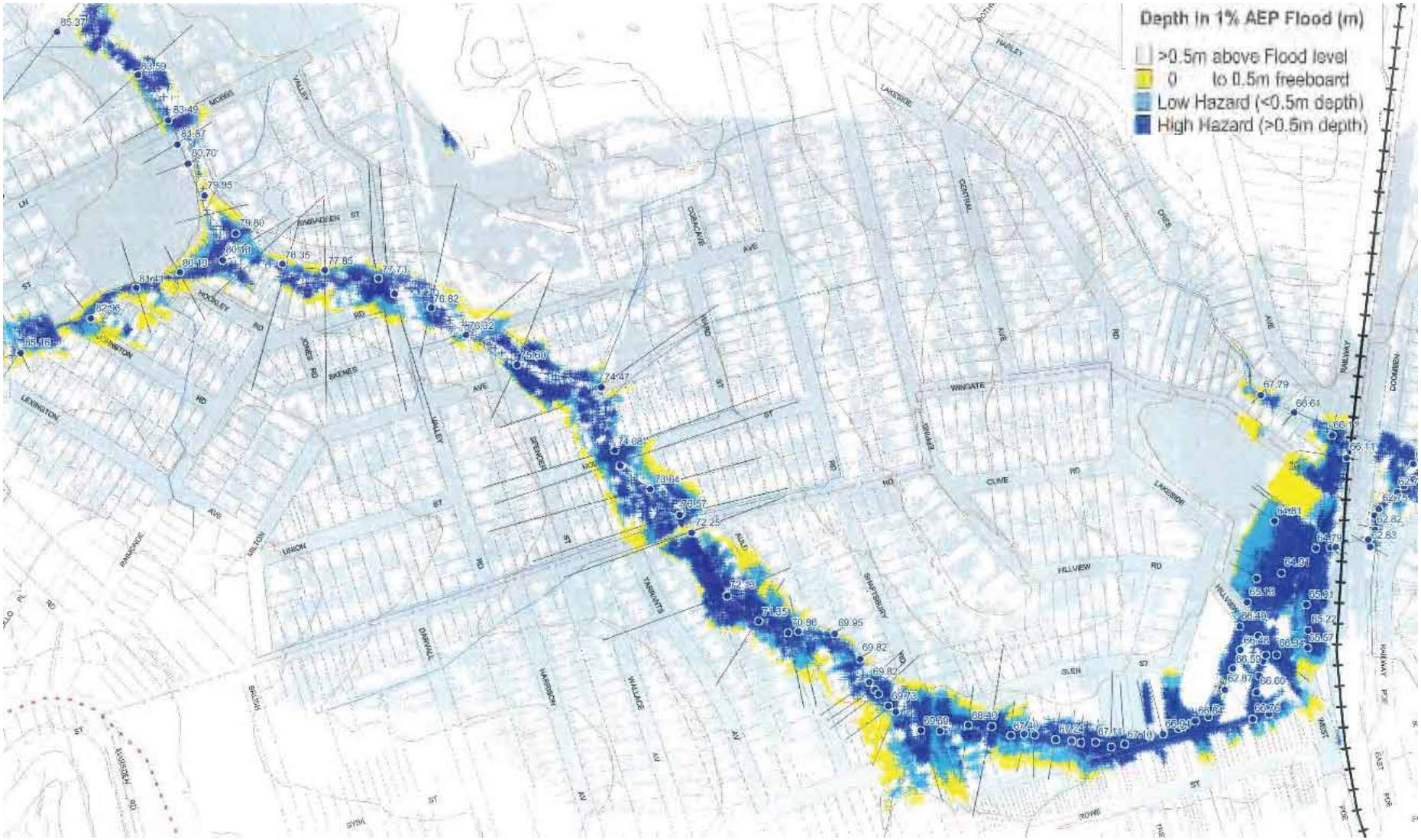


Figure 31 1% AEP flood Risk Modeling Results for Terry's Creek upstream from Eastwood town centre (Extracted from Cardno & Willing 2005)

5.4.5 Climate variability and Climate Change

Climate change projections for the Sydney region have been presented in CSIRO (2007) and are reproduced in Figure 32.

Table 2. Current and Projected Climate Change in the Sydney Catchments

	Present (1990)[1]	Projected Change	
		2030	2070
Temperature			
Average	17 – 26°C[2]	+0.2 – +1.6°C	+0.7 – +4.8°C
No. Days below 0°C	0	0	0
No. Days above 35°C	3	4 – 6	4 – 18
No. Days above 40°C	0	0 – 1	1 – 4
Rainfall			
Annual Average	1,094 mm	-13 – +7%	-40 – +20%
Extreme Rainfall[3]		-3 – +12%	-7 – +10%
Evaporation		+1 – +8%	+2 – +24%
No. Droughts per decade[4]	3	2 – 5	1 – 9
Extreme Winds		-5 – +8%	-16 – +24%
No. Fire Days[5]	9	9 – 11	10 – 15

1 Present day conditions for temperature and rainfall represent long-term averages from the Bureau of Meteorology. For extreme temperatures, the present average is based on 1964-2003. For fire danger, the present average is based on 1974-2003. For drought, the present average is for a period centred on 1990.

2 Range represents average July and January maximum temperature.

3 Defined as 1 in 40 year 1-day rainfall total. Values represent the range in seasonal projections from a limited set of climate models for central eastern NSW. However, given strong spatial gradients in extreme rainfall projections (see Hennessy et al., 2004b), these regional results may not be applicable for Sydney.

4 The values for drought represent average monthly drought frequencies, based upon the Bureau of Meteorology's criteria for serious rainfall deficiency (see also Burke et al., 2006).

5 Number of days annually with a "very high" or "extreme" fire danger index. Changes are for 2020 and 2050, respectively, as in Hennessy et al. (2005).

Figure 32 Current and projected climate change in the Sydney Region (extracted from CSIRO 2007)

More recently, Hunter (2012) reviewed and summarised the potential impacts of climate change on stormwater infrastructure in the Sydney Metropolitan area and presented the following key points (extracted directly from Hunter, 2012):

- Rainfall Intensities for extreme events (40-year ARI, 24-hour duration) will increase by at least 12%. (CSIRO, 2007b)
- Current criteria used in the design of floodplain infrastructure will need to be assessed to accommodate projected increases in rainfall intensities, runoff volumes and flood levels.
- Seasonal Runoff Volumes will increase by as much as: 26% (Summer); 19% (Autumn); 7% (Winter) and 4% (Spring), (DECC, 2008/519). Water balance assessments, undertaken to assess the viability of stormwater harvesting and reuse schemes should be based on revised

rainfall data, and take into account projected changes in rainfall intensities and seasonal patterns.

- Existing drainage systems (including pipelines, channels, basins, and on site detention) will be under-designed in the future and the existing Prescribed Site Discharge and Site Storage Requirements, currently used in the design of On Site Detention systems, will have to be re-assessed to accommodate increased runoff peak flows and volumes and downstream.
- Populations Density will increase to 6,000,000 (2036). (DOP, 2010b).

The literature review undertaken by Hunter (2012) resulted in the general recommendation that design rainfall Intensities be increased by 15%. This recommendation may have implications for management actions for Terry's Creek:

- Flood studies undertaken in the study area indicate relatively few low flood risks in the upper catchment, however future studies taking into account higher rainfall intensities may result in changes to this risk classification.
- Erosion rehabilitation, vegetation management and channel form works will need to consider higher rainfall intensities and therefore larger peak flows and associated erosion (Figure 33).

Figure 33 Higher rainfall intensities and increases in peak flows will lead to more erosion such as this scouring around a pipe outlet at David Hamilton Reserve

6 REVIEW OF LITERATURE AND SITE SURVEYS: CULTURAL HERITAGE

The Preliminary Heritage Assessments are presented as two separate reports (Appendix Two), as the Aboriginal and Non-Aboriginal heritage assessments are each conducted in relation to different statutory regimes and assessment methodologies.

6.1 INDIGENOUS HERITAGE (AHMS, 2013)

6.1.1 Findings

The findings of the Preliminary Aboriginal Heritage Assessment are:

- Areas within Edna May Hunt Sanctuary, Mobbs Lane Reserve and Skenes Avenue Reserve have areas of undisturbed land which may contain Aboriginal objects insitu (Figure 34);
- The risk of harming Aboriginal objects within the disturbed lands identified in the study area is considered low;
- The majority of the parks and reserves in the subject site are composed of disturbed land with no remnant top soil and have modern fill overlying clay/residual geology.

Figure 34 Aboriginal Heritage Sensitivity Mapping showing survey area outlined in black: red = high sensitivity, orange = medium sensitivity, green = low sensitivity, grey = no sensitivity (Parramatta City Council Aboriginal Heritage Study. Prepared by: Mary Dallas Consulting Archaeologists 2003)

6.1.2 Recommendations

The Recommendations arising from the Preliminary Aboriginal heritage assessment should be read in full in the accompanying report however in terms of selecting the appropriate methodologies for rehabilitation works your attention is drawn to these main points:

1. Where possible, Parramatta City Council should aim to avoid subsurface impacts in the areas which have been assessed as having medium to high potential to contain Aboriginal objects in Edna Hunt Sanctuary (Figure 35), Mobbs Lane Reserve (Figure 36) and Skenes Avenue Reserve (Figure 37). Avoidance of harm obviously provides the best heritage outcome. Depending on the rehabilitation methods that need to be employed it may be necessary to carry out further assessment with a focus on subsurface testing in these areas. An Aboriginal Heritage Impact Permit may be required and the processes for obtaining this are regulated. (Further information about the documents recommended above is available in the Preliminary Aboriginal Heritage Assessment, AHMS, 2013a; Appendix Two).

Figure 35 Edna Hunt Sanctuary with areas of low disturbance and high potential for archaeological sites out lined in blue (AHMS, 2013a).

Figure 36 Mobbs Lane Reserve with areas of low disturbance and high potential for archaeological sites indicated in blue (AHMS, 2013a)

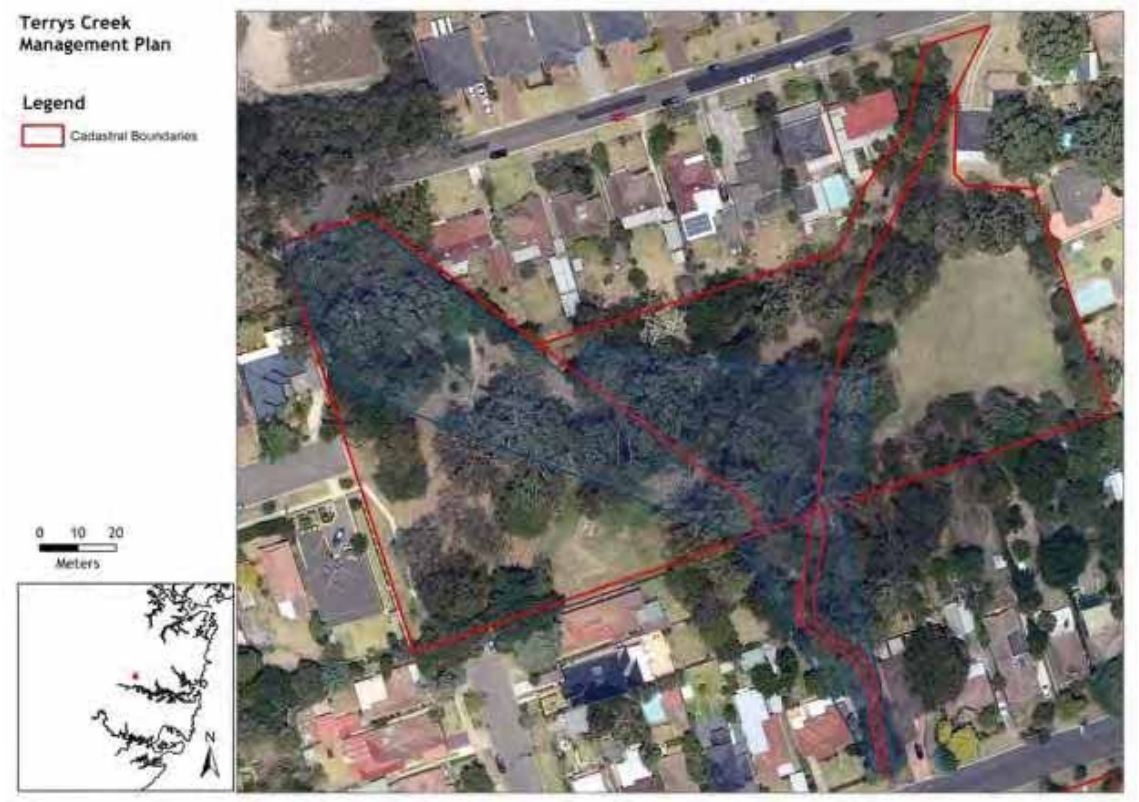


Figure 37 Skenes Ave Reserve with areas of low disturbance and high potential for archaeological sites indicated in blue (AHMS, 2013a)

2. In the cases noted above the areas of medium to high potential should be temporarily fenced when rehabilitation activities are being undertaken in close proximity to avoid inadvertent impact.
3. Works that avoid or involve minimal disturbance can be interpreted to be of 'negligible impact' under the Office of Environment & Heritage Due Diligence Code of Practice. Therefore, no further assessment or approvals are required prior to the proposed activity and work may proceed with caution.
4. Where no archaeological objects, sites or places have been recorded and the areas have been identified as of 'high disturbance' (all reserves and areas not indicated in blue shading in Figure 35 to Figure 37) no further Aboriginal archaeological considerations or mitigation options are required under section 87 (4) of the Office of Environment & Heritage Due Diligence Code of Practice. In these areas of low Aboriginal archaeological potential, it is still possible that unexpected finds may occur therefore it is recommended wherever possible the proposed methodologies minimise ground surface or disturbance or are constrained to modern fill layers (not natural top soil) where works are unlikely to impact any Aboriginal objects. No further assessment or approvals are required prior to the proposed activities in these areas (this is all areas other than those highlighted in blue).

6.2 NON-INDIGENOUS HERITAGE (AHMS, 2013)

The first road through the area developed from about 1816, when Governor Macquarie assigned a group of convicts to timber-cutting duties for the colonial government. The trees were tall, mainly blue gum, blackbutt and some cedar. The Pennant Hills Sawing Establishment was located in the vicinity of what today is Pennant Hills Road, near its intersection with Hull Road and Beecroft Road, and comprised one Superintendent, two Overseers and eighty labouring convicts employed in collecting and sawing timber, splitting shingles and burning charcoal.

The timber was hauled by bullocks along a winding route to the Government Wharf on the Parramatta River at today's Ermington and, in 1816 this was formed into a proper road: "By order of the Governor in order to facilitate the Conveyance of Timber for the use of (the) Government to the Water Side, as well as to afford Convenience to the settlers on the Pennant Hills and Castle Hill Settlements to bring their produce to market". This track remains largely traceable as the route of Pennant Hills Road (from its intersection with Beecroft Road), Marsden Road and Wharf Street. Beecroft Road, in this vicinity, was part of the original Old North Road and continued past the intersection with Pennant Hills Road through Dural to Wisemans Ferry.

In 1817, the success of the Pennant Hills Sawing Establishment led to the creation of a second, similar establishment. This was located on the eastern side of today's Epping Station and the convict camp included sleeping huts, a cooking and eating shelter and the sawmill. These two sawmills were so effective that, by 1825, the area west of Epping was known as "Barren Ridges".

West of the Field of Mars Common, the western side of today's Epping comprised two major land grants, one granted by Governor Hunter to Lieutenant William Kent (the Governor's nephew) of 170 acres (69.8 hectares) and another of 460 acres (186.1 hectares) granted to Kent's nephew, William George Carlile Kent, in 1803. West of this latter land was a large grant of 173 ha (427 acres) to James Dunlop, the Government Astronomer (Figure 38). These grants were never occupied by the grantees and all were traded later for their land value.

Figure 38 Parish Map of the Parish of Field of Mars, circa 1880s, showing the original grants covering the study area (outlined in black). The area is contained within two grants, the eastern to Lieutenant William Kent and the western to James Dunlop. (Source: NSW LPI; cited in AHMS, 2013b)

After the sawing establishments closed circa 1830, the Epping area evolved into mostly orchards and vegetable farms, with most produce carted to the Government Wharf at Ermington and sent by boat to the Sydney markets.

In the 1820s, William Mobbs took up farming in the district and acquired 12ha of land on the western side of Marsden Rd overlooking the Dundas Valley. After clearing the land, he established an orchard that he called "The Orange Grove". He prospered and he acquired more land and, by 1828, William Mobbs owned over 290ha along the ridgeline of what is now Pennant Hills Rd, stretching from Carlingford (originally known as Mobbs Hill) northwards to North Rocks Rd. He grew grain and several varieties of fruit but was renowned for his oranges. In 1833, William Mobbs was granted land in the area of today's Mobbs Lane.

The small land allotments created during the mid-century subdivisions were ideal for orchards and small farms and attracted Chinese market gardeners following the goldrush of the 1850s.

The railway line through the district opened on 1886 and Epping railway station opened in 1887 as Field of Mars Station, and then was renamed 'Carlingford' the following year (Figure 39). As the post office was called East Carlingford and the different names caused confusion, the township and station were renamed 'Epping' in 1899. This followed from the opening of the private branch line from Rosehill to the suburb of Carlingford in 1896 (later known as the "Carlingford Line"), the terminal station being named 'Pennant Hills'. In 1901, this station was renamed 'Carlingford'.

When the Carlingford Line opened in 1896, Carlingford Station became the major route for agricultural produce from the district to be delivered to the city markets. A produce store opened next to the station and operated until the 1980s, serving the last of the market gardens.

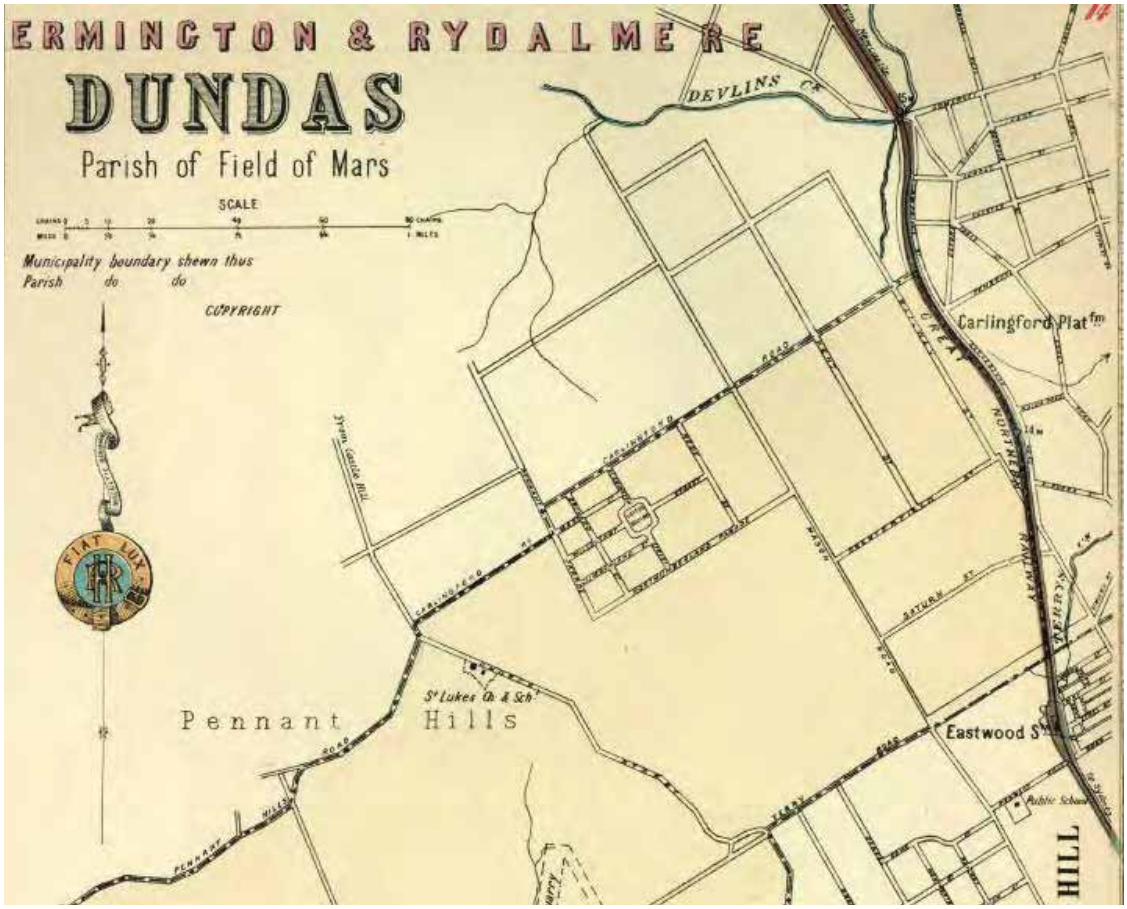


Figure 39 Higginbotham & Robinson Map of the Dundas area, circa 1890, showing the development of the railway and the roads in the study area. (Source: LPI; cited in AHMS, 2013b)

The only non-agricultural industry established in the area occurred when the Great Northern Brick Company established brickworks on the south side of Mobbs Lane in 1912. These brickworks, which later became part of the Brickworks Limited group, continued to supply the building trade of the area until the 1980s. In 2008, redevelopment of the site for medium-density housing, including the preservation of a kiln and two stacks, was approved (Figure 40).

In 1923, the Methodist Church established the Dalmar Children's Home on 6.1ha (15 acres) of land near Marsden Road. The property eventually had many residential cottages, a hospital, an orchard and vegetable gardens and it continues to operate as a respite and foster care centre. In the 1980s, the extensive grounds surrounding the Home were redeveloped and are now occupied by the Alan Walker Retirement Village.

As Sydney expanded following World War II and with no heavy industry in the area, Carlingford, Eastwood and west Epping underwent rapid urbanisation. Initially, large family houses were built on large blocks of land, the advent of private motor cars providing independence from the railway transport and the still semiagricultural nature of the district providing a bucolic environment for child-raising.

Figure 40 Early stages of decommissioning of the Eastwood Brickworks site, circa 2008

The agricultural character of the Carlingford district at the time was demonstrated by the acquisition, in 1948, of the land for James Ruse Agricultural High School and the opening of this school in 1956, initially as an annex of the Carlingford District Rural School. By 1959, it had been reformed as the "James Ruse Agricultural High School". The rapid pace of urbanisation soon made the school and its large farm an anachronism amongst the houses that soon dominated the district. Progressively over the following three decades, most of the small farms and orchards were subdivided and sold.

These key developments are currently protected in Parramatta's Local Environment Plan (LEP) 2011 (Figure 41).

6.2.1 Findings

The findings of the Preliminary Non-Aboriginal Heritage Assessment are:

- The Edna Hunt Sanctuary is a heritage item in its own right, owing to it containing rare remnant local flora and fauna which, although largely regrown following prior partial logging and clearance, is an important alternative to the manufactured landscapes within the other reserves within the Study Area.
- There are no structures, places or objects within the boundaries of the Public Reserves within the Study Area that of sufficient heritage significance to warrant specific management actions or approaches to ensure their conservation.
- The examples of watercourse channelisation within the Reserves which utilise materials and approaches which have positive aesthetic qualities, particularly the sandstone masonry within Skenes Reserve and David Hamilton Park, should be managed in a way that enhances their long term quality and consistency.

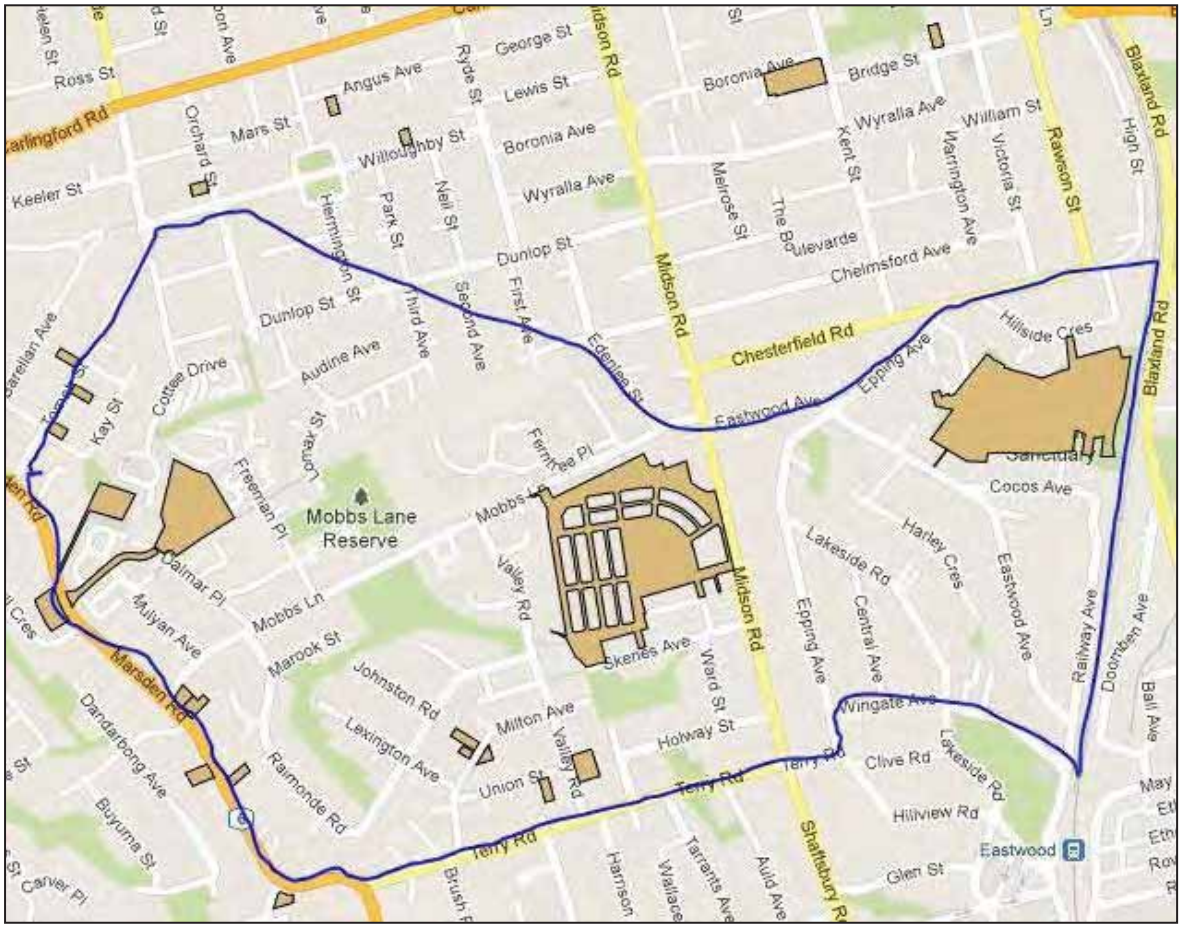


Figure 41 Parramatta LEP, 2011 with key heritage areas: Dalmar Childrens Home (on western boundary), Eastwood Brickworks (centre of study area), and Edna Hunt Sanctuary (on eastern boundary)

6.2.2 Recommendations

The Recommendations arising from the Preliminary Non-Aboriginal heritage assessment are:

- The Edna Hunt Sanctuary should be managed to conserve and enhance its natural heritage values and its remnant local ecological qualities.
- Management of the Upper Terry's Creek Catchment should be undertaken in a manner that does not compromise the conservation of any of the identified Heritage Items within the Study Area.
- Should works within the Reserves discover or expose any works or relics which may have heritage significance, the work or relic should be assessed to determine its significance and appropriate management arrangements should be put in place to conserve any identified heritage values.

7 REVIEW OF LITERATURE: BUFFER ZONES AND SETBACK

7.1 REVIEW OF SCIENTIFIC KNOWLEDGE

7.1.1 The importance of the riparian zone

A riparian zone is broadly defined as "the area of land that forms the banks of a waterbody and the adjacent land it directly affects, including the vegetation". Riparian systems play an important role in maintaining the ecological and geomorphic health of ecosystems, particularly in urban areas where the last remaining remnant vegetation often exists adjacent to streams within a catchment. Riparian systems also have disproportionately high levels of biodiversity in relation to the surrounding area because of their position at an interface between fluvial and terrestrial environments. Riparian zones can provide connected wildlife corridors that are important for the movement of flora and fauna across environmental gradients as well as helping to maintain high levels of genetic diversity in urban areas.

Riparian vegetation contributes large woody debris to the channel which is important for in stream habitat for fish and macroinvertebrates and affecting the flow of water. This vegetation plays a significant role in influencing the geomorphic condition of a stream by preventing bank erosion, aiding rainfall and runoff infiltration and contributing to soil, bank and channel stability. Riparian zones are sources of nutrients to the stream through leaf litter and organic matter and also nutrient sinks, storing nutrients from upslope, which is particularly significant in nutrient rich urban catchments. These zones act as a filter and a buffer against pollutants which may be derived from upslope urban or industrial areas. In addition to the ecosystem services they provide, riparian zones provide valuable social value due to their usefulness as aesthetic visual buffers, flood mitigation, property protection and enhanced economic value as well as amenity.

7.1.2 Riparian zones in an urbanised environment

Unfortunately, the highly productive nature of riparian land makes it a prime target for intensive cropping, intensive grazing and intensive irrigation, and this was part of the early history of land use change in the Terry's Creek Catchment. Today, the scenic values associated with waterways can make adjacent land a prime target for development. Past patterns of modification along Terry's Creek drive the direction of more recent changes in land use. Tradeoffs will exist, depending on the relative importance of development and waterway improvement to the community.

In a disturbed catchment, once the nutrient levels in the water of the creek and creekbank soils become too high, the natural vegetation becomes out-competed by weeds. Consequently, relying solely on protection from clearing or erosion is insufficient to protect the integrity of the riparian vegetation. As a consequence of the high ecological and social value of riparian zones, there are often conflicting interests between conservation and development. Although some studies have examined the relationship between buffer width and biodiversity, there remains a paucity of research in that area particularly with respect to urban environments.

7.1.3 Riparian buffers and zone boundaries

Current literature generally accepts the following assumptions:

- the riparian zone is a definable biophysical unit;

- a riparian buffer is a practical/functional construct, which may be influenced by the width of the riparian zone, but can include considerations of social equity, cost, practicality etc;
- the riparian zone width can vary between streams and along streams; and
- geomorphologic protection generally defines a minimum riparian zone (see Rutherfurd et al, 1999).

The use of nominated riparian buffer distances is common in planning and development regulation (e.g. a 40m protection zone applied in the Rivers and Foreshores Improvement Act 1948). However, the basis for these distances is not always apparent and may have a number of shortcomings, including:

- compromises which reflect social and political realities;
- adherence to a single width, regardless of biophysical context;
- use of arbitrary distances which may bear little relationships to a functional riparian zone; and
- a wide range of distances used in plans and policies, for example a range from 5m to 400m is used in a selection of Australian planning documents.

A more effective approach to defining the riparian zone was to use both structural (channel geomorphology, vegetation type) and functional (geomorphologic, hydrological and water quality processes) relationships. On this basis, different reaches will generally have different riparian zone widths and the best depiction of the zone is a continuously mapped line. The approach adopted the largest of a range of estimates at reach scale, based on using one or more of the methods in Table 8 and Table 9.

Table 8 Alternative methods for riparian zone estimation (adapted from Montgomery Watson Harza (MWH) Australia P/L, 2003)

BASIS FOR WIDTH	METHOD	COMMENTS
Channel depth and erosion rate	5m minimum, plus depth factor, plus establishment allowance[1]	The method is a means of determining widths for revegetation. For stable channels, riparian width may be underestimated (minimum 5m). Very useful for modified creeks.
Flora	Extent of riparian vegetation species or associations	Transitional or ecotonal vegetation tends to blur the boundaries. Clearing or weed growth can invalidate the estimate by masking potential riparian areas. Most useful for natural systems, but reliant on detailed species mapping. Some weed species can also be good indicators of zone, due to their response to moisture and nutrients.
Flood levels	The zone of influence of relatively frequent flood events (e.g. ARI 1 year flood zone)	Choice of recurrence interval is subjective; inundation zone tends to increase rapidly from headwaters to lowlands. Otherwise, the method is reasonably precise and simple - if flood studies are available[2]. Wong et al (2000) suggested that 1.5 year ARI represents a re-set mechanism for

BASIS FOR WIDTH	METHOD	COMMENTS
		stream communities. 1.5 year ARI may be a reasonable benchmark for riparian zones, although more research is needed to determine whether it is equally valid for pristine or fully developed streams. For small creeks, the entire floodplain may be narrow and smaller floods may not exceed channel capacity. Riparian vegetation may extend well above flood levels due to deep roots of some trees.
Water quality	The minimum distance through which the effects of surface water runoff are likely to be attenuated. The distance is primarily a function of soils, rainfall intensity, groundcover densities, slope and type of pollution.	This recognises that the riparian zone protects waterways from the direct influence of overland flow and the associated dissolved and particulate matter. The corollary is that the riparian zone itself influences water quality, ecology and local geomorphology (e.g. by supplying organic matter to the stream). Table 9 provides some rules of thumb.
Channel form	The shape of the channel can be used to infer a riparian zone for rock platforms (edge of platform) and for steep-sided gorges (edge of gorge at base).	The majority of channels in the LGA do not fall into these categories and channel form is difficult to use as a surrogate for riparian zones.

Notes:
1. Abernethy and Rutherfurd (1999); establishment is erosion rate (m/yr) multiplied by time for natural riparian forest to mature and stabilise banks (yr).
2. Terry's Creek sub-catchment management plan (Cardno & Willing, 2005).

Table 9 Minimum distances to attenuate impacts of overland flow[A]

SLOPE	GROUNDCOVER DENSITY		
	Low	Medium	High
Steep	50m	40m[B]	30m
Moderate	35m	30m	20m
Gentle	20m[C]	15m[C]	10m[C]

Notes:
A. There is no definitive scientific study of water quality processes in the riparian zone in Australia, and the figures are a rough estimate, based on a various publications. The figures do not allow for rainfall intensity and soil type variation across the LGA.
B. A number of US brochures suggest a range of 38-46m for nutrient removal in forests with medium density groundcover on moderate slopes (e.g. Connecticut River Joint Commission, 1998)
C. Based on a study by McKergow et al (1999) and allowing for lower rainfall intensities and overland flow velocities; LWA (2000) recommend a minimum of 20m as being suitable for most situations, but needing to be wider where pollutant loads and slopes are greater.

Determining values associated with fauna movement can also be complex, although such considerations may be useful, especially if a creek's value would increase through the provision of a basic corridor linkage (i.e. ecological connectivity).

The implication of this approach is that 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).

7.2 REVIEW OF CURRENT LEGISLATION

7.2.1 Planning Instruments and Controls (Buffer Zones and Setbacks)

Land zoning surrounding Terry's Creek is provided in the Parramatta Local Environment Plan (2011) and reproduced below. Terry's Creek itself is generally classified as Natural Waterway (W1). Land zoning surrounding Terry's Creek primarily consists of (see Figure 42):

- RE1, Public recreation (includes most of the immediate surrounding areas)
- E2, Environment Conservation (smaller areas adjacent to the waterway)
- R2, Low density residential (most of the remaining areas adjacent to the waterway)
- R1, General residential (a small area, comprising most of the old Channel 7 site)
- SP2, Infrastructure (Educational Establishment, includes a small area adjoining the Channel 7 site)

Design principles regarding development that may apply to these land use zones adjacent to the Terry's Creek in the LEP relating to the protection of waterways are:

- P.1 Development is to make provision for buffer areas for the preservation and maintenance of floodway, riparian corridors and habitat protection. Refer to Clause 6.7 Foreshore Building Line and Clause 6.5 Water Protection in the Parramatta LEP 2011.
- P.2 Development on land subject to Clause 6.5 Water Protection in the Parramatta LEP 2011 or that abuts a waterway is to be landscaped with local indigenous species, to protect bushland and wildlife corridors and soften the interface between the natural landscape and the urban environment. Riparian vegetation also plays an important role in stabilising bed and banks and attenuating flood flows.
- P.3 The piping, enclosing or artificial channeling of natural watercourses and drainage channels is not permitted. Consideration is to be given to re-opening piped or lined drainage systems wherever feasible.
- P.4 Development is to ensure that natural channel design principles are incorporated in any works on or in waterways.
- P.5 Ongoing maintenance costs are to be considered in the design of any waterway protection features.

Figure 42. Land Use Zoning along Terry's Creek. PCC LEP 2011

The specific reference to provision of buffers in design principle P1 (above) refers to Clause 6.7 Foreshore Building Line and Clause 6.5 Water Protection in the Parramatta LEP 2011. This clause requires that development will not cause environmental harm to a range of aquatic habitat including marine habitat, wetland areas, fauna and flora habitats. There is no specific reference to buffers or setbacks under Clause 6.5 Water Protection or Clause 6.7 Foreshore Building Line that suggest a specific buffer distance or setback to riparian land and waterways.

7.2.2 Additional local provisions

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, including the following:

a) protecting native fauna and flora,
b) protecting the ecological processes necessary for their continued existence,
c) encouraging the recovery of native fauna and flora and their habitats.

This clause applied to the following private lands (Figure 43 overleaf).

Part 6.5 Water protection aims to maintain the hydrological functions of riparian land, waterways and aquifers, including protecting the following:

a) water quality,
b) natural water flows,
c) the stability of the bed and banks of waterways,
d) groundwater systems.

And applied to the following private lands (Figure 44 overleaf).

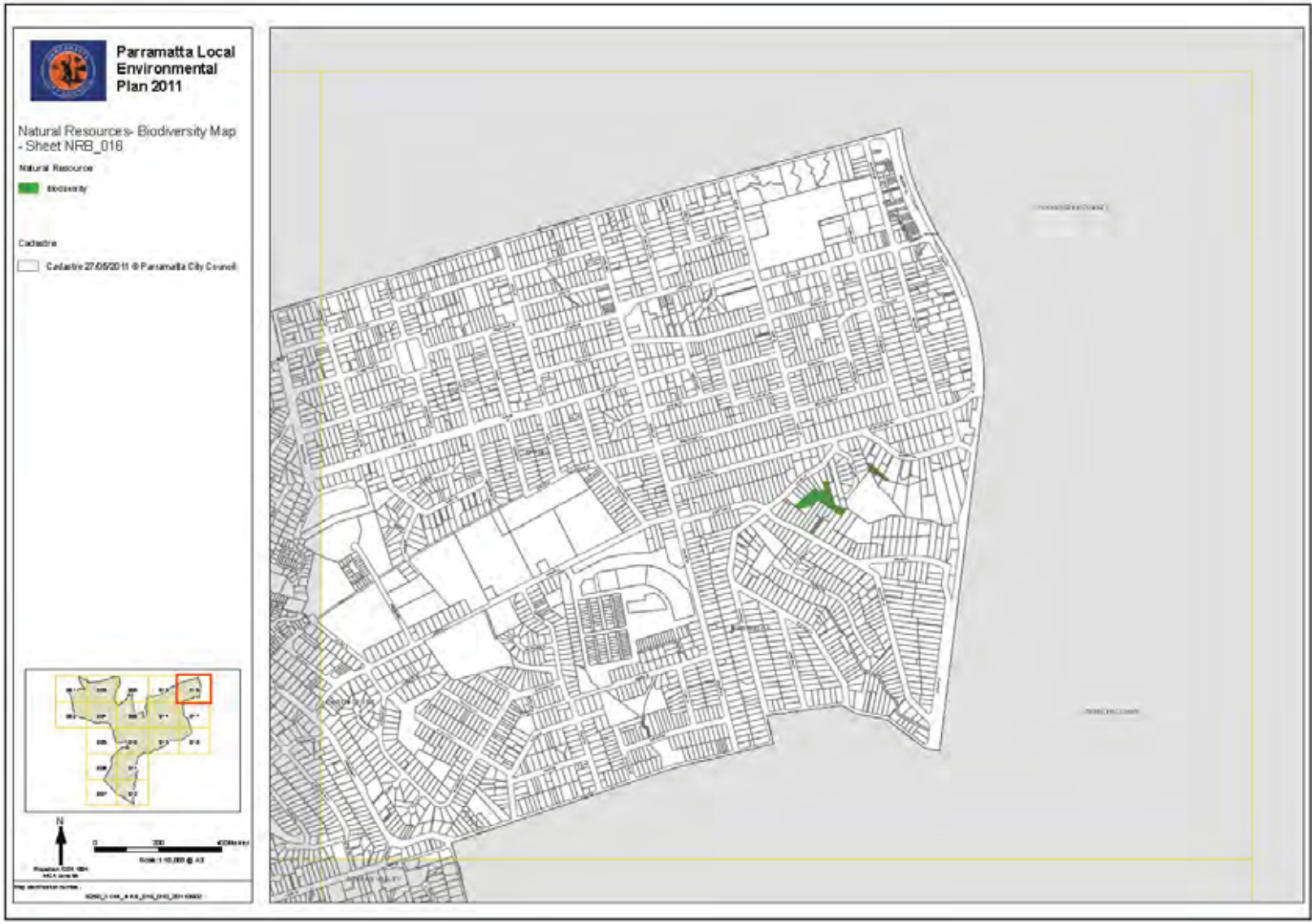


Figure 43. Areas protected under Clause 6.4 Biodiversity protection (LEP 2011)

Figure 44. Areas protected under Clause 6.5 Water protection (LEP 2011)

7.3 REVIEW OF SETBACKS AND BUFFERS FOR NEW DEVELOPMENT

7.3.1 Historical flooding

Low to moderate flooding was reported by Bewsher (1991) for one property in Cumberland St, three in Cottee Drive, and two in Dunlop St. This was attributed to excess runoff from surrounding properties and was predominantly restricted to backyard, front yard and garage flooding. Overfloor flooding of the vulnerable properties in Dunlop St was reported in November 1984, and below floor flooding occurred in February 1990.

One property in Audine Ave and several in Third Ave reported back and front yard flooding, and garage flooding in November 1984. Additional flooding of yards was reported in Hakea Place and Lomax St, where one property reported garage flooding during February 1990. This was attributed to excessive runoff from roads and surcharging at several pits and headwalls.

Immediately west, several properties in Mulyan Ave reported flooding of yards and garages during November 1984 and February 1990, with below floor flooding in one house. This was attributed to localised runoff from upslope properties. Footpath flooding has been recorded in Dalmar Place, along with yard flooding in several properties, which then flooded properties on the eastern side of Mulyan Ave and Grimes Lane. Over floor flooding was reported from shops and offices in November 1984 due to excessive ponding in the retail/commercial car park on the corner of Mulyan Ave and Mobbs Lane.

Below Mobbs Lane there are two locations that experienced major flood problems – inundation resulting in surcharging at local roads bridges on Valley Road and Holway St, with general inundation of properties that back onto the creek in these areas. Away from the main creek channel flooding is more localised. Properties reported flooding in Apollo Place, Raimonde Rd and Inala Place, although this is generally restricted to yard and garage flooding.

Further flooding occurs in properties on Mobbs Lane and Maismonde Place and Marook St on a western tributary of Terry's Creek. Flooding also occurs in a number of properties on Hockley Rd and Johnston St near James Hoskin Reserve. These tributaries join to form one channel that merges with the northern tributary from Mobbs Lane Reserve, and confluence waters flow through Fred Spurway Park, affecting properties on Bimbadeen St, Valley Rd and the eastern end of Raimonde Rd. Much of the channel clearing and revegetation in this part of Terry's Creek has been in response to flooding issues (Bewsher, 1991).

Downstream of Valley Rd flooding occurs in the yards of properties on Skenes Ave, Holway St and Terry Rd. Localised flooding was also reported from properties in Midson Rd, Ward St, Cobac Ave and Spencer St. In major storm events flood flows crossed Holway St into David Hamilton Reserve and again overtopped the culvert at Terry Rd.

Some of the recommended flood mitigation actions have been implemented, including replacement of pipes/culverts at Holway St and Terry Rd. However, ongoing development in the catchment has increased the impervious surface area, which shortens the time of concentration and increases the peak flows at key points. As a result, many of these properties are still vulnerable to main channel and localised flooding in the Terry's Creek catchment (Figure 45; Cardno & Willing, 2005).

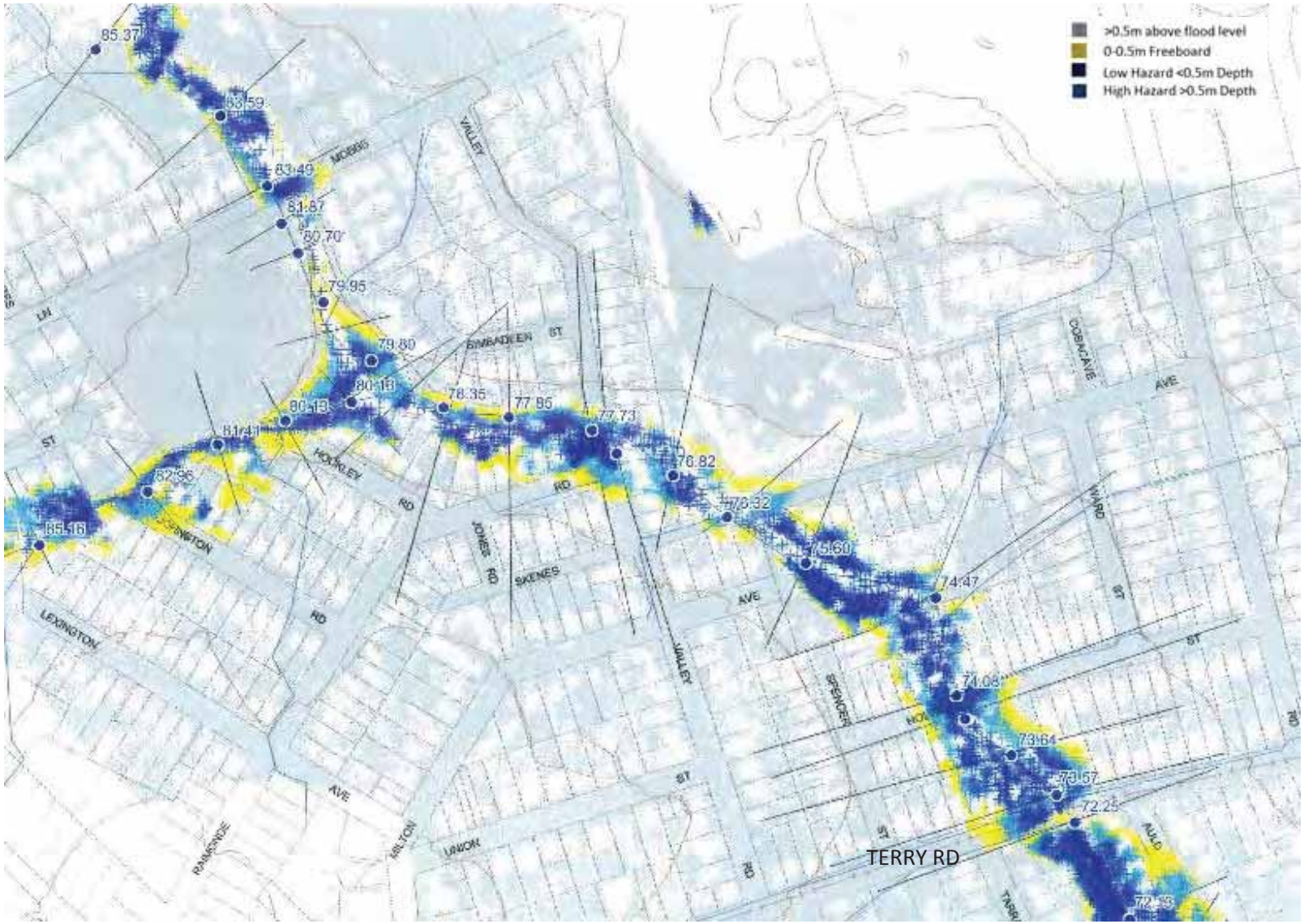


Figure 45 Flood modeling shows properties that are vulnerable to property flooding in a 20 year and 100 year storm event (Cardno & Willing, 2005)

7.3.2 Requirements for flood protection

The development of Council's approach to flooding has regard to and complies with the New South Wales Government's Floodplain Development Manual (FDM 2005). Section 2.4.2 of Parramatta's DCP 2011 covers aspects of water management for new developments. These include flooding (Section 2.4.2.1), protection of waterways (Section 2.4.2.2), and protection of groundwater (Section 2.4.2.3).

Parramatta's DCP 2011 provides criteria for new developments that may be affected by flooding. Council objectives are to manage flood liable land in an economically, environmentally and socially sustainable manner, and to minimise the risk to life and minimise damage to property, including motor vehicles. These and other objectives are met through the application of design principles (see Section 2.4.2.1) and design controls. The procedure to determine which design standards apply to proposed development involves:

Step 1: identify the land use category of the development from Table 2.6 of DCP 2011;

Step 2: determine which flood risk category applies to the land (refer to Catchment Management Unit of Council for the Flood Risk Precincts and relevant flood risk mapping); and

Step 3: apply the objectives and design principles as outlined in this section and then the design standards in the planning matrix at Table 2.7 (presented as Figure 46 in this document, overleaf) as applicable to the floodplain and land use category.

From the floodplain planning matrix (Figure 46) it is clear that the only development permitted in high flood risk areas is open space (including non-urban) and concessional development, which applies to redevelopment of existing structures.

Table 2.7: FLOODPLAIN MATRIX

Planning & Development Controls

Planning Consideration	Flood Risk Precincts (FRP's)																										
	Low Flood Risk									Medium Flood Risk									High Flood Risk								
	Sensitive Uses & Facilities	Critical Uses & Facilities	Subdivision	Filling	Residential*	Commercial & Industrial	Tourist Related Development	Open Space & Non-Urban	Concessional Development	Sensitive Uses & Facilities	Critical Uses & Facilities	Subdivision	Filling	Residential*	Commercial & Industrial	Tourist Related Development	Open Space & Non-Urban	Concessional Development	Sensitive Uses & Facilities	Critical Uses & Facilities	Subdivision	Filling	Residential*	Commercial & Industrial	Tourist Related Development	Open Space & Non-Urban	Concessional Development
Floor Level		3			2, 5	2, 5	2, 5							2, 5	2, 5	2, 5	1, 5	4, 5								1, 5	4, 5
Building Components		2												1	1	1	1	1								1	1
Structural Soundness		2												1	1	1	1	1								1	1
Flood Affectation		2	2	1	2	2	2					1		1	1	1	2	1								1	1
Car Parking & Driveway Access		1, 3, 5, 6			1, 3, 5, 6	1, 3, 5, 6	1, 3, 5, 6	2, 4, 6, 7						1, 3, 5, 6, 7	1, 3, 5, 6, 7	1, 3, 5, 6, 7	2, 4, 6, 7	1, 5								2, 4, 6, 7	1, 5
Evacuation		2, 4, 6	5		3, 4	4	4					5, 3, 4		3, 4, 6	3, 4, 6	3, 4, 6	1, 4	3, 6								1, 4	3, 4 6
Management & Design		2, 3, 4	1									1		2, 3, 4	2, 3, 4	2, 3, 4	2, 3, 4	2, 3, 4								2, 3, 4	2, 3, 4

Not Relevant Unsuitable Land Use * For redevelopment of an existing dwelling refer also to ' Concessional Development' provisions

i. Freeboard equals an additional height of 500mm.

ii. The Parramatta LEP 2011 identifies development permissible with consent in various zones. Notwithstanding, constraints specific to individual sites may preclude Council granting consent for certain forms of development on all or part of a site. The above matrix identifies where flood risks are likely to determine where certain development types will be considered "unsuitable" due to flood related risks.

iii. Filling of the site, where acceptable to Council, may change the FRP considered to determine the controls applied in the circumstances of individual applications.

iv. Any fencing that forms part of a proposed development is subject to the relevant Flood Effects and Structural Soundness planning considerations of the applicable land use category.

v. Development within the floodplain may be subject to Clause 6.7 Foreshore Building Line in the Parramatta LEP 2011.

Figure 46 Floodplain risk matrix for application to new developments (Parramatta DCP 2011)

7.3.3 Biophysical requirements

The following vegetated riparian buffer requirements have been noted in scientific literature:

- 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).

7.3.4 Protection of waterways through development controls (DCP 2011)

Parramatta's DCP 2011 allows for protection of waterways as part of new developments (Section 2.4.2.2). The objective of this clause is to ensure development contributes to the protection and rehabilitation of waterways in order to improve waterway health and to develop and maintain ecologically sustainable waterways. This objective is to be achieved through application of design principles that "make provision for buffer areas for the preservation and maintenance of floodway, riparian corridors and habitat protection'.

