**Synopsis:** This is WBM’s report developed for the City of Port Phillip to assess water quality and identify structural stormwater treatments for the Elster Creek catchment.
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GLOSSARY OF TERMS

As – arsenic
Baseflow – the underlying flow rate that cannot be directly attributed to storm events.
Cd- cadmium
Cond (Conductivity) - or specific conductance, an indirect measure of charge particles (electrolytes) in water. Conductivity is used as an estimate of salinity.
Cr- chromium
Cu- copper
DO – dissolved oxygen
DOM – dissolved organic matter
E. coli- Eschericha coli as an indicator of untreated sewage contamination
First Flush - the condition, often occurring in stormwater discharges, in which an unusually high pollution load is carried in the first portion of the discharge.
Flow- stream discharge (usually expressed in megalitres per day)
Gauge- location on a stream or waterway where stream height or flow are recorded
GPT – gross pollutant trap
Impervious Area - impermeable surfaces, such as pavement or rooftops, which prevent the infiltration of water into the soil.
Infiltration - the seepage of stormwater runoff through the soil and subsoil, eventually passing to groundwater.
Infiltration Basin - a basin that retains stormwater and allows for infiltration into the subsoil.
Infiltration Trench - an excavation, filled with gravel or other media, used to dispose of stormwater by infiltration.
MUSIC – Model for Urban Stormwater Improvement Conceptualisation
NH3-N- ammonia expressed as mg/L equivalent to nitrogen
Ni- nickel
NO2-N – nitrite expressed as mg/L equivalent to nitrogen
NO3-N – nitrate expressed as mg/L equivalent to nitrogen
NOX-N  – nitrate and nitrite expressed as mg/L equivalent to nitrogen
O-P – filterable reactive phosphorus
Org N- organic nitrogen
Pb- lead
pH – the hydrogen ion concentration. Acidic solutions have a pH < 7, basic solutions have a pH > 7.
%SatDO – dissolved oxygen as percentage saturation
Surcharge - the flow condition occurring in closed pipes, tanks or pits when the flow is pressurised or the hydraulic grade line is above the top of the pipe, tank or pit.
Stormwater - water resulting from precipitation, which either infiltrates into the soil, runs off freely from the surface, or is captured by drainage systems.
SS - suspended solids. This consists of fine material in stormwater and waterways and includes sediment (clay and silt), living organisms and particulate organic matter.
Temp- temperature
Time of Concentration – the period of time between the first rainfall and the observance of the hydrograph peak of the catchment outflow.

TKN- total kjeldahl nitrogen (includes organic nitrogen and NH3)

TN – total nitrogen (Sum of TKN+NO₃+NO₂)

TP – total phosphorus

TSS – total suspended solids

Turb – turbidity expressed as nephelometric turbidity units (NTU)

Urban Runoff - surface runoff from an urban drainage area that reaches a stream or other body of water.

Water quality – a general term describing the suitability of water for a given use (e.g., human drinking, aesthetics, stock water, etc.)

Zn- zinc
EXECUTIVE SUMMARY

Background

This report presents the results of an investigation into structural opportunities to treat stormwater in the Elster Creek catchment. The primary objective of the Elster Creek Catchment Study (ECCS) is to provide guidance to allow improvement of water quality in the Elster Creek and Elwood Canal through the recommendation of appropriate structural stormwater treatments within the Elster Creek catchment.

Structural Treatment Assessment

Structural treatments with potential for application in the Elster Creek catchment were short-listed for assessment against a set of criteria. Estimates were undertaken of the ability of a variety of structural treatments to cost effectively reduce loads of nutrients (nitrogen and phosphorus), sediments and gross pollutants such as litter and leaf debris. This required some pollutant export modelling to be undertaken. The study also identified how the implementation of potential planning control requirements for future development will improve stormwater in the study area for 10 and 25 years through pollutant export modelling. Stream rehabilitation in sections of the Elster Creek was also considered, but was not assessed for its stormwater treatment benefits. However, it was assumed that there would be some stormwater treatment capability associated with rehabilitation of lower sections of the Elster Creek and Elwood Canal.

Results

Structural treatments recommended for treating urban stormwater runoff in the Elster Creek catchment area as follows:

- Streetscape bioretention in residential areas within each municipality where feasible as street upgrades occur.
- Gully-pit baskets in identified commercial hot spots, which include:
  - Within City of Glen Eira – Elsternwick, Caulfield North, Caulfield South, Glenhuntly, Carnegie, Ormond, McKinnon, Bentleigh, Centre Road (East Bentleigh) shopping strips and Moorabbin Shopping Centre.
  - Within City of Port Phillip- Glen Eira Road and Ormond Road shopping strips.
- One site-specific bioretention system at Princes Park within the City of Glen Eira, given that further design warrants it feasible.
- Treatment train of bioretention system at Mallanbool Reserve draining to wetland upgrade at Packer Park within the City of Glen Eira, given that detailed design warrants it feasible.
- Seven gross pollutant traps located in specific locations in the Elster Creek catchment, two would be the responsibility of the City of Port Phillip, one for City of Glen Eira and four for Melbourne Water.

Locations of bioretention systems within the two parks are presented below. These stormwater treatments are likely to be implemented in the longer term, given that Master Plans and works have recently been completed at both parks.
Estimated Pollutant Load Removal

The estimated removal rate of sediments loads is approximately 5.6% if the park location structural treatments opportunities considered potentially feasible were implemented. Approximately the same reduction again could be achieved with the construction of seven gross pollutant traps at specific locations in the catchment. In addition, it was identified that further reductions of approximately 11% (streetscape bioretention) and 17% (gully pit baskets) could be achieved if either treatment was implemented in 20% of the catchment. In practice, site constraints, poor design and maintenance may reduce the performance of the structural treatment measures. The implementation of new planning controls on all new developments may achieve significant reductions of approximately 10.3% in catchment loads over the next 10 years. As development proceeds over the next 25 years even greater gains of approximately 14.3% could be achieved with the implementation of the planning controls. Without such planning controls, pollutant loads will increase in the future.

Cost Analysis

Life-cycle costs analysis found that an equivalent annual payment of approximately $164,138 would be necessary to implement the site-specific structural treatments (including treatment trains, bioretention basins, stream rehabilitation and gross pollutant traps). The equivalent annual payment of implementing streetscape bioretention and gully pit baskets or GPTs in 20% of the catchment over the next 20 years is approximately $338,239 and $792,977 or $292,981 respectively. A cost comparison table is presented below.

Cost comparison table

<table>
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<tr>
<th>Element Types</th>
<th>Location</th>
<th>Lifetime</th>
<th>Construction Cost</th>
<th>Annual Maintenance Cost</th>
<th>Total Construction and Maintenance Cost adjusted for inflation and discount at 10% per annum over life time</th>
<th>Annual Equivalent Cost Over 50 Years</th>
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<td>Bioretention Basin (100m x 20 m)</td>
<td>Princes Park</td>
<td>20</td>
<td>$99,050</td>
<td>$6,933</td>
<td>$176,813</td>
<td>$8,841</td>
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<td>Bioretention system (150m x 3m), Wetland (500m2), Swales</td>
<td>Packer Park</td>
<td>20</td>
<td>$395,250</td>
<td>$8,918</td>
<td>$495,271</td>
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<td>Streetscape Bioretention System (1m x 8421m)</td>
<td>20% of catchment</td>
<td>20</td>
<td>$4,168,445</td>
<td>$291,791</td>
<td>$6,764,779</td>
<td>$338,239</td>
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<tr>
<td>GPT 1</td>
<td>Along Koorang Rd (corner of Koorang Park)</td>
<td>20</td>
<td>$215,058</td>
<td>$21,506</td>
<td>$456,273</td>
<td>$22,814</td>
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<td>GPT 2</td>
<td>Between 31 and 33 Almond St</td>
<td>20</td>
<td>$225,658</td>
<td>$22,566</td>
<td>$478,762</td>
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<td>GPT 4</td>
<td>Opposite 425 Kooyong Road</td>
<td>20</td>
<td>$173,944</td>
<td>$17,394</td>
<td>$369,045</td>
<td>$18,452</td>
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<td>GPT 3</td>
<td>Corner of Yanakie St and Garrell St</td>
<td>20</td>
<td>$150,641</td>
<td>$15,064</td>
<td>$319,605</td>
<td>$15,980</td>
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<td>GPT 7</td>
<td>Corner of Glenhuntly Road and Brighton Road</td>
<td>20</td>
<td>$107,981</td>
<td>$10,798</td>
<td>$229,095</td>
<td>$11,456</td>
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<td>GPTs in 20% of catchment</td>
<td>20% of catchment</td>
<td>20</td>
<td>$2,761,849</td>
<td>$276,185</td>
<td>$5,859,613</td>
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<td>GPT 6</td>
<td>Corner of Foam Street and Ormond Rd</td>
<td>20</td>
<td>$56,449</td>
<td>$5,645</td>
<td>$119,763</td>
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<td>Streetscape Gully Pit Baskets</td>
<td>20% of catchment</td>
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<td>$2,400,000</td>
<td>$1,200,000</td>
<td>$15,859,544</td>
<td>$792,977</td>
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<td>GPT 5</td>
<td>Corner of Beach Avenue and Wave Street</td>
<td>20</td>
<td>$57,950</td>
<td>$5,795</td>
<td>$122,948</td>
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<td>Swale/Stream Habitat Enhancement (450m x 6m)</td>
<td>Golf Course Catchment</td>
<td>50</td>
<td>$324,000</td>
<td>$6,750</td>
<td>$399,710</td>
<td>$7,994</td>
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<td>Stream Enhancement (1000m x 6m)</td>
<td>Upstream of Drain Diversion</td>
<td>50</td>
<td>$720,000</td>
<td>$15,000</td>
<td>$888,244</td>
<td>$17,765</td>
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Recommendations

