CITY OF CAPE TOWN
SURFACE STORMWATER SYSTEMS

ENVIRONMENTAL AUTHORISATION FOR MAINTENANCE AND MANAGEMENT INTERVENTIONS UNDERTAKEN BY THE CITY IN ITS SURFACE STORMWATER SYSTEMS:

ENVIRONMENTAL MANAGEMENT PROGRAMME
(Appendix H of the Basic Assessment Report)

DRAFT

Compiled with contributions from

Coastec Coastal & Environmental Consultants
Freshwater Consulting Group

January 2014
J31110
ENVIRONMENTAL AUTHORISATION FOR MAINTENANCE AND MANAGEMENT MEASURES UNDERTAKEN BY THE CITY IN ITS SURFACE STORMWATER SYSTEMS

ENVIRONMENTAL MANAGEMENT PROGRAMME

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<tr>
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<tr>
<td>Branch Head</td>
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<td>E&amp;HM Environmental Control Officer</td>
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<td>Roads and Stormwater District 4 – Somerset West</td>
<td>Dennis de Villiers</td>
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<tr>
<td>District Manager</td>
<td>Roelou Malan</td>
<td>021 8504404</td>
</tr>
<tr>
<td>River Maintenance Project Manager</td>
<td>Azanne van Wyk</td>
<td>021 8504094</td>
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<tr>
<td>E&amp;HM District Manager</td>
<td>Natalie Newman</td>
<td>021 8504132</td>
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<tr>
<td>E&amp;HM Environmental Control Officer</td>
<td>Johan de Beer</td>
<td>021 4006426</td>
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<tr>
<td>Roads &amp; Stormwater District 5 – Cape Town Central &amp;</td>
<td>Peter Koen (Acting)</td>
<td>021 4006431</td>
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<tr>
<td>Atlantic Seaboard District Manager</td>
<td>Roelou Malan</td>
<td>021 8504404</td>
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<td>River Maintenance Project Manager</td>
<td>Azanne van Wyk</td>
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<td>E&amp;HM District Manager</td>
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<td>Manager</td>
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<td>021 7108050</td>
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<td>E&amp;HM District Manager</td>
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<td>E&amp;HM Environmental Control Officer</td>
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<td>Roads &amp; Stormwater District 7 – Khayelitsha District</td>
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<td>Manager</td>
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<td>E&amp;HM District Manager</td>
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<td>Roads &amp; Stormwater District 8 – Plumstead &amp; South</td>
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<td>Talcott Persent</td>
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<tr>
<td><strong>E&amp;HM Environmental Control Officer</strong></td>
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<td><strong>021 7108005</strong></td>
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<td>Melkbos Fire Station</td>
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<td><strong>021 444 7308</strong></td>
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<td>Durbanville Fire Station</td>
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<td><strong>021 444 7290/ 88</strong></td>
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<td>Saltriver Fire Station</td>
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<td>Kuilsriver Fire Station</td>
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<td>Strand Fire Station</td>
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<td>Lansdowne Road Fire Station</td>
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<td>Khayalitsha Fire Station</td>
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<td>Metropolitan Police</td>
<td>-</td>
<td><strong>021 427 5000/ 5100</strong></td>
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<tr>
<td>Department of Water Affairs</td>
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<td><strong>021 941 6196</strong></td>
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<tr>
<td>Heritage Western Cape</td>
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**ABBREVIATIONS**

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<thead>
<tr>
<th><strong>BAR</strong></th>
<th>Basic Assessment Report</th>
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<tr>
<td><strong>BPG</strong></td>
<td>Best Practice Guideline</td>
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<tr>
<td><strong>CBA</strong></td>
<td>Critical Biodiversity Area</td>
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<tr>
<td><strong>CBD</strong></td>
<td>Convention on Biological Diversity</td>
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<tr>
<td><strong>CFR</strong></td>
<td>Cape Floristic Region</td>
</tr>
<tr>
<td><strong>CCT</strong></td>
<td>City of Cape Town</td>
</tr>
<tr>
<td><strong>CMA</strong></td>
<td>Cape Town Metropolitan Area</td>
</tr>
<tr>
<td><strong>CSRM</strong></td>
<td>Catchment Stormwater and River Management Branch</td>
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<tr>
<td><strong>DEA</strong></td>
<td>Department of Environmental Affairs (National)</td>
</tr>
<tr>
<td><strong>DEA&amp;DP</strong></td>
<td>Department of Environmental Affairs and Development Planning (Western Cape)</td>
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<tr>
<td><strong>DWA</strong></td>
<td>Department of Water Affairs (National)</td>
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<tr>
<td><strong>ECO</strong></td>
<td>Environmental Control Officer</td>
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<tr>
<td><strong>ERM</strong></td>
<td>Environmental Resource Management Department</td>
</tr>
<tr>
<td><strong>E&amp;HM</strong></td>
<td>Environment and Heritage Management Branch</td>
</tr>
<tr>
<td><strong>EIA</strong></td>
<td>Environmental Impact Assessment</td>
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<tr>
<td><strong>EMPPr</strong></td>
<td>Environmental Management Programme</td>
</tr>
<tr>
<td><strong>GDP</strong></td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td><strong>GDPR</strong></td>
<td>Gross Domestic Product by Region</td>
</tr>
<tr>
<td><strong>GIS</strong></td>
<td>Geographic Information System</td>
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<tr>
<td><strong>IEM</strong></td>
<td>Integrated Environmental Management</td>
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<tr>
<td><strong>IMEP</strong></td>
<td>Integrated Metropolitan Environmental Policy</td>
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<tr>
<td><strong>MMP</strong></td>
<td>Maintenance Management Plan</td>
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<tr>
<td><strong>MOU</strong></td>
<td>Memorandum of Understanding</td>
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<tr>
<td><strong>NCA</strong></td>
<td>National Conservation Act (Act No. 73 of 1989)</td>
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<td><strong>NEMA</strong></td>
<td>National Environmental Management Act (Act No.107 of 1998)</td>
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<td>NWCS</td>
<td>National Wetland Classification System</td>
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<td>R&amp;S</td>
<td>Roads and Stormwater Department</td>
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<td>SA-FRoG</td>
<td>South African Frog Re-assessment Group</td>
</tr>
<tr>
<td>SANBI</td>
<td>South African National Biodiversity Institute</td>
</tr>
<tr>
<td>SEMA</td>
<td>Specific Environmental Management Acts</td>
</tr>
<tr>
<td>SHE</td>
<td>Safety, Health and Environment(al)</td>
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<td>WMA</td>
<td>Water Management Area</td>
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**DEFINITIONS**

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<tr>
<td>Alluvial</td>
<td>Deposited by riverine activity</td>
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<td>Cambium</td>
<td>A layer within the stem or trunk of plants consisting of actively dividing cells used for growth</td>
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<td>CCT Environmental Team</td>
<td>The CCT Environmental Team will typically comprise E&amp;HM District Staff with support from a suitably qualified freshwater ecologist and/or botanist where required.</td>
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<tr>
<td>City of Cape Town (CCT) area</td>
<td>The geographical area which falls within the jurisdiction of the City of Cape Town Municipality.</td>
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<td>Construction Activity</td>
<td>A construction activity is any action taken by the Contractor, his subcontractors, suppliers or personnel during the construction process.</td>
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<td>Contractor</td>
<td>The main organisation appointed by the City, through the Project Manager, to undertake construction / maintenance activities on the site.</td>
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<td>Critical Biodiversity Area (CBA)</td>
<td>Terrestrial and aquatic areas which are critical for conserving biodiversity and maintaining ecosystem functioning.</td>
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<td>Ecosystem</td>
<td>An ecosystem is a community of living (biotic) organisms (plants, animals and microbes) interacting with non-living (abiotic) components of their environment (air, water, soil, minerals, etc.). The ecosystem is viewed as a complexity of interacting organisms through nutrient cycles and energy flows. Each ecosystem invariably is confined to a specific area or habitat.</td>
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<tr>
<td>Endemic</td>
<td>A species which is only found in a given location and nowhere else in the world.</td>
</tr>
<tr>
<td>Environmental Control Officer</td>
<td>The ECO advises the Project Manager on environmental matters relating to construction / maintenance activities.</td>
</tr>
<tr>
<td>Environmental Management Programme (EMPr)</td>
<td>The EMPr for the project sets out general instructions that will be included in a contract document for the construction phase of the project. The EMPr will ensure the construction activities are conducted and managed in an environmentally sound and responsible manner.</td>
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<tr>
<td>Environment (NEMA)</td>
<td>The surroundings within which humans exist and that are made up of: (i) the land, water and atmosphere of the earth (ii) micro-organisms, plant and animal life (iii) any part of combination of (i) and (ii) and the interrelationships among and between them: and (iv) the physical, chemical, aesthetic and culture properties and conditions of the foregoing that influence human health and well-being: (NEMA, 1998)</td>
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<tr>
<td>Environmental Specifications</td>
<td>Instructions and guidelines for specific construction activities designed to help prevent, reduce and/or control the potential environmental implications of these construction activities.</td>
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<td>Estuary</td>
<td>An estuary is a partially enclosed coastal body of water which is either permanently or periodically open to the sea and within which there is a measurable variation of salinity due to the mixture of seawater with fresh water derived from land drainage.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td>Floodplain</td>
<td>Land bordering a river made up of sediments deposited during flooding.</td>
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<td>Invasive</td>
<td>Species which outcompete other species leading to environmental degradation. The term invasive covers native and alien species.</td>
</tr>
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<td>Indigenous / native vegetation</td>
<td>Vegetation consisting of plant species occurring naturally in an area.</td>
</tr>
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<td>Method Statement</td>
<td>A written submission in response to a Specification setting out the plant, materials, labour, timing and method the Contractor/Contract staff proposes to use to carry out an activity.</td>
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<td>Project</td>
<td>This refers to all construction/maintenance activities associated with the proposed Project.</td>
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<tr>
<td>Project Manager</td>
<td>Responsible for overall management of the construction / maintenance activities including management of contractors.</td>
</tr>
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<td>Red Data Species</td>
<td>Plant and animal species officially listed in the Red Data Lists as being rare, endangered or threatened.</td>
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<td>Rehabilitation</td>
<td>The recovery of ecosystem functions and processes in a degraded habitat. Rehabilitation addresses disturbed habitats and involves establishing geological and hydrological stable environments. Rehabilitation does not necessarily return an environment to the pre-disturbed condition</td>
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<td>Riparian vegetation</td>
<td>A specific band of vegetation of variable width fringing a watercourse.</td>
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<td>River</td>
<td>A natural channel which moves water across the landscape from higher to lower elevations.</td>
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<td>Solid Waste</td>
<td>Means all solid waste, including construction debris, chemical waste, excess cement/concrete, wrapping materials, timber, tins and cans, drums, wire, nails, food and domestic waste (e.g. plastic packets and wrappers).</td>
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</table>
| Watercourse (NWA, 36 of 1998))            | “Watercourse” means-  
• a river or spring;  
• a natural channel or depression in which water flows regularly or intermittently;  
• a wetland, lake or dam into which, or from which water flows; and  
• any collection of water which the Minister may, by notice in the Gazette declare to be a watercourse as defined in the National Water Act, 1998 (Act No. 36 of 1998) and a reference to a watercourse includes, where relevant its bed and banks. |
| Wetland (NWA, 36 of 1998)                 | Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil. |

**APPENDICES**

- **Appendix A:** Plant species control table
- **Appendix B:** Erosion control measures: technical assessment
- **Appendix C:** Equipment used for sediment and aquatic plant / reedbed management
- **Appendix D:** Illustrations of watercourse types
- **Appendix E:** List of Nature Reserves in CCT jurisdiction
PART 1: INTRODUCTION AND CONTEXT

1 INTRODUCTION

1.1 What is an Environmental Management Programme?
An EMPr presents and describes actions and methods to prevent, minimise, mitigate and manage environmental impacts associated with specific activities. These impacts are typically identified during an environmental impact assessment process. The EMPr covers all stages of a project from planning, the execution of the construction or maintenance activity, and the management of impacts during the operational periods post construction.

The EMPr is a “living” document which will be updated as projects progress, and in response to changes in the receiving environment, and legislation.

EMPrs are required as part of the regulated Environmental Impact Assessment (EIA) process in terms of the EIA Regulations (GNR 543, 18 June 2010).

In the case of this application, the City of Cape Town (CCT) is seeking authorisation for the undertaking of a number of routine maintenance and management measures on its surface stormwater features such as such as rivers, wetlands, canals, dams and ponds. A Basic Assessment Report (BAR) and Technical Assessment Report have been compiled and describe the nine categories of proposed maintenance and management measures and their associated impacts. This EMPr presents standards for the undertaking of these measures and is intended to guide the manner in which these are executed. The EMPr will be submitted to Department of Environmental Affairs and Development Planning (DEA&DP) as part of the application, and if approved, will be binding on the CCT. Finally, it gives guidance and presents minimum performance conditions which will be used to compile waterbody-specific Maintenance Plans for all areas where maintenance and management measures will be undertaken.

1.2 Content of an Environmental Management Programme
Section 24N of the National Environmental Management Act (107 of 1998) (NEMA), as amended (9 January 2009), lists the required contents of an EMPr, summarised below.

The EMPr must contain:

- Proposed management, mitigation, protection or remedial measures to be undertaken to address identified environmental impacts during all phases of the project.
- Details and expertise of the person who prepared the EMPr;
- Detailed description of the aspects covered by EMPr;
- Details of the persons who will be responsible for implementation of the EMPr;
- Mechanisms proposed for monitoring and reporting compliance with the EMPr;
- Reasonable measures to rehabilitate any affected environment;
- A description of how to:
Appendix H: Environmental Management Programme

1.3 Context of the Environmental Management Programme

This EMPPr is designed to meet the requirements of the NEMA and EIA regulations of 2010. A number of stormwater maintenance and management activities undertaken by the City of Cape Town require an environmental assessment to be completed in terms of the 2010 Environmental Impact Assessment regulations. The City of Cape Town is in the process of completing a basic assessment to be submitted to the DEA&DP for environmental authorization. As such, this EMPPr forms part of the BAR submitted to the competent authority for consideration.

This EMPPr has been compiled as a guideline for the minimisation, prevention and mitigation of potential environmental degradation and pollution during routine storm water infrastructure maintenance and rehabilitation activities as undertaken by the City of Cape Town, and appointed contractors conducting maintenance and rehabilitation activities on the city's behalf.

An important background document to both the BAR and this EMPPr is the City of Cape Town Surface Stormwater Systems Technical Assessment Report which forms part of this environmental application. This technical report provides considerable detail on important aspects in the field of stormwater management within the City. Whilst details are not repeated here, for brevity, the following is important contextual information:

- The central rationale for the stormwater management measures is the fiduciary obligation of the authorities to keep the City's stormwater system functioning at an optimal level, to prevent flooding, and damage or loss of infrastructure and property, and to maintain safe living conditions by managing safety and public health threats.
- Whilst some components of the city's stormwater management system comprises engineered infrastructure and artificial (“man-made”) aquatic features, naturally-occurring river and wetland systems are also part of the stormwater system and are therefore used for stormwater storage, conveyance or treatment, and consequently many systems are moderately or substantially altered from their natural condition. The City has the concomitant obligation to demonstrate due diligence, duty of care and to be compliant with environmental legislation, by maintaining and, where feasible, in some cases even improving ecosystem
condition through rehabilitation of degraded systems where natural systems form part of the stormwater system.

- The Technical Assessment Report and EMPr aim primarily to facilitate this dual obligation.

1.4 For whom is this EMPr written?
This EMPr is intended chiefly for the City’s District Roads and Stormwater Department staff, but also the District Environment and Heritage Management, Biodiversity Management and City Parks staff who may also undertake certain maintenance and management interventions near watercourses. The content of the EMPr is also intended to inform the duties and responsibilities of appointed contractors in order to ensure that the appropriate environmental mitigation is achieved.

1.5 When does this EMPr apply?
This EMPr applies only to maintenance, minor construction and rehabilitation activities as authorised under the application to Department of Environmental Affairs and Development Planning (DEA&DP) (reference 16/3/1/3/1/A7/4/2031/12). These activities are listed below in this report and detailed in the Technical Assessment Report (CCT, 2013 unpublished).

1.6 Where does this EMPr apply?
This EMPr only applies to the afore-mentioned activities where they are undertaken within the jurisdiction of the eight Roads and Stormwater management districts of the CCT, which includes Blaauwberg (1), Kraaifontein (2), Bellville (3), Somerset West (4), Cape Town (5), Athlone (6), Khayelitsha (7), and Plumstead (8) (refer to Figures 1 and 2).

1.7 What is not included in this EMPr?
Any maintenance, minor construction and rehabilitation activities, not addressed in the documents mentioned in section 1.5 are excluded and must be dealt with on their own merits. All large construction activities are also excluded and not covered by this EMPr. Separate authorisation would have to be sought for excluded activities, where these trigger the EIA requirements. This EMPr does however also provide best practice guidelines applicable to all work, even those which do not trigger any authorisation requirements.

1.8 How to use this EMPr
This EMPr provides clear practical instructions to City officials of what steps are required in undertaking any of the listed management actions, with the steps being aligned to the type and condition of watercourse or waterbody under consideration. The watercourse types considered are presented in Table 1 and a list of the maintenance measures are given in Table 2.

The EMPr is a living document and is designed to be updated continually as new rehabilitation and maintenance techniques are developed, and changes to legislation are enacted.
For the present:

- The City’s surface water systems have been categorised where appropriate according to (i) their “watercourse/ hydrogeomorphic” type (see Table 1 and Figure 1), and (ii) their ecological importance (Figure 2). Details of how these watercourse types and importance categories have been applied are in the “Technical Assessment Report” (refer to section 3.2). A key product of the Technical Assessment Report is the provision of a map book that illustrate this classification, at relevant scales for District officials. Illustrations of different watercourse types are presented in Appendix D.

- This two-way classification has been used to determine the level of protection and / or care that should be exercised in undertaking stormwater maintenance. Different specifications (“Best Practise Methods”) are thus identified in Part 2 of this report for each stormwater measure for different categories of waterbody and for different levels of ecological importance.

- In addition to management actions that carry the legal obligation for assessment / management plans, many of the routine activities do not trigger the environmental regulations because they are below stipulated thresholds or simply not NEMA listed activities. Despite this, the Technical Assessment Report and this EMPr describes and defines best practise methods / specifications for all the actions included under the suite of stormwater maintenance and management measures.

Table 1. Watercourse types: Hydrogeomorphic categories of river and wetlands and their allocation to one of six watercourse groups for this assessment.

<table>
<thead>
<tr>
<th>System type</th>
<th>River / Wetland</th>
<th>Hydrogeomorphic Type Classification</th>
<th>Type grouping for Stormwater Maintenance Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inland systems</td>
<td>Rivers</td>
<td>Gorge (GO) Mountain streams and transitional rivers (MS) Upland floodplain rivers (UFP) Foothill cobble bed (FCB) Foothill gravel bed (FGB)</td>
<td>Group 1 – Gorges, mountain and foothill rivers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lowland rivers (LR) Lowland floodplain river (LLFP)</td>
<td>Group 2 – Lowland and lowland floodplain rivers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wetland transitional rivers(WT)</td>
<td>Group 3 - Valley bottom and floodplain wetlands; wetland transitional rivers</td>
</tr>
<tr>
<td>Wetland</td>
<td>Valley-bottom wetlands (VBW) and including floodplain wetlands</td>
<td></td>
<td>Group 4 - Seeps</td>
</tr>
<tr>
<td></td>
<td>Seeps (S)</td>
<td></td>
<td>Group 5 - Flats and depressions</td>
</tr>
<tr>
<td></td>
<td>Flats &amp; Depressions (FD)</td>
<td></td>
<td>Group 6 - Dams</td>
</tr>
<tr>
<td></td>
<td>Depressions Dams (D)</td>
<td>Note: these include natural and semi-natural features, but exclude features associated with Waste Water Treatment Works (WWTW).</td>
<td></td>
</tr>
</tbody>
</table>
1.9 **Availability of the Environmental Management Programme**

The District Manager or relevant Roads and Stormwater District official must ensure that a copy of the signed and approved EMPr is available at all times. The EMPr can also be requested by the authorities or their representatives.
<table>
<thead>
<tr>
<th>No.</th>
<th>Maintenance/management measure</th>
<th>Intervention sub-type</th>
<th>EMP section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vegetation management</td>
<td>1.1.1 Manual removal</td>
<td>5.1.1</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1.2 Mechanical removal</td>
<td>5.1.1</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1.3 Biocontrol</td>
<td>Box 1</td>
<td>28</td>
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<td></td>
<td></td>
<td>1.1.4 Chemical control</td>
<td>Box 2</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1.5 Manipulation of water levels</td>
<td>5.1.2</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>1.1. Aquatic (submerged and floating) vegetation management</td>
<td>1.2.1 Manual removal</td>
<td>5.2.1</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2.2 Mechanical removal</td>
<td>5.2.1</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2.3 Chemical control</td>
<td>Box 2</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2.4 Burning</td>
<td>5.2.1</td>
<td>32</td>
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<tr>
<td></td>
<td></td>
<td>1.2.5 Manipulation of water levels</td>
<td>5.1.2</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>1.2. Reedbed and indigenous emergent vegetation management</td>
<td>1.3.1 Manual removal</td>
<td>5.3.1</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3.2 Mechanical removal</td>
<td>5.3.1</td>
<td>38</td>
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<tr>
<td></td>
<td></td>
<td>1.3.3 Biocontrol</td>
<td>Box 1</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3.4 Chemical control</td>
<td>Box 2</td>
<td>29</td>
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<tr>
<td></td>
<td></td>
<td>1.3.5 Burning</td>
<td>5.3.1</td>
<td>38</td>
</tr>
<tr>
<td>2</td>
<td>Erosion control</td>
<td>2.1 River channel profile enhancement</td>
<td>6.1</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2 Construction, maintenance, and expansion of erosion control structures</td>
<td>6.2</td>
<td>41</td>
</tr>
<tr>
<td>3</td>
<td>Sediment Management</td>
<td>3.1 Construction, maintenance and expansion of sediment traps/retention areas</td>
<td>10, 10.3</td>
<td>60, 61</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.2 Manual/mechanical sediment removal from sediment traps/retention areas</td>
<td>7.1</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.3 Manual/mechanical sediment removal from canals, channels and waterbodies</td>
<td>7.1</td>
<td>48</td>
</tr>
<tr>
<td>4</td>
<td>Channel Enclosure</td>
<td>4.1 Conversion of an open channel to an enclosed pipe / culvert system</td>
<td>8</td>
<td>55</td>
</tr>
<tr>
<td>5</td>
<td>Litter and debris management</td>
<td>5.1 Litter and debris removal using either mechanical or manual methods</td>
<td>9.1</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.2 Removal of structures to reduce water obstruction</td>
<td>9.2</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.3 Construction, maintenance and expansion of litter management infrastructure</td>
<td>10.2</td>
<td>61</td>
</tr>
<tr>
<td>6</td>
<td>Construction, maintenance and expansion of minor stormwater infrastructure</td>
<td>6.1 Stormwater outlets, scour valves, headwalls and culverts</td>
<td>10.4</td>
<td>64</td>
</tr>
<tr>
<td>7</td>
<td>Maintenance of attenuation infrastructure</td>
<td>7.1 Weirs</td>
<td>11.1</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.2 Retention / detention ponds, dams registered in terms of the National Water Act as dams with a Safety Risk</td>
<td>11.2.1</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.3 Flood protection embankments / berms</td>
<td>11.3</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.4 SUDS facilities</td>
<td>11.2</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.5 Other dams / ponds</td>
<td>11.2</td>
<td>66</td>
</tr>
<tr>
<td>8</td>
<td>Recreational access</td>
<td>8.1 Construction, maintenance and expansion of footbridges, boardwalks, or bird hides.</td>
<td>12</td>
<td>69</td>
</tr>
<tr>
<td>9</td>
<td>Management of river / estuary mouths</td>
<td>9.1 Breaching: removal of sand bars deposited in mouth</td>
<td>13</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.2 Straightening: redirecting meandering mouth across the shortest route directly towards the sea</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 1: Overview map showing location of different watercourses in terms of type (as defined for this application).
Figure 2: Overview map showing location of different watercourses (wetlands and rivers) in terms of Ecological Importance (as defined for this application).
2 ROLES AND RESPONSIBILITIES

Due to the scale of the project, the large geographical area it covers and the number of included interventions, there are numerous role players involved in this project.

The routine stormwater management and maintenance tasks will be District-based. Teams comprising Roads and Stormwater District personnel along with Environment and Heritage Management will most often oversee the activities taking place within each relevant District area. The team could also however include City Parks\(^1\), Biodiversity Management and broader involvement from the Environmental Resource Management Department in certain situations such as during maintenance tasks involving public open space, park infrastructure, nature reserves or rehabilitation projects. In such cases, the District and Project Manager roles will be fulfilled by representatives of the applicable lead Department.

This application for authorisation is submitted on behalf of the City of Cape Town as the “applicant”. This means that a range of line departments (e.g. listed above) could undertake the various maintenance and management tasks, provided that the requirements of the authorisation and the best practise methods stipulated in the Technical Assessment document and EMPr are followed.

Upon authorisation, the District teams will identify the management and maintenance tasks required for specific watercourses and water bodies within their respective District areas and collectively agree and document the approach that will be followed to achieve the various tasks. Best practice method statements and details of particular tasks will be articulated within succinct internal site specific Maintenance Plan documents. Specialist support from the Catchment, Stormwater and River Management Branch will be available in specific cases where a greater level of technical guidance and expertise is required.

Typically, on-site manual work will be undertaken by small contract teams\(^2\) appointed by the relevant District. Operation of heavy plant such as long boom excavators, mud-dozers etc. is usually undertaken by operators from the City’s Specialised Technical Services.

The section below describes the various role players and their responsibilities in more detail.

---

\(^1\) In many cases the land is under the management of the City’s Parks Department.
\(^2\) These contract teams are available in terms of the annual / bi-annual tender process.
2.1 District Manager

The respective District Managers within the eight Roads and Stormwater District offices will generally have overall responsibility for the maintenance activities which take place within his/her District. District Managers of other Departments will have overall responsibility should their respective Departments be taking the lead in undertaking the maintenance activity.

2.1.1 Role

The District Manager must chiefly ensure that the EMP is implemented which has a number of attendant requirements. These responsibilities have been listed in the section below.

2.1.2 Responsibilities

- Be familiar with the contents of the EMP, and the various roles and responsibilities as defined therein.
- Indicate who will undertake the role of the “Project Manager” and assign responsibilities as appropriate.
- Request a representative from the District E&HM office to undertake the role of “ECO”.
- Facilitate the formation of integrated multi-department District teams who will identify and document the various site specific maintenance and management tasks that are pertinent to the District.
- Facilitate proactive communication between all role-players in the interests of effective environmental management.
- Ensure the latest version of the EMP is available to staff where necessary, and that they understand the content thereof (delegated to Project Manager).
- Ensure general compliance of all role players with the EMP and other pertinent site specifications (delegated to Project Manager).
- Designate a multi-department District team to identify and document the various maintenance and management tasks that are pertinent to the District and compile the relevant site specific Maintenance Plans.
- Ensure that internal working documentation in the form of site specific “Maintenance Plans” are compiled (delegated to Project Manager).
- Where the works are outsourced, the District Manager will ensure that the site specific Maintenance Plans and any other relevant supporting material are provided to the Contractor (delegated to Project Manager).