It highlights the importance of riparian vegetation for stabilising bed and banks and attenuating flood flows, and to protect bushland and wildlife corridors and soften the interface between the natural landscape and the urban environment. It also recommends that natural channel design principles are incorporated in any works on or in waterways (Figure 47). Once again, however, there is no specific buffer distance mentioned, and developments appear to be considered on a case by case basis.

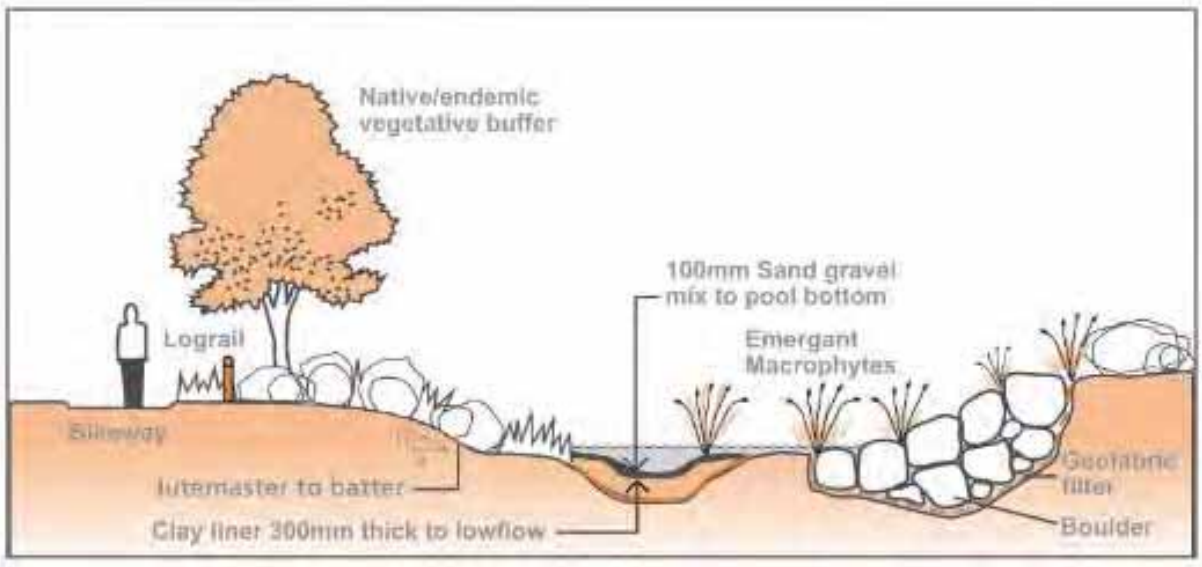


Figure 47 Elements of the Natural Drainage System. Sources: Stormwater outlets in parks and waterways (Brisbane City Council, 2001), reproduced in Parramatta DCP 2011

7.3.5 Zoning and setbacks

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. To date, none of the flood studies have recommended minimum riparian buffer zones, although elsewhere in the Parramatta LGA Molino Stewart (2011) suggested 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.

These principles should also be applied for the Terry's Creek Catchment.

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 portions of residential properties on each of the tributaries that flow into Edna Hunt Sanctuary, including properties on Hillside Cres, Eastwood Ave and Epping Ave. In a number of instances this includes large sections of the lots, and this land should be targeted for acquisition.

Part 6.5 Water protection aims to maintain the hydrological functions of riparian land, waterways and aquifers, and applies to a section of narrow channel between a number of private properties that forms most of SKENES AVE 1 reach. While the zoning does little for waterway protection under existing conditions it will help to shape any future development on the adjoining lots.

The DCP's recommendations for setbacks are congruent with the requirements under each relevant section of Parramatta LEP 2011. However, it should be noted that this will not accommodate the projected impacts of climate change. The NSW Climate Impact Profile (DECCW, 2010) states that the combination of rising sea levels and catchment-driven flooding are likely to increase flood frequency,

height and extent. Increases in the intensity of flood-producing rainfall events are likely to change flood behaviour, although this may be ameliorated by catchment conditions at the time of each storm event. Predicted changes in rainfall for the Parramatta area are most pronounced in summer, with current average rainfall over summer of 304mm likely to increase to between 365mm and 456mm, an increase of 20-50%. More recent predictions indicate that these estimated increases are conservative, and will almost certainly be exceeded.

7.3.6 Additional protection of waterways through WSUD

Water Sensitive Urban Design (WSUD) is an approach that aims to minimise the impacts of development upon the water cycle and achieve more sustainable forms of urban development. It aims to integrate stormwater management systems into the landscape in a manner that provides multiple benefits including stormwater retention and detention and water efficiency, whilst addressing the pre-development considerations of flooding, waterways and groundwater protection, habitat creation and improving visual amenity. This is achieved through the establishment of design principles for management of stormwater in new developments, implementation of stormwater treatment targets, and design controls.

Under the design controls all new developments must have a Site Stormwater Management Plan (SSMP) which identifies the potential impacts associated with stormwater run-off for a proposed development and provides a range of appropriate measures for maintaining water quantity, water quality and water efficiency and re-use. Water efficiency aims to reduce consumption of potable water, harvest rainwater and urban stormwater runoff for use, and reduce waste water discharge through increased capture, treatment and reuse where appropriate. Grey water is the wastewater from your washing machine, laundry tub, kitchen sink, dishwasher, shower, bath and hand basins, and can be used around the home or business as an alternative to drinking water.

The net effect of these measures is to reduce the impacts of poor water quality on waterways, and reduce the effects of elevated peak flow events resulting from higher levels of imperviousness in urban environments. Thus better quality water is discharged over a longer time to streams, maintaining baseflows and causing less harm to the riparian and aquatic environments.

8 OBJECTIVES OF THE MASTERPLAN

8.1 RESTORATION OBJECTIVES

The current condition of significant parts of the Terry's Creek Catchment is moderately degraded/ moderately restored, requiring ongoing 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 of time - five to ten years is recommended. The objectives are:

- Protect threatened species
- Rehabilitate endangered ecological communities and improve connectivity
- Maintain/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 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 catchment health to reduce downstream impacts
- Repair important civil structural assets (e.g. stormwater, sewer assets)
- Ensure all new development has appropriate environmental controls to minimise impact on the receiving ecosystem health

8.2 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.

Assessments were conducted for the following reaches (Table 10):

Table 10 Summary of reaches assessed for each survey and for preparation of works plans

REACH NAME	HYDRO-GEOMORPHIC ASSESSMENT	ECOLOGICAL ASSESSMENT	EXCLUDED (REASONS)	WORKS PLANS PREPARED
DON STEWART 1	y		yes, grassed swale with piped baseflow	
DON STEWART 2	y		yes, grassed swale with piped baseflow	
MOBBS LANE 1	y	y	Partially, due to private ownership	y
MOBBS LANE 2	y	y		y
MOBBS LANE 3	y	y		y
MOBBS LANE 4	y	y		y
JAMES HOSKIN 1	y	y		y
JAMES HOSKIN 2	y	y		y
JAMES HOSKIN 3	y	y		y
FRED SPURWAY 1	y	y		y
FRED SPURWAY 2	y	y		y
FRED SPURWAY 3		y		y
FRED SPURWAY 4	y	y		y
FRED SPURWAY 5		y		y
UNNAMED RESERVE 1	y	y		y
UNNAMED RESERVE 1A		y		y
UNNAMED RESERVE 2		y		y
UNNAMED RESERVE 3	y	y	Partially, due to private ownership	y
SKENES AVENUE 1	y	y		y
SKENES AVENUE 2	y	y		y
SKENES AVENUE 2A		y		y
DAVID HAMILTON 1	y	y		y
BLUE GUM 1	y	y	yes, concrete trapezoideal drain, mostly private	

EDNA HUNT 1	y	y	Partially, due to private ownership	y
EDNA HUNT 1A		y		y
EDNA HUNT 2	y	y		y
EDNA HUNT 3	y	y	Partially, due to private ownership	y
EDNA HUNT 4	y	y		y
TOTAL SURVEYED/ASSESSED	22	26		25

A total of 25 reaches were selected as appropriate for council management, and are examined later in this report.

Figure 48 Considerable work has been done to restore natural riparian vegetation, including here in Mobbs Lane Reserve

9 DEVELOPMENT OF A REHABILITATION WORKS PLAN

9.1 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 11). Each component of the overall condition is scored as indicated, with a maximum possible total of 22 for a reach. Contributing factors to these scores are explained in Table 11.

Table 11 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 (/6)	Instream: 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 and pipes, or partial barriers to passage eg. stepping stones weir **Habitat score = Instream 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 = 22

The overall score gives a useful ranking of stream condition (Table 12). In general, higher scoring reaches should be worked first.

Table 12 Overall scores and colour coded condition rankings for reaches

SCORE RANGE	STREAM CONDITION
18-22	EXCELLENT
14-17.9	GOOD
10-13.9	FAIR
5-9.9	POOR
0-4.9	HIGHLY DEGRADED

Primary management objectives are determined from the overall condition scores (Table 14). 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 > 4; and a high sensitivity score is ≥ 4. Subscores with noteworthy values are indicated by purple text with pale grey background in score boxes for individual reaches on their reserve summary sheets. 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 5.9 (Fred Spurway 5) to 14.8 (Edna Hunt 1&2) and 14.6 (Edna Hunt 4), providing an indication of the variation in condition of different reaches in the catchment.

Reach trajectory was determined from the bank and bed stability score (Table 13; see Section 5.4.1). This trajectory gives information about the probable future condition of a reach if it continues with its current management regime, and provides useful insight into the type of works required and the immediacy of that requirement.

Table 13 Reach trajectories derived from bank and bed stability scores

STABILITY SCORE	BANK & BED CONDITION	REACH TRAJECTORY
1	Stable	Stable
2	Minor erosion	Stable
3	Moderate erosion	Degrading
4	Highly eroding	Degrading
5	Very highly eroding	Highly degrading

Table 14 Individual scores, overall score and priority category for Terry's Creek reaches

REACH NAME	GEOMOR-PHOLOGY SCORE	RIPARIAN VEGETATION SCORE	INSTREAM HABITAT SCORE	SENSITIVITY SCORE	CONDITION SCORE	REACH TRAJEC-TORY	PRIMARY MANAGEMENT OBJECTIVE
MOBBS LANE 1	3.2	3.3	1.5	3	11.0	stable	EXISTING RIPARIAN RESTORATION
MOBBS LANE 2	3	3.4	4	3	13.4	degrading	GOOD RIPARIAN HABITAT, EXISTING RIPARIAN RESTORATION
MOBBS LANE 3	3.5	3.8	2	2	11.3	degrading	EXISTING RIPARIAN RESTORATION
MOBBS LANE 4	2.5	4.0	4	3	13.5	degrading	GOOD RIPARIAN HABITAT, EXISTING RIPARIAN RESTORATION
JAMES HOSKIN 1	4.3	3.4	4	1	12.7	degrading	EXISTING RIPARIAN RESTORATION
JAMES HOSKIN 2	3.5	2.5	1.5	0	7.5	stable	REDUCE DOWNSTREAM IMPACTS
JAMES HOSKIN 3	4.3	4.0	4	1	13.3	degrading	EXISTING RIPARIAN RESTORATION
FRED SPURWAY 1	3.5	2.0	3.5	0	9.0	degrading	EXISTING RIPARIAN RESTORATION
FRED SPURWAY 2	3.5	1.5	2.5	1	8.5	stable	EXISTING RIPARIAN RESTORATION
FRED SPURWAY 3	3.2	1.0	5	1	10.2	stable	REDUCE DOWNSTREAM IMPACTS
FRED SPURWAY 4	4	1.8	5.5	1	12.3	degrading	GOOD INSTREAM HABITAT, EXISTING RIPARIAN RESTORATION
FRED SPURWAY 5	2.7	1.2	1	1	5.9	stable	REDUCE DOWNSTREAM IMPACTS
UNNAMED RESERVE 1	3.7	2.4	4.5	1	11.6	degrading	GOOD INSTREAM HABITAT
UNNAMED RESERVE 1A	3	4.0	0.5	1	8.5	stable	EXISTING RIPARIAN RESTORATION
UNNAMED RESERVE 2	2.5	1.6	2.5	0	6.6	degrading	REDUCE DOWNSTREAM IMPACTS
UNNAMED RESERVE 3	3.5	4.0	2.5	1	11.0	stable	EXISTING RIPARIAN RESTORATION
SKENES AVE 1	2.5	1.7	2.5	2	8.7	highly	REDUCE DOWNSTREAM IMPACTS

						degrading	
SKENES AVE 2	3.5	3.3	3.5	2	12.3	degrading	EXISTING RIPARIAN RESTORATION
SKENES AVE 2A	3.5	2.2	0.5	2	8.2	stable	EXISTING RIPARIAN RESTORATION
DAVID HAMILTON 1	3.2	3.7	3.5	1	11.4	highly degrading	EXISTING RIPARIAN RESTORATION
EDNA HUNT 1	4.3	4.5	3	3	14.8	degrading	GOOD RIPARIAN HABITAT, GOOD HYDROGEOMORPHOLOGY
EDNA HUNT 1A	0.5	3.5	0.5	3	7.5	highly degrading	REDUCE DOWNSTREAM IMPACTS
EDNA HUNT 2	3	3.8	5	3	14.8	degrading	EXISTING RIPARIAN RESTORATION
EDNA HUNT 3	3	3.3	4	3	13.3	degrading	EXISTING RIPARIAN RESTORATION
EDNA HUNT 4	3.8	3.8	3	4	14.6	stable	GOOD RIPARIAN HABITAT, EXISTING RIPARIAN RESTORATION

9.2 DEVELOPMENT OF A PRIORITISED REHABILITATION PLAN

9.2.1 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 15).

Table 15 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.

9.2.2 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.

9.2.3 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 Terry's Creek 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.

10 REHABILITATION WORKS AND ACTIVITIES

10.1 TYPES OF WORK

The following table provides a brief outline of the aims of activities that are recommended for restoration and management works (Table 16).

Table 16 A brief outline of the aims and activities included in recommended works

MASTERPLAN WORKS/ACTIVITY	BRIEF DESCRIPTION
Maintenance/follow up weed control	Ongoing process of weed control in areas that have had previous bush regeneration works completed
Bush regeneration weed control	Removal of weeds in predominantly healthy bushland
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
Control noxious and environmental weeds	Targeted weed control to reduce the spread of problematic weeds in the downstream environment
Local provenance plant propagation	Cultivation of plants for revegetation using seed or propagules derived from local native species where possible; this is strongly recommended for all plant stock introduced to these sites
Infill planting for diversity	Additional planting that 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	Planting using specifically selecting deep rooted, fast establishing species for planting in areas susceptible to erosion
Supplementary/revegetation planting	Higher density supplementary planting to replace weeds that have been removed; select plant species that will reproduce the original vegetation structure, improve habitat resources, maintain bank stability
Install jute matting with stabilisation planting	Soft engineering solutions to minor/localised erosion issues, and may include the use of jute matting or jute mesh

MASTERPLAN WORKS/ACTIVITY	BRIEF DESCRIPTION
Install coir logs and/or sandbags	Suited to localized erosion control in streams with a typically low flow; stabilizes the bank/toe while vegetation becomes reestablished
Monitor for erosion; may require earthworks	For areas with dense weed infestations and moderate flows; weed removal may expose soils making them more susceptible to erosion
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, reshaping, geotextile lining, rock lining, retaining wall construction: aims to provide control of bank erosion from a number of possible causes
Channel bed stabilisation works	eg. construction of rock riffles, rock chutes, rock groynes; aims to prevent further channel bed lowering and sediment mobilization through reduction in shear stress energies
Outlet protection	Rock armouring is used to control localised erosion around stormwater discharge points; for highly eroded outlets these may need to be relocated back into the new bank configuration
Investigate hydraulic requirements	Current conditions indicate that discharge points may need to be resized and/or relocated
Water quality monitoring point	Aims to collect data that will help identify high pollution generating sub-catchments through a process of community involvement)
Install informative signage	Aims to provide facilities that encourage education and 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

See Appendix Three for a full description of works activities.

11 WATERWAYS CORRIDOR RESPONSES TO MASTERPLAN WORKS AND ACTIVITIES

See Appendix Three for full description of works.

11.1 POTENTIAL RESPONSES TO BIODIVERSITY ENHANCEMENT WORKS

Table 17 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 maintenance/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 Also applies to targeted control of noxious and environmental weeds	• 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 Recommended for all planting	• 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 local genetic makeup

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
Infill planting for diversity supplementary planting for restoration of vegetation communities	• 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 • Maintenance of biodiversity resources through active conservation of species and

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
			local genetic makeup
Supplementary/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 Also applies to riparian extension planting	• 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
Install jute matting with stabilisation planting soft engineering solutions to minor/localised erosion issues; includes coir logs and sandbags	• 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

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
			erosion and sediment mobilisation

11.2 POTENTIAL RESPONSES TO EROSION CONTROL WORKS

Table 18 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

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
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	• Minimising potential for toe failure and subsequent bank slumping and retreat – reduction in potential for 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.	• 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
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	• 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	• 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	• Improved aquatic ecology through water quality enhancement • Enhanced aquatic habitat through addition of habitat complexity components • Structure allows fish migration; no anticipated

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
floodplain	centralise low flows, reducing bank failure risk	pier protection works • No anticipated variation in flood level or risk to property	influence on fish breeding areas
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

11.3 POTENTIAL RESPONSES TO WATER QUALITY IMPROVEMENT WORKS

Table 19 Potential geomorphic, hydrological and ecological responses to works activities proposed for water quality improvement

MASTERPLAN WORKS/ACTIVITY	GEOMORPHIC RESPONSE	HYDROLOGICAL RESPONSE	ECOLOGICAL RESPONSE
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

11.4 POTENTIAL RESPONSES TO COMMUNITY AND RECREATION ACTIVITIES

Table 20 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 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
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

12 REHABILITATION WORKS AND ACTIVITIES – THE MASTERPLAN

12.1 OVERVIEW

See following pages

Note: In the following tables, works are considered the responsibility of asset managers, including Civil Infrastructure (CI) if they relate to stormwater infrastructure, while community land (parks), Edna Hunt Sanctuary, and Bushcare related works such as weed control and revegetation planting are the responsibility of Open Space & Natural Resources (OS&NR). Monitoring of water quality falls under the jurisdiction of City Strategy (CS).

UPPER TERRY'S CREEK CATCHMENT OVERVIEW

Waterway Drainage Line Stormwater Pipe

N

1: 15000 @ A4

applied ecology

Base layers supplied by client
Stormwater pits and pipes
Waterways by Applied Ecology P/L
Drainage Lines by Applied Ecology P/L
MGA94 56
created 4/4/2013 AnneCarey
cp/TCMP/gis/workspaces/A4

MOBBS LANE RESERVE
CONDITION & ASSET SCORING

REACH NAME	GEOMORPHOLOGY SCORE	RIPARIAN VEGETATION SCORE	INSTREAM HABITAT SCORE	SENSITIVITY SCORE	CONDITION SCORE
MOBBS LANE 1	3.2	3.3	1.5	3	11
MOBBS LANE 2	3	3.4	4	3	13.4
MOBBS LANE 3	3.5	3.8	2	2	11.3
MOBBS LANE 4	2.5	4	4	3	13.5

SCORE RANGE	STREAM CONDITION
18-22	EXCELLENT
14-17.9	GOOD
10-13.9	FAIR
5-9.9	POOR
0-4.9	HIGHLY DEGRADED

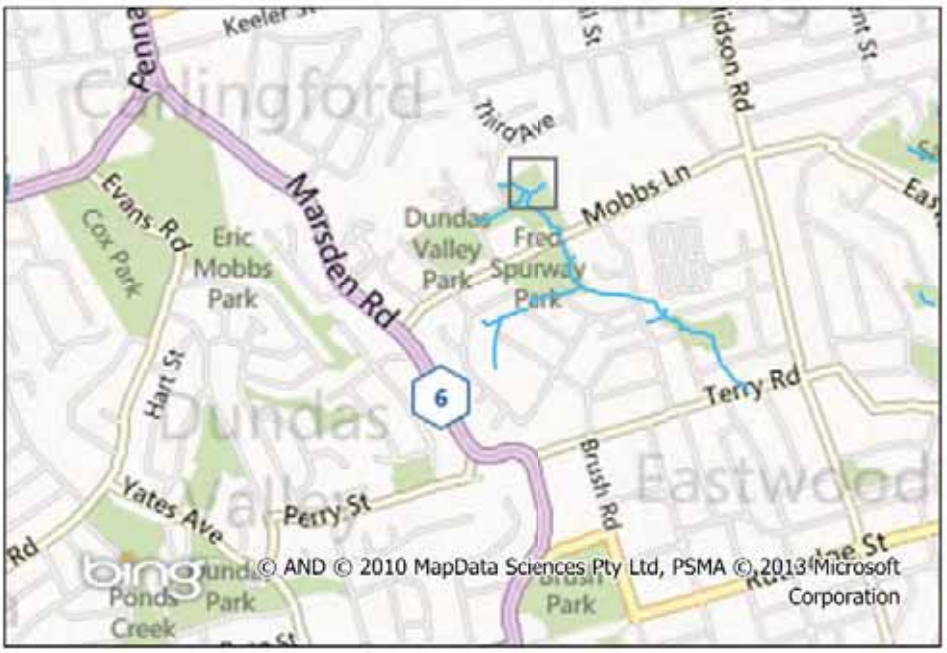
X.X Noteworthy score- see Section 9.1 for details

REACH NAME	PRIMARY MANAGEMENT OBJECTIVE	TRAJECTORY SCORE	REACH TRAJECTORY
MOBBS LANE 1	EXISTING RIPARIAN RESTORATION	2	stable
MOBBS LANE 2	GOOD RIPARIAN HABITAT, EXISTING RIPARIAN RESTORATION	3	degrading
MOBBS LANE 3	EXISTING RIPARIAN RESTORATION	4	degrading
MOBBS LANE 4	GOOD RIPARIAN HABITAT, EXISTING RIPARIAN RESTORATION	4	degrading

data collected 6-8/03/2013

MOBBS LANE RESERVE

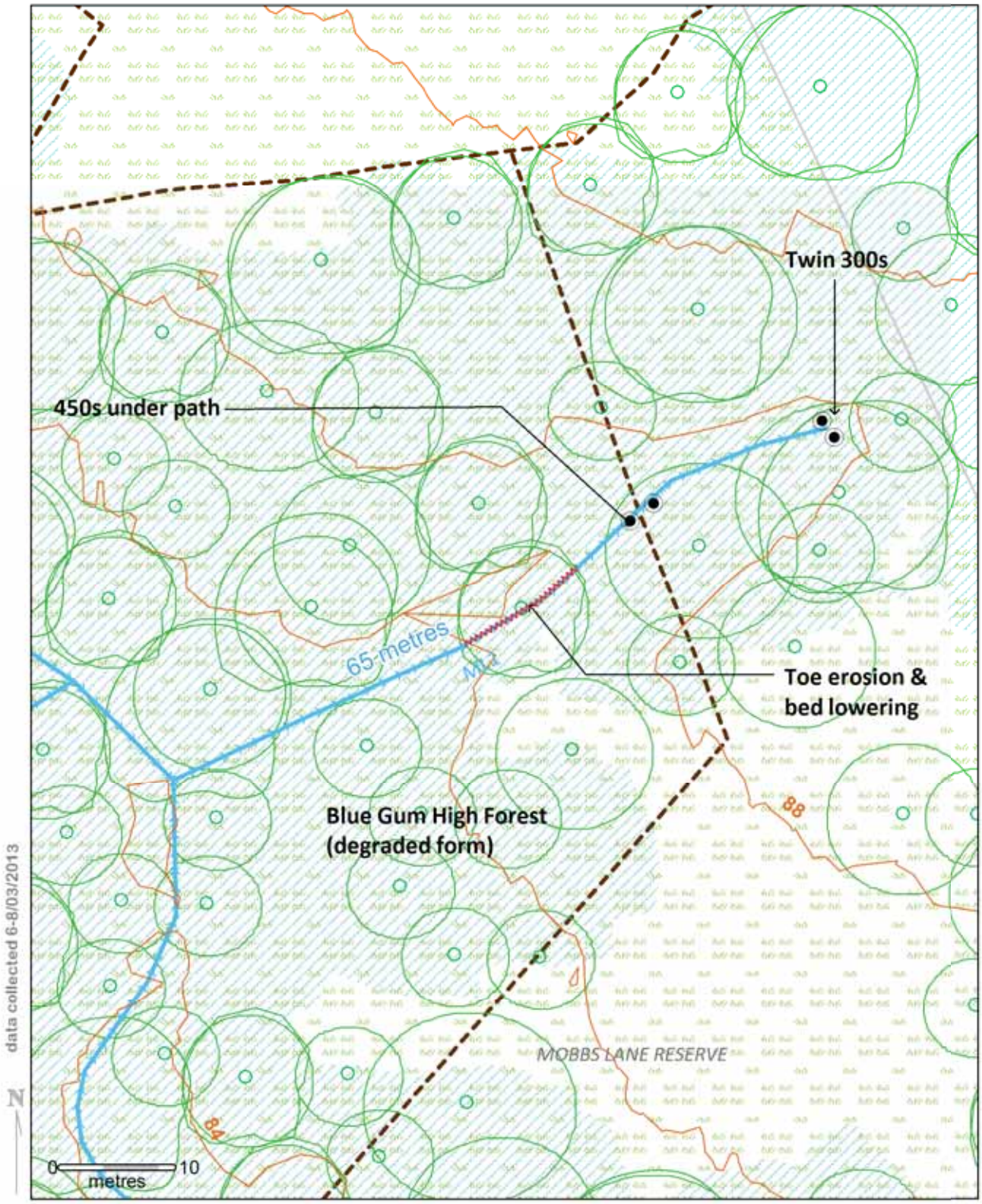
SITE CONTEXT: REACH 1 (ML1)



data collected 6-8/03/2013

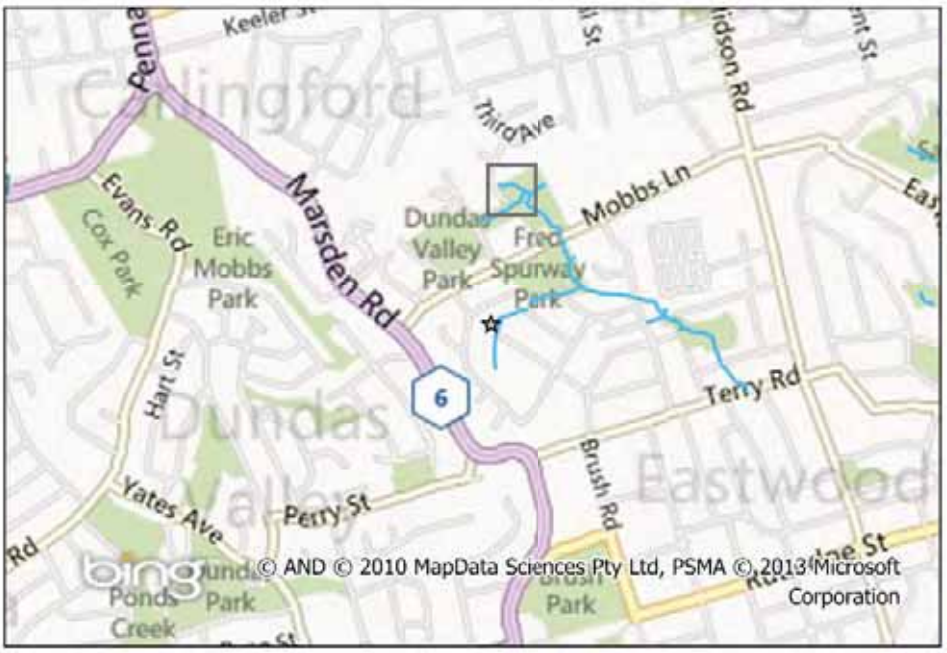
MOBBS LANE RESERVE

EXISTING SITUATION: REACH 1 (ML1)



MOBBS LANE RESERVE

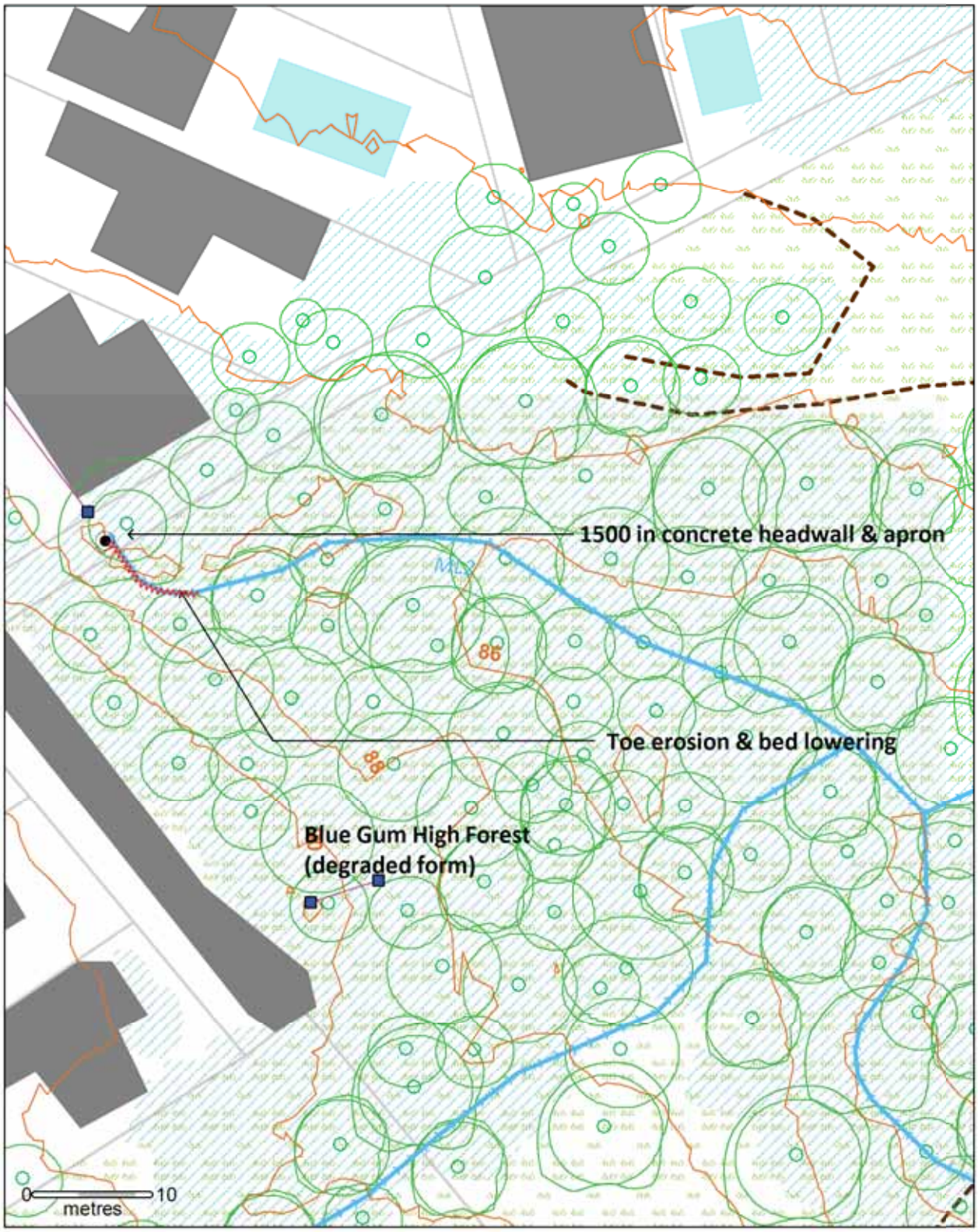
SITE CONTEXT: REACH 2 (ML2)



data collected 6-8/03/2013

MOBBS LANE RESERVE

EXISTING SITUATION: REACH 2 (ML2)



Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

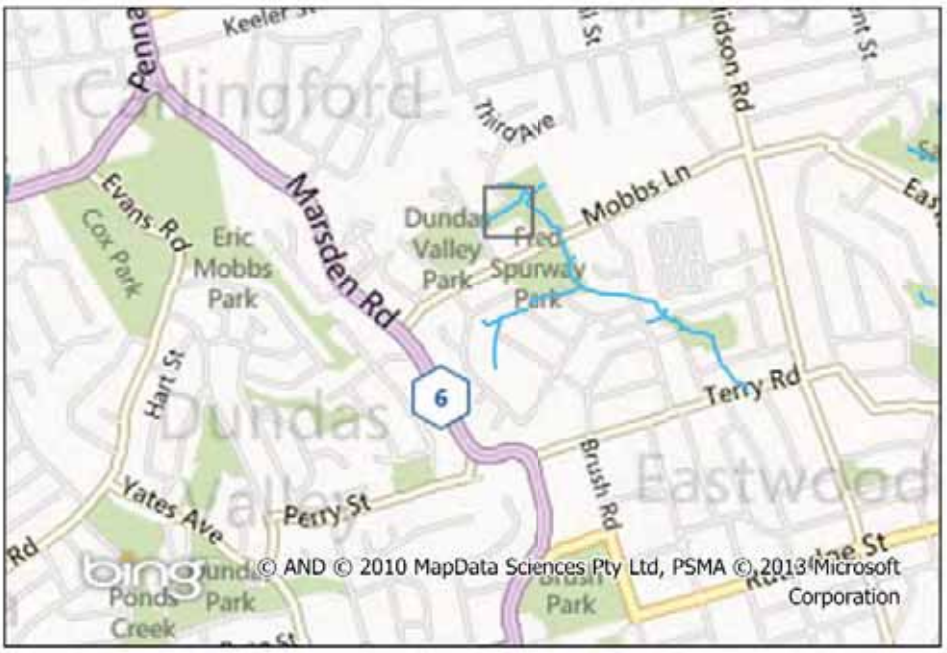
Cadastre Lot Boundary

Stormwater Pit

EEC Blue Gum High Forest

MOBBS LANE RESERVE

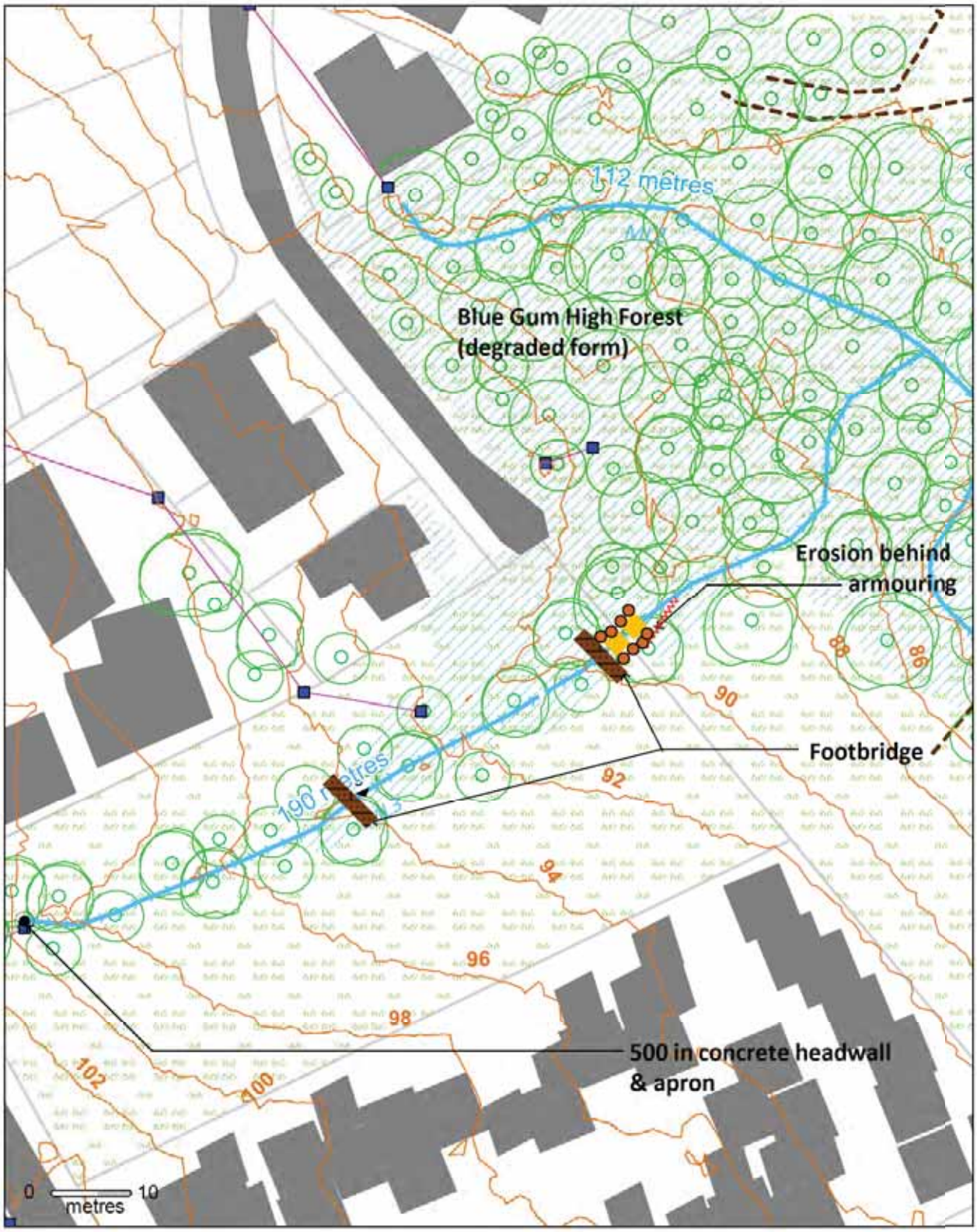
SITE CONTEXT: REACH 3 (ML3)



data collected 6-8/03/2013

MOBBS LANE RESERVE

EXISTING SITUATION: REACH 3 (ML3)



Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

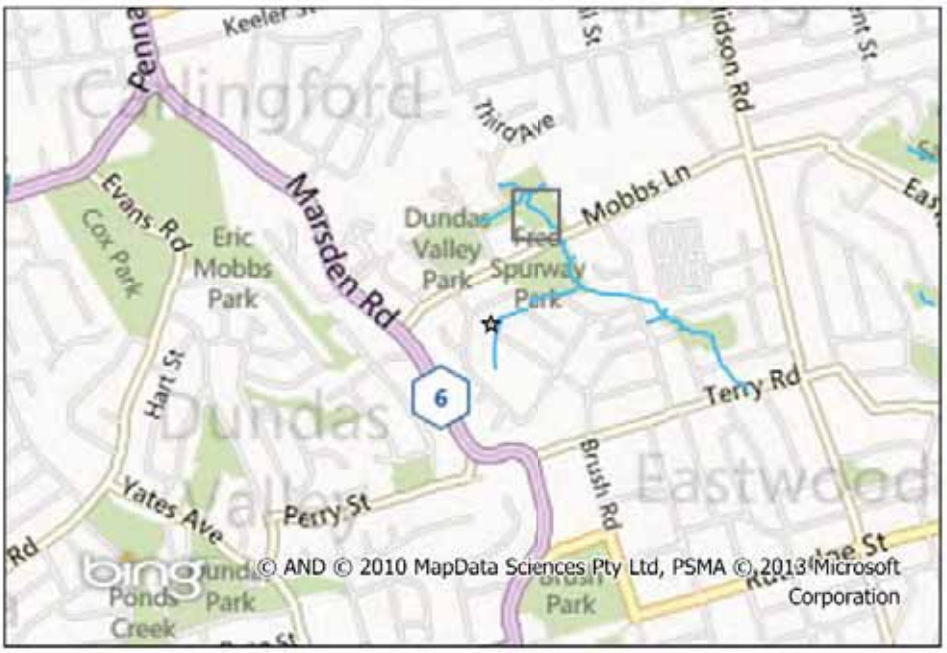
Cadastre Lot Boundary

Stormwater Pit

EEC Blue Gum High Forest

MOBBS LANE RESERVE

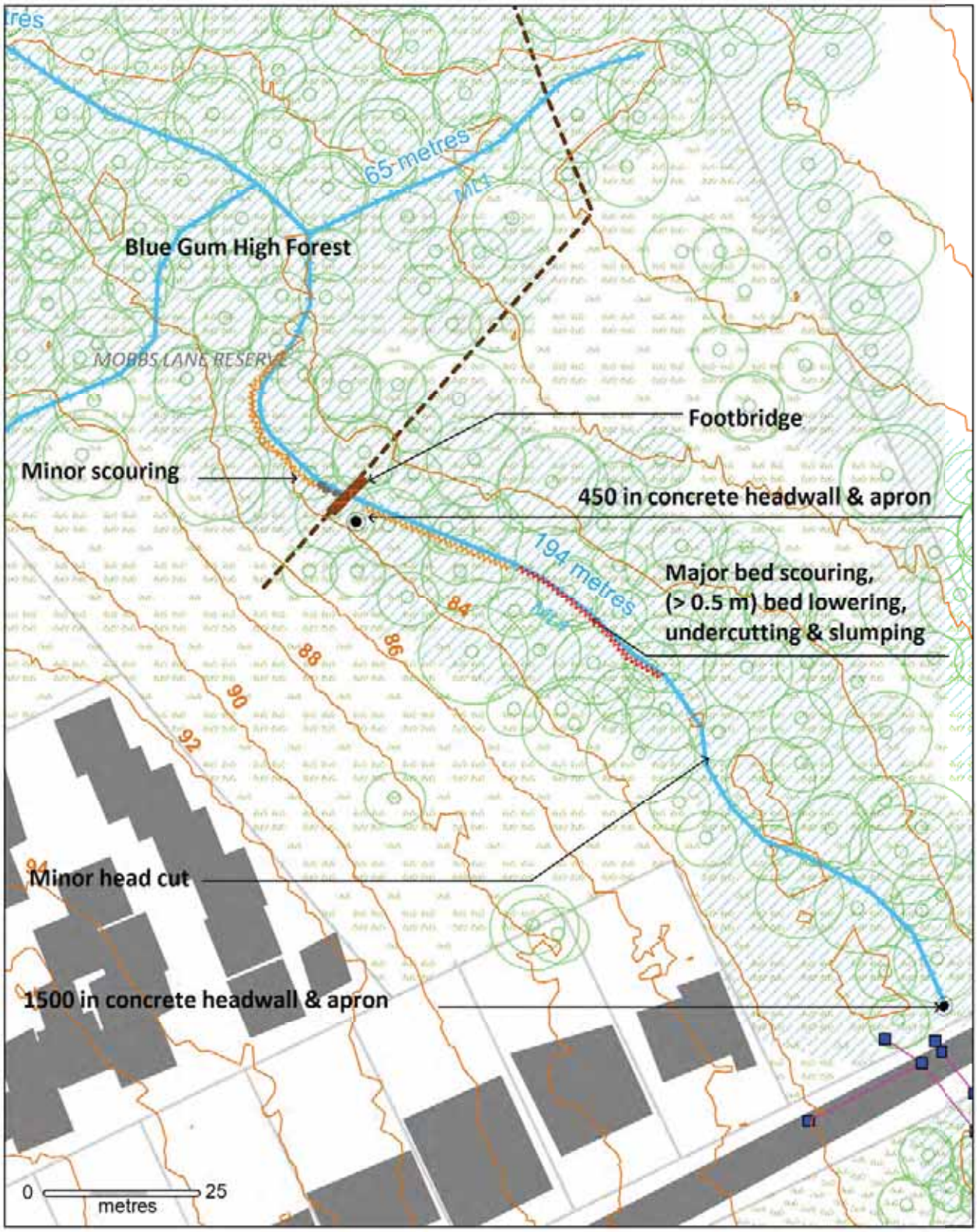
SITE CONTEXT: REACH 4 (ML4)



data collected 6-8/03/2013

MOBBS LANE RESERVE

EXISTING SITUATION: REACH 4 (ML4)



Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

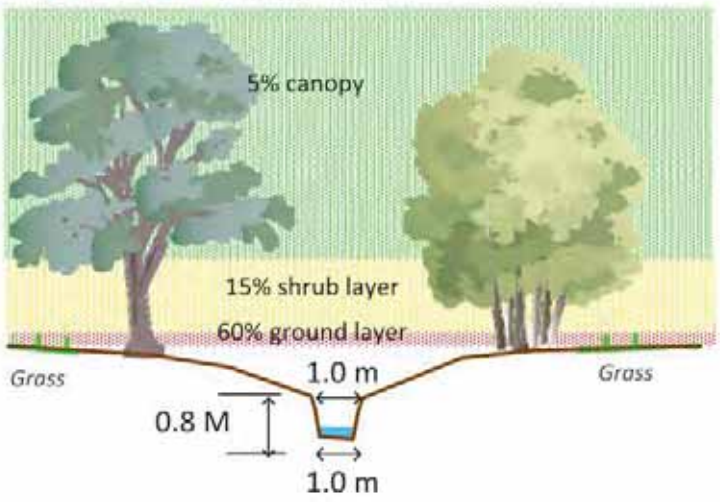
Cadastre Lot Boundary

Stormwater Pit

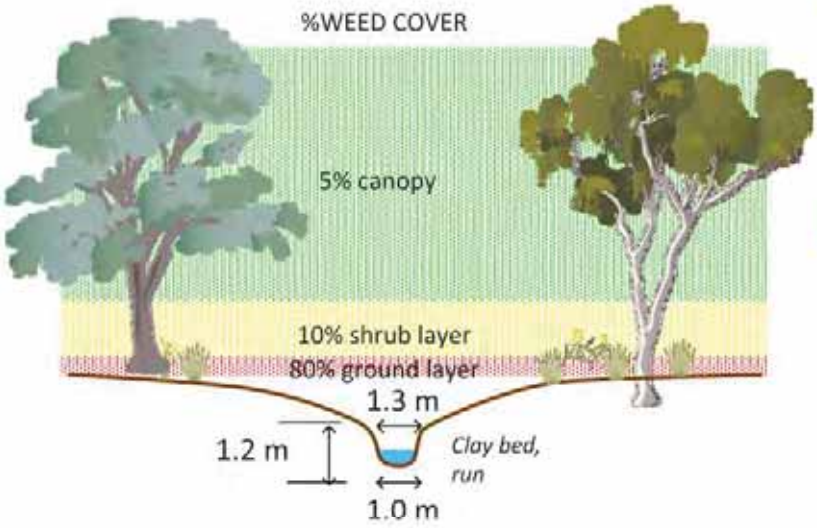
EEC Blue Gum High Forest

MOBBS LANE RESERVE CROSS SECTIONS

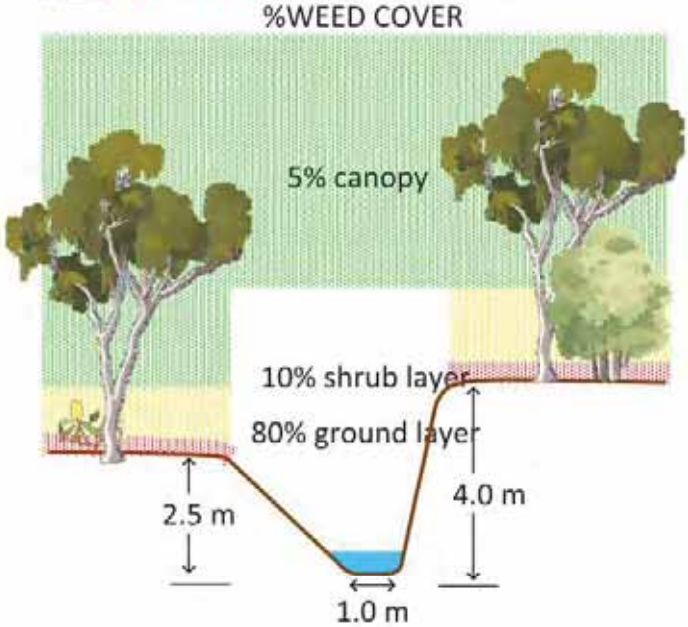
ML1



ML2a



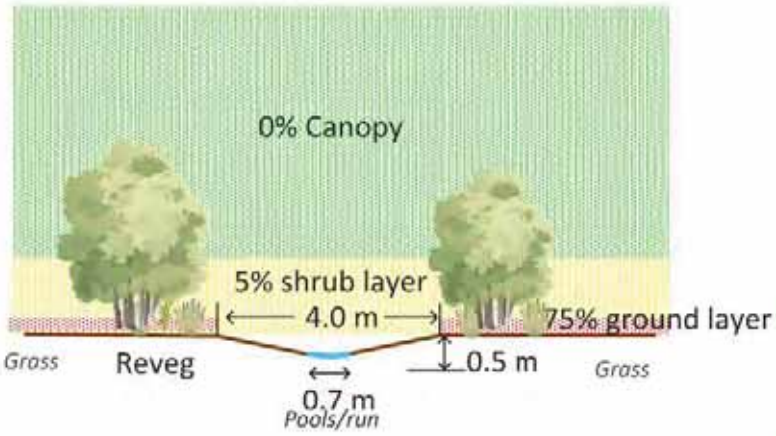
ML2b

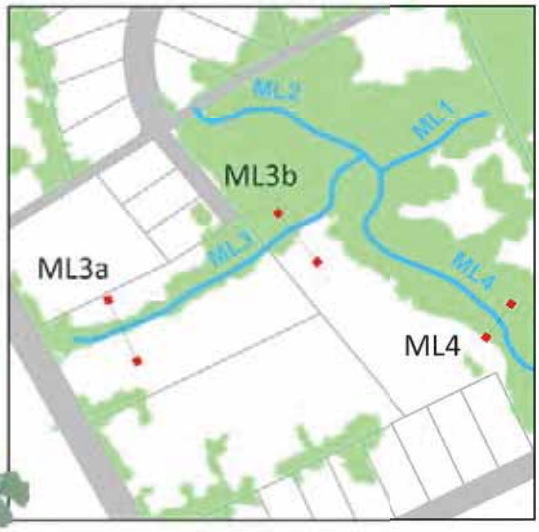


data collected 6-8/03/2013

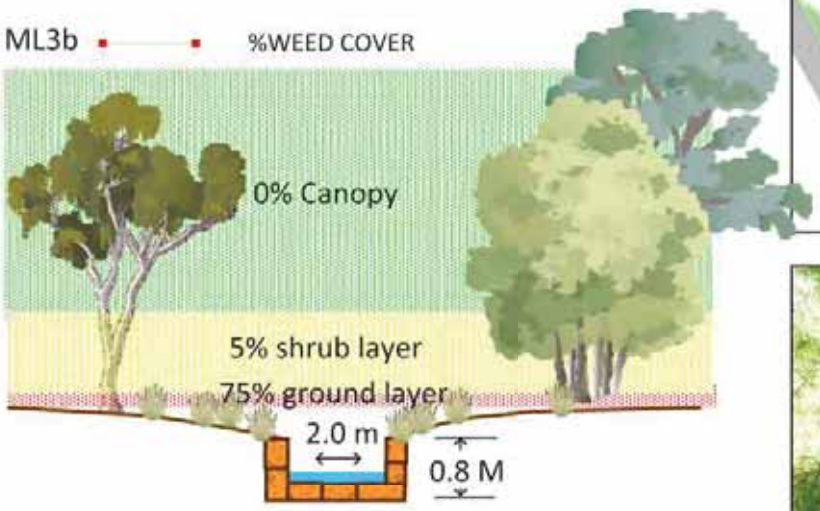
MOBBS LANE RESERVE CROSS SECTIONS

ML3a %WEED COVER



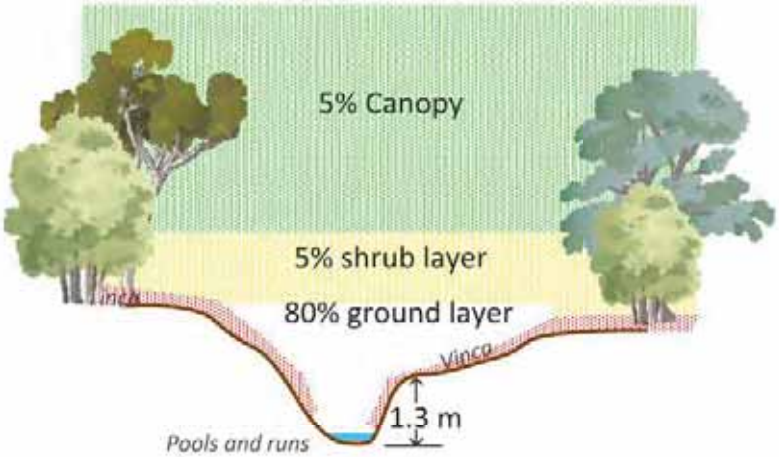


ML3b %WEED COVER



ML4

%WEED COVER



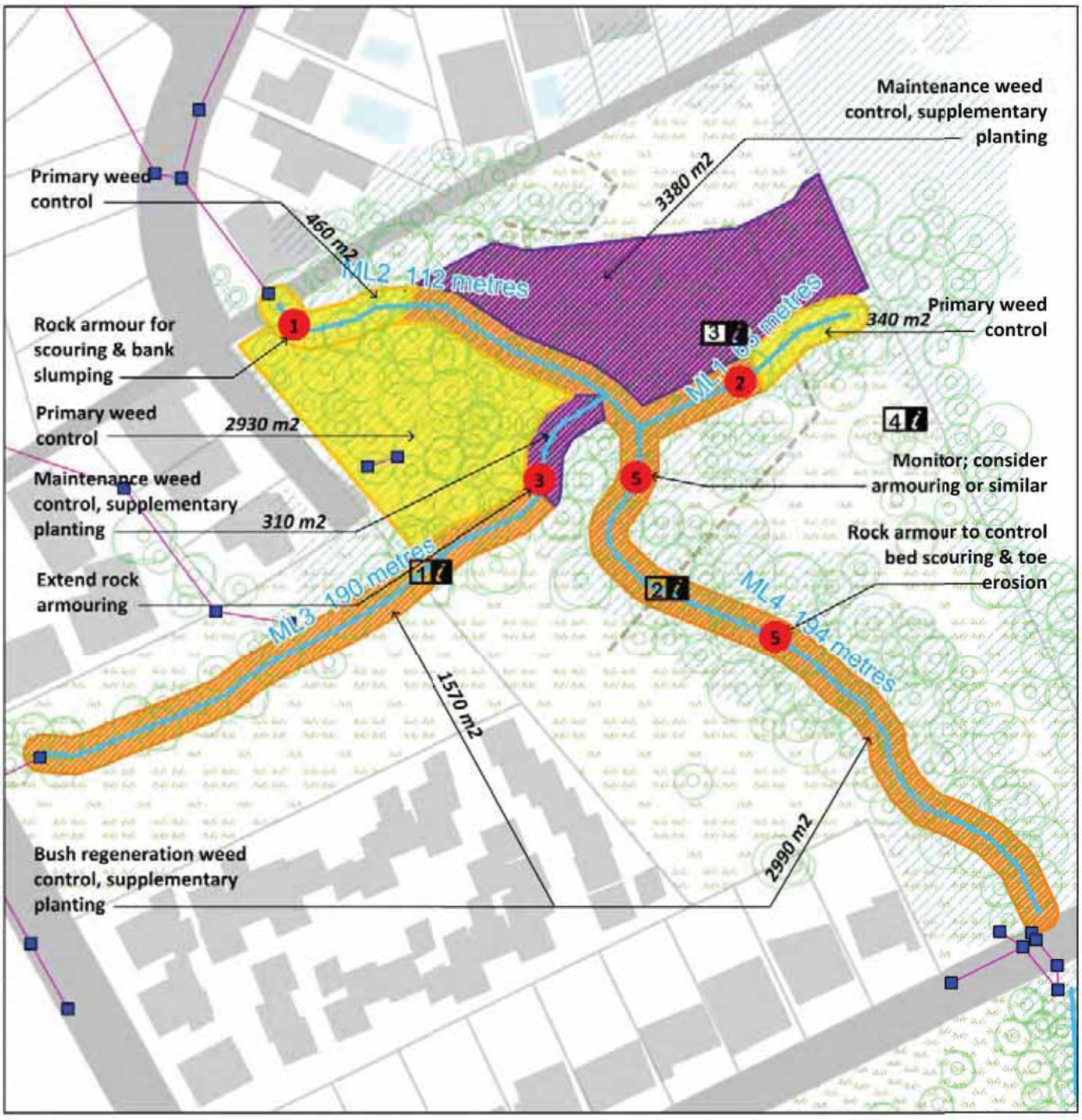
data collected 6-8/03/2013

MOBBS LANE RESERVE

WORKS PLAN

VEGETATION COMMUNITIES

Blue Gum High Forest (BGHF)