- It is recommended that the Working Group continue to meet to discuss the implementation of the structural treatments on a regular basis to ensure continued involvement of each organisation and their ongoing commitment to the implementation of recommended structural treatments.

- It is recommended that the first activity for the Working Group should be to utilise the structural ranking table (Table 6-1) and Figures 6-1 to 6-7 provided in this report to guide prioritisation of implementation planning. Implementation of priority structural treatments should be a medium to long-term goal and implementation should occur through a scheduled program, with flexibility to accommodate opportunistic projects (as an example road upgrades or new developments).

- Site-specific structural opportunities at the park level offer many challenges in terms of their feasibility. It is therefore recommended that WSUD principles be integrated into each Council’s operations (such as street upgrades) and management framework.

- The most viable form of structural treatment for reducing nutrients and heavy metals is streetscape bioretention. The implementation of streetscape bioretention has the potential to significantly reduce pollutant loads, however with only a small number of street upgrades occurring per year, implementation through these means would be considered long term. To achieve significant reductions sooner, it is recommended that designs of the site-specific structural treatments be advanced in order of priority over the near to medium term, to identify those to construct. The detailed design phase may require revision of designs and forecast expenditure depending on how well these recommended treatments could be integrated within each specific site.

- It is recommended that costs and pollutant removal efficiencies be monitored as a part of the implementation of structural measures. This will enable implementation to be evaluated and refined using the principle of ‘adaptive environmental management’, reflecting the outcomes of monitoring and in accordance with each organisations’ budget planning activities.

- It is recommended that a proactive approach to stormwater management be adopted to minimise the impacts of new and in-fill developments. Long-term stormwater quality improvements can be assured through changes to the planning and design requirements to implement new and improved stormwater management methods. It is recommended that WSUD be included as part of Councils’ planning documentation frameworks to encourage developers to address stormwater quality management issues as part of the development design process. It is recommended that Councils engage in implementing WSUD through their planning schemes and that the planning controls examined in this report should be adopted for new developments located throughout the Elster Creek catchment.

- The catchment is predominantly residential. It is recommended that a multi-faceted approach be adopted to effectively manage stormwater in the Elster Creek catchment by utilising non-structural stormwater management tools such as education, planning, regulation and enforcement in addition to the stormwater treatments recommended. For example, it is recommended that Councils consider planning and enforcement options to control sediment from building sites in addition to treatment measures. In addition, education and enforcement may be a better alternative to manage some pollutants such as E.coli and pathogens, which are commonly derived from illegal connections, animal droppings or sewer leakages. These stormwater management tools also have the potential to offer an improved benefit to cost ratio.

- Instream habitat improvement in the lower reaches of the Elster Creek and Elwood Canal should occur in conjunction with improvements in stormwater treatment in the catchment. It is recommended that further investigation be undertaken by Melbourne Water to demonstrate if stream restoration is warranted based on whether it improves instream biotic communities and stream health.
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1 INTRODUCTION

The City of Port Phillip, in conjunction with the municipalities of Glen Eira and Bayside, has embarked on a process to investigate structural opportunities to treat stormwater in the Elster Creek catchment. WBM was appointed to perform the study with assistance and input from key stakeholders who were involved in the management of urban stormwater in the catchment.

The Elster Creek Study provides recommendations for structural treatments to improve stormwater in the catchment. In this regard, the study is intended to provide the basis for an ongoing process that is aimed at improving the environmental values associated with Elster Creek that are currently threatened by poor stormwater runoff quality.

The report provides detailed information on:

- The approach adopted to undertake the study;
- Examination of current water quality in the Elster Creek catchment;
- Recommendations for structural treatment measures in the Elster Creek catchment; and
- Examination of the improvement to water quality in the Elster Creek catchment with the adoption of new planning controls in new developments.

1.1 Stormwater Management in the Elster Creek catchment

Modification of the natural characteristics of the Elster Creek catchment, through processes such as land use change and development, has had a significant impact on the nature of stormwater runoff. The Elster Creek catchment’s stormwater system is composed of modified waterways, constructed drains, lakes and retarding basins. The system has been developed to minimise the threat of flooding. This urbanisation has resulted in the creation of large areas of impermeable surfaces, consisting of roads, car parks, shopping strips and roof areas. Traditional drainage design focussed on the efficient conveyance of stormwater from where it could pose a risk to life or property. This has resulted in significant changes to the catchment hydrology, with reduced times of concentration and greater frequency of discharge and increased flows as a result of storm events.

In particular, the process of urbanisation typically causes increased runoff volumes and pollutant loads and mobilisation and transport and the introduction of anthropogenic contaminants. These pollutants become entrained with stormwater runoff and are efficiently delivered to the receiving environment. Their accumulation within the receiving environment can result in severe and often irreversible impacts, which ultimately affect the quality of life enjoyed by the community.

Stormwater management is concerned with the development and implementation of a range of strategies to minimise the impacts of stormwater pollution and to protect the values of the receiving environment. These strategies can include a range of site-specific structural and non-structural measures as well as plans, policies and procedures aimed at managing activities that could potentially result in stormwater pollution.

Stormwater management within the Elster Creek catchment should consist of a multi-faceted approach. This project should be seen as one tool (on-ground implementation) from a larger set that can be used to manage the improvement of stormwater quality within the catchment. It is a tool that should be supported by the other management options available to Councils.
These tools can be summarised into a number of basic categories, which all contribute to stormwater quality improvements (refer to Figure 1-1 below).

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<th>On-ground implementation</th>
<th>Education</th>
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<td>• WSUD in new and in-fill developments</td>
<td>• Community Awareness</td>
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<td>• Local Laws</td>
<td>• Retrofitting</td>
<td>• Target hot-spots</td>
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<td>• Procedures</td>
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<td>• Schools Education</td>
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<td>• Contractual Requirements</td>
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<td>• Council Contractors and Staff</td>
</tr>
<tr>
<td>• Enforcement</td>
<td></td>
<td>• Reward success</td>
</tr>
</tbody>
</table>

**Figure 1-1** Stormwater improvement tools summarised into basic categories

Each of the above categories plays a role in the potential improvements that can be achieved by Councils. Each tool, on its own, is not as effective as in combination with others. In reading this report and applying its outcomes, the reader is encouraged to consider how to enhance the value that can be gained from the stormwater treatment options that are recommended by utilising some of the other tools.

For example, implementation of bio-retention systems within public areas such as parks and streetscapes will be an opportunity to educate the public about the Council’s commitment to the environment and also to inform relevant Council officers about maintenance issues and ultimate goals of the treatment measure. Councils may also identify a need to review how stormwater management in in-fill developments can be addressed via the planning process, thus further reducing the environmental impact of urbanisation within the catchment.

The environmental impact of development and of polluted stormwater runoff on waterways within the Elster Creek catchment has previously been addressed through the development of Stormwater Management Plans for the municipalities of Bayside and Port Phillip and also in the Port Phillip Coastal Marine Planning Program Stormwater Implementation Project: Statutory Framework and Standards. The scope of these strategies did not consider or assess specific opportunities for structural treatments and the water quality outcomes of adopting water sensitive urban design.

This study is concerned with:

- Assessing site-specific structural measures within the Elster Creek catchment such as physical works to treat stormwater runoff to remove pollutants; and
- Assessing proposed Association of Bayside Municipalities planning controls to achieve pollutant reductions through the implementation of water sensitive urban design in new developments.
1.2 **Study Objectives**

The primary objective of the Elster Creek study is to provide guidance to allow the improvement of water quality in Elster Creek and Elwood Canal through the identification of structural stormwater treatment opportunities throughout the catchment.