2.2 Project Manager

The Project Manager will typically be a District Roads and Stormwater representative responsible for routine stormwater and river maintenance and management activities in that district. However, in certain circumstances, the Project Manager role could be performed by a different line department. For example, where a specific task involves:

- Maintenance of park / open space land or infrastructure, the role of Project Manager will be performed by a City Parks representative.
- Maintenance within a City nature reserve, the role of Project Manager will be performed by a Biodiversity Management Branch representative.
- Rehabilitation, the role of Project Manager may be jointly undertaken by representatives from the District Roads and Stormwater and Environmental Resource Management Departments.

2.2.1 Role
The Project Manager oversees internal and/or external contracted maintenance teams operating at a specific site. The Project Manager also liaises with the ECO.

2.2.2 Responsibilities
- Be familiar with the contents of the EMPr, and the various roles and responsibilities as defined therein.
- Participate in the integrated multi-department District teams to identify and document the various maintenance and management tasks that are pertinent to the District. The Maintenance Plans are to be compiled using information contained in all relevant supporting documentation including the EMPr and Technical Assessment Reports.
- Approve / sign off the site specific Maintenance Plans.
- Where the labour works are outsourced, the Project Manager will ensure that the site specific Maintenance Plans are included along with any other documents issued to appointed contractors.
- Where operational works are undertaken in-house, the Project Manager will ensure that the site specific Maintenance Plans are included in internal work instruction documents.
- Inform the ECO regarding the planned date of commencement of activities in terms of the site specific Maintenance Plans.
- Oversee the general compliance of the Contractor and/or internal operational staff with the EMPr and requirements of the site specific Maintenance Plans.
- Liaise between and with the Contractor and ECO on environmental matters, as well as any pertinent engineering matters where these may have environmental consequences.
- Issue site instructions verbally and in writing to the Contractor regarding the advice, recommendations and requirements of the ECO where necessary.
- Review complaints received and make instructions as necessary.
- Issue fines/penalties for infringements of specifications of contract documentation when necessary.
- Implement temporary work stoppages as advised by the ECO, where serious environmental infringements and non-compliances continue to occur.
- Facilitate proactive communication between all role-players in the interests of effective environmental management.
2.2.3 Reporting Structure
The Project Manager reports to the District Manager.

2.3 Environmental Control Officer (ECO)
The “ECO” role will typically be fulfilled by an in-house representative from the relevant Environment and Heritage Management Branch (E&HM) District office. If the CCT does not have capacity the role of ECO may be outsourced to an independent company.

2.3.1 Role
The ECO’s primary role is to ensure environmental compliance during the proposed maintenance works.

2.3.2 Responsibilities
- Advise the Project Manager on the interpretation of the EMPr, including evaluation of non-compliances, the requirements of any relevant site specific Maintenance Plan, and the need to ensure that construction/maintenance staff are trained and understand all environmental requirements.
- Provide environmental input, including demarcation of particularly sensitive and No-Go areas, to the site specific Maintenance Plans.
- In consultation with the District Heritage practitioner (ERM Department), advise the Project Manager if a heritage application would be required. Heritage authorisation has not been covered by this application, and hence will have to be dealt with on a project by project basis.
- Identify any basic physical changes to the environment as a consequence of any construction or maintenance works – e.g. evidence of erosion, dust generation and silt loading in runoff.
- Attend site meetings between the Project Manager and Contractors where necessary.
- Where the duration of work is longer than 1 month, the ECO will undertake regular monthly audits of the construction works.
- Communicate with the Project Manager to ensure effective, proactive environmental management, with the overall objective of preventing or reducing negative environmental impacts and/or enhancing positive environmental impacts.
- Advise the Project Manager on remedial actions for the protection of the environment in the event of any accidents or emergencies during maintenance/construction activities.
- Identify and make recommendations for minor amendments to the EMPr as and when appropriate.

2.3.3 Reporting Structure
Where there are issues of non-compliance noted, the ECO is to communicate with the Project Manager.
2.4 **Contractor**
Routine maintenance tasks involving manual labour will generally be undertaken by external contractors where in-house capacity is limited.

2.4.1 **Role**
The Contractor is contractually required to undertake the activities in an environmentally responsible manner, as described in the site specific Maintenance Plans. The appointed Contractor will typically include a Site Manager or Foreman (or both) who oversees a small manual labour team (workforce).

2.4.2 **Responsibilities**
- The Site Manager/Foreman and his/her workforce must be familiar with the contents of the EMPr and the site specific Maintenance Plans and the “Contractor” role and responsibilities as defined therein.
- The Site Manager/Foreman must sign the site-specific Maintenance Plan as a record of acknowledgement of the work terms of reference and environmental requirements set out therein.
- The Site Manager/Foreman and his/her workforce must undertake the required works within the designated working areas.
- The Site Manager/Foreman and his/her workforce must comply with the environmental specifications contained in the EMPr and site specific Maintenance Plans.
- The Site Manager/Foreman must notify the Project Manager, verbally and in writing, immediately in the event of any accidental infringements of the environmental specifications and ensure appropriate remedial action is taken.
- The Site Manager/Foreman must ensure environmental awareness among his/her workforce so that they are fully aware of, and understand the EMPr, the site specific Maintenance Plan and environmental specifications and the need for them. He/she must maintain a record of the fact that his / her workforces have been informed of the EMPr and Maintenance Plan requirements prior to commencing work. This record must be presented to CCT if requested.
- The Site Manager/Foreman must communicate and liaise frequently and openly with his/her workforce, to ensure effective, proactive environmental management with the overall objective of preventing or reducing negative environmental impacts while enhancing positive environmental impacts.
- The Contractor must have an appropriate Health and Safety Plan in place.

2.4.3 **Reporting Structure**
The Contractor will report to and receive instructions from the Project Manager.
3 PRE-MAINTENANCE PLANNING

3.1 Key Considerations during the Planning Phase

During the planning phase for any maintenance activity there are 8 key considerations that must be taken into account before maintenance activities commence and in the compilation of internal Maintenance Plan documentation (CCT, 2002).

1. **Multi-disciplinary planning.** This consideration requires consultation with a wide range of disciplines to ensure that all legislative, policy and good practice requirements of these disciplines are met before and during all maintenance activities.

2. **Determining the need for maintenance.** This consideration requires that the District Manager or designated responsible person/s (Project Manager) assesses the need for maintenance along any reach of a particular river, especially in instances where a pre-defined maintenance interval for certain maintenance activities has been specified. As a general rule maintenance should only be conducted if necessary to mitigate an unacceptable level of flood risk to life and infrastructure or environmental degradation.

3. **Environmental considerations.** This consideration requires that the CCT, in consultation with relevant stakeholders, determine whether any of the watercourse reaches requiring maintenance are in close proximity to environmentally sensitive areas such as bird breeding areas, critical biodiversity areas, areas with rare or endangered amphibians and other fauna, areas of cultural and social importance, and areas where alien vegetation should be removed.

4. **Underground infrastructure.** This consideration requires that the location of underground services and infrastructure be determined in consultation with all the relevant directorates and departments in the CCT in order to prevent damage during maintenance activities. The services must be pointed out to all machine operators and manual labour. Underground activities are however not covered by this EMPr.

5. **Access.** In order to conduct maintenance inspections and activities easy pedestrian and machinery access tracks must be provided and maintained in the relevant catchment areas and next to river reaches. Where possible tracks must always follow contour lines to minimise erosion impacts.

6. **Timing of activities.** The timing of maintenance activities is very important to minimise the impact on the different river reaches. Generally, river channel maintenance activities are undertaken between October to April to coincide with low flows in the natural systems and to facilitate a measure of vegetation regrowth prior to the onset of high flows during the winter season. Maintenance activities in areas or river reaches containing sensitive fauna should be avoided during breeding seasons.
7. **Methods and machinery.** The choice of method, including whether to use manual or mechanical methods, is an important consideration before embarking on maintenance activities. Manual labour is generally used for small jobs and in areas where sensitive vegetation is dominant or where underground services are unavoidable. Machinery on the other hand is used in less sensitive environments or where large-scale maintenance is required.

8. **Records and approvals.** Before embarking on any maintenance activities, it is important to ensure that the required activities are encompassed within this envisaged authorisation from DEAD&DP and that the proposed maintenance activities are captured and described in this EMPr. If an activity triggers EIA requirements, but is not covered by this EIA application and EMPr, the CCT will have to pursue a separate application.

### 3.2 Internal CCT Pre-work Planning

A level of specific planning must take place prior to commencement of maintenance and management interventions. This pre-work planning is essential for internal processes such as record keeping, budget planning and to assist the operational teams who will ultimately undertake the on-site work. On-site operations will typically be undertaken by CCT internal work crews or by external appointed contractors under the supervision of the Project Manager with the environmental guidance of the ECO.

Pre-work planning will entail the following consultative, multi-disciplinary internal process. Teams comprising officials from Roads and Stormwater (R&S), Environment and Heritage Management (E&HM) and possibly others from City Parks, ERM and CSRM will discuss and agree on the required routine maintenance and management tasks for the various watercourses and water bodies in the District.

Succinct site specific documents (“Maintenance Plans”) will be compiled for each work area as and when the work is required. These internal documents will include the following aspects and be approved (signed) by the Project Manager and accepted (signed) by the Contractor:

- Location description and co-ordinates (with photographs, maps, schematics where appropriate);
- Site layout (including access routes, temporary stockpile areas, areas for storage of plant or other equipment, portable toilets, underground services);
- Description of work required;
- Environmental considerations (general as well as site-specific where relevant);
- Identification of the need for Heritage approval or not;
- Maintenance methods to be used (these methods will follow established best practise and be informed by the generic contents of this EMPr and the BAR and Technical Assessment Reports);
- Timing and frequency (in cases where routine but repetitive work is required);
- Working hours;
- Identification of specific role players and contact details (Project Manager, ECO, Contractors, others);
Appendix H: Environmental Management Programme

- Machinery, equipment and materials;
- Staffing requirements (e.g. internal workforce vs. external contractors);
- Health and Safety considerations;
- Emergency procedures (e.g. relating to fire and pollution incidents);
- Waste management (e.g. appropriate disposal of sediment, vegetation, rubble, litter);
- Pollution control;
- Stormwater and erosion control;
- Record keeping is an important aspect of ensuring that the EMPr is implemented correctly. Such records form part of the site specific Maintenance Plans and must be retained for future reference e.g. during internal and external audit processes. In addition to maintaining a record of reports and any important written communications between the various role players, the following information should also be recorded:
  - maintenance record (start and end dates, duration, work undertaken, contractor details, budgets);
  - incident report sheet (record of incidents, non-compliance and remedial steps);
  - fines and penalties issued.

In specific situations where additional engineering or environmental guidance is needed for the compilation of these Maintenance Plans the CSRM will assist, or appoint an external consultant, as appropriate.

Compliance with the EMPr and Maintenance Plans will be articulated as a requirement in the contract / annual tender documentation where external contractors are to be used for the operational work. Both internal operational staff / appointed contractors will use the EMPr and Maintenance Plans to guide their work and may in some cases be required to provide additional detail in the form of supplementary method statements where these are deemed necessary by the Project Manager.
PART 2: SPECIFICATIONS

The specifications of this EMPr are presented as General Specifications (Section 4) followed by a series of Technical Specifications (Sections 5 to 13) that are more directly focused on the specific types of stormwater management interventions and tasks that are listed in Table 2.

A detailed description of what these interventions entail is provided in the Technical Assessment Report (CCT, 2013).

The Technical Specifications in Sections 5 – 13 are based on current best practice guidelines and methods, pertinent to the particular sensitivities of different water body types. In these sections, information is presented about alternatives available to undertake the work, and importantly, a series of “restrictions” that set out clearly where a method may or may not be used, depending on the type and importance of the water body.

Maintenance Plans will be compiled for each major site of regular maintenance work. Each Project Manager must ensure that the specifications and restrictions for any of the stormwater measures being implemented are captured within these Maintenance Plans so that they can be clearly communicated to the maintenance team before any work is undertaken.

4 GENERAL SPECIFICATIONS

The General Specifications comprise a set of basic due diligence measures to be implemented at any work site to avoid environmental impacts, regardless of whether or not the work triggers the environmental regulations. All Project Managers, ECOs, internal operational staff and Contractors must be aware of these specifications and implement them every day on site while undertaking stormwater management and maintenance tasks.

4.1 Environmental Awareness

1. An initial environmental awareness training session for all construction/maintenance staff is required prior to any work commencing at a site. This is to be undertaken by the Contractor using material provided within the Maintenance Plan.

2. The emphasis should be on any (potential) environmental impacts relating to the construction/maintenance tasks to be undertaken on site and the related environmental precautions, which need to be taken to avoid or mitigate these impacts.

3. Staff should also be informed of fines and penalties associated with contraventions of the tender specifications.
4.2 Site Establishment
1. A demarcated site at, or close to the work area, must be provided for the temporary storage of maintenance equipment and plant if such a site is necessary. In most cases a site camp will not be required since small equipment items are generally removed on a daily basis. Plant will be parked in a specific area overnight.

2. If a site camp is necessary, this site shall be determined in collaboration with the Project Manager and ECO before being established, such that it is effectively isolated from the sensitive elements of the surrounding environment.

3. If the site camp is to be situated on private land, approval must be obtained from the landowner prior to site establishment.

4. The Project Manager shall produce a photographic record of the area earmarked for the site camp prior to site establishment. This will serve as the benchmark against which rehabilitation will be measured and shall be kept in the site environmental file.

5. It will be the responsibility of the Contractor to reinstate the site camp to its original condition at the time of commencement of the project once the work has been completed.

6. Where necessary, the No-Go areas shall be identified and indicated on the site map. The No-Go areas may be demarcated on site if need be.

7. The Project Manager and Contractor shall ensure that no person, plant equipment or material will enter the No-Go areas at any time.

4.3 Vegetation Impacts
1. No flora shall be removed, damaged or disturbed nor shall any vegetation be planted except to the extent necessary for the carrying out of the construction or maintenance tasks.

2. Vegetation clearance should be kept to a minimum i.e. only that which is necessary for the work activities to take place.

3. Site clearing must take place in phased manner, as and when required.

4. Spoil that is removed from the site must be removed to an approved spoil site or municipal licensed landfill site.

5. Silt fences and erosion control measures must be implemented in areas where these risks are more prevalent. These include wetlands and steep areas.

6. Seeds from alien vegetation collected during site clearance must not be dispersed so as to counter the spread of this vegetation type. Failure to do so may result in prosecution in terms of the Conservation of Agricultural Resources Act, Act 43 of 1983, which states that any person removing any weed (which includes alien vegetation) shall ensure that it is not able to reproduce itself.
4.4 Biodiversity Impacts

Animals will usually move away from sources of disturbance without human intervention. In an instance where animals are present on site the following must be adhered to:

1. Trapping, poisoning and/or shooting of animals is strictly forbidden.
2. Any reptiles encountered should be allowed to escape to suitable habitat away from the disturbance. No reptile should be intentionally killed, caught or collected during any phase of the project.

If animals do not move away from the site and their removal is required e.g. a dangerous species or there is a risk to the animal from construction activities, the following must be adhered to:

1. Any animals rescued or recovered must be relocated to the closest suitable habitat away from the work site in consultation with the City’s Biodiversity Management Branch.
2. The CCT staff at the closest nature reserve, or SANParks, could assist in identifying the most suitable relocation site. The site specific Maintenance Plans should include details of the closest nature reserve. The following key contact details are provided:
   - CCT Nature Reserves: See Appendix E.
   - SPCA Wildlife Unit:
     - Office Hours: Tel: 021 700 4158/4159 or
     - After Hours: Cell: 083 326 1604
   - Table Mountain National Park: Tel: 021 712 2337 / 0537
3. Dangerous animals such as venomous snakes must only be handled by a suitably trained and qualified person.

4.5 Topsoil

1. If the stripping of topsoil is required, it will be undertaken in such a manner as to minimise erosion by wind or runoff.
2. The Contractor shall ensure that subsoil and topsoil are not mixed during stripping, reinstatement and rehabilitation.
3. Topsoil will be temporarily stockpiled, in areas as approved by the ECO (these areas will generally be above any visible flood debris line and the normal inundation area, or as stipulated in the Maintenance Plan).
4. Soil must not be stockpiled on drainage lines without prior consent from the ECO.
5. Stockpiles should not exceed 2m in height.
6. If stockpiles are exposed to windy conditions or heavy rain, they should be covered to prevent loss of topsoil.
4.6 Construction Plant and Material Management

1. All vehicles and equipment shall be kept in good working order and inspected daily for leaks and spills. This will generally be undertaken by the City’s Fleet Services or the Contractor if vehicles and plant do not belong to the City.
2. Materials removed during maintenance activities shall be appropriately secured to prevent spillage between destinations.
3. The Contractor shall be responsible for any clean-up resulting from the failure by his staff or supplier to properly secure materials to be transported.

4.7 Solid Waste Management

1. No burning, burying or dumping of any waste materials, vegetation, litter or refuse shall be permitted.
2. River spoils / material shall be removed from site within 2 weeks by the maintenance staff or appropriate service provider.
3. Solid waste shall be recycled where possible and the remainder deposited at an approved municipal land fill site or waste disposal service provider.
4. Disposal certificates for each waste removal event issued to the contractor by the landfill operators should be provided to the Project Manager for record keeping.

4.8 Wastewater Management

1. No grey water runoff or uncontrolled discharges from the site/working areas to adjacent or nearby areas including water bodies shall be permitted.
2. Runoff loaded with sediment and other suspended materials shall be prevented from discharging from the site/working areas to adjacent watercourses and/or storm water infrastructure.
3. Where feasible, runoff from contaminated stockpiled sediment should be prevented from leaching into adjacent watercourses.
4. The Contractor shall notify the Project Manager and ECO of any pollution incidents on site.

4.9 Sanitation

1. Portable chemical toilets at a ratio of one toilet per 15 workers shall be provided at the site camp.
2. All portable toilets shall be secured to the ground to the satisfaction of the Project Manager to prevent them from toppling over or being blown over by wind.
3. The location of the toilets shall be approved by the Project Manager prior to establishment. No septic tanks are to be established.
4. The Contractor shall ensure maintenance of all toilets in a clean sanitary condition to the satisfaction of the Project Manager. Toilets are to be serviced at least once per week and toilet paper shall be provided.
5. The Contractor shall ensure that no spillage occurs when the toilets are cleaned or emptied and that the contents are removed from the site to an appropriate location/facility. The service provider is to provide proof that the toilet contents are disposed of at an appropriate facility.

4.10 Fuels, Oil and other Hazardous Substances

1. Fuel shall not be stored on site, but shall be transported to the site in small quantities as and when required.

2. The Contractor shall ensure that there is always a supply of absorbent material readily available to absorb/break down any hydrocarbon spillage. The quantity of such materials shall be able to handle a minimum of 200 litres of hydrocarbon liquid spill. This material must be approved by the Project Manager prior to any refuelling or maintenance activities.

3. In the case of a spill, contaminated material must be removed from the site immediately and disposed of at an appropriate hazardous waste facility. The City’s Water Pollution Control inspectorate can be contacted for advice and assistance.

4. All potentially hazardous raw and waste materials are to be handled and stored in accordance with manufacturer’s instructions and legal requirements.

5. Where hazardous substances are removed from site for disposal, proof of disposal for auditing purposes shall be kept in the form of disposal certificates.

4.11 Stormwater Management and Erosion

1. The Contractor shall take all reasonable measures to control storm water and the erosive effects thereof and to protect areas susceptible to erosion.

2. Areas affected by construction, related activities and/or susceptible to erosion must be monitored regularly for evidence of erosion.

3. The erosion prevention measures must be implemented where erosion is likely or has become evident, and to the satisfaction of the Project Manager and ECO.

4.12 Air Quality

1. The Project Manager must ensure that all vehicles and plant used are maintained in good working order to reduce air emissions.

2. The burning of substances is not permitted on site.

3. Dust control measures shall include, when needed, regular spraying of working/exposed areas with water at an application rate that will not result in soil erosion or runoff.

4. The excavation, handling and transport of erodible materials shall be avoided under high wind conditions.
5. Soil stockpiles shall be wetted and/or covered as required to prevent loss of material.

4.13 Noise Control
1. The Contractor shall ensure that noise levels are kept within acceptable limits and shall comply with all relevant guidelines and regulations.
2. All vehicles and machinery shall be fitted with appropriate silencing technology that shall be properly maintained.
3. Any complaints received regarding noise will be recorded and communicated to the Project Manager.

4.14 Concrete Batching
1. Where possible, concrete required for maintenance activities shall be sourced from a recognised service provider.
2. Batching areas shall not be located within 150 m of any water body or any “No-Go” areas, unless written approval has been granted by the ECO.
3. Concrete shall not be mixed directly on the ground. Mixing trays, wheelbarrows or concrete mixing machines can be used.
4. The Contractor shall ensure that minimal water is used for washing of concrete batching equipment.
5. Used cement bags must be stored tidily in weather proof containers until disposal off-site. Unused cement bags must be stored under dry conditions to prevent leaching of cement.
6. All reasonable measures must be taken to ensure that transportation of concrete does not result in spillage.
7. Cleaning of equipment and flushing of mixers shall not result in pollution of the surrounding environment.
8. Waste concrete, cement sludge and mortar leftovers shall be removed from site to an approved landfill site.

4.15 Trenching and Excavations
1. Top soil and subsoil excavated during trenching may be stockpiled next to the trench, but must be set back from the edge of the trench be a minimum distance of 1 m.
2. A ladder or exit point must always be available close to the workforce in the trench.
3. The Contractor (Site Manager or Foreman) and/or Project Manager must check the walls of all trenches for stability daily before staff may be allowed to enter a trench.
4. The Contractor (Site Manager or Foreman) shall further check all trenches for wild animals and dangerous reptiles every morning before staff will be allowed to commence work in a trench. Animals may not be harmed and must be released back into the environment away from the construction site. Animals should be given the opportunity to move off site. Dangerous animals should only be handled by an experienced and qualified specialist.

5. All trenches must be demarcated or barricaded at all times to warn staff and the general public of the danger.

6. Staff shall not be allowed to work in isolation in a trench. Each worker will pair up with a co-worker and will work in close proximity to one another at all times while conducting work in a trench.

4.16 Access Roads
1. Existing access roads must be used where possible.

4.17 Working Times
1. Maintenance activities shall be executed solely between sunrise and sunset from Monday to Friday, inclusive, of any week.

2. For any deviation from the ordinary working hours the written approval of the Project Manager must be obtained before such work commences. In emergency situations the need for deviation can be communicated verbally with the Project Manager provided this is followed up in writing in due course.

4.18 Health and Safety
1. The work area shall be off limits to the general public at all times during the construction period and during site clean-up.

2. No entry signs should be used to demarcate the site.

3. Where a site camp has been established, emergency numbers for local police, fire department, and the Project Manager must be placed in a prominent clearly visible area on site.

4. A speed limit of 40 km/h must be adhered to by all vehicles and plant.

5. PPE must be made available to all construction staff and the wearing and use of PPE must be compulsory.

6. No person is to enter the site without the necessary PPE.

7. A health and safety plan in terms of the Occupational Health and Safety Act (85 of 1993) must be developed by the contractor to govern staff safety while on site.

8. A record of health and safety incidents must be kept on site and incidents must be reported to the Project Manager immediately.

9. At least one person trained in first aid should be present on site and first aid facilities must be available on site at all times.
10. Sufficient solid waste bins with vermin proof lids shall be present within a 5 m radius of any cooking/eating area at all times.

4.19 Fire Prevention and Control
1. No fires for heating purposes shall be allowed on site.
2. The Contractor shall be responsible for ensuring immediate notification of the Fire Department (see Key Contacts list on pg. 5) and appropriate actions in the event of a fire and shall ensure that employees are aware of the procedures to be followed.
3. Fire prevention awareness must be included in the general environmental awareness material in the Maintenance Plan to create an awareness of the risks of fire.
4. Ideally there should be no smoking on site. If smoking is required a designated smoking area with fire-fighting equipment should be provided.

4.20 Works and Site Decommissioning
1. All structures, vehicles, plant and material comprising the site camp are to be removed from site.
2. The site camp footprint area is to be checked for spills of contaminant substances, and these shall be cleaned up and disposed of appropriately.
3. All hardened surfaces within the construction camp footprint area should be ripped and the area covered with top soil and seeded appropriately to facilitate re-vegetation.

4.21 Rehabilitation
1. Disturbed areas shall be rehabilitated as specified in site specific Maintenance Plans to the satisfaction of the ECO.

4.22 Monitoring and Compliance
1. The Project Manager or suitably qualified and experienced staff member acting on his/her behalf, shall inspect the site regularly to ensure that general contract specifications and environmental specifications of the EMPr are adhered to.
2. Fines / penalties for infringements of contract specifications may be imposed by the Project Manager. In addition, the contractor will be required to make good any damage caused as a result of the infringement at his own expense.
3. The Contractor shall maintain a record of incidents as well as corrective and preventive actions taken, for submission to the Project Manager at the scheduled project meetings. These documents are to be collated by the Project Manager as part of site specific Maintenance Plan records.
4. The ECO shall be notified in writing of dates of work commencement and of any incidents and will conduct site inspections at appropriate intervals to ensure that the system for implementation of the EMPr is operating effectively.

5. Compliance with the EMPr is deemed to not have been achieved if:
   o There is evidence of contravention of the EMPr clauses within the boundaries of the site.
   o Environmental damage ensues due to negligence.
   o The Contractor fails to comply with corrective or other instructions issued by the Project Manager, within a time period specified by the Project Manager.

4.23 Heritage and Archaeology

1. Should any human burials and/or remains or any other items of significant heritage value be uncovered or exposed during earthworks, excavation or any other kind of activity on the application property, all such works and/or activities must be immediately stopped and such items, burials and/or remains be immediately reported to the South African Heritage Resources Agency (i.e. SAHRA at contact no. 021 462 4502) and Heritage Western Cape (i.e. HWC at contact no. 021 483 9693), and the E&HM Branch notified.
5  SPECIFICATIONS FOR MANAGEMENT OF VEGETATION

5.1  Removal or Control of Submerged / Floating Aquatic Alien Invasive Vegetation and / or Pondweed

The purpose of management of submerged or floating aquatic vegetation is to improve biodiversity, water quality, hydraulics or recreational access.

The bulk of the negative impacts of aquatic alien vegetation removal stem from the manner rather than the fact of its removal. Restrictions on the removal methods, access routes and stockpiling areas or times can effectively mitigate many of the impacts.

![Examples of invasive aquatic vegetation found in the CCT area (* exotic species; ** indigenous species)](image)

5.1.1  Manual and mechanical removal methods

- Manual removal of aquatic weeds is by hand pulling, shovelling, or drag lines drawn along the channel (pulled by a person holding the line on each bank). Manual removal has less impact on the bottom sediments of a channel or wetland depression than mechanical means. Manual removal is however not possible where large infestations are present or in deep water bodies. Illustrations of different watercourse types are presented in Appendix D.

- Mechanical removal e.g. 13 or 21 m longboom excavator with water bucket is not selective and may not have adequate reach, requiring machine to traverse the bank / littoral zone. Other machinery and application to different environments is described in Appendix C.