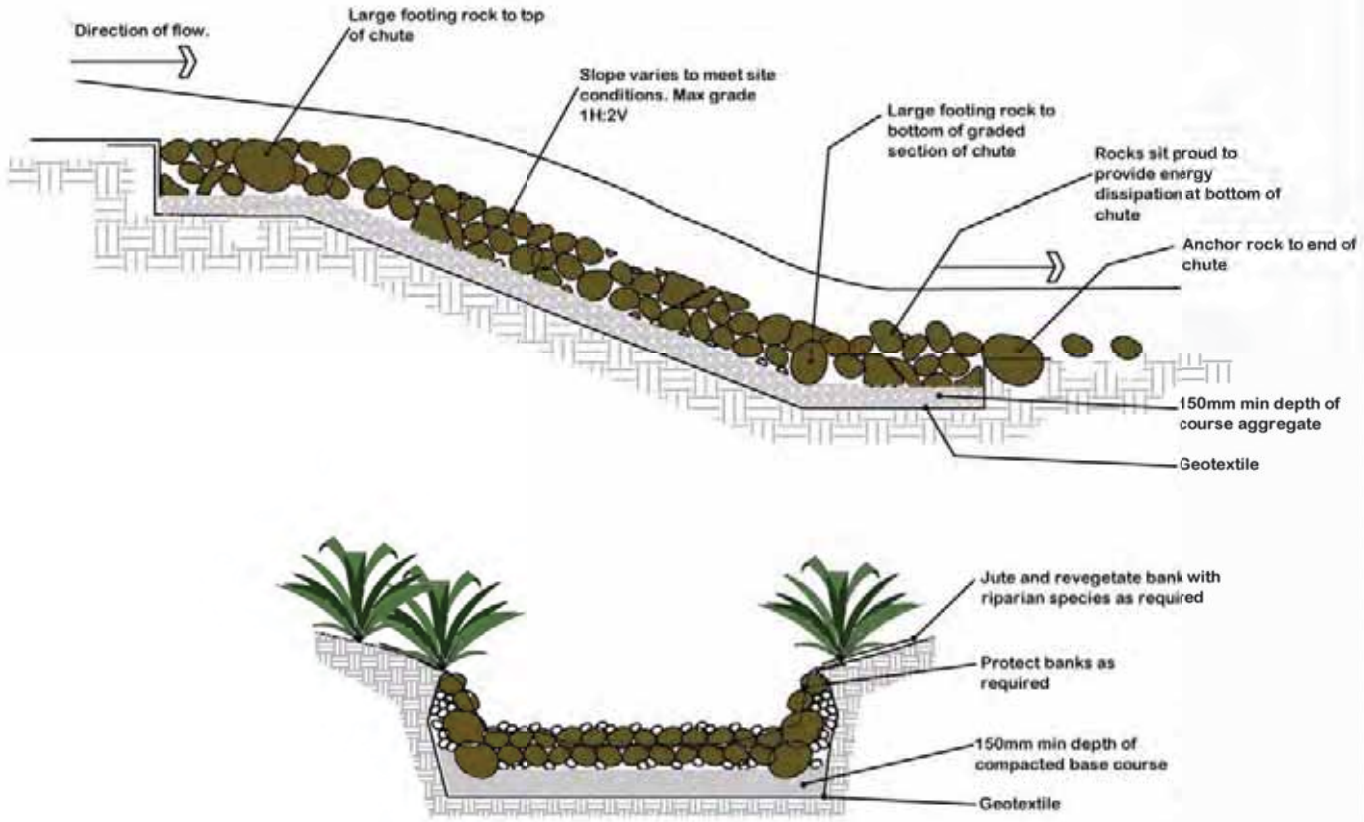
i Install informative signage near bridges/crossing points discussing:

1) the importance of riparian zones;
2) Blue Gum High Forest; and
3) important plant species of this community
4) channel 7 television heritage on the adjoining land (face towards the former studio location)

MOBBS LANE RESERVE WORKS PLAN

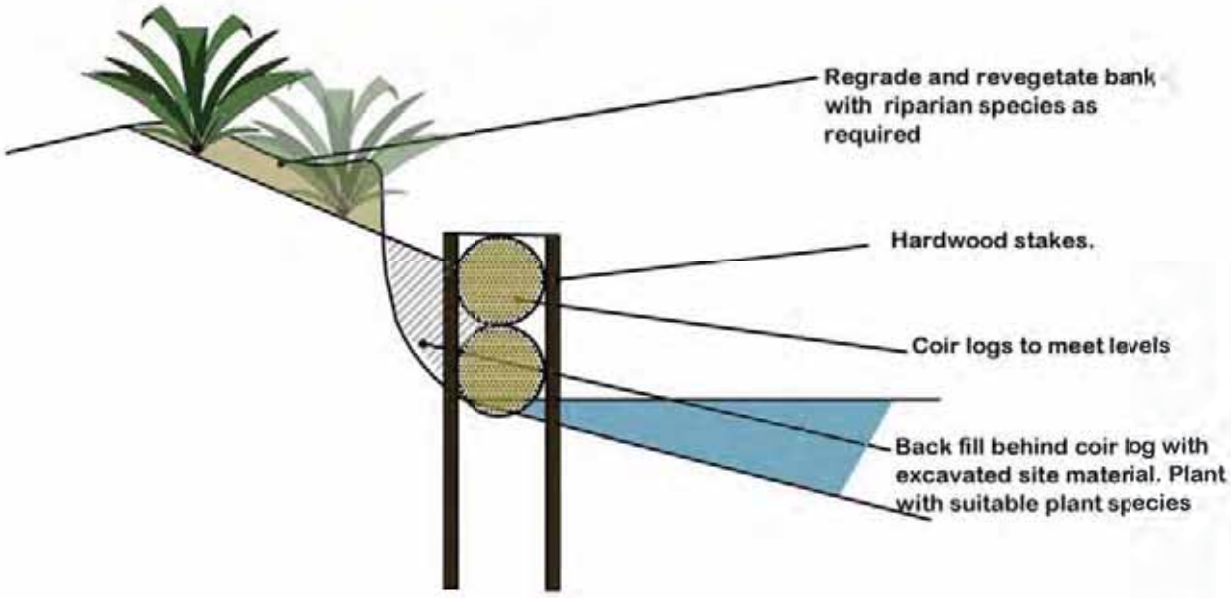
1 3 5

ROCK CHUTE (NTS)



2

COIR LOG TOE PROTECTION (NTS)



12.3 MOBBS LANE RESERVE WORKS PLANS & COSTINGS

12.3.1 MOBBS LANE 1

Table 21 Management actions and works required for reach ML1 in MOBBS LANE RESERVE

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
ML1	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	340m2	$3-5K	$1-2K	OS&NR
ML1	Biodiversity enhancement: coir logs/sandbags for minor toe erosion, plant with Blue Gum High Forest species	High	5m	$1-2K	N/A	OS&NR
ML1	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	Medium	300m2	$2-4K	$1K	OS&NR
ML1	Community and recreation: install 2 information signage (see design drawing for recommended topics)	Medium	2 units	$5-10K	<$1K	OS&NR
ML1	Biodiversity enhancement: supplementary planting using Blue Gum High Forest species	Medium	1980m2	$1K	N/A	OS&NR
ML1	Biodiversity enhancement: followup/maintenance weed control	Ongoing	1980m2	$1-2K	<$1K	OS&NR

12.3.2 MOBBS LANE 2

Table 22 Management actions and works required for reach ML2 in MOBBS LANE RESERVE

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
ML2	Erosion control: rock armouring for toe	Urgent	10m	$15-20K	$1-2K	OS&NR

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
	erosion/bank slumping					
ML2	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	440m2	$3-5K	$1K	OS&NR
ML2	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	High	690m2	$2-5K	<$1K	OS&NR
ML2	Biodiversity enhancement: revegetation/riparian extension planting using Blue Gum High Forest species	Medium	2930m2	$2-5K	<$1K	OS&NR
ML2	Biodiversity enhancement: followup/maintenance weed control	Ongoing	3380m2	$2-4K	<$1K	OS&NR

12.3.3 MOBBS LANE 3

Table 23 Management actions and works required for reach ML3 in MOBBS LANE RESERVE

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
ML3	Erosion control: rock armouring for toe erosion/bank slumping	Very high	10m	$10-15K	$1-2K	OS&NR
ML3	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	High	1570m2	$6-10K	<$1K	OS&NR
ML3	Community and recreation: install information signage (see design drawing for recommended topics)	Medium	1 unit	$2-5K	N/A	OS&NR
ML3	Biodiversity enhancement: supplementary planting using Blue Gum High Forest	Medium	310m2	$1K	<$1K	OS&NR

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
	species					
ML3	Biodiversity enhancement: revegetation/riparian extension planting using Blue Gum High Forest species	Medium	SEE MOBBS LANE 2			OS&NR
ML3	Biodiversity enhancement: followup/maintenance weed control	Ongoing	310m2	$1K	<$1K	OS&NR

12.3.4 MOBBS LANE 4

Table 24 Management actions and works required for reach ML4 in MOBBS LANE RESERVE

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
ML4	Erosion control: rock line channel to control bed lowering	Very high	50m	$15-20K	$1-2K	OS&NR
ML4	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	High	2000m2	$3-6K	$1-2K	OS&NR
ML4	Community and recreation: install information signage (see design drawing for recommended topics)	Medium	1 unit	$2-5K	<$1K	OS&NR
ML4	Biodiversity enhancement: monitor for erosion; may require earthworks	Ongoing	N/A	N/A	N/A	OS&NR

JAMES HOSKIN RESERVE
CONDITION & ASSET SCORING

REACH NAME	GEOMORPHOLOGY SCORE	RIPARIAN VEGETATION SCORE	INSTREAM HABITAT SCORE	SENSITIVITY SCORE	CONDITION SCORE
JAMES HOSKIN 1	4.3	3.4	4	1	12.7
JAMES HOSKIN 2	3.5	2.5	1.5	0	7.5
JAMES HOSKIN 3	4.3	4	4	1	13.3

SCORE RANGE	STREAM CONDITION
18-22	EXCELLENT
14-17.9	GOOD
10-13.9	FAIR
5-9.9	POOR
0-4.9	[illegible]

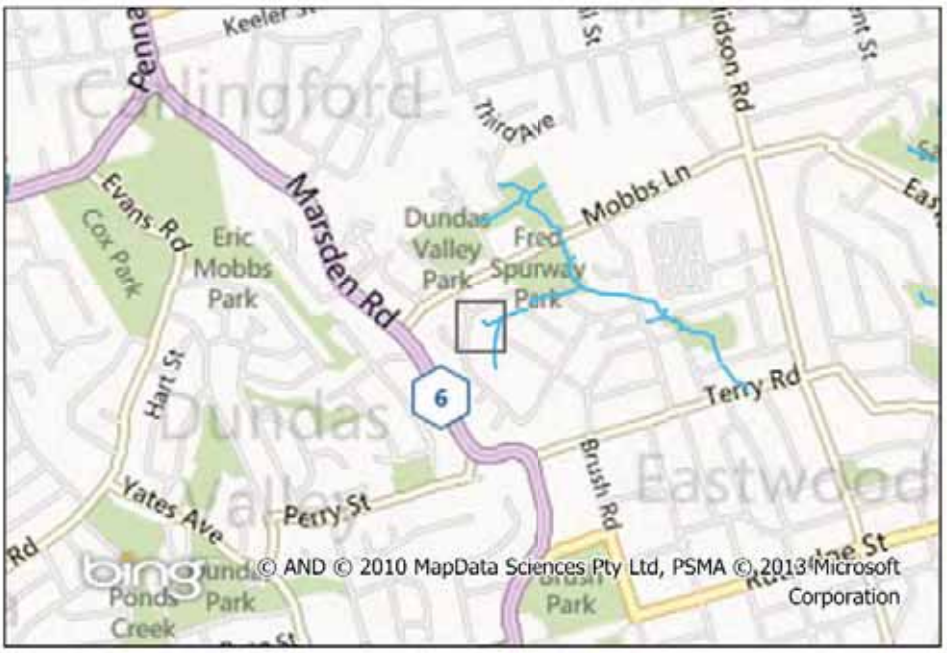
X.X Noteworthy score- see Section 9.1 for details

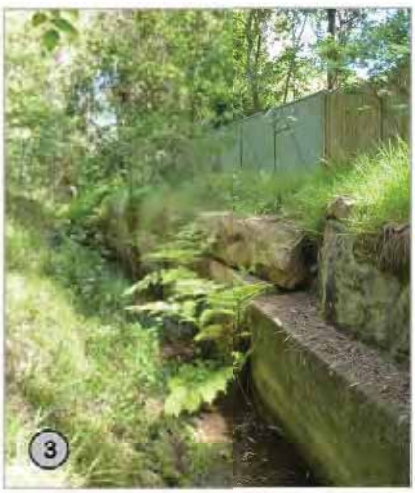
REACH NAME	PRIMARY MANAGEMENT OBJECTIVE	TRAJECTORY SCORE	REACH TRAJECTORY
JAMES HOSKIN 1	EXISTING RIPARIAN RESTORATION	4	degrading
JAMES HOSKIN 2	REDUCE DOWNSTREAM IMPACTS	2	stable
JAMES HOSKIN 3	EXISTING RIPARIAN RESTORATION	3	degrading

data collected 6-8/03/2013

JAMES HOSKIN RESERVE

SITE CONTEXT: REACH 1 (JH1)

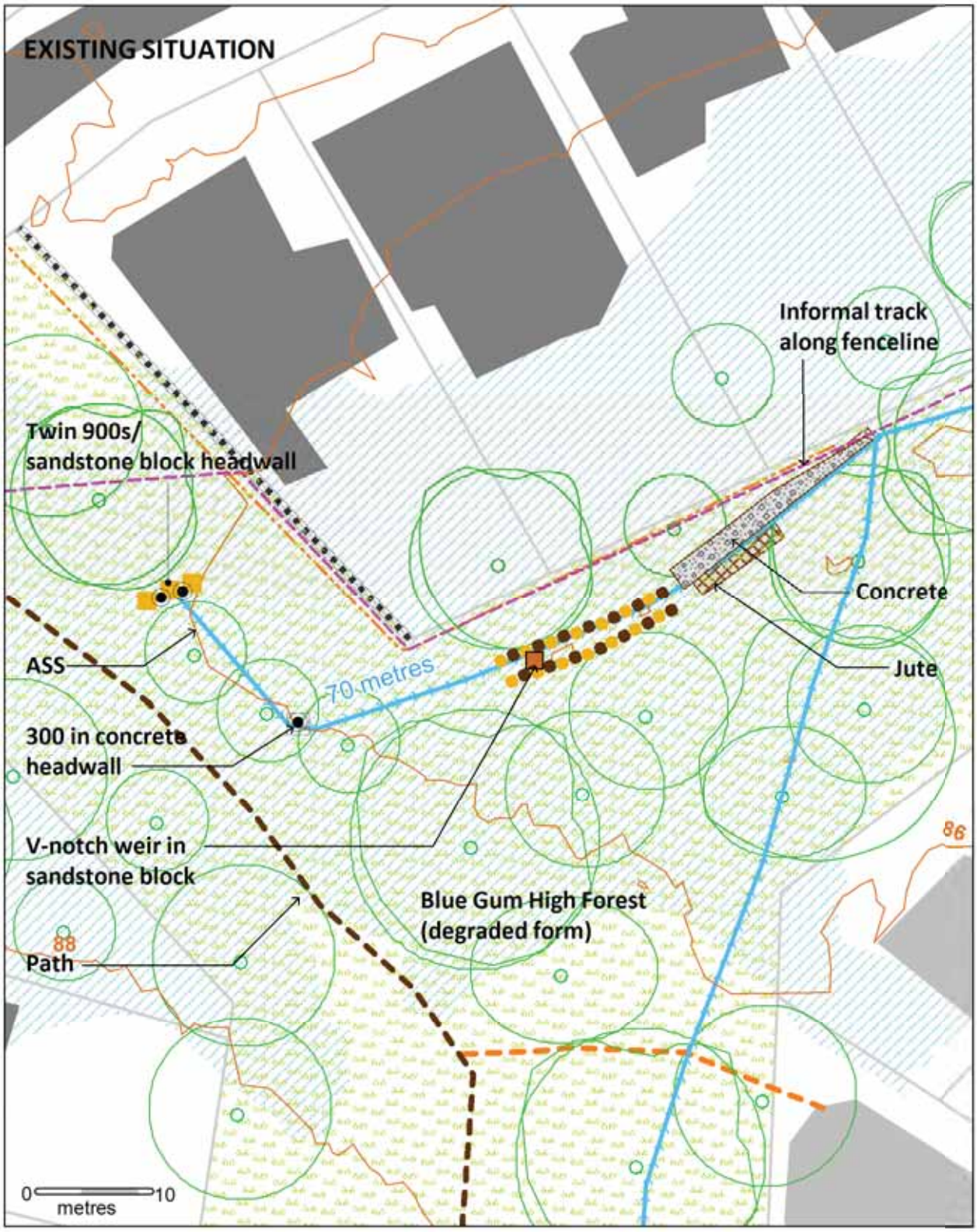




data collected 6-8/03/2013

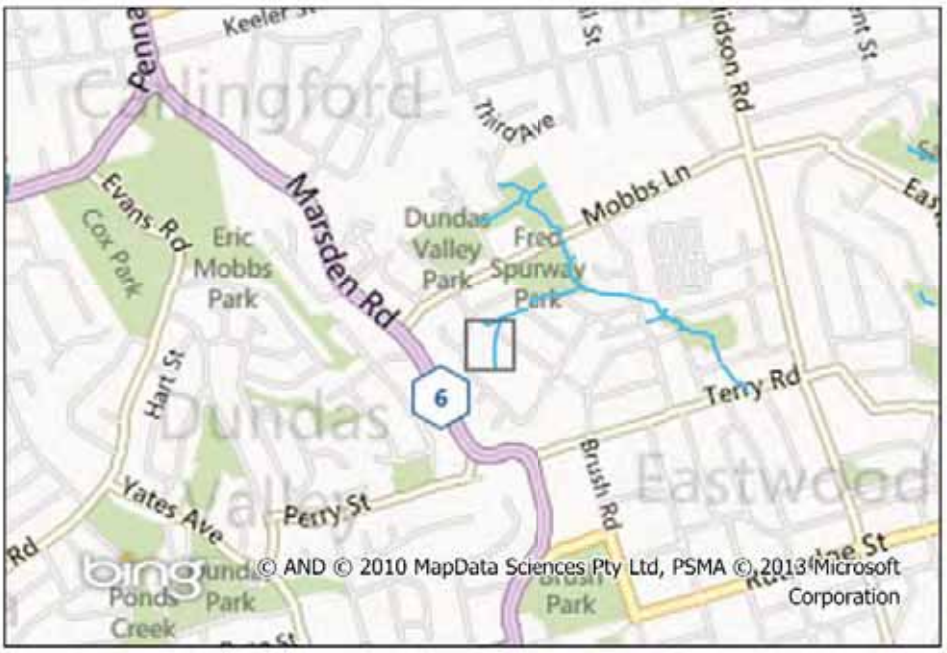
JAMES HOSKIN RESERVE

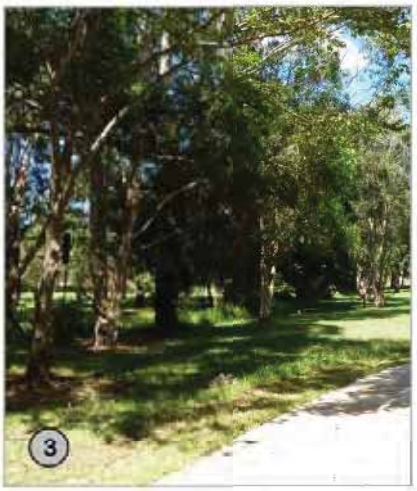
EXISTING SITUATION: REACH 1 (JH1)



JAMES HOSKIN RESERVE

SITE CONTEXT: REACH 2 (JH2)

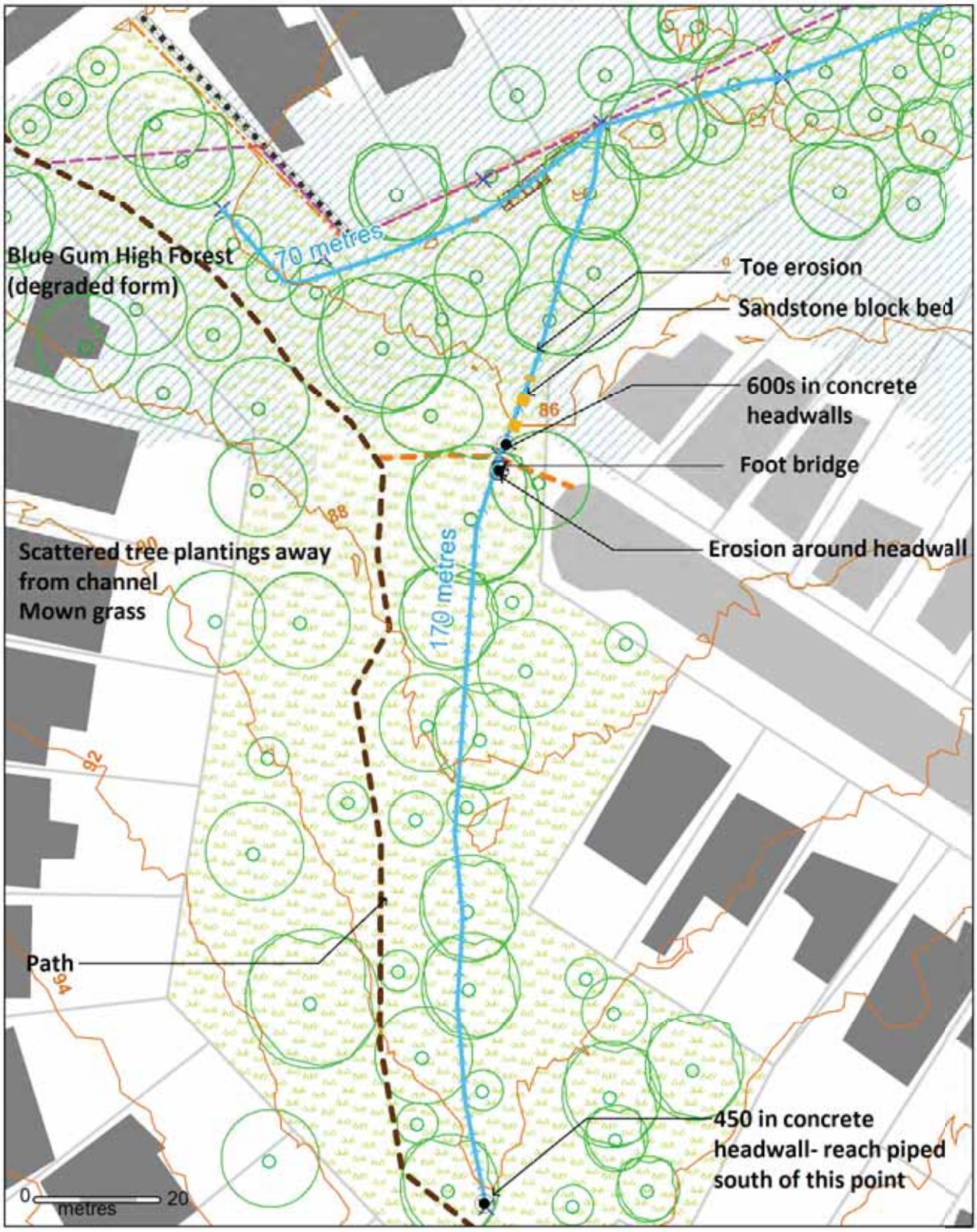




data collected 6-8/03/2013

JAMES HOSKIN RESERVE

EXISTING SITUATION: REACH 2 (JH2)



Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

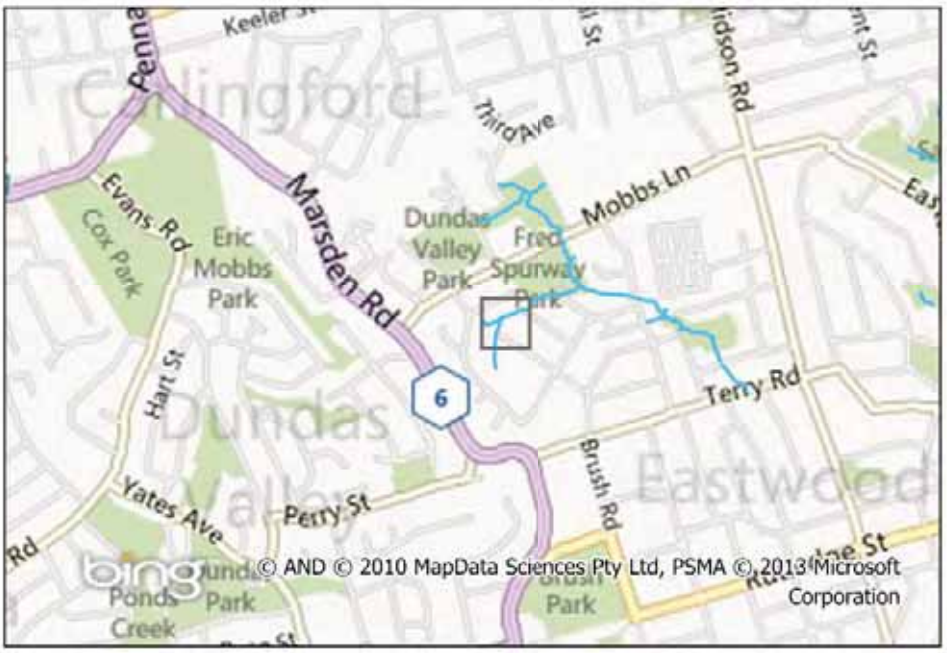
Cadastre Lot Boundary

Stormwater Pit

EEC Blue Gum High Forest

JAMES HOSKIN RESERVE

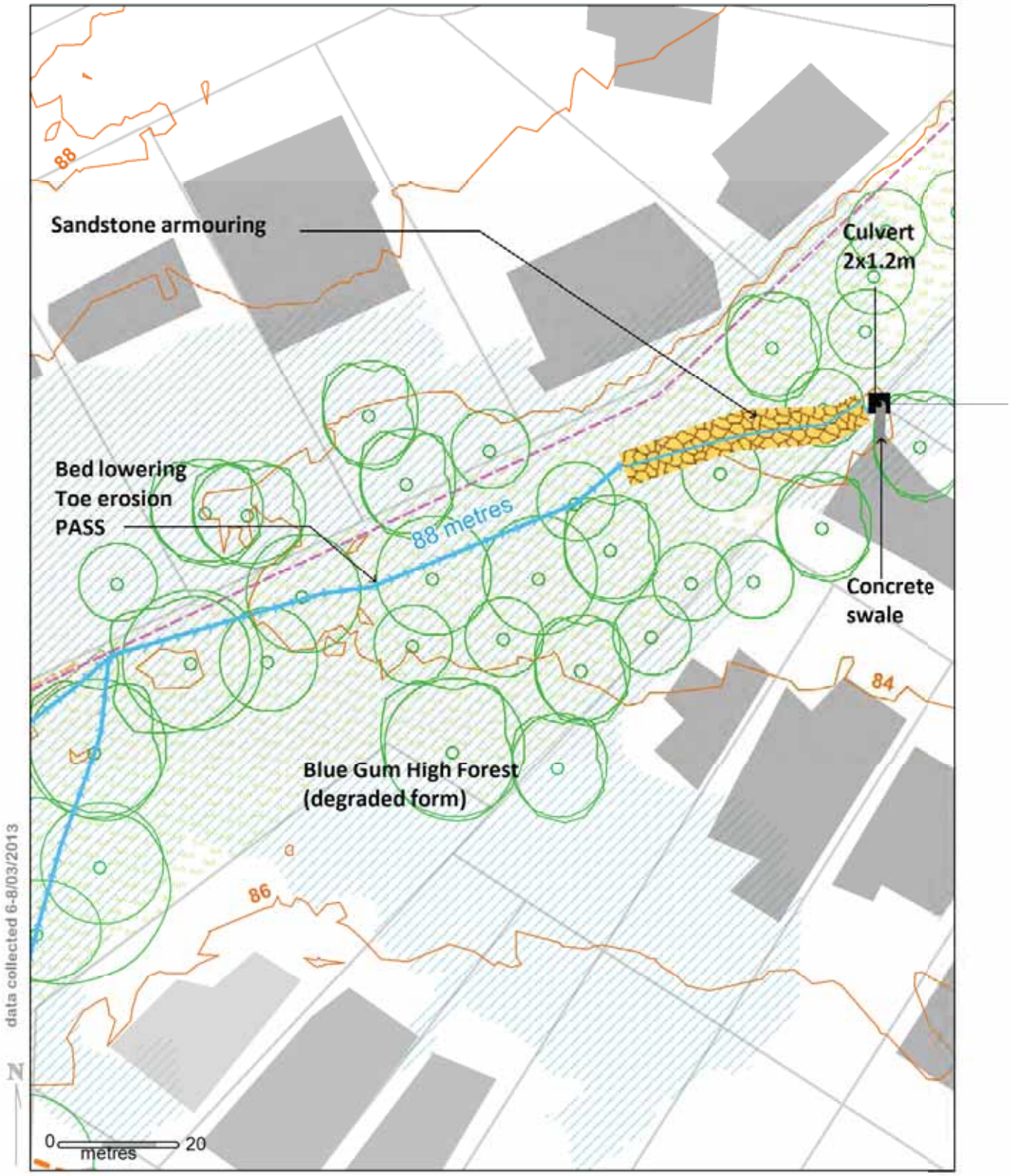
SITE CONTEXT: REACH 3 (JH3)



data collected 6-8/03/2013

JOHN HOSKIN RESERVE

EXISTING SITUATION: REACH 3 (JH3)



Stormwater Pipe

Open Watercourse

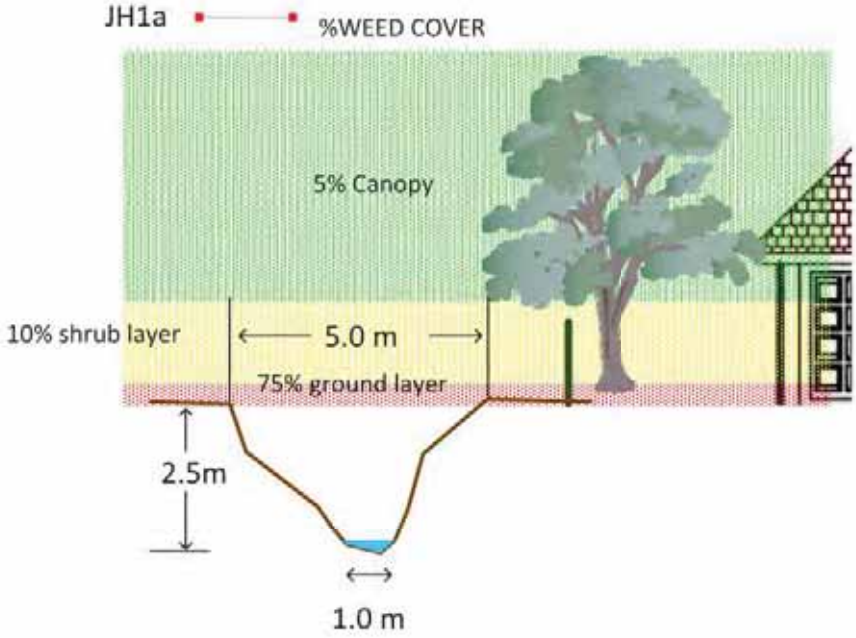
Sub-catchment Boundary

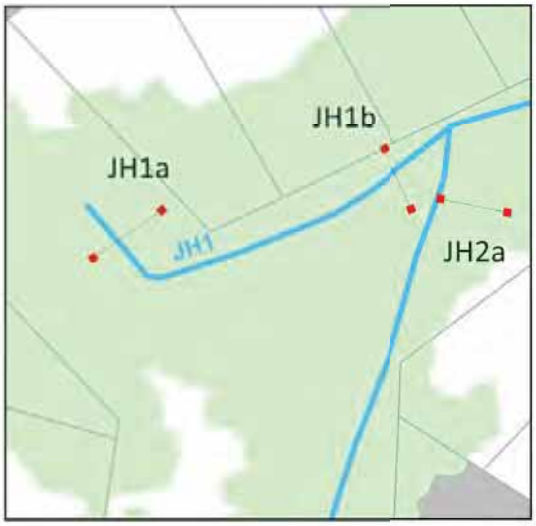
Cadastre Lot Boundary

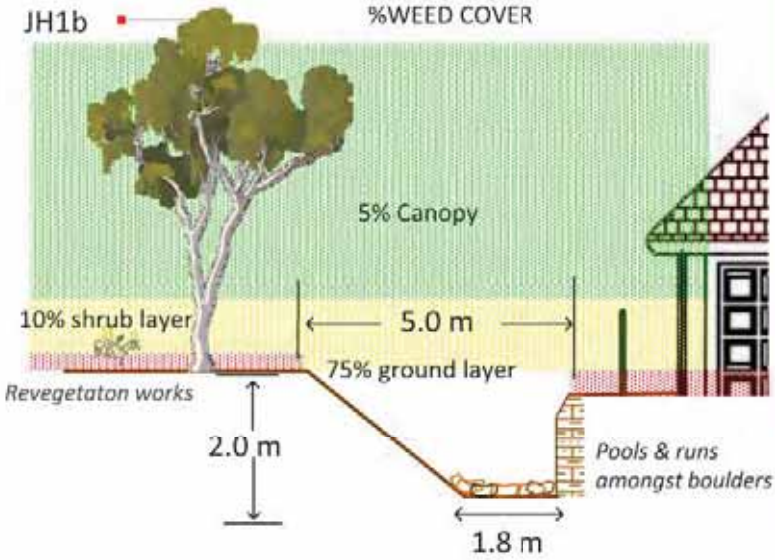
Stormwater Pit

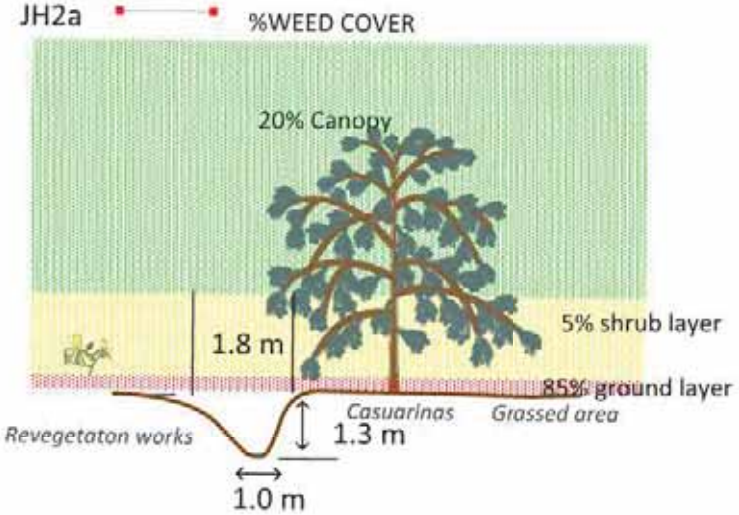
EEC Blue Gum High Forest

JAMES HOSKIN RESERVE CROSS SECTIONS



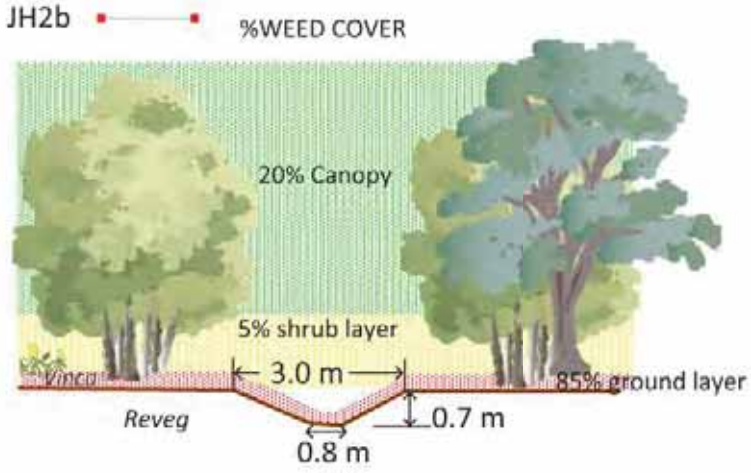


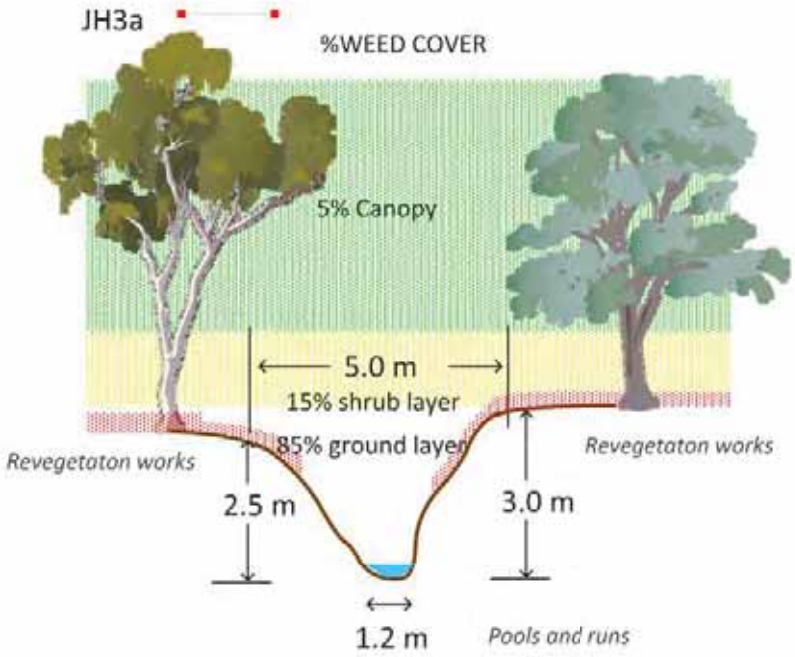


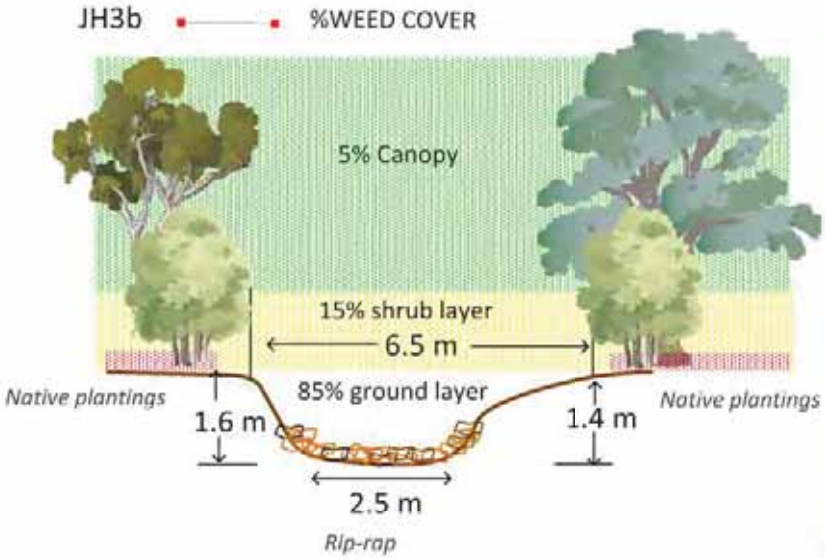


data collected 6-8/03/2013

JAMES HOSKIN RESERVE CROSS SECTIONS

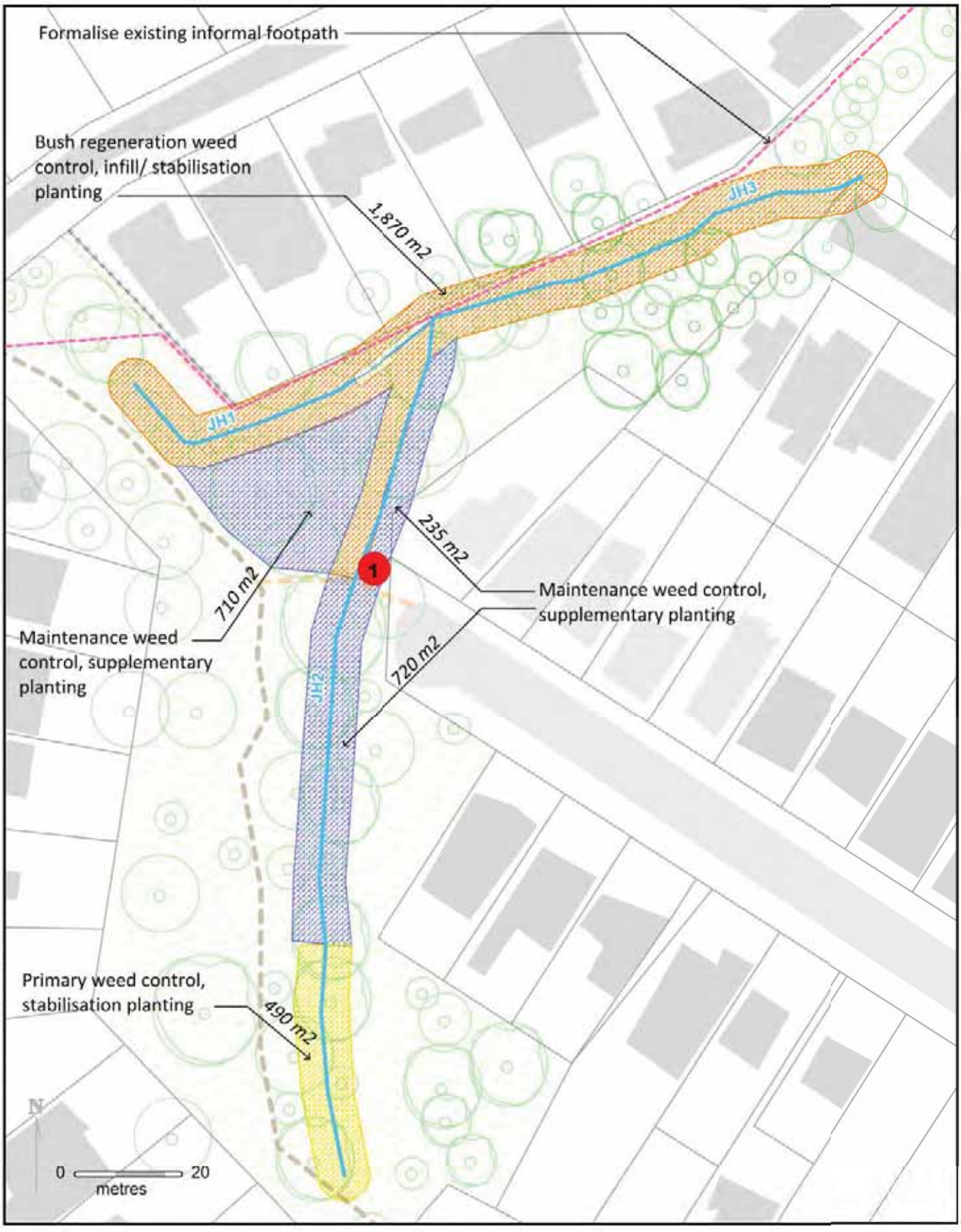






data collected 6-8/03/2013

JAMES HOSKIN RESERVE WORKS PLAN

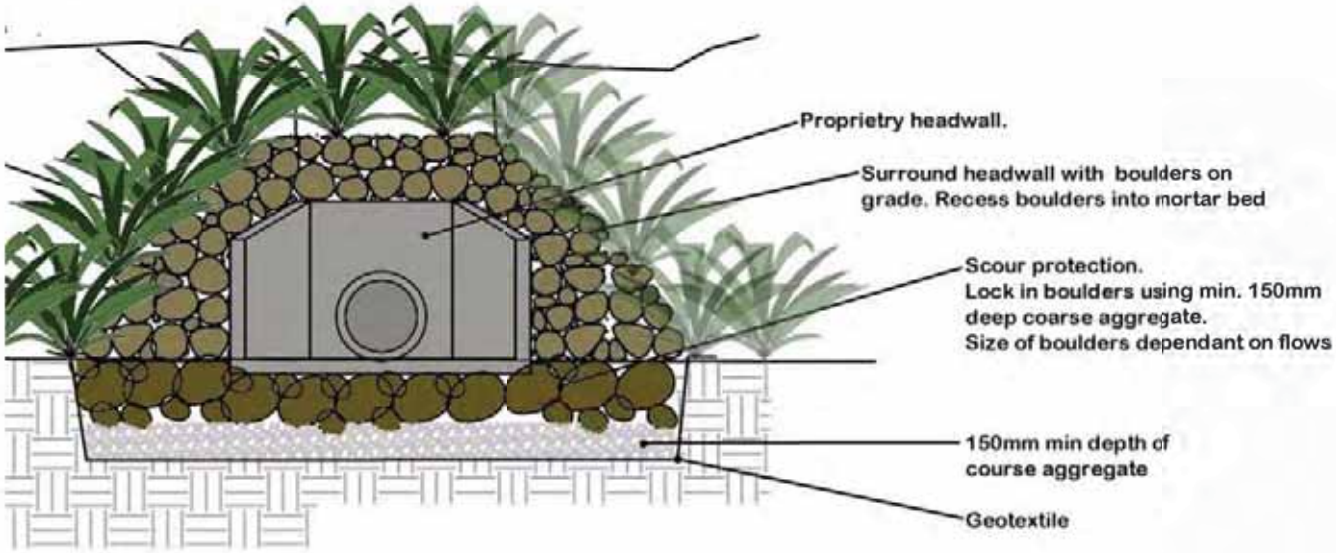


JAMES HOSKIN RESERVE WORKS PLAN

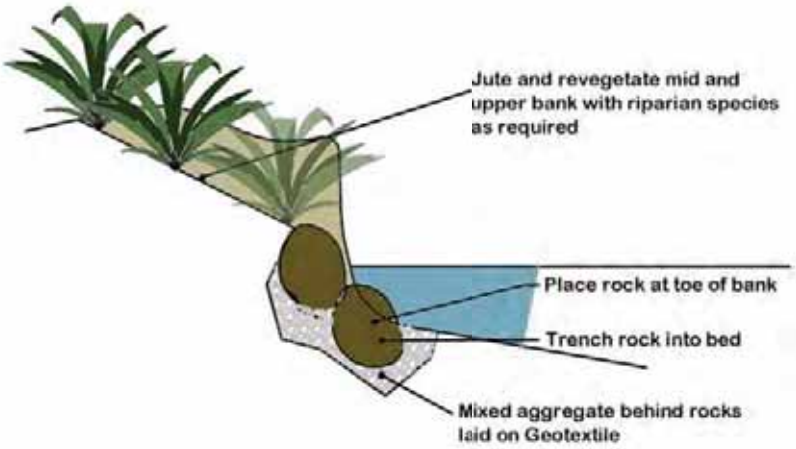
VEGETATION COMMUNITIES

Blue Gum High Forest (BGHF)

1 CULVERT PROTECTION (NTS)



1 TOE PROTECTION (NTS)



12.5 JAMES HOSKIN RESERVE WORKS PLANS & COSTINGS

12.5.1 JAMES HOSKIN 1

Table 25 Management actions and works required for reach JH1 in JAMES HOSKIN RESERVE

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
JH1	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	High	700m2	$2-3K	<$1K	OS&NR
JH1	Biodiversity enhancement: followup/maintenance weed control	Ongoing	710m2	$1-2K	<$1K	OS&NR
JH1	Community and recreation: formalise footpath with all-weather crushed granite/sandstone	Medium	220m	$5-10K	<$1K	OS&NR

12.5.2 JAMES HOSKIN 2

Table 26 Management actions and works required for reach JH2 in JAMES HOSKIN RESERVE

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
JH2	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	490m2	$2-5K	<$1K	OS&NR
JH2	Erosion control: rock armouring for culvert/headwall protection	Medium	unit	$5-10K	<$1K	OS&NR
JH2	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	Medium	170m2	$1-2K	<$1K	OS&NR
JH2	Biodiversity enhancement: followup/maintenance weed control	Ongoing	955m2	$1-3K	<$1K	OS&NR

12.5.3 JAMES HOSKIN 3

Table 27 Management actions and works required for reach JH3 in JAMES HOSKIN RESERVE

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA / LENGTH	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
1	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	High	1000m2	$5-8K	$1-2K	OS&NR
2	Biodiversity enhancement: followup/maintenance weed control	Ongoing	100m2	$1K	<$1K	OS&NR
3	Community and recreation: formalise footpath with all-weather crushed granite/sandstone	Medium	SEE JAMES HOSKIN 1			