To achieve the overall objective of the study, a number of specific study objectives have been adopted that also reflect the approach to the study and its proposed application.

These objectives include:
- Identification of subcatchments discharging to Elster Creek and Elwood Canal and key stormwater issues;
- Assessment of pollutant types, loads and distribution at a subcatchment scale;
- Identification of water quality issues in the Elster Creek catchment; and
- Identification of abatement solutions and options for stormwater treatment in the Elster Creek catchment.

1.3 **Study Process**

The approach that has been adopted in performing the study, is based on five separate study phases:

- Preliminary activities;
- Assessment of pollutant types and loads;
- Water quality issues assessment;
- Assessment of treatment train solutions and options; and
- Reporting.

This process is concerned primarily with defining existing stormwater and water quality issues in the Elster Creek catchment and identifying suitable structural treatments that respond to these issues. As part of this study an investigation will be conducted into the pollutant reductions that may be achieved through the implementation of new planning controls on future residential developments in the Elster Creek catchment. Figure 1-2 provides a schematic representation of the process adopted by the study. A more detailed discussion of the specific approaches adopted in undertaking key components is provided in the relevant sections of the report.

---

**Figure 1-2 Study process**
1.4 Stakeholder Consultation and Involvement

A key feature of the study process was the involvement of stakeholders as part of regular meetings and information sessions at key stages throughout the study. These stakeholders participated in a Working Group that met on five occasions with WBM during the study. The Working Group was made up of Council Officers from each of the participating Councils and a representative from Melbourne Water.

Stakeholder involvement and commitment as part of the study’s development was critical to its ultimate ability to achieve the proposed objectives. In this regard, the Working Group played a critical role in:

- Subcatchment breakdown approach;
- Identification of key stormwater issues in the catchment; and
- Identification of structural treatment opportunities.

Working Group Meetings typically lasted between two and three hours. Meetings generally commenced with a presentation by the study team outlining relevant information that would form the basis for the meeting, followed by open discussion between the group regarding the particular issues being considered during each phase of the study.

Brief discussion papers were distributed to all Project Working Group members approximately one week prior to each meeting. These discussion papers and presentations are provided on a CD Rom inside the back cover of this report. Table 1-1 provides an overview of each meeting.

<table>
<thead>
<tr>
<th>Meeting</th>
<th>Key Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Study initiation to discuss methodology, timing and approach.</td>
</tr>
<tr>
<td>2</td>
<td>To discuss stormwater issues in catchment, sub catchment breakdown, field inspection planning.</td>
</tr>
<tr>
<td>Field Inspection</td>
<td>To identify stormwater issues and treatment opportunities.</td>
</tr>
<tr>
<td>3</td>
<td>Presentation of MUSIC modelling approach, confirmation of key water quality issues, location of treatment trains and identification of treatment opportunities.</td>
</tr>
<tr>
<td>4</td>
<td>Evaluation of structural treatment trains.</td>
</tr>
<tr>
<td></td>
<td>Confirmation of development scenarios in sub catchments for modelling Association of Bayside Municipalities stormwater retention targets for new developments.</td>
</tr>
<tr>
<td>5</td>
<td>Discussion of draft report.</td>
</tr>
<tr>
<td>6</td>
<td>Presentation of final report.</td>
</tr>
</tbody>
</table>
2 THE ELSTER CREEK CATCHMENT

2.1 Study Area Location

The Elster Creek catchment occupies an area of 4,010 ha and is located approximately 8 km south-east of the Melbourne CBD. Figure 2-1 shows the Elster Creek catchment, which is represented by three municipalities: Bayside, Glen Eira and Port Phillip. The catchment is highly urbanised and comprised of predominantly well-established residential land. The catchment also supports a small proportion of commercial and industrial land uses. Figure 2-2 shows the distribution of land uses throughout the Elster Creek catchment.

The Elster Creek catchment contains a number of major roads including the Nepean Highway, North Road, Centre Road, Glen Huntly Road and Hawthorn Road (some of which have trams lines) and also two rail lines for metropolitan transport.

The Elster Creek catchment drains to Port Phillip Bay. A report on the water quality in Port Phillip Bay has played a significant part in providing the momentum and urgency for changes and improvements in the management of urban stormwater runoff. The Port Phillip Bay Environmental Study (Harris, et al, 1996) involved field studies, laboratory analyses and computer modelling to identify the key issues impacting the long-term health and viability of the Bay. The report ultimately set a target for the reduction of pollutant loads that entered the Bay from Melbourne’s urban catchments such as Elster Creek. The report recommended that wherever possible, total suspended solids and nitrogen loads from urban stormwater to the Bay should be reduced and that strategies to reduce nitrogen loads to the Bay should be given the highest priority to maintain the Bay’s long-term health (Harris, et al 1996). Supporting this study were numerous environmental studies, which found that some of the main areas of poor environmental quality in Victoria’s waterways correspond with urban stormwater inputs from drains, creeks and rivers (EPA 2003). As such, improving stormwater quality in the Elster Creek catchment will assist in ultimately protecting the long-term health of Port Phillip Bay.

Figure 2-1 Study location
Figure 2-2  Existing land use distribution
2.2 Existing Structural Management Devices

There are five existing gross pollutant traps (GPTs) located within the Elster Creek catchment (Figure 2-5). Two of these are located in Bayside City Council and three are located within the Glen Eira City Council. Details of each of these GPTs are presented in Table 2-1. In addition to GPTs, there are 284 litter baskets located within Bayside City Council of which, an estimated 86 are located within the Elster Creek catchment. Melbourne Water also has a floating debris boom located within the lower reaches of the Elwood Canal.

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
<th>Municipality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kokaribb Rd, Carnegie</td>
<td>600 mm pipe, drains commercial area, functions poorly</td>
<td>Glen Eira City Council</td>
</tr>
<tr>
<td>Mitchell St, Bentleigh Shopping Centre</td>
<td>450 mm pipe, drains commercial area, contemporary design</td>
<td>Glen Eira City Council</td>
</tr>
<tr>
<td>Bendigo Avenue, Bentleigh Shopping Centre</td>
<td>450 mm pipe, drains commercial area, functions poorly</td>
<td>Glen Eira City Council</td>
</tr>
<tr>
<td>New Street, Elsternwick Golf Course</td>
<td>Ecosol GPT, drains residential area</td>
<td>Bayside City Council</td>
</tr>
<tr>
<td>Clonaig Street, Elwood</td>
<td>675 mm pipe, drains residential area, CDS GPT</td>
<td>Bayside City Council</td>
</tr>
</tbody>
</table>

The City of Bayside’s litter baskets are cleaned at least every two months. Their gross pollutant traps are inspected for operational capacity on a monthly basis and serviced and cleaned at least every three months. The Ecosol GPT near the Elsternwick Golf Course has been recorded on two separate occasions (November 2003 and September 2003) to have 0.5 m³ of material removed. On both occasions most of the material comprised vegetation (50% and 80%) with sediment also representing a large proportion (40% and 15%) with litter being identified as the remaining constituent (10% and 5%).

Apart from this information, there is very limited monitoring data available to assess each of these GPTs’ performance. Apart from the City of Bayside’s GPTs, which undergo regular maintenance, it is unlikely that the performance of GPTs that are currently located in the Elster Creek catchment is optimal as clean outs are generally irregular and occur less often than every three months (which is what is commonly recommended).

GPT’s that are not cleaned out at regular intervals have the potential to pose a greater risk to receiving environments because they have been known to convert pollutants to forms that are more readily bioavailable. Figure 2-3 and Figure 2-4 present two different types of GPTs within Bentleigh Shopping Centre, which have very similar catchment sizes and have not been cleaned for some time. Based on a visual inspection, it appears that the Mitchell Street GPT’s performance is much better than Bendigo Avenue GPT.

It is recommended that all existing and future litter baskets and gross pollutant traps be regularly inspected and cleaned three monthly unless monitoring indicates a different cleaning frequency.
2.3 Stormwater Management Roles, Responsibilities and Jurisdictions

The responsibility for waterway and water infrastructure within the Elster Creek catchment is shared amongst four municipalities (Port Phillip, Glen Eira, Bayside and Kingston) and Melbourne Water. Melbourne Water is responsible for regional drainage infrastructure within the Elster Creek catchment, while each Council is responsible for its local drainage infrastructure. Figure 2-5 indicates the location of drains and waterways within the catchment and which of these falls under regional or municipal responsibility. Figure 2-6 shows municipal boundaries.
Figure 2-5  Existing drainage and current structural treatments
Figure 2-6  Drainage system and management responsibility within the Elster Creek Catchment
3 APPROACH TO ASSESSING STRUCTURAL TREATMENTS

The approach undertaken to identify and assess the opportunities for the location of treatment measures in the Elster Creek catchment follow the initial steps in the Water Sensitive Urban Design (WSUD) process. As part of this investigation, the Study Team identified potential locations where stormwater treatment measures could be implemented. In addition, types of treatments were also identified that would result in the maximum benefit to the overall network of treatments proposed for the Elster Creek catchment. This stage of the study provides the basis for the next steps of the WSUD process, where the treatment opportunities can be conceptually designed. The assessment of structural treatments took into account specific catchment areas, runoff volumes, and pollutant loads for each individual location. Pollutant export modelling can then be used to model the treatment measure, and an assessment made of the effectiveness of this measure as based on the site-specific opportunities and constraints.