- Manual or mechanical removal can be undertaken in tandem with biological and chemical control (see Box 1 and Box 2), or following the manipulation of water levels to kill off aquatic vegetation.
• Regular manual removal of aquatic weeds may lessen the requirement for mechanical removal.
• Collect and remove from site as much material as possible to prevent re-growth and blockages.
• Place nets downstream to catch fragments of plants.
• Clearing of vegetation should always start up river and move downstream to avoid re-infesting cleared patches. Wind however sometimes affects the success of this approach and is therefore not always possible.
• The frequency of removal depends on the target species, but should aim to prevent whole-scale re-infestation of the weed.

Figure 4: Mechanical removal of aquatic vegetation using an excavator and manual removal in a shallow canal.

5.1.2 Manipulation of Water Levels
• Water-level manipulation (draw-down) is only possible in the case of reservoirs, or regulated lakes, and typically results in stranded rotting biomass which should be removed. Areas where this has been undertaken include Zeekoevlei and Rondevlei.
• Manipulation of water levels should be undertaken during low water in summer as periods of high precipitation can reduce the effectiveness of the method.
• The “CCT environmental team” (see definitions list) will assist the District operational staff with advice on the suitability of water level manipulation.

5.1.3 Access and Storage
• Access routes for all systems being cleared of aquatic weeds should be located at right angles to the channel, especially when working in a valley bottom or floodplain wetland, or to minimise the footprint when working in a depressional wetland with a wide littoral fringe (e.g. Princess Vlei).
• Access routes must ensure that drainage patterns are not altered, in particular during high flows, and that culverts of adequate size are installed in any permanent access route.
• Areas of temporary storage are to be located outside of the riparian zone and any visible flood debris line.
• Vegetation should not be stockpiled for drying for long periods (refer to Table 3).

BOX 1

Biological control of alien vegetation (aquatic or riparian)

✓ Biocontrol refers to the use of natural agents to control plant growth and is most commonly used to target alien or invasive plant species, both aquatic and terrestrial / riparian. Most biocontrols are generally exotic species imported from the country from which the invasive weed originates and tend to feed on that particular species (See Appendix A for a list of target plants).

✓ Biocontrol is preferred where these agents can be effectively introduced, because it prevents proliferation of the invasive plant, reducing the requirement for removal of large biomass.

✓ Always maintain a reserve of the target plant to support a population of the biocontrol agent.

✓ Herbicides and chemicals can negatively affect biocontrol agents. Limit the use of these around release sites.

✓ Biocontrol agents may target more than one plant species. Care must be taken not to release a biocontrol agent that will target a species of economic or environmental importance.

✓ The choice of biocontrol proposed for a problematic invasive weed must be informed by the past effectiveness of the biocontrol on the target plant or family, and in the local conditions. The use and administration of a biocontrol agent must be adequately motivated for by the implementing agency, clearly indicating the optimal timing and frequency of release recommended by a professional services provider.

✓ Regular inspections will be required to establish the effectiveness of biocontrol agents.

✓ Monitoring of target the population is necessary to establish whether additional releases are required.
BOX 2

**Chemical control of vegetation (aquatic, reedbeds or riparian)**

- Chemical control (herbicides) avoids the damage caused by mechanical excavation of the root mass of alien vegetation such as emergent species and alien riparian vegetation, but disposal of dead material is still required.
- Chemical control is generally NOT recommended for floating / submerged weeds because chemicals readily enter the water column and dead biomass reduces water quality. Careful use of herbicides on large mats of water hyacinth is however sometimes possible, as part of an integrated large scale vegetation management approach, and in these cases the use of a dye to indicate areas that have been sprayed is most useful.
- Systemic herbicides are preferred – these spread through the plant from the point of application and kill the whole plant including the roots, provided that sufficient chemical is applied.
- Only spray in windless condition to avoid spray-drift onto non-target species.
- Chemical control methods employed by CCT are:

<table>
<thead>
<tr>
<th>Treatment Type</th>
<th>Applicability</th>
<th>Usefulness / recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foliar (leaf) application: only kill the plants when they are translocated to the roots</td>
<td>Wide range of plants incl. saplings of woody spp.</td>
<td>Slow. Rain or heavy dew after application can reduce effectiveness of treatment. Requires leaf surfaces to be large and plant not to be dormant.</td>
</tr>
<tr>
<td>Basal bark treatment: application of the herbicide around the basal stem or trunk of woody plants</td>
<td>Plants with stem / trunk diameter of 5-15cm</td>
<td>Lower risk compared to other chemical methods and can be used year round.</td>
</tr>
<tr>
<td>Cut stump treatment</td>
<td>Plants with diameter greater than 15 cm</td>
<td>As above; essential for many woody species following felling at the base to prevent coppicing.</td>
</tr>
<tr>
<td>Soil applied herbicides - chemical is placed on the soil surface where it dissolves in rain and is taken up by roots and kills the plants.</td>
<td>Bush</td>
<td>Not recommended for general use – highly unselective and persistent in the soil.</td>
</tr>
</tbody>
</table>

- May only be applied under the auspices of trained and certified personnel, using the latest products approved by DWA / Working for Wetlands / professional service provider.
- Safety regulations must be followed.
5.1.4 Restrictions

The specifications regarding appropriate methods for removal of floating and submerged aquatic vegetation, and restrictions on access and storage of collected material depending on the watercourse type and importance are provided in Table 3.

Table 3. Restriction on removal methods for floating and submerged aquatic vegetation removal for different types and importance categories of waterbody.

<table>
<thead>
<tr>
<th>Watercourse Type</th>
<th>Ecological Importance ranking for stormwater maintenance and management measures</th>
<th>Acceptable methods with appropriate restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Rivers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upland</td>
<td>HIGH (Category 1 or 2)</td>
<td>Vegetation removal not typically required in such systems (aquatic vegetation seldom becomes problematic), however if required, then the same constraints as for Medium importance systems (below), should be applied.</td>
</tr>
<tr>
<td>Gorge</td>
<td>MEDIUM (Category 3)</td>
<td>Manual, with machine only to collect / load dumped / dry material, single track pedestrian access to channel; areas for temporary storage to be outside of riparian strip; machine access track not to be closer than 5 m from top of bank; pre-identified (limitation) stockpiles.</td>
</tr>
<tr>
<td>Foothill</td>
<td>LOW (Category 4 or 5)</td>
<td>Manual or mechanical as desired; range of machinery: bank channelisation acceptable, but limit to one side (see EMPr for general guidelines, but implement only as far as practical)</td>
</tr>
<tr>
<td>2) Rivers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowland</td>
<td>HIGH (Category 1 or 2)</td>
<td>Manual only and / or with raft-collection; labour to carry to temp storage / loading area for truck which must be &gt;10 m from floodplain/ riparian edge in designated areas; maximum storage time 2 weeks;</td>
</tr>
<tr>
<td>Lowland with floodplain</td>
<td>MEDIUM (Category 3)</td>
<td>Manual with raft-collection or long-boom machine on bank only to collect hand-pulled material, access track for machine limited to one path per 1 km river length and not to be closer than 1 m from top of bank; no steepening of bank / channelization allowed (track machine travelling to and fro along bank to access water surface); if access across floodplain required, this to follow stringent guidelines in this EMPr.</td>
</tr>
<tr>
<td></td>
<td>LOW (Category 4 or 5)</td>
<td>Manual or mechanical as desired; range of machinery incl. mud dozer, drag-lines; bank / berm formation acceptable (see this EMPr for general guidelines, but implement only as far as practical)</td>
</tr>
<tr>
<td>3) Wetlands:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetland</td>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Manual only; stockpiling by hand outside of wetland buffer; removal by machine from stockpile only; maximum storage time 2 weeks.</td>
</tr>
<tr>
<td>transitional rivers;</td>
<td>MEDIUM (Critical Ecological Support Area / Category 3)</td>
<td>Manual only to prevent channelization with long-boom machine on edge only to collect hand-pulled material, access track not to be closer than 1 m from top of bank; if access across floodplain required, this to follow stringent guidelines in this EMPr.</td>
</tr>
<tr>
<td>Valley-bottom wetlands;</td>
<td>LOW (Other Ecological Support Areas / Category 4 or 5)</td>
<td>Manual or mechanical; berms for machine travel within wetland acceptable if valley bottom of low importance, but such berms must not prevent flow – see guidelines in this EMPr.</td>
</tr>
<tr>
<td>Floodplain wetlands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Wetlands:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>seeps</td>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Manual only; stockpiling by hand outside of wetland buffer; removal by machine from stockpile only; pedestrian access lines through seep to be brush-cut.</td>
</tr>
<tr>
<td></td>
<td>MEDIUM (Critical Ecological Support Area)</td>
<td>Manual only to prevent channelization with long-boom machine &gt;1m from edge only to collect hand-cut material, access track not to be closer than 1m from edge of seep) and only one access point to the edge per 100m; pedestrian access lines through seep to be brush-cut.</td>
</tr>
<tr>
<td></td>
<td>LOW (Other Ecological Support Areas)</td>
<td>Manual or mechanical; berms for machine travel within wetland acceptable but such berms must not prevent flow – see guidelines in this EMPr.</td>
</tr>
<tr>
<td>5) Wetlands:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flat &amp; depressions</td>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Manual only or with raft / weed harvester (e.g. where Potamogeton is target); stockpiling by hand outside of wetland buffer; removal by machine from stockpile only</td>
</tr>
<tr>
<td></td>
<td>MEDIUM (Critical Ecological Support Area)</td>
<td>Manual only to prevent disturbance / deepening with long-boom machine on edge only to collect hand-pulled material, alternatively floating weed harvester; access track not to be closer than 5m from edge unless very large system; if access across littoral / marginal vegetation required, this to follow stringent guidelines in this EMPr.</td>
</tr>
<tr>
<td></td>
<td>LOW (Other Ecological Support Areas)</td>
<td>Manual or mechanical; berms for machine travel within wetland acceptable but such berms must not prevent flow – see guidelines in this EMPr.</td>
</tr>
<tr>
<td>6) Wetlands:</td>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Not applicable (High and Medium Importance categories do not exist for DAMS)</td>
</tr>
<tr>
<td></td>
<td>MEDIUM (Critical Ecological Support Area)</td>
<td>LOW (Other Ecological Support Areas)</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td><strong>7) Estuaries</strong></td>
<td><strong>HIGH</strong></td>
<td>Manual or with weed harvester with raft-collection; labour to carry to temp storage / loading area for truck which must be &gt;10 m from floodplain edge in designated areas; maximum storage 2 weeks.</td>
</tr>
</tbody>
</table>
5.2 **Removal or control of indigenous reedbed and emergent in-channel vegetation**

Emergent vegetation like reeds, sedges, restios and grasses is most often limited to the margins of fast-flowing rivers, but, in channelled valley bottom wetlands and low-gradient river channels may also extend across the channel base. Many detention ponds are vegetated with reeds, either intentionally or as a result of invasion. In the rivers of the CMA nutrient enrichment is an almost inevitable consequence of their use as stormwater conduits. The inevitable consequences of eutrophication are that plants grow better, faster and often become larger, clogging river channels, exacerbating sediment deposition and hampering the passage of floodwaters. In many systems therefore, removal of the vegetation (and the deposited sediments – see section 7) is required:

- to increase stormwater conveyance capacity or retention volume;
- occasionally at culvert inlets / outlets to prevent their acting as bottlenecks to the movement of flood waters;
- to improve biodiversity value. Reed management can create structural variation including open, wet habitat, pools, glades, reed edge etc., ideal conditions for wildlife. Many reedbed birds favour ‘edges’ or younger, more open reedbed patches, either for feeding or breeding.

Mechanical removal of vegetation can be destructive, and mitigation of these impacts is not possible in all cases, given the overriding need to prevent flooding as a result of choked watercourses.

![Manual removal of reedbed and emergent vegetation](image)

**Figure 5**: Manual removal of reedbed and emergent vegetation in channels / wetlands: over-clearing and specifically the removal of indigenous emergent (in-channel and riparian) vegetation should be avoided except where there is a real threat of flooding associated with the capacity of the channel relative to the stormwater flows and no possibility of expanding channel capacity.

5.2.1 **Manual / mechanical removal and burning**

- Manual removal of reed material is by scythe, weed-eater, brush-cutter or similar device, with cut material carried to the side of the waterbody.
• Manual removal of reeds should be done at the end of the dry season to facilitate ground-level cutting of stems and their inundation in winter (>8 cm) so that the plant (or at least a portion thereof) drowns.

• Manual removal has less impact on the channel/wetland than mechanical means, but re-growth is faster as root material is not removed.

• Manual removal in water >50 cm deep is not possible (cannot cut stems low enough; safety hazards in deep water).

• Mechanical removal from deep areas may be done with a 13 or 21 m Longboom Excavator with water bucket. If the machine has insufficient reach it would be necessary to traverse the bank/littoral zone or through the wetland which would disturb the habitat, and this should be avoided where possible. The longer boom arm will have better reach across sensitive river banks/wetland vegetation where mechanical means is unavoidable.

• In extensive areas where the substratum is seasonally dry, mechanical removal of aerial portion of the reedbed can be performed with a brushcutter and tractor.

• In wide channels with marginal reedbed fringes, reed control is best achieved using a motorised boat with reed-cutter.

• Chemical control of reed beds in not preferred except where careful application can be done to ensure there are no chemical spills (see Box 2).

• Burning at the end of the dry season is highly efficient and cost-effective for controlling reedbed expansion, but must be performed with a Fire Plan endorsed by the local fire authority.

5.2.2 Ecosystem support

• Large-scale removal of reed beds should take place no more frequently that every two years, to allow recovery between disturbances.

• Consideration must be given to bird breeding season (September – November) and western leopard toad breeding seasons (August – December). Vegetation used for breeding or nesting purposes must not be cleared during these times.

• A cutting regime that creates different age mosaics of reed (patches at different maturity) with a high degree of reed/water interface should ideally be aimed for, even in reedbeds whose function is primarily filtration and water quality management.

• For reedbeds whose function is primarily filtration and water quality management, the maintenance programme should aim for sheet flow of water across the full extent of the reedbed, to maximise the water-soil-microbial interaction and decrease velocity. Having a “low flow” channel through the reed bed is not desirable for these systems.

5.2.3 Access and storage of removed material

• Access routes for all systems where reedbed is removed should be located at right angles to the channel, especially when working in a valley bottom or floodplain wetland, or located to minimise the footprint when working in a depression wetland with a wide littoral fringe (e.g. Princess Vlei).
• Access routes must ensure that drainage patterns are not altered, in particular during high flows, and that culverts of adequate size are installed in any permanent access road.

• Areas of temporary storage are to be located outside of the riparian zone and any visible flood debris lines / the normal inundation area or as stipulated in the site specific Maintenance Plan.

• A two-week maximum period from stockpiling of material to its removal should be observed, to minimize the impacts associated with piles of rotting vegetation (refer to Table 4 for more stringent conditions in sensitive systems).

### 5.2.4 Restrictions

Restrictions on methods employed for reedbed and emergent in-channel vegetation clearing depend on the watercourse type and importance and are provided in Table 4 and described below.

• Specific attention is drawn to the requirement for reed and emergent indigenous vegetation control in Medium and High Importance systems to be specifically linked to a functional (flood control) function, or safety, rather than based on a notion of “neatness” or aesthetics.

• Reed removal should generally only take place from river channels and channelled valley bottom wetlands and floodplains.

• The need for clearing of (non-reedbed) indigenous emergent wetland vegetation\(^3\) within channelled systems should be confirmed by the “CCT Environmental Team” who will assist the District operational staff with advice in such cases. The following circumstances are regarded as appropriate motivation for the removal of indigenous emergent vegetation that is not a mono-specific reedbed:
  o There is a real threat of flooding associated with the capacity of the channel relative to the stormwater flows.
  o There is no alternative to enhance channel capacity, for example widening of the channel (see section 6.1: Channel profile enhancement)

• Excavation of reeds and other emergent vegetation from un-channelled wetland systems should be undertaken with extreme care with the advice and planning of the “CCT Environmental Team” since it could result in the formation of unnatural channels and conduits which would negatively affect the functional integrity and hydrology of the system.

---

\(^3\)i.e. wetland species that are not monospecific stands of *Typha capensis* and *Phragmites australis*: typical species may include *Schinopectis littoralis*, *Bulboschoenus maritimus*, *Ficinia nodosa*, *Juncus skraussii*, *Psoralea spp.*, *Isolepis prolifer*, *restios* etc.
Table 4. Restriction on removal methods for reedbed and emergent in-channel vegetation for different types and importance categories of waterbody.

<table>
<thead>
<tr>
<th>Watercourse Type</th>
<th>Ecological Importance ranking for stormwater maintenance and management measures</th>
<th>Acceptable methods with appropriate restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Rivers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upland</td>
<td>HIGH (Category 1 or 2)</td>
<td>Not applicable (reedbed formation does not occur in these river types)</td>
</tr>
<tr>
<td>Gorge</td>
<td>MEDIUM (Category 3)</td>
<td></td>
</tr>
<tr>
<td>Foothill</td>
<td>LOW (Category 4 or 5)</td>
<td></td>
</tr>
<tr>
<td>2) Rivers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowland with floodplain</td>
<td>HIGH (Category 1 or 2)</td>
<td>Only for functional (e.g. maintaining hydraulic flow) not aesthetic reasons (e.g. mowing or reed trimming). Manual only; temp storage &gt;10 m from floodplain/riparian edge in designated areas; maximum storage time 2 weeks; 2-yr cycle of removal; if access across floodplain required, this to follow stringent guidelines in this EMP.</td>
</tr>
<tr>
<td></td>
<td>MEDIUM (Category 3)</td>
<td>Only for functional (e.g. maintaining hydraulic flow) not aesthetic reasons (e.g. mowing or reed trimming). Manual with long-boom machine on bank only to collect hand-cut reeds, access track for machine limited to one path per 1km river length (incl. through floodplain, which would have to be constructed on berm); in-house check on hydrological changes; 2-yr cycle of removal; if access across floodplain required, this to follow stringent guidelines in this EMP.</td>
</tr>
<tr>
<td></td>
<td>LOW (Category 4 or 5)</td>
<td>Manual or mechanical; depth of excavation of (reedbed) root material to be set on site; berms for machine travel within wetland acceptable but not to prevent flow – see EMP for guidelines</td>
</tr>
<tr>
<td>3) Wetlands:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetland transitional rivers;</td>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Only for functional (e.g. maintaining hydraulic flow) not aesthetic reasons (e.g. mowing or reed trimming). Manual only; stockpiling by hand outside of wetland margin; removal by machine from stockpile only.</td>
</tr>
<tr>
<td>Valley-bottom wetlands;</td>
<td>MEDIUM (Critical Ecological Support Area / Category 3)</td>
<td>Only for functional (e.g. maintaining hydraulic flow) not aesthetic reasons (e.g. mowing or reed trimming). Manual only; access track not to be closer than 1m from top of bank; if access across valley bottom required, this to follow stringent guidelines in EMP.</td>
</tr>
<tr>
<td>Floodplain wetlands</td>
<td>LOW (Other Ecological Support Areas / Category 4 or 5)</td>
<td>Manual or mechanical; depth of excavation of (reedbed) root material to be set on site; berms for machine travel within wetland acceptable but not to prevent flow – see EMP for guidelines</td>
</tr>
<tr>
<td>4) Wetlands:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>seeps</td>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Only for functional (e.g. maintaining hydraulic flow) not aesthetic reasons (e.g. mowing or reed trimming). Manual only; stockpiling by hand outside of wetland buffer; removal by machine from stockpile only; pedestrian access lines through seep to be brush-cut.</td>
</tr>
<tr>
<td></td>
<td>MEDIUM (Critical Ecological Support Area)</td>
<td>Only for functional (e.g. maintaining hydraulic flow) not aesthetic reasons (e.g. mowing or reed trimming). Manual only; in order to prevent channelization, long-boom machine &gt;1m from edge only to collect hand-cut material, access track not to be closer than 5 m from edge of seep; only one access point to the edge per 100m; pedestrian access lines through seep to be brush-cut and removed from seep.</td>
</tr>
<tr>
<td></td>
<td>LOW (Other Ecological Support Areas)</td>
<td>Manual or mechanical; berms for machine travel within wetland acceptable but not must not prevent flow; depth of excavation of (reedbed) root material to be set on site.</td>
</tr>
<tr>
<td>5) Wetlands:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flats &amp; depressions</td>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Only for functional (e.g. maintaining hydraulic flow) not aesthetic reasons (e.g. mowing or reed trimming). Manual only; stockpiling by hand outside of wetland buffer; removal by machine from stockpile only.</td>
</tr>
<tr>
<td></td>
<td>MEDIUM (Critical Ecological Support Area)</td>
<td>Only for functional (e.g. maintaining hydraulic flow) not aesthetic reasons (e.g. mowing or reed trimming). Manual only; stockpiling by hand &gt;5 m from edge; removal by machine from stockpile; access track not to be closer than 5 m from edge.</td>
</tr>
<tr>
<td>Ecological Support Areas</td>
<td>Management</td>
<td></td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>LOW</td>
<td>Manual or mechanical; berms for machine travel within wetland acceptable but must not prevent flow; depth of excavation of (reedbed) root material to be set on site / determined according to aims e.g. preventing re-growth (detention ponds).</td>
<td></td>
</tr>
</tbody>
</table>

6) Wetlands: Dams

<table>
<thead>
<tr>
<th>Importance Category</th>
<th>Management注意事项</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Importance category does not exist for dams (all “Low”).</td>
</tr>
<tr>
<td>MEDIUM (Critical Support Area)</td>
<td>Importance category does not exist for dams (all “Low”).</td>
</tr>
<tr>
<td>LOW (Other Ecological Support)</td>
<td>Manual or mechanical as desired.</td>
</tr>
</tbody>
</table>

7) Estuaries

<table>
<thead>
<tr>
<th>Importance Category</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH</td>
<td>Only for functional (e.g. maintaining hydraulic flow) not aesthetic reasons (e.g. mowing or reed trimming). Manual only; temp storage &gt;10 m from edge in designated areas; maximum storage time 2 weeks; 2-yr cycle of removal; if access across floodplain required, this to follow stringent guidelines in EMPr.</td>
</tr>
</tbody>
</table>
5.3 Removal or control of woody riparian / terrestrial vegetation in channels and wetlands

Many urban river systems are infested with alien riparian species as a result of past physical disturbances, such as bank clearing and channel modification, infilling and fires, that open up space for the establishment of aliens. Woody alien species also establish a toe-hold in the drier (e.g. seasonally saturated) patches of seeps, valley bottom and floodplain wetlands often in response to anthropogenic disturbance. Detention ponds and other depression wetlands used in the stormwater system for the most part are either artificial systems constructed for this purpose or heavily modified naturally-occurring systems: both categories are also prone to the establishment of aliens on disturbed margins and the gradual creep of these over the drier area of the depression. The City’s Invasive Species Unit (ERM Department) can assist with guidance regarding the management of invasive alien plant species. Under no circumstances should species listed as protected under the National Forests Act (Act No. 84 of 1998) be removed unless the appropriate authorisation has been obtained in terms of this act. These include species such as yellow wood, silver tree and milkwood.

Removal of dense riparian / marginal vegetation is required:

- to increase conveyance capacity or retention volume for stormwater management;
- in artificial, grassed dry detention ponds, to facilitate recreational use;
- for aesthetic requirements (neatness)
- in terms of the requirements of the Alien and Invasive Species Regulations of the National Environmental Management: Biodiversity Act, 2004 (Act No.10 of 2004);
- all woody / bushy vegetation, including indigenous species, is removed from dam walls for technical safety. Grasses are generally not removed.

![Figure 6: Typical invasive alien terrestrial species in the CCT area, image from CSRM, 2003](image_url)
5.3.1 **Recommended removal methods**

- The most common removal methods employ either hand-pulling of small saplings or manual extraction using a “tree popper” device for small trees.
- Large trees are best removed by chainsaw, with stumps cut close to the ground and chemical treatment of cut stumps (see Box 2).
- Always temporarily store the removed vegetation above the flood debris line / normal inundation area.
- Burning of vegetation must be restricted to pre-designated areas only and should only be undertaken under the advice and guidance of the Biodiversity Management Branch.
- Where riparian vegetation is >80% alien, with especially dense undergrowth, the use of fire as a clearing approach is permissible. However, consideration should be given to preventing the fall of partially burnt trees across the channel where they are more difficult to cut or remove and present an erosion threat.
- When burning woody invasive vegetation on wetland flats or floodplains, unburned patches must be retained as a refuge for wildlife.
- A fire plan must be developed with relevant departments within the local authority including emergency services and specialists.
- Clearing should be followed-up timeously, at least annually but in some cases bi-annually, to prevent re-infestation by seedlings.

5.3.2 **Rehabilitation**

- In areas where all vegetation has been removed, short-term measures to stabilise banks and prevent erosion may become necessary.
- In densely infested areas with little remaining natural vegetation, stabilisation of one or both slopes and a replanting programme may be required to realise the gains of alien clearing.
- In **Medium and High** Importance systems cleared slopes must ideally be replanted with appropriate indigenous plant species to prevent erosion and colonisation by invasive species, and to improve riparian integrity.

Stabilisation and/or planting plans should be confirmed by the CCT Environmental Team.

5.3.3 **Recreational and aesthetic considerations**

Where removal of vegetation is undertaken for recreational or aesthetic motives (see Box 3), the following guidelines should apply:

- The low-flow channel of dry detention areas should preferably remain un-mowed and the establishment of short indigenous species (e.g. sedges) should be promoted. This low flow channel may however be permanently wet, depending on the catchment characteristics.
The practise of mowing of green open space adjacent to stream channels (typically undertaken by City Parks) must avoid the riparian zone, to encourage the development of vegetated buffers which can assist with improving runoff water quality and provide a corridor function. Manual cutting of tall vegetation is acceptable where this constitutes a safety hazard.

5.3.4 Restrictions

The following restrictions on clearing of riparian vegetation apply:

- In systems of Medium and High Importance ranking, only the methods described above should be used, i.e. no use of bulldozers or other mechanised methods are acceptable. Temporary storage of felled material shall be in pre-identified stockpiles (approved by the ECO), outside of the riparian belt, with access tracks for loading material onto a vehicle extending no closer than 5 m from top of bank; maximum storage time at medium and high importance watercourses is 2 weeks.

- Work force size must be limited where vegetation control is undertaken on sensitive bank or muddy habitats as trampling can cause notable environmental degradation.

- The need for clearing of indigenous riparian or marginal vegetation should be confirmed by the CCT Environmental Team. Clearing of indigenous riparian / marginal vegetation should only take place where:
  - There is a real threat of flooding associated with the capacity of the channel relative to the stormwater flows.
  - There is no alternative to enhance channel capacity, for example widening of the channel (see section 6.1: Channel profile enhancement).
Nearly all of the streams passing through the urban areas of the City of Cape Town are subjected to hydrological and hydraulic alteration (e.g. increased runoff, channel narrowing, loss of riparian zones, diversion), a consequence of which is erosion. A significant requirement of the urban stormwater management programme therefore is to address either or both the cause and effects of these changes.

6.1 River Channel Profile Enhancement

Where feasible (where physical space and budgets are available and ecological gains are warranted i.e. on a medium or high importance ecosystem) redressing erosion should aim at reinstating as much of the natural channel profile as possible.

Where the dual goals are the upgrading of stormwater functioning to address erosion, and simultaneously the increase in conditions that would improve biodiversity, this task is often termed river or wetland "rehabilitation".