FRED SPURWAY PARK
CONDITION & ASSET SCORING

REACH NAME	GEOMORPHOLOGY SCORE	RIPARIAN VEGETATION SCORE	INSTREAM HABITAT SCORE	SENSITIVITY SCORE	CONDITION SCORE
FRED SPURWAY 1	3.5	2	3.5	0	9
FRED SPURWAY 2	3.5	1.5	2.5	1	8.5
FRED SPURWAY 3	3.2	1	5	1	10.2
FRED SPURWAY 4	4	1.8	5.5	1	12.3
FRED SPURWAY 5	2.7	1.2	1	1	5.9

SCORE RANGE	STREAM CONDITION
18-22	EXCELLENT
14-17.9	GOOD
10-13.9	FAIR
5-9.9	POOR
0-4.9	HIGHLY DEGRADED

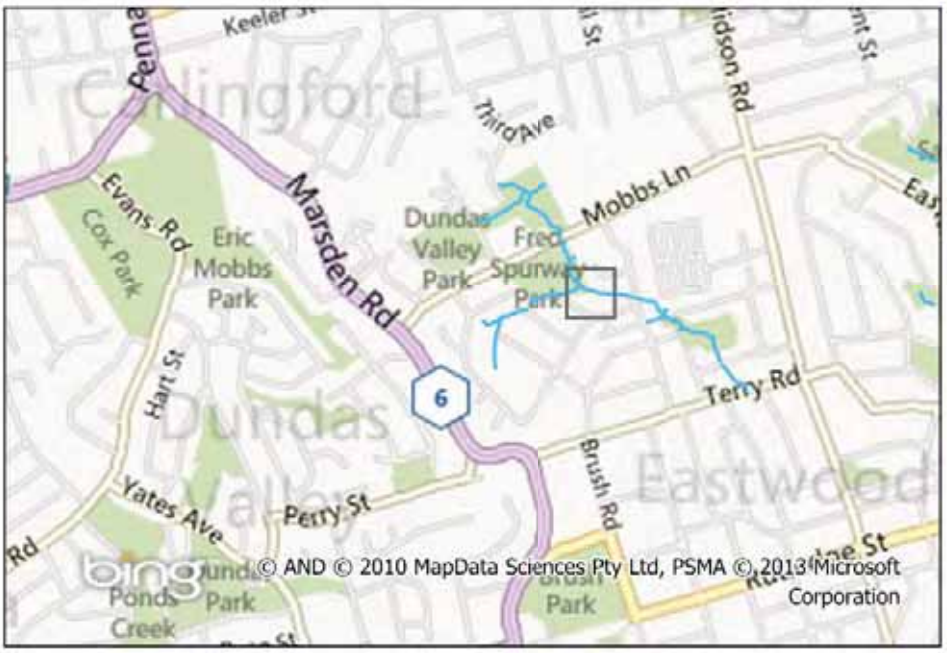
X.X Noteworthy score- see Section 9.1 for details

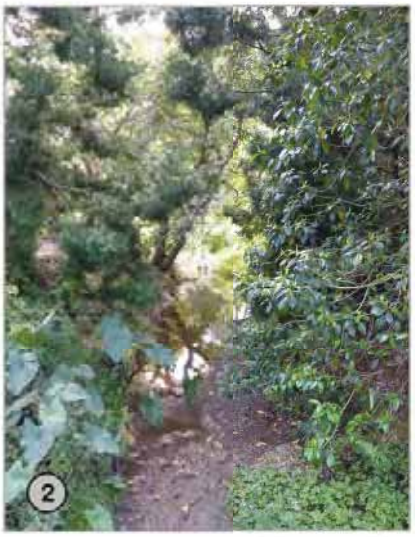
REACH NAME	PRIMARY MANAGEMENT OBJECTIVE	TRAJECTORY SCORE	REACH TRAJECTORY
FRED SPURWAY 1	EXISTING RIPARIAN RESTORATION	3	degrading
FRED SPURWAY 2	EXISTING RIPARIAN RESTORATION	2	stable
FRED SPURWAY 3	REDUCE DOWNSTREAM IMPACTS	2	stable
FRED SPURWAY 4	GOOD INSTREAM HABITAT, EXISTING RIPARIAN RESTORATION	3	degrading
FRED SPURWAY 5	REDUCE DOWNSTREAM IMPACTS	1	stable

data collected 6-8/03/2013

FRED SPURWAY PARK

SITE CONTEXT: REACH 1 (FS1)

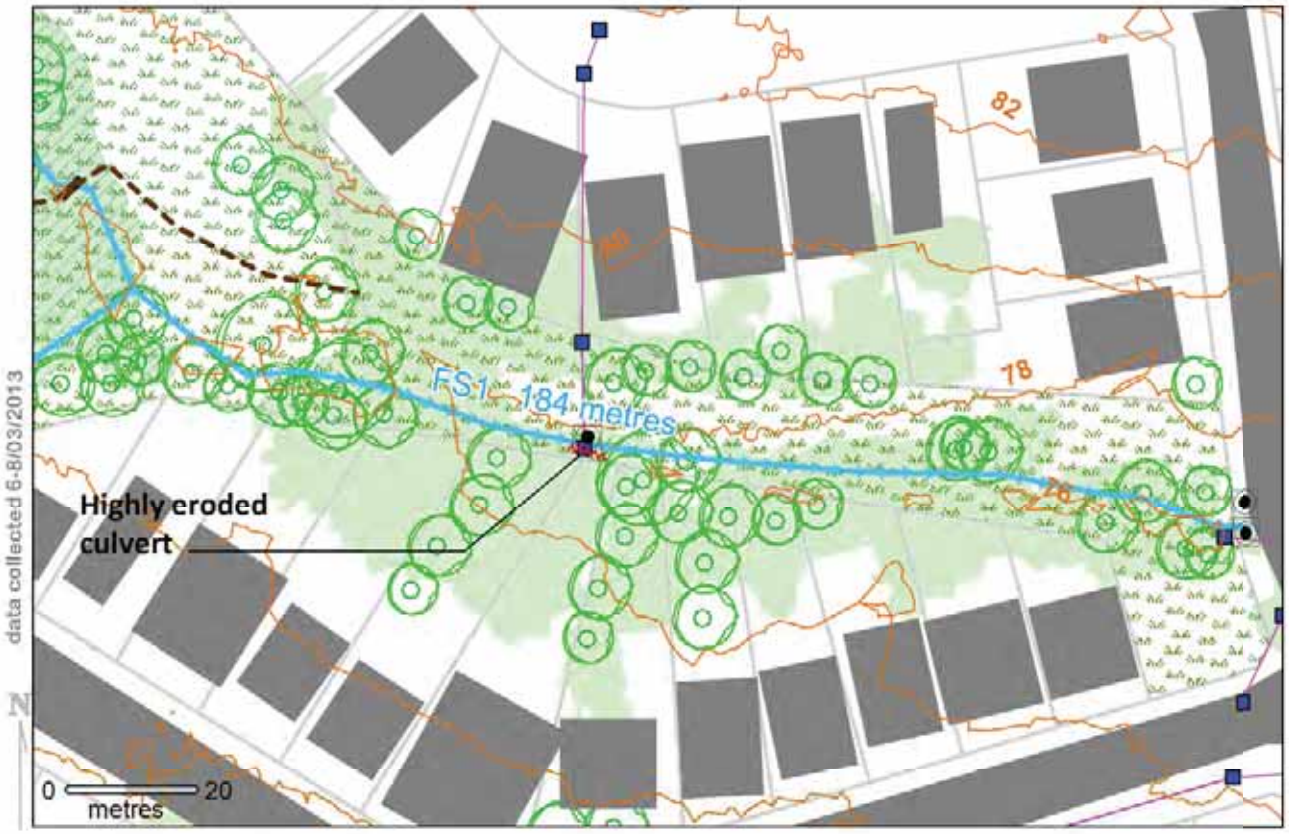




data collected 6-8/03/2013

FRED SPURWAY PARK

EXISTING SITUATION: REACH 1 (FS1)



Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

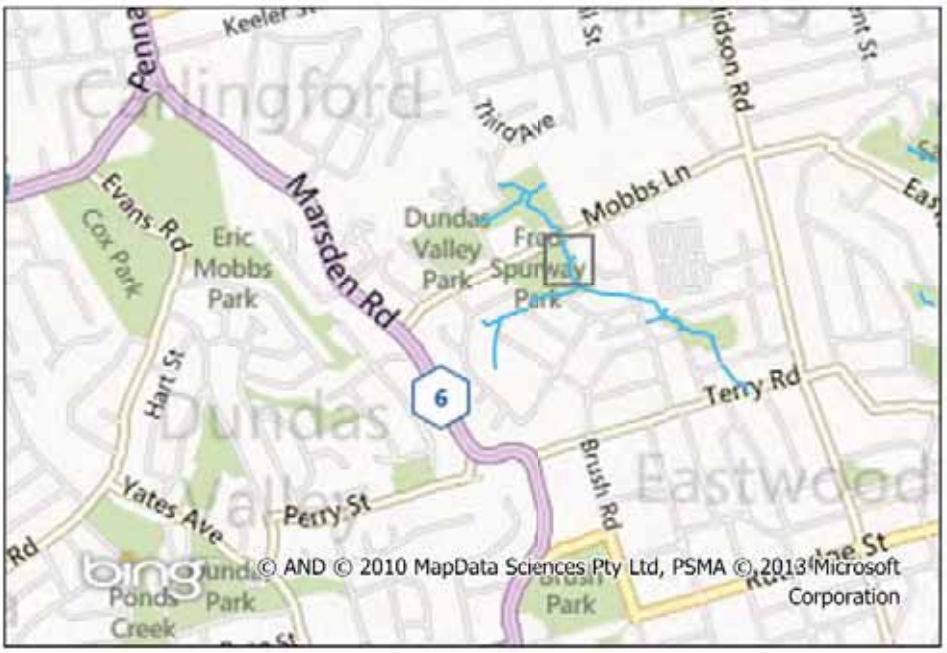
Cadastre Lot Boundary

Stormwater Pit

EEC Blue Gum High Forest

FRED SPURWAY PARK

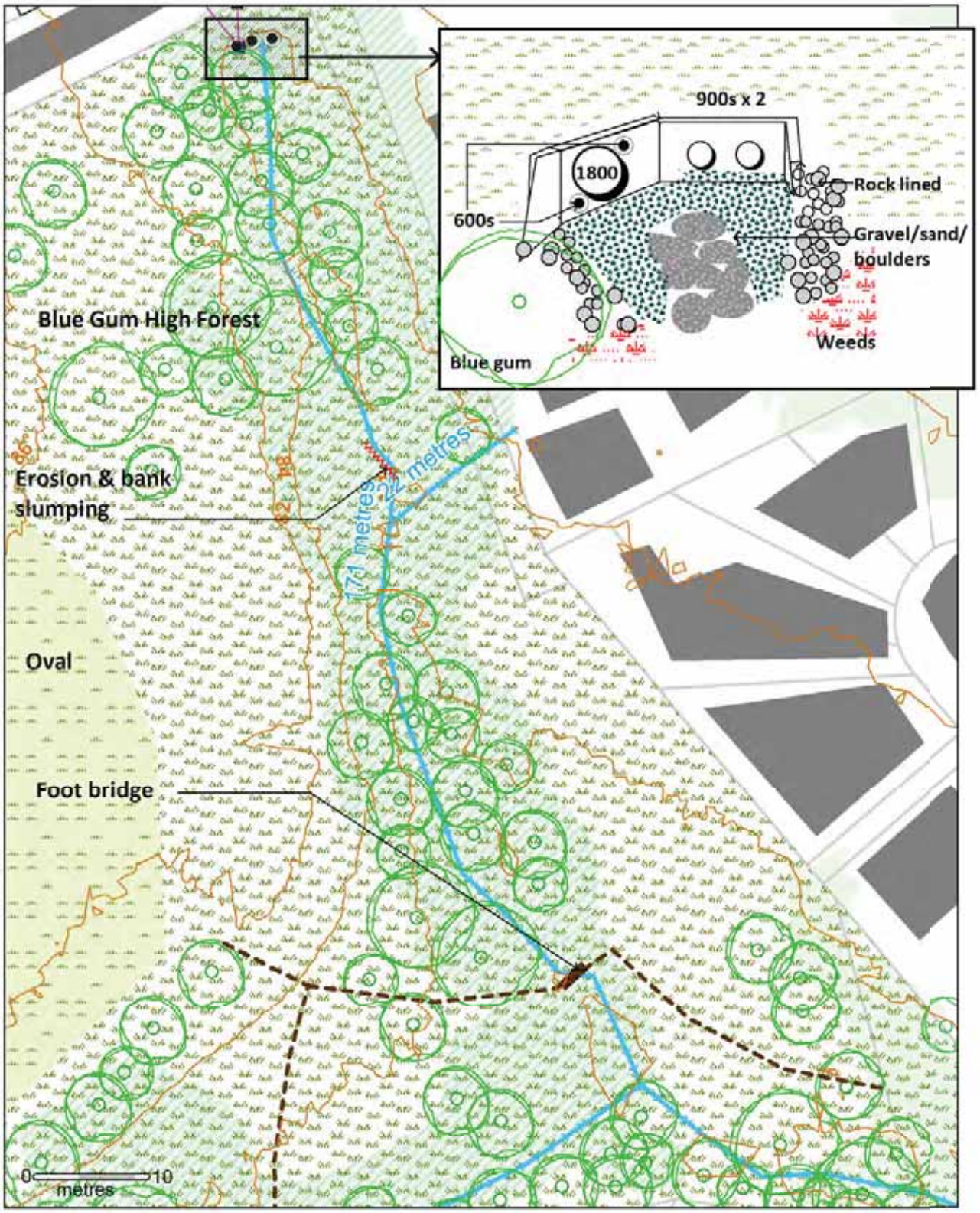
SITE CONTEXT: REACH 2 (FS2)



data collected 6-8/03/2013

FRED SPURWAY PARK

EXISTING SITUATION: REACH 2 (FS2)



Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

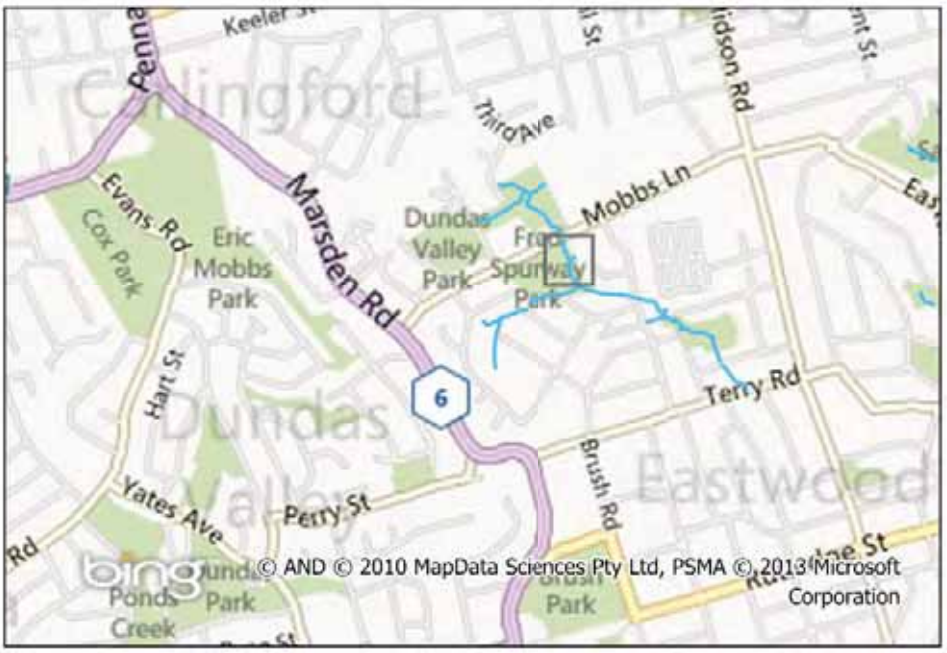
Cadastre Lot Boundary

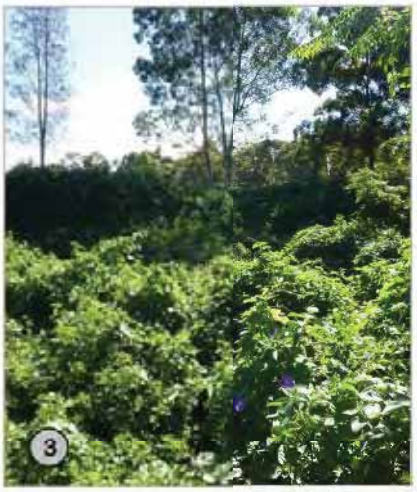
Stormwater Pit

EEC Blue Gum High Forest

FRED SPURWAY PARK

SITE CONTEXT: REACH 3 (FS3)

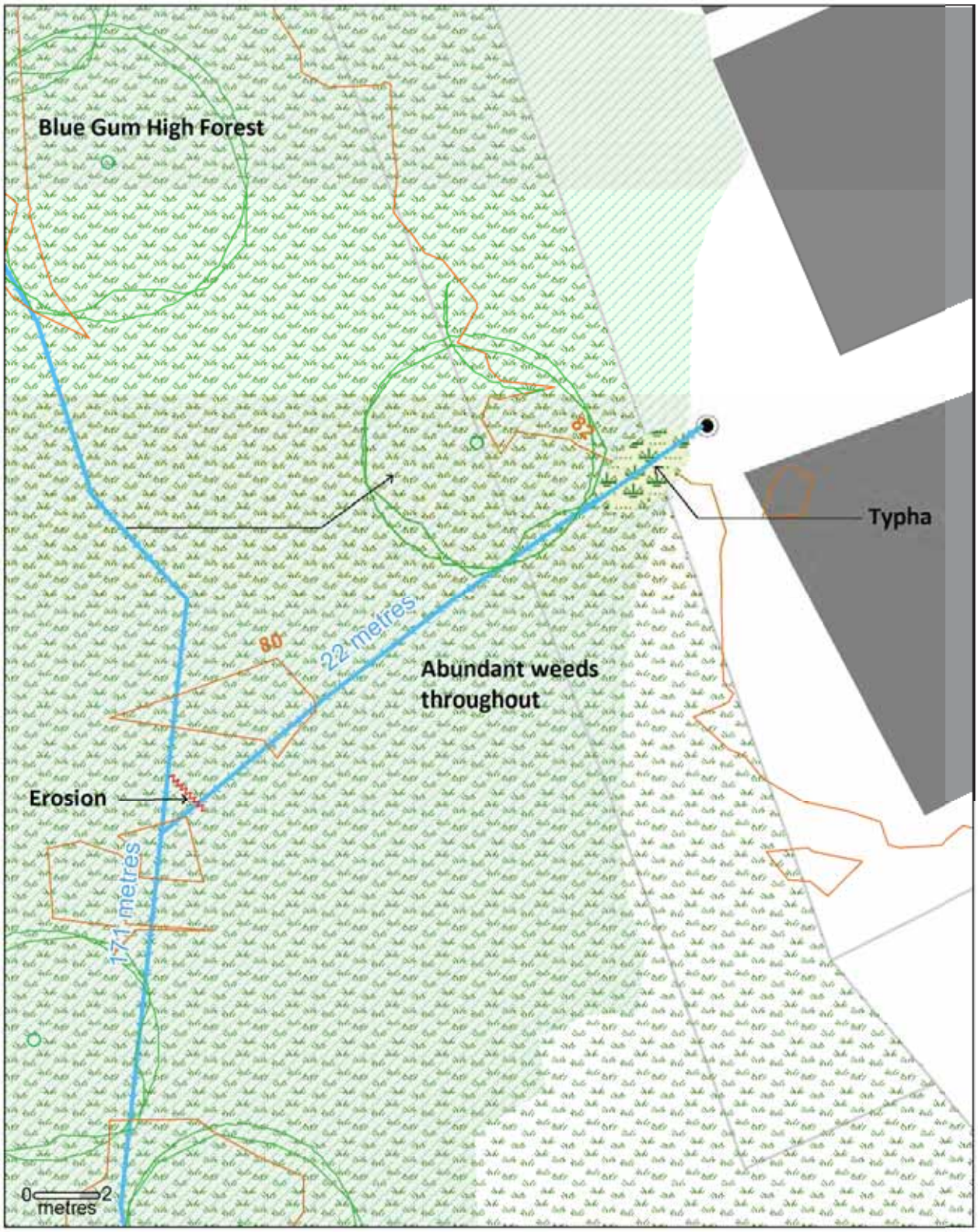




data collected 6-8/03/2013

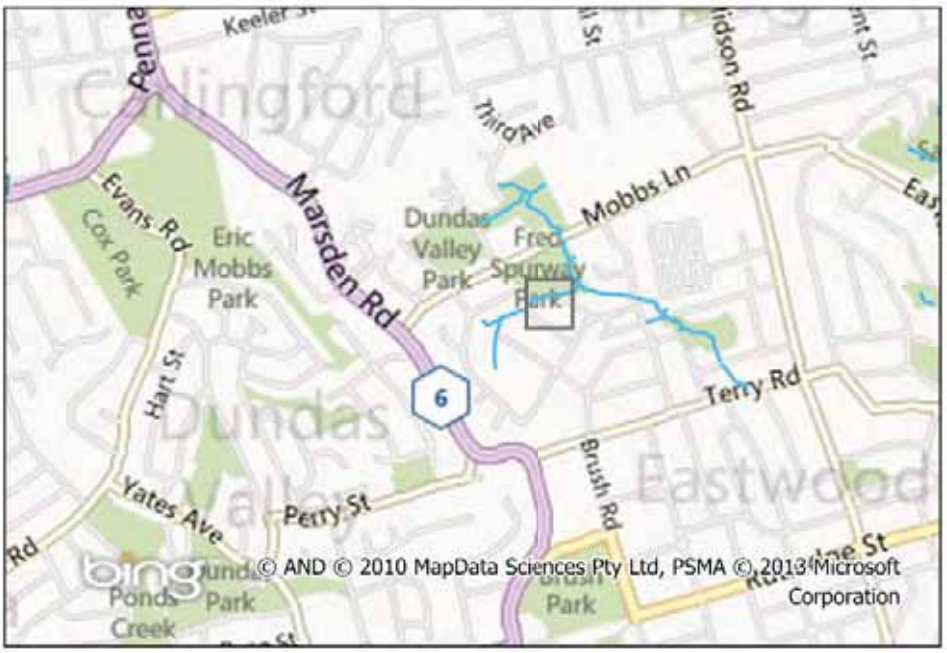
FRED SPURWAY PARK

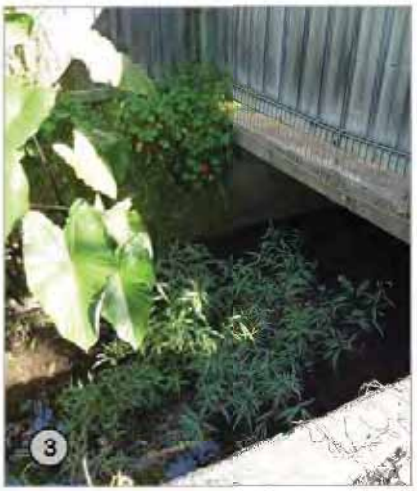
EXISTING SITUATION: REACH 3 (FS3)



FRED SPURWAY PARK

SITE CONTEXT: REACH 4 (FS4)

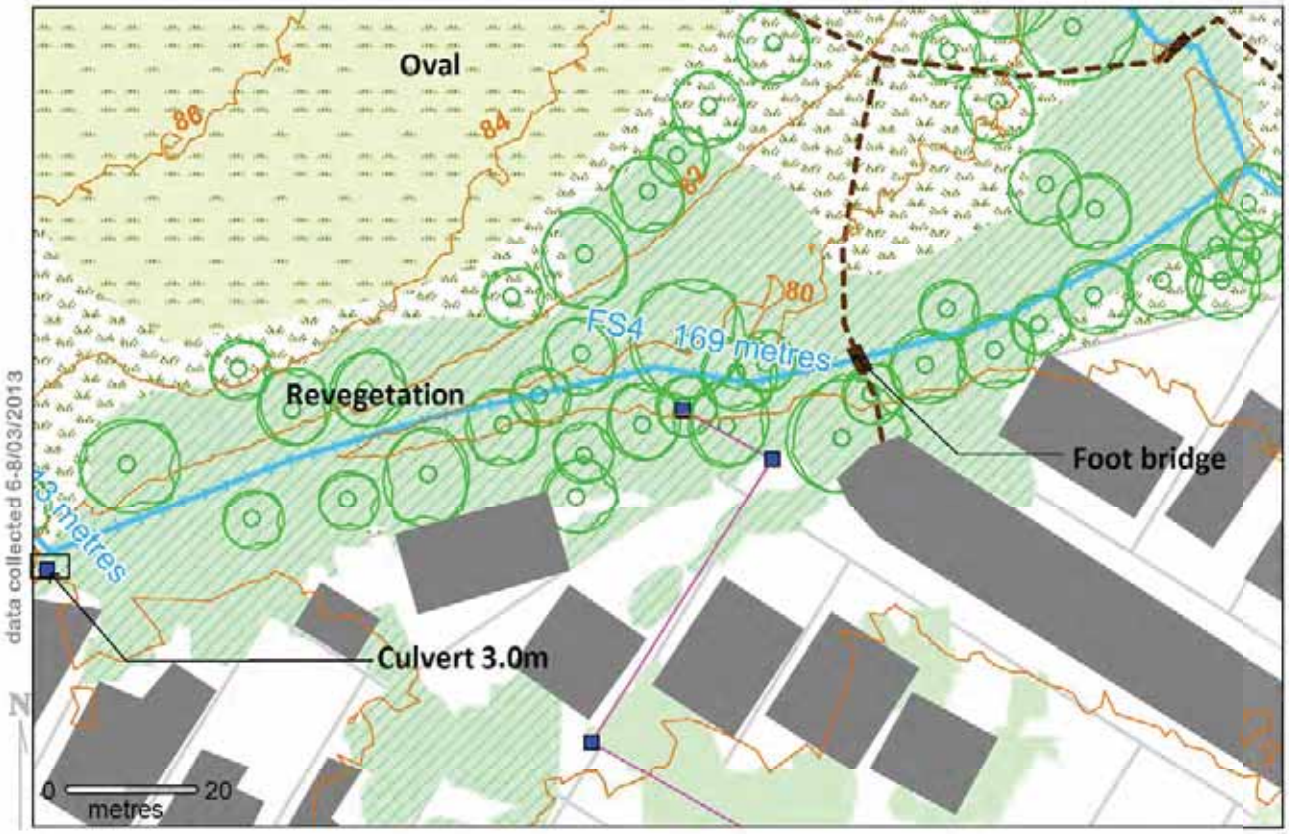




data collected 6-8/03/2013

FRED SPURWAY PARK

EXISTING SITUATION: REACH 4 (FS4)



Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

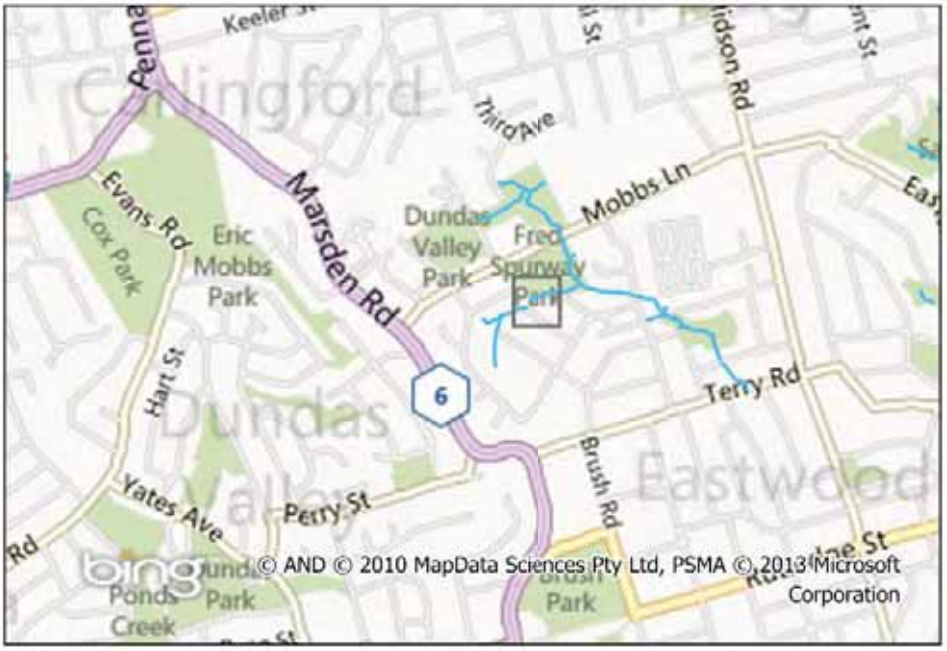
Cadastre Lot Boundary

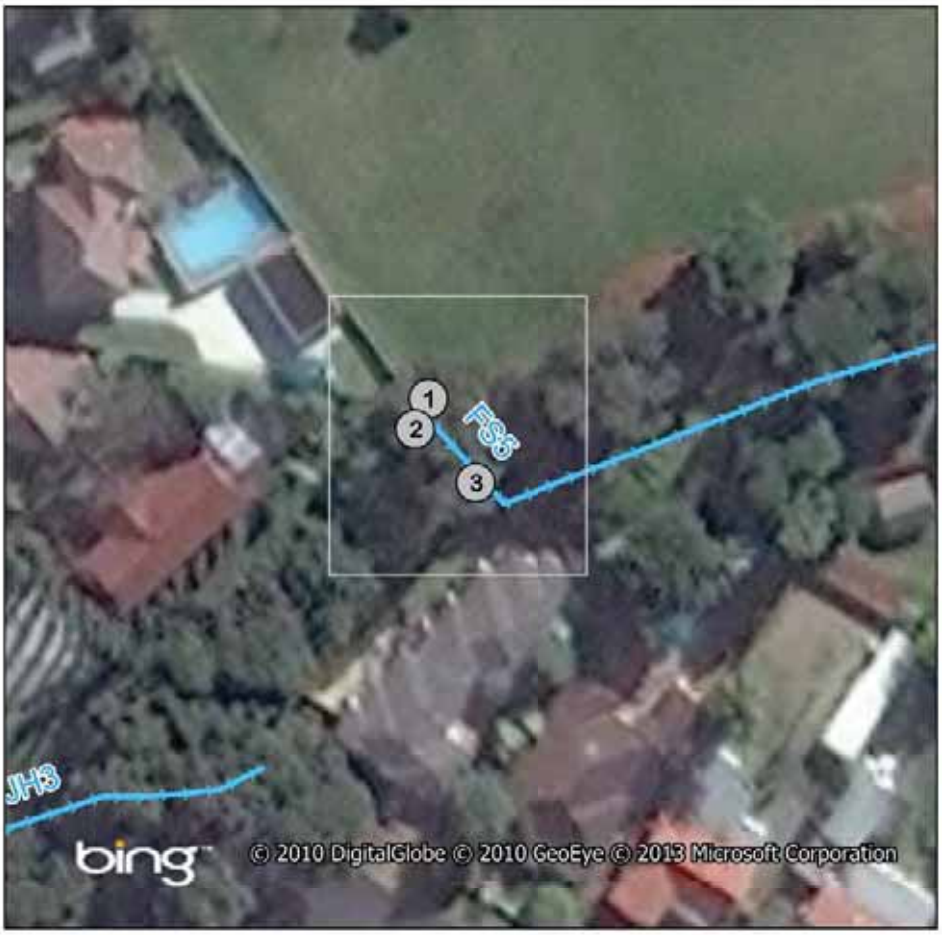
Stormwater Pit

EEC Blue Gum High Forest

FRED SPURWAY PARK

SITE CONTEXT: REACH 5 (FS5)

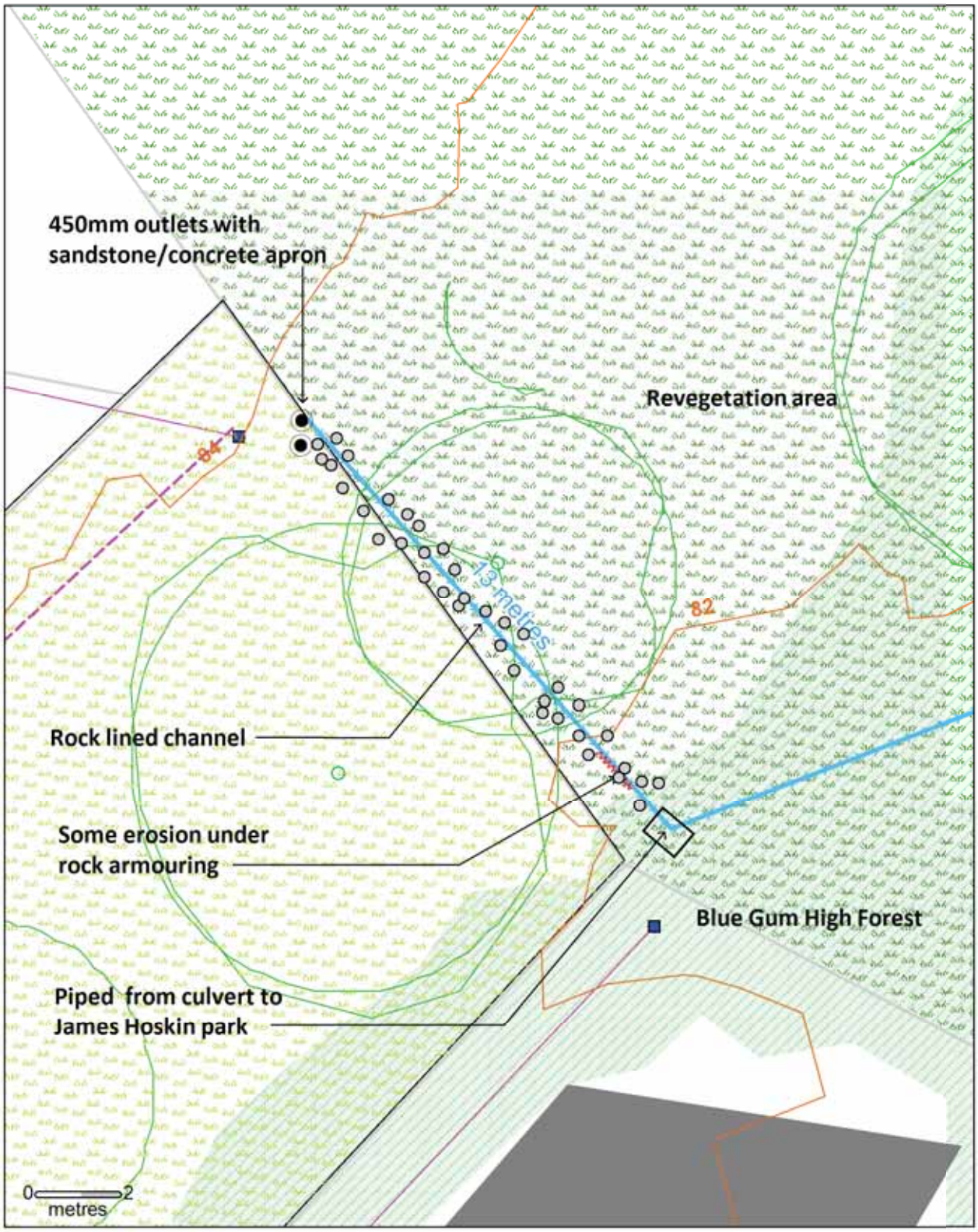




data collected 6-8/03/2013

FRED SPURWAY PARK

EXISTING SITUATION: REACH 5 (FS5)



Stormwater Pipe

Open Watercourse

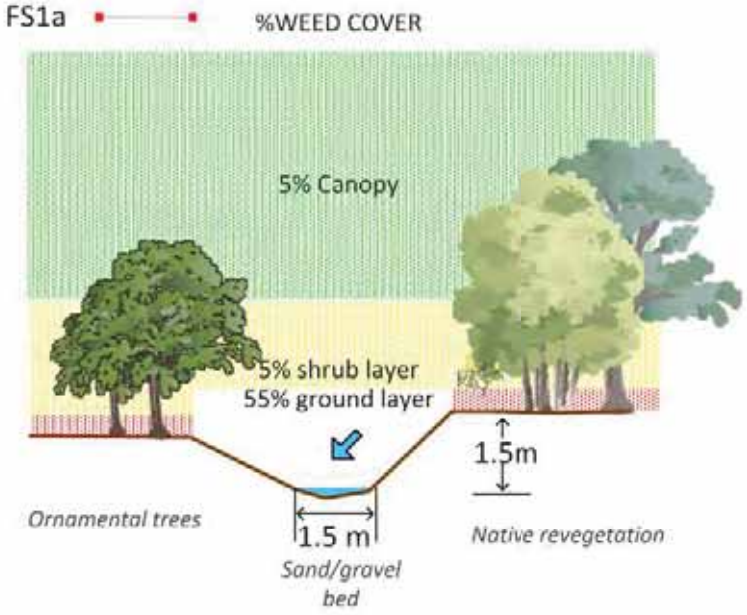
Sub-catchment Boundary

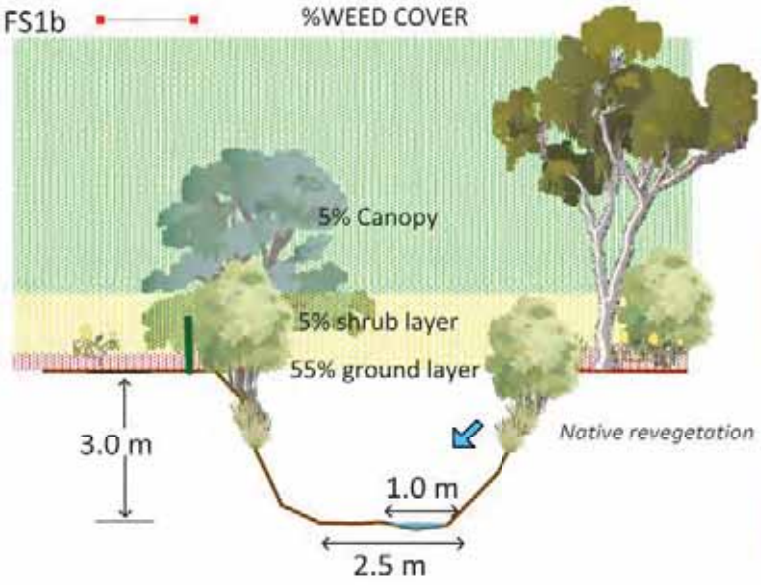
Cadastre Lot Boundary

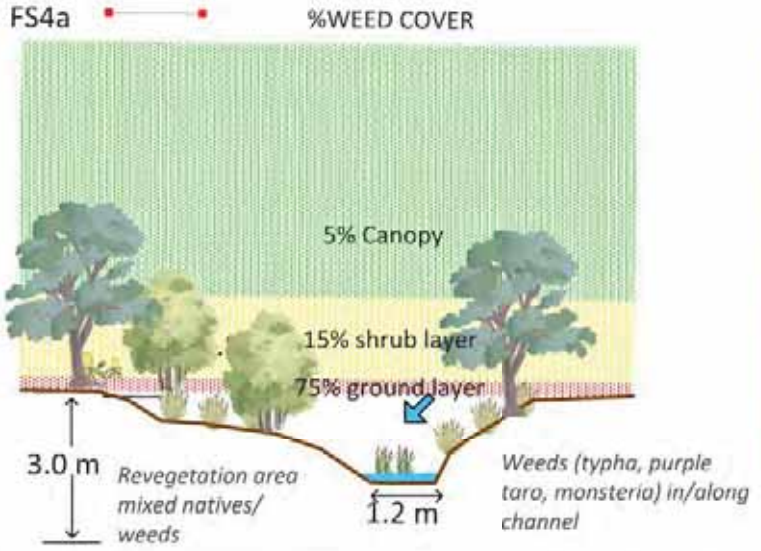
Stormwater Pit

EEC Blue Gum High Forest

FRED SPURWAY PARK CROSS SECTIONS

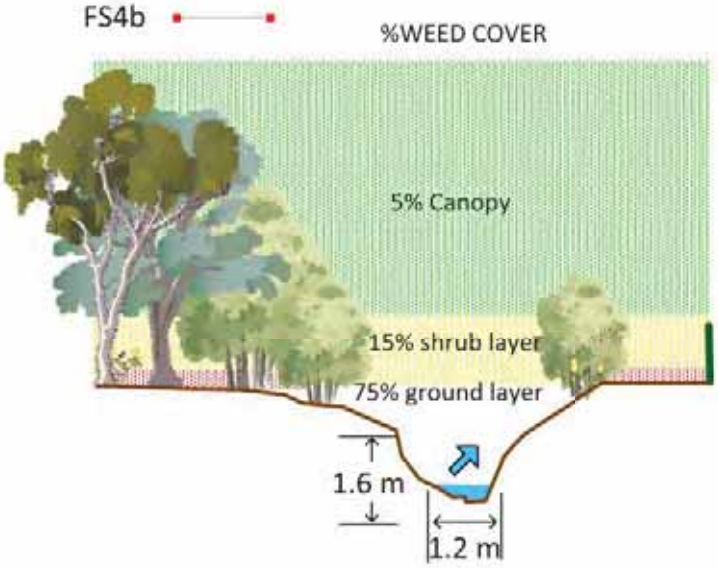


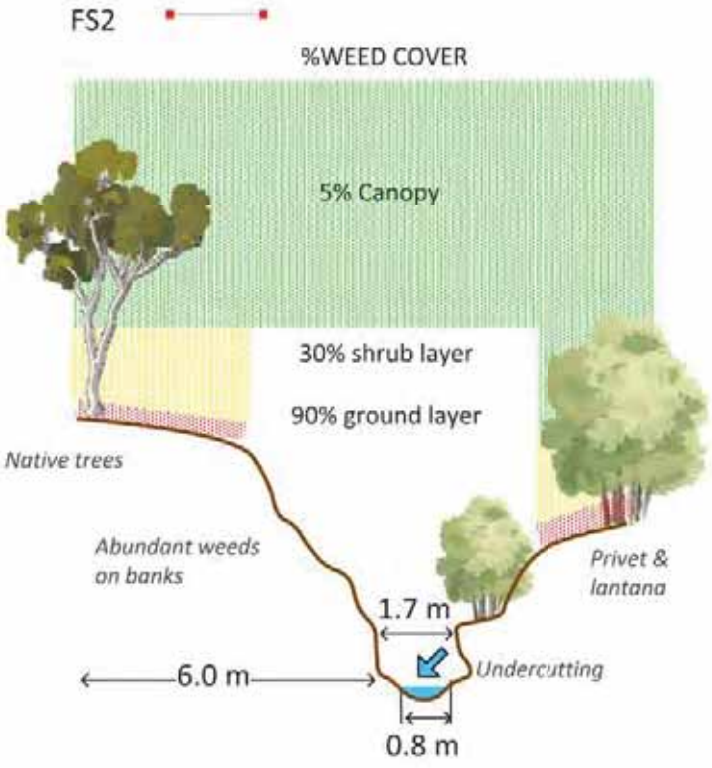




data collected 6-8/03/2013

FRED SPURWAY PARK CROSS SECTIONS





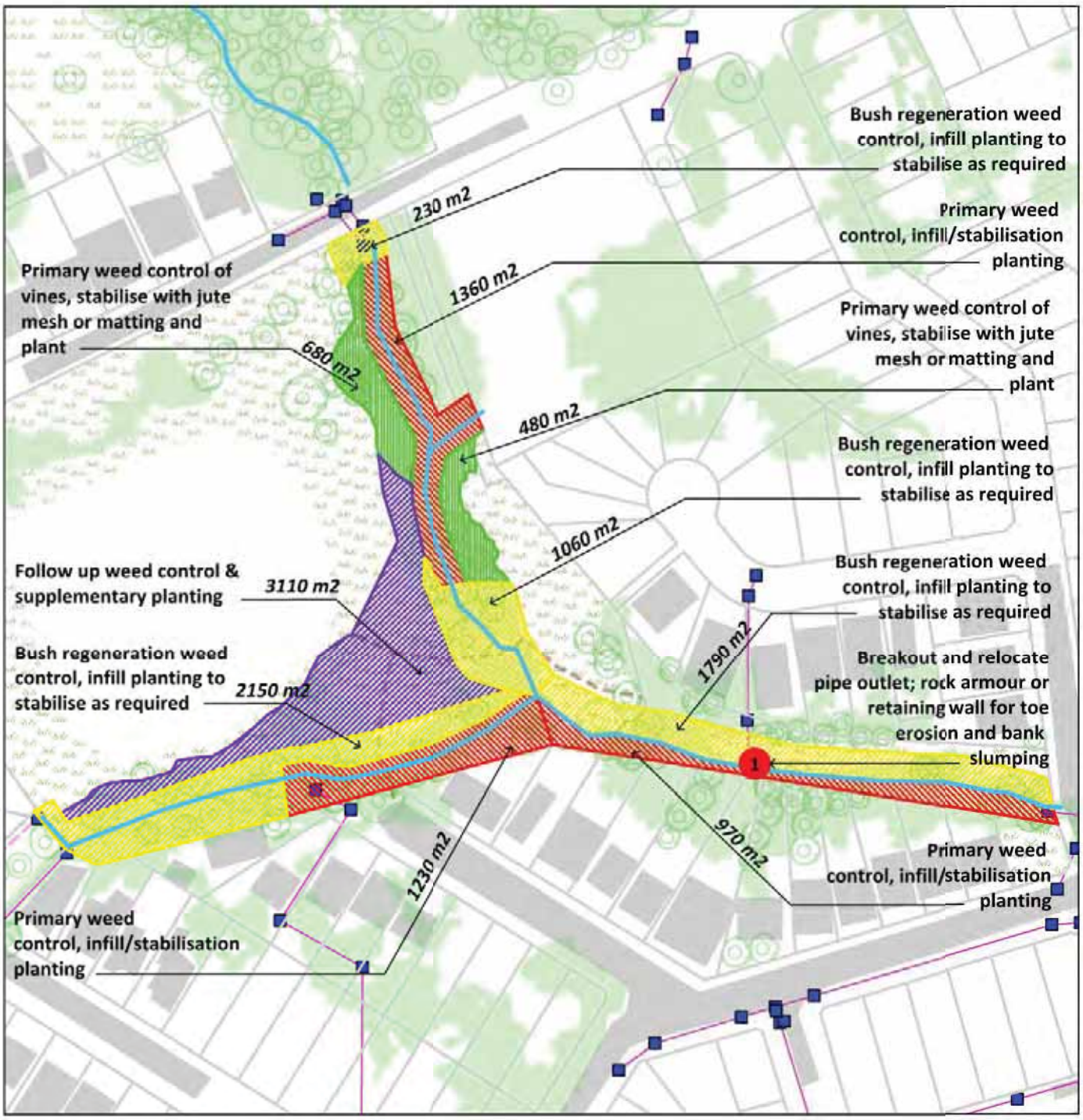
data collected 6-8/03/2013

FRED SPURWAY PARK

WORKS PLAN

VEGETATION COMMUNITIES

Blue Gum High Forest (BGHF)

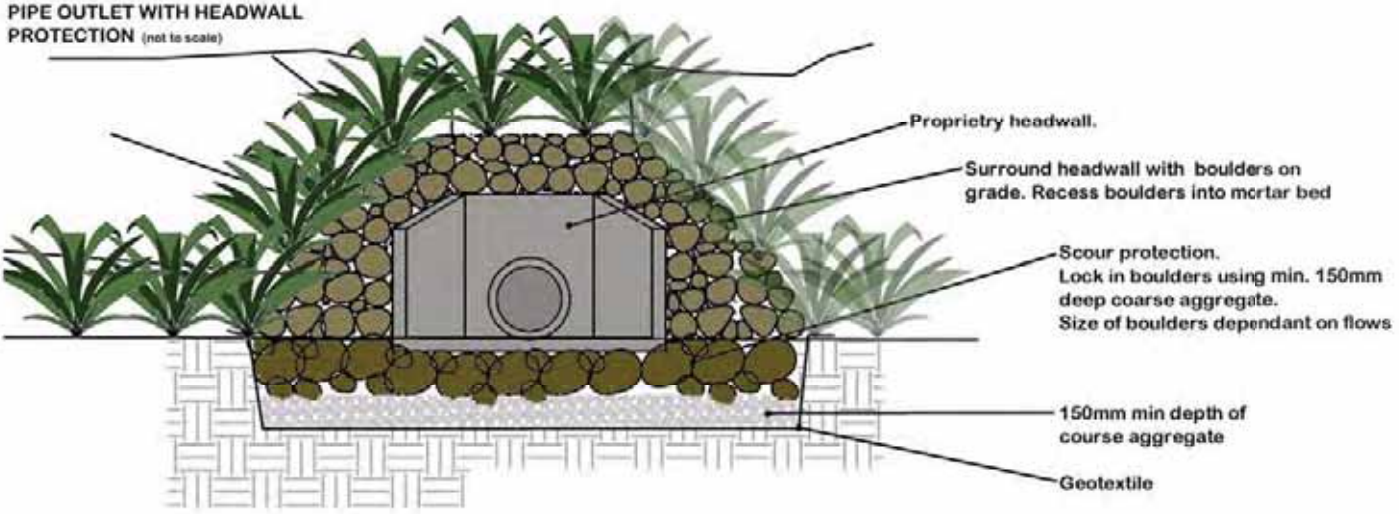


FRED SPURWAY PARK

WORKS PLAN

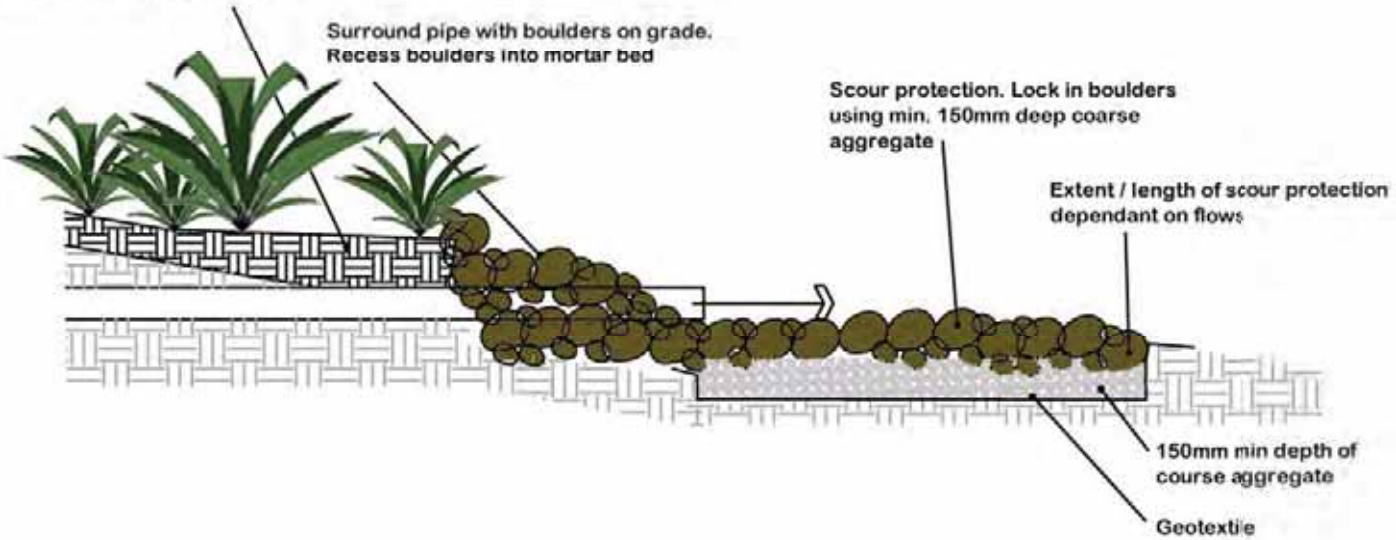
1

PIPE OUTLET WITH HEADWALL PROTECTION (not to scale)



PIPE OUTLET PROTECTION (not to scale)

Mound top soil locally over pipe.