The detailed design stage of WSUD allows for advancement of the structural treatment assessment to a stage where detailed plans can be developed for integration with the existing stormwater infrastructure. The detailed design of structural treatments is not a component of this report. Approximations of expenditure for stormwater treatment measures form part of all three stages of WSUD (investigative, conceptual and detailed design). Chapter 6 of this report deals in more detail with the costing of proposed WSUD measures. The following section describes the process undertaken to identify the potential locations and treatment options for stormwater treatment within the Elster Creek catchment.

3.1 Treatment Opportunity Identification

When determining the location for stormwater treatment measures, many factors must be considered. Given the size of the catchment, large-scale treatment near the end of the catchment is not practical because in this area of the Elster Creek catchment limited space is available for the treatment structures needed to effectively treat stormwater runoff. In addition, the aim of the structural treatments is to improve water quality entering and within Elster Creek not just at the point where the Elwood Canal meets the Bay. Consequently, a number of smaller measures were considered throughout the catchment using a distributed or ‘treatment train’ approach. This also has the benefit of reducing the land area required for effective treatment and positioning the measures closer to the source of pollution.

Locating treatment opportunities using a treatment train approach has a number of other advantages, which include

- Improved protection – water quality protection may be distributed along a greater length of Elster Creek;
- Localised treatment – specific targeting of treatments may be directed at highly polluted sites;
- Distributed risk – the treatment train approach has a lower risk of overall system failure, as the failure of any single treatment will not usually impact significantly on the total treatment system performance;
- Improved removal efficiencies – distributed treatments are typically located in areas of lower flow. Lower flow velocities, volumes and higher pollutant concentrations in the stormwater at these sites, leads to higher operating efficiencies; and
- Staged implementation – individual sites may be brought into operation in stages allowing for the prioritisation of costs.

Using this distributed approach, a number of structural treatment opportunities were identified as potentially suitable based on size of open space areas and do not include areas within sports fields. Figure 3-1 shows the location of each of these structural opportunities and the type of treatment considered such as wetlands, channel infiltration and bioretention systems. For comparative purposes, GPTs were also examined as alternatives at many of these sites. Table 3-1 provides each treatment location, type, catchment size, available treatment area, description and responsibility. Appendix E provides photographs of each location specific opportunity. Section 5.3 further examines the feasibility of these structures.
In addition, a number of opportunities that have the potential to be implemented on a broader scale across the catchment were considered. These included streetscape bioretention, mesh gutter/gully pit traps and GPTs. In all cases, the implementation of these in 20% of the entire catchment (across approximately 800 ha) were used to assess their treatment capabilities.

Details of the different types of treatments examined and recommended are provided in Appendix D.

3.2 Subcatchment Breakdown

For the purposes of this study, the Elster Creek catchment was separated into a series of subcatchments. The breakdown of subcatchments was based on:

- Defining the areas above identified locations with treatment opportunities in addition to the location of key drainage points to the Elster Creek and Elwood Canal;
- The creek as a catchment boundary;
- Local drainage networks; and
- The exclusion of the coastal fringe, which drains directly to the Bay (Figure 3-2).
Figure 3-1 Spatially specific water sensitive urban design treatment opportunities.

Note: locations for gross pollutant traps reported elsewhere.
### Table 3-1 Spatially specific structural treatment opportunities

<table>
<thead>
<tr>
<th>Location</th>
<th>Treatment Type</th>
<th>Area Treated (ha)</th>
<th>Area Available (ha)</th>
<th>Heritage Overlay (Yes or No)</th>
<th>Description/Comment</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caulfield Park</td>
<td>Bioretention System</td>
<td>139.8</td>
<td>0.30</td>
<td>Yes (Western Segment)</td>
<td>Sand filter to preserve heritage values as an alternative to a bioretention basin. Would require surcharge to the surface.</td>
<td>Glen Eira City Council/ Melbourne Water</td>
</tr>
<tr>
<td>Greenmeadow Gardens</td>
<td>Bioretention System</td>
<td>14.6</td>
<td>0.28</td>
<td>Yes</td>
<td>Sand filter to preserve heritage values as an alternative to a bioretention basin. Would require surcharge to the surface.</td>
<td>Glen Eira City Council</td>
</tr>
<tr>
<td>Golf Course Catchment</td>
<td>Stream Restoration</td>
<td>3218.1</td>
<td>450 m rehab</td>
<td>No</td>
<td>Stream rehabilitation would be aimed at improving stream health not to treat urban stormwater.</td>
<td>Melbourne Water</td>
</tr>
<tr>
<td>Upstream of Drain Diversion</td>
<td>Stream Restoration</td>
<td>3116.7</td>
<td>1000 m rehab</td>
<td>No</td>
<td>Stream rehabilitation would be aimed at improving stream health not to treat urban stormwater.</td>
<td>Melbourne Water</td>
</tr>
<tr>
<td>Victory Reserve</td>
<td>Bioretention System</td>
<td>54.8</td>
<td>0.10</td>
<td>No</td>
<td>Would require upwelling* of water to surface from drainpipe (2400mm) into treatment. Limited space available.</td>
<td>Glen Eira City Council/ Melbourne Water</td>
</tr>
<tr>
<td>Allnutt Park</td>
<td>Bioretention System</td>
<td>1359.2</td>
<td>1.00</td>
<td>No</td>
<td>Requires upwelling of water to surface from large (2550mm) drainpipe into treatment, which may limit its feasibility.</td>
<td>Glen Eira City Council/ Melbourne Water</td>
</tr>
<tr>
<td>Bentleigh-Hodgson Reserve</td>
<td>Bioretention System</td>
<td>88.0</td>
<td>0.20</td>
<td>No</td>
<td>Would require upwelling* of water to surface from drainpipe (1350mm) into treatment. Limited space available.</td>
<td>Glen Eira City Council/ Melbourne Water</td>
</tr>
<tr>
<td>Halley Park</td>
<td>Bioretention System</td>
<td>553.2</td>
<td>0.10</td>
<td>No</td>
<td>Would require upwelling* of water to surface from drainpipe (2325mm) into treatment. Limited space available.</td>
<td>Glen Eira City Council/ Melbourne Water</td>
</tr>
<tr>
<td>Joyce Park</td>
<td>Bioretention System</td>
<td>181.7</td>
<td>0.10</td>
<td>No</td>
<td>Would require upwelling* of water to surface from drainpipe (1350mm) into treatment. Limited space available.</td>
<td>Glen Eira City Council/ Melbourne Water</td>
</tr>
<tr>
<td>Duncan McKinnon Reserve</td>
<td>Bioretention System</td>
<td>147.2</td>
<td>0.42</td>
<td>No</td>
<td>Would require upwelling* of water to surface from drainpipe (1875mm) into treatment.</td>
<td>Glen Eira City Council/ Melbourne Water</td>
</tr>
<tr>
<td>Packer Park &amp; Mallanbool Reserve</td>
<td>Treatment train</td>
<td>316.2</td>
<td>0.50</td>
<td>No</td>
<td>Bioretention system through Mallanbool Reserve, for approximately 150m, followed by wetland and swale system in Packer Park.</td>
<td>Glen Eira City Council</td>
</tr>
<tr>
<td>Velodrome at Packer Park</td>
<td>Bioretention System</td>
<td>32.0</td>
<td>0.30</td>
<td>No</td>
<td>Would require upwelling* of water to surface from drainpipe (1650mm) into treatment. Need to maintain usable space for cyclists.</td>
<td>Glen Eira City Council/ Melbourne Water</td>
</tr>
<tr>
<td>Lord Reserve</td>
<td>Bioretention System</td>
<td>142.0</td>
<td>0.23</td>
<td>No</td>
<td>Would require upwelling* of water to surface from drainpipe (1800mm) into treatment. Limited space available.</td>
<td>Glen Eira City Council/ Melbourne Water</td>
</tr>
<tr>
<td>EE Gunn Reserve</td>
<td>Bioretention System</td>
<td>91.0</td>
<td>0.20</td>
<td>No</td>
<td>Would require upwelling* of water to surface from drainpipe (1800mm) into treatment. Limited space available.</td>
<td>Glen Eira City Council/ Melbourne Water</td>
</tr>
<tr>
<td>Princes Park</td>
<td>Bioretention System</td>
<td>301.4</td>
<td>0.20</td>
<td>No</td>
<td>Would require upwelling* of water to surface from drainpipe (1125mm) into treatment. Limited space available.</td>
<td>Glen Eira City Council/ Melbourne Water</td>
</tr>
</tbody>
</table>

*Note: Upwelling refers bringing water for treatment to the surface. This can be achieved when land gradients are steep enough to allow water to be delivered from the start of the park/reserve and reach the surface at the proposed treatment location. Further discussion of these opportunities feasibility is presented in Section 5.2.*
Figure 3-2  Elster Creek study subcatchment and treatment opportunity locations (excluding gross pollutant traps)
4 POLLUTANT TYPES, LOADS AND DISTRIBUTION

One of the key outcomes of the Elster Creek Catchment Study is the recommendation of structural treatments to minimise the impacts of stormwater pollutants on Elster Creek. This chapter discusses the approach and outcomes of identifying key pollutant types and loads and their distribution throughout the catchment.