The range of actual steps included in this process differs, depending on the specifics of a river reach or wetland, but would include some of the following:

- channel bed widening and / or roughening,
- conversion of concrete-lined channels to rock / earth channels with concomitant re-shaping,
- installation of snags,
- creation of meanders, braids or bars,
- installation of cross gabions to reduce longitudinal gradients,
- flattening and sculpting of banks to reduce erosion and increase structural habitat,
- establishing vegetation with appropriate species.

6.1.1 Planning

- The possibilities and options regarding widening and reshaping should be assessed on a case by case basis, to ensure maximum ecological gain for the (not insubstantial) cost. In this regard, the CCT Environmental Team will assist the District operational staff and decide on the most appropriate strategy.
- Re-shaping of beds or banks should be completed between October and April – before winter rains to allow vegetation to recover and to minimise erosion potential.
- Re-vegetation / a planting plan should always be a component of channel profile enhancement (refer to Appendix B).

6.1.2 Restrictions

Since channel profile enhancement falls into the category of rehabilitation, there are no restrictions on what activities can be undertaken on different watercourses or
wetland types, as long as appropriate technical (for example hydrological, engineering, ecological, botanical) input is obtained. In such projects, the Environmental Resource Management Department is likely to play a key role.

6.2 Erosion control structures

In most instances, extensive re-shaping and reinstating of natural channel dimensions is not possible, and measures to address specific points of bed or bank erosion or gulley formation are required. Typically, these measures involve the installation of a variety of built erosion control structures. The typical location of these erosion points are:

- Pipe outlets, culverts, weirs, bridges and pipe crossings
- Areas of overland / sheet flow
- Outsides of river bends
- Interface between lined and unlined reaches
- Incised channels / rivers with in-filled macro-channels

The merits of different approaches are detailed in Ecological Guidelines for River / Wetland Upgrading Projects (CSRM 2003). This information is provided in Appendix B of this EMP, and compared in summary in Box 4.

Note: this application precludes the construction of mass concrete weirs; canals and the conversion of streams to concrete canals (refer to section 6.3). However, depending on the extent of reinforcing required against erosion, the measures contemplated here may in some circumstances verge on the extensive hardening of short stretches of river which may be seen by some as effective “canalisation”. Due care and advice from the CCT Environmental Team is essential in such cases.

6.2.1 Restrictions

Restrictions on methods employed for erosion control, depending on the watercourse type and importance are provided in Table 5.

To ensure appropriate mitigation, the erosion control structures should be planned with the guidance and expertise of the Roads and Stormwater Department’s engineers and with the support of the CCT Environmental Team. In Medium and High Importance rivers the installation of reinforced bed and bank sections should only be allowed where:

- There is a direct threat to built infrastructure (i.e. excluding gardens and open space areas) from flooding.
- There is no alternative to enhance channel capacity, for example widening of the channel (see section 6.1 channel profile enhancement).

The choice of structure is often constrained by the severity of the erosion problem that dictates specific engineering solutions. In general, however, “softer” options, especially where these facilitate planting as a component of bank or bed stabilisation, should be selected. For example:

- Rock-pile weirs should be selected where possible over gabion weirs as they provide better habitat; gabions are in turn better than mass concrete weirs;
• Rip rap against channel banks or as culvert protection provides for stability with cavities for establishment of riparian vegetation if constructed correctly;

• All-bank gabions must be constructed with at least a low-level step to facilitate establishment of wet bank vegetation. Coir-mat lining and filling of voids between rocks with topsoil, or the use of “green gabions”, will improve establishment of vegetation and can provide a degree of riparian function (see Box 5).

• Reinforced bank and channel floor sections should not be constructed from mass concrete.
## BOX 4

### Comparison of erosion control structures

<table>
<thead>
<tr>
<th>Structure</th>
<th>Features / advantages</th>
<th>Comparative comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stabilising vertical bed erosion and down-cutting, through energy dissipation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rockpile weirs</td>
<td>Maintains high-energy hydraulic habitats (riffle and run), unlike gabion weirs; dissipates energy through roughness</td>
<td>Preferred to gabion weirs except where channel widening or depositional habitats are required</td>
</tr>
<tr>
<td>Gabion weirs</td>
<td>Effective means to re-build channel gradient where deep erosion has already occurred; weir width can be tailored to widen river and create depositional habitats</td>
<td>Stronger effect on longitudinal profile can be achieved in a small localised area compared to rockpile weir; use when hydraulics would not support the latter.</td>
</tr>
<tr>
<td>Sandbag weirs</td>
<td>protection of side slopes and water course from erosion, through energy dissipation</td>
<td>Use as temporary stabiliser e.g. after a fire</td>
</tr>
<tr>
<td>Bank and channel stabilisation and prevention of erosion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riprap lining</td>
<td>Large / mixed rock stabilisers, heterogeneity of form and bank slope; interstitial spaces filled with finer material</td>
<td>Most natural effect, especially if inter-planted with vegetation; use as first preference</td>
</tr>
<tr>
<td>Groynes</td>
<td>Vertical gabion structure for bank protection in laterally confined areas (urban encroachment) hydraulic design input required to space the groyne structures correctly</td>
<td>Advantage of being very localised. River bank sections between groynes can be allowed to stabilise with natural vegetation or comprise gabion baskets; the latter is not preferred because it creates sterile bank</td>
</tr>
<tr>
<td>Gabion and Reno mattress linings</td>
<td>Gabion and reno thickness and sizing are dictated by flow velocities and volumes, and require specialist geotechnical and hydraulic engineering input</td>
<td>Provide stability function during extreme loading (e.g. flooding) where other methods (e.g. rip-rap lining, ACBs) do not possess the same integrity; Ecologically sterile, not recommended except where no other option viable, or over short sections of channel</td>
</tr>
<tr>
<td>Articulated concrete blocks (ACB)</td>
<td>Continuous “blanket” of interlinked concrete blocks, narrow interstitial spaces for planting of small plants / grass</td>
<td>Inflexible and poorly reflect the natural (or landscaped) contours of a river bank, making for a homogeneous and ecologically relatively sterile environment.</td>
</tr>
<tr>
<td>Geocells</td>
<td>Easy to install with unskilled labour; Useful in relatively low gradient areas subject to flood-erosion</td>
<td>Create uniform environment of short vegetation (small root mass); support a “tidy” look in stormwater swales; useful in watercourses where e.g. reedbed formation is desirable</td>
</tr>
<tr>
<td>Geofabrics</td>
<td>Fabric sheets for lining banks, within which slits can be created for planting / large plant growth</td>
<td>Better sculptural fit to naturally shaped bank contours; supports large plants; must be associated with planting programme</td>
</tr>
<tr>
<td>Planting</td>
<td>In tandem with bank shaping or other structures</td>
<td>Most natural approach; requires intensive effort in medium term</td>
</tr>
</tbody>
</table>
Table 5: Restriction on erosion control structures for different types and importance categories of waterbody

<table>
<thead>
<tr>
<th>Watercourse Type</th>
<th>Ecological Importance ranking for stormwater maintenance and management measures</th>
<th>Acceptable methods with appropriate restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Rivers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upland Gorge</td>
<td>HIGH (Category 1 or 2)</td>
<td>Limited to where no channel profile enhancement at all possible and where built infrastructure is directly threatened; minimise height / steps in gabions to allow riparian planting; ensure internal / external engineering and ecologist input; softest options in terms of materials (see ranked structures in Box 4 and Appendix B)</td>
</tr>
<tr>
<td>Foothill</td>
<td>MEDIUM (Category 3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOW (Category 4 or 5)</td>
<td>As required; use softest options possible; allow marginal / instream vegetation to be establish where possible e.g. low steps for gabions; removal of alternate blocks in reno mattress for root establishment – see Appendix B.</td>
</tr>
<tr>
<td>2) Rivers:</td>
<td>HIGH (Category 1 or 2)</td>
<td>It is unlikely naturally functioning systems will receive significant quantities of stormwater and require erosion control. Nonetheless, if required, then the same constraints as for Medium Importance systems (below) should be applied.</td>
</tr>
<tr>
<td>Lowland Lowland</td>
<td>MEDIUM (Category 3)</td>
<td>Low steps for gabions / reno or preferably sub-surface with earth overlay 0.5 m, where maintenance of channel flow essential, but allowing overtopping onto floodplain</td>
</tr>
<tr>
<td>with floodplain</td>
<td>LOW (Category 4 or 5)</td>
<td>As required; use softest options possible;</td>
</tr>
<tr>
<td>AND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Wetlands:</td>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Gabion weirs &lt; 1 m above the natural ground surface are permitted; use softest options in terms of materials (see ranked structures e.g. geocells); aim to improve channel / wetland interface; replanting plan essential.</td>
</tr>
<tr>
<td>Wetland</td>
<td>MEDIUM (Critical Ecological Support Area / Category 3)</td>
<td>Gabion weirs &lt; 1 m; use softest options in terms of materials; bank gabions in channelled valley bottoms to be limited to where erosion is serious and a series of weirs would not be possible; maximum length 100 m; single gabion rise only i.e. protrude above ground level by &lt; 1 m; set low to allow flow in to valley-bottom; reno footprint only part of gabion weir; replanting plan essential.</td>
</tr>
<tr>
<td>transitional rivers; Valley-bottom wetlands; Floodplain wetlands</td>
<td>LOW (Other Ecological Support Areas / Category 4 or 5)</td>
<td>As required; use softest options possible;</td>
</tr>
<tr>
<td>4) Wetlands:</td>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Aim to improve channel / wetland interface through reinstating eroded channel base level; gabion weirs &lt; 0.5 m above the natural ground surface are permitted; for erosion use softest options in terms of materials (see ranked structures e.g. trash racks, geocells); replanting plan essential.</td>
</tr>
<tr>
<td>seeps</td>
<td>MEDIUM (Critical Ecological Support Area)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOW (Other Ecological Support Areas)</td>
<td>As required; use softest options possible;</td>
</tr>
<tr>
<td>5) Wetlands:</td>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Erosion control not typically needed in such systems. For managing localised erosion at stormwater outlets and culverts, see best practice activities presented for measure 6.1 (Construction, maintenance and expansion of minor stormwater infrastructure).</td>
</tr>
<tr>
<td>Flat &amp; depressions</td>
<td>MEDIUM (Critical Ecological Support Area)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOW (Other Ecological Support Areas)</td>
<td>As required; use softest options possible;</td>
</tr>
<tr>
<td>6) Wetlands:</td>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Importance category does not exist for dams (all “Low”)</td>
</tr>
<tr>
<td>Dams</td>
<td>MEDIUM (Critical Ecological Support Area)</td>
<td>Importance category does not exist for dams (all “Low”)</td>
</tr>
<tr>
<td></td>
<td>LOW (Other Ecological Support Areas)</td>
<td>As required; use softest options possible;</td>
</tr>
<tr>
<td>7) Estuaries</td>
<td>HIGH</td>
<td>unlikely that this will be required. If required, ensure low steps for gabions, reno or preferably sub-surface with earth overlay 0.5 m, allowing overtopping onto floodplain.</td>
</tr>
</tbody>
</table>
BOX 5

**Best practice guidelines for gabion weirs and linings**

- All bank gabions must be constructed with at least a low-level step and cavity for establishment of wetbank vegetation. Vertical gabions should be avoided.
- Minimise height/steps in gabions to allow for riparian planting.
- Bank gabions in channelled valley bottoms to be limited to where erosion is serious. A series of gabion weirs maintaining the longitudinal profile is a preferable solution.
- Gabion assembly and installation must be done according to design specifications.
- Geotextile should line all sides of the baskets that are exposed.
- Where possible, and where establishment of vegetation on gabions will be practicable, the use of “green gabions” should be considered. Green gabions consist of rock-filled wire mesh gabions lined internally with a biodegradable coir mat. The cavities between rocks are filled with topsoil to encourage establishment of plants. Water corrosivity should be considered at each site. If necessary, PVC coated gabions should be used.
- Soil dispersivity should be considered at each site. If dispersive soils are detected, a technical advisor should be contacted.
- Density of fill material must satisfy the gabion design, i.e. must not be smaller than mesh size. Clay bricks, weathered rock, sandstone and shale may not be used as fill material.
- Any unconventional fill material must be approved by the Project Manager.
- Where fill material is hauled to its point of placement by means of wheelbarrows, the haul distance may not be greater than 150m.
- Workers must be trained in gabion construction using the guidance and design assistance provided by the supplier.
- Minimum 2.5 mm double galvanised wire must be used, with a mesh size that is appropriate to the size of the rock being used.
- Support and binding wire will be a minimum 2.2 mm.
- Lacing will be done according to specification.
- Support wires will be in place (bracing).
- All adjoining baskets will be laced together.
- Inspections of known erosion sensitive reaches of watercourses should be done on an ad hoc basis especially after heavy rains during the wet season.
6.3 “Canalisation”

Canalisation typically involves extensive stretches of reinforced bed and bank, such that a continuous lining of the watercourse over some distance is created. Concrete canals are an existing feature of many stormwater conduits and river reaches in the City. However, from an ecological perspective, construction of concrete canals and extensive lining of bed or banks are extreme engineering options that are no longer considered desirable as a treatment for watercourses. The alternative more desirable solution is to make use of rip-rap, gabion or other forms of protection which all provide at the very least some interaction between the surface flow and the substratum / subsurface layers below the stream bed and the banks (Figures 7 - 9). The extent of works or point at which gabion / reno installations would move from being considered “gabion work” to “canalisation”, is however subjective.

The installation of new concrete-lined sections of watercourses is not included in the application for environmental authorisation. Such an activity would require more detailed engineering motivation (e.g. flood and hydraulic studies) and specific ecological assessment and would be part of a separate application for authorisation. Maintenance of existing sections of concrete canal is however permitted.

Figure 7: Concrete and rock lined canals, image from CRSM, 2002
Figure 8: Concrete canalisation of a small stream, combined with articulated concrete blocks for bank stabilisation in a tidy but ecological sterile stream course in this park.

Figure 9: Example of a concrete canal in the CCT area.
In urban developed catchments substantially more sediment is washed into the rivers draining the landscape than under natural conditions. The gradient of many of the man-made canals and the lowland rivers of the CCT is extremely shallow, with the result that this sediment settles out, reducing the depth of the river channels and providing an ideal substrate for plants, thereby reducing the carrying capacity of the channels. Removal of sediment from certain waterbodies is an unavoidable necessity to maintain conveyance capacity and thus to prevent overbank flooding and bank erosion.

This section deals with methods of sediment removal from waterbodies. Specifications regarding the construction of sediment traps or related infrastructure are provided in Section 10.

7.1 Manual vs. mechanical removal of sediment
- Manual removal of sediment has extremely limited application compared with mechanical means, because of the huge labour effort.
- Manual removal from small areas, such as the inlets to depression wetlands is a viable approach and the preferred approach for High Importance wetlands (Table 6).
- For most systems the location of sediment removal areas or reaches is subject to restrictions / specifications.
- Three sediment removal scenarios are envisaged as part of the City’s stormwater management measures:
  - Removal of sediments from formally constructed sediment traps and other stormwater infrastructure (Figure 10).
  - Removal of sediments from “designated areas” where sediment deposition and accumulation is identified to occur consistently, as opposed to from a constructed sediment trap.
  - Removal of sediments continuously along a river reach or an area of a waterbody or pond, for example a detention pond

7.2 Equipment
Appendix C describes the use of different mechanical plant / machinery under different circumstances.

7.3 Restrictions pertaining to sediment removal from constructed traps and designated sediment removal areas
7.3.1 Location
- In upland and foothill rivers of High / Medium Importance, sediment may only be removed by mechanical methods from constructed sediment traps, as these systems are most susceptible to bed and bank alteration by excavation of their
substrata. Manual removal of sediment from other areas in such streams is allowed, as the extent of such work will generally be very limited.

- Similarly, in Medium or High Importance waterbodies sediment may be removed by mechanical methods from constructed sediment traps (where these exist) or from designated sediment removal areas. Sediment removal in other areas of such waterbodies may be undertaken in terms of a site specific rehabilitation management plan (approved by the Environmental Resource Management Department).

- No sediment removal should take place in un-channelled wetlands (since this excavation could result in the formation of unnatural flow paths and conduits through the wetland) without a site specific rehabilitation management plan (approved by the Environmental Resource Management Department). An area located just upstream of an un-channelled valley bottom wetland should preferably be identified as a “designated sediment removal area”. The location of such an area should be well planned and based on surveys and appropriate data to demonstrate the position of sediment depositional zones.

- The size of a designated sediment removal area for cleaning will depend on the nature of the system. The location and size thereof must be approved by the CCT Environmental Team.

- Designated sediment removal areas and sites for temporary sediment storage must be shown on a map in site specific Maintenance Plans and approved by the CCT Environmental Team. Although the storage areas will depend on the nature of the operation, where possible these are to be located a minimum of 5 m from the top of the bank, or 5 m from the outer edge of the littoral vegetation of a depression wetland.

- Sediment removal is not envisaged to be necessary from hillslope seeps except perhaps from any stormwater infrastructure where such features exist.

- Machine-removal of sediment is permitted in any system for a longitudinal distance of 20 m from inlet and outlet structures of road culverts, or for a radius of 20 m from where pipes or canals enter depression wetlands (e.g. a culvert entering Princess Vlei). These sediments are often associated with clogging vegetation which also requires simultaneous management.
7.3.2 Access and storage of removed sediment

- Access routes to waterbodies should be located at right angles to the channel, especially when working in a valley bottom or floodplain wetland, or located to minimise the footprint when working in a depressional wetland with a wide littoral fringe (e.g. Princess Vlei).

- Access routes must ensure that drainage patterns are not altered, in particular during high flows, and that culverts of adequate size are installed in any permanent access road.

- Ensure there is no continuous removal of vegetation along the bank by either restricting the access into the channel (where clearing is by e.g. mud dozer), or by having set access points for heavy machinery at a minimum of 25 m intervals. Dozers should access these entry points along the bank by first reversing along the current access path to outside of the riparian belt / littoral zone and then subsequently re-entering the next access point from the upland area.

- Where possible, access routes that are likely to be repeatedly used should be permanent and maintained.

- An alternative, depending on the frequency with which sediment areas are cleared, is the compilation of a method statement regarding the placement of fill for a temporary access route to the site, which should be approved by the CCT Environmental Team. Such a procedure would include:
  - Utilising clean fill material,
  - Maintaining pre-construction ground levels when material is removed from site,
  - Appropriate disposal of the fill, and
  - Stabilisation of the disturbed ground surface to prevent erosion, or the establishment of alien / weedy species.

- Truck access roads are to extend only to temporary storage areas.
7.3.3 Operations

- Constructed sediment traps generally have a solid base layer that indicates the level to which excavation should be undertaken. In less formal designated sediment retention / deposition areas, a set of four permanent, marked stakes should be installed to indicate the correct excavation level.
- Where stormwater outlets and banks are protected with concrete, armourflex or gabions, a shield/guard must be used on the bucket of the machine to prevent damage.
- Where suitable, leave islands in the middle of river intact to provide habitat for birds.
- Silt screens are to be considered down-stream of the site.
- Stockpiled sediment is to be removed within 2 weeks of completion of the operation.
- Sediment removal activities should start upstream and work downstream.
- Sediment removal should ideally occur during the spring and summer when water levels are low and to allow time for re-growth of instream vegetation before the winter rains. Annual or bi-annual sediment management programmes may be necessary depending on catchment characteristics and the rate of sediment accumulation.
- Where feasible, trucks transporting sediment should be covered to minimize dust.
- Mud and sand resulting from the loading of sediment should be cleaned from the road at the end of each day.
- Where possible, materials should be re-used (e.g. top soil or composting).
- If the sediment is removed from a heavily impacted / polluted system, the levels of heavy metals or pollutants in silt should be tested to determine the correct method of disposal. If in doubt or no quality tests are possible, the material from heavily polluted systems should automatically be disposed of at an appropriately registered landfill site and not re-used.
- Monitor banks for erosion.
- Prior to the wet season (i.e. last sediment removal period of the season), the track into the waterbody should be “made good” (de-compacted / ripped) and stabilised to prevent erosion where necessary.

7.4 Restrictions pertaining to sediment removal continuously along a watercourse

- Sediment removal along a continuous section of channel, or extensively over a depression / pan is only permitted in LOW IMPORTANCE systems, for example, detention ponds, dams, and artificial and / or concrete canals etc. These systems are usually substantially physically altered and / or have lost their riparian connectivity.
- There are no restrictions in this category on the type of machine used or the extent of clearing in low importance systems.
- A permanent stake (or a record of e.g. the level of downstream weir) should be used to guide the depth of sediment excavation, so as not to cause ponding / deepening of the channel.

- It is accepted that machinery will traverse the length of the watercourse, with concomitant impacts chiefly the loss of riparian vegetation and the compaction / steepening of the banks or creation of berms. However, where possible this should:
  - be restricted to one bank and
  - Maintain existing hydrological patterns, including the extent of lateral flooding (e.g. inundation of marginal habitats) where this is relevant.
Table 6. Restriction on sediment removal methods for different types and importance categories of waterbody.

<table>
<thead>
<tr>
<th>Watercourse Type</th>
<th>Ecological Importance ranking for stormwater maintenance and management measures</th>
<th>Acceptable methods with appropriate restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Rivers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upland Gorge</td>
<td>HIGH (Category 1 or 2)</td>
<td>Manage sediment at source as per catchment management best practice. Sediment removal unlikely for such systems but if required may take place from sediment traps / designated sediment removal areas or stormwater infrastructure (hand or machine); Location of these with in-house ecologist input (+ engineer). Ensure no channel modification occurs during sediment removal process.</td>
</tr>
<tr>
<td>Foothill</td>
<td>MEDIUM (Category 3)</td>
<td>Manage sediment at source as per catchment management best practice. Sediment removal unlikely for such systems but if required may take place from sediment traps / designated sediment removal areas or stormwater infrastructure (hand or machine); Location of these with in-house ecologist input (+ engineer). Ensure no channel modification occurs during sediment removal process.</td>
</tr>
<tr>
<td></td>
<td>LOW (Category 4 or 5)</td>
<td>Sediment removal unlikely for such systems but where required manual or mechanical methods as desired may be used; depth of excavation to be set on site (e.g. permanent stake or level of downstream weir); operations must not cause ponding / deepening of channel below set levels; restrict access to water body and machine movement to one bank, and avoid the creation of steeply incised embankments.</td>
</tr>
<tr>
<td>2) Rivers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowland &amp; Lowland with floodplain</td>
<td>HIGH (Category 1 or 2)</td>
<td>From sediment traps / designated removal areas or stormwater infrastructure (hand or machine); location and construction of these with in-house senior ecologist input (+ engineer). Sediment traps to be located preferably upstream of important floodplain or valley bottom reaches to protect them - rather than traversing through floodplain / valley bottom; If unavoidable, and access across floodplain / valley bottom required, this to follow stringent guidelines in the EMPr. No excavation in unchannelled wetlands without a site-specific Maintenance Plan– preferably allow depositional process / trap unnatural sediment upstream in “designated sediment retention area”. Sediment removal in such wetlands may include the supported reeds (subject to site specific Maintenance Plan)</td>
</tr>
<tr>
<td>3) Wetlands:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetland transitional rivers; Valley-bottom wetlands; Floodplain wetlands</td>
<td>MEDIUM (Category 3)</td>
<td>Manual or mechanical as desired; range of machinery including mud dozer; depth of excavation to be set on site (e.g. permanent stake or level of downstream weir), operations must not cause ponding / deepening of channel below set levels; Where conditions require it, the installation of access berms across a riparian or wetland vegetation to the location of sediment removal is allowed in low Importance systems. Similarly, portions of the channel may be compacted where machines are required to traverse up and down a section of the bank to remove sediment. However, care should be taken to ensure that existing patterns of flow are not blocked, for example so that flooding or detention in areas adjacent to the channel are not prevented by these berms, as these will cause stormwater problems up- or downstream.</td>
</tr>
<tr>
<td></td>
<td>LOW (Category 4 or 5)</td>
<td></td>
</tr>
<tr>
<td>4) Wetlands:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>seeps</td>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Sediment removal unlikely to be necessary in wetland seeps, but may be required around stormwater infrastructure (inlets etc.), no channel modification allowed for sediment removal. Preferably manage sediment at source as per catchment management best practice</td>
</tr>
<tr>
<td></td>
<td>MEDIUM (Critical Ecological Support Area)</td>
<td>Sediment removal unlikely to be necessary in wetland seeps, but may be required around stormwater infrastructure (inlets etc.), no channel modification allowed for sediment removal. Preferably manage sediment at</td>
</tr>
<tr>
<td>Source</td>
<td>Sediment removal unlikely to be necessary in wetland seeps. No specific restrictions if required around stormwater infrastructure (inlets etc.)</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>LOW (Other Ecological Support Areas)</td>
<td>Manual only at designated sediment retention areas and at inlet / outlet structure.</td>
<td></td>
</tr>
<tr>
<td>MEDIUM (Critical Ecological Support Area)</td>
<td>Manual or mechanical, but from designated sediment retention areas and at inlet / outlet structure; depth of excavation of to be set on site (e.g. permanent stake) to prevent deepening; stockpile &gt;5 m from edge, outside riparian fringe; access track not to be closer than 5 m from edge unless very large system; if access across marginal / littoral vegetation required, this to follow stringent guidelines in the EMPr. Sediment removal in such wetlands may include the supported reeds (subject to site specific Maintenance Plan)</td>
<td></td>
</tr>
<tr>
<td>LOW (Other Ecological Support Areas)</td>
<td>Manual or mechanical as desired; range of machinery incl. mud dozer; depth of excavation of to be set on site (e.g. permanent stake or level of downstream weir); operations must not cause ponding / deepening below set levels.</td>
<td></td>
</tr>
<tr>
<td>HIGH (Critical Biodiversity Area)</td>
<td>Importance category does not exist for dams (all “Low”).</td>
<td></td>
</tr>
<tr>
<td>MEDIUM (Critical Ecological Support Area)</td>
<td>Importance category does not exist for dams (all “Low”).</td>
<td></td>
</tr>
<tr>
<td>LOW (Other Ecological Support Areas)</td>
<td>Manual or mechanical as desired; range of machinery incl. mud dozer; depth of excavation of to be set on site (e.g. permanent stake or level of downstream weir); operations must not cause ponding / deepening below set levels.</td>
<td></td>
</tr>
<tr>
<td>HIGH</td>
<td>Sediment removal in estuaries will tend be limited to designated areas at outlet / mouth and at river inlets at the upstream extent of the estuary unless part of an approved rehabilitation plan. Further details are provided in Section 13 of the EMPr.</td>
<td></td>
</tr>
</tbody>
</table>
8 CHANNEL CLOSURE

This measure refers only to the enclosing of stormwater channels in high-density urban areas that are subject to extreme levels of pollution due to disposal of liquid and solid waste into these open systems. This management action would only be contemplated in engineered, artificial concrete or earthen stormwater channels draining high-density urban areas where pollution loads are intense, as part of a pollution risk management strategy.