12.7 FRED SPURWAY PARK WORKS & COSTINGS

12.7.1 FRED SPURWAY 1

Table 28 Management actions and works required for reach FS1 in FRED SPURWAY PARK

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
FS1	Erosion control: rock armouring for toe erosion/bank slumping **OR**	Very high	5-8m	$10-15K	$2-5K	OS&NR
FS1	Erosion control: construct retaining wall to control bank erosion	High	5-8m	$10-20K	$1-2K	OS&NR
FS1	Erosion control: breakout and relocate pipe outlet/headwall	High	Unit	$25-40K	N/A	C&I
FS1	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	970m2	$3-5K	$1-2K	OS&NR
FS1	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	Medium	1790m2	$3-5K	$1-2K	OS&NR

12.7.2 FRED SPURWAY 2 AND 3

Table 29 Management actions and works required for reaches FS2 and FS3 in FRED SPURWAY PARK

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
FS2 &3	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	1360m2	$5-8K	$2-3K	OS&NR
FS2 &3	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	High	1290m2	$5-8K	$1-2K	OS&NR
FS2 &3	Biodiversity enhancement: primary weed control of vines,	High	1160m2	$5-8K	$2-3K	OS&NR

	infill/stabilisation planting using Blue Gum High Forest species					
FS2	Biodiversity enhancement: supplementary planting using Blue Gum High Forest species	High	As req'd	As req'd	N/A	OS&NR
FS2	Biodiversity enhancement: jute matting with stabilisation planting using Blue Gum High Forest species	Medium	As req'd	As req'd	N/A	OS&NR
FS2	Biodiversity enhancement: followup/maintenance weed control	Medium	1500m2	$2-5K	<$1K	OS&NR

12.7.3 FRED SPURWAY 4 AND 5

Table 30 Management actions and works required for reaches FS4 and FS5 in FRED SPURWAY PARK

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
FS4 &5	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	1230m2	$5-8K	$2-3K	OS&NR
FS4 &5	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	High	2150m2	$5-8K	$1-2K	OS&NR
FS4	Biodiversity enhancement: supplementary planting using Blue Gum High Forest species	Medium	1610m2, as req'd	As req'd	N/A	OS&NR
FS4	Biodiversity enhancement: followup/maintenance weed control	Ongoing	1610m2	$2-5K	<$1K	OS&NR

UNNAMED RESERVE VALLEY ROAD

CONDITION & ASSET SCORING

REACH NAME	GEOMORPHOLOGY SCORE	RIPARIAN VEGETATION SCORE	INSTREAM HABITAT SCORE	SENSITIVITY SCORE	CONDITION SCORE
UNNAMED RESERVE 1	3.7	2.4	4.5	1	11.6
UNNAMED RESERVE 1A	3	4	0.5	1	8.5
UNNAMED RESERVE 2	2.5	1.6	2.5	0	6.6
UNNAMED RESERVE 3	3.5	4	2.5	1	11

SCORE RANGE	STREAM CONDITION
18-22	EXCELLENT
14-17.9	GOOD
10-13.9	FAIR
5-9.9	POOR
0-4.9	HIGHLY DEGRADED

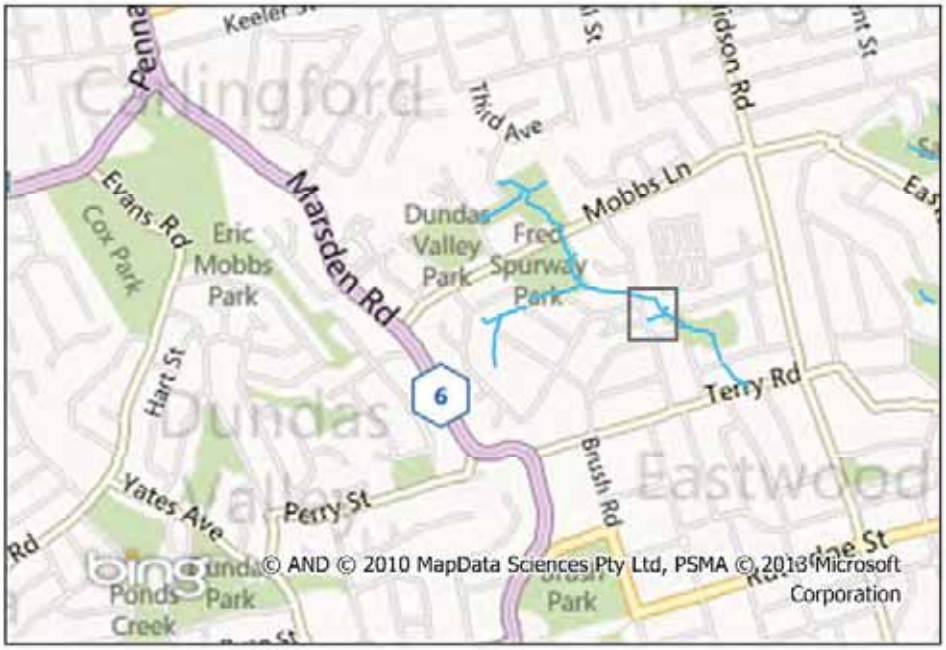
X.X Noteworthy score- see Section 9.1 for details

REACH NAME	PRIMARY MANAGEMENT OBJECTIVE	TRAJECTORY SCORE	REACH TRAJECTORY
UNNAMED RESERVE 1	GOOD INSTREAM HABITAT	3	degrading
UNNAMED RESERVE 1A	EXISTING RIPARIAN RESTORATION	1	stable
UNNAMED RESERVE 2	REDUCE DOWNSTREAM IMPACTS	4	degrading
UNNAMED RESERVE 3	EXISTING RIPARIAN RESTORATION	2	stable

data collected 6-8/03/2013

UNNAMED RESERVE VALLEY ROAD

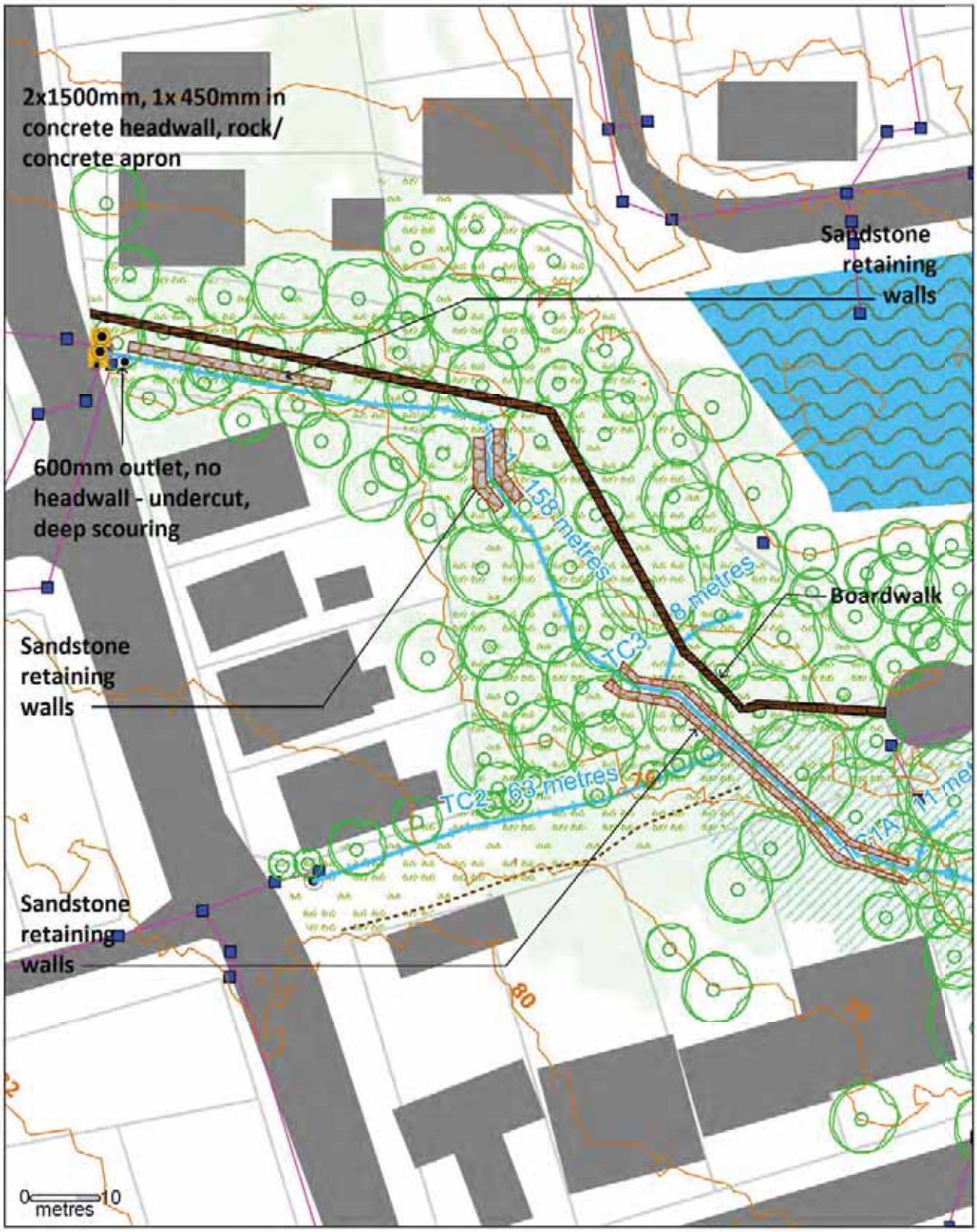
SITE CONTEXT: REACH 1 (TC1)



data collected 6-8/03/2013

UNNAMED RESERVE VALLEY ROAD

EXISTING SITUATION: REACH 1 (TC1)



Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

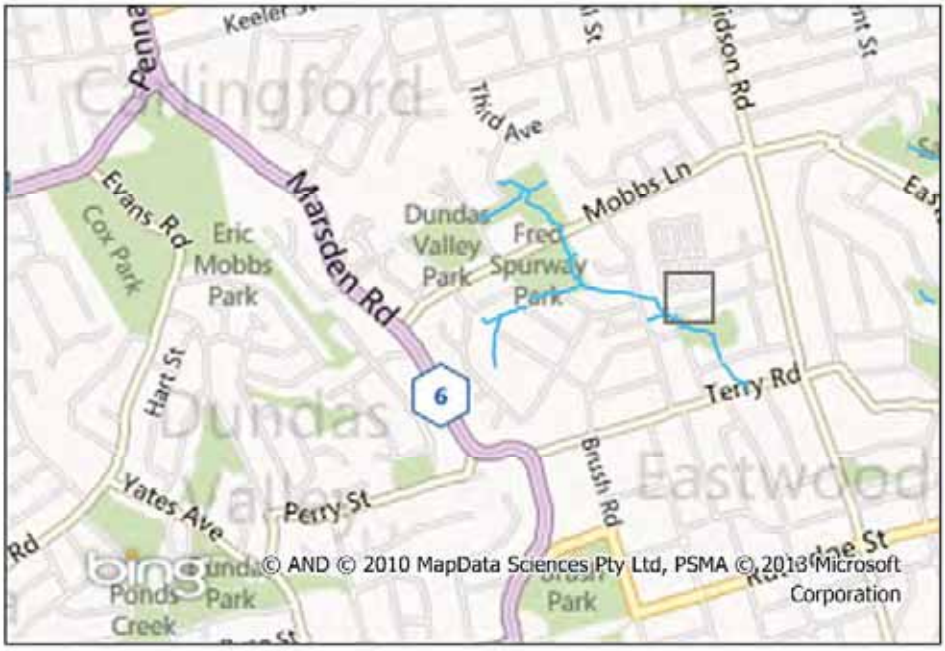
Cadastre Lot Boundary

Stormwater Pit

EEC Blue Gum High Forest

UNNAMED RESERVE VALLEY ROAD

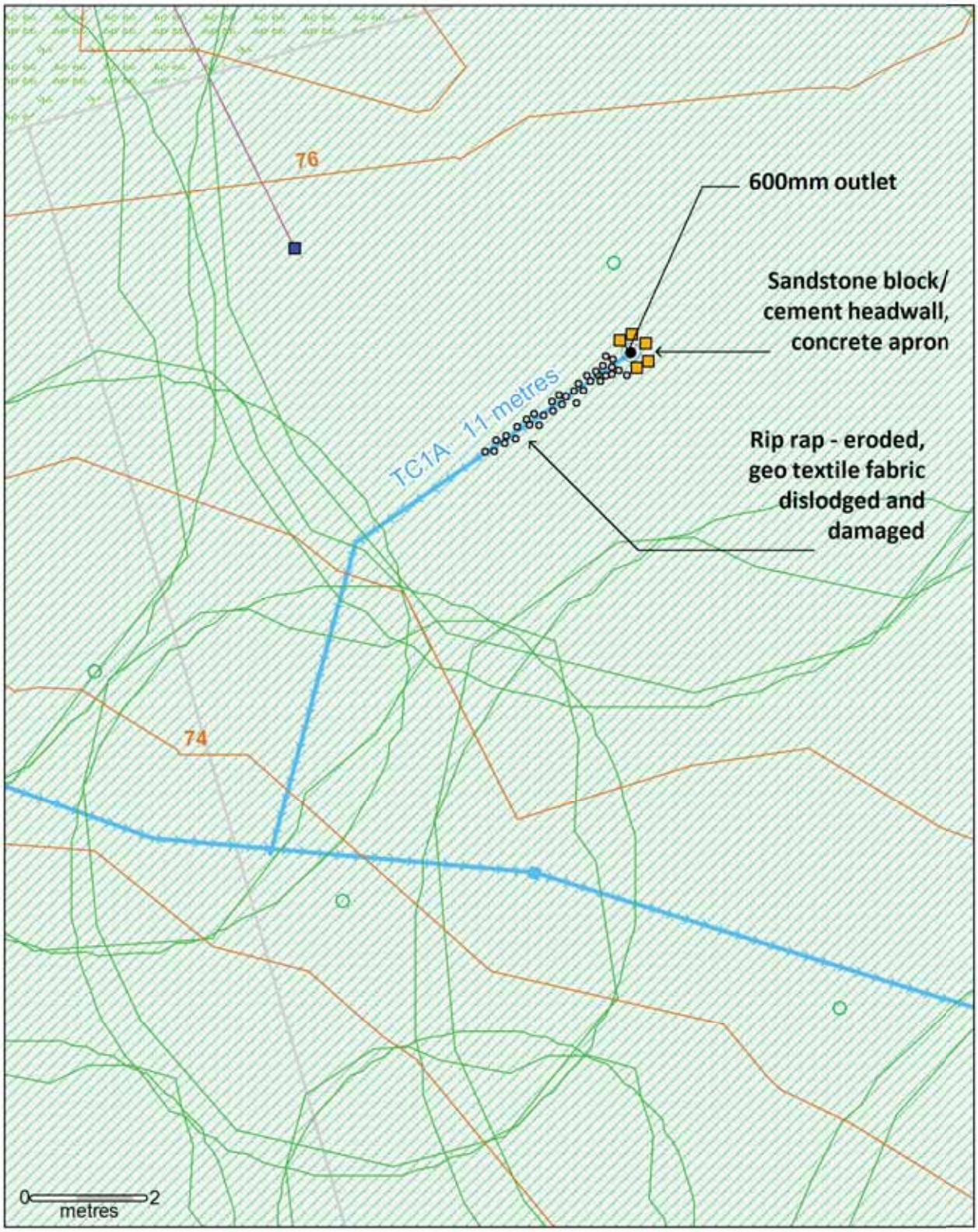
SITE CONTEXT: REACH 1A (TC1A)



data collected 6-8/03/2013

UNNAMED RESERVE VALLEY ROAD

EXISTING SITUATION: REACH 1A (TC1A)



Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

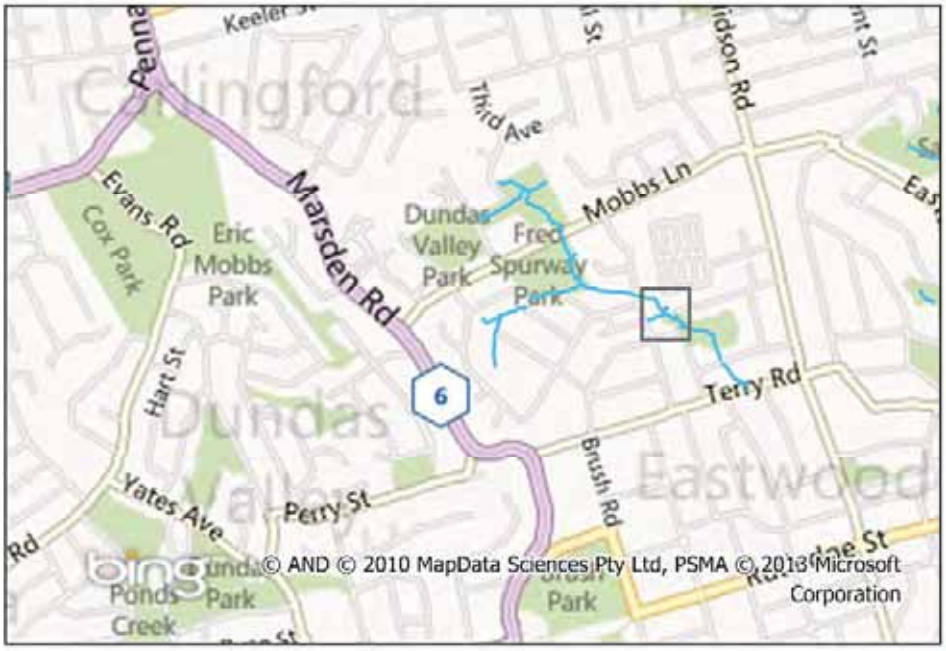
Cadastre Lot Boundary

Stormwater Pit

EEC Blue Gum High Forest

UNNAMED RESERVE VALLEY ROAD

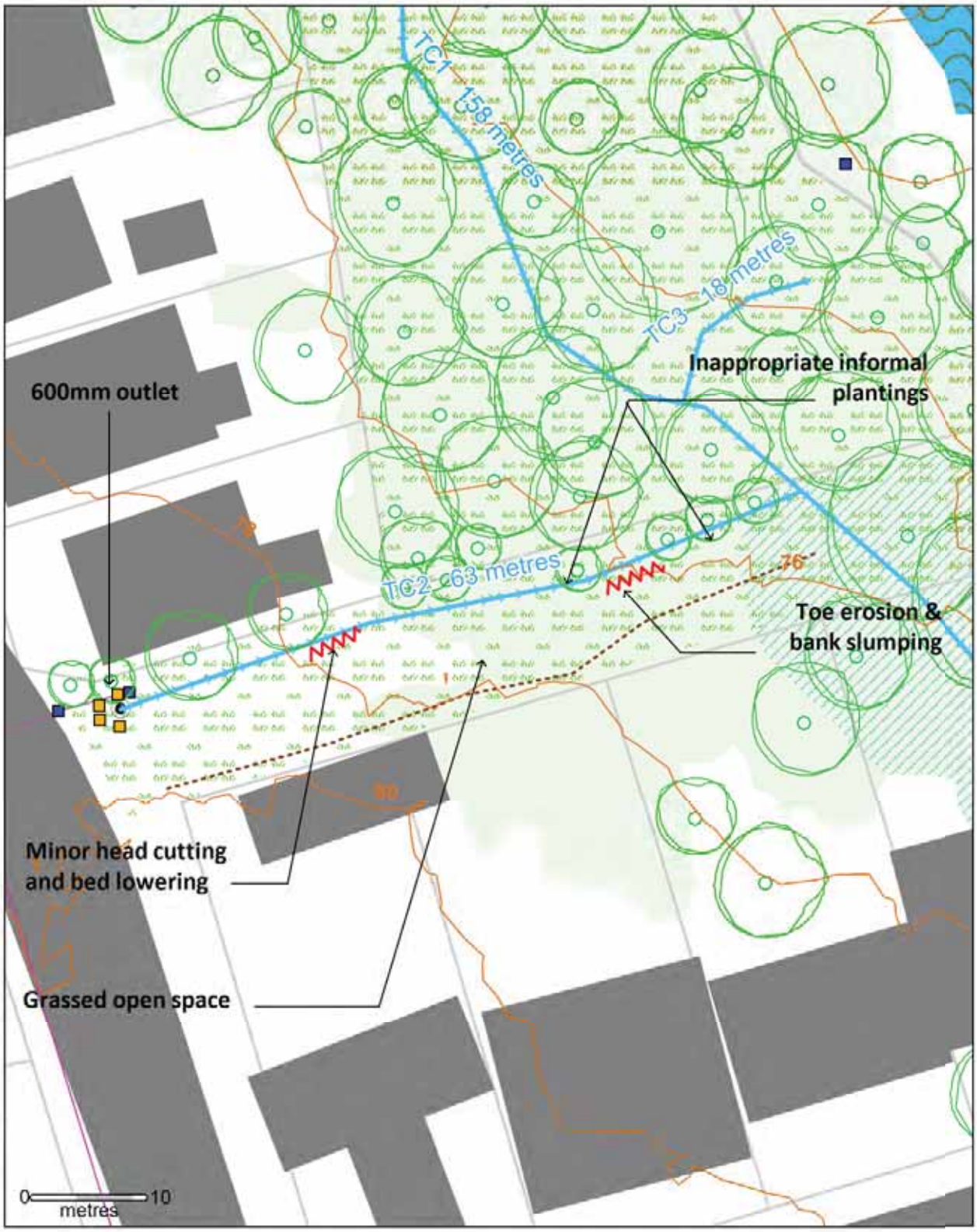
SITE CONTEXT: REACH 2 (TC2)



data collected 6-8/03/2013

UNNAMED RESERVE VALLEY ROAD

EXISTING SITUATION: REACH 2 (TC2)



data collected 6-8/03/2013

N

Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

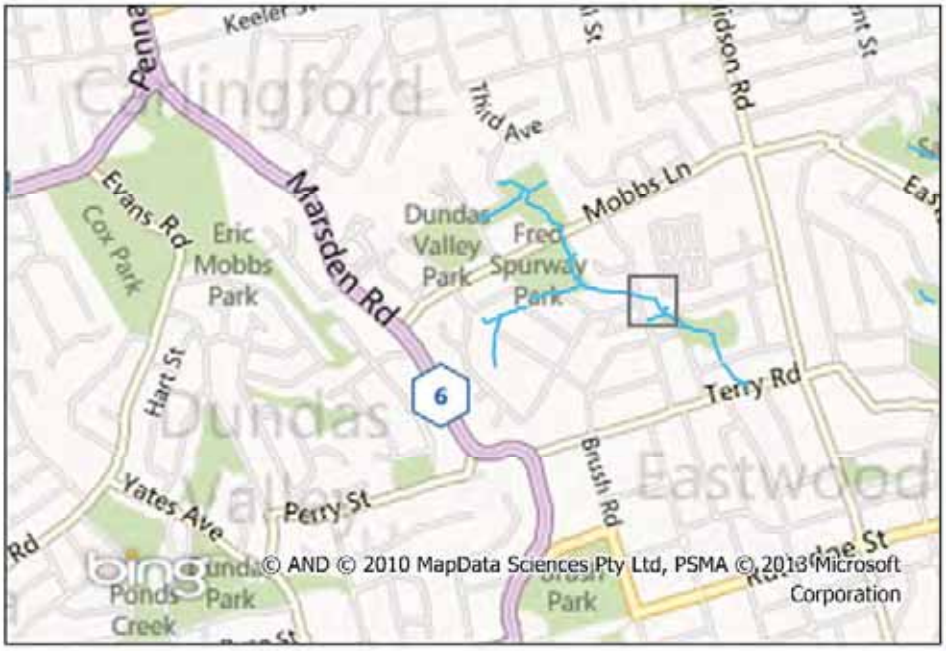
Cadastre Lot Boundary

Stormwater Pit

EEC Blue Gum High Forest

UNNAMED RESERVE VALLEY ROAD

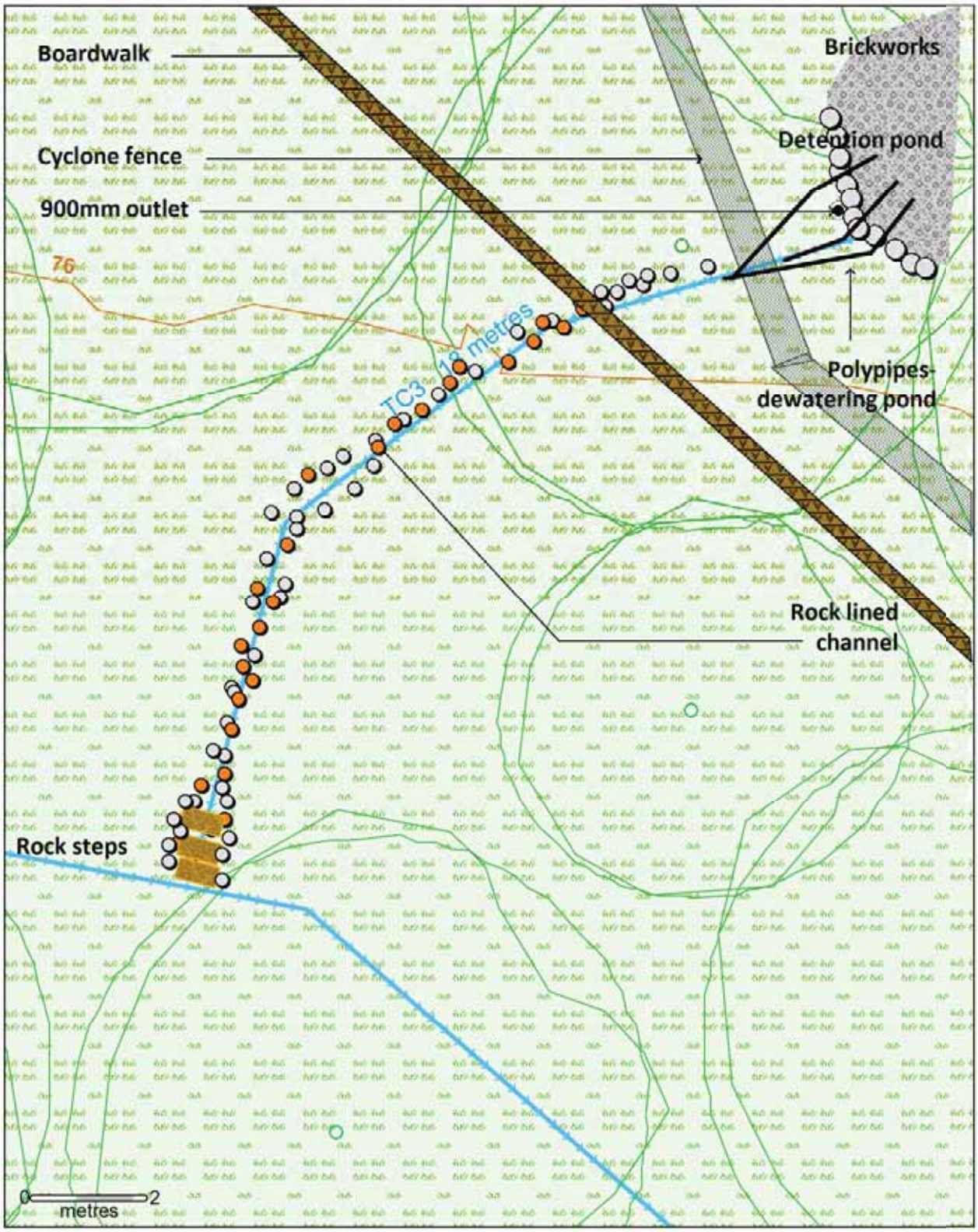
SITE CONTEXT: REACH 3 (TC3)



data collected 6-8/03/2013

UNNAMED RESERVE VALLEY ROAD

EXISTING SITUATION: REACH 3 (TC3)



Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

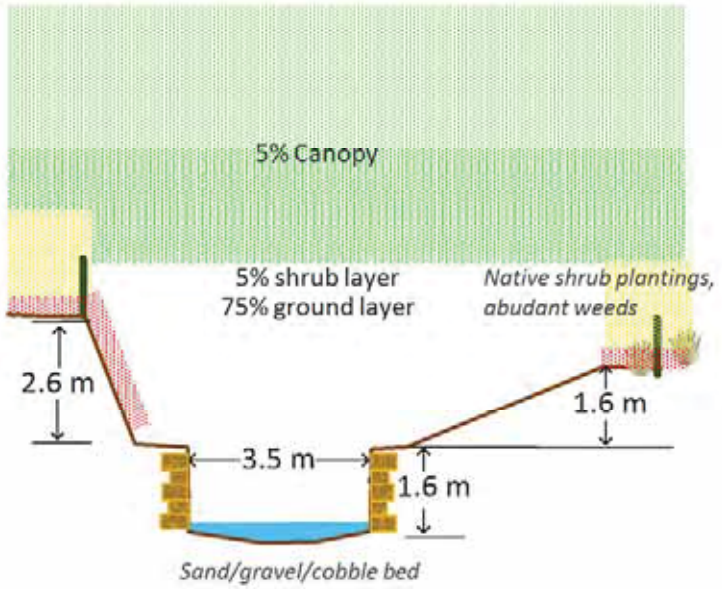
Cadastre Lot Boundary

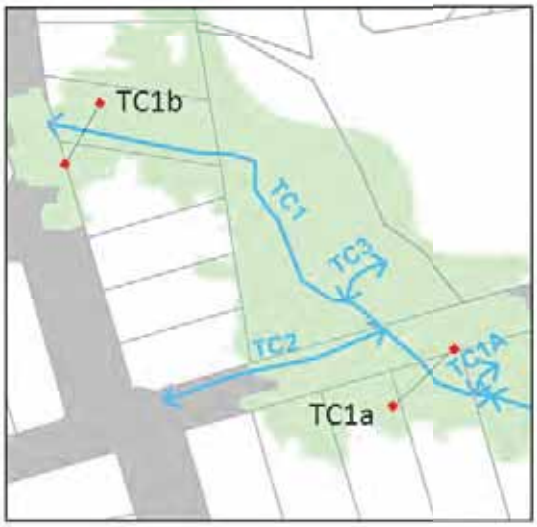
Stormwater Pit

EEC Blue Gum High Forest

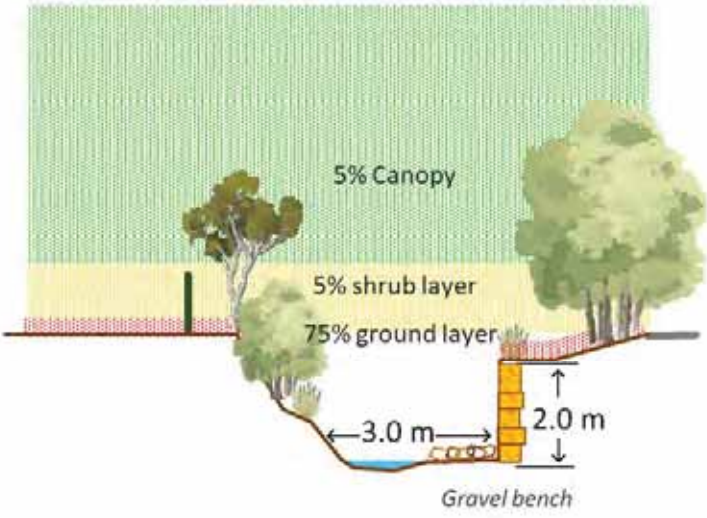
UNNAMED RESERVE
VALLEY ROAD
CROSS SECTIONS

TC1a %WEED COVER





TC1b %WEED COVER



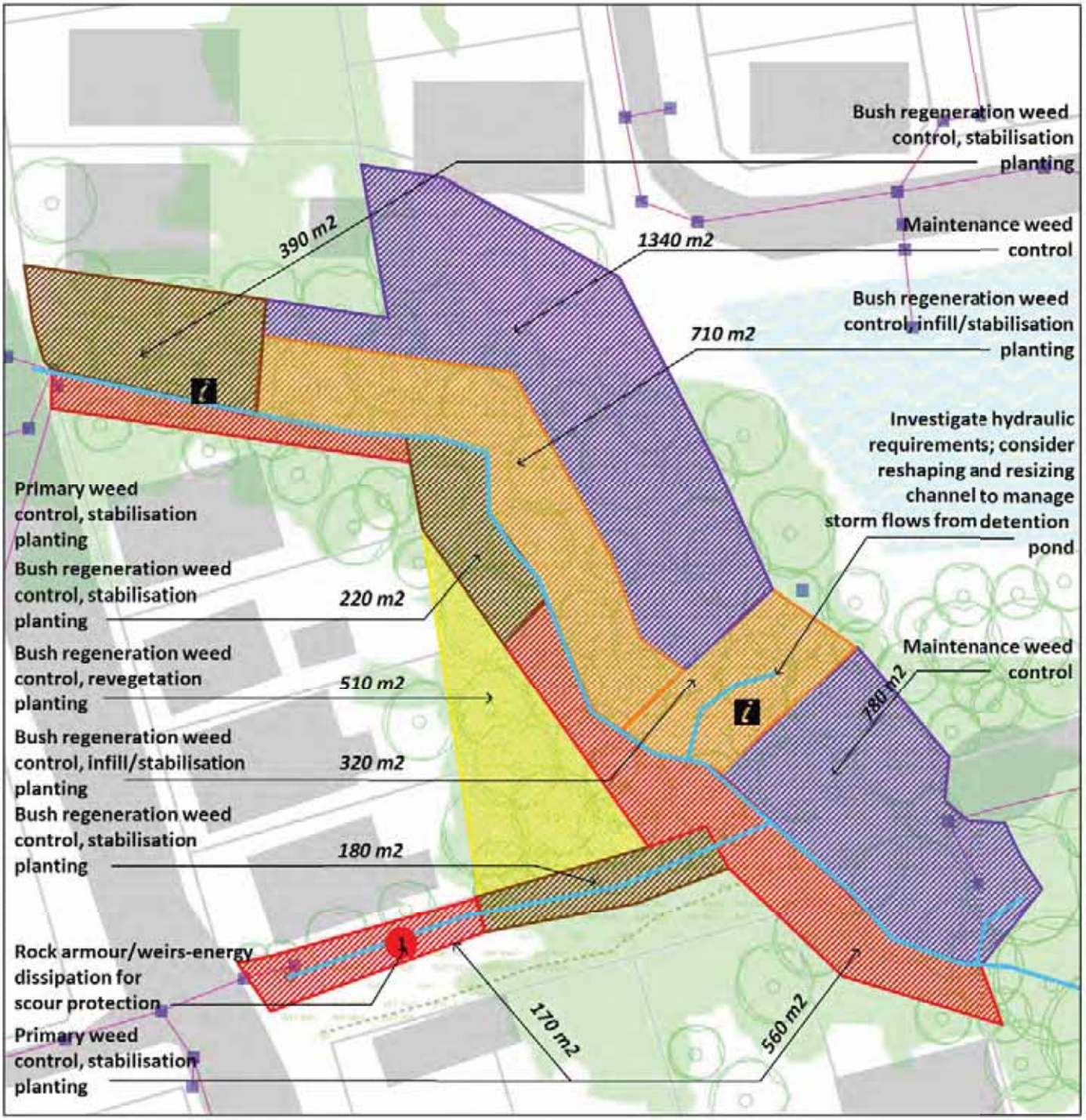
data collected 6-8/03/2013

UNNAMED RESERVE VALLEY ROAD

WORKS PLAN

VEGETATION COMMUNITIES

Blue Gum High Forest (BGHF)



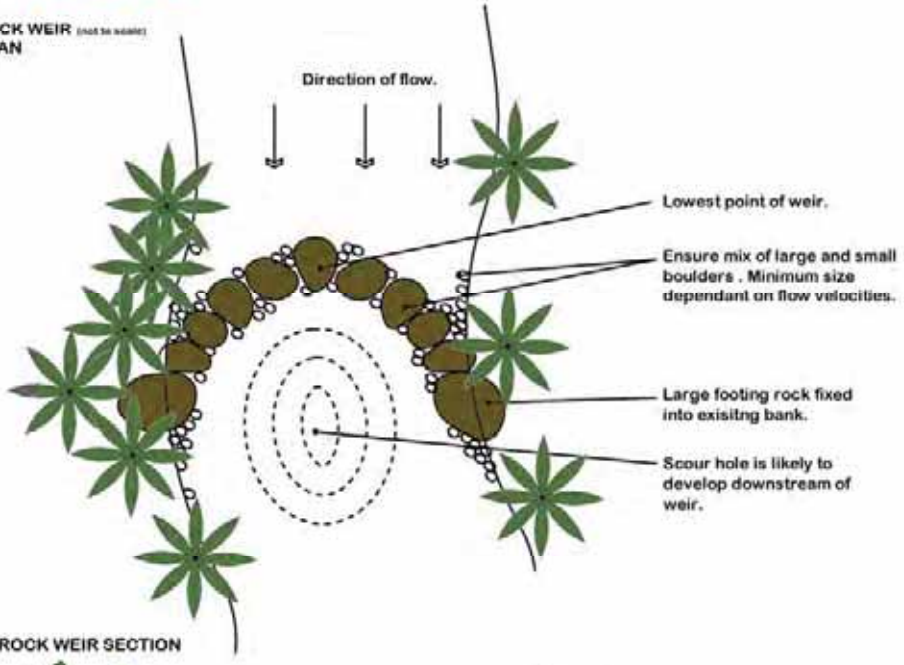
Install informative signage near bridges/crossing points discussing:
1) the importance of riparian zones;
2)water quality; and
3) settlement histroy of Terry's Creek

UNNAMED RESERVE VALLEY ROAD

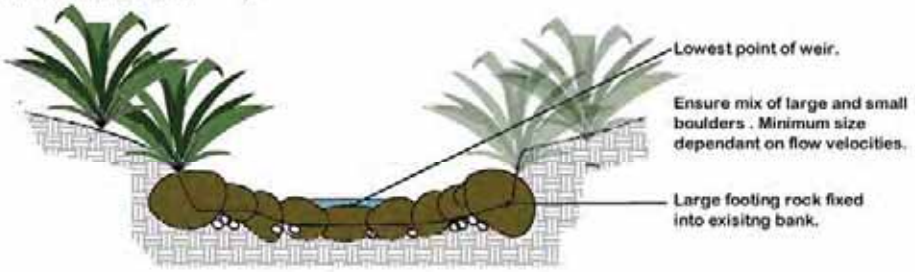
WORKS PLAN

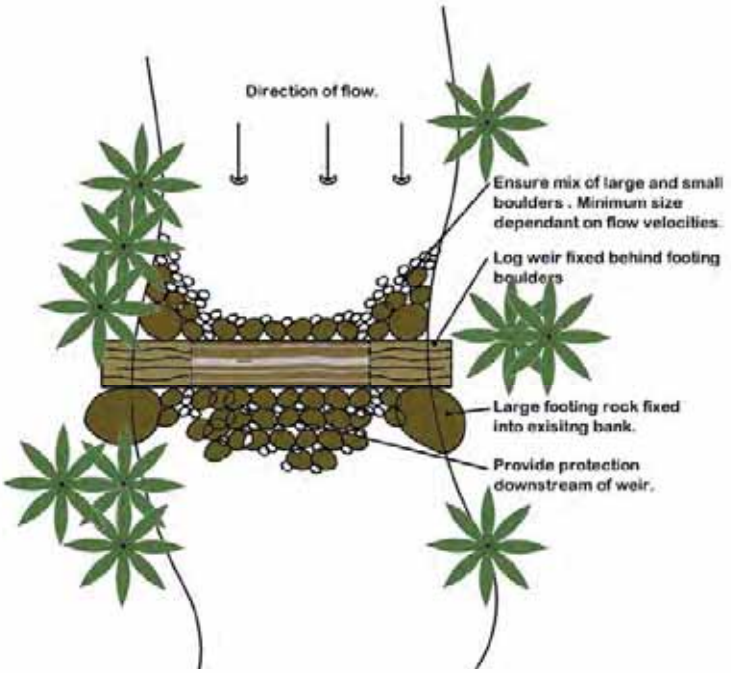
1

ROCK WEIR (not to scale)
PLAN

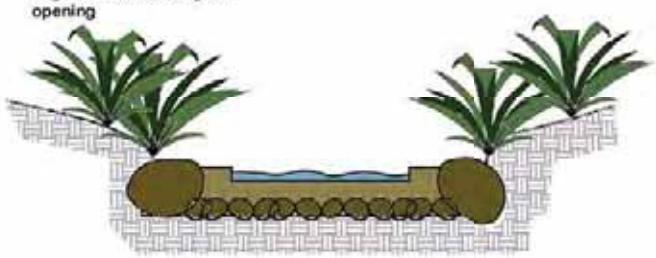


ROCK WEIR SECTION

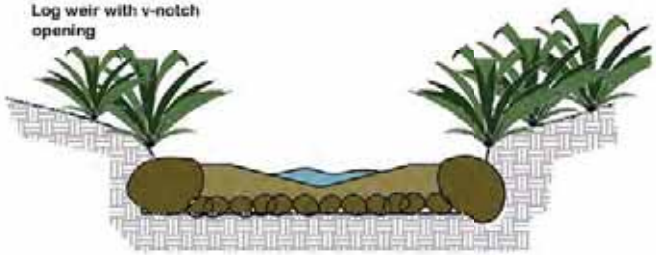




Log weir with rectangular opening



Log weir with v-notch opening



12.9 UNNAMED RESERVE VALLEY ROAD WORKS PLANS & COSTINGS

12.9.1 UNNAMED RESERVE 1 AND 1A

Table 31 Management actions and works required for reaches UR1 and UR1A in UNNAMED RESERVE VALLEY ROAD

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
UR1	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	730m2	$5-10K	$2K	OS&NR
UR1	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	High	1100m2	$3-5K	$1K	OS&NR
UR1	Community and recreation: install information signage (see design drawing for recommended topics)	Medium	2 units	$5-10K	$1-2K	OS&NR
UR1 &1A	Biodiversity enhancement: followup/maintenance weed control	Ongoing	2120m2	$3-5K	$1K	OS&NR
UR1	Water quality: monitor water quality with regular sampling	Ongoing	1 site	$1-2K	$1-2K	CS

12.9.2 UNNAMED RESERVE 2

Table 32 Management actions and works required for reach UR2 in UNNAMED RESERVE VALLEY ROAD

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
UR2	Erosion control: rock lining/plunge pool for drop scour protection	High	5m	$10-15K	$1-2K	OS&NR
UR2	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	170m2	$2-3K	$1K	OS&NR

UR2	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	High	180m2	$1-2K	<$1K	OS&NR
UR2	Biodiversity enhancement: revegetation/riparian extension planting using Blue Gum High Forest species	Medium	SEE UNNAMED RESERVE VALLEY ROAD 1			OS&NR
UR2	Biodiversity enhancement: monitor for erosion; may require earthworks	Ongoing	As req'd	N/A	N/A	OS&NR

12.9.3 UNNAMED RESERVE 3

Table 33 Management actions and works required for reach UR3 in UNNAMED RESERVE VALLEY ROAD

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
UR3	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	High	320m2	$1-2K	<$1K	OS&NR
UR3	Water quality: investigate hydraulic requirements and sediment control	High	N/A	$5-10K??	N/A	CS
UR3	Community and recreation: install information signage (see design drawing for recommended topics)	Medium	1 unit	$2-5K	<$1K	OS&NR

SKENES AVENUE RESERVE
CONDITION & ASSET SCORING

REACH NAME	GEOMORPHOLOGY SCORE	RIPARIAN VEGETATION SCORE	INSTREAM HABITAT SCORE	SENSITIVITY SCORE	CONDITION SCORE
SKENES AVE 1	2.5	1.7	2.5	2	8.7
SKENES AVE 2	3.5	3.3	3.5	2	12.3
SKENES AVE 2A	3.5	2.2	0.5	2	8.2

SCORE RANGE	STREAM CONDITION
18-22	EXCELLENT
14-17.9	GOOD
10-13.9	FAIR
5-9.9	POOR
0-4.9	HIGHLY DEGRADED

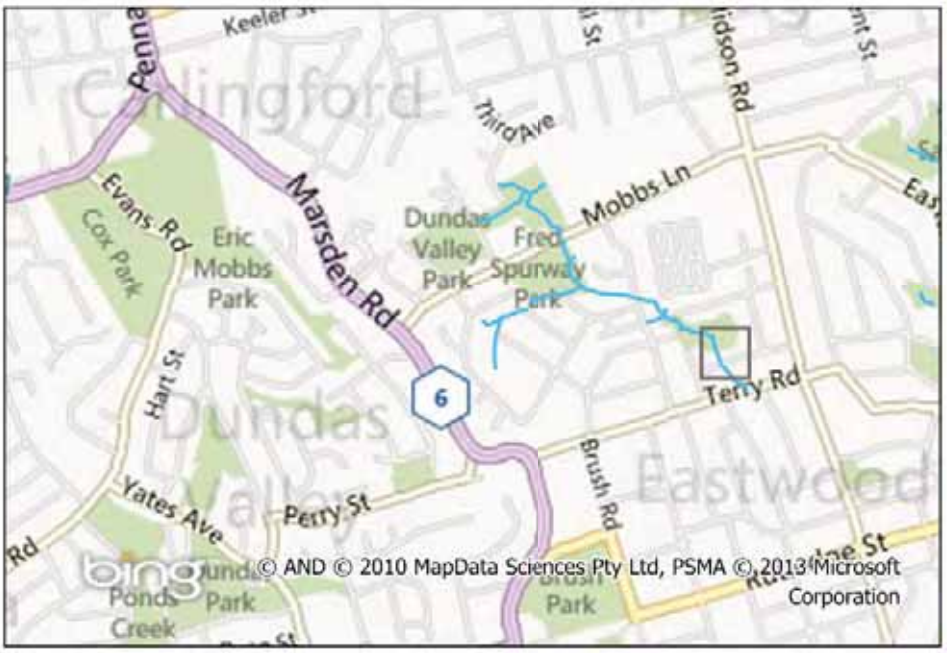
X.X Noteworthy score- see Section 9.1 for details

REACH NAME	PRIMARY MANAGEMENT OBJECTIVE	TRAJECTORY SCORE	REACH TRAJECTORY
SKENES AVE 1	REDUCE DOWNSTREAM IMPACTS	5	highly degrading
SKENES AVE 2	EXISTING RIPARIAN RESTORATION	4	degrading
SKENES AVE 2A	EXISTING RIPARIAN RESTORATION	1	stable

data collected 6-8/03/2013

SKENES AVENUE RESERVE

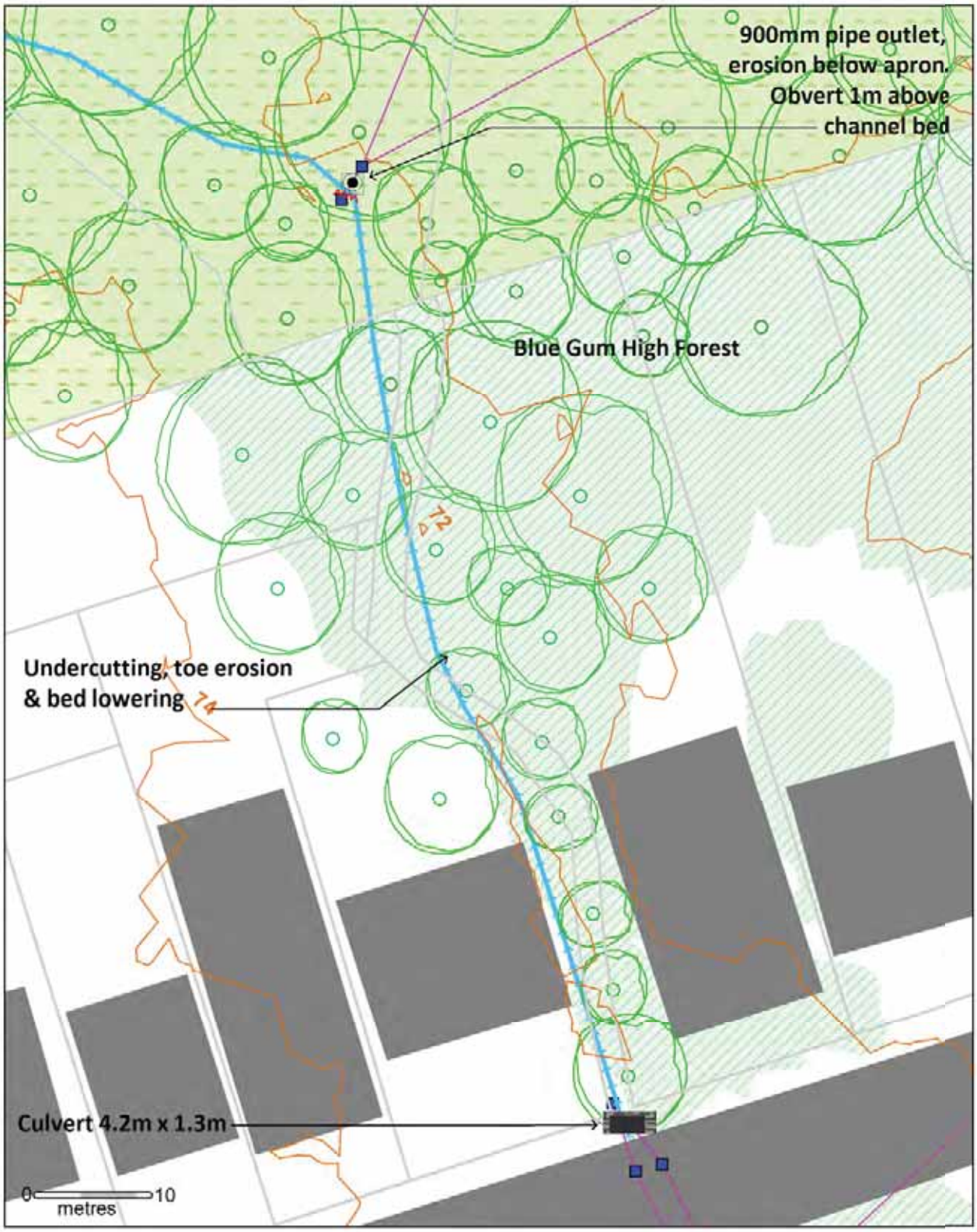
SITE CONTEXT: REACH 1 (SA1)



data collected 6-8/03/2013

SKENES AVENUE RESERVE

EXISTING SITUATION: REACH 1 (SA1)



Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

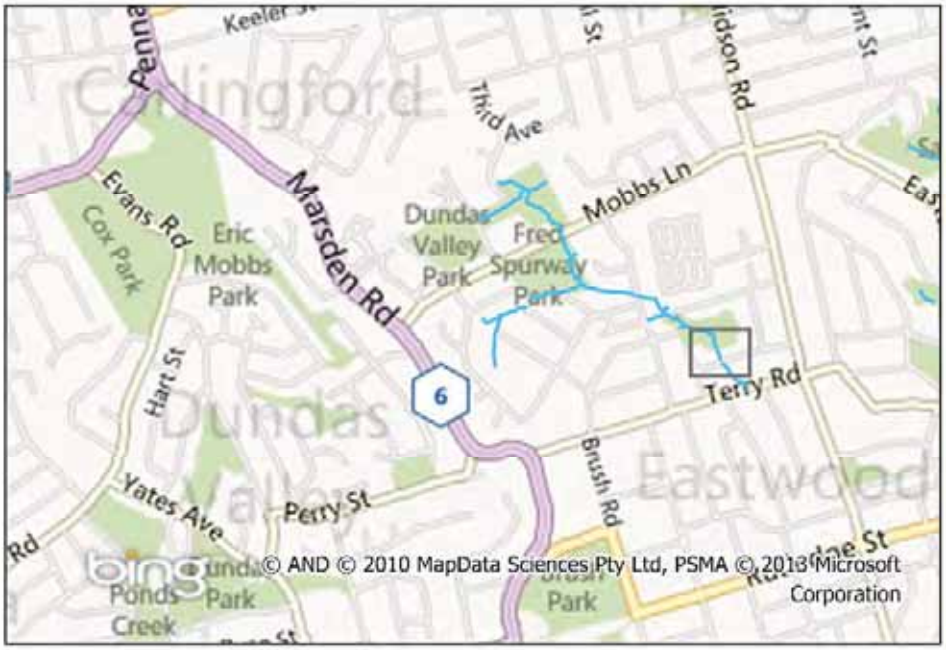
Cadastre Lot Boundary

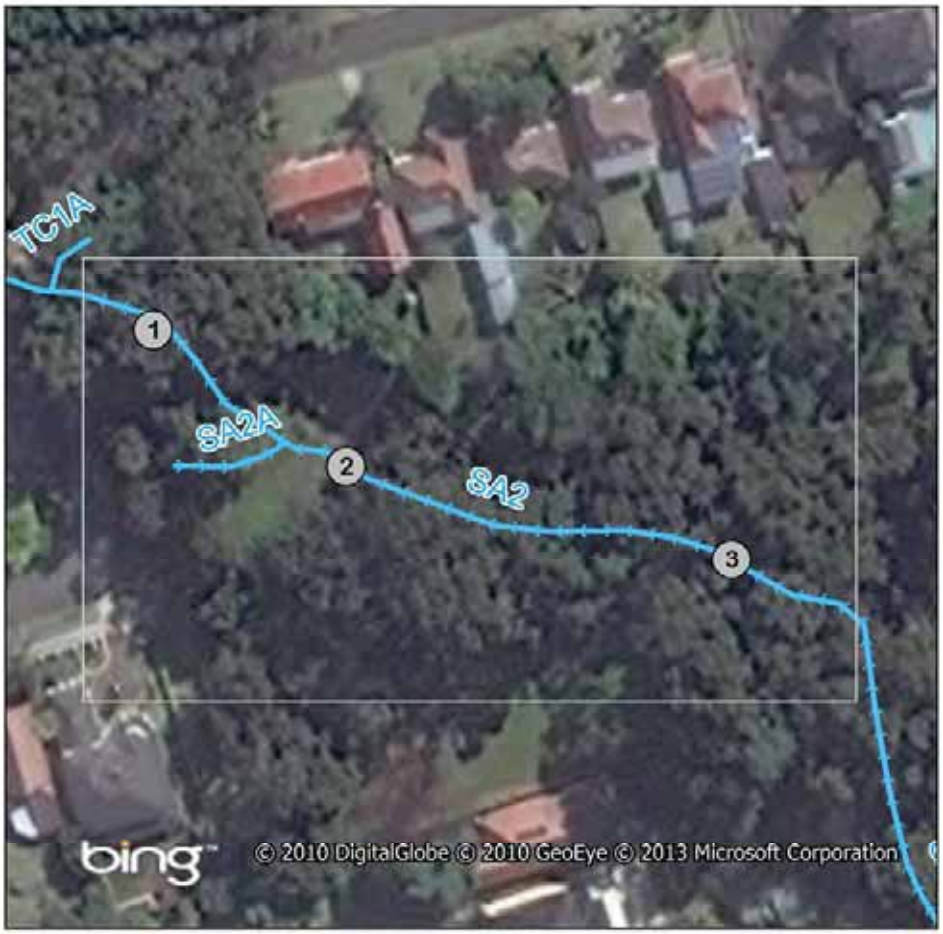
Stormwater Pit

EEC Blue Gum High Forest

SKENES AVENUE RESERVE

SITE CONTEXT: REACH 2 (SA2)





data collected 6-8/03/2013

SKENES AVENUE RESERVE

EXISTING SITUATION: REACH 2 (SA2)

Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

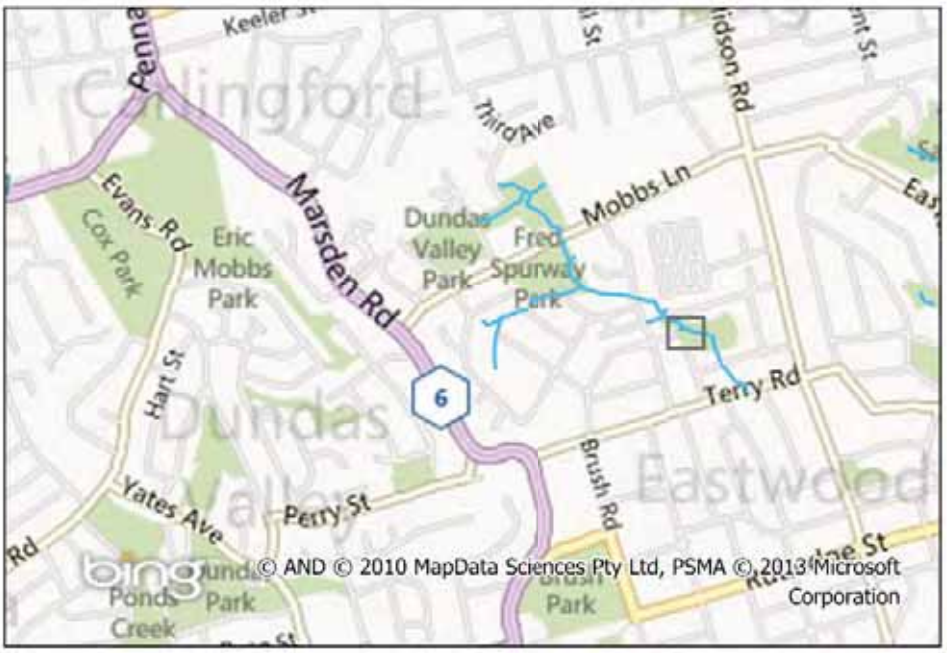
Cadastre Lot Boundary

Stormwater Pit

EEC Blue Gum High Forest

SKENES AVENUE RESERVE

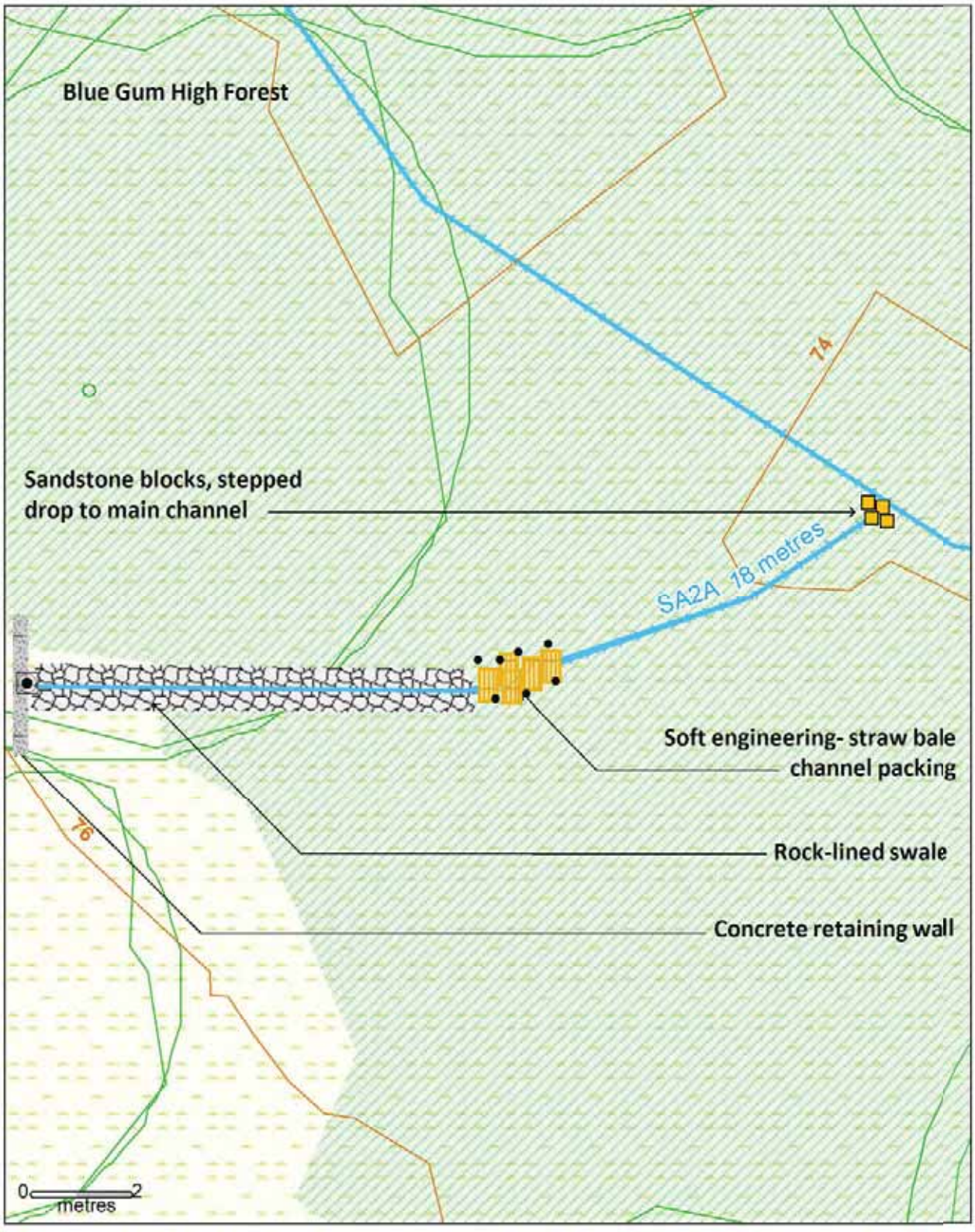
SITE CONTEXT: REACH 2A (SA2A)



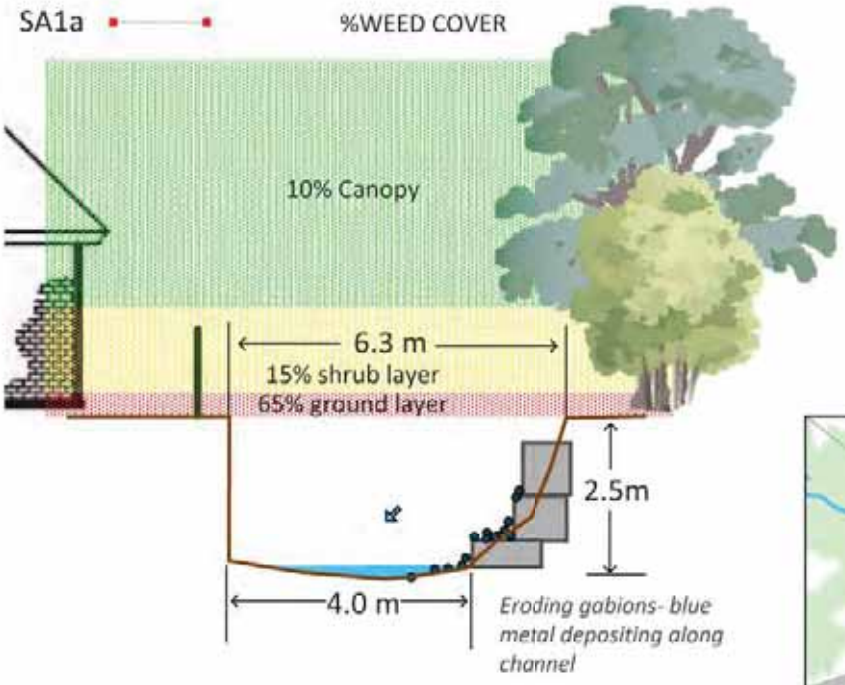
data collected 6-8/03/2013

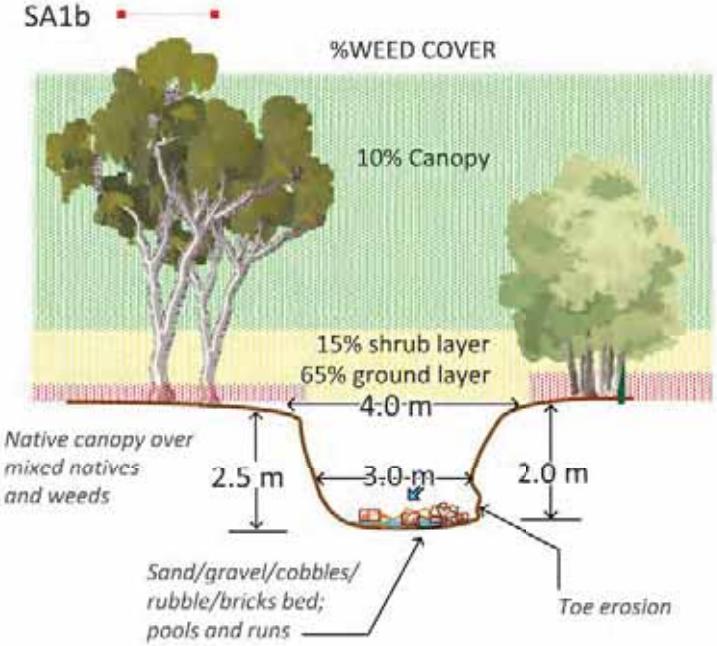
SKENES AVENUE RESERVE

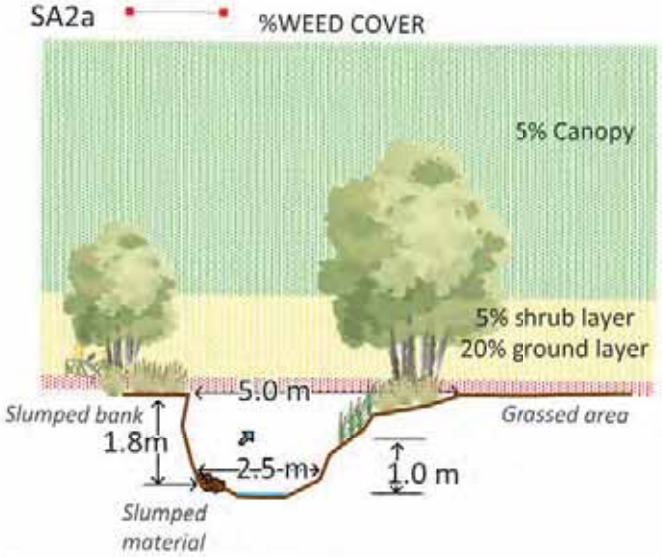
EXISTING SITUATION: REACH 2A(SA2A)



SKENES AVENUE RESERVE CROSS SECTIONS

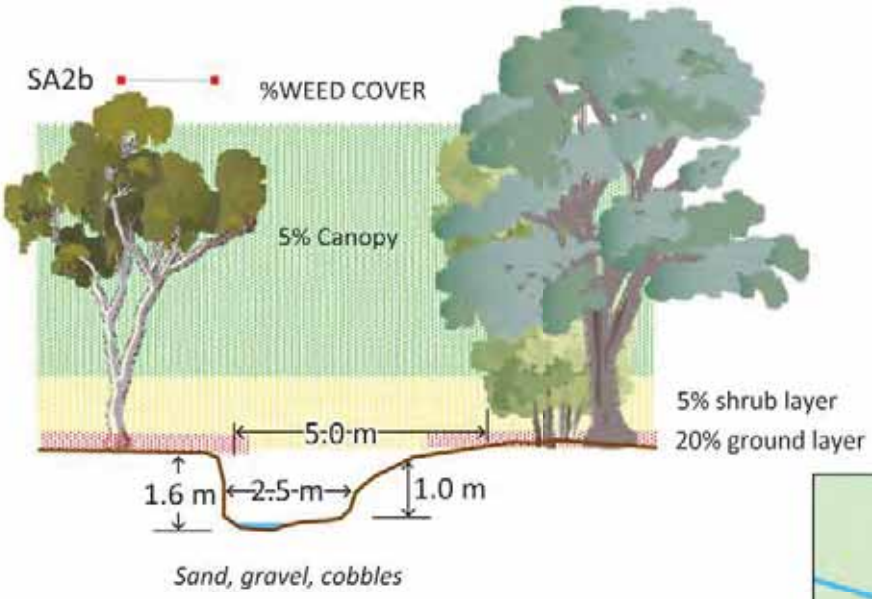


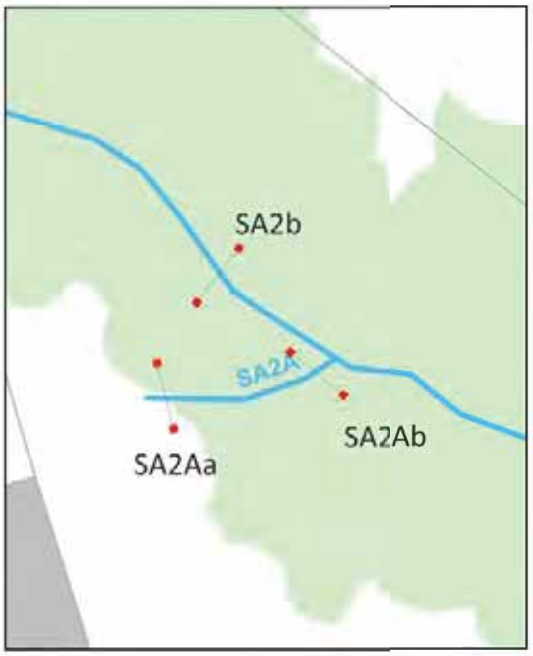


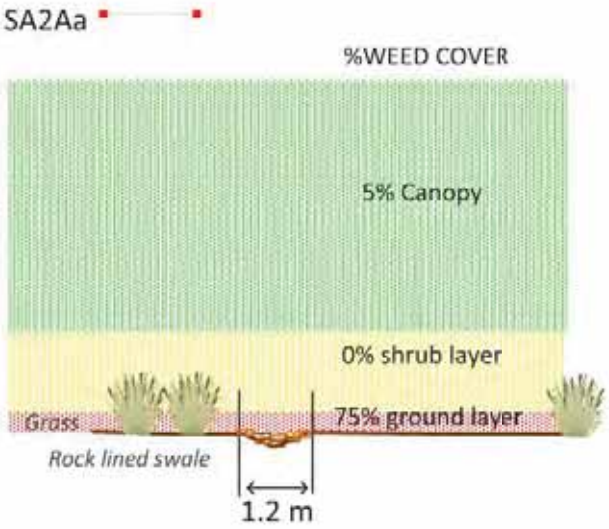


data collected 6-8/03/2013

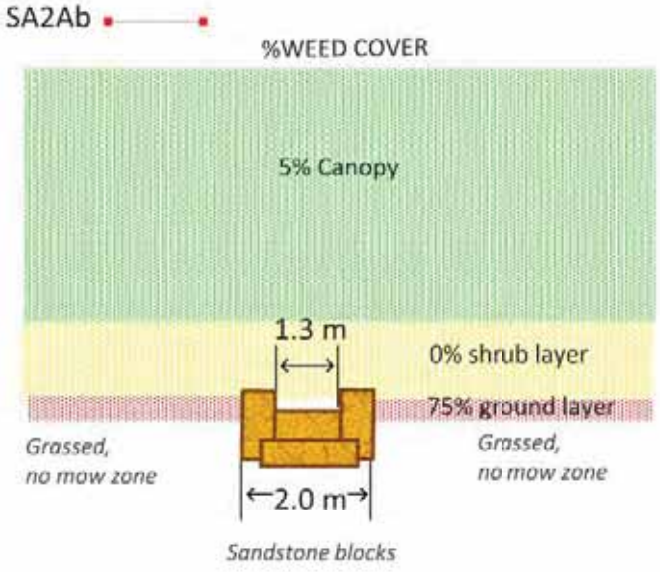
SKENES AVENUE RESERVE CROSS SECTIONS







1.2 m



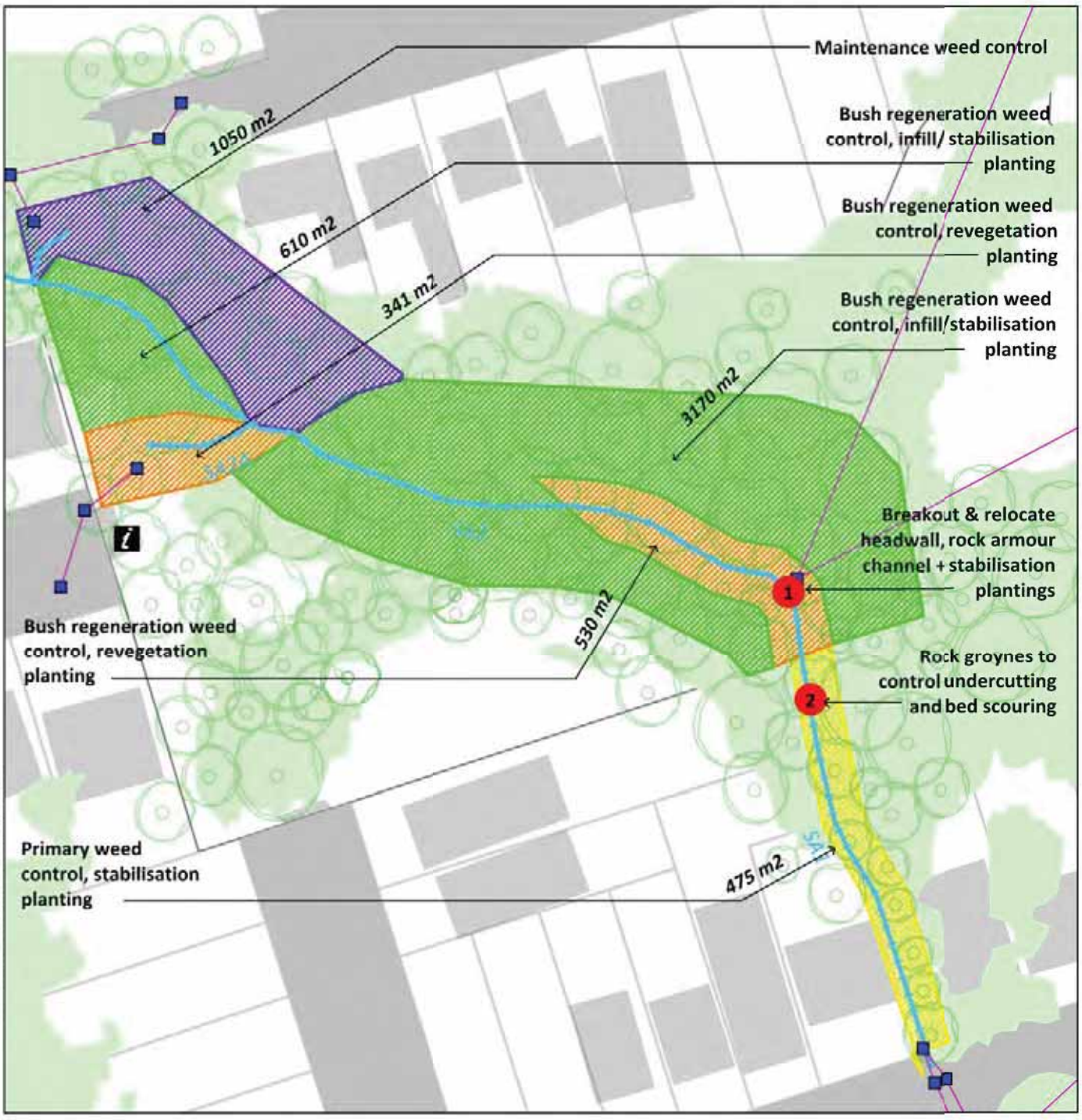
data collected 6-8/03/2013

SKENES AVENUE RESERVE

WORKS PLAN

VEGETATION COMMUNITIES

Blue Gum High Forest (BGHF)



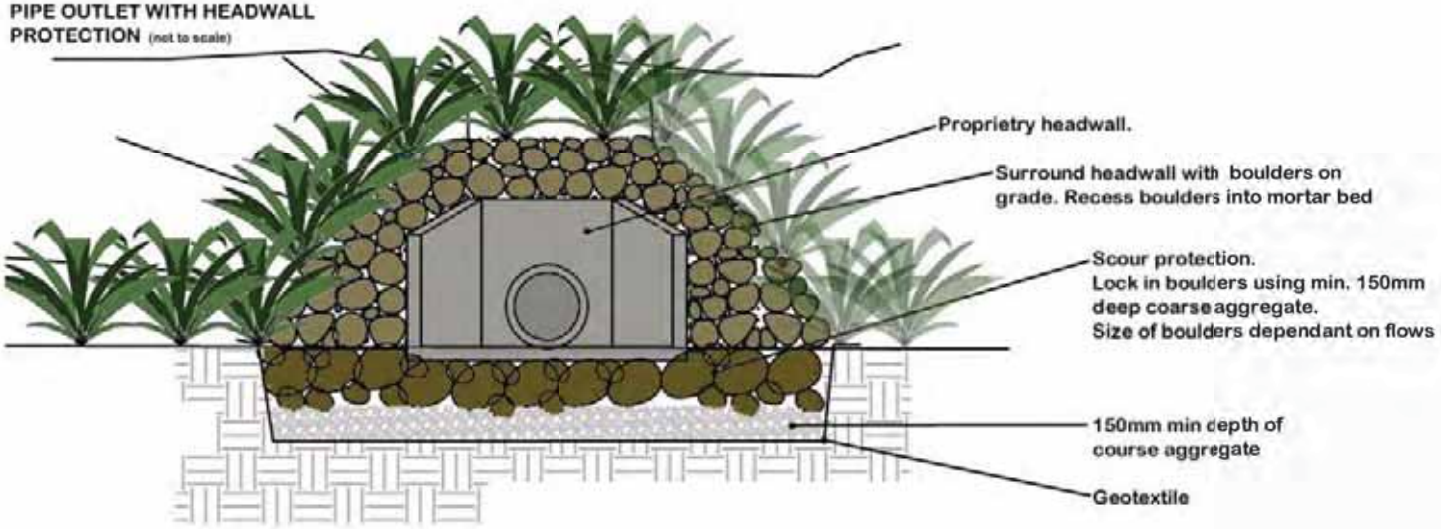
i Install informative signage near bridges/crossing points discussing:
1) the importance of riparian zones;
2) Blue Gum High Forest; and
3) important plant species of this community

SKENES AVENUE RESERVE

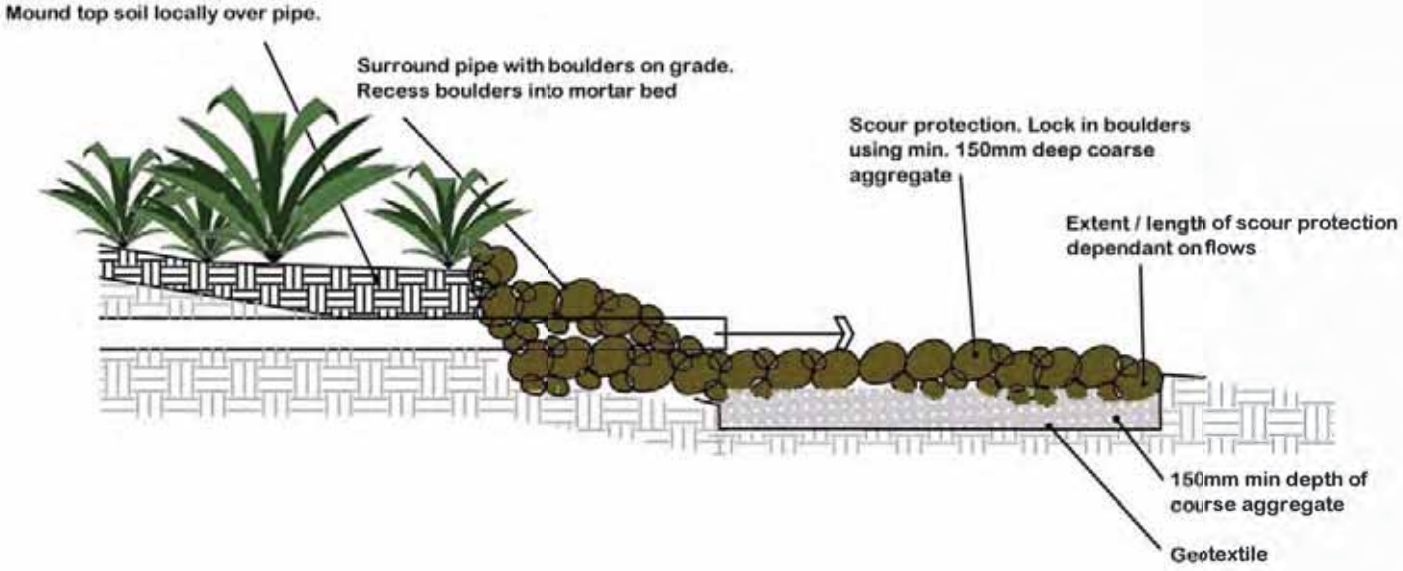
WORKS PLAN

1

PIPE OUTLET WITH HEADWALL PROTECTION (not to scale)



PIPE OUTLET PROTECTION (not to scale)



12.11 SKENES AVE RESERVE WORKS PLANS & COSTINGS

12.11.1 SKENES AVE 1

Table 34 Management actions and works required for reach SA1 in SKENES AVE RESERVE

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
SA1	Erosion control: rock groynes for bed scour/toe erosion	Very high	70m	$20-30K	$2-3K	OS&NR
SA1	Erosion control: breakout and relocate pipe outlet/headwall	Very high	Unit	$20-30K	$1K	C&I
SA1	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	475m2	$5-8K	$1-2K	OS&NR
SA1	Biodiversity enhancement: monitor for erosion; may require earthworks	Ongoing	As req'd	N/A	N/A	OS&NR

12.11.2 SKENES AVE 2

Table 35 Management actions and works required for reach SA2 in SKENES AVE RESERVE

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
SA2	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	High	530m2	$3-5K	$1-2K	OS&NR
SA2	Biodiversity enhancement: followup/ maintenance weed control, infill planting	Medium	3170m2	$5-8K	$1-2K	OS&NR
SA2	Water quality: monitor water quality with regular sampling	Ongoing	1 site	$1-2K	$1-2K	CS
SA2	Biodiversity enhancement: monitor for erosion; may require earthworks	Ongoing	As req'd	N/A	N/A	OS&NR

12.11.3 SKENES AVE 2A

Table 36 Management actions and works required for reach SA2A in SKENES AVE RESERVE

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (pa)	RESPONSIBILITY
SA2A	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	High	340m2	$2-4K	$1K	OS&NR
SA2A	Biodiversity enhancement: revegetation/riparian extension planting using Blue Gum High Forest species	High	200m2	$1-2K	N/A	OS&NR
SA2A	Biodiversity enhancement: monitor for erosion; may require earthworks	Ongoing	As req'd	N/A	N/A	OS&NR

DAVID HAMILTON RESERVE
CONDITION & ASSET SCORING

REACH NAME	GEOMORPHOLOGY SCORE	RIPARIAN VEGETATION SCORE	INSTREAM HABITAT SCORE	SENSITIVITY SCORE	CONDITION SCORE
DAVID HAMILTON 1	3.2	3.7	3.5	1	11.4

SCORE RANGE	STREAM CONDITION
18-22	EXCELLENT
14-17.9	GOOD
10-13.9	FAIR
5-9.9	POOR
0-4.9	[illegible]

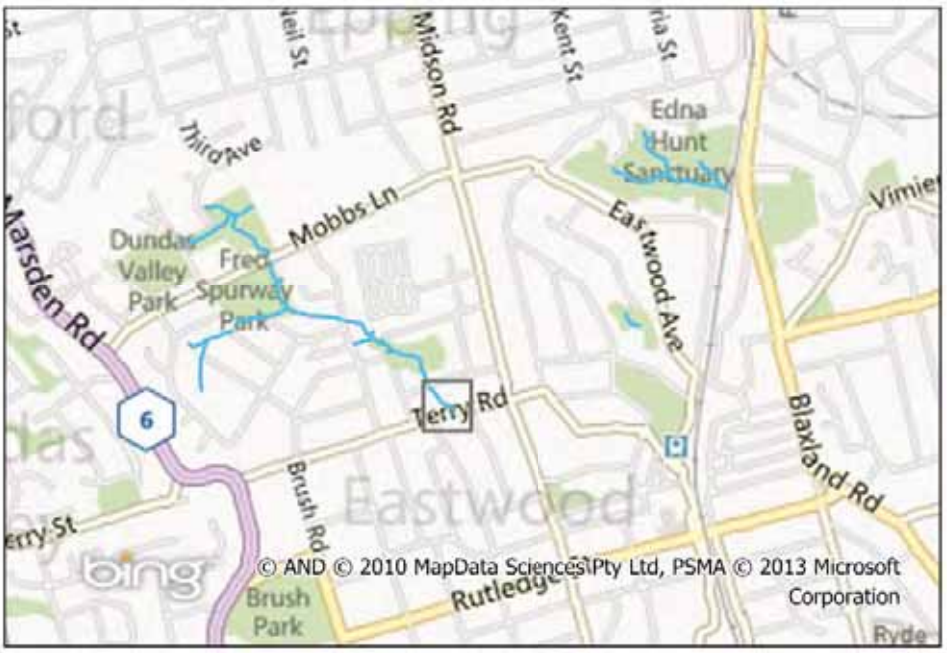
X.X Noteworthy score- see Section 9.1 for details

REACH NAME	PRIMARY MANAGEMENT OBJECTIVE	TRAJECTORY SCORE	REACH TRAJECTORY
DAVID HAMILTON 1	EXISTING RIPARIAN RESTORATION	5	highly degrading

data collected 6-8/03/2013

DAVID HAMILTON RESERVE

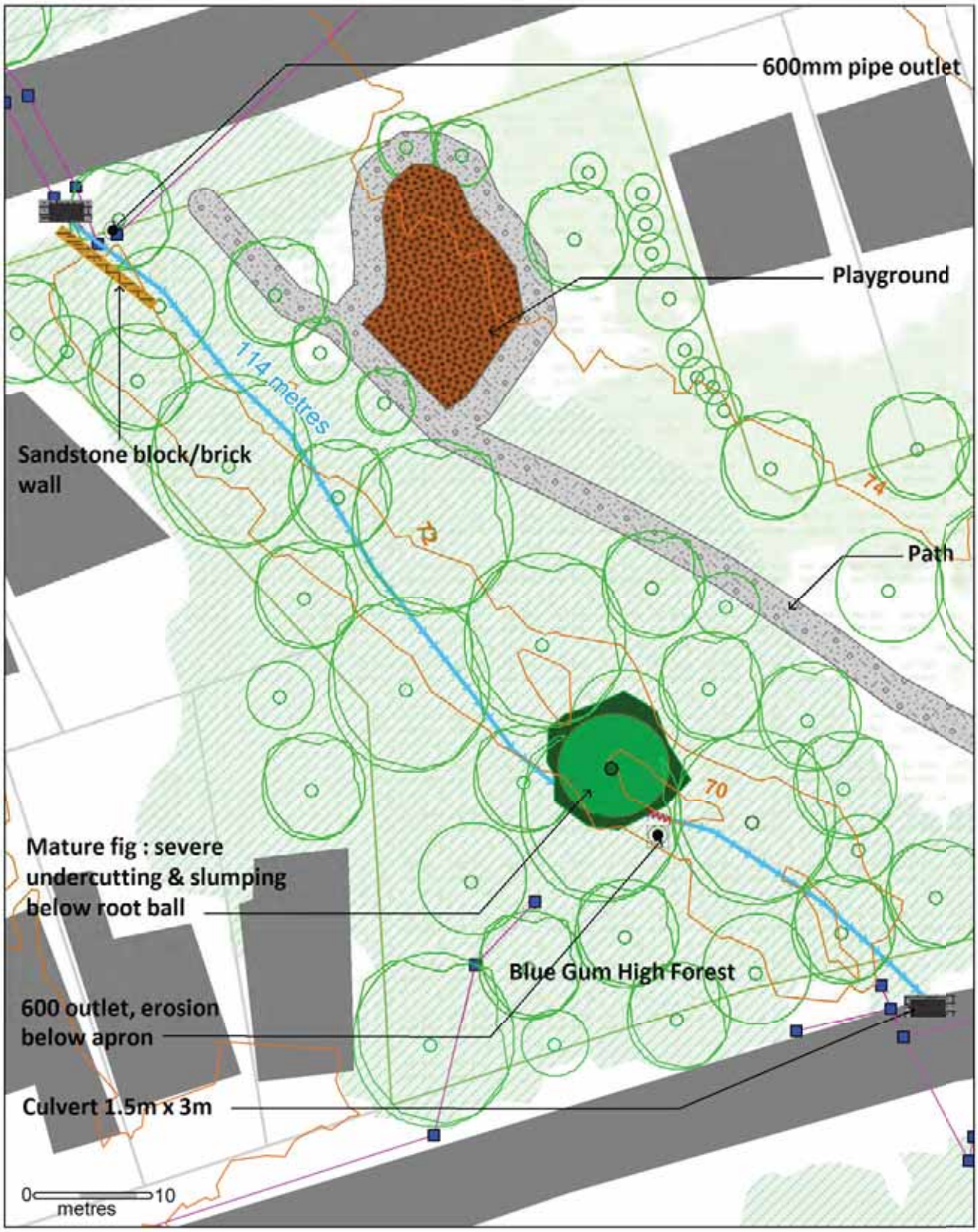
SITE CONTEXT: REACH 1 (DH1)



data collected 6-8/03/2013

DAVID HAMILTON RESERVE

EXISTING SITUATION: REACH 1 (DH1)



Stormwater Pipe

Open Watercourse

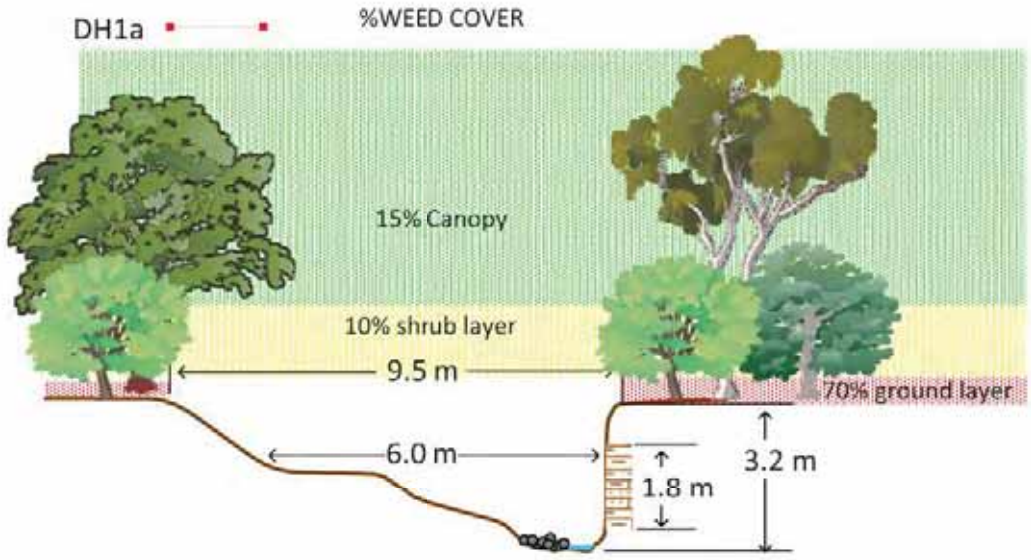
Sub-catchment Boundary

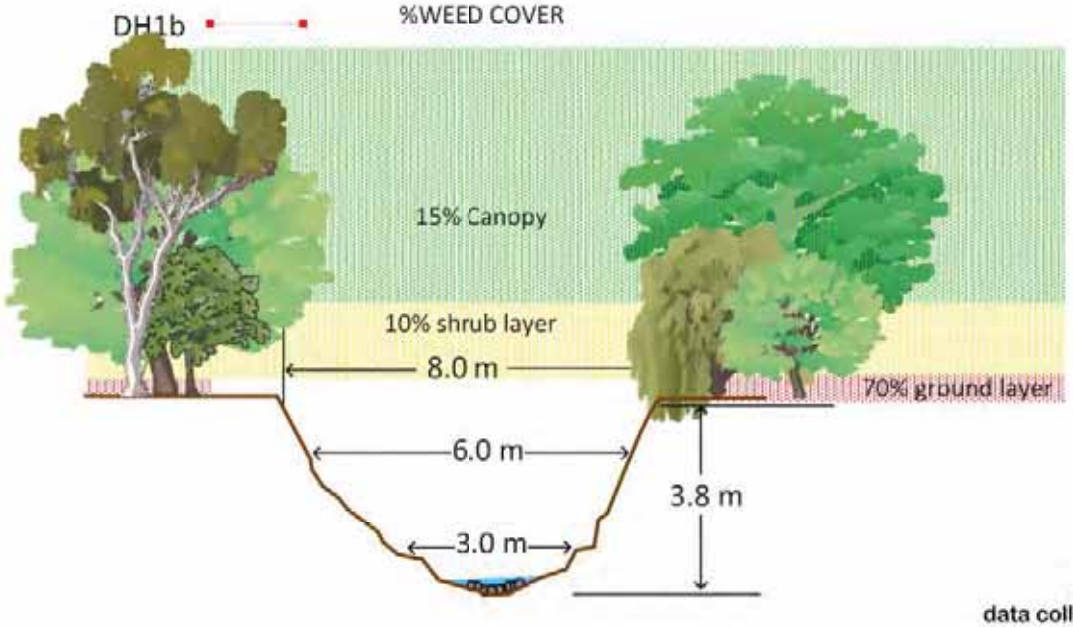
Cadastre Lot Boundary

Stormwater Pit

EEC Blue Gum High Forest

DAVID HAMILTON RESERVE CROSS SECTIONS





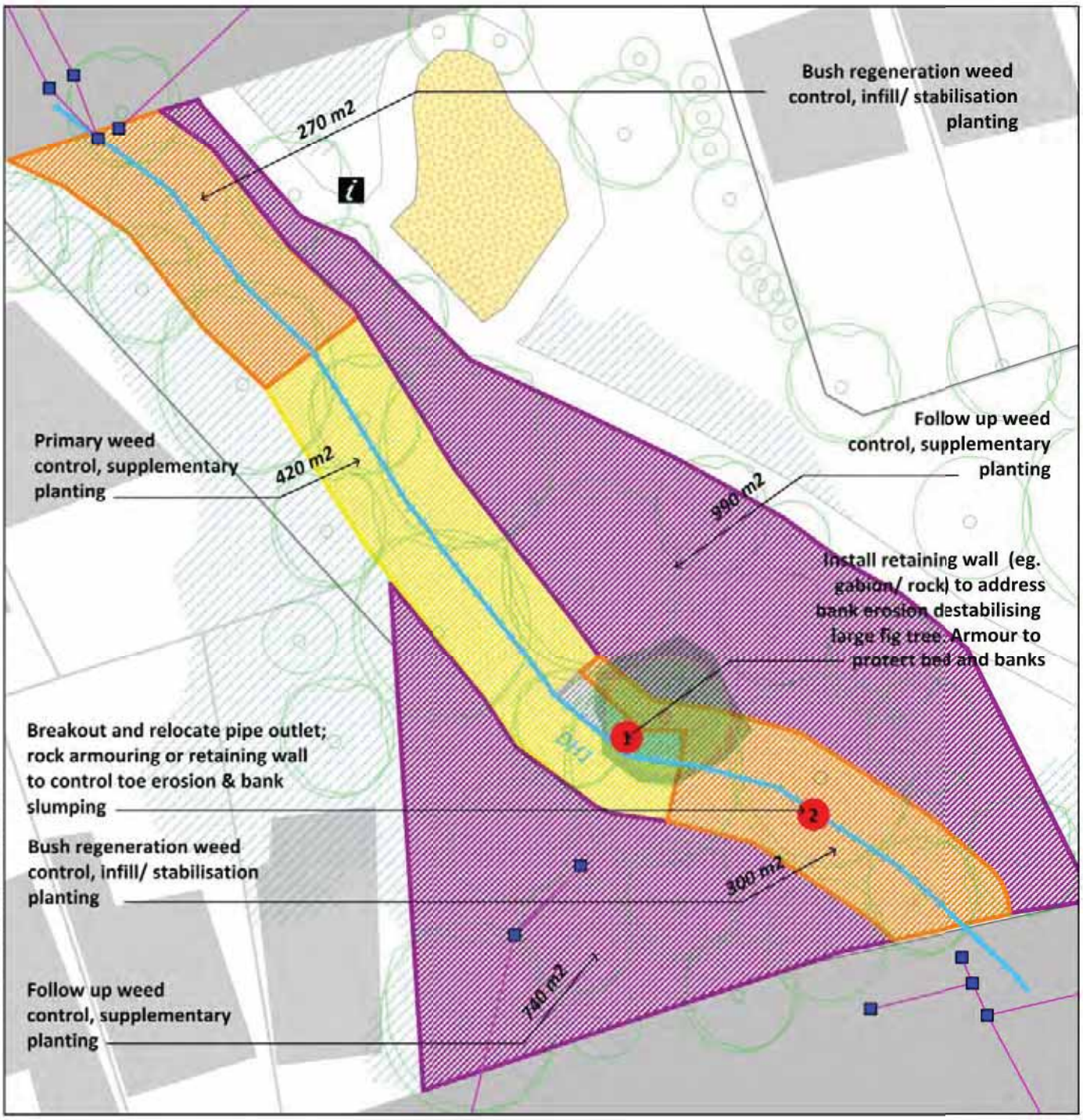
data collected 6-8/03/2013

DAVID HAMILTON RESERVE

WORKS PLAN

VEGETATION COMMUNITIES

Blue Gum High Forest (BGHF)



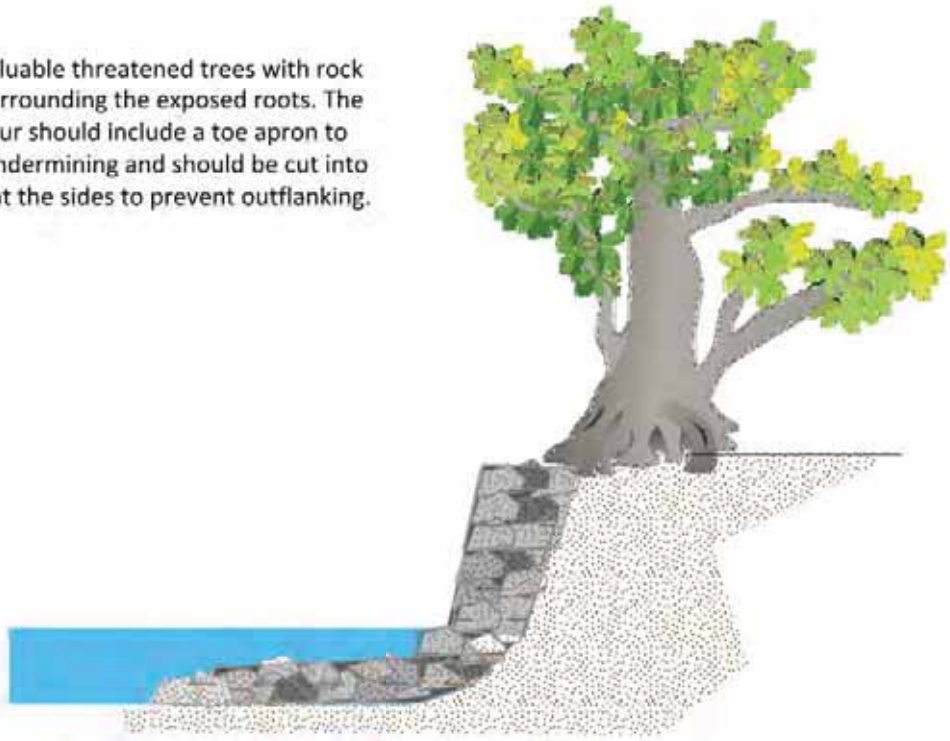
Install informative signage near bridges/crossing points discussing:
1) the importance of riparian zones;
2) Blue Gum High Forest; and
3) important plant species of this community

DAVID HAMILTON RESERVE

WORKS PLAN

1

Protect valuable threatened trees with rock armour surrounding the exposed roots. The rock armour should include a toe apron to prevent undermining and should be cut into the bank at the sides to prevent outflanking.