The approach adopted to identifying these pollutant types, loads and distribution included:

- Examining land use breakdown and the nature of pollution;
- Assessment of available water quality monitoring data; and
- Considering pollutant export results from a model depicting current catchment conditions. This was done using the MUSIC modelling package.

4.1 Land use types and nature of pollution

For the purposes of this study, stormwater pollutants were initially defined in a generic context across the Elster Creek catchment. This was done by considering:

- Dominant land uses where runoff contributes to stormwater pollution;
- Specific activities that may generate stormwater pollution;
- Observations made as part of field visits; and
- Advice from the Working Group in relation to stormwater pollution issues.

As discussed in Chapter 2, the predominant land use type within the Elster Creek Catchment is residential and this is confirmed in Figure 4-1, which presents the Elster Creek catchment’s land use breakdown. Key causes of pollutants in the catchment are therefore likely to be associated with residential land use such as atmospheric deposition and build up from traffic, washing cars, fertiliser application, poor waste management, lawn clippings and vegetation.

Table 4-1 presents the land use breakdown within each subcatchment. It was identified that the general breakdown of land uses within each subcatchment was very similar, with the majority of land being residential (Table 4-1).
### Table 4-1: Land use breakdown within each subcatchment

<table>
<thead>
<tr>
<th>Subcatchment</th>
<th>Land Use</th>
<th>Area (ha)</th>
<th>% Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Allnutt Park</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parks and Recreation</td>
<td>25.86</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Commercial and Public Use</td>
<td>54.8</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>0.51</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Mixed Use</td>
<td>1.98</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td><strong>Residential</strong></td>
<td>521.27</td>
<td>87%</td>
<td></td>
</tr>
<tr>
<td>Major Road</td>
<td>21.89</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Parks and Recreation</td>
<td>12.06</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Commercial and Public Use</td>
<td>2.2</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td><strong>Residential</strong></td>
<td>75.46</td>
<td>95%</td>
<td></td>
</tr>
<tr>
<td>Major Road</td>
<td>1.36</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td><strong>EE Gunn Reserve</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parks and Recreation</td>
<td>45.89</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Commercial and Public Use</td>
<td>11.69</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>Mixed Use</td>
<td>4.27</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td><strong>Residential</strong></td>
<td>63.85</td>
<td>69%</td>
<td></td>
</tr>
<tr>
<td>Major Road</td>
<td>8.78</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Special Use</td>
<td>4.53</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td><strong>Caulfield Park</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parks and Recreation</td>
<td>9.64</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Commercial and Public Use</td>
<td>5.55</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>22.21</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td>Mixed Use</td>
<td>0.38</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td><strong>Residential</strong></td>
<td>103.18</td>
<td>75%</td>
<td></td>
</tr>
<tr>
<td>Major Road</td>
<td>6.22</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td><strong>Duncan McKinnon Reserve</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parks and Recreation</td>
<td>10.99</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Commercial and Public Use</td>
<td>20.43</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Mixed Use</td>
<td>1.02</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td><strong>Residential</strong></td>
<td>456.95</td>
<td>91%</td>
<td></td>
</tr>
<tr>
<td>Major Road</td>
<td>23.71</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td><strong>Elwood Canal 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parks and Recreation</td>
<td>10.99</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Commercial and Public Use</td>
<td>20.43</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Mixed Use</td>
<td>1.02</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td><strong>Residential</strong></td>
<td>456.95</td>
<td>91%</td>
<td></td>
</tr>
<tr>
<td>Major Road</td>
<td>23.71</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td><strong>Elwood Canal 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parks and Recreation</td>
<td>10.22</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Commercial and Public Use</td>
<td>9.4</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td><strong>Residential</strong></td>
<td>50.38</td>
<td>77%</td>
<td></td>
</tr>
<tr>
<td>Major Road</td>
<td>5.52</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td><strong>Golf Course 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parks and Recreation</td>
<td>7.08</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Mixed Use</td>
<td>1.4</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Commercial and Public Use</td>
<td>10.96</td>
<td>19%</td>
<td></td>
</tr>
<tr>
<td>Major Road</td>
<td>5.63</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td><strong>Residential</strong></td>
<td>38.8</td>
<td>68%</td>
<td></td>
</tr>
<tr>
<td><strong>Golf Course 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parks and Recreation</td>
<td>5.11</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Commercial and Public Use</td>
<td>3.02</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td><strong>Residential</strong></td>
<td>27.38</td>
<td>87%</td>
<td></td>
</tr>
<tr>
<td>Major Road</td>
<td>1.21</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td><strong>Greenmeadow Gardens</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parks and Recreation</td>
<td>1.33</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td><strong>Residential</strong></td>
<td>13.28</td>
<td>98%</td>
<td></td>
</tr>
<tr>
<td>Major Road</td>
<td>0.21</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Subcatchment</td>
<td>Land Use</td>
<td>Area (ha)</td>
<td>% Urban</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------</td>
<td>-----------</td>
<td>---------</td>
</tr>
<tr>
<td>Halley Park</td>
<td>Parks and Recreation</td>
<td>32.33</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Commercial and Public Use</td>
<td>25.88</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>108.93</td>
<td>21%</td>
</tr>
<tr>
<td></td>
<td>Mixed Use</td>
<td>0.36</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td><strong>Residential</strong></td>
<td><strong>363.22</strong></td>
<td><strong>70%</strong></td>
</tr>
<tr>
<td></td>
<td>Major Road</td>
<td>22.44</td>
<td>4%</td>
</tr>
<tr>
<td>Hodgson Reserve</td>
<td>Parks and Recreation</td>
<td>1.1</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Commercial and Public Use</td>
<td>2.05</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td><strong>Residential</strong></td>
<td><strong>82.96</strong></td>
<td><strong>96%</strong></td>
</tr>
<tr>
<td></td>
<td>Major Road</td>
<td>1.91</td>
<td>2%</td>
</tr>
<tr>
<td>Joyce Park</td>
<td>Parks and Recreation</td>
<td>11.16</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Commercial and Public Use</td>
<td>14.09</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>6.77</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>Mixed Use</td>
<td>0.24</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td><strong>Residential</strong></td>
<td><strong>142.88</strong></td>
<td><strong>84%</strong></td>
</tr>
<tr>
<td></td>
<td>Major Road</td>
<td>6.61</td>
<td>4%</td>
</tr>
<tr>
<td>Lord Reserve</td>
<td>Parks and Recreation</td>
<td>30.32</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>1.22</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td><strong>Residential</strong></td>
<td><strong>115.69</strong></td>
<td><strong>82%</strong></td>
</tr>
<tr>
<td></td>
<td>Commercial and Public Use</td>
<td>17.2</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>Major Road</td>
<td>7.48</td>
<td>5%</td>
</tr>
<tr>
<td>Packer Park</td>
<td>Parks and Recreation</td>
<td>15.15</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Commercial and Public Use</td>
<td>0.15</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Mixed Use</td>
<td>0.22</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td><strong>Residential</strong></td>
<td><strong>13.74</strong></td>
<td><strong>90%</strong></td>
</tr>
<tr>
<td></td>
<td>Major Road</td>
<td>1.08</td>
<td>7%</td>
</tr>
<tr>
<td>Princes Park</td>
<td>Parks and Recreation</td>
<td>15.87</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Commercial and Public Use</td>
<td>24.61</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td><strong>Residential</strong></td>
<td><strong>242.21</strong></td>
<td><strong>87%</strong></td>
</tr>
<tr>
<td></td>
<td>Major Road</td>
<td>10.02</td>
<td>4%</td>
</tr>
<tr>
<td>Upstream Diversion 2</td>
<td>Parks and Recreation</td>
<td>16.13</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Commercial and Public Use</td>
<td>22.95</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>1.13</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td><strong>Residential</strong></td>
<td><strong>300.23</strong></td>
<td><strong>85%</strong></td>
</tr>
<tr>
<td></td>
<td>Major Road</td>
<td>26.93</td>
<td>8%</td>
</tr>
<tr>
<td>Upstream Diversion 1</td>
<td>Parks and Recreation</td>
<td>6.47</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Commercial and Public Use</td>
<td>38.75</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>Mixed Use</td>
<td>0.75</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td><strong>Residential</strong></td>
<td><strong>463.31</strong></td>
<td><strong>89%</strong></td>
</tr>
<tr>
<td></td>
<td>Major Road</td>
<td>20.77</td>
<td>4%</td>
</tr>
<tr>
<td>Velodrome</td>
<td>Parks and Recreation</td>
<td>4.56</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Commercial and Public Use</td>
<td>0.02</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td><strong>Residential</strong></td>
<td><strong>26.07</strong></td>
<td><strong>96%</strong></td>
</tr>
<tr>
<td></td>
<td>Major Road</td>
<td>1.03</td>
<td>4%</td>
</tr>
<tr>
<td>Victory Reserve</td>
<td>Parks and Recreation</td>
<td>1.57</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Commercial and Public Use</td>
<td>9.49</td>
<td>18%</td>
</tr>
<tr>
<td></td>
<td><strong>Residential</strong></td>
<td><strong>41.75</strong></td>
<td><strong>79%</strong></td>
</tr>
<tr>
<td></td>
<td>Major Road</td>
<td>1.93</td>
<td>3%</td>
</tr>
</tbody>
</table>
While commercial land only represents 7% of the land within the Elster Creek catchment, it is of particular concern because of its potential to contribute higher loads of pollutants to urban stormwater (such as litter and oil and grease (hydrocarbons) from motor vehicles and poor waste management practices) in comparison with most other urban areas. In addition, commercial land use within the Elster Creek catchment most commonly occurs in shopping strips, which can be easily identified and managed.