![Example of highly polluted, unsafe, open canals which may be a candidate for upgrade to an enclosed channel.](image)

8.1 Procedural requirements

- Due to the complexities, costs and potential impacts associated with this activity, preliminary hydrological and ecological evaluation should be undertaken to inform the design process, as appropriate.
- Water quality sampling and / social investigation of the situation should be undertaken to demonstrate the necessity of such a step.
- The Aquatic Ecologist within CCT Environmental Team will confirm the ecological state of, and review water quality data collected from, any system contemplated for closure.
- Construction specifications listed in Section 10 pertain to the implementation of this activity.
9 LITTER AND DEBRIS MANAGEMENT

Litter and other debris are introduced into waterbodies by wind or as a result of dumping. The accumulation of particulate litter in systems is of such a magnitude that in some areas it poses a risk to hydraulic conveyance and is therefore a flooding threat. Elsewhere, dumping of rubble, and the remains of long-demolished structures like pedestrian culverts or weirs constrict channels already burdened with unnaturally high flood volumes. Litter also results in water quality impairment and in some cases may lead to public health risks. A central component of the stormwater management undertaken by CCT is therefore the removal of this material. A great deal of litter is trapped on natural snags in rough channels, making manual clearing the only realistic option in such cases. The construction and maintenance of litter traps on badly affected systems is also part of the City’s routine channel maintenance strategy.

9.1 Litter and Debris Removal

9.1.1 Assessment and planning

- While some aspects of litter removal are “ad hoc”, a proactive programme of litter control could be developed by each District Manager, based on evaluation of the litter load affecting each watercourse or waterbody, as this will be highly specific. Such a programme should:
  
  o Identify the locations for cleaning – these may be spot locations, such as the location of a litter trap, or reach sections, where litter accumulates because of hydraulics or snagging on vegetation.
  
  o Identify the frequency of collection and number of teams required for each clean-up (see 9.1.2).
  
  o The equipment necessary for cleaning: sacks and rakes may be required for river-reach cleaning, or wheelbarrows where litter is too heavy to drag to the stockpiles effectively; spades and forks may be required to clear litter traps.
  
  o The safety / health protection measures required of cleaning personnel – at a minimum all personnel should be provided with boots and rubber gloves. In some systems waders may be required.
  
  o Link cleaning operations to logistical arrangements for collection and transportation of litter to an appropriate landfill site.
  
  o If required the locations of stockpiles for temporary storage of material should be identified. Stockpiles should be accessible for vehicular transport.

- Review of the success of the litter removal operation should take place in collaboration with the operational staff, with a view to:
  
  o Revising details of the programme in each area, for example labour size, cleaning frequency etc.
  
  o Identifying the desirability of installing additional litter traps or structures to allow for localised collection, rather than the more time consuming river-reach clearing.
9.1.2 Standards

- Where feasible, litter traps should be fenced off to make them inaccessible to the public, especially in the case of larger traps.
- Litter removal should be carried out proactively throughout the year IF resources and water levels permit it (see 9.1.1):
  - Ideally litter should be removed from watercourses and constructed litter traps before and after rain periods, depending on loading, to maintain an acceptable environment.
  - As part of the City’s winter preparedness activities, mid – late summer intensive clearing should be undertaken to ensure that hydraulic capacity is maintained and to prevent blocking of outlet structures.
  - Key areas should be checked after heavy rains, with allowance for ad-hoc cleaning as necessary.
- Manual clearing of litter is usually necessary given the dispersed nature of much litter and the accessibility of many litter trap structures. The suitability of achieving this through the Expanded Public Works Programme which utilises local manual labour teams as part of its poverty alleviation objectives should be considered.
- Larger litter traps may be cleaned by machine where this can be achieved, especially where litter and sediment traps are combined.
- If machine clearing of areas protected with concrete, armourflex® or gabions takes place, a shield/guard must be used on the excavator bucket to prevent damage.
- Clearing and removal of debris and litter should always be done in a downstream direction.
- Nets should be placed downstream of litter traps to catch any litter dislodged during cleaning of traps where necessary.
- Temporary stockpiling of removed litter:
  - Should be avoided but if it is necessary it should be located above the normal inundation area / visible flood debris lines or as specified in site specific Maintenance Plans.
  - Stockpiled litter can be redistributed if not timeously removed and are community eyesores. Stockpiles should be removed within 1 to 2 days of the completion of an operation which should allow sufficient drying.
  - Where the debris includes fines or light matter, stockpiles should ideally be covered to avoid wind-redistribution.
- Truck access routes to collection points or stockpiles will be required, and should be established in areas where the route is not blocked by large trees or dense vegetation.
- Trucks transporting litter should be ideally covered to prevent litter falling or blowing out.
Where water hoses / jets are used to flush litter from stormwater infrastructure such as pipes, appropriate measures (e.g. netting) must be taken to ensure that dislodged material containing litter is captured and does not become dispersed further down in the stormwater system or watercourses.

9.1.3 Management of operations

- Contract service providers are generally employed to undertake litter removal, using local labour. Inspections are advisable to ensure an adequate level of service and compliance with the terms of the contract.
- In some Districts, such as Somerset West, a mechanism of financial incentives linked to cleaning operations, for example payment upon site inspection, at an agreed time, has proved highly successful.
- Local community involvement is encouraged, both in the recruitment of contract personnel and in liaison with representatives to identify parallel programmes that help to reduce litter / improve collection at source. In this regard, co-ordination with the Solid Waste Department to address these issues is advised.

9.2 Removal of structures to reduce water obstruction

In certain areas, structures such as old boundary walls, or remnants of structures, or dumped rubble / brick occur within a watercourse, and either constrict flow or create areas of local scour and erosion. The removal of these structures is encouraged to restore flow in these systems.

9.2.1 Methods and precautions

- The heritage value of structures must be determined by personnel from the District E&HM office or by Heritage Western Cape.
- The present use of the structure, if any, must be determined before any actions are taken to remove it. Where these form any part of inhabited structures, the correct procedures to determine the legal right to remove such structures must be followed.
- Where it is suspected that these are part of, or contribute to the value of neighbouring private property, neighbouring property owners must be informed / consulted as appropriate.
- Care must be taken to limit riparian vegetation damage during manual and mechanical removal of structures or temporary storage of the rubble / materials.
- The rubble / material must be removed from site within 1 week.
- Ecologically important habitats should be avoided if access roads or tracks need to be constructed.
- A truck / trailer will be required to remove material from site.
- The appropriate transport vehicle must be provided.
- The appropriate disposal location/facility must be identified.
• Workers and heavy machinery should use existing access roads or tracks to reduce disturbance to vegetation.

Figure 12: Example of an old concrete wall structure in watercourse in the Athlone District.

9.3 Restrictions
Since the impact of litter and debris removal is generally positive resulting in an improvement in ecological / water quality condition, few restrictions apply apart from those in systems of High / Medium Importance:
• Non-localised litter removal (i.e. where this is not from a litter trap) shall be manual.
• Access for vehicles and operation of machinery for the removal of dumped materials / old structures shall be compiled into the Maintenance Plan for the watercourse in question.
10 CONSTRUCTION, MAINTENANCE AND EXPANSION OF MINOR STORMWATER INFRASTRUCTURE

The network of stormwater management facilities within CCT includes a number of built structures which facilitate the conveyance of water, ensure hydraulic capacity is maintained and minimise erosion. Changes in catchment hydrology or sediment loads may require the installation of a new works, such as additional or larger culverts, or drainage conduits from new developments. Construction and maintenance of the following minor structures is envisaged as part of the stormwater management and maintenance programme included in the authorisation:

- Construction, maintenance or expansion of litter management infrastructure.
- Installation and maintenance of sediment trapping devices or built traps.
- Construction and maintenance of headwalls, inlet and outlet structures, culverts, and new artificial drainage channels to convey runoff to the stormwater network.
- Construction of the following major infrastructure is NOT included in this authorisation, as they constitute major engineering works that would require a separate study and authorisation application (maintenance of these structures is however included):
  - Dams and detention ponds
  - Permanent diversion or relocation of watercourses
  - Concrete canals.

10.1 Specifications pertaining to all construction activities

- Due to the complexities, costs and potential impacts associated with activities like these, hydrological and ecological investigations should be undertaken beforehand in order to inform the design process.
- Construction may require earth-moving / excavation, concrete works and temporary disruption to flow.
- Localised, short-term construction-related impacts shall be minimised by:
  - Developing a method statement for each phase of the work, for approval by the Project Manager, including the position of work areas, access routes, site camp establishment, temporary material stockpiles etc.
  - An E&HM representative or nominee shall be the ECO on site to supervise implementation of the environmental controls
  - Site establishment, including temporary materials store, if needed, must be monitored by an ECO.
  - Silt screens are to be erected down-stream of the site works where this takes place in or immediately upstream of waterbodies of Medium to High Importance.
  - Construction of new infrastructure and maintenance should take place under summer low flow conditions.
o Emergency repair of infrastructure during winter must ensure that all materials, equipment, stockpiles and waste are kept outside of areas subject to potential flooding.

o Temporary watercourse diversion (e.g. coffer dam) may be required. This may be achieved by sandbag diversion, or a coffer dam with a pumped or gravity diversion via pipeline. Clean sand fill is to be used in sandbags in High or Medium Importance systems.

o Dewatering of construction works shall be into a settlement area if the water in the works has higher sediment loads than the watercourse.

o The use of sediment for fill shall be subject to approval by the ECO and shall exclude any clay or fine silt.

o Washing of cement, concrete, oils etc. from vehicles and equipment shall not take place on site.

o Restoration of disturbed areas is to be facilitated by ensuring that soil is uncompacted to promote natural recovery of vegetation or as stipulated in the site specific Maintenance Plan. In high importance systems, where large exposed areas remain after the activity it is advisable to actively re-vegetate the area.

o The restrictions regarding vegetation and sediment removal (for earthworks) as specified in Sections 5.2, 5.3 and Section 7 shall be implemented.

o Special care shall be taken to implement the General Specifications in Section 4 of this document.

10.2 Litter traps

Litter management infrastructure are engineered in-stream structures which trap waterborne litter facilitating its removal. They are generally only effectively installed in sections of watercourses that have been artificially lined e.g. concrete canals. Options for litter trap design include:

- simple in-stream grids (e.g. Figure 13 left)
- more complex weirs which divert flow over grids (e.g. Figure 13 right)
- installation of snag structures or floating booms in a widened section of channel.

10.3 Sediment traps

Sediment traps are an effective means of protecting important river reaches and wetlands from the impacts of unnatural sedimentation. They also reduce the need for manual and mechanical sediment removal along the length of a watercourse (see Figure 14). Basic site management and good design and construction planning could provide effective mitigation of impacts, with the benefit that an effective sediment trap will protect other portions of river channels. A range of designs for such features are applicable to different circumstances, from concrete structures within canalised reaches to in-channel excavated depressions (sometimes lined) that retard velocities and this facilitate settling out of sediments.
As a minimum, the following must be undertaken when planning and constructing a sediment trap:

- The need and desirability for a constructed sediment trap versus simply utilising “designated sediment retention areas” for removal of deposited load must be evaluated by the CCT Environmental Team.

- In waterbodies with a Medium or High importance ranking, the location of sediment traps should be approved by the CCT Environmental Team to ensure that features of particular sensitivity are protected.

- The most important consideration for any sediment retention / removal structure, formal or informal, is its location along the watercourse. Planners should aim to locate sediment traps upstream of valley bottom and floodplain areas, so that a) access impacts are minimised and b) these wetland types are protected from sediment. The downstream end of the sediment retention area may be demarcated with a low gabion weir.

- Design options for sediment removal should be evaluated against the nature of the problem. A plethora of information is available on the design of small and large sediment traps, some of which suggests:
  - A well-designed sediment trap is ultimately preferable to on-going excavation of sediment from waterbodies, albeit more costly in the short-term.
  - Installing several small traps at strategic locations is often better than building one large basin.
  - Designing traps with long flow paths between the inlet and outlet also helps to increase sediment removal efficiency by extending the detention time.
  - Where space restrictions prevent long basin designs, barriers placed in the trap can lengthen detention times by creating a serpentine flow path between the inlet and outlet.
  - Sediment removal strategies should be balanced by examining catchment management practices that can address erosion at source.

Figure 13: Two litter trap designs in the CCT
- Access routes should be located at right angles to the channel, especially if locating a sediment trap in a valley bottom or floodplain channel is unavoidable. Access routes must ensure that drainage patterns are not altered, in particular during high flows and that culverts of adequate size are installed in any permanent access route.

- An alternative, depending on the frequency with which sediment traps are cleared, is the compilation of a standard operating procedure / method statement regarding the placement of fill for a temporary access route to the site. Such a procedure would include:
  - Utilising clean fill material
  - Maintaining pre-construction ground levels when material is removed from site
  - Appropriate disposal of the fill
  - Stabilisation of the disturbed ground surface to prevent erosion, or the establishment of alien / weedy species.

Figure 14: Sediment traps can reduce the need for manual and mechanical sediment removal along the length of a watercourse. Image from CSRM, 2002
10.4 Stormwater Outlets, Scour Valves, Headwalls and Culverts

The network of stormwater management facilities within CCT includes a number of built structures such as headwalls, inlet and outlet structures, culverts, canals, gabions and weirs which facilitate the conveyance of water and minimise erosion. Regular evaluation of structural integrity and repair work where required, is necessary to maintain the functionality of the stormwater system. In some cases changes in catchment hydrology or sediment loads requires the installation of a new works, such as additional or larger culverts, or drainage conduits from new developments., nonetheless the following must be considered:

- In waterbodies with a Medium or High importance ranking, the location of these features should be approved by the CCT Environmental Team to ensure that features of particular sensitivity are protected.
- The designs for many of these would be standardised, however in waterbodies with a Medium or High importance ranking, the designs should be approved by the CCT Environmental Team.
- Where stormwater outlets are set back from the receiving system, any earth drain portion between the outlet and the channel or waterbody should be sloped, shaped and vegetated so as to facilitate filtration and prevent erosion.
- At stormwater outlets, and any areas where erosion is likely to occur, energy dissipaters must be considered and installed as appropriate. The CCT Environmental Team is to advise in this regard (see examples Figure 15 below).

![Figure 15: Examples of energy dissipaters at stormwater outlets.](image-url)
11 MAINTENANCE OF ATTENUATION INFRASTRUCTURE

The City's stormwater management program includes maintenance of weirs, flood protection embankments and Sustainable Urban Drainage Systems (e.g. constructed wetlands detention / retention facilities, bioretention systems). Regular, comprehensive inspections and maintenance of dams is important, particularly those that are listed as Dams with a Safety Risk in terms of section 120 of the National Water Act.

Maintenance of the aforementioned stormwater management infrastructure includes most of the measures already described, including:

- Vegetation management / removal;
- Sediment removal / reshaping of detention ponds and SUDS;
- Purging of silt from scour valves;
- Concrete works to repair infrastructure such as inlet / outlet structures on dams, valves, overflow structures, gabions etc.;
- Removal of mole burrows and bird / insect nests that may compromise integrity of banks and retaining walls;
- Embankment repair may also involve mechanical earth works.

The following sections present a check-list for ensuring diligent maintenance of the stormwater infrastructure. In all cases:

- The provisions for minimising pollution during construction work contemplated in Section 10.1 apply
- The restrictions regarding vegetation and sediment removal as specified in Sections 5.2, 5.3 and Section 7 shall be implemented.
- Special care shall be taken to implement the General Specifications in Section 4 of this document.

11.1 Weirs

- Weirs should be inspected regularly for signs of damage and maintenance should be based on the condition of the structures.
- Typical maintenance includes cleaning, repairs to the crests, installation of sluices to facilitate water level management, installing revetments and mattresses to prevent erosion of banks and downstream, or underpinning walls and foundations undermined by erosion. Maintenance of weirs should be completed between October and April once the water level has receded to allow vegetation to recover before winter rains and minimise erosion potential.
- Rockpile weirs need to be inspected after major flood events for new erosion points.
- Weirs require regular inspections especially after heavy rainfall events so any damage can be recorded and the appropriate action taken.
- Regular inspections of gabion baskets are required as basket damage can lead to total structure failure.
- A damaged gabion weir must be replaced quickly to prevent total loss of the structure.

11.2 Retention/Detention Ponds, and Sustainable Urban Drainage Systems (SUDS) Facilities

Retention/detention ponds are (usually) constructed features which serve to control stormwater runoff in developed areas. Retention ponds retain water permanently, and have an outflow/overflow point higher than the level of the pond floor. By contrast, detention ponds only hold water during and immediately after rain events, and serve to “detain” run-off and release water slowly thereby reducing flood risks. Their outflow is typically level with the pond floor.

- Maintenance of ponds usually involves the removal of litter, silt and vegetation to restore hydraulic capacity of the pond. The best practices around these are addressed in the relevant sections of this report.
- In the case of retention ponds, dewatering may have to be planned if silt removal is to be undertaken. In such a case the temporary storage of silt or vegetation on site, and the transportation and disposal thereof will have to be planned.
- Maintenance of inlet and outlet structures, embankments and pond basins may also be periodically required.

![Figure 16: Dry retention pond image from CSRM, 2002](image-url)
11.2.1 Dams

- Dams are used for the storage of water and in many cases also offer downstream protection from flood damage. The main dams supplying potable water to the CCT are situated in the mountain catchment areas and many are outside the boundary of the city. These bulk water dams will not be covered by this application. There is however a number of smaller dams located within the CCT, which are subject to maintenance as part of the stormwater management process. Some of these are registered as Dams with a Safety Risk in terms of Section 120 of the National Water Act and therefore require particular attention. Inspections of these dams follow routine inspection plans.
- Maintenance of dams usually involves the removal of litter, silt and vegetation to restore hydraulic capacity.
- Embankments, dam outlets and scour valves, dam walls, toe drains, spillways and the up- and downstream slopes and flanks should be inspected regularly (at least every six months or as stipulated in routine dam inspection plans) for signs of damage and maintenance should be based on the condition of the structures.
- Dam maintenance activities should be completed between October and April once the water level has receded, unless remedial works is required to prevent definite damage public or private property, or endanger lives.
- Maintenance activities should be limited to those falling within the capability of the works team. All technical work must be planned by a qualified engineer.

11.3 Flood Prevention Embankments/ Berms

- In some areas earth banks or floodplain embankments have been constructed to create artificial levees or flood walls to control flooding.
- Embankments should be inspected and maintained on a regular basis, at least annually and after heavy rain events.
- Levee crests should be kept level and free of vegetation other than trimmed grass so as to ensure that inspection is possible. Side slopes should also be kept clear.
- The activity of burrowing animals in the levee will have to be monitored.
- Maintenance can be undertaken routinely throughout the year, but low flow spring months are preferable in some cases.
12 RECREATIONAL ACCESS

The construction and maintenance of recreational facilities (footbridges, boardwalks, paths, crossings and bird hides) close to the stormwater network are unlikely to trigger the NEMA requirements due to their limited scale.

12.1.1 Construction and Expansion

- Walkways are often associated with improvements to parks or public open space and are installed as needed.
- Depending on the proximity to the watercourse, walkways and boardwalks may be constructed any time of the year.
- Footpaths and boardwalks should ideally be constructed in areas that have previously been disturbed such as old maintenance tracks.
- No construction of footbridges and boardwalks should occur in environmentally sensitive areas.
- Design of recreational features that traverse these waterbodies provides an opportunity for public engagement with the functions of river and wetland ecosystems. Where possible, attributes of the ecosystem that are of value and enhance appreciation of the natural world (e.g. a vista from a boardwalk across bird breeding habitat in a treatment reedbed; seasonal ponding supporting frog spawning) should be incorporated into the layout of access routes in recreational spaces.

12.1.2 Maintenance and Repair

- Footbridges and boardwalks should be inspected regularly for signs of damage and maintenance should be based on the condition of the structures.
- Maintenance can be undertaken throughout the year, depending on the required water levels.
- The implications of closing the boardwalks or walkways for maintenance must be considered. Alternative access routes may have to be provided and demarcated.
13 MANAGEMENT OF RIVER / BEACH OUTLETS AND ESTUARY MOUTHS

Stormwater management has to include the point at which stormwater and river flows enter the sea, namely at discharge from stormwater pipes, river mouths and estuaries, in order to deal with contingency situations involving flood risk.

If a sandbar forms across a river mouth, periods of high catchment runoff may result in high water levels backing up behind the sandbar and subsequent flooding of properties and infrastructure. Unpredictable patterns of sand deposition also sometimes cause river mouths to meander parallel to the shore resulting in potential damage to infrastructure (such as roads, railways, water / sanitation reticulation or buildings) and dune buffers. Under such situations, artificial breaching or straightening of the mouth is considered a necessary action to safeguard property as well as important features like buffer dunes. “Straightening” involves redirecting a meandering mouth across the shortest route directly towards the sea.

Another category of mouth management pertains to a requirement to manage pollution loads in the stormwater system, in the event of accidental spills into an estuary during a period of mouth closure, particularly if the estuary or river mouth is utilised for contact recreation.

A similar process is required at stormwater outlets that traverse the beach. Sand build-up must be removed periodically to facilitate the flow of stormwater to the sea, rather than creating pooled areas in the back dunes or upper beach, particularly given the at-times compromised quality of stormwater.

These activities include:
- Track-machine access onto the beach, and excavation of a channel to the sea;
- Some (limited) dune reconstruction with excavated sand, where erosion has been severe;
- Spreading of excavated material in a thin layer over the beach surface.

13.1 Restrictions on river mouth / estuarine breaching

- River mouth / estuarine breaching or straightening may only be undertaken if approved by the CCT Environmental Team, in terms of a site specific mouth management plan.
- Site specific mouth management plans are to be compiled in consultation with the City’s coastal unit expertise and/or an external estuarine specialist. The plan should include the following information where appropriate to the particular system in question:
  - Optimal water depth for the ecosystem;
  - Water depth requirements for recreation e.g. sailing and canoeing;
  - The risk of flooding if no action is taken;
  - Salinity effects on the ecosystem;
  - Scouring effects;
  - Migration times of fish and other fauna;
- Seasonal user requirements (e.g. canoeing, yachting etc.)
- Public safety in particular beach users;
- Position where the mouth is to be breached or straightened.

- CCT should engage the Estuary Management Forum (EMF) should one be in existence.
- The breaching of an estuary mouth should preferably be timed to coincide with the spring high tide.
- Breaching should generally be delayed for as long as possible until the estuary water levels are at a maximum, but without significantly increasing the flood risk.
- Opening of the mouth in late autumn may assist in reducing potential flooding during the winter.
- Recommended plant is the bull-dozer.
- Access routes must be mapped prior to the activity in order to minimise disturbance.
- Attention should be given to bird nesting areas and periods in the year, and avoidance of the former if artificial breaching / straightening is likely to coincide with breeding
- Where feasible DEA&DP, and any relevant EMF, must be given at least 7 days’ notice prior to breaching the mouth.
- No fishing activities should be allowed at the estuary mouth during breaching or for one week post breaching.
- A breached mouth must be inspected by an appropriate CCT employee the day following breaching.
- Accurate records must be kept of the mouth opening and closing activities.

13.2 Clearing stormwater outlets that traverse the beach

- This is to be done manually where sand volumes are minor.
- In cases where stormwater flows over the beach pose a threat (e.g. pollution threat), an excavator may be used to construct a path representing the shortest distance from the outlet to the water, with the following considerations:
  - The sides of the channel should be flat, so that it is easily passable and does not pose a threat to safety e.g. drowning.
  - Material excavated should be spread over the beach in such a manner as to be unobtrusive and also taking care not to smother any natural habitats e.g. dune vegetation.
14 ENVIRONMENTAL AWARENESS AND CAPACITY BUILDING

General environmental awareness must be fostered among all role players to encourage the implementation of environmentally sound practices. The onus is on the different parties involved in the various stages of the City’s stormwater maintenance program to be environmentally conscious. This is an important aspect of the implementation of the EMPr.

City personnel from the various line departments will undergo training following authorisation of the project by DEA&DP. This training will be comprehensive and include inter alia the following:

- Overview of the City’s stormwater maintenance and management programme;
- District based operating model for undertaking maintenance work;
- Legislative context and the importance of the EMPr;
- Details of the EMPr and the various roles and responsibilities articulated therein;
- Contents of site specific Maintenance Plans;
- Record keeping;
- Environmental effects associated with the various stormwater maintenance and management activities;
- Best practise methods for achieving environmentally conscious stormwater maintenance and management.
- Training targeted at specific personnel for example operators of heavy machinery.

Environmental awareness material for Contractors must be simple and include the aspects listed below. The Site Manager/ foreman must provide the standardised information to his/her labour team.

- The importance of the EMPr and summarised details;
- Site specific Maintenance Plans;
- Contractor’s role in compliance with the EMPr;
- Environmental effects associated with the activities;
- Basic guidelines and best practise methods to follow;

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4Gibb have been contracted to prepare material for, and undertake, four District training sessions.
15 DOCUMENTATION AND RECORD KEEPING

Documentation demonstrating implementation of, and compliance with, the EMPPr is required. Responsibilities must be assigned to relevant personnel for ensuring that this documentation system is maintained and that document control is ensured through access by and distribution to, identified personnel.

Documentation which will be maintained by the District (Project Manager) may include:

- site specific Maintenance Plans (contents as described in Section 3.2);
- any supplementary site instructions or method statements;
- training records;
- site inspection / monitoring reports;
- incident reports;
- complaints received.

An internal compliance monitoring system will be maintained by CSRM. Records will be compiled annually (July – June budget cycle) and comprise summaries of the site specific activities and records provided by the various Districts (i.e. the above documentation and records).
COMPLIANCE MONITORING

Monitoring is a process of observation, based on specified approaches and schedules, used to detect whether any changes have occurred in the defined, measurable features of the particular environment. The objective of monitoring is to ensure that the mitigation measures are correctly implemented and have the desired result.

"Monitoring" therefore has three aspects:

1. Baseline measuring. This must occur prior to the start of the project or activity in order to determine the level and status of the environmental parameters prior to any impacts associated with the project or activity. This component will be dealt with in the compilation of site specific Maintenance Plans which will describe pertinent environmental features of the site;

2. Impact (or performance) monitoring. This monitoring must be implemented to ensure that environmental impacts are within the predicted levels. Sites will be inspected at appropriate intervals during the course of the maintenance activities; and

3. Compliance monitoring. This monitoring must be implemented to ensure that the prescribed mitigation measures are having the predicted and desired effect. The programme must make provision for remedial measures to be effectively implemented in the event of non-compliance. All role players have the responsibility to ensure the EMP is implemented and to record and report incidents of non-compliance.
17 REVIEW OF THE EMPR

An internal review of the EMPr will take place 18 months after receipt of Environmental Authorisation in order to evaluate the following:

- implementation of the EMPr across the Districts;
- reporting lines, processes and record keeping;
- any changes or additions to the EMPr which may be required.

The findings of this review will be documented.

An external review of the EMPr will take place every 5 years.
The following documents were used in the development of this document:

2. City of Cape Town (undated pamphlet) Catchment, Stormwater and River Management, Rivers and Wetlands in Our Backyards
9. Day. L and Ractliffe G. Assessment of River and Wetland Engineering and Rehabilitation Activities Within the City of Cape Town


APPENDIX A

Plant species control table
PLANT SPECIES CONTROL TABLE

The following species control table gives details of manual, chemical and biocontrol method of common invasive species in the CCT area, this table contains details of all known invasive species in the CCT. The effect of biocontrol agents on other species should be taken into account before the release of agents, the use of chemical control on vegetation in waterways should only be considered as a last option and care must be taken when using herbicides on riparian vegetation.