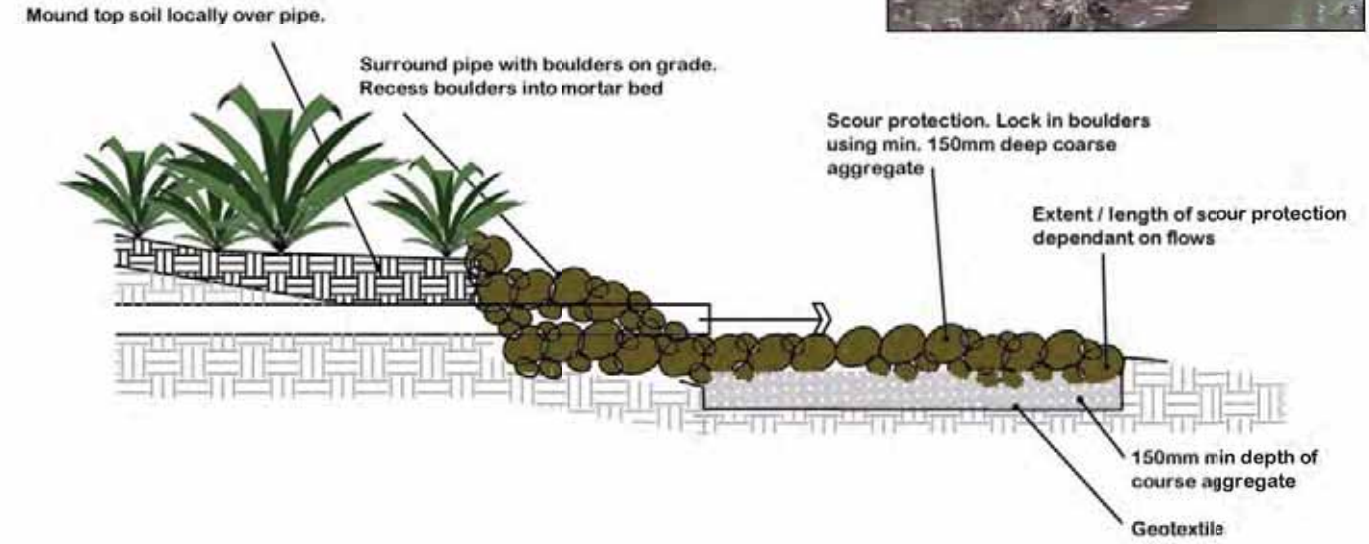


DAVID HAMILTON RESERVE

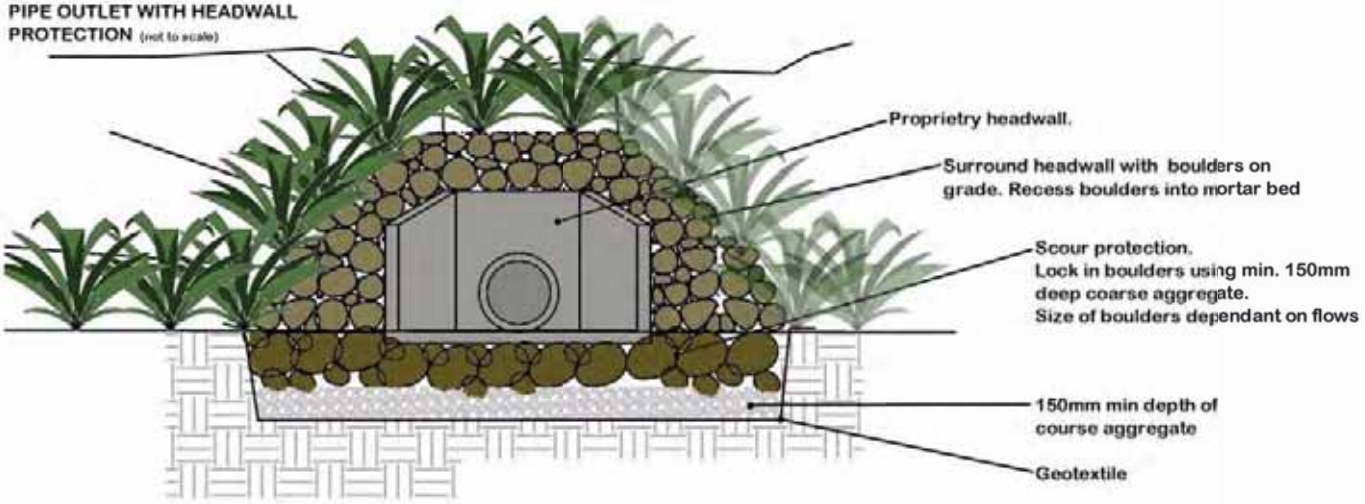
WORKS PLAN

2

PIPE OUTLET PROTECTION (not to scale)



PIPE OUTLET WITH HEADWALL PROTECTION (not to scale)



12.13 DAVID HAMILTON RESERVE WORKS PLANS & COSTINGS

Table 37 Management actions and works required for reaches in DAVID HAMILTON RESERVE

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
DH1	Erosion control: breakout and relocate pipe outlet/headwall	Very high	Unit	$50-75K	<$1K	CI
DH1	Erosion control: rock armouring for toe erosion/bank slumping	Very high	10m	$10-20K	$1-2K	OS&NR
DH1	Erosion control: construct retaining wall or provide rock armouring with toe apron to control bank erosion	Very high	20m	$20-30K	$2-5K	OS&NR
DH1	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	420m2	$2-5K	$1-2K	OS&NR
DH1	Erosion control: rock line channel to control bed lowering	High	20-40m	$25-50K	$1-2K	OS&NR
DH1	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	High	570m2	$2-5K	$1-2K	OS&NR
DH1	Biodiversity enhancement: followup/maintenance weed control	Medium	0.168ha	$2-5K	$1-2K	OS&NR
DH1	Biodiversity enhancement: supplementary planting using Blue Gum High Forest species	Low	0.168ha	$2-5K	$1-2K	OS&NR

EDNA HUNT SANCTUARY
CONDITION & ASSET SCORING

REACH NAME	GEOMORPHOLOGY SCORE	RIPARIAN VEGETATION SCORE	INSTREAM HABITAT SCORE	SENSITIVITY SCORE	CONDITION SCORE
EDNA HUNT 1	4.3	4.5	3	3	14.8
EDNA HUNT 1A	0.5	3.5	0.5	3	7.5
EDNA HUNT 2	3	3.8	5	3	14.8
EDNA HUNT 3	3	3.3	4	3	13.3
EDNA HUNT 4	3.8	3.8	3	4	14.6

SCORE RANGE	STREAM CONDITION
18-22	EXCELLENT
14-17.9	GOOD
10-13.9	FAIR
5-9.9	POOR
0-4.9	HIGHLY DEGRADED

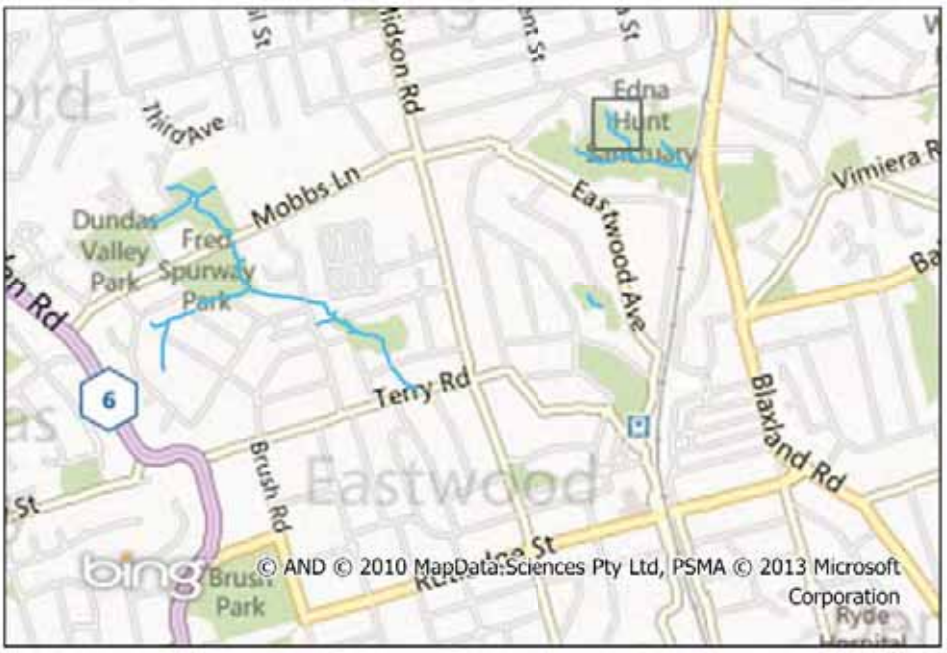
X.X Noteworthy score- see Section 9.1 for details

REACH NAME	PRIMARY MANAGEMENT OBJECTIVE	TRAJECTORY SCORE	REACH TRAJECTORY
EDNA HUNT 1	GOOD RIPARIAN HABITAT, GOOD HYDROGEOMORPHOLOGY	3	degrading
EDNA HUNT 1A	REDUCE DOWNSTREAM IMPACTS	5	highly degrading
EDNA HUNT 2	EXISTING RIPARIAN RESTORATION	3	degrading
EDNA HUNT 3	EXISTING RIPARIAN RESTORATION	4	degrading
EDNA HUNT 4	GOOD RIPARIAN HABITAT, EXISTING RIPARIAN RESTORATION	1	stable

data collected 6-8/03/2013

EDNA HUNT SANCTUARY

SITE CONTEXT: REACH 1 & 1A (EH1 &1A)

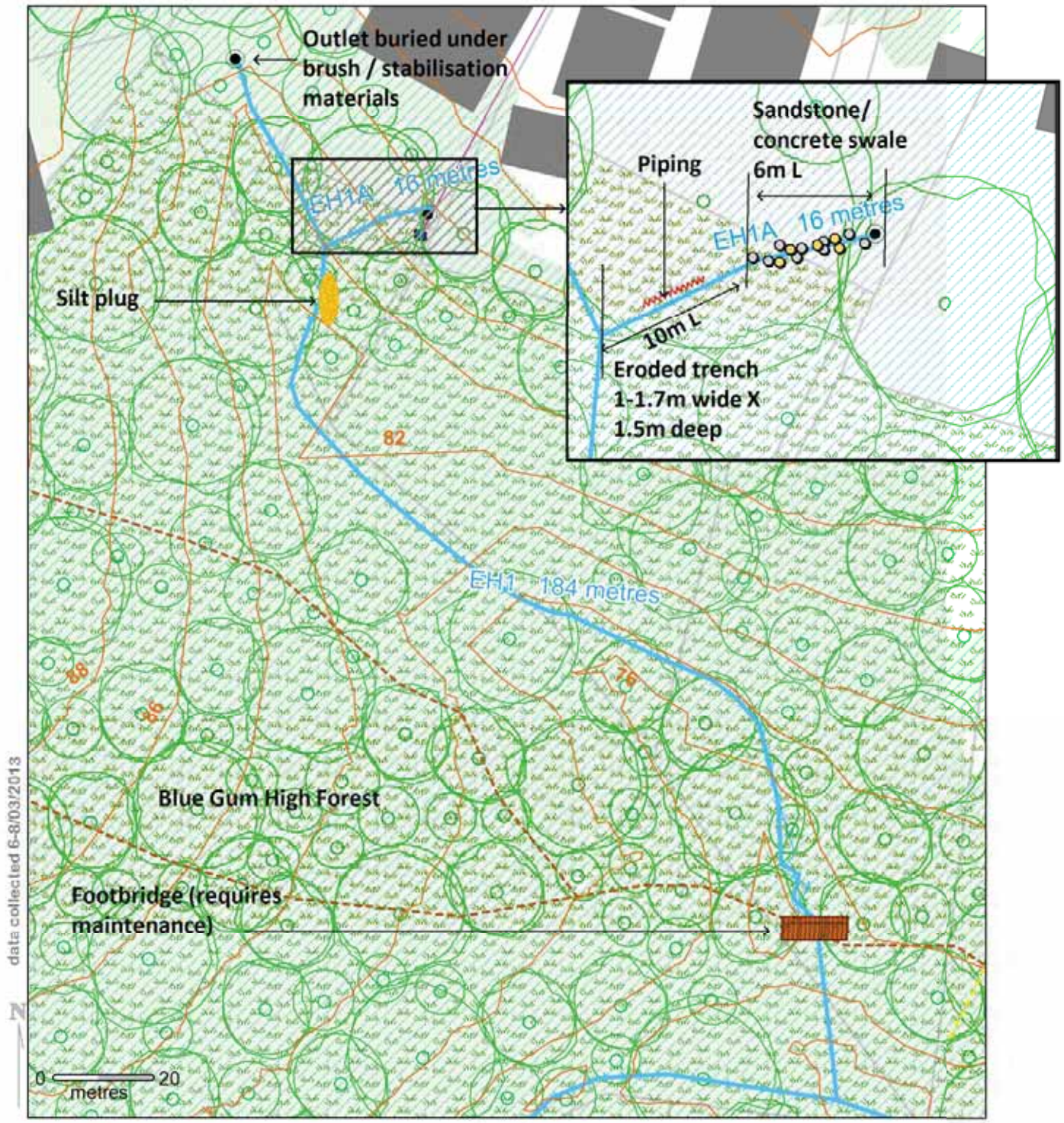


data collected 6-8/03/2013

EDNA HUNT SANCTUARY

EXISTING SITUATION:

REACH 1 & 1A (EH1 & EH1A)



Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

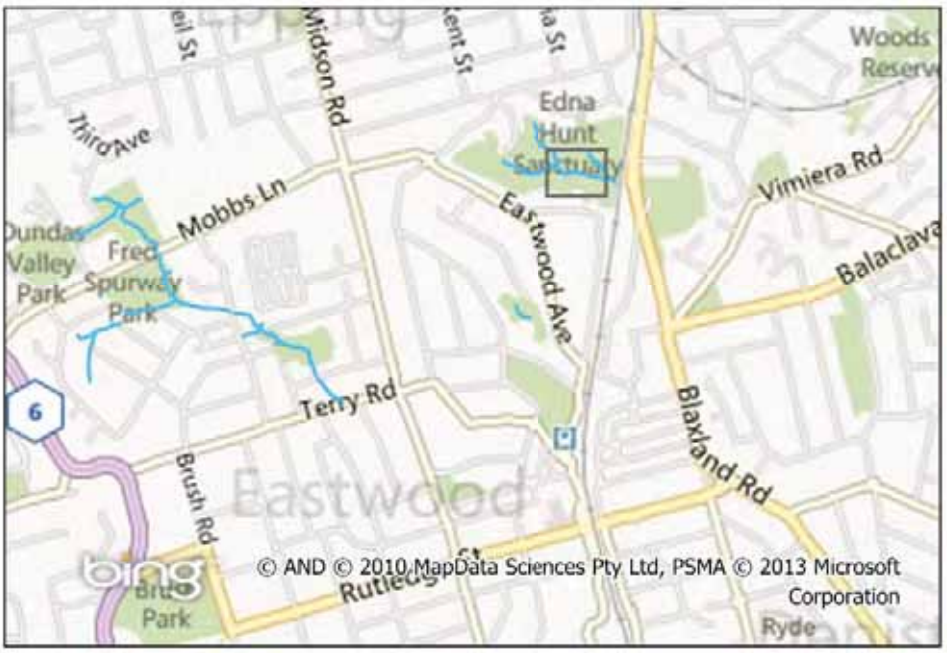
Cadastre Lot Boundary

Stormwater Pit

EEC Blue Gum High Forest

EDNA HUNT SANCTUARY

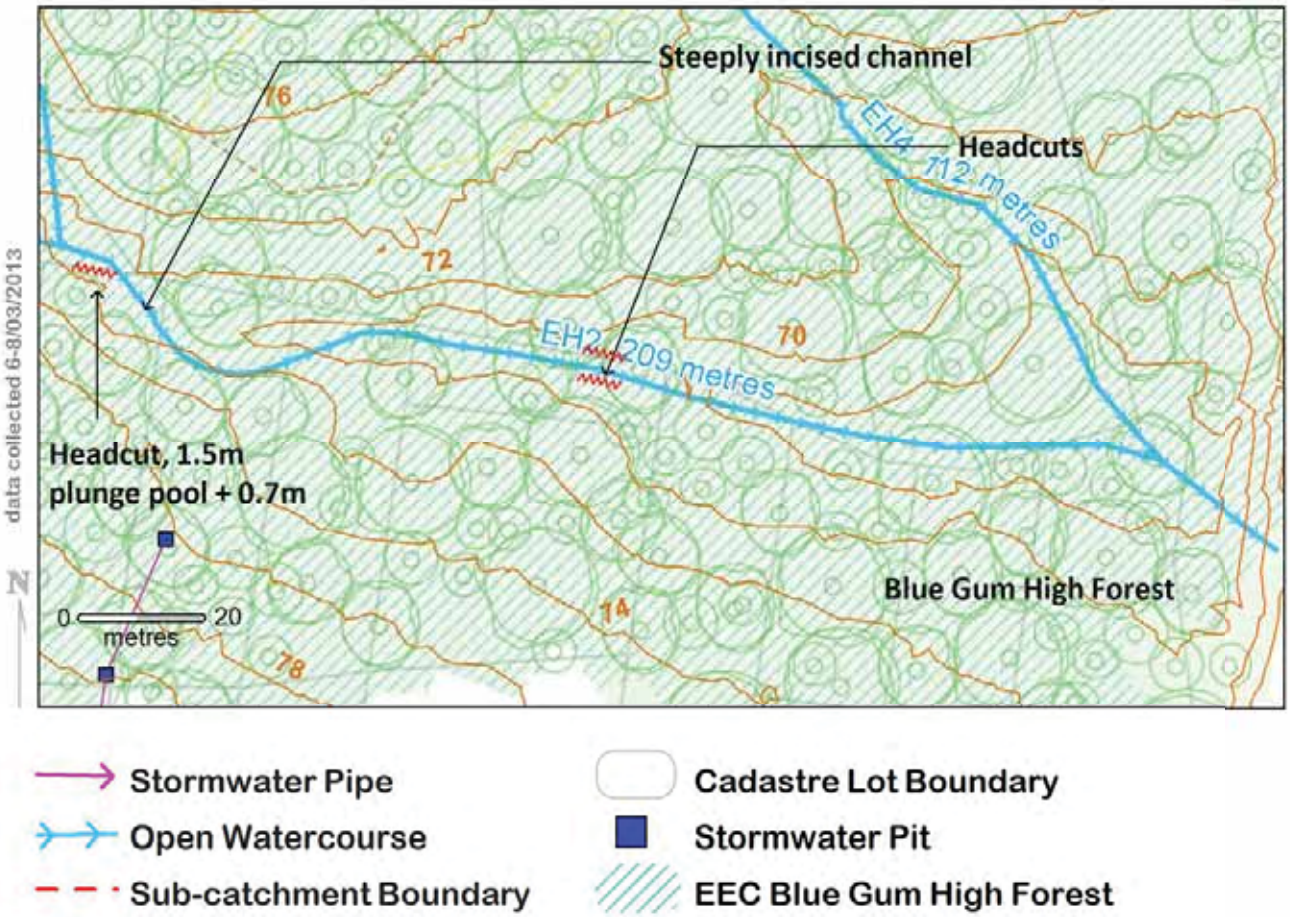
SITE CONTEXT: REACH 2 (EH2)



data collected 6-8/03/2013

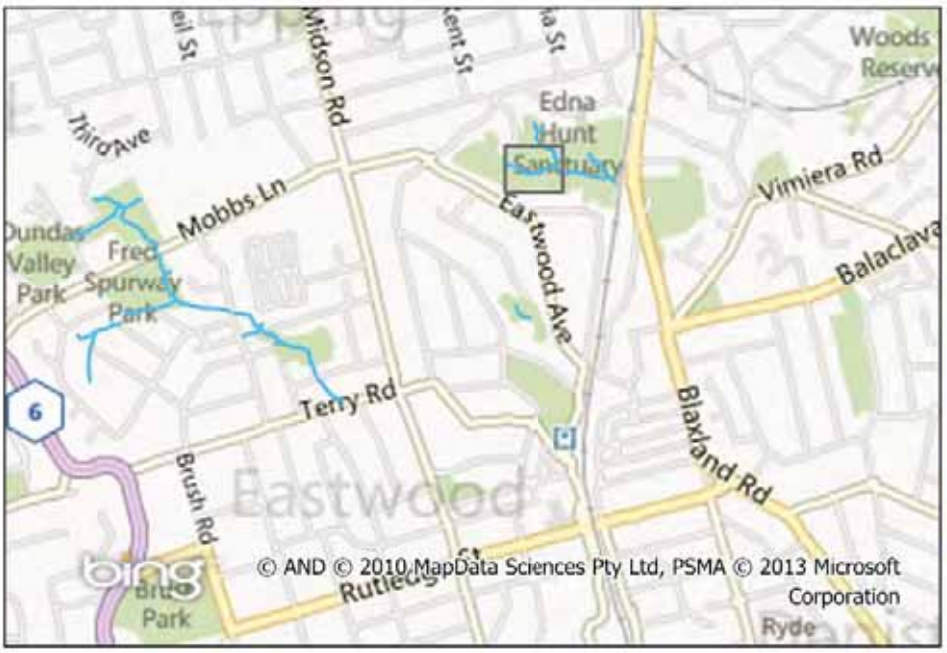
EDNA HUNT SANCTUARY

EXISTING SITUATION: REACH 2 (EH2)



EDNA HUNT SANCTUARY

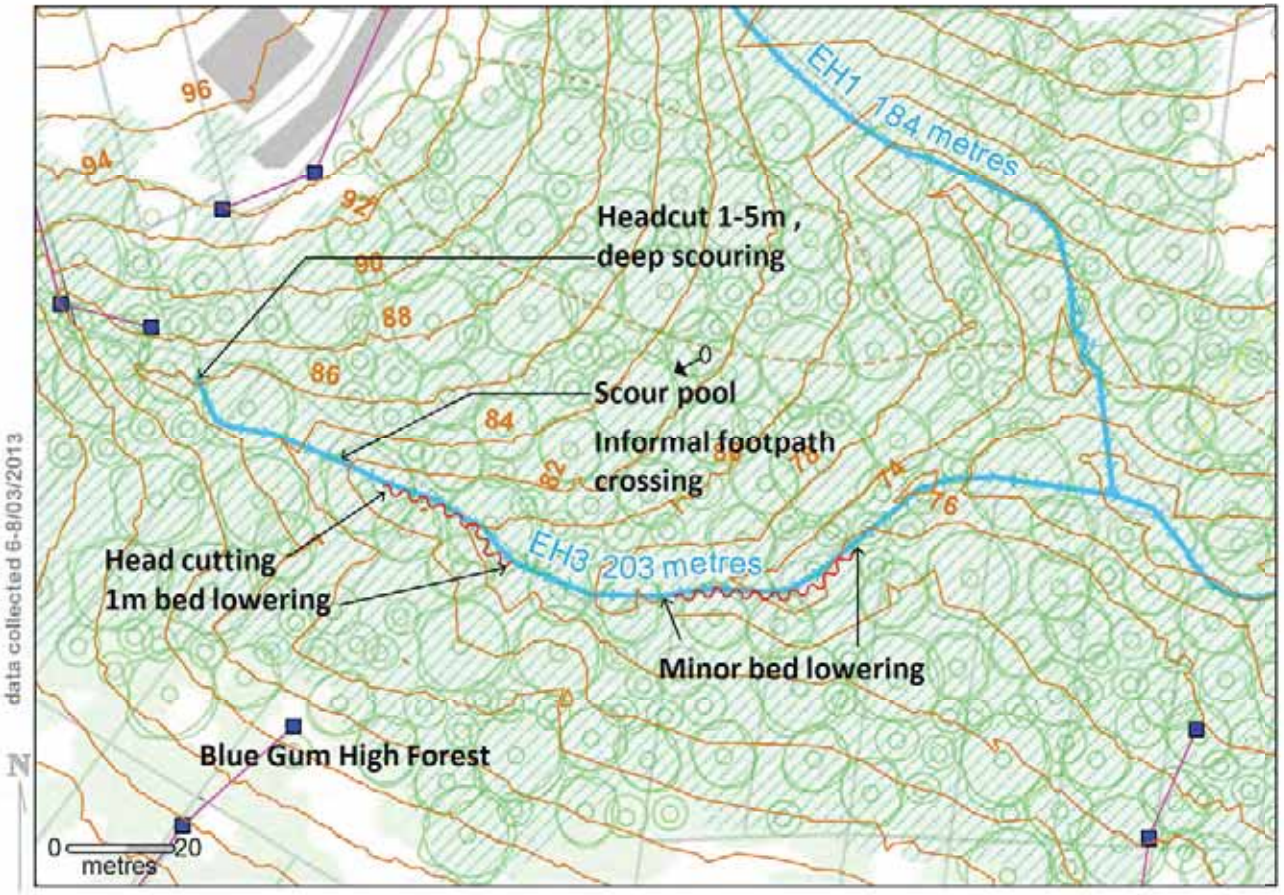
SITE CONTEXT: REACH 3 (EH3)



data collected 6-8/03/2013

EDNA HUNT SANCTUARY

EXISTING SITUATION: REACH 3 (EH3)



Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

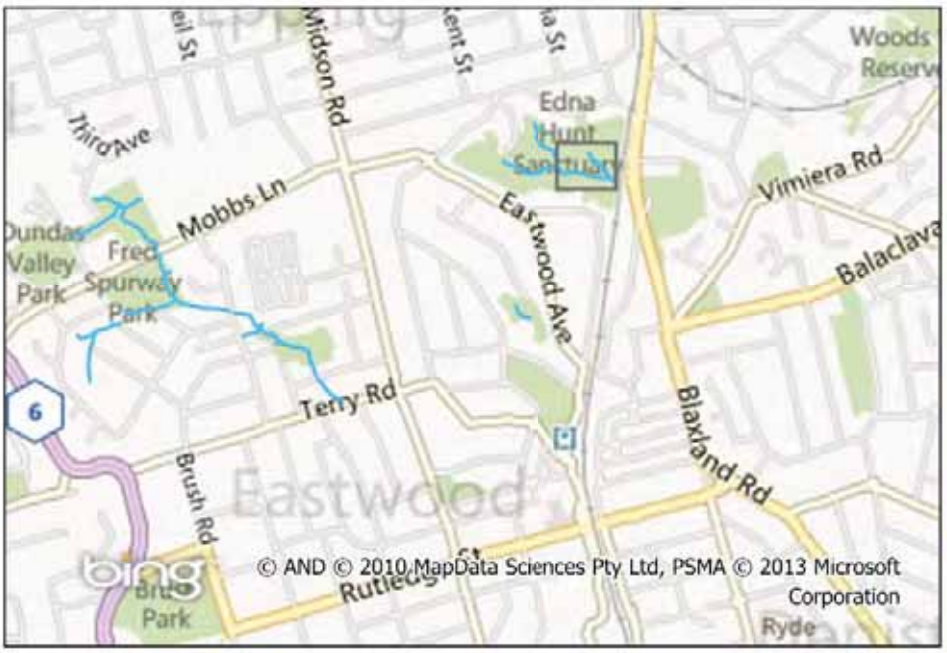
Cadastre Lot Boundary

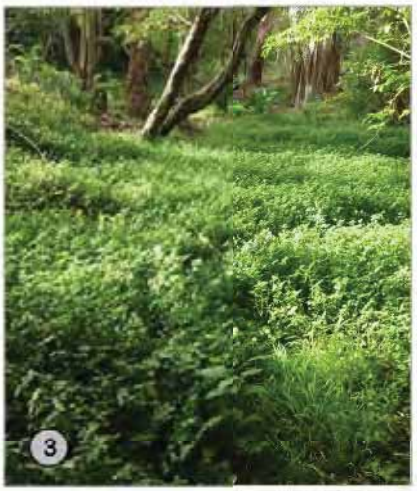
Stormwater Pit

EEC Blue Gum High Forest

EDNA HUNT SANCTUARY

SITE CONTEXT: REACH 4 (EH4)





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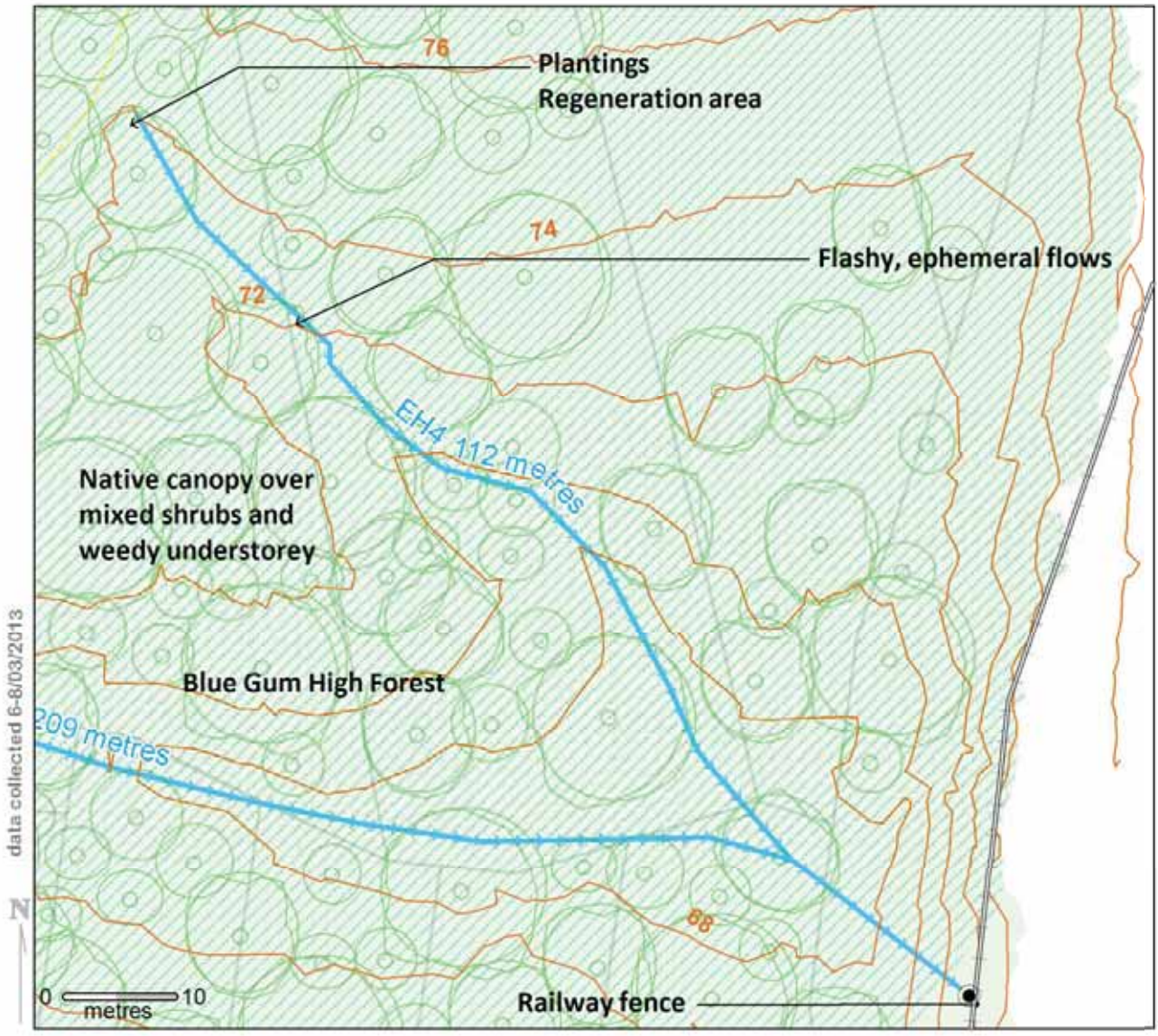


Stormwater Pipe

Open Watercourse

Sub-catchment Boundary

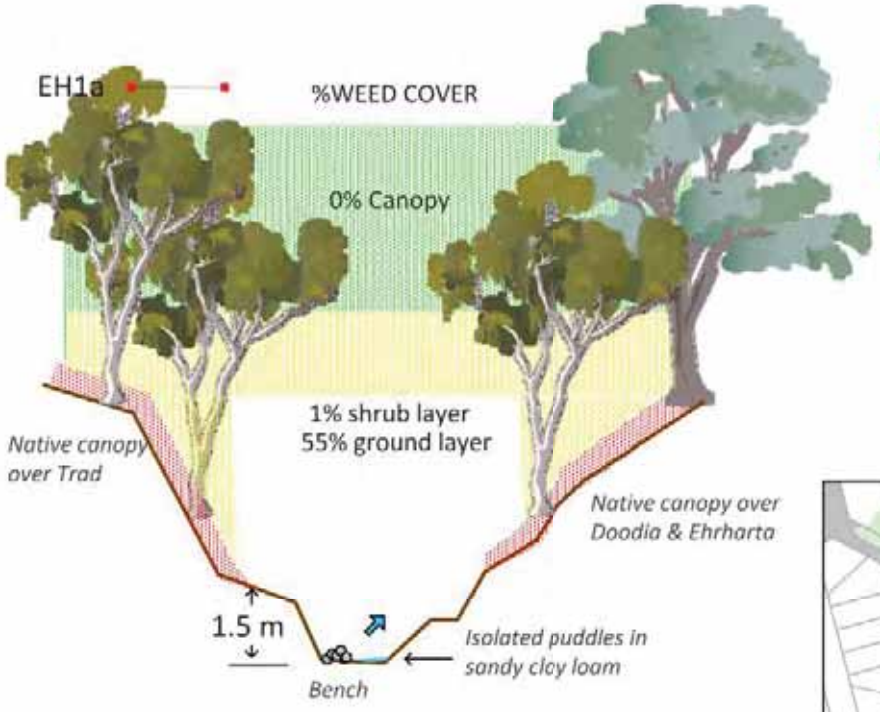
Cadastre Lot Boundary

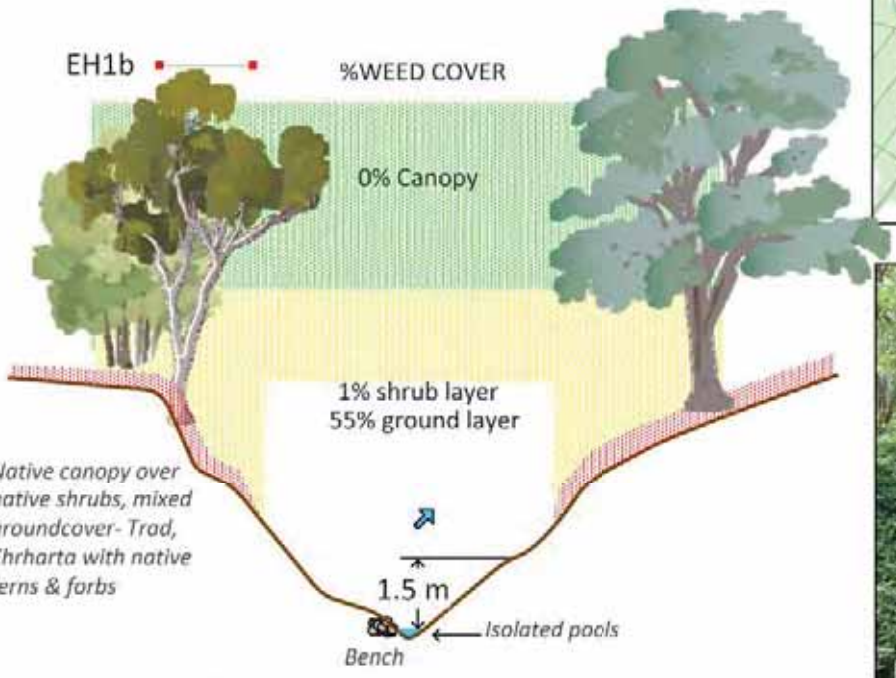
Stormwater Pit

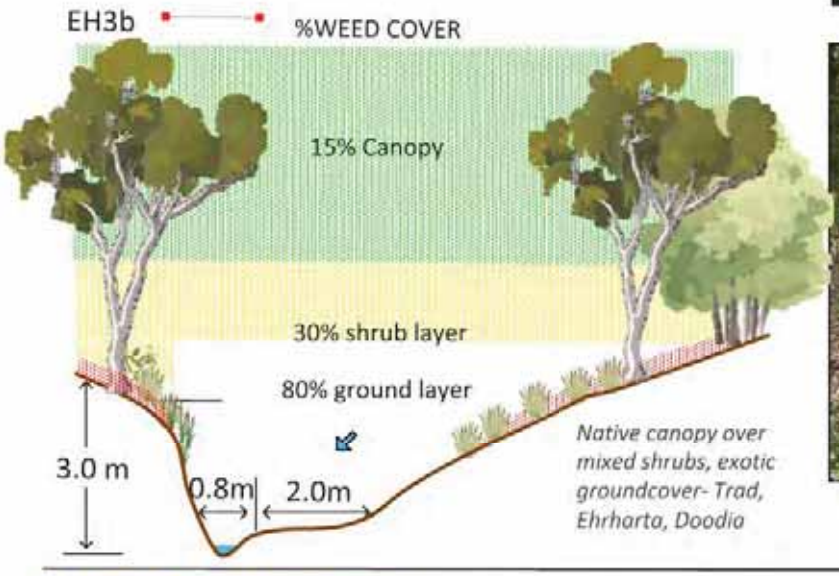
EEC Blue Gum High Forest

EDNA HUNT SANCTUARY

CROSS SECTIONS







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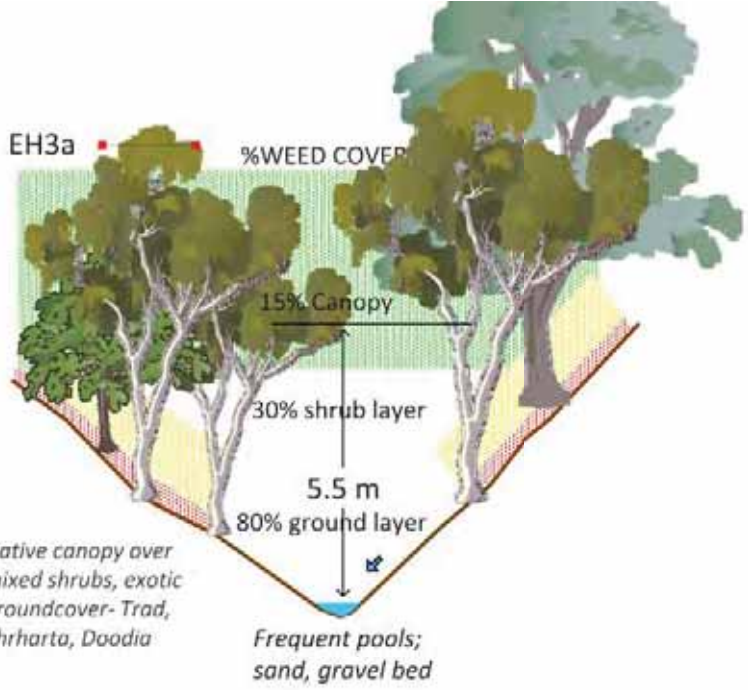

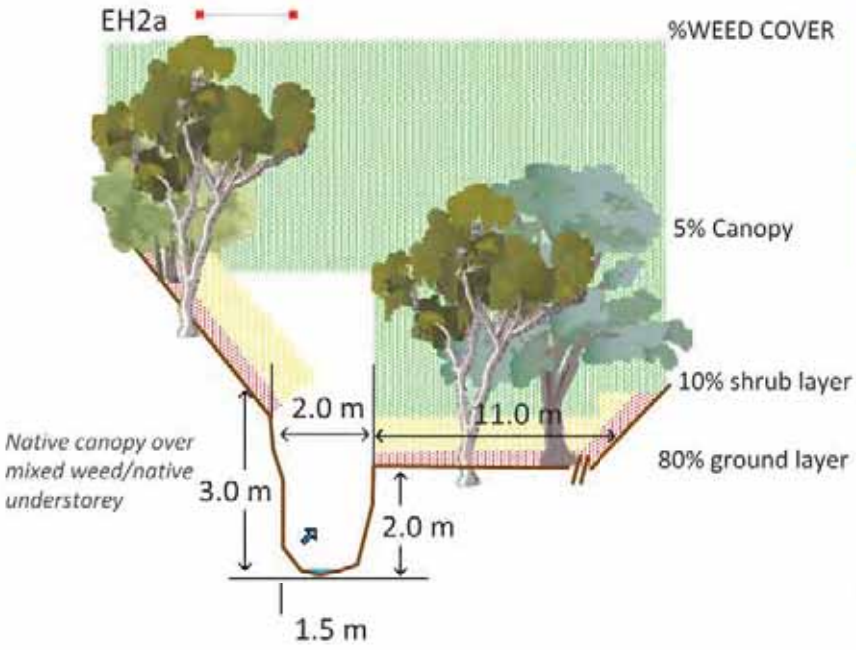

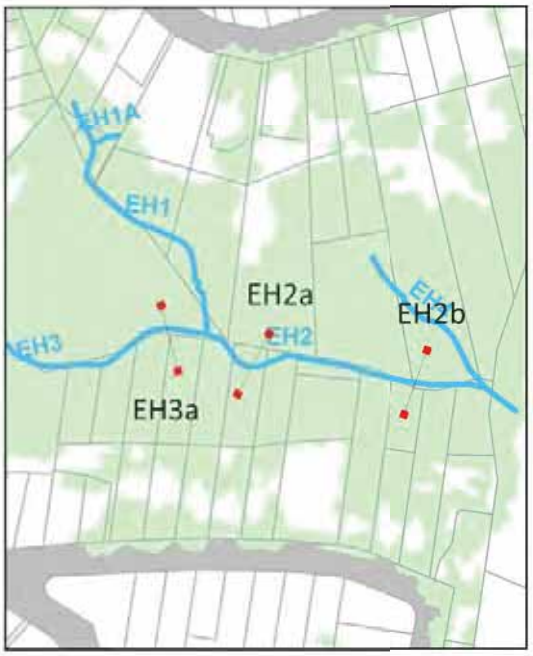

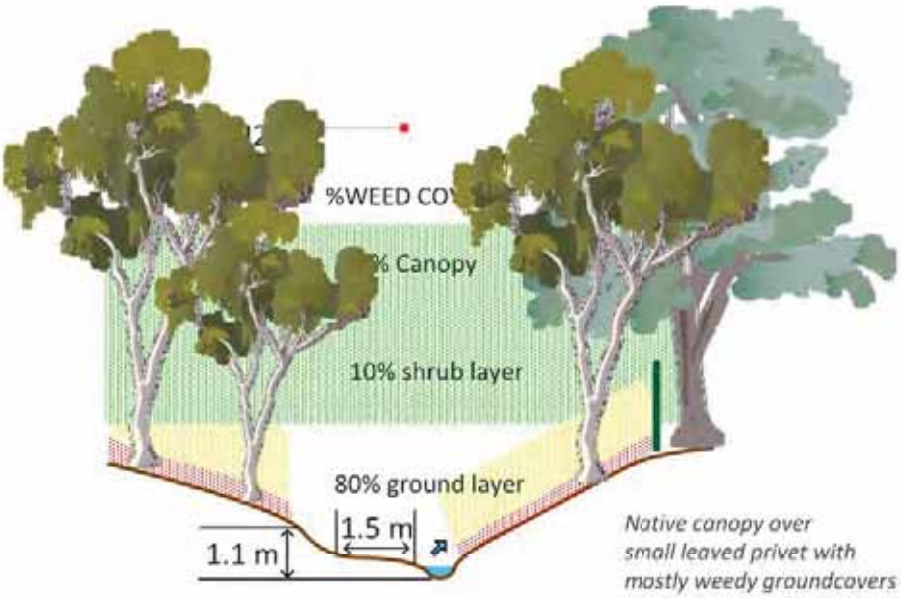

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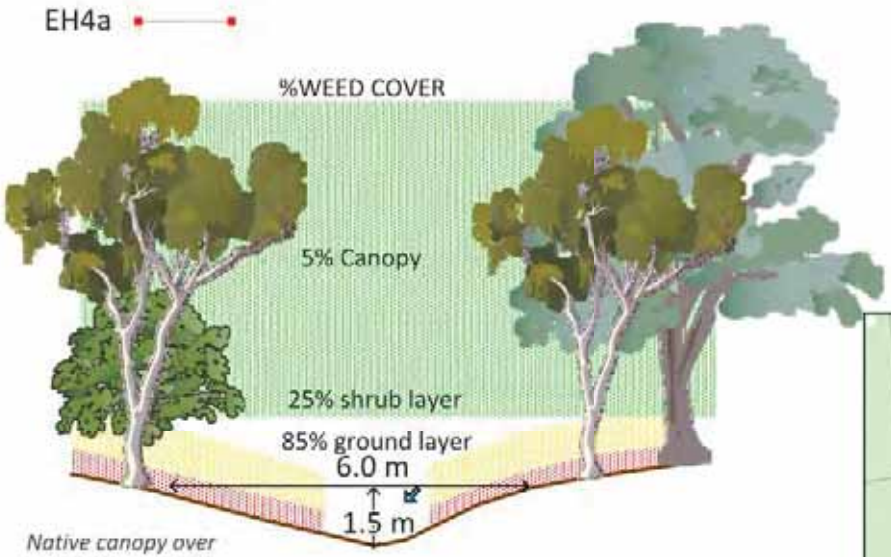
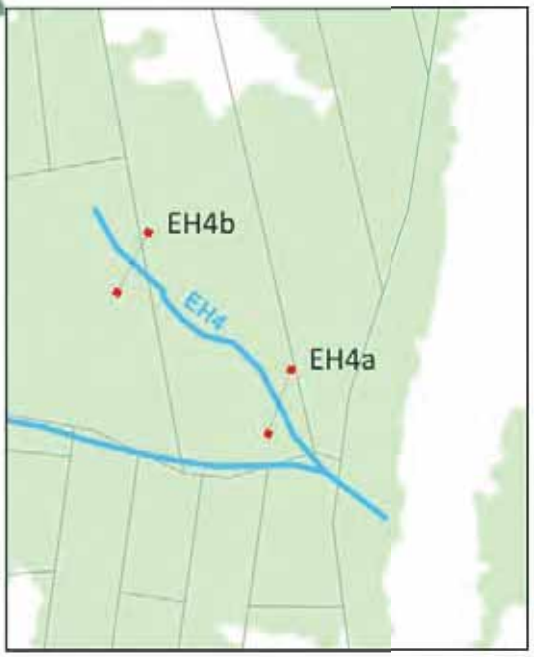
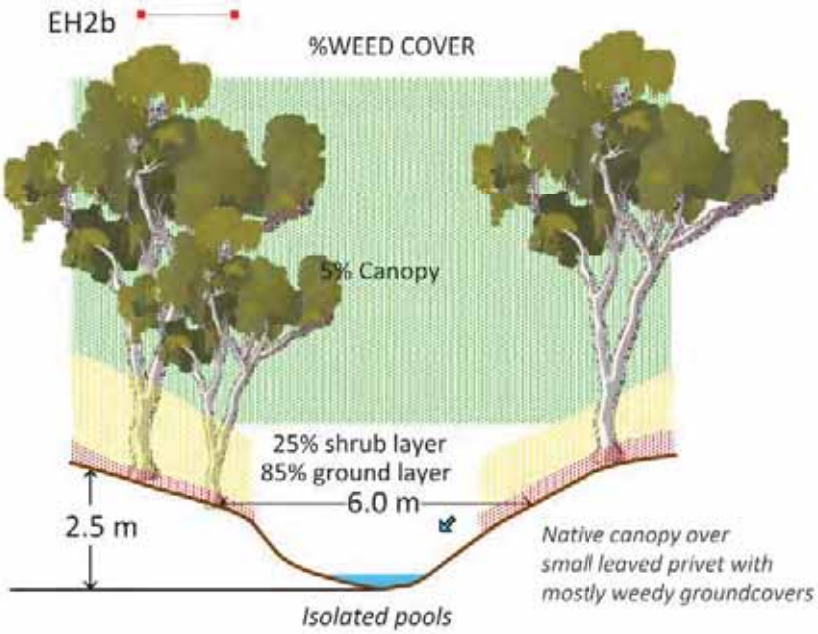
CROSS SECTIONS



Native canopy over mixed shrubs, and predominantly native groundcovers





Native canopy over small leaved privet with mostly weedy groundcovers

Isolated pools

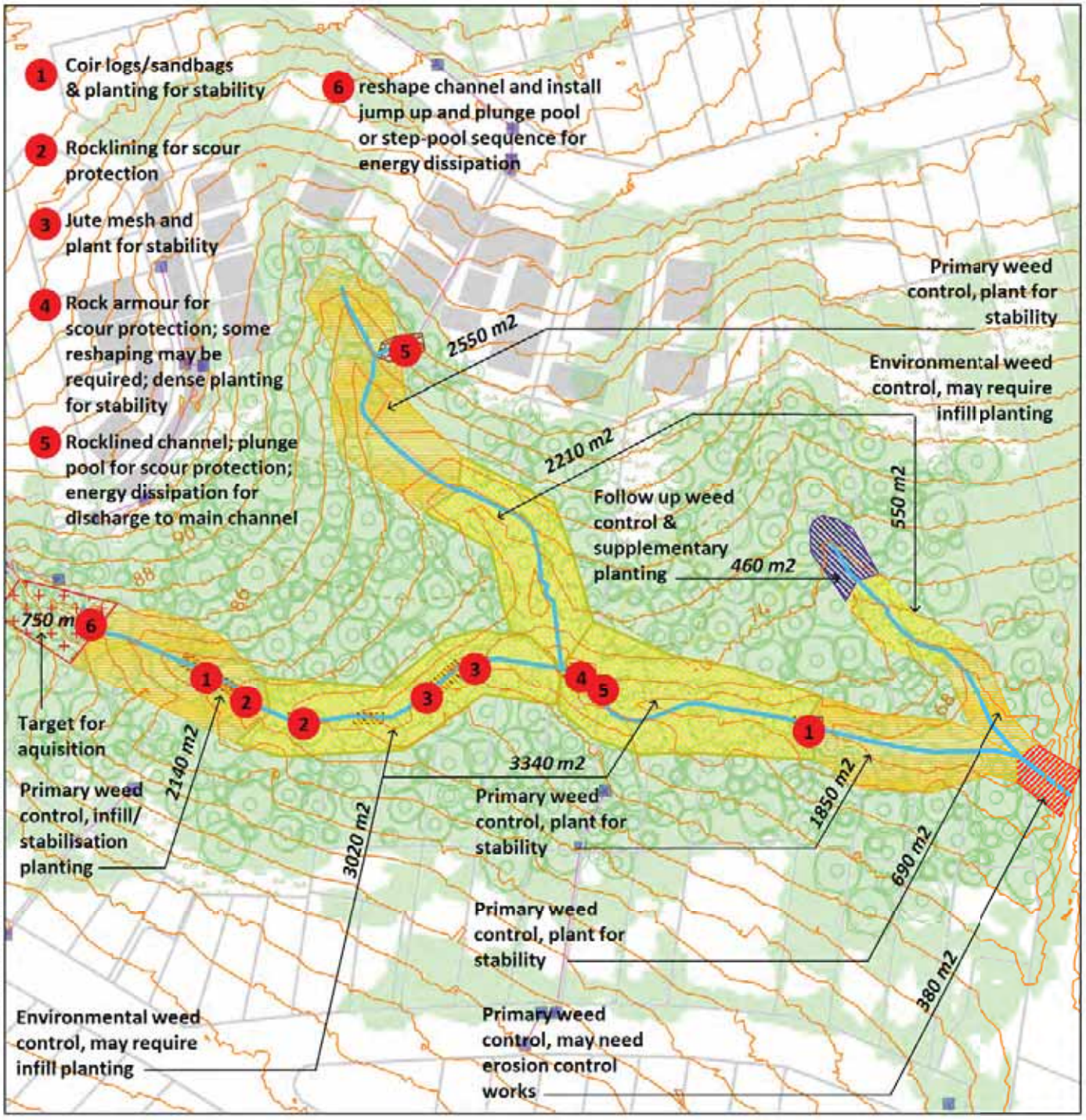
data collected 6-8/03/2013

EDNA HUNT SANCTUARY

WORKS PLAN

VEGETATION COMMUNITIES

Blue Gum High Forest (BGHF)

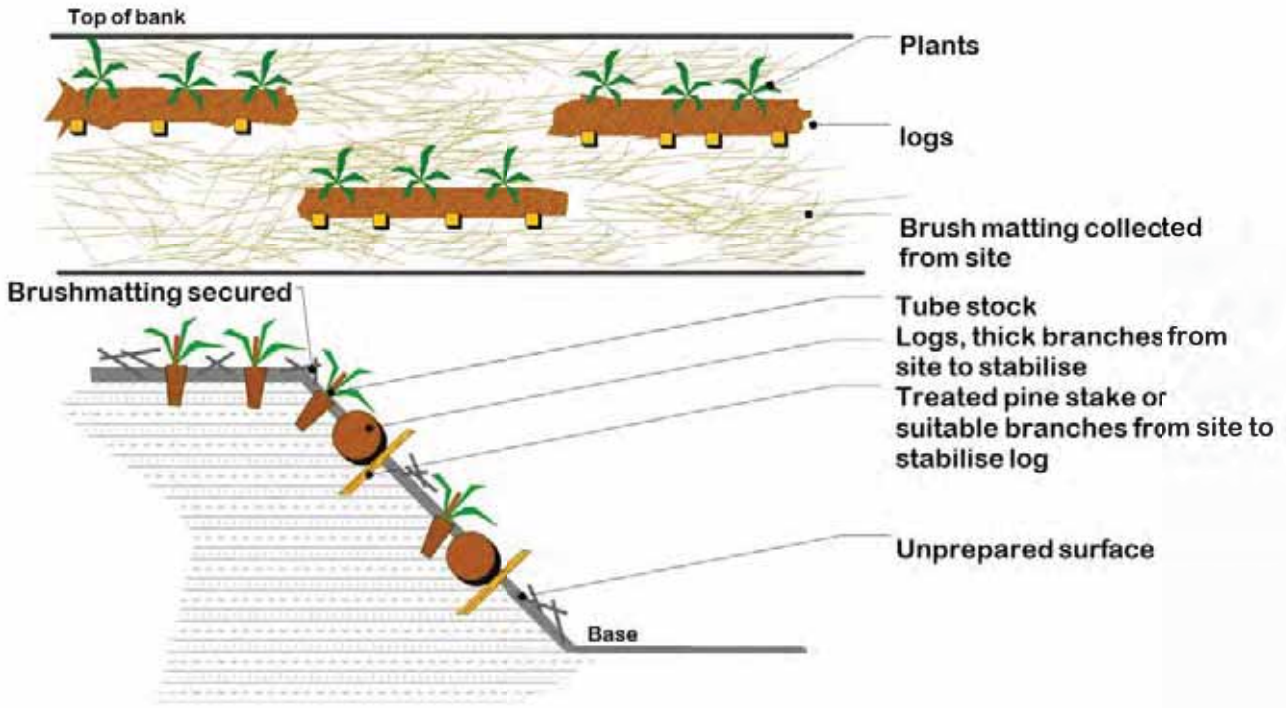


EDNA HUNT SANCTUARY

WORKS PLAN

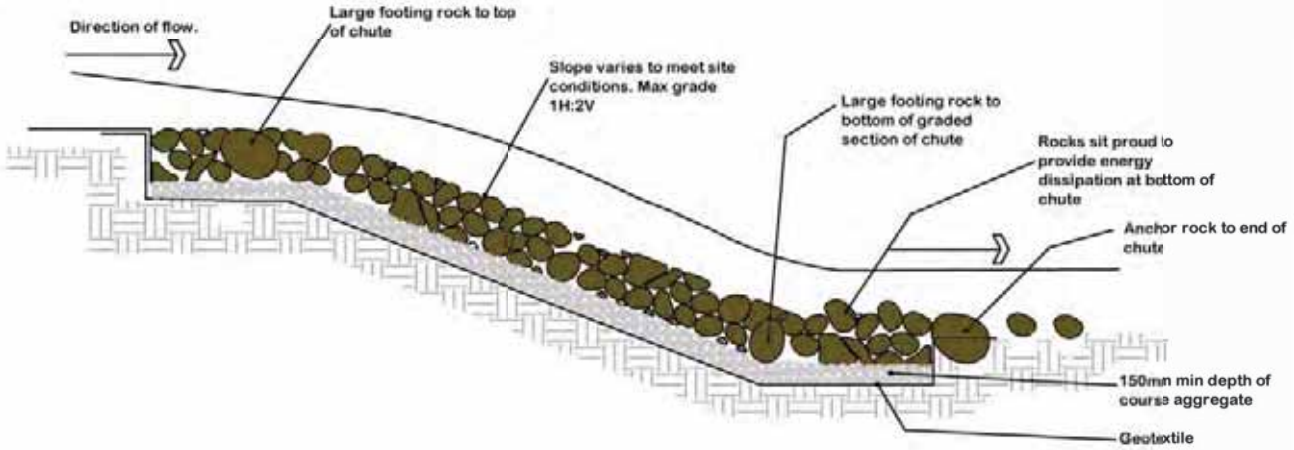
1

BANK TREATMENT USING LOGS AND STAKES (NTS)



2 4

ROCK CHUTE (not to scale)