High-density commercial areas, such as shopping strips, experience large traffic volumes (both vehicular and pedestrian) and have been identified as significant sources of pollutants. The causes of the concentrated pollution sources are related to the number of people present, the types of products available (for example take away food wrapping has been found to be a significant source of litter in shopping strips) and poor waste management practices. Shopping strips within the Elster Creek catchment such as Bentleigh, McKinnon, Ormond and Carnegie, Glenhuntly Road in Elsternwick, Glenhuntly, Gardenvale, Nepean Highway, Ormond Road, Elwood Road, Centre Road and Moorabbin Shopping Centre, should therefore be targeted specifically for urban stormwater treatment. Commercial area hotspots are presented in Figure 4-3. Maps of each commercial hot spot presenting the drainage and opportunities for treatment are presented in Appendix F.

The distribution of commercial land use within each subcatchment across the study area was examined (Figure 4-2). Five of the nineteen subcatchments represent 61% of the total commercial land use area (Allnutt Park, Halley Park, Princes Park, Upstream Diversion 1 and Upstream Diversion 2) (Figure 4-2). By addressing urban stormwater pollution from shopping strip areas within these five subcatchments, a significant proportion of the pollution derived from commercial land use within the Elster Creek catchment would therefore be addressed.

![Figure 4-2 Percentage of commercial land use represented in each subcatchment](image-url)
Figure 4-3  Commercial area hot spots for urban stormwater pollution
The key stormwater inputs and pollutant types identified were based on an assessment of land use breakdown. Those pollutants associated with the land use mix found in the Elster Creek catchment include: increased flow, sediment, nutrients, litter, oxygen depleting material, hydrocarbons, pathogens, trace metals, pesticides and surfactants. The potential impacts and time scales of these stormwater pollutants’ are described in Table 4-2.

Table 4-2 Pollutant types, common sources, potential impacts and time scales

(modified from Table 1.1 in Urban Stormwater: best practice environmental management guidelines, 1999 CSIRO)

<table>
<thead>
<tr>
<th>Pollutant type</th>
<th>Common sources</th>
<th>Potential impacts</th>
<th>Time scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic Effects – Increased flow</td>
<td>Sealed surfaces in urban environments such as roads, car parks, footpaths, roofs and driveways.</td>
<td>Elster Creek is either underground or a concrete channel (apart from earthen channel in Elsternwick Golf Course). Impacts that would generally occur in less disturbed waterways, such as bed disturbance and erosion, are therefore minimal. This includes the earthen channel section because it is located below a flood diversion weir, which removes high flows. Pollutant transport rates with increased flows are still likely to increase.</td>
<td>Instantaneous to hours</td>
</tr>
<tr>
<td>Suspended Solids</td>
<td>Building and construction sites, pavement and vehicle wear, organic matter, weathering of buildings/structures, car washing, atmospheric deposition and eroding waterways.</td>
<td>Includes sediments such as silt and clays, living organisms and particulate organic matter. Light available for plant growth is reduced, which reduces food supplies for other organisms. Can clog and damage sensitive tissues such as the gills of fish. Can suffocate organisms, which are in the stream bed. Metals and nutrients can be adsorbed to sediment surface.</td>
<td>Days to years</td>
</tr>
<tr>
<td>Nutrients</td>
<td>Fertiliser application, atmospheric deposition of nitrogen, washing cars with phosphate detergents, organic matter, animal/bird faeces and spillage/illegal discharge.</td>
<td>Increases algae concentrations, often favouring blue-green algae (cyano bacteria). Increases growth of aquatic macrophytes, but often reduces diversity. Reduces diversity of invertebrates and fish. Increases turbidity due to algal growth. Lowers dissolved oxygen levels due to algal decay</td>
<td>Months to years</td>
</tr>
<tr>
<td>pH</td>
<td>Atmospheric deposition, spillage/illegal discharge, organic matter decay and erosion of roofing material</td>
<td>Increased acidity damages plants and animals</td>
<td>Instantaneous to Years</td>
</tr>
<tr>
<td>Toxic Organics</td>
<td>Pesticides, herbicides, spillage/illegal discharge and sewer overflows/septic leaks.</td>
<td>May be lethal to fish and invertebrates at high levels (rare in stormwater) and can bioaccumulate in the food chain, affecting predators. Low levels may hinder reproduction by fish and invertebrates. Herbicides may reduce the abundance of algae and macrophytes.</td>
<td>Years</td>
</tr>
<tr>
<td>Gross Pollutants (Litter and Debris)</td>
<td>Pedestrians and vehicles, waste collection systems (unsecured bins); leaf-fall from trees; lawn clippings and spills and accidents.</td>
<td>Physical harm to aquatic biota Bruiusal visual impact</td>
<td>Weeks to years</td>
</tr>
<tr>
<td>Oxygen Demanding Materials</td>
<td>Organic matter decay, atmospheric deposition, sewer overflows/septic tank leaks, animal/bird faeces, spillage/illegal discharges.</td>
<td>Reduces dissolved oxygen concentrations. Reduces diversity and can change the structure of aquatic biota communities. Can hinder respiration of fish and possibly reach lethal levels. Increases levels of bacteria and some algae and unpleasant odours can result. Decreases growth of most macrophytes. May increase sediment release rates of nutrients and metals.</td>
<td>Hours to weeks</td>
</tr>
<tr>
<td>Pathogens</td>
<td>Sewer overflows, animal/bird faeces and organic matter decay.</td>
<td>Contain very high numbers of bacteria and viruses. Some of these organisms can cause illnesses, including hepatitis and gastroenteritis.</td>
<td>Less than 1 week</td>
</tr>
<tr>
<td>Toxic Trace Metals</td>
<td>Derived from a variety of sources such as atmospheric deposition, vehicle wear, refuse leachate, weathering of buildings/structures and illegal discharges.</td>
<td>Poison living organisms or damage their life processes in some other way. Toxic to fish, invertebrates, algae and can bioaccumulate in the food chain, particularly affecting predators. Generalised toxicity ranking of metals commonly found in stormwater is as follows (high to low): Copper, cadmium, zinc, lead, aluminium, nickel, iron, chromium</td>
<td>Years</td>
</tr>
<tr>
<td>Oils and surfactants</td>
<td>Oil spills and leaks from motor vehicles, illegal discharges, organic matter, asphalt pavements and washing cars.</td>
<td>High levels of hydrocarbons and surfactants are toxic to fish, invertebrates and macrophytes. Reduction in photosynthesis. Fish respiration and feeding may be hindered by hydrocarbons.</td>
<td>Hours to months</td>
</tr>
</tbody>
</table>
4.2 Water Quality Data Analysis

Monthly water quality monitoring data were downloaded from Melbourne Water’s web site (www.melbournewater.com.au). These data were collected from Elster Creek at Cochrane Street Elwood (Figure 4-4) over a period from February 1994 to May 2003.