<table>
<thead>
<tr>
<th>Species</th>
<th>Origin</th>
<th>Category invasive</th>
<th>Likely habitat</th>
<th>Manual/ mechanical control</th>
<th>Chemical control</th>
<th>Biological control</th>
<th>Effect on other species and the environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia cyclops (Rooikrans) (pg. 142)</td>
<td>South-western Australia</td>
<td>Transformer; Category 2 invader</td>
<td>Primarily coastal dunes; banks of watercourses, occasionally water edges; can colonise shallow water; Resprouter</td>
<td>Hand pulling or hoeing of seedlings or saplings Grubbing, hoeing and digging out of immature stage up to 2m Felling and cutting of stump to the ground for large mature trees</td>
<td>Seedlings/ saplings – Garlon 4/ Viroaxe Immature stage – Garlon 4/ Viroaxe Large mature tree stumps – Timbrel 3A</td>
<td>Indigenous field mice eat the seeds Rooikrans seed weevil</td>
<td>Contact Plant Protection Research Institute before releasing field mice as they may target seeds from other species</td>
</tr>
<tr>
<td>Acacia longifolia (Long leafed wattle) (pg. 144)</td>
<td>South-eastern Australia &amp; Tasmanian</td>
<td>Transformer; Category 1 declared weed</td>
<td>Banks of watercourses, occasionally water edges Resprouter</td>
<td>Hand pulling of seedlings or saplings Grubbing, hoeing and digging out of immature stage up to 2m Felling and stump cut to ground level of large mature trees</td>
<td>Seedlings/ saplings – Garlon 4 / Viroaxe Mature tree stumps – treatment not necessary</td>
<td>Bud galling wasp (Trichilogaster acaiae longifoliae) Seed feeding weevil (Melanterius ventralis)</td>
<td>Seed weevil (Melanterius maculates) also targets Black wattle, Black wood, Golden Wattle,</td>
</tr>
<tr>
<td>Acacia mearnsii (Black wattle) (pg. 222)</td>
<td>South &amp; east Australia</td>
<td>Transformer: Category 2 invader</td>
<td>Banks of watercourses, occasionally water edges; can colonise shallow water Resprouter</td>
<td>Hand pulling of seedlings or saplings &lt;40 cm Grubbing Hoeing Digging of immature trees up to 2m Felling used for large mature trees Ringing, ring of 10cm width in large plants</td>
<td>Seedlings – Mamba, Garlon 4, Viroaxe Tree stumps - Timbrel 3A</td>
<td>Stump fungus (Cylindrobasidium laeve) applied to freshly cut stumps Seed weevil (Melanterius maculates)</td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>Origin</td>
<td>Category invasive</td>
<td>Likely habitat</td>
<td>Manual/mechanical control</td>
<td>Chemical control</td>
<td>Biological control</td>
<td>Effect on other species and the environment</td>
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<tr>
<td>Acacia melanoxylon (Blackwood) (pg. 145)</td>
<td>South &amp; east Australia</td>
<td>Transformer: Category 2 invader</td>
<td>Banks of watercourses, occasionally water edges</td>
<td>Grubbing and hand pulling of seedlings (ensure most of the root material is removed)</td>
<td>Seedlings – Starane Immature stage up to 2m tall – Garlon 4/ Viroaxe, also apply to cut stumps</td>
<td>Seed weevil (Melanterius maculates)</td>
<td>Stump fungus also affects Golden Wattle Seed weevil (Melanterius maculates) also targets Blackwood, long leaved wattle</td>
</tr>
<tr>
<td>Acacia pycnantha (golden wattle) (pg.146)</td>
<td>South &amp; east Australia</td>
<td>Transformer: Category 1 declared weed</td>
<td>Banks of watercourses, occasionally water edges</td>
<td>Hand pulling of seedlings or saplings Grubbing, hoeing or diggings out of immature stage up to 2m Felling and cutting of stump to the ground for large mature trees</td>
<td>Seedlings/ saplings – Mamba/ Garlon 4/ Viroaxe/ Touchdown Immature stage - Garlon 4/ Viroaxe/ Touchdown Mature tree stumps – mixture of Garlon 4 and diesel</td>
<td>Gall rust fungus (Uromycladium tepperianum)</td>
<td>Production of large dead biomass and resultant fire hazard</td>
</tr>
<tr>
<td>Acacia saligna (Port Jackson) (pg. 147)</td>
<td>South-west Australia</td>
<td>Transformer; Category 2 invader</td>
<td>Banks of watercourses, occasionally water edges; can grow in shallow water</td>
<td>Resprouter</td>
<td>Resprouter</td>
<td></td>
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<tr>
<td>Ageratina adenophora (Eupatorium adenophorum) (crofton weed) (pg. 38)</td>
<td>Central America</td>
<td>Special effects weed; Category 1 declared weed</td>
<td>Banks of watercourses</td>
<td></td>
<td></td>
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<tr>
<td>Arundo donax (Spanish reed) (pg. 10)</td>
<td>Mediterranean</td>
<td>Transformer; Category 1 declared weed</td>
<td>Banks of watercourses, occasionally water edges</td>
<td>Repeatad removal Cutting of stalks</td>
<td>Glyphosate - Rodeo</td>
<td></td>
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<tr>
<td>Azolla filiculoides (Red water fern) (pg. 19)</td>
<td>Tropical South America</td>
<td>Transformer; Category 1 declared weed</td>
<td>Removal of plants using a net or rake. Stack removed plants above high water mark</td>
<td></td>
<td>Frond feeding weevil (Stenopelmus rufinasus)</td>
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<td></td>
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<tr>
<td>Species</td>
<td>Origin</td>
<td>Category invasive</td>
<td>Likely habitat</td>
<td>Manual/ mechanical control</td>
<td>Chemical control</td>
<td>Biological control</td>
<td>Effect on other species and the environment</td>
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<tr>
<td><em>Canna indica</em> (Canna) (pg. 44)</td>
<td>Tropical America &amp; West Indies</td>
<td>Potential transformer; Category 1 declared weed</td>
<td>Banks of watercourses; can grow in shallow water</td>
<td>Grubbing, Hoeing, Digging – remove the entire rhizome</td>
<td>None registered</td>
<td></td>
<td></td>
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<tr>
<td><em>Ceratophyllum demersum</em> (Water/ rigid hornwort)</td>
<td>Not in Weed Book</td>
<td></td>
<td>Open water</td>
<td>Hand removal using rakes, nets or an excavator for small scale infestations</td>
<td>Weed harvester for dense infestations</td>
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<tr>
<td><em>Cestrum laevigatum</em> (inkberry) (pg. 170)</td>
<td>South America</td>
<td>Transformer; Category 1 invader</td>
<td>Banks and edges of watercourses</td>
<td></td>
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<tr>
<td><em>Commelina benghalensis</em> (Wandering jew)</td>
<td>Not in weed book</td>
<td>Potential transformer; not Categorised</td>
<td>Banks of watercourses, usually at water edges</td>
<td>Propagates from fragments</td>
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<tr>
<td><em>Cortaderia selloana</em> (Pampas grass) (pg. 12)</td>
<td>South America</td>
<td>Potential transformer; Category 1 declared weed</td>
<td>Banks of watercourses, occasionally water edges</td>
<td>Hand pulling of entire plant</td>
<td>If hand removal not possible remove flowers</td>
<td></td>
<td></td>
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<tr>
<td><em>Eichhornia crassipes</em> (Water hyacinth)</td>
<td>Tropical South America</td>
<td>Transformer</td>
<td>Open water</td>
<td>Hand removal of plants, ineffective for large scale infestations</td>
<td>Glyphosate, Diquat, Terbutryn</td>
<td>Two petiole-boring weevil species (Neochetina bruchi and Neochetina eichhorniae)</td>
<td>Petiole-boring moth (Niphograpta albiguttalis)</td>
</tr>
</tbody>
</table>

Appendix H: Environmental Mangement Programme
<table>
<thead>
<tr>
<th>Species</th>
<th>Origin</th>
<th>Category invasive</th>
<th>Likely habitat</th>
<th>Manual/ mechanical control</th>
<th>Chemical control</th>
<th>Biological control</th>
<th>Effect on other species and the environment</th>
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</thead>
<tbody>
<tr>
<td><em>Echium plantagineum</em> (Patterson’s curse/ blou-echium) (pg. 47)</td>
<td>Europe &amp; Asia</td>
<td>invasive</td>
<td>Ruderal and agrestal weeds; category 1 declared weed</td>
<td>Banks of watercourses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Eucalyptus camaldulensis</em> (Red river gum) (pg. 149)</td>
<td>Australia</td>
<td>Transformer; Category 2 declared invader</td>
<td>Banks of water courses</td>
<td></td>
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</tr>
<tr>
<td><em>Eucalyptus lehmannii</em> (Spider gum/ spinnekop bloekom) (pg. 153)</td>
<td>South-western Australia</td>
<td>Transformer; Category 2 invader</td>
<td>Banks of watercourses</td>
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<tr>
<td><em>Hakea drupacea</em> (Sweet Hakea) (pg. 102)</td>
<td>South-western Australia</td>
<td>Transformer; Category 1 declared weed</td>
<td>Banks of watercourses</td>
<td>Hand pull small plants &lt; 40cm tall</td>
<td>Cut larger plants to the ground below the level of branches or leaves which can re-sprout</td>
<td></td>
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</tr>
<tr>
<td><em>Hakea gibbosa</em> (rock Hakea, harige hakea) (pg. 103)</td>
<td>South-eastern Australia</td>
<td>Transformer; Category 1 declared weed</td>
<td>Banks of watercourses</td>
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<tr>
<td><em>Hakea sericea</em> (silky hakea, Sygere hakea) (pg. 104)</td>
<td>South-eastern Australia</td>
<td>Transformer; Category 1 declared weed</td>
<td>Banks of watercourses</td>
<td></td>
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<tr>
<td><em>Ipomoea indica</em> (morning glory) (pg. 75)</td>
<td>?West Indies</td>
<td>Transformer; Category 1 declared weed</td>
<td>Banks of watercourses</td>
<td></td>
<td></td>
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<tr>
<td><em>Ipomoea purpurea</em> (Morning glory) (pg. 75)</td>
<td>Tropical America</td>
<td>Special effect weed: Category 3 declared weed</td>
<td>Banks of watercourses</td>
<td></td>
<td></td>
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<tr>
<td>Species</td>
<td>Origin</td>
<td>Category invasive</td>
<td>Likely habitat</td>
<td>Manual/ mechanical control</td>
<td>Chemical control</td>
<td>Biological control</td>
<td>Effect on other species and the environment</td>
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</tr>
<tr>
<td><em>Lantana camara</em> (Lantana)</td>
<td>Central &amp; South America</td>
<td>Transformer; Category 1 declared weed</td>
<td>Banks of watercourses</td>
<td>Hand pulling of seedlings or saplings; grubbing; hoeing of small patches; cutting is ineffective as plant coppices, use of herbicides needed; large infestation should be crushed or rolled with brush cutters then stumps treated with herbicides</td>
<td>Seedlings/ saplings – Touchdown / Access; Mature tree stumps – Chopper / Access / Timbrel 3A</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Lemna gibba</em> (Duckweed)</td>
<td>Northing in Weed Book</td>
<td></td>
<td>Open water</td>
<td>Remove plants by hand, using a net or rake; a floating or amphibious weed harvester can be used; stack the removed plants above high water mark</td>
<td>Glyphosate – to be used as a last resort</td>
<td></td>
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</tr>
<tr>
<td><em>Leptospermum laevigatum</em> (Australian myrtle)</td>
<td>South-eastern Australia &amp; Tasmanian</td>
<td>Transformer</td>
<td>Category 1 declared weed</td>
<td></td>
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</tr>
<tr>
<td><em>Lythrum salicaria</em> (Purple loose strife)</td>
<td>Eurasia</td>
<td></td>
<td>Mainly in the Liesbeek River</td>
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<tr>
<td><em>Myriophyllum aquaticum</em> (Parrot’s feather)</td>
<td>South America</td>
<td>Potential transformer; Category 1 declared weed</td>
<td>Open water</td>
<td>Removal of plants using rakes or nets, care must be taken to remove all fragments</td>
<td>Glyphosate as a last resort</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Paraserianthes (Albizia) lophantha</em> (Stinkbean)</td>
<td>Western and south-western Australia</td>
<td>Transformer; Category 1 declared weed</td>
<td>Banks of watercourses</td>
<td>Hand pulling of seedlings; grubbing, hoeing and digging out of saplings by the roots; cutting down as close to ground as possible for immature – mature trees</td>
<td>Cut stumps – Timbrel 3A</td>
<td></td>
<td>Seed weevil (Melanterius servulus)</td>
</tr>
<tr>
<td>Species</td>
<td>Origin</td>
<td>Category invasive</td>
<td>Likely habitat</td>
<td>Manual/ mechanical control</td>
<td>Chemical control</td>
<td>Biological control</td>
<td>Effect on other species and the environment</td>
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<tr>
<td><em>Pennisetum clandestinum</em></td>
<td>Tropical and east &amp; north-east Africa</td>
<td>Likely transformer; Proposed Category 1 declared invader</td>
<td>Banks of water courses, but occasional on water's edge</td>
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<tr>
<td><em>(Kikuyu)</em> (pg. 15)</td>
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<tr>
<td><em>Persicaria lapathifolia</em></td>
<td>Not in Weed Book</td>
<td>Likely transformer</td>
<td>Open water and edges of water courses</td>
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<td></td>
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<tr>
<td><em>(Persicaria)</em></td>
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</tr>
<tr>
<td><em>Persicaria senegalensis</em></td>
<td>Tropical and subtropical Africa</td>
<td>Likely transformer</td>
<td>Edges of water courses, occasionally shallow water</td>
<td></td>
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</tr>
</tbody>
</table>
| *Phragmites australis*        | Cosmopolitan (worldwide)      | Likely transformer | Shallow water and edges of watercourses | Use an excavator to remove plants and rhizomes  
                      |                               |                   |                                                                                  | Brush cutter on the floodplain with mounted sicklebars instead of rotary motors |                  |                    |                                             |
| *(fluitjiesriet)*             |                               |                   |                                                                                  |                                                                                           |                  |                    |                                             |
| *Pinus hale pensis*           | Mediterranean                  | Transformer; Category 2 declared invader | Occasional banks of watercourses | Hand pull small tree <40 cm tall  
                      | (Aleppo pine) (pg. 108)       |                   |                                                                                  | Remove a ring of bark 30-40cm wide on larger trees  
                      |                               |                   |                                                                                  | Cut large trees to ground level |                  |                    |                                             |
| *Pinus pinaster*              | Mediterranean                  | Transformer; Category 2 declared invader | Occasional banks of watercourses | Hand pull small tree <40 cm tall  
                      | (Cluster pine) (pg. 110)      |                   |                                                                                  | Remove a ring of bark 30-40cm wide on larger trees  
                      |                               |                   |                                                                                  | Cut large trees to ground level |                  |                    |                                             |
| *Pinus pinea* (stone pine)   | Northern Mediterranean         | Special effect weed |                                                                                  | Hand pull small tree <40 cm tall  
                      | (pg. 111)                     |                   |                                                                                  | Remove a ring of bark 30-40cm wide on larger trees  
<pre><code>                  |                               |                   |                                                                                  | Cut large trees to ground level |                  |                    |                                             |
</code></pre>
<table>
<thead>
<tr>
<th>Species</th>
<th>Origin</th>
<th>Category invasive</th>
<th>Likely habitat</th>
<th>Manual/ mechanical control</th>
<th>Chemical control</th>
<th>Biological control</th>
<th>Effect on other species and the environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Pinus radiata</em> (Monterey pine) (pg. 112)</td>
<td>South-western North America</td>
<td>Transformer; Category 2 declared invader</td>
<td></td>
<td>Hand pull small tree &lt;40 cm tall Remove a ring of bark 30-40cm wide on larger trees Cut large trees to ground level</td>
<td></td>
<td></td>
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</tr>
<tr>
<td><em>Pistia stratiotes</em> (Water lettuce) (pg. 24)</td>
<td>South America</td>
<td>Transformer; Category 1 declared weed</td>
<td>Open water</td>
<td>Remove plants using raking, nets or an excavator A floating weed harvester can be used</td>
<td>Herbicides used as a last resort Terbutryn, Roundup, Glyphosate</td>
<td>Weevil (Neohydronomus affinis)</td>
<td></td>
</tr>
<tr>
<td><em>Pittosporum undulatum</em> (Australian cheesewood) (pg. 160)</td>
<td>Eastern Australia</td>
<td>Potential transformer; Category 1 declared weed</td>
<td>Banks of watercourses</td>
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<tr>
<td><em>Pontederia cordata</em> (Pickerel weed) (pg. 25)</td>
<td>North, south &amp; central America</td>
<td>Special effect weed; Category 2 invader</td>
<td>Open water and edges of watercourses</td>
<td></td>
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<tr>
<td><em>Populus canescens</em> (Grey poplar)</td>
<td>Europe &amp; Asia</td>
<td>Transformer; Category 2 invader</td>
<td></td>
<td>Hand pulling – seedlings Saw off low down on truck of immature stage up to 2 m Felling used for large mature trees</td>
<td>Seedling / saplings / immature plants – Garlon 4, Viroaxe Stumps – Chopper Mature tree stumps – Chopper / Timbrel 3A</td>
<td></td>
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</tr>
<tr>
<td><em>Pyracantha velutina</em> (Velvet mesquite/ fluweel prosopis)</td>
<td>North and Central America</td>
<td>Transformer; Category 2 invader</td>
<td></td>
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<tr>
<td><em>Ricinus communis</em> (Castor-oil plant) (pg. 139)</td>
<td>Tropical east and north-east Africa</td>
<td>Special effect weed; poisonous; Category 2 invader</td>
<td>Banks of watercourses</td>
<td></td>
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<tr>
<td>Species</td>
<td>Origin</td>
<td>Category invasive</td>
<td>Likely habitat</td>
<td>Manual/ mechanical control</td>
<td>Chemical control</td>
<td>Biological control</td>
<td>Effect on other species and the environment</td>
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<tr>
<td><em>Rorippa nasturtium-aquaticum</em> <em>(Nasturtium aquaticum)</em> (Watercress) (pg. 26)</td>
<td>Europe</td>
<td>Special effect weed; Category 2 invader</td>
<td>Open water</td>
<td>Removal of plants by hand using nets or excavator</td>
<td></td>
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</tr>
<tr>
<td><em>Rubus fruticosus</em> <em>(European blackberry (pg. 129) and probably other species/hybrids)</em></td>
<td>Europe &amp; Mediterranean</td>
<td>Transformer; Category 2 invader</td>
<td>Banks of watercourses</td>
<td></td>
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</tr>
<tr>
<td><em>Salix babylonica</em> <em>(Weeping willow/ treurwilg) (pg. 161)</em></td>
<td>Asia</td>
<td>Transformer; Category 2 invader</td>
<td>Banks and edges of watercourses,</td>
<td></td>
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<tr>
<td><em>Salvinia molesta</em> <em>(Kariba weed) (pg. 27)</em></td>
<td>South America</td>
<td>Transformer; Category 1 declared weed</td>
<td>Open water</td>
<td>Remove plants using rakes and nets, take care to remove all the pieces</td>
<td>Glyphosate, Diquat and Igran to be used as a last resort</td>
<td>Snout beetles, Leaf feeding beetles, Weevil <em>(Salvinia molesta)</em>, <em>Cyrtobagous salviniae</em></td>
<td></td>
</tr>
<tr>
<td><em>Sesbania punicea</em> <em>(Red Sesbania / Rooisebania) (pg. 214)</em></td>
<td>South America</td>
<td>Transformer; Category 1 declared weed</td>
<td>Banks of watercourses</td>
<td>Cutting of plants to as close to ground level as possible and treat with chemicals, NOTE: Sesbania is poisonous so wash hands after handling</td>
<td>Garlon 4, Viroaxe, Touchdown, Mamba, Chopper, Timbrel 3A</td>
<td>Sesbania flower bud weevil <em>(Trichapion lativentre)</em>, Sesbania seed weevil <em>(Rhyssomatus marginatus)</em>, Sesbania stem borer <em>(Neodiplogrammus quadrivittatus)</em> If two of the three control agents are present no other control measures are needed</td>
<td></td>
</tr>
</tbody>
</table>
### Additional species:

- **Monatoka** – *Myoporum tenuifolium monatum*— invades dune systems and watercourses (CCT SOER 2009)
- **Patterson’s curse** *Echium platagineum* (CCT SOER 2009) – Unable to find information on likely habitat for this species it may not be a problem for watercourses.
- **Willow herb** (*Ludwigia adscendens*) small isolated patches found in the Keyers River (subcatchment 1) extends from M3 (Simon van der Stel Freeway) Highway to Zandvlei.

### Table of Invasive Species

<table>
<thead>
<tr>
<th>Species</th>
<th>Origin</th>
<th>Category invasive</th>
<th>Likely habitat</th>
<th>Manual/mechanical control</th>
<th>Chemical control</th>
<th>Biological control</th>
<th>Effect on other species and the environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Solanum mauritianum</em> (bugweed/luisboom) (pg. 195)</td>
<td>South America</td>
<td>Transformer; Category 1 invader</td>
<td>Banks of watercourses</td>
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<tr>
<td><em>Spartium junceum</em> (Spanish broom) (pg. 98)</td>
<td>Europe &amp; Britain</td>
<td>Potential transformer; Category 1 declared weed</td>
<td>Banks of watercourses</td>
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<tr>
<td><em>Typha capensis</em> (Bulrush)</td>
<td>Cosmopolitan: Africa from Uganda southward; throughout South Africa</td>
<td>Transformer; no declared status but an aggressive invasive in City waters</td>
<td>Shallow water and lower wet banks of watercourses</td>
<td>Cut reeds to at least 7.5cm below water level Use a brush cutter to cut Typha. Remove all cut material to prevent regrowth</td>
<td></td>
<td></td>
<td>Broad based herbicide</td>
</tr>
</tbody>
</table>
APPENDIX B

Erosion control measures: technical assessment
B1 Rockpile weirs

<table>
<thead>
<tr>
<th>Primary design objective</th>
<th>Stabilising vertical bed erosion, through energy dissipation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary design objective</td>
<td>Providing a natural-appearing channel form</td>
</tr>
<tr>
<td>Location of assessed example</td>
<td>High Constantia development, Constantia</td>
</tr>
<tr>
<td>Year implemented</td>
<td>2003</td>
</tr>
</tbody>
</table>

Description of technique

A vertical erosion step developed in a newly diverted, shallow (ca50cm deep) river channel. Imported river rock was piled to bank height across the step. The rock pile was extended upstream of the erosion nick by about 2m, and downstream by a further 3m, with the height of the structure tapering off in either direction. The underlying river bed was first lined with a permanent geofabric, to prevent further undercutting beneath the rocks. In time, further rock piles were necessary in the reaches some 30m upstream, as minor erosion nicks threatened. This resulted in a section of cobble and rock-lined stream, interspersed with sandy pools.

Assessment

Ecological implications

- Results in the creation of a cobble-bed, riffle-dominated system, often at the expense of the more natural soft-bottomed, wetland-dominated habitat type (nevertheless an improvement over the probability of creation of a deep, steep sided earth canal if the problem is not addressed)

- Unlike gabion weirs, the structure itself provides habitat diversity in the form of a range of fast-flow habitats, from riffle through to cascades, coupled with sediment bars and upstream pools and backwaters

- Extent of cobble lining originally envisaged may be extended, if erosion points are deflected up or downstream - specialist hydraulic and sedimentation input is needed at the design stage

- Tendency to overstabilise and create a homogeneous rocklined canal

Rockpile weir on Pagasvlei Stream, High Constantia. Arrows indicate main drop points.
Large boulders tend to exacerbate erosion, by causing fast flow around the boulder edges, rather than allowing dissipation of energy by passage of water through smaller rock piles. Often employed more for landscaping effect, than for actual channel stabilisation, they should be employed with caution near to the river.

The weir is likely to silt up in time, except at steeper drop points, and thus revert to soft-bottomed wetland habitat.

Siltation is problematic in areas where Typha capensis is likely to become established – removal of this species on appearance would usually be a management recommendation, except where water quality improvement is also a major objective (T. capensis is effective in water quality improvement).

The ecological implications of this intervention technique depend on the natural characteristics of the river reach in which it is implemented. If the natural river bed is characterised by cobbles or boulders, as in many foothill rivers, the strategy assessed here will be in keeping with the natural habitat type. If the river in the affected reach would naturally be dominated by soft substrata (sand, mud), then implementation of this strategy involves a fundamental change in habitat type, at least in the short term. How important this is depends on the condition of the actual system affected. In many urban rivers, natural habitats have already been altered to such a degree that attempts to try to restore elements of these are futile, and a better quality of habitat, in terms of habitat diversity, may be obtained by imposition of a new habitat type. In other cases, where a river has retained large components of its natural habitat characteristics, changes such as this would be ecologically less desirable.

Social implications

Creation of long riffles in an otherwise slow flowing, sandy bottomed stream provides pleasing sound effects, often valued by local communities.

Potentially more aesthetically pleasing than the alternative of gabion weirs.

Vulnerable to destruction and loss of function if rocks are removed or rearranged on a large scale – e.g. in areas where children likely to play in streams and create minor dams etc.

Placement of rockfill can be done as a labour-intensive contract, creating temporary employment.

Technical considerations

The development of vertical erosion nicks in a system indicates a system that is not in hydraulic equilibrium. A hydraulic engineer or sedimentologist should inform design (i.e. height and placement) of weirs, to prevent deflection of erosion points up and downstream.

The use of rockpile weirs will often require a series of structures to ensure energy dissipation is achieved, particularly downstream of the rehabilitation area to a point where the stream is in natural equilibrium again.

Particle size distribution, height and shape of rock pile should all be decided in consultation with a hydraulic engineer.

In cases where minor erosion threatens, this technique is effective as a short-term solution until plant establishment has occurred.
✓ Technique is management-intensive - needs to be inspected after major storms for signs of new erosion points.
✓ Backwater effects of the weir should be assessed to establish whether flooding risks are increased.

**Other comments**

✓ Potentially cheaper option than alternative of gabion weirs – but may be more costly long-term, if erosion problems need to be dealt with on an on-going basis.
✓ In certain circumstances, gabion costs increase if the availability of rock is a problem – this will similarly increase the costs of constructing rockpile weirs, particularly in larger structures.

**Ecological recommendations to incorporate if strategy implemented**

Attention should be paid during rock placement to avoid the creation of a straight, lined canal – rocks should be piled in erosion nick areas, and taper off upstream in a U-shape, and downstream in an inverted U-shape (“U” viewed from upstream), to spread flows. Minor channel lining between nick points should not involve the orderly placement of rocks in rows along the channel and its edges. For example, the creation of minor side-channels as a result of limited erosion during high flows could often dramatically improve habitat diversity and vertical heterogeneity in an artificially landscaped system.
B2. Gabion weirs

<table>
<thead>
<tr>
<th>Primary design objective</th>
<th>Dissipate energy to counteract vertical erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary design objective</td>
<td>Reduce sedimentation in downstream reaches improve river habitat quality</td>
</tr>
<tr>
<td>Location of assessed examples:</td>
<td>Diep River – Constantia green belt near Le Sueur Ave Silvermine River; Brommaert Ave, Constantia</td>
</tr>
<tr>
<td>Year implemented:</td>
<td>1996 – 1999 (separate phases)</td>
</tr>
</tbody>
</table>

**Description of technique**

- Gabion weirs are constructed across a channel. They are used to minimise downstream scour by breaking the force and flow of water.
- Downstream area protected from scour by reno section, unless deepwater pool likely to provide same function.
- Allow build-up of silt in upstream reaches, and dissipation of energy at weir drop point.
- Gabions porous, so allow trickle flow through as well as over gabion.
- Either combination of several shallow weirs used, placed at intervals, or fewer, deeper weirs. The former design allows spreading of shallow flow – either method is **hydraulically designed** to dissipate energy over that reach of the river that is not in equilibrium. The failure mechanism of back-cutting from an erosion nick point upstream is dealt with in this way.
- Often used in combination with bank regrading where erosion of a steep-sided earth canal has already occurred (e.g. Diep River: Photo A).
- Used to prevent erosion in new / realigned channels, where longitudinal channel gradient steep (e.g. Silvermine: Photo B).