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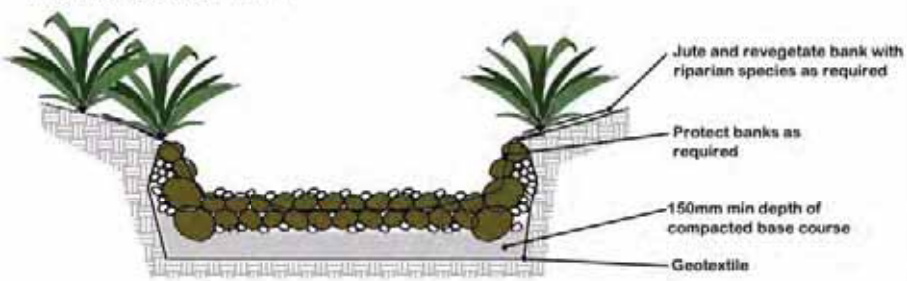
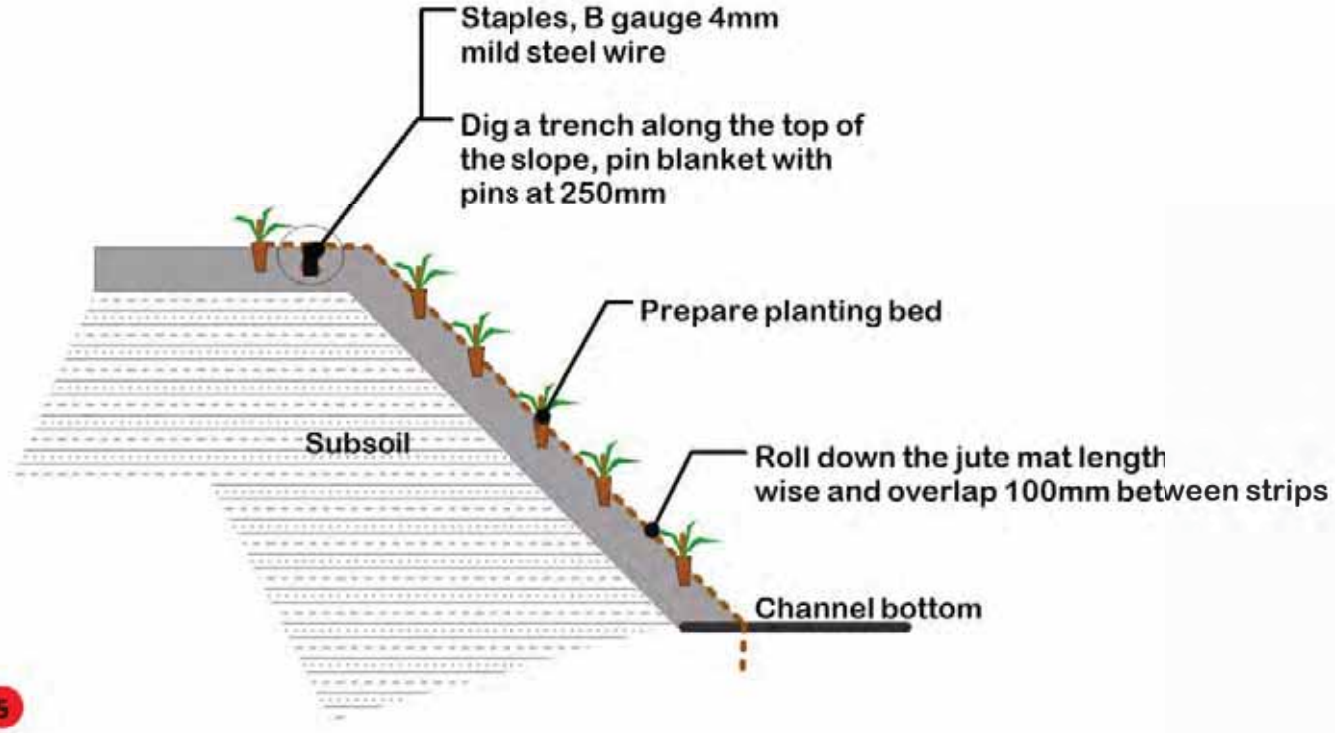


EDNA HUNT SANCTUARY

WORKS PLAN

3

JUTE MAT BANK TREATMENT (NTS)



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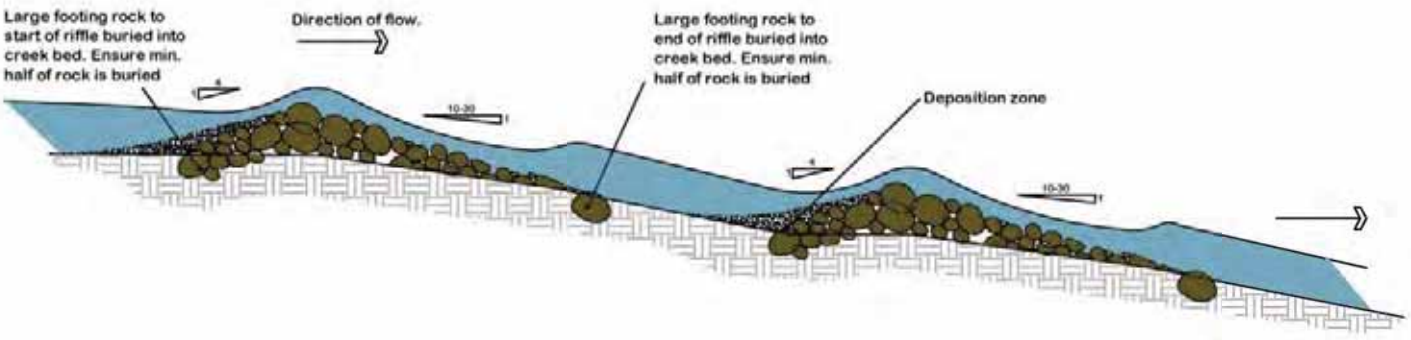
ROCK RIFFLE (not to scale)

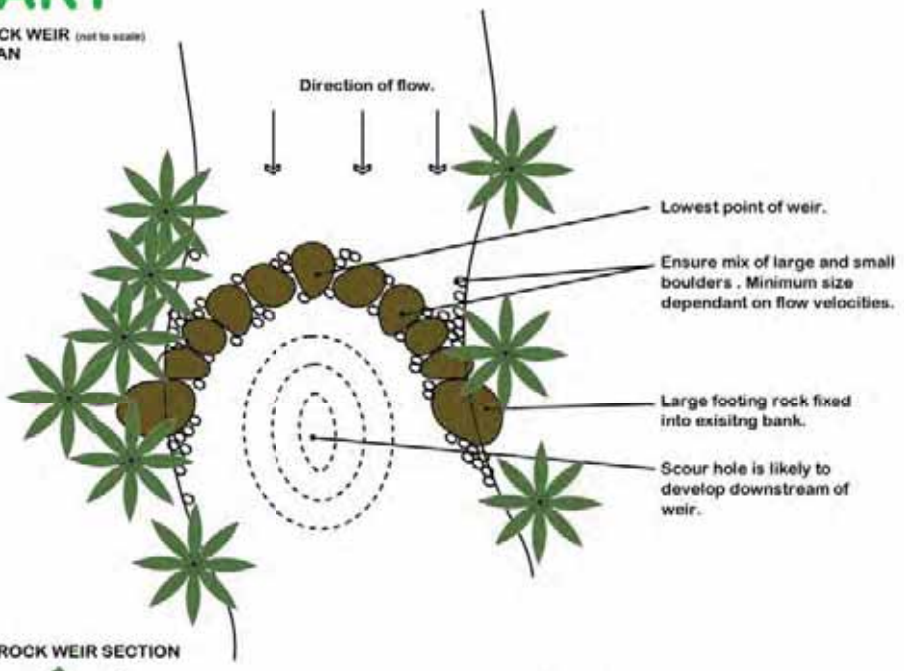


EDNA HUNT SANCTUARY

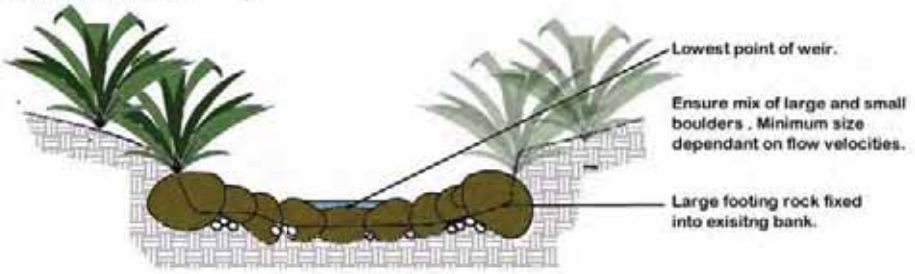
WORKS PLAN

4 5

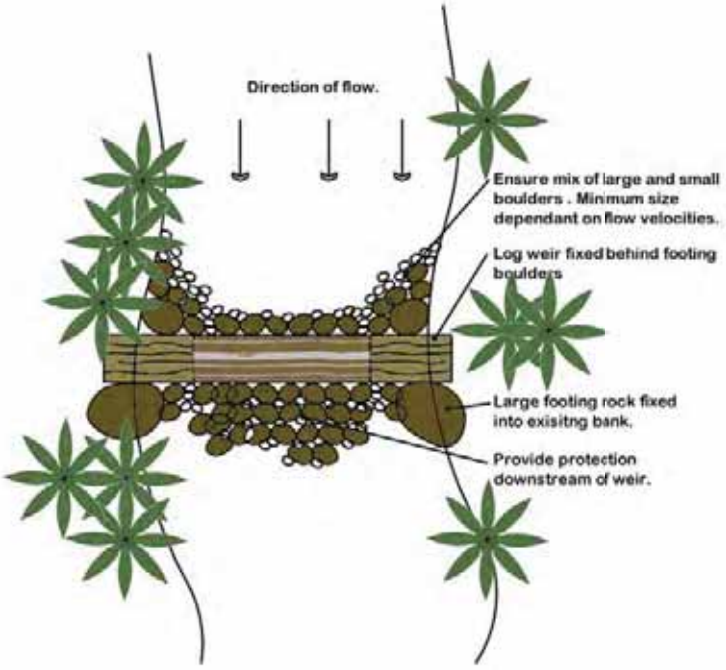
ROCK WEIR (not to scale)
PLAN



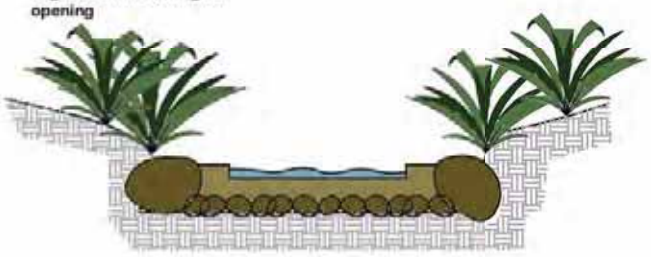
ROCK WEIR SECTION



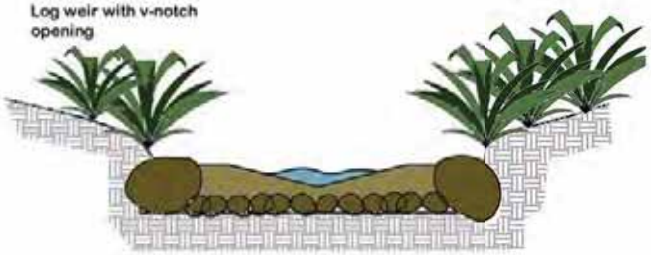
LOG WEIR (not to scale)
PLAN



Log weir with rectangular opening



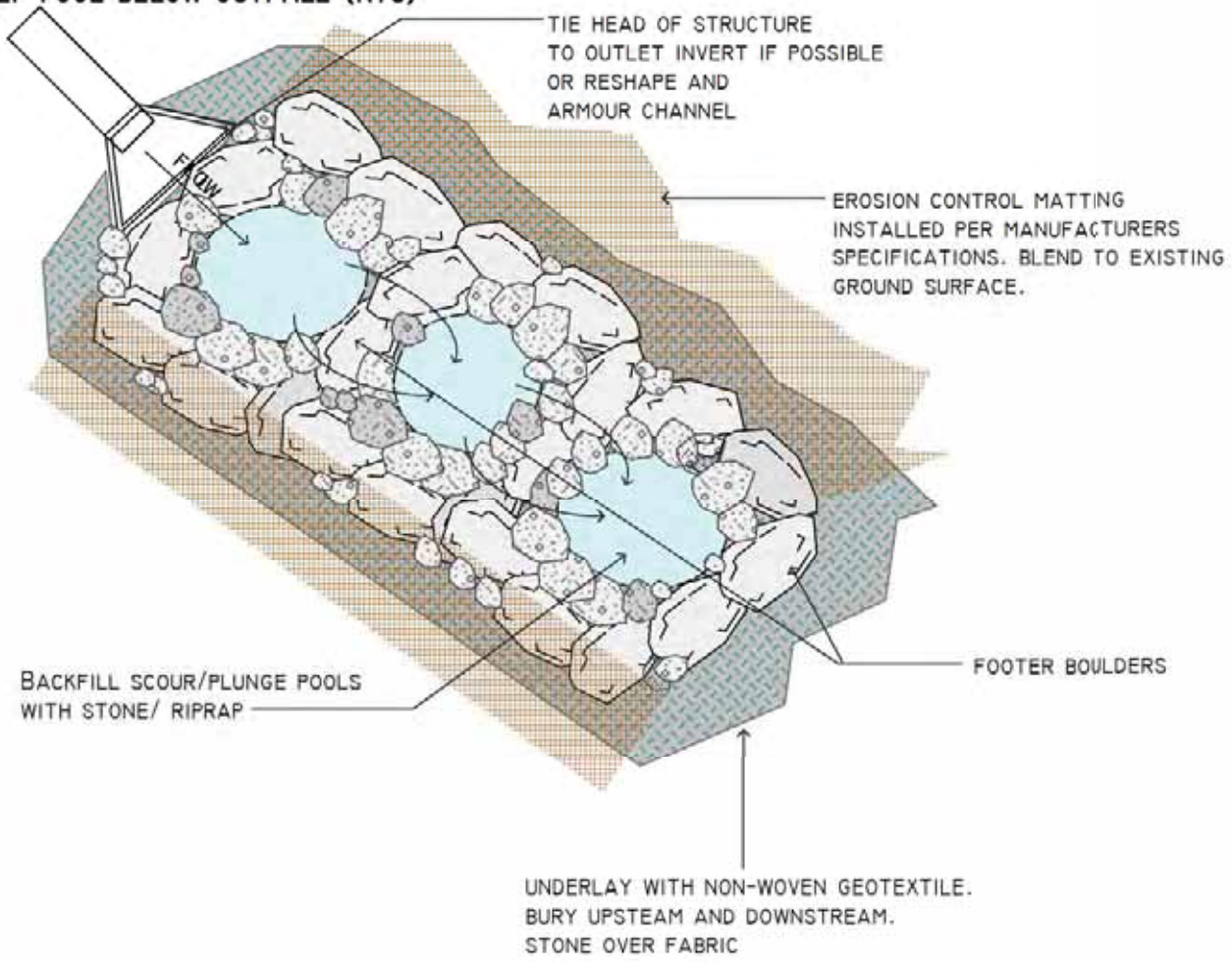
Log weir with v-notch opening



EDNA HUNT SANCTUARY

WORKS PLAN

6 STEP-POOL BELOW OUTFALL (NTS)



12.15 EDNA HUNT WORKS PLANS & COSTINGS

12.15.1 EDNA HUNT 1

Table 38 Management actions and works required for reaches EH1 and EH1A in EDNA HUNT SANCTUARY

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
EH1	Community and recreation: footbridge repairs, including handrails	Very high	Unit	Dependent on extent of repairs required	N/A	OS&NR
EH1	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	2550m2	$5-8K	$1-2K	OS&NR
EH1	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	Medium	2210m2	$2-5K	$1-2K	OS&NR
EH1A	Erosion control: rock lining/plunge pool for drop scour protection	Very high	15m	$25-50K	<$2K	OS&NR
EH1A	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	100m2	$1-2K	<$0.5K	OS&NR

12.15.2 EDNA HUNT 2

Table 39 Management actions and works required for reach EH2 in EDNA HUNT SANCTUARY

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSI-BILITY
EH2	Erosion control: rock lining/plunge pool for drop scour protection	Very high	20m	$30-50K	$1-2K	OS&NR

EH2	Erosion control: reshape channel banks/bed	High	30m	$25-40K	$2-5K?	OS&NR
EH2	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	1850m2	$10-15K	$1-2K	OS&NR
EH2	Biodiversity enhancement: jute matting with coir logs/sandbags, and stabilisation planting using Blue Gum High Forest species	High	30m	$8-12K	$1-2K	OS&NR
EH2	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	Medium	3340m2	$8-12K	$1-2K	OS&NR
EH2	Biodiversity enhancement: monitor for erosion; may require earthworks	Ongoing	Through out	As req'd	N/A	OS&NR
Extension area	Biodiversity enhancement: control noxious and environmental weeds	High	380m2	$3-5K	<$1K	OS&NR
Extension area	Biodiversity enhancement: coir logs/sandbags for minor toe erosion, plant with Blue Gum High Forest species	Medium/ ongoing	380m2	$5-8K	<$1K	OS&NR

12.15.3 EDNA HUNT 3

Table 40 Management actions and works required for reach EH3 in EDNA HUNT SANCTUARY

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
EH3	Erosion control: rock lined channel/rock armouring	Very high	20m	$25-50K	$1-2K	OS&NR

EH3	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	2140m2	$5-8K	$1-2K	OS&NR
EH3	Biodiversity enhancement: jute matting with stabilisation planting using Blue Gum High Forest species	High	30m	$5-8K	$1-2K	OS&NR
EH3	Biodiversity enhancement: coir logs/sandbags for minor toe erosion, plant with Blue Gum High Forest species	High	10m	$3-5K	$1-2K	OS&NR
EH3	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	Medium	3020m2	$3-5K	$1-2K	OS&NR

12.15.4 EDNA HUNT 4

Table 41 Management actions and works required for reach EH4 in EDNA HUNT SANCTUARY

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA (ha) / LENGTH (m)	INITIAL COST	ONGOING COSTS (per annum)	RESPONSIBILITY
1	Biodiversity enhancement: primary weed control and stabilisation planting using Blue Gum High Forest species	High	690m2	$2-3K	$1-2K	OS&NR
2	Biodiversity enhancement: bush regeneration weed control, infill/stabilisation planting using Blue Gum High Forest species	Medium	550m2	$1-2K	<$1K	OS&NR
3	Biodiversity enhancement: followup/maintenance weed control	Medium	460m2	$1K	<$1K	OS&NR

13 FLORA SPECIES FOR REVEGETATION

13.1 BLUE GUM HIGH FOREST (Vegetation class S_WSF01; SMCMA, 2010)

Blue Gum High Forest (Benson & Howell 1990) is a tall wet sclerophyll forest found on fertile shale soils in the high rainfall districts of Sydney's north shore. It is dominated by Sydney blue gum (*Eucalyptus saligna*), blackbutt (*Eucalyptus pilularis*) and turpentine (*Syncarpia glomulifera*) with a number of other eucalypts occurring patchily. A sparse to open cover of small trees is found at most sites and includes a variety of sclerophyllous and mesophyllous species. The ground layer can be variable in both composition and cover. It may be ferny, grassy or herbaceous depending on topographic situation and disturbance history. At some sites vines and climbers may be prolific.

Blue Gum High Forest is found on a range of shale or shale influenced substrates in areas receiving between 900 and 1300 millimetres of mean annual rainfall. This includes elevated gullies, ridgelines, crests and slopes underlain by Wianamatta Shales as well as small gully heads where downlslope movement of shale soil lies above sandstone bedrock. In these latter situations sandstone outcrops may be present although occupy a minor component of the site. Typically it occurs at altitudes above 117 metres above sea level although it is known to occur as low as 30 metres and as high as 185 metres. It is most common across the ridgelines between Castle Hill and St Ives with small areas found in Ryde, Lane Cove and Willoughby where it is found at lower elevations.

Blue Gum High Forest is listed as a Critically Endangered Ecological Community under Schedule 1 of the NSW Threatened Species Conservation Act 1995. Blue Gum High Forest in the Sydney Basin Bioregion is also listed as Critically Endangered Ecological Community under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Floristically this community is similar to Coastal Sandstone Enriched Moist Forest and Sydney Turpentine Ironbark Forest. It grades into Sydney Turpentine Ironbark Forest at low elevations near Ryde.

Table 42 Species recommended for revegetation in Blue Gum High Forest

CORE SPECIES	ADDITIONAL SPECIES
TREES & SHRUBS	
Angophora costata	*Acacia floribunda*
Breynia oblongifolia	*Acacia implexa*
Eucalyptus paniculata ssp paniculata	*Acacia parramattensis*
Eucalyptus pilularis	*Allocasuarina torulosa*
Eucalyptus saligna	*Clerodendrum tomentosum*
Notelaea longifolia	*Elaeocarpus reticulatus*
Pittosporum revolutum	*Glochidion ferdinandi*
Pittosporum undulatum	*Homalanthus populifolius*
Polyscias sambucifolia	*Maytenus silvestris*

CORE SPECIES	ADDITIONAL SPECIES
Syncarpia glomulifera	*Melia azedarach*
Trema tomentosa	*Ozothamnus diosmifolius*
	Zieria smithii
VINES & GROUNDCOVERS	
Cayratia clematidea	*Blechnum cartilagineum*
Clematis glycinoides var. glycinoides	*Calochlaena dubia*
Desmodium varians	*Centella asiatica*
Dichondra repens	*Clematis aristata*
Echinopogon ovatus	*Commelina cyanea*
Entolasia marginata	*Dianella caerulea*
Eustrephus latifolius	*Digitaria parviflora*
Geranium homeanum	*Doodia aspera*
Glycine microphylla	*Echinopogon caespitosus var. caespitosus*
Leucopogon juniperinus	*Glycine clandestina*
Oplismenus aemulus	*Glycine tabacina*
Oplismenus imbecillis	*Hardenbergia violacea*
Pandorea pandorana	*Hydrocotyle peduncularis*
Poa affinis	*Imperata cylindrica*
Pratia purpurascens	*Kennedia rubicunda*
Pseuderanthemum variabile	*Lomandra longifolia*
Sigesbeckia orientalis	*Microlaena stipoides var. stipoides*
Tylophora barbata	*Morinda jasminoides*
Veronica plebeia	*Oxalis perennans*
	Platylobium formosum
	Rubus parvifolius
	Sarcopetalum harveyanum
	Smilax glyciphylla
	Solanum prinophyllum
	Stephania japonica var. discolor

14 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

14.1 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.

14.2 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

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APPENDICES

1) FEDERAL AND STATE LEGISLATION AND POLICIES
2) HERITAGE REPORTS
    i. INDIGENOUS HERITAGE ASSESSMENT
    ii. EUROPEAN HERITAGE ASSESSMENT
3) WORKS ACTIVITIES – DESCRIPTIONS
4) ADDITIONAL DETAILED MAPPING
    i. Catchment overview
    ii. Elevation model
    iii. Pipe network, GPTs and weirs
    iv. Stormwater pipe network diameters
    v. Vegetation communities
    vi. Bushcare/contract sites
    vii. Reach condition score
    viii. Reach geomorphology score
    ix. Reach riparian vegetation score

16 APPENDIX ONE: FEDERAL AND STATE LEGISLATION AND POLICIES

Table A 1. Overview of Legislation and its relevance for maintenance and rehabilitation in Terry's Creek waterways corridor (PCC lands)

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
COMMONWEALTH (LEGISLATION)		
Environment Protection and Biodiversity Conservation Act 1999	The main objects of this Act are: "_ to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance" and "_ to promote ecological sustainable development through the conservation and ecologically sustainable use of natural resources".	A Commonwealth Act supporting Ecologically Sustainable Development (ESD), providing a significant overlap with NSW State Legislation such as the Environmental Planning & Assessment Act 1979 and the Threatened Species Conservation Act 1995. Future activities in waterway corridors should be undertaken within a framework of ESD. If approvals are required, NSW system can be accredited upon application being made to the Commonwealth Department.
COMMONWEALTH (POLICIES)		
Our Cities, Our Future: A National Urban Policy for a productive, sustainable and liveable future (2010)	This National Urban Policy sets a vision for our cities to deliver future prosperity and wellbeing for our communities and reinforces the Council of Australian Governments' (COAG) national objective to ensure Australian cities are globally competitive, productive, sustainable, liveable, socially inclusive and well placed to meet future challenges and growth. The National Urban Policy complements the Australian Government's Sustainable Population Strategy and our ongoing focus and commitment to Regional Australia. It recognises the strong interrelationships between cities and regions. The policy does not focus on capital cities alone, but recognises the important role that our major regional centres also play, and the substantial challenges that they face in dealing with the complexities of the modern economy. This policy reports that people value an attractive natural environment.	The Australian Government's objective is to advance the sustainability of Australia's natural and built environment through better resource and risk management. The policy outlines several funding strategies to support protection of our natural and built environments. It recommends avoiding and mitigating the impacts on critical environments, and incorporating quality green space, microclimate and water sensitive design into urban systems. Several strategies relating to management of climate change are also mentioned, including land use planning and reduction of emissions.
Australia's Biodiversity Conservation Strategy 2012-2030 (2010)	This Strategy describes the importance of biodiversity conservation, and briefly reviews some of the main threats. The Strategy highlights three priorities for action:	Priorities for Action 1 include mainstreaming biodiversity, increasing indigenous engagement, and enhancing strategic investments and partnerships. For Action 2 they are protecting biodiversity,

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
	1 Engaging all Australians 2 Building ecosystem resilience in a changing climate 3 Getting measurable results	maintaining and re-establishing ecosystem functions, and reducing threats to biodiversity. For Action 3 priorities are improving and sharing knowledge, delivering conservation initiatives efficiently, and implementing robust national monitoring, reporting and evaluation.
Wetlands Policy of the Commonwealth Government of Australia	This policy provides strategies to ensure that the activities of the Government promote the conservation, ecologically sustainable use and enhancement, where possible, of wetlands functions. Among others, those strategies include: "Involving the Australian people in wetlands management" and "working in partnership with State/Territory and Local Governments".	The policy seeks to promote and support local government efforts in wetlands conservation and management, through encouragement of the preparation of local wetlands policies. Such local policies may form part of future waterway maintenance and rehabilitation master plans.
Local Agenda 21	In 1992, at a UN conference on environment and development, Agenda 21 was endorsed, and set out how both developed and developing countries could work towards sustainable development. Local authorities were one of the groups recognised as being fundamental in working towards sustainable development (and hence "Local" Agenda 21). At the local level in Australia, the 1997 "Newcastle Declaration" (made at an international conference focussing on the challenge of sustainability for local government) clarified and re-stated the commitment of local government in Australia to Agenda 21 and sustainable development.	The application of the principles of Local Agenda 21 during the preparation and implementation of waterway maintenance and rehabilitation master plans will ensure management within a framework of ESD. Stakeholder and Focus Group meetings were designed to involve the community through the development of specific "Vision" for Terry's Creek catchment.

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
STATE (LEGISLATION)		
Catchment Management Authorities Act 2003	The purpose of the Act is to establish Catchment Management Authorities (CMAs) as the key regional government bodies to manage the State's natural resources at the catchment level. The CMAs are responsible for developing Catchment Action Plans (CAPs) and facilitating natural resource management investment in their regions.	CMAs are being replaced as the key regional body for management of natural resources, and are being replaced with Local Land Services (LLS) which will be run by farmers.
Environmental Planning &	This Act and its accompanying Regulation are the primary legislation for landuse planning in NSW. The Act encourages, among other	The Act ensures that future activities in the waterway corridors are undertaken within a framework of ESD, and that future maintenance and

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
Assessment Act, 1979	things: • the "proper management, development and conservation of natural and artificial resources"; • the "protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats"; and • "ecological sustainable development".	rehabilitation activities are permissible within each landuse zone within which the waterway corridor lies, and that the environmental impact of any activity or work has been properly assessed.
Fisheries Management Act 1994	This Act aims to "conserve develop and share the fishery resources of the State for the benefit of present and future generations". Among other things, the Act aims to "conserve threatened species, populations and ecological communities of fish and marine vegetation" and "to promote ecologically sustainable development".	This Act will ensure that any future activities in the waterway corridors will maintain and enhance aquatic habitat. Approvals may be required under this Act depending on the nature of the proposed works.
Local Government Act 1993	This is an Act to guide the operation of Local Government. It requires Councils among other things, "to carry out activities, appropriate to the current and future needs of local communities …..". The Act directs Councils to prepare plans of management for, among others, community land. Where community land is categorised as a "natural area", and is further categorised as a "watercourse", specific directions are made as to the core management objectives. Where land is categorised as a "natural area" the core management objectives include: • to "conserve biodiversity and maintain ecosystem function"; • to "maintain the land,..., in its natural state and setting"; • to "provide for the restoration and regeneration of the land …..". Where land is further categorised as a "watercourse" the core management objectives also include: • to "manage watercourses so as to protect the biodiversity and ecological values of the instream environment, particularly in relation to water quality and water flows"; • to "manage watercourses so as to protect the riparian environment, particularly in relation to riparian vegetation and habitats and bank stability";	The Council's management of its waterways, and in particular the preparation of waterways Maintenance and Rehabilitation master plans, is driven through compliance with this Act.

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
	• to "restore degraded watercourses"; and • • to "promote community education and community access to and use of the watercourse".	
Noxious Weeds Act 1993	This act aims to ensure appropriate measures for the control of noxious weeds throughout NSW, and requires control of weed species listed under various schedules.	As a landowner, Council has an obligation to control noxious weeds along waterway corridors. Noxious weeds declared in Parramatta LGA and recorded in Terry's Creel catchment include: • Asparagus Fern – Class 4 • Asthma Weed – Class 4 • Balloon Vine – Class 4 • Blackberry – Class 4 • Bridal Creeper – Class 4 • Lantana – Class 4 • Large-leaved Privet – Class 4 • Madeira Vine – Class 4 • Morning Glory – Class 4 • Small-leaved Privet – Class 4
Protection of the Environment Operations Act 1997	This Act has as one of its objectives, among other things, to "protect, restore and enhance the quality of the environment in New South Wales having regard to the need to maintain ecologically sustainable development". The Act provides for a range of key pollution control legislation including waters, noise and air. These Regulations enable the classification of waters in NSW and regulate the permissible discharge of pollutants to those waters.	Parts of this Act regulate the discharge of pollutants into waterways in NSW.
Protection of the Environment Administration Act 1991	The principal objective of this Act is to constitute the Environment Protection Authority and to provide for the integrated administration of environmental protection. The Act requires that regard be had to the need for ecologically sustainable development.	This Act ensures that future activities within waterway corridors are undertaken within a framework of ESD.
Soil Conservation Act 1938	This Act makes provision for the conservation of soil resources and for the mitigation of soil erosion.	A landowner may be directed under the provisions of this Act to undertake remedial works to reduce an erosion hazard. Should the bed or banks of any waterway be identified as such a hazard, Council, as a landowner, may be directed to carry out such works. The Masterplans will identify appropriate works.

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
Threatened Species Conservation Act 1995	An Act to conserve threatened species, populations and ecological communities. Among other things, the objects of this Act include: • to "conserve biological diversity and promote ecologically sustainable development" and • to "protect the critical habitat of those threatened species, populations and ecological communities that are endangered".	Where any activities, proposed to be carried out in the Masterplans, are located within or adjacent to an endangered species or critical habitat, compliance with this Act may require the preparation of an eight part test to assess likely impacts and if necessary, the preparation of a Species Impact Statement, or may require the provision of alternative conservation measures.
Water Management Act 2000	This Act replaces the Water Act 1912 and the River and Foreshores Improvement Act 1948 and provides for "the protection, conservation and ecologically sustainable development of the water sources of the state". The Act sets out water management principles which include: • "water sources, floodplains and dependant ecosystems (including groundwaters and wetlands) should be protected and restored and, where possible, land should not be degraded"; • "habitats animals and plants that benefit from water or are potentially affected by managed activities should be protected and (in the case of habitats) restored".	This Act ensures that future activities in the waterway corridors are undertaken within a framework of ESD. If a 'controlled activity' is proposed on 'waterfront land', an approval is required under the Water Management Act. (s91) 'Controlled activities' include, inter alia: • the removal of material or vegetation from land by excavation or any other means; • the deposition of material on land by landfill or otherwise; or • any activity that affects the quantity or flow of water in a water source. 'Waterfront land' is defined as the bed of any river or lake, and any land lying between the river or lake and a line drawn parallel to and forty metres inland from either the highest bank or shore (in relation to non-tidal waters) or the mean high water mark (in relation to tidal waters).

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
STATE (POLICY)		
Flood Prone Land Policy	The primary objective of the policy is "to reduce the impact of flooding and flood liability on individual owners and occupiers of floodprone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible". The policy provides for among other things: "… the need to consider ways of maintaining and enhancing the riverine and floodplain ecology in the development of floodplain risk management plans".	Any future activity to be implemented through the master plans will be considered from a floodplain risk management perspective. Impacts of works or activities will be assessed against predicted impacts on flood behaviour. The policy sets out the process leading to the preparation of Floodplain Risk Management Plans, for the waterways and associated floodplains.

Rivers and Estuaries Policy	A Policy which has as its objectives the management of the State's Rivers and Estuaries in ways which: • "slow, halt or reverse the overall degradation in their systems"; • "ensure the long term sustainability of their essential biophysical functions"; and • "maintain the beneficial use of these resources."	One of the principles of this Policy is: "Environmentally degraded areas should be rehabilitated and their biophysical functions restored". This principle will guide the planned activities to be implemented through the Terry's Creek master plans.
NSW Biodiversity Strategy	A strategy launched by the NSW Government in 1999. The strategy commits all government agencies to biodiversity conservation across all landscapes of the State. Goals of the strategy include, among others: "_ Protecting native species and ecosystems"; "_ Managing natural resources better"; and "_ Involving landowners and communities in biodiversity conservation".	This strategy ensures that State Government authorities involved throughout the preparation and implementation of master plans will focus broadly on biodiversity conservation.
NSW Weirs Policy	The aim of this policy is to reduce and remediate the environmental impact of weirs. Main components of the policy require: _ the limiting of approvals for new and expanded weirs; _ the review of all existing weirs in NSW; and _ the consideration of the need for fishways ateach structure.	Elements of this policy will ensure the consideration of fish migration where in-stream structures (eg. a rock riffle) are proposed for implementation in the master plans.
NSW Fisheries – Policy and Guidelines for Aquatic Habitat Management and Fish Conservation	These Policies and Guidelines support one of the principal functions of NSW Fisheries, that is, the protection and management of fish resources, marine vegetation and aquatic habitat. General policies include, among others: "Fish and their aquatic habitats are important natural resources, and impacts on these resources must be assessed, in all development and planning procedures, using a precautionary approach"; and, "Terrestrial areas adjoining freshwater, estuarine and coastal habitats should be carefully managed in order to minimise landuse impacts on these aquatic habitats. As a precautionary approach, foreshore buffer zones at least 50 metres wide should be established and maintained, with their natural features and vegetation prescribed….".	Elements of these policies and guidelines will provide direction as to the protection of aquatic habitat during the preparation and implementation of the waterway master plans.
State Environmental Planning Policy (SEPP) 19 – Bushland in Urban Areas	SEPP 19 offers protection to natural bushland on areas zoned or reserved for public open space purposes	Where any works or activities to be implemented through the Masterplan impacts on areas of urban bushland, the provisions of SEPP 19 will apply. Those provisions relate to the extent that the Council must consider the conservation of any bushland proposed to be disturbed.

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
LOCAL GOVERNMENT PLANS		
Parramatta Local Environmental Plan (LEP) 2011	Parramatta LEP 2011 describes the planning controls which apply to landuse zones throughout the Parramatta local government area. Most of the land within the riparian corridor is zoned: • E2 - Environmental conservation • RE1 – Public recreation	Any action or work required through implementation of the Masterplan will be prepared in accordance with the objectives and requirements of the relevant land use zone.
Parramatta Development Control Plan (DCP) 2011	The DCP 2011 provides controls to support the standards set down in the LEP 2011. This document will consolidate all of Council's existing DCPs into a single document. The controls will include requirements for such issues as setbacks.	Future actions or works proposed to be implemented through the Masterplans will be assessed against the appropriate performance standards set down in Parramatta's DCP 2011
Parramatta City Council Tree Preservation Order	The purpose of Council's Tree Preservation Order is to: "establish procedures for the proper management of trees in order to minimise the unnecessary loss of significant tree resources".	Any activity or work required through implementation of the Masterplans, where trees or bushland may be impacted, will require consent under Council's Tree Preservation Order.
Stormwater Management Plans (various catchments)	During 1997, the NSW Environment Protection Authority (EPA) issued Notices to Councils in NSW requiring the preparation of Stormwater Management Plans (SMPs) for catchments under each Council's management. In metropolitan Sydney, most of the SMPs were completed and submitted to the EPA during 1999 and 2000. Each plan described existing catchment conditions, and established catchment values through a process of consultation. Management options and implementation strategies were developed to achieve aims and objectives set out in the SMPs.	Development of a "Vision" for each of Council's waterway corridors will be assisted by the range of catchment values developed during preparation of SMPs. It is expected that waterway Masterplans will be consistent with the aims and objectives of each relevant SMP.
Lane Cove River Estuary Management Plan 2004	This plan provides a series of short and long term management strategies for the implementation of sustainable management of the estuary, and includes a number of directives that relate to riparian corridors in the upper catchment, which are to be protected and managed for biodiversity conservation. The strategy also provides an overview of the catchment's estuarine vegetation and habitat and identifies opportunities for achieving their conservation and enhancement.	Having regard to the rehabilitation of riparian vegetation along waterway corridors and the conservation of biodiversity, actions and implementation strategies proposed in waterway Masterplans should be consistent with those identified in the Lane Cove River Estuary Management Plan and supporting documents.
Eastwood & Terry's Creek Floodplain Risk Management Study & Plan 2008	This Study and Plan were developed in response to repeated significant flooding events in Eastwood town centre and other parts of Terry's Creek. A review of flood mitigation options was undertaken, as well as various council planning initiatives.	Any action or work required through implementation of the Masterplan should take into consideration the objectives and recommendations of the Floodplain Risk Management Plan.

17 APPENDIX TWO: HERITAGE REPORTS

17.1 APPENDIX TWO (a): INDIGENOUS HERITAGE ASSESSMENT

ABORIGINAL HERITAGE ASSESSMENT

TERRY'S CREEK UPPER CATCHMENT

PRELIMINARY REVIEW AND RECOMMENDATIONS

FOR

1943 Aerial Photograph of the study area

March 2013

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17.2 APPENDIX TWO (b): NON-INDIGENOUS HERITAGE ASSESSMENT

PRELIMINARY NON-ABORIGINAL HERITAGE ASSESSMENT UPPER TERRY'S CREEK CATCHMENT AREA

FOR

APPLIED ECOLOGY

Draft Report

March 2013

AHMS

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18 APPENDIX THREE: DESCRIPTION OF WORKS ACTIVITIES

18.1 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
Maintenance/followup weed control	Preservation requirements Restoration works	Applies to bushland areas where there has been previous weed control activities, and is particularly important for areas where there has been planting. Ensures that ecological gains are not lost to subsequent weed invasion.
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

SPECIFIC WORKS REQUIRED	WORKS CATEGORY	GUIDELINES AND COMMENTS
		• Invasion of native plant communities by exotic perennial grasses
Primary weed control of vines	Restoration works	Applies to bushland areas where there are 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 this report.
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.
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 described in this report.
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 matting with native plant material that includes fruiting or seeding structures is a

SPECIFIC WORKS REQUIRED	WORKS CATEGORY	GUIDELINES AND COMMENTS
		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 described in this report. Give priority to species that develop deep roots quickly, or provide good groundcover – a mixture of these is best.
Supplementary/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 described in this report.
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.

18.2 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.

18.3 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
Water quality monitoring point	Preservation requirements Ongoing maintenance	Liaise with local primary and high schools to implement a Streamwatch monitoring 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.

18.4 WORKS ACTIVITIES FOR COMMUNITY AND RECREATION

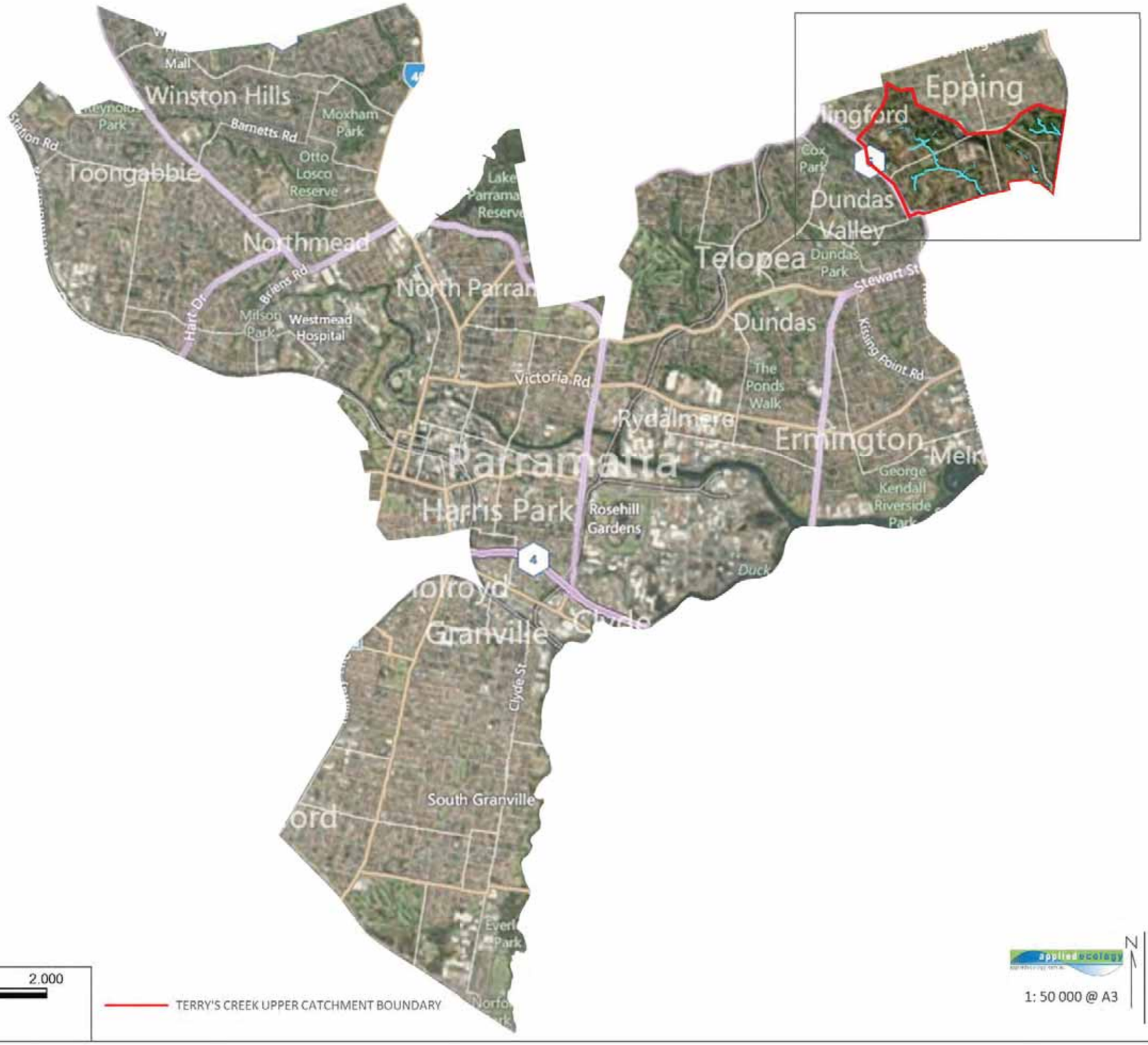
Table A 10. Works activities recommended for community involvement and recreation, with works category, guidelines and comments

WORKS REQUIRED	WORKS CATEGORY	GUIDELINES AND COMMENTS
Install informative signage	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

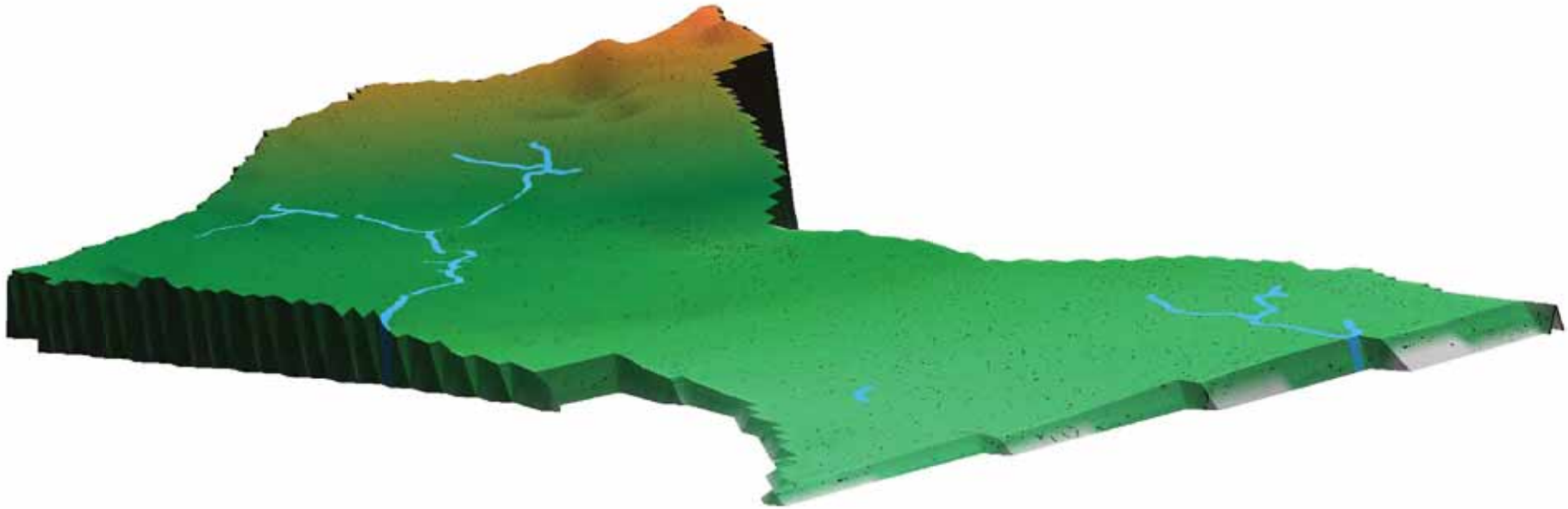
19 APPENDIX FOUR: DETAILED MAPPING OF THE TERRY'S CREEK CATCHMENT

1) OVERVIEW OF TERRY'S CREEK CATCHMENT IN PARRAMATTA LGA
2) ELEVATION MODEL OF TERRY'S CREEK CATCHMENT IN PARRAMATTA LGA
3) PIPE NETWORK, GPTS AND WEIRS OF TERRY'S CREEK CATCHMENT IN PARRAMATTA LGA
4) STORMWATER PIPE SIZING, GPTS AND WEIRS OF TERRY'S CREEK CATCHMENT IN PARRAMATTA LGA
5) VEGETATION OF TERRY'S CREEK CATCHMENT IN PARRAMATTA LGA
6) BUSHCARE SITES OF TERRY'S CREEK CATCHMENT IN PARRAMATTA LGA
7) REACH CONDITION SCORE
8) REACH GEOMORPHOLOGY SCORE
9) REACH RIPARIAN VEGETATION SCORE

OVERVIEW: CONTEXT TERRY'S CREEK CATCHMENT PARRAMATTA LGA



ELEVATION MODEL OF TERRY'S CREEK CATCHMENT PARRAMATTA LGA



Elevation (metres)

200 125 85 50 10

Base layers supplied by client
2m Contour
Waterways by Applied Ecology P/L

MGA94 56
created 4/4/2013 AnneCarey
cp/TCMP/gis/workspaces/A3/3D

PIPE NETWORK, GPTs AND WEIRS OF TERRY'S CREEK CATCHMENT PARRAMATTA LGA

GPT, Weir

Stormwater Pit

Stormwater Pipe

Waterway

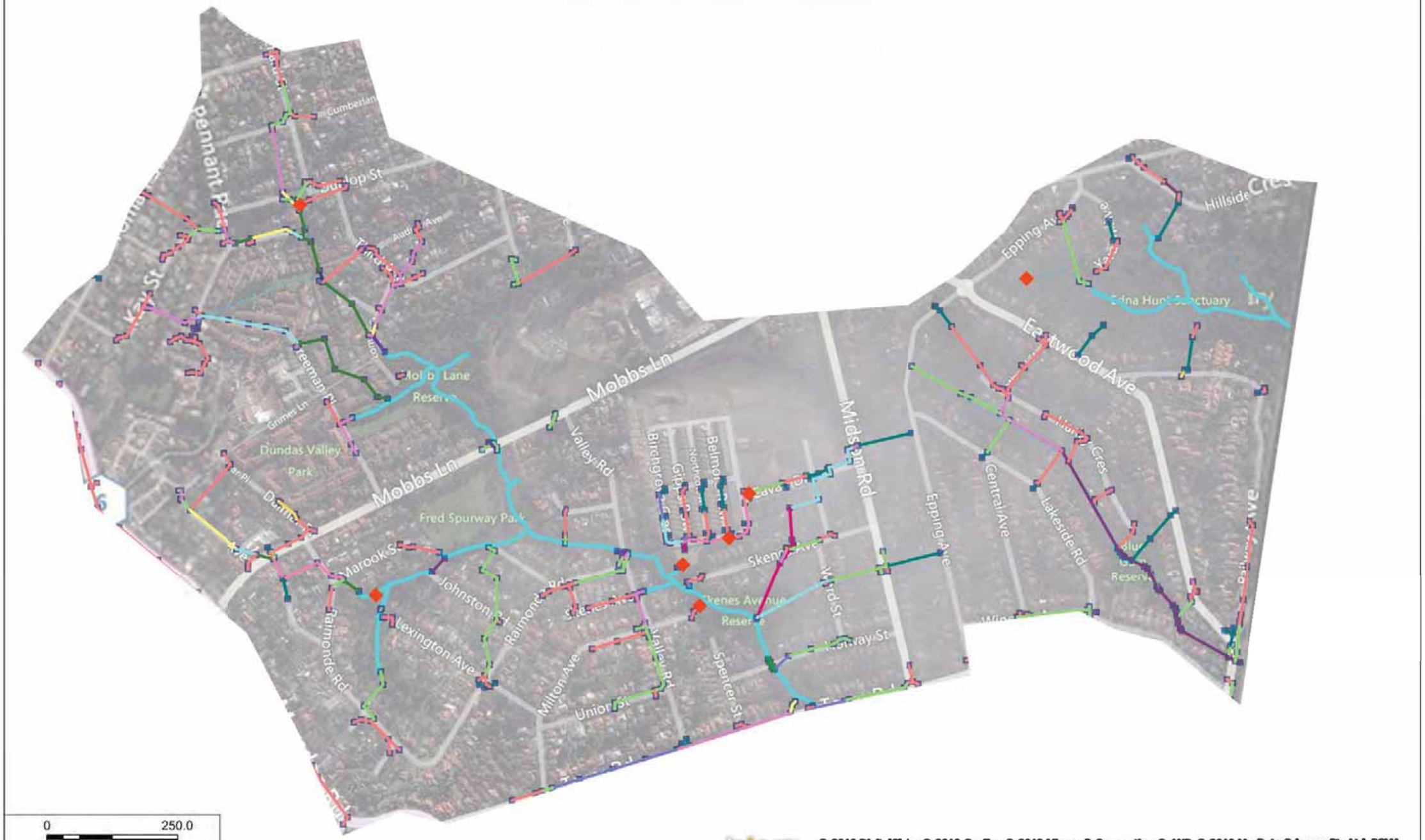
N

1: 7500 @ A3

Base layers supplied by client
Stormwater pits and pipes
Weirs/GPTs by Applied Ecology P/L
Waterways by Applied Ecology P/L

MGA94 56
created 4/4/2013 AnneCarey
cp/TCMP/gis/workspaces/A3

PIPE NETWORK, GPTs AND WEIRS OF TERRY'S CREEK CATCHMENT PARRAMATTA LGA 2



GPT, Weir Stormwater Pit Waterway

Stormwater Pipe by Diameter (mm)

100	150	225	1050	1200	1300	1350	1500	1600	1800	1950	

N

1: 7500 @ A3

Base layers supplied by client
Stormwater pits and pipes
Weirs/GPTs by Applied Ecology P/L
Waterways by Applied Ecology P/L

MGA94 56
created 4/4/2013 AnneCarey
cp/TCMP/gis/workspaces/A3

applied ecology

VEGETATION OF TERRY'S CREEK CATCHMENT PARRAMATTA LGA

Other urban: exotic and native remnant trees

Blue Gum High Forest

Waterways

N

1: 7500 @ A3

Base layers supplied by client
SMCMA 2010 draft vegetation mapping
Waterways by Applied Ecology P/L

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created 4/4/2013 AnneCarey
cp/TCMP/gis/workspaces/A3

applied ecology

BUSHCARE SITES OF TERRY'S CREEK CATCHMENT PARRAMATTA LGA

Waterway

Public Park or Reserve

Recent works 2012-2013

Bushcare

Contractor: Southern Habitat

Contractor: Hills Regenerators

N

1: 7500 @ A3

Base layers supplied by client
Parks
Bushcare sites by Applied Ecology P/L
Waterways by Applied Ecology P/L

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cp/TCMP/gis/workspaces/A3

REACH CONDITION SCORE

Reach Condition Score

12.5 to 15 — 10 to 12.5 — 7.5 to 10 — 5 to 7.5

N

1: 7500 @ A3

Base layers supplied by client

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cp/TCMP/gis/workspaces/A3

REACH GEOMORPHOLOGY SCORE

Reach Geomorphology Score

4-5 3-4 2-3 1-2 0-1

N

1: 7500 @ A3

Base layers supplied by client

Waterways by Applied Ecology P/L

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cp/TCMP/gis/workspaces/A3

REACH RIPARIAN VEGETATION SCORE

Reach Riparian Vegetation Score

4-5 | 3 to 4 | 2-3 | 1-2 | 0-1

N

1: 7500 @ A3

Base layers supplied by client

Waterways by Applied Ecology P/L

MGA94 56
created 4/4/2013 AnneCarey
cp/TCMP/gis/workspaces/A3