![Sampling site location](image)

The following measurements were made during this monitoring:

- General (Date, Time, Gauge, Flow)
- Physico/Chem (Temp, DO %, satDO, Cond, pH)
- Sediment (Turb, SS)
- Nutrients (NO3-N, NO2-N, NOX, NH3N, TKN, T-N, O-P, T-P)
- Biological (E.coli)
- Metals (As, Cd, Cr, Cu, Pb, Ni, Zn)

Sources of these pollutants have been explained previously in Table 4-2 and abbreviations expanded in a Glossary of Terms, located at the beginning of this report.
The monitoring data were assessed against appropriate objectives in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ) (2000) and State Environment Protection Policy Waters of Victoria (SEPP (WoV)) (2003). The SEPP provides more regionally specific water quality objectives and was therefore used for the assessment when available, with the ANZECC/ARMCANZ water quality objectives applied otherwise. A summary of this data, water quality objectives and whether they are met is presented in Table 4-3.

Based on this assessment approach it was identified that the pollutants of most concern in the Elster Creek catchment were nutrients and some heavy metals (zinc, copper and lead). The elevated metals were of concern because they can be readily accumulated in plants and animals and can be toxic to algae, invertebrates and fish (particularly in fresh waters). They readily adsorb to suspended material and complex with dissolved organic matter and this can sometimes reduce their toxicity, but it has not been clearly demonstrated. Nutrients are also of concern because they can lead to excessive algal growth and can lower the dissolved oxygen in the water with the death and decay of algae (a process called eutrophication).

The occurrence of unpleasant odours from the lower reaches of the Elwood Canal may indicate the build up of decaying organic matter and the breakdown of other urban pollutants such as hydrocarbons in the sediment. This phenomenon commonly occurs in urban waterways such as rivers, lakes and wetlands that receive untreated urban stormwater. In many such cases, in addition to treating the urban stormwater entering the waterway, the polluted sediment requires removal with careful consideration of its likely contaminated state. In the case of the lower reaches of the Elwood Canal, further investigation would be required to confirm the level of contamination of the sediment and the processes driving the unpleasant odour.

E. coli was also determined to be elevated at times. However, a review of Faecal Surveys (2000-2001) by Melbourne Water found that levels were relatively low in dry weather. It identified that while there was evidence to suggest faecal contamination from the Caulfield South Main Drain, the relatively low flows from this drain have little influence on the water quality of Elster Creek. The high E. coli levels detected in the Caulfield South drain suggest sewer overflows or illegal connections of household sewage to the stormwater may be occurring. Wet weather sewer overflows are possible, especially in highly urbanised catchments, where the time of concentration of stormwater runoff is relatively short (resulting in high peak storm discharges). Under such conditions stormwater can enter the sewer system, causing it to overflow. These issues may require further investigation to confirm the source of the elevated E. coli levels.

The most likely sources of metals within the Elster Creek catchment are from weathering of buildings and structures (such as galvanised roofing and pipe infrastructure), road runoff and vehicle use from residential areas (as well as major roads). Road transport is potentially a major source of metals to the stormwater system, contributing lead from vehicle emissions, and copper and zinc from vehicle component wear. The most likely sources of nutrients are possibly from overland flow from residential areas (e.g., detergents, animal faeces, fertilised gardens, and lawns) and atmospheric deposition of nitrogen.

Based on this information, it is considered important to target residential stormwater runoff when assessing opportunities for structural treatments.
### Table 4-3 Water quality data assessment

<table>
<thead>
<tr>
<th></th>
<th>Number of Data Points</th>
<th>Mean</th>
<th>25th %ile</th>
<th>50th %ile</th>
<th>75th %ile</th>
<th>90th %ile</th>
<th>Water Quality Objectives</th>
<th>Objectives Met?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physico chem</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DO (mgL⁻¹)</strong></td>
<td>84</td>
<td>10</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>15</td>
<td>Below 6</td>
<td>7% of time not met</td>
</tr>
<tr>
<td><strong>% satDO (percent saturation)</strong></td>
<td>74</td>
<td>106</td>
<td>78</td>
<td>99</td>
<td>126</td>
<td>159</td>
<td>25th %ile exceed 85%</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Conductivity (MicroSiemens/centimetre)</strong></td>
<td>84</td>
<td>715</td>
<td>630</td>
<td>760</td>
<td>850</td>
<td>930</td>
<td>75th %ile exceed 500</td>
<td>No</td>
</tr>
<tr>
<td><strong>PH (units)</strong></td>
<td>84</td>
<td>8.2</td>
<td>7.4</td>
<td>8.2</td>
<td>9.0</td>
<td>9.5</td>
<td>75th %ile exceed 7.7</td>
<td>No</td>
</tr>
<tr>
<td><strong>Turbidity (NTU)</strong></td>
<td>84</td>
<td>17</td>
<td>7</td>
<td>10</td>
<td>18</td>
<td>30</td>
<td>75th %ile exceed 10</td>
<td>No</td>
</tr>
<tr>
<td><strong>SS (mgL⁻¹)</strong></td>
<td>84</td>
<td>11</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td>16</td>
<td>50</td>
<td>2% of time not met</td>
</tr>
<tr>
<td><strong>Nutrients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td><strong>NOX (mgL⁻¹)</strong></td>
<td>166</td>
<td>0.62</td>
<td>0.02</td>
<td>0.27</td>
<td>1.20</td>
<td>1.60</td>
<td>0.04</td>
<td>100% of time not met</td>
</tr>
<tr>
<td><strong>NH₃N (mgL⁻¹)</strong></td>
<td>69</td>
<td>0.04</td>
<td>0.01</td>
<td>0.02</td>
<td>0.04</td>
<td>0.08</td>
<td>0.02</td>
<td>56% of time not met</td>
</tr>
<tr>
<td><strong>TKN (mgL⁻¹)</strong></td>
<td>83</td>
<td>0.98</td>
<td>0.72</td>
<td>0.92</td>
<td>1.10</td>
<td>1.30</td>
<td>0.48</td>
<td>99% of time not met</td>
</tr>
<tr>
<td><strong>T-N (mgL⁻¹)</strong></td>
<td>83</td>
<td>2.2</td>
<td>1.7</td>
<td>2.2</td>
<td>2.6</td>
<td>3.1</td>
<td>0.6</td>
<td>100% of time not met</td>
</tr>
<tr>
<td><strong>O-P (mgL⁻¹)</strong></td>
<td>83</td>
<td>0.06</td>
<td>0.05</td>
<td>0.06</td>
<td>0.07</td>
<td>0.11</td>
<td>0.02</td>
<td>98% of time not met</td>
</tr>
<tr>
<td><strong>T-P (mgL⁻¹)</strong></td>
<td>83</td>
<td>0.14</td>
<td>0.11</td>
<td>0.13</td>
<td>0.16</td>
<td>0.22</td>
<td>0.05</td>
<td>100% of time not met</td>
</tr>
<tr>
<td><strong>Metals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>As (mgL⁻¹)</strong></td>
<td>67</td>
<td>0.004</td>
<td>0.003</td>
<td>0.004</td>
<td>0.005</td>
<td>0.006</td>
<td>0.094</td>
<td>20% of time not met</td>
</tr>
<tr>
<td><strong>Cd (mgL⁻¹)</strong></td>
<td>67</td>
<td>0.0004</td>
<td>0.0002</td>
<td>0.0002</td>
<td>0.0005</td>
<td>0.0005</td>
<td>0.0004</td>
<td>25% of time not met</td>
</tr>
<tr>
<td><strong>Cr (mgL⁻¹)</strong></td>
<td>67</td>
<td>0.010</td>
<td>0.002</td>
<td>0.003</td>
<td>0.005</td>
<td>0.009</td>
<td>0.006</td>
<td>36% of time not met</td>
</tr>
<tr>
<td><strong>Cu (mgL⁻¹)</strong></td>
<td>67</td>
<td>0.0137</td>
<td>0.0093</td>
<td>0.0120</td>
<td>0.0150</td>
<td>0.0188</td>
<td>0.0018</td>
<td>100% of time not met</td>
</tr>
<tr>
<td><strong>Pb (mgL⁻¹)</strong></td>
<td>67</td>
<td>0.0310</td>
<td>0.0033</td>
<td>0.0040</td>
<td>0.0070</td>
<td>0.0186</td>
<td>0.0056</td>
<td>46% of time not met</td>
</tr>
<tr>
<td><strong>Ni (mgL⁻¹)</strong></td>
<td>67</td>
<td>0.005</td>
<td>0.004</td>
<td>0.005</td>
<td>0.006</td>
<td>0.007</td>
<td>0.013</td>
<td>21% of time not met</td>
</tr>
<tr>
<td><strong>Zn (mgL⁻¹)</strong></td>
<td>67</td>
<td>0.229</td>
<td>0.140</td>
<td>0.180</td>
<td>0.295</td>
<td>0.382</td>
<td>0.015</td>
<td>100% of time not met</td>
</tr>
<tr>
<td><strong>Biological</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E.coli (Organisms/100 millilitres)</strong></td>
<td>66</td>
<td>1635</td>
<td>480</td>
<td>890</td>
<td>1650</td>
<td>3800</td>
<td>Median 1000</td>
<td>57% of time not met</td>
</tr>
</tbody>
</table>