A Gabion weir on Diep River, Constantia greenbelt. Insert: creation of instream bars and islands following sedimentation upstream of weir.
B (top): Wide gabion weir at Silvermine, allowing space for extensive wetland habitat upstream of gabion
(bottom): Gabion weir at stream channel at Silvermine, stabilising drop into wetland below, but providing
little habitat in itself.
**Assessment**

**Ecological implications**

- Gabion structure itself is ecologically sterile – little potential for plant growth, as flows too strong for sedimentation; rocks do not provide the “fast riffle” habitat of rock pile weirs. However, the weir is a discrete structure, covering a relatively small area (Photo C).
- Technique can allow creation of better quality riverine habitats up and downstream, by stabilisation of erosion. This can allow build-up of sediment, creating in-channel bars and backwaters, and allowing establishment of marginal and instream vegetation.
- Over-zealous or unsupervised river “maintenance” activities (e.g. dredging of sediment bars) can destroy improved habitat types.
- Channel bars and depositional features lend themselves to potential invasion by *Typha capensis*. Removal of this species on appearance would usually be a management recommendation, except where water quality improvement is also a major objective (*T. capensis* is effective in water quality improvement).
- Habitat improvement only likely where there is sufficient lateral space – a series of wide, shallow weirs, each allowing spreading of shallow flows into seasonal wetland habitat is often a desirable ecological outcome, particularly in naturally soft-bottomed systems. Where space is restricted, weirs tend to be deeper, the channel is more confined and low diversity of habitat is achieved (e.g. Brommaert Ave).
- Weirs can create deeper river habitat, at the expense of more natural shallow, wide-spread wetland habitat. To prevent this, weirs should be shallow and wide, and sufficient space should be allowed to facilitate lateral spreading of wetland areas into adjacent open space. Such a wetland would probably have a more substantial effect on water quality improvement through filtration.

**Social implications**

- Gabion wire vulnerable to vandalism and destruction by fire, leading to failure of structures.
- If used in areas with high litter loads, gabion weirs tend to act as unsightly litter traps.
Where weirs prevent down cutting and channelisation of a stream, can assist in integrating the river with areas of public open spaces, by making the river more visually and physically accessible to passers-by.

Where weirs are very wide (e.g. Silvermine (P2)), vertical weir wall can be barren unless attention paid to planting with screening marginal and instream vegetation.

Placement of gabions is labour-intensive, creating temporary employment.

**Technical considerations**

- While construction of several wide, shallow weirs is often ecologically preferred, it is a more expensive option than construction of fewer deeper weirs, across a narrower channel.
- Inadequate maintenance of gabions leads to failure – breaking of wire etc. Visual access an important factor to allow monitoring of gabion condition.
- Need ongoing inspections, particularly after heavy rains, so that undercutting or bypassing of weirs is detected at an early stage.
- Hydraulic design of gabion structures is often required to reduce maintenance requirements.
- Specification of gabion box structures must be made to reduce the risk of corrosion in aggressive environments.
- The physical weight of gabions and their drainage characteristics when acting as retaining structures promote their being used in adverse hydraulic and geotechnical situations.

**Other comments**

- Desirability (and outcomes) of structures dependent on:
  - availability of space on either side of channel;
  - type of stream system (e.g. cobble bed or wetland transitional);
  - vertical extent of retaining structures required;
  - availability of rockfill, impacting on cost;
  - likelihood of weir destruction through vandalism/ fire, and
  - funds available for ongoing maintenance of structures.

**Ecological recommendations to incorporate if strategy implemented**

- Sufficient width should be provided on either side of the flow channel, to allow spreading of shallow flows, and the creation of seasonally inundated habitat.
- The long-term maintenance regime for this section of the river should allow the creation of habitat types associated with upstream deposition— e.g. channel bars, which are often automatically dredged out as part of river maintenance.
B3. Sandbag weirs

<table>
<thead>
<tr>
<th>Primary design objective</th>
<th>Protection of non-perennial, steeply sloped water courses from erosion, through energy dissipation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary design objective</td>
<td>Eastern slopes of Redhill, Simonstown</td>
</tr>
</tbody>
</table>

**Location of assessed example:** Eastern slopes of Redhill, Simonstown

**Description of technique**

These structures comprise rolled sandbags, made of shade cloth, extending the width of the water course, and tying into the side of the river valley. They are intended to act as energy dissipators, and are arranged in series down the slope. The structures are not permanent, and are intended to provide temporary stability while vegetation is established in areas that have been destabilised – e.g. by fire.

**Assessment**

**Ecological implications**

- Provide little habitat per se, and are best suited to steeply-graded ephemeral watercourses, which flow briefly after rainfall. Scarcity of water in these systems means that establishment of quality riverine or wetland vegetated habitat is unlikely, and the structures provide stability primarily to allow the establishment of terrestrial vegetation.

- Should not be used where seasonal, rather than ephemeral, flow regimes exist – more ecologically suitable measures in these situations would include construction of gabion weirs and attention to planting and establishment of a zone of riparian / wetland vegetation, to stabilise the riverine zone.
Social implications

- Unsightly structures, but only temporary
- Placement of sandbags can be done as a labour intensive contract, creating temporary employment

Technical considerations

- Relatively inexpensive measures, provided adequate vegetation cover is established before structures disintegrate
- Attention should be paid to tying structure in to slope, such that the weir extends across the whole potential width of the water course, and side-cutting will not occur
- Prevention of downstream erosion is important
- The need for maintenance of sandbag weirs after rain events is likely
- Botanical design is as important as hydraulic design in these structures as the establishment of vegetation in the short to medium term is crucial.

Other comments

- Structures should be inspected frequently, to check whether vegetation establishment is adequate at potential nick points – frequency of inspection may be problematic where structures located on steep, inaccessible areas.
- Where vegetation fails to be established on and along sandbag weirs, consideration should be given to implementation of a planting programme.
B4. Groynes

<table>
<thead>
<tr>
<th>Primary design objective</th>
<th>Protection of river banks from erosion, in confined areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary design objective</td>
<td>Improved provision of bank habitat</td>
</tr>
<tr>
<td>Location of assessed examples:</td>
<td>Stellenbosch: Eerste River; Spier Estate; stream near CSIR (Stellenbosch)</td>
</tr>
<tr>
<td>Year implemented:</td>
<td>ca1997</td>
</tr>
</tbody>
</table>

**Description of technique**

- Vertical gabion structures installed at intervals along one side of a river bank, extending into the river channel and deflecting flow away from the bank.
- Used where river bank constricted on terrestrial side (e.g. by encroachment of buildings, roads into the former river flood plain).
- Design 1: (Photo A): unlined river bank between groynes allowed to stabilise with vegetation.
- Design 2: Krohnlgabion® system (Photos B, C): integration of gabion and reno mattress protection works, resulting in sections between groynes being stabilised with gabion baskets, to protect against slope failure initiated by erosion of backfilled river bank. Topsoil applied to reno mattress.

**Assessment**

**Ecological implications**

- Groynge gabion structure itself is ecologically sterile – gabions vegetated by weedy elements, and allow accumulation of litter.

![Design 1 groynes intruding into Eerste River channel, at Spier Estate, Stellenbosch](image)
Main ecological advantage of Design 1: extent of gabion stabilisation limited to discrete sections of river bank. Sections of bank in between groynes allowed to stabilise naturally, resulting in the creation of marginal habitat, backwaters and sand bars, where deposition occurs in more sheltered conditions downstream of, and behind, groyne.

Design 2 groyne: extent of gabion lining does not allow establishment of vegetation likely to create high quality marginal habitat. Gabions lend themselves at best to being covered by grass or other groundcovers.

Design 2 creates a more homogeneous profile, with little opportunity for the creation of backwaters, sand bars, and marginal vegetation habitat along the edge of the channel.

Used where space on either side of river is constricted, and there is little practical possibility of addressing bank erosion by stream widening, bank regrading and planting.

Social implications

Design 2 creates a “neat” (but unnaturally straight) river profile

Both designs create an aesthetically more pleasing system than if erosion had been allowed to continue unchecked.

The rehabilitation of eroded river banks using groyne structures is a long term process, relying on cyclical/seasonal variation in flows to promote deposition and the establishment of vegetation. It must be made known that aesthetic improvement is therefore a slow process.
In deep river channels, the vertical drop from the top of the groyne down to the river bed may be a safety concern – as would be the vertical drop from the top of an undercut embankment to the river bed.

Placement of groynes can be done as a labour-intensive contract, creating temporary employment.

**Technical considerations**

- Design 1 requires specialist hydraulic design to correctly space the groyne structures, thus ensuring that erosion nick points do not occur between structures or, more importantly, behind individual structures resulting in destabilization of groynes.
- Design 2 is applicable only in specific cases (e.g. where lateral support is required in conjunction with groyne erosion protection) - in most other cases, however, the normal philosophy of intermittent groyne structures, correctly spaced to avoid erosion, and specifically designed to avoid lining of long sections of river bank with reno mattress and gabions refers.
- Design 1 is cheaper than Design 2, as involves shorter extents of gabion.
- Design 2 is only applicable.
- Since groynes deflect high velocity flow away from eroded areas, there is a risk that their construction can result in new erosion problems downstream. This phenomenon needs to be checked in the design.

**Ecological recommendations to incorporate if strategy implemented**

- In limited circumstances where Design 2 is used, reno mattress sections should incorporate large-sized, bidem-lined planting holes; at level of summer baseflow (i.e. so plants have access to water all year round). Holes should be sized such that they can support plants with large root structures (40cm planting hole diameter recommended): this modification will have cost implications. Holes should be planted as part of construction phase.
- Habitat quality of unstabilised banks downstream of Design 1 groynes can be enhanced, where the project budget allows planting of appropriate indigenous riparian species. Where budgets are limited, such planting should be limited to the lower, wetter river margins, where survival rates will be higher.
B5 Riprap linings

<table>
<thead>
<tr>
<th><strong>Primary design objective:</strong></th>
<th>Channel stabilisation and prevention of erosion (as part of channel re-design for flood management)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Secondary design objective:</strong></td>
<td>Moddergat River; Brookwood Stream; sections of Pagasvlei Stream on High Constantia housing development</td>
</tr>
<tr>
<td><strong>Location of assessed example:</strong></td>
<td>Moddergat River; Brookwood Stream; sections of Pagasvlei Stream on High Constantia housing development</td>
</tr>
<tr>
<td><strong>Year implemented:</strong></td>
<td>2000/2001 (Moddergat); 1998 (Brookwood)</td>
</tr>
</tbody>
</table>

**Description of technique**

This comprises large to huge clasts packed against a structure to be protected, or forming the lining of the channel margins. The size of the material is determined relative to the power of the watercourse (a function of discharge and gradient) or intensity of scour around structures like culverts. Bed / banks will be protected by lining with material too large to be moved by the power of floods of that system.

Three examples:

- **Brookwood Stream (photo A):**
  - Trapezoidal channel, with rock (cobble to medium boulder) lining, 0.3m thick
  - Riprap overlaying bidem lining; straight channel
  - Stilling ponds at nodes where channel changes direction

- **Moddergat Stream (photo B):**
  - Used in combination with gabion weirs

- **Pagasvlei Stream (High Constantia) (Photo in Section B1):**
  - Cobble lined stream, between rock-pile weirs
  - Rocks placed in channel in response to development of (induced) erosion nicks

**Assessment**

**Ecological implications**

- The projects assessed provided (at least in the short term) more diverse habitats than their pre-intervention condition, comprising, steep-sided earth-lined trenches/canals, vegetated with *Typha capensis* or invasive garden exotics. Rock-lined areas provided riffle and run habitat, interspersed with vegetated sand bars in areas where sediment has accumulated.

- Rock / cobble instream habitat probably not natural to any of the streams assessed – they were probably soft-bottomed systems, associated with broad wetland swathes. The significance of this aspect must be assessed in the context of the individual systems. In many cases, given an urban location, with extensive catchment-level impacts, including changes in natural drainage patterns, water quality and availability of space on either side of the channel, restoration to the natural condition is not a realistic possibility, and the short term creation of diverse, albeit unnatural habitats, is an improvement over the pre-intervention condition.
Riprap provides habitat diversity in the form of riffle to cascade habitat, coupled with sediment bars and upstream pools and backwaters. However, flood stabilisation in the form of gabion weirs at Moddergat Stream, as well as the use of pre-selected cobbles within a specific size range, limits the extent to which natural sorting of cobbles occurs, and the consequent creation of low-flow channel meanders across the cobble bed.

In the short-term, rock lining inhibits the encroachment of invasive vegetation into the channel, at least in the short-term – in Brookwood stream, kikuyu invasion was restricted; in Moddergat Stream, *T. capensis* invasion from the flood channel was restricted. Note that without maintenance, these functions are likely to be short-lived (e.g. Moddergat Channel was highly invaded by *T. capensis* in 2003).

In time, sedimentation of all channels occurred and allowed the establishment of instream vegetation, including *Typha capensis*.

With the exception of sedimented areas subject to dense invasion by *T. capensis*, habitat diversity increased following sedimentation, which allowed the creation of side channels, sand bars and stands of marginal and instream vegetation.

The strategy is however associated with a tendency to overstabilise – e.g. creation of minor unlined side-channels and backwaters during high flows could dramatically improve habitat diversity and vertical heterogeneity in an artificially landscaped system. Once rock-lining becomes the norm at a site, these minor channels are often included in the stabilising programme, even where there is little risk of undercutting or the creation of “problem” erosion areas.
Social implications

- Compared to alternative channel designs, riprap lining is a safer option than steep-sided earth channels or concrete-lined canals.
- Laying of riprap is labour-intensive, and lends itself to the creation of employment opportunities for local communities.
- Rock lining creates a pleasing sound of running water.
- Sediment accumulation is likely to create conditions suitable for invasion by *T. capensis*. This species is associated with health and aesthetic problems, and can quickly result in monospecific unsightly stands. It requires ongoing maintenance.

Technical considerations

- May be used in combination with a gabion weir or other dissipation devices, as an alternative to more formal channel lining (e.g. reno or articulated concrete blocks (ACBs)).
- Correct grading of rip-rap material and depth of rip-rap lining relative to accurately determined hydraulic loads is advantageous from a maintenance point of view.
- When implemented in the correct context (hydraulic environment) the technique should result in a stable, maintenance-free system.
- Used in combination with a permanent bidem lining, the technique can prevent undercutting and the creation of vertical nick points, but may interfere with rooting of instream plants – consider cutting holes in bidem, to allow rooting or choosing an alternative geofabric designed to allow root penetration (see section 1.5.10).
**Other comments**

- Riprap lining is usually an ecologically preferred option to more formal channel linings.
- The strategy can be used in combination with / instead of gabion and rockpile weirs in certain circumstances.

**Ecological recommendations to incorporate if strategy implemented**

- Attention should be paid during rock placement to avoid the creation of a straight, lined canal – variation in riprap height (within parameters that will prevent erosion) would allow increased diversity in what may otherwise become a homogeneous cobble bed. In flatter sections of the channel, pools, separated by cobble bars, should be considered as a means of improving habitat diversity. Shaping of channel should allow for sinuosity in low flows, but conservation of the original channel shape in high flows, to enhance physical habitat diversity without inducing erosion in high flows.
- Channel slopes should also be shaped to allow for flatter, more heterogeneous slopes, by varying the position of the toe and the gradient of the slope.
- Large boulders should be used with caution – they tend to exacerbate erosion, by causing fast flow around the boulder edges, rather than allowing dissipation of energy by flow through smaller rock piles.
- Riprap should comprise river rock. The rock should not however be sourced from functioning river floodplains / beds, but taken from areas where existing invasion into former floodplains (e.g. by farming activities) has resulted in the collection and need for disposal of river rock.
B6. Gabion and reno mattress linings

<table>
<thead>
<tr>
<th>Primary design objective</th>
<th>Scour protection; channel stabilisation and prevention of erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary design objective</td>
<td>Provision of instream/ marginal habitat</td>
</tr>
<tr>
<td>Location of assessed examples:</td>
<td>Keysers River; Lourens River; Diep River (downstream of Burnham Road); Moddergat Stream, Liesbeek River</td>
</tr>
<tr>
<td>Year implemented:</td>
<td>Keysers (1997/98); Lourens (2002/03); Liesbeek Rivers (1990s); Moddergat Stream (2000, 2001)</td>
</tr>
</tbody>
</table>

**Description of technique**

- Common technique for erosion protection from epoxy coated, rock-filled wire-basket.
- Often used immediately downstream of stormwater outlets, to protect against scour.
- Also used in stream-scale projects:
  - In some cases (e.g. Keysers and Lourens Rivers), topsoil added to reno mattress, and planted (photos A and B)
  - In other cases (e.g. Moddergat Stream; Liesbeek River; Soet River) – sediment allowed to accumulate naturally on reno mattresses, set in base of stream (photo C – E)
  - Planting never attempted or encouraged in many cases – e.g. reno and gabions at Silvermine and upper floodchannel of Moddergat Stream (photo F)
  - Planting spaces provided on gabion steps (Silvermine – photo G)

![A: Keysers River upstream of Main Road. Reno stabilising on sections of high flow channel allows development of marginal vegetation (see inset).]
Assessment

Ecological implications

- Although gabions and reno mattress linings can play important roles in addressing erosion and scour, fast flows often prevent the accumulation of sediment necessary for the establishment of vegetation. In practice, most assessed examples provided ecologically sterile habitats, often supporting little vegetation other than weedy elements.

**Lourens River upstream of T2**, showing plant establishment on topsoiled reno of upper bank. Photo courtesy R. Suthers. Africa gabions.

**C: Gabions on Liesbeek River** with 1st step set just above water level. No planting, and no top soil applied to bottom step. High flow areas would suit colonisation by *Isolepis prolifera*. Shading by alien trees is a problem.
✓ Where gabions are used on channel sides, stepped gabions, with the lowest step set at bed level, may allow planting to be carried out behind the gabion, or even in sediment that accumulates on the edge of the gabion, outside of the main flow. Such planting, if successful, and where carried out using appropriate indigenous riverine species, both screens gabion structures, and provides a degree of sheltered marginal vegetation habitat at wetted bank level (e.g. Keysers River, and potentially Liesbeek River if planting is carried out).

✓ Where sedimented, wetted structures are allowed to revegetate on their own, it is possible to provide good instream habitat, although there is often a risk of invasion by ecologically undesirable species – e.g. kikuyu grass; *Typha capensis*, weedy annuals and various garden exotics.

✓ Where the only flows discharging from a structure are sporadic, establishment of plants other than hardy weeds is often difficult.

✓ Note that vegetation on the upper steps of gabions often has little ecological value, contributing rather to the aesthetic appeal of the structure, by screening of otherwise barren gabion terraces. Marginal stream vegetation requires connectivity between the stream and the planted section of the gabion, such that overhanging vegetation is able to provide sheltered aquatic habitat, and/or feeding and breeding grounds for aquatic fauna. The greater the vertical and textural diversity of marginal vegetation, the more habitat requirements it is likely to be able to meet. Thus planted gabion baskets along the
channel at Silvermine and vegetated gabions along the Diep River (see photos) contribute little other than aesthetic “softening” of what is essentially a rock-lined canal.

- Gabions above the wetted stream edge are rapidly drained, and may tend to overheat roots, resulting in a low success of revegetation.
- The best quality marginal habitat is usually created along the wetted channel margins, where plants have access to water – higher up the bank, there is a need for irrigation, at least through the establishment phase, making successful revegetation of these zones unlikely except in private developments, where funding is often less restricted.
- Where sediment is allowed to accumulate naturally in instream structures, revegetation is slower, and often primarily by weedy species, rather than by species likely to contribute towards the creation of longitudinal corridors of marginal river habitat, able to provide shelter, feeding and breeding grounds to small riverine fauna.
- Shaded areas, even where reno or gabions are covered with topsoil, are unlikely to support much vegetation – this is often a problem where the channel has been invaded by alien vegetation (e.g. Diep River)

- Unsedimented structures provide ecologically sterile habitats, unlikely to support vegetation of any ecological value. This is of less concern where only a short extent is necessary – for example, reno mattresses downstream of weirs, bridges or at stormwater discharge points.

- As in-channel structures, in areas where flow is unlikely to allow sediment accumulation, reno mattresses and gabions provide a homogeneous,
engineered restriction to erosion. Ecologically preferred options, where flow velocities allow, would usually be riprap linings, which provide more scope for heterogeneity in the river profile.

**Social implications**

- Basket wire vulnerable to vandalism and destruction by fire, leading to failure of structures with high financial implications and damage to the river environment.
- If used in areas with high litter loads, structure tends to act as an unsightly litter trap.
- Packing of baskets lends itself to use of local unskilled labour.

**Technical considerations**

- Gabions are ideal lateral support structures in an environment where lateral earth pressures are likely to be increased by the presence of groundwater (i.e. in the case of rivers that have fluctuating levels), since they are free draining. Their high mass, as a result of the rockfill, lends stability and gabions are therefore good gravity retaining structures.
- Reno mattresses also afford stable protection to river beds due, primarily, to the high cohesion afforded them by the wire baskets.
- As in all structural design, stability against worst case scenario loading is required to prevent failure of the structure. Gabions and reno mattresses are therefore often perceived to be ‘overkill’ for erosion protection, but they form a more important stability function during extreme loading (e.g. flooding) where other methods (e.g. rip-rap lining, ACBs) do not possess the same integrity.
- Gabion and reno thickness and sizing are dictated by flow velocities and volumes, and require specialist geotechnical and hydraulic engineering input.

**Ecological recommendations to incorporate if strategy implemented**

- The addition of topsoil to gabions or reno that are in contact with, or only slightly above, summer baseflow levels, followed by planting, can create effective marginal vegetation habitat, with the following provisos:
  - topsoil is only likely to remain in place in hydraulically sheltered areas – soil is washed out in areas subjected to fast flows. Instream vegetation such as *Isolepis prolifera* should be considered for establishment on inundated sections of reno exposed to current: the species roots in sediment or rocky areas, and provides a low-growing habitat, suitable as shelter for many aquatic invertebrates, and feeding ground for fish and birds;
  - allowance should be made for weeding of topsoil, until an adequate cover of indigenous vegetation has been obtained;
  - soil is vulnerable to erosion until vegetation has been effectively established: the timing of soil placement is important, and should ideally take place during late summer/ autumn, when there is still time for vegetation to take root, before the onset of winter rains. Where this is not possible, packing soil into reno and lining the reno lid with coconut fibre is an option to hold the soil in place. The use of
other products (e.g. Biomac®, Macmat®) that will degrade over two seasons is another means of allowing ample time for vegetation establishment;

- the size of plants is limited by the size of the wire mesh. More flexibility is allowed if reno or gabion lids are constructed of (for example) geofabric, such as MacMat®;

✓ Gabions above the wetted stream edge are rapidly drained, and may tend to overheat roots, resulting in a low success of revegetation. Where fines are provided in the infill matrix, capillary action should allow wetting of substrates up to about 400 mm above the water surface;

✓ Where sedimented, wetted structures are allowed to revegetate on their own, there is often a high risk of invasion by ecologically undesirable species – e.g. kikuyu grass; Typha capensis, weedy annuals and various garden exotics. These do not usually create good marginal vegetation habitat.

✓ As a rule, where banks require gabion stabilisation, efforts should focus on maximising the width of flat gabion surface at, or immediately below, summer base flows. This is the zone in which there is a good chance of establishing marginal vegetation, even without maintenance programmes. Above this level, the gabions may be as high as possible, without compromising safety issues, and, if aesthetically desirable, screened by growing hanging groundcovers from the top of the channel, down over the gabions.

✓ Construction of mattresses on site allows a better fit to the channel profile, marginally reducing the overall “engineered” appearance of the structure.
B7. Geocells

<table>
<thead>
<tr>
<th>Primary design objective</th>
<th>Preventing bed and bank erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary design objective</td>
<td>Allowing limited planting and softening of “canal” structure</td>
</tr>
<tr>
<td>Location of assessed example:</td>
<td>Stormwater outlet from Cafda wetlands into Rondevlei</td>
</tr>
<tr>
<td>Year implemented:</td>
<td>2001</td>
</tr>
</tbody>
</table>

**Product description**

- Hyson® cells used as the example of a geocell. These comprise a mat of square, hollow geocells made of thin plastic film
- Standard cell sizes range between 150mm x 150mm and 400mm x 400mm
- Cell depth varies between 50mm and 4 metres.
- Mats cut and joined on site
- In riverine areas, cells below water level filled with concrete or no fines concrete
- In assessed example, all cell holes (150x150mm) filled with topsoil, and allowed to revegetate naturally.

A: Hyson®-lined channel into Rondevlei, from Cafda wetlands – a few weeks after laying.

B: Channel (shown in A) 4 months later, showing dense growth of *Typha capensis*. 
Assessment

Ecological implications

✓ Homogeneous habitat created, with little opportunity for creation of depositional or erosional channel features. The ecological significance of this depends on the context of, and existing habitat at, each site.

✓ The assessed example was rapidly colonised by *Typha capensis*. This species is an effective water quality polisher, but provides a low-quality ecological habitat.

✓ *Typha capensis* is able to establish itself in dense stands, by sending roots down into individual geocells and spreading across the surface of the structure. Faster colonisation as sediment accumulates. Less effective colonisation by *T. capensis* likely in higher-velocity environments, where less sediment accumulation.

✓ The ecological implications / desirability of the strategy are dependent on its extent and context:
  • as a short section of monospecific vegetated reedbed, the structure allows water quality treatment and would provide protection for more ecologically important habitats downstream;
  • on its own, the structure is unlikely to result in the development of diverse or aesthetically attractive habitat, particularly where small cell size used (as per assessed example). Most rooted riverine plants, other than small sedges and grasses, require larger planting holes.

The ecological desirability of the strategy as a whole should be guided by existing habitat availability – where habitat quality is a priority, selection of this option is problematic. Where water quality improvement is a priority, to protect downstream reaches, and sedimentation such that establishment of *T. capensis* likely, then this option is more favourable.

Social implications

✓ Geocells lend themselves to the use of unskilled labour in implementation.

✓ They are unsightly in the short-term. However, in low-gradient, depositional systems, the structures are rapidly obscured by *T. capensis*. They are likely to be more visible if planted with discrete species growing out from a single rooted base, rather than spreading out as per *T. capensis*.

✓ *Typha capensis* itself is associated with health / aesthetic problems: it produces large numbers of tiny seeds, which cling to curtains/ laundry and have been linked to respiratory problems such as asthma.

✓ The social desirability of these structures is dependent on the type of vegetation likely to colonise them at particular flow rates, as well as their proximity to humans.

✓ As an alternative to a lined canal, geocells are probably a safer option, allowing easier canal access.
Technical considerations

Permanent, robust structures

- They allow mechanical sediment removal – the recommended method for removal of weeds within cells is by passing a ball of rolled barbed wire across its surface.
- The manufacturer recommends the use of no-fines concrete to fill geocells, rather than the (cheaper) option of filling with topsoil and seeding. This is because, in practice, topsoil and irrigation quality is often sacrificed to save costs.
- A vegetated solution without no-fines concrete depends on the root biomass to actually do the work. In these cases, the choice of suitable plants and adequate irrigation are critical.
- Any variations to the above (e.g. half concrete, half topsoil fill) should be reviewed by Hyson® cells prior to construction.

Other comments

- The overall desirability of the structures is dependent on the type of vegetation likely to colonise them at particular flow rates, as well as their proximity to humans.
- When the cells are filled with concrete below the water level and grassed above the water margins, a tidy but unnatural visual effect, providing little quality riverine habitat (e.g. sheltering marginal vegetation) is obtained.

Ecological recommendations to incorporate if strategy implemented

- Largest available cell sizes should be used, filled with topsoil and planted where stream velocities allow, to increase potential for more diverse habitat. Large cells will lend themselves to selection of deeper rooted reeds and other riverine plants, offering greater structural support.
- Planted cells may need to be interspaced with concrete-filled cells for structural strength (this has implications for ease of installation). If this occurs, the planted cell: concrete cell ratio needs to be assessed. Sparsely planted cells are unlikely to create a high quality habitat.
B8. Articulated concrete blocks (ACBs)

<table>
<thead>
<tr>
<th>Primary design objective</th>
<th>Channel stabilisation and prevention of erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary design objective</td>
<td>Potential for planting: softening of structure / creation of habitat</td>
</tr>
<tr>
<td>Location of assessed examples:</td>
<td>Langevlei Canal; Princessvlei and Wildevoëlvei stormwater outlets</td>
</tr>
<tr>
<td>Year implemented:</td>
<td>1999 / 2000</td>
</tr>
</tbody>
</table>

**Description of technique**

The following structures were assessed as examples of this form of erosion protection:

- Grassblocks® (Princessvlei Stormwater outlet)
- Terrafix® (Langevlei Canal Upgrade – Phase 1)
- Armourflex® (Wildevoëlvei stormwater outlet)

- All assessed structures comprise articulated concrete blocks, joined on site in a matrix. Armourflex blocks are strung together by epoxy-coated wire.
- Each block includes a number of open-ended cells, passing from upper to lower surface.

![A: Terrafix blocks at Langevlei canal](image)

Cell size typically is less than 15cm internal diameter. Cells are intended either to increase porosity, or to allow space for establishment of plants.
Under certain conditions, where flow velocities and risk of erosion permit, alternative blocks may be left out of matrix during placement, to provide space for growth of larger plants.

**Assessment**

**Ecological implications**

- Once installed, block matrices are inflexible and poorly reflect the natural (or landscaped) contours of a river bank, making for a homogeneous and ecologically relatively sterile environment
- None of the assessed structures provided conditions suitable for the establishment of vegetation of any value in terms of creation of riverine or wetland habitat. As a rule, the blocks were sparsely vegetated, primarily by weedy annuals or, where planting had occurred, by stunted plugs of grass.
- The reasons for poor vegetation of assessed structures might include:
  - Small planting spaces in cells mean that plant roots, above the water edge, become excessively hot during summer
  - Plants have little room to expand their root systems as they establish
  - Soil easily flushed out of small planting holes in high flow velocity environments
  - Structures tend to act as “French drains”, promoting rapid infiltration of water through them, and thus resulting in drying of plant roots – this aspect can potentially
be overcome by using bidem or other suitable geotextiles to line the base of the structure

- The structures are vulnerable to excessive wear by cyclists and other human traffic – the hard surfaces encourage bicycle traffic, even on steep slopes, where they are sometimes used as informal obstacle courses.
- Establishment of vegetation in blocks improves in lower, damper areas of the bank, where plant roots have easy and permanent access to water (e.g. Langevlei)
- Where blocks are used to create narrow overflow areas (e.g. Wildevolevlei), there is a risk of bypassing and undercutting of the formal channel, in favour of an unlined, more direct flow path.
- Leaving alternate blocks out of the block matrix does provide sufficient space for the establishment of discrete clumps of riverine vegetation, useful in preventing further erosion and improving marginal habitat availability. This is however effective mainly in areas where there is sufficient budget for planting and at least short-term maintenance of planted areas, or where planted areas lie within permanently moist to wet sections of the channel
- Overall, the use of the assessed structures in erosion control is of low ecological desirability.

Social implications

- ACBs are vulnerable to theft, either of individual blocks, resulting in compromise of the whole structure, or outright removal of large sections of the matrix
- Grassed structures, where grass is able to establish itself, have a neat, green appearance, of more aesthetic appeal than a concrete canal, although ecologically less clear distinction.
- Unvegetated or weedy grassblocks contribute to an air of neglect in many areas
- The structures are vulnerable to excessive wear by cyclists and other human traffic.

Technical considerations

- While removal of alternate blocks from matrices might be ecologically desirable, from a technical perspective it may lead to compromise of the stabilising structure, particularly structures reliant on wire bonding to increase overall cohesiveness, and should only be considered in small systems, where flow velocities are relatively low.
- The use of ACBs is not recommended unless a sound hydrological/hydraulic investigation of flow velocities has been undertaken.

Ecological recommendations to incorporate if strategy implemented

- The critical determinant of the ecological success of stabilising blocks, in terms of their ability to provide riverine / wetland habitat, in addition to meeting their erosion control objective, lies in the size of the hole available for the establishment of plants. As a general guideline, planting holes of minimum diameter 35cm are recommended, to provide sufficient space for rooting of riverine and wetland plants that are likely to provide
vertical and horizontal marginal riverine habitat. It should be noted that, once established, such vegetation will play a role in protecting a bank from erosion.

✓ Consideration should be given to using ACBs in combination with other, larger-holed structures (e.g. Winblocks®). Winblocks® are an alternative structure that has been used to great effect in Langevlei. These blocks comprise large square concrete blocks (35cm internal width). These were installed 300mm below the canal base, to ensure wetting of plants during summer low flows. The large size of the plantable hole allowed establishment of large, reedy elements (e.g. Schoenoplectus maritimus and Cyperus textilis). Once established, these plants contributed to trapping of sediment, providing a sedimented surface across the designated area, suitable for colonisation by other reedy species (including Typha capensis).

✓ The ecological implications of erosion should be weighed up against the poor aesthetics of ACBs when deciding on their use as most of these products are unlikely to be obscured by vegetation even in the long term.
B.9 Geofabrics

<table>
<thead>
<tr>
<th>Primary design objective</th>
<th>Erosion protection along the banks of water courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary design objective</td>
<td>Allowing establishment of plants</td>
</tr>
<tr>
<td>Location of assessed example:</td>
<td>Small tributary of Berg River at entrance to Paarl Golf Course</td>
</tr>
<tr>
<td>Year implemented:</td>
<td>2003</td>
</tr>
</tbody>
</table>

**Description of product and technique**

- MacMat® geomat assessed as example of geofabric
- Composite material of MacMat™, reinforced with double twisted hexagonal mesh
- Permanent geomat, made of non-degradable polypropylene
- Used on slopes up to 1:1, depending on velocity of water
- Fabric cut to shape on site, and pinned into ground, or attached to other erosion control structures (e.g. gabions)
- Two assessed examples – one grassed (Photo A); the other planted with indigenous riparian vegetation (Cyperus textilis; various restios; arums – Photo B)

**Assessment**

**Ecological implications**

- As an alternative to channel linings such as gabions, geomat allows development of a more natural vegetated streambank
- This can be an ecologically acceptable solution in situations where space on either side of the channel is restricted, making the usually more desirable regrading of banks impractical.
- The strategy allows planting of large-rooted species, including sedges and reeds, with root diameters > 30cm. Planting is achieved by cutting crosses in mesh, and allowing stretching of the mesh hole as the plant grows.
- The mat is flexible, so it can accommodate existing topographical conditions, providing a less homogenous bank profile.
- Depending on plant species selected, geofabric has the potential to allow the establishment of a high quality marginal vegetation zone. Steep, upper sections of the bank are less likely to achieve high habitat quality, unless adequate irrigation and other maintenance measures in place, at least during the establishment phase. This problem is not confined to the vegetation of geofabrics, but applies to all revegetation plans (see Section B10
- The geofabric can be used to avoid problems associated with late planting of destabilised river banks, or on banks where emergency erosion treatment is needed, following bank collapse or undercutting. Geofabric holds the soil in place immediately, until vegetation has established. Since the material is permanent, it provides underlying stability, in the event of future loss of vegetation or temporary failure due, for example, to inadequate watering or drought.
The strategy can be used as a means of retaining other features along a manipulated channel – e.g. retention of an oak tree in the assessed channel at Paarl Golf course – the steep slopes of the embankment are protected from erosion by the geofabric.

Of the two assessed examples, grassed geofabric (photo A) provides extremely low quality marginal vegetation habitat, with provision of virtually no vertical shelter. The only ecological function being performed is filtration of sediment and possibly some nutrients from road and golf course runoff.

**Social implications**

- The fabric is easily cut to shape by unskilled labour, thus allowing potential employment of local communities.
- Once vegetated, the fabric is virtually invisible; when exposed, its dark colour is readily visible, but unobtrusive.
- Unvegetated fabric is vulnerable to vandalism (e.g. by cutting), potentially jeopardising bank integrity.
- Even when only grassed, the fabric provides a neat, aesthetically pleasing channel form (but see ecological comments).
Technical considerations

- High roughness and permeability of MacMat® enhances deposition of sediment in flowing water and improves water retention.
- Relatively simple to install
- Prevents underlying soil from being washed away before vegetation is established.
- Prevents gully erosion and loss of topsoil from unvegetated surfaces (Photo B).
- It is important to pin the fabric down adequately, and prevent lifting and rolling of geofabric, before vegetation is established.
- The fabric can be used in combination with other erosion control techniques, e.g. reno, gabions, riprap, planting.
- Many other geofabrics are commercially available that have similar qualities to MacMat®.
- These products are manufactured in varying grades of integrity to allow cost saving where possible.
- Under high hydraulic loads, a careful assessment of the suitability of geofabrics is required as they carry a high risk of being uprooted whilst vegetation is establishing.

Other comments

- May be a less costly long-term option than ongoing attempts to stabilise eroding slopes by planting and repeated bank re-grading.

Ecological recommendations to incorporate if strategy implemented

- Before applying the geofabric, attention should be paid to shaping of the bank, ensuring that a varied slope is obtained, by varying the length of the slope and the position of its toe. The overlying geofabric should assume this shape.
### B.11 Planting

<table>
<thead>
<tr>
<th>Primary design objective</th>
<th>preventing or addressing bank erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary design objective</td>
<td>improving riverine habitat and aesthetic appeal</td>
</tr>
<tr>
<td>Location of assessed examples:</td>
<td>Examples include Kuils River (Westbank); Pagasvlei River; Langevlei Canal (Phase 2); Wildevoëlvlei stormwater outlet</td>
</tr>
<tr>
<td>Year implemented:</td>
<td>Various</td>
</tr>
</tbody>
</table>

**Description of technique**

This section refers to the vegetation or re-vegetation of river banks that have been cleared of vegetation, or of exposed surfaces that have been re-shaped in the process of upgrading a river or wetland. Planting is frequently also a possible component of other techniques for addressing or preventing erosion (e.g. gabion baskets; geocells, geofabrics). Recommendations regarding planting under these conditions are covered in the appropriate sections in this handbook.

**Assessment**

**Ecological implications**

- ✓ This option should be encouraged, where space and instream flow dynamics permit.
- ✓ While planting, usually in combination with appropriate bank regrading, has the potential to provide a relatively “natural” solution to an erosion problem, its failure can result in the overall deterioration in the ecological condition of a river, at times exacerbating ongoing erosion to the point where far more engineered solutions to the erosion problem are required, than would originally have been necessary. Some reasons for the failure of planting as a strategy to address erosion include:
  - delayed planting, such that plants have not established prior to the onset of winter rains
  - unforeseen early, or unseasonal heavy rains, before establishment has taken place
  - unrealistic shaping of stream / river profiles in regraded or rerouted streams, resulting in the creation of rapidly eroding, unstable sections of channel or bank – in these cases, stabilisation by other means (e.g. installing energy dissipating structures) is often required, before planting will succeed
  - reliance on hydroseeding for soil stabilisation, when an insufficient period for germination, growth and stabilising of plants is allowed
  - reliance on poor seed, or poor quality plants
  - failure to provide adequate irrigation facilities – allowance should be made for all plants, with the exception of those planted into the wetted zone, to be irrigated over at least one, and preferably two, summers
  - failure to weed newly planted areas, and replace dead plants in the early stages following planting, resulting in smothering of desirable plants by weedy invasives
  - failure of irrigation systems through vandalism or theft
Appendix H: Environmental Management Programme

- loss of plants to theft or vandalism
- planting of inappropriate species (either non-indigenous species or species with different habitat requirements to the areas in which they are planted). This is sometimes the result of a lack of commercial availability of desired indigenous species, and sometimes due to unknown / unquantified changes in inundation levels as a result of reshaping.

**Social implications**

- Planting can lend itself to the use of unskilled labour, as well as to the involvement of local communities. However, it is essential that work groups are supervised by a botanist, landscape architect or horticulturist, especially during the plant establishment phase.
- Depending on the choice of species, the long-term result of successfully planted river channels should be a near-natural appearance.
- Public access to newly planted areas should be restricted, so that plants can establish without disturbance.
- Where theft of plants is likely, species should not include expensive individuals
- Large plant specimens are less vulnerable to theft and vandalism than smaller ones
- Seeds and bulbs, which come up en masse, and are initially inconspicuous, are less likely to be casually uprooted by vandals, than are freshly planted shrubs
- Showy species are more likely to be stolen than inconspicuous ones
- Trees should be planted at least 5m from pathways, in areas where vandalism is likely to occur. This reduces the risk of passers-by breaking off their growing tips

**Technical considerations**

- The impact of established plants on erosion / deposition of sediments (e.g. trees and reeds), and flooding, needs to be taken into account when planting.
- Where there is a high risk of plant failure, due to steepness of slopes, or volume / velocity of streamflow, the use of additional low-level, possibly only temporary, forms of stabilisation should be considered at an early stage. Failure to recognise the likelihood of failure of planted areas runs the risk of exacerbating erosion and necessitating the final use of more drastic erosion-control methods. The use of geotextiles provides stability during the establishment phase of plants. Temporary stabilising fabrics, such as biofabrics, provide short-term stability during the establishment phase.

**Ecological recommendations to incorporate if strategy implemented**

- This option should be encouraged, where space on either side of the river, and the instream flow dynamics, permit.
- Planting should take place at the appropriate time of year. In the Western Cape, this period is usually late autumn, in order to catch the early light winter rains and allow establishment of species before the onset of heavier rains. This means that all activities, from the start of the construction phase, should be planned with this time constraint in mind.
✓ Planting should not take place during the hot dry summer months, unless provision can be made for adequate irrigation. All plants should be irrigated during at least the first summer after planting, and preferably over two summers.

✓ A planting plan, specifying type, number, location and required cover of species, should be produced prior to initiation of the programme. This should be developed with the assistance of a botanist, landscape architect or horticulturist. Species should be indigenous to the area, and preferably to the catchment. It is noted that there is often a vast discrepancy between a list of ecologically desired plant species, and those that are actually available through nurseries. Sufficient time should be allowed for sourcing of plants such that, if necessary, certain key species may be propagated specifically for the project in question.

✓ Plant species should be carefully chosen, with due consideration for their preferred habitat (e.g. marginal versus submerged species) and growth form (e.g. ground cover versus canopy species). Species requiring a constant water supply must be planted near the water’s edge.

✓ Planted areas must be regularly monitored during the establishment phase, and dead plants removed and replaced.

✓ Weeding during the establishment period should be a requirement of all planting programmes, particularly where planting is restricted, as disturbed and bare ground is vulnerable to establishment of weeds. Alien plant species should be removed before planting, and should be monitored and removed appropriately on appearance (see also River Maintenance Guidelines: CCT, 2002). Adequate establishment and cover of indigenous plants will reduce the likelihood of future invasion by unwanted species.

✓ Planting of rooted plants is often more successful than seeding, particularly where there is limited time for the establishment of plants. Seeding increases the likelihood of natural dispersal of a particular species within the area, for instance through spread of seed as a result of fluctuations in water level, but the viability of seeds is often not known until planted.

✓ Hydro-seeding can nevertheless be a viable back-up plan for planting, as it allows a greater potential species diversity, and better long-term cover. Where hydroseeding is used, seeds should be pre-tested for viability.
APPENDIX C

Equipment used for sediment and aquatic plant / reedbed management
### Table C1: Equipment used for sediment and aquatic plant / reedbed management

<table>
<thead>
<tr>
<th>Machine</th>
<th>Application</th>
<th>Environmental considerations with use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bobcat</td>
<td>Concrete canals only</td>
<td>• Points of access to waterbody must be such that they minimise disturbances to banks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ensure the vehicle is in good condition and no vehicle oil leaks occur. This applies to all machinery used in, or close to, an aquatic environment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Frequent use may result in loss of riparian vegetation.</td>
</tr>
<tr>
<td></td>
<td>Removal of material (silt, rubble) from rivers, small ponds, and silt traps.</td>
<td>• Steepening of river banks may occur.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Compaction of riverbanks may occur in areas frequently traversed by the excavator.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Points of access to waterbody must be such that they minimise disturbances to banks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ensure the vehicle is in good condition and no vehicle oil leaks occur. This applies to all machinery used in, or close to, an aquatic environment.</td>
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<td></td>
<td></td>
<td>• Steepening of river banks may occur.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Compaction of riverbanks may occur in areas frequently traversed by the excavator.</td>
</tr>
<tr>
<td></td>
<td>As above but used at larger waterbodies where longer reach is required.</td>
<td>As above</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Access to the site may result in vegetation loss.</td>
</tr>
<tr>
<td></td>
<td>Stockpile management and transferring stockpile to haulage vehicles.</td>
<td>• Movement of the loader in close proximity to river bank should be minimised so as to prevent soil compaction and vegetation loss.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Loading of stockpiles should not be undertaken during strong winds.</td>
</tr>
<tr>
<td>Drag lines</td>
<td>Removal of large volumes of material (silt, rubble, including vegetation) from the banks of large waterbodies were long reach distance is required.</td>
<td>• Compaction of banks and loss of riparian vegetation may occur in the vicinity of the machinery.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The depth of excavation to be planned and monitored to ensure over-excavation does not occur.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The stockpiling, and subsequent transfer of sediment to haul vehicles should be planned so as to minimise vehicle movement.</td>
</tr>
<tr>
<td>Reed cutter</td>
<td>The removal of aquatic reeds in deep water where vehicle access is not possible.</td>
<td>• The cut reeds or weeds may cause increased dispersal of weeds in the waterbody.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Damage to the bank of the waterbody may occur at the access points if these are not carefully maintained. The number of access points should be limited.</td>
</tr>
<tr>
<td>Weed harvester</td>
<td>The removal of aquatic weeds (typically submerged) in deep waters</td>
<td>• As above. If not operated correctly, the heavy duty cutters required for removing reeds may significantly disrupt the bed of the waterbody, and resuspend sediments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Harvested reed material that is stockpiled on banks should be removed timeously once dried to prevent rotting.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Due to their large size, the access points for the harvester should be few in number, and carefully selected, constructed and maintained so as to minimise riparian vegetation loss and erosion.</td>
</tr>
<tr>
<td></td>
<td>Shallow waterbodies, where large volumes of silt or aquatic vegetation is to be removed, or silt or vegetation is to be removal over large areas.</td>
<td>• Access routes to waterbodies to be planned so as to minimise vegetation loss.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Points of access to waterbody must be such that they minimise disturbances to banks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The depth of excavation to be planned and monitored to ensure over-excavation does not occur.</td>
</tr>
<tr>
<td>Bull dozer</td>
<td>Construction of access roads Opening of river mouths</td>
<td>• Where opening river mouths, dozer activities are to be limited to the river mouth area as far as possible so as to prevent potential damage to beach dune systems.</td>
</tr>
</tbody>
</table>
Bobcat operating in a concrete-lined canal. Canals have to have access ramp at one end for entry / exit. Efficient machine for collecting sediment or aquatic weeds to a single point where excavator on the bank can remove the material.

Excavator removing sediment from the depositional reach of a watercourse. Where this is done continuously along a reach, the impact is severe: loss of riparian vegetation, steepening of channel banks to facilitate access and destabilisation of channel substrata.

Long-boom excavator has greater reach, but similar considerations apply as for other excavator models. In High and Medium Importance systems restrictions around access for removal of vegetation or sediment thus apply.

Effects of traversing the margins of this depression are noticeable in compaction, loss of cover and uniformity of banks.

Front-end loader and haulage truck alongside a sediment stockpile. Stockpile areas may be “made good” prior to winter rains, but obviously have a dedicated function in systems where removal of sediment is annual or more frequent, as recovery of vegetation between uses cannot occur. This is the reason to limit stockpile number and specify location.

In High and Medium Importance systems, access / removal of reedbed and sediment by excavator should be restricted to approved localities. Other mechanisms for reed removal e.g. reed cutter on a raft should be considered in deep water.
Excavator working along a constructed “road” into a floodplain wetland. Where permanent, roads must be located so that they do not block the natural / present-day hydrological functioning of the wetland. Careful consideration to be given to access by haulage vehicles.

Aquatic weed harvester, used to control inter alia indigenous pondweed in waterbodies.

Mud-dozer pushing alien aquatic vegetation to a single collection point on the margin of the waterbody. Careful consideration of mechanical vs. manual methods for aquatic vegetation control should be applied in High and Medium Importance systems, dozing the full extent of the bottom surface has long-lasting impacts on ecosystem integrity.

Floating boom / berm to trap aquatic vegetation in an accessible area for removal.

Manual collection of aquatic vegetation to one location, to be removed by excavator, minimising bank disturbance.

Bulldozer opening stormwater outlet across the beach.
In many detention ponds of adequate size, dredging of bottom sediments is a far preferable approach to removal of muddy sediments by an excavator, as the latter will both damage the marginal vegetation and result in considerable stirring up of anoxic sediments into the water column, making these difficult to remove. The dried sediments can go to normal municipal landfill.
APPENDIX D

Illustrations of watercourse types

WATERCOURSE TYPES

Figure D1: Typical location of different wetland types within a catchment. Illustration from Ollis D., Snaddon K., Job N. and Mbona N., 2013. Classification System for Wetlands and other Aquatic Ecosystems in South Africa, User Manual: Inland Systems. SANBI Biodiversity Series.

Continued on next page...
APPENDIX E

List of Nature Reserves in CCT jurisdiction
City of Cape Town Nature Reserves

Cape Town is a remarkable city – an urban centre of international importance, right in the middle of one of the world’s biodiversity hotspots. A visit to the City’s nature reserves will take you through a diverse network of spectacular flora and fauna.

South Area

False Bay Nature Reserve (FBNR)
— Rondevlei Section - FBNR
Tel: 021 706 2404  Fax: 021 706 2405
E-mail: RondevleiNatureReserve@capetown.gov.za
Cnr Perth Road and Fisherman’s Walk, Grassy Park/Zeekoevlei
— Zeekoevlei and Strandfontein Sections - FBNR
Tel: 021 396 4281  Fax: 021 396 4291
E-mail: ZeekoevleiNature.Reserve@capetown.gov.za / Strandfontein.BirdingArea@capetown.gov.za
Zeekoevlei Road, Pelican Park

Zandvlei Estuary Nature Reserve
Tel: 021 701 7542  Fax: 021 701 7542
E-mail: Zandvlei.Nature.Reserve@capetown.gov.za
Coniston Avenue, Marina Da Gama, Steenberg

Edith Stephens Nature Reserve
Tel: 021 691 8070  Fax: 021 691 7375
E-mail: Luzann.Isaacs@capetown.gov.za
Lansdowne Road, Philippi (off Vanguard Drive)

East Area

Helderberg Nature Reserve
Tel: 021 851 6982  Fax: 021 851 2148
E-mail: HelderbergNature.Reserve@capetown.gov.za
Verster Avenue, Somerset West

Steenbras Nature Reserve
E-mail: Steenbras.NatureReserve@capetown.gov.za
Faure Marine Drive (R44), about 9 km from Gordon’s Bay

Harmony Flats Nature Reserve
E-mail: HarmonyFlats.NatureReserve@capetown.gov.za
11th Avenue, Strand

Wolfgat Nature Reserve
Tel: 021 392 5134/5  Fax: 021 392 8878
E-mail: Wolfgat.NatureReserve@capetown.gov.za
Baden Powell Drive, Mitchell’s Plain

www.capetown.gov.za/naturereserves

Central Area

Tygerberg Nature Reserve
Tel: 021 913 5695  Fax: 021 913 6268
E-mail: Tygerberg.NatureReserve@capetown.gov.za
Main entrance: Totius Road, Welgevonden
Secondary gate: Meyboom Avenue, Plattekloof

Bothasig Fynbos Nature Reserve
Tel: 021 913 5695  Fax: 021 913 6268
E-mail: Tygerberg.NatureReserve@capetown.gov.za
Border of Visserhof, Bosmansdam and Potsdam Roads, Bothasig

Bracken Nature Reserve
Tel: 021 444 0380  Fax: 086 563 6476
E-mail: Bracken.NatureReserve@capetown.gov.za
2 Reservoir Road, Brackenfell

Durbanville Nature Reserve
Tel: 021 979 0060  Fax: 021 979 0093
E-mail: Durbanville.NatureReserve@capetown.gov.za
Racecourse Road, Durbanville

Uitkamp Wetland Nature Reserve
Tel: 021 979 0060  Fax: 021 979 0093
E-mail: Uitkamp.Wetland@capetown.gov.za
Mosselbank Road, Durbanville

Botterblom Nature Reserve
Tel: 021 979 0060  Fax: 021 979 0093
E-mail: Durbanville.NatureReserve@capetown.gov.za
Botterblom Road, Vierlanden, Durbanville

North Area

Table Bay Nature Reserve
Tel: 021 444 0315  Fax: 021 444 7226
E-mail: TableBay.NatureReserve@capetown.gov.za
Grey Avenue, Table View (Rietvlei Section)

Blaauwberg Nature Reserve
Tel: 021 444 7318 / 19 / 20  Fax: 021 554 8156
E-mail: Blaaauwberg.NatureReserve@capetown.gov.za
Eerste Steen Resort, Otto du Plessis Drive (M14), Bloubergstrand

Witzands Aquifer Nature Reserve
Tel: 021 444 7687  Fax: 086 628 4872
E-mail: Witzands.NatureReserve@capetown.gov.za
Cnr West Coast Rd (R27) and Dassenberg Drive (R307), near Atlantis
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(b) By release of the report to the Third Party, that Third Party does not acquire any rights, contractual or otherwise, whatsoever against GIBB and GIBB, accordingly, assume no duties, liabilities or obligations to that Third Party; and
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