**Key**

- ANZECC/ARCMANZ Water Quality Objectives
- SEPP (WoV) Water Quality Objectives

---

S:\M6612\BL\ELSTERCREEK\CATCHMENTSTUDYRM6612.001.07.FINALREPORT.DOC 17/10/05 14:10
4.3 MUSIC Modelling

Stormwater quality modelling of the current catchment condition was performed using the Cooperative Research Centre for Catchment Hydrology (CRCCCH) Model for Urban Stormwater Conceptualisation (MUSIC Version 2.10). MUSIC allows for pollutant assessments for gross pollutants, total phosphorus (TP), total nitrogen (TN) and total suspended solids (TSS). These were considered representative parameters as they are commonly recognised as indicators of urban stormwater quality. Although the SEPP (WoV) lists a range of pollutants of concern in aquatic environments, the Best Practice Urban Stormwater Management Guidelines (1999) recognised that all of these parameters were not practical to measure. As a result, TSS, TP and TN were chosen as suitable stormwater quality indicators. Appendix B contains details and discussion of the parameters adopted for modelling pollutant exports, i.e. pollutant-loading rates and hydrologic parameters.

Heavy metals have been identified as pollutants present within the Elster Creek and are most likely to be derived from urban stormwater pollution. The amount of suspended solids in the water column in urban environments correlates strongly with heavy metal concentration. This is due to the propensity for heavy metals to readily adsorb to suspended sediment particles and particulate organic matter (ANZECC/ARMCANZ, 2000). Metal association with the suspended sediments may differ, as the propensity of sediment to adsorb contaminants is influenced by the availability of binding sites. Metals, hydrocarbon by-products, nutrients and pesticides found in urban stormwater have been found to readily attach to fine sediments (Randell et al., 1982; DeGroot, 1995; Greb and Bannerman, 1997). In Australia 40% or more of suspended solids were found to be finer than 100 µm (Walker and Wong, 1999). As a result, the suspended solids output from the model was used as an indicator of the probable level of treatment of heavy metals identified to be of concern during the water quality assessment.

The modelling approach allowed for the estimation of suspended sediment, total phosphorus, total nitrogen and gross pollutant loads into the entire catchment (Table 4-4) and different segments of Elster Creek (Table 4-5) under current catchment conditions, whereby current conditions include current structural treatments as identified in Figure 2-5.

Table 4-4 MUSIC model results for Elster Creek Catchment under current conditions

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Sources (kg/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Suspended Solids (kg/yr)</td>
<td>1,688,100</td>
</tr>
<tr>
<td>Total Phosphorus (kg/yr)</td>
<td>3,500</td>
</tr>
<tr>
<td>Total Nitrogen (kg/yr)</td>
<td>24,879</td>
</tr>
<tr>
<td>Gross Pollutants (kg/yr)</td>
<td>402,460</td>
</tr>
</tbody>
</table>

The Elster Creek segments represent the catchments of the four dominant Melbourne Water drains entering Elster Creek/Elwood canal at different points and the catchment area of the Elsternwick Golf Course (Figure 4-5). These modelled segments provide an indication of the loads entering Elster Creek/Elwood Canal at key points in the catchment (Table 4-5). The greatest pollutant loads entering the system are from the drains derived from the Allnutt Park and Upstream Diversion 2 segments.

MUSIC results for each subcatchment under current conditions were also extracted from the model and are presented in Table B-4 in Appendix B. Pollutant loads generated from each subcatchment are also presented in Figure 4-6. In addition,
Table 4-6 presents locations of each hot spot, their corresponding subcatchments and the annual load per hectare of pollutant generated with each subcatchment.

Figure 4-5  Elster Creek Catchment segments representing four dominant Melbourne Water drains and the Golf Course subcatchment

Table 4-5  Simulated pollutant loads into different segments of Elster Creek under current conditions

<table>
<thead>
<tr>
<th>Elster Creek/Elwood Canal Segments</th>
<th>Segment Size (Ha)</th>
<th>Total Suspended Solids (kg/yr)</th>
<th>Total Phosphorus (kg/yr)</th>
<th>Total Nitrogen (kg/yr)</th>
<th>Gross Pollutants (kg/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elwood Canal</td>
<td>743.2</td>
<td>305,000</td>
<td>627</td>
<td>4,430</td>
<td>73,900</td>
</tr>
<tr>
<td>Golf Course</td>
<td>100.5</td>
<td>32,100</td>
<td>81</td>
<td>609</td>
<td>6,360</td>
</tr>
<tr>
<td>Upstream of Diversion 1</td>
<td>831.6</td>
<td>360,000</td>
<td>742</td>
<td>5,320</td>
<td>86,200</td>
</tr>
<tr>
<td>Upstream of Diversion 2</td>
<td>975.5</td>
<td>426,000</td>
<td>880</td>
<td>6,120</td>
<td>100,000</td>
</tr>
<tr>
<td>Allnutt Park</td>
<td>1,359</td>
<td>565,000</td>
<td>1,170</td>
<td>8,400</td>
<td>136,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4009.8</strong></td>
<td><strong>1,688,100</strong></td>
<td><strong>3,500</strong></td>
<td><strong>24,879</strong></td>
<td><strong>402,460</strong></td>
</tr>
</tbody>
</table>
Figure 4-6  Pollutant loads generated from each subcatchment
Table 4-6 Commercial hot spots, subcatchments and pollutant loads

<table>
<thead>
<tr>
<th>Commercial Hot Spots</th>
<th>Subcatchment</th>
<th>Pollutants</th>
<th>Sources kg/yr/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glen Eira Road and Caulfield North Shopping</td>
<td>Elwood Canal1</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>458.1</td>
</tr>
<tr>
<td>Strips</td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>6.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>114.0</td>
</tr>
<tr>
<td>Elsternwick Shopping Strip</td>
<td>Elwood Canal2</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>366.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>91.1</td>
</tr>
<tr>
<td>Ormond Road Shopping Strip</td>
<td>Golf Course1</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>5.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>0.9</td>
</tr>
<tr>
<td>Sections of Nepean Highway</td>
<td>Upstream of Drain Diversion1</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>837.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>11.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>186.4</td>
</tr>
<tr>
<td>Carnegie, Bentleigh, McKinnon and Ormond</td>
<td>Allnutt Park</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>201.6</td>
</tr>
<tr>
<td>Shopping Strips</td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>46.9</td>
</tr>
<tr>
<td>Moorabbin Shopping Centre</td>
<td>Halley Park</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>73.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>17.6</td>
</tr>
<tr>
<td>Centre Road (East Bentleigh)</td>
<td>Joyce Park</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>412.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>101.8</td>
</tr>
<tr>
<td>Glenhunty Shopping Strip</td>
<td>Lord Reserve</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>449.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>108.0</td>
</tr>
<tr>
<td>Caulfield Shopping Strip</td>
<td>Princes Park</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>444.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>99.5</td>
</tr>
</tbody>
</table>
5  Efficacy and Prioritisation of Proposed Treatment Measures

Pollutant export concentrations and loads have also been determined for a number of treatment scenarios using the MUSIC program. MUSIC was developed to simulate a common range of stormwater treatment structures such as gross pollutant traps, swales, bioretention systems and wetlands. MUSIC is a concept design tool, and as such, can assist in determining the optimal treatment strategy for a given catchment and allows the “gaming” of various scenarios so that identified constraints or design changes can be tested to evaluate their impact. Key components of the MUSIC model include:

- Simulation of hydrologic behaviour of catchments;
- Generation of pollutant loads for TSS, TP, TN and Gross Pollutants; and
- Assessment of efficiency by a range of treatment measures such as wetlands, bioretention systems and GPTs.

The MUSIC modelling approach was developed to assess structural treatment opportunities at two levels:

- A broad scale opportunity-based assessment such as wetlands, bioretention basins and GPTs; and
- The assessment of local treatment scenarios such as upgrades of streetscapes to include gully pit baskets and street bioretention across 20% of the catchment. For comparative purposes GPTs were also modelled as an alternative.

In addition, two future development scenarios were examined. These are presented and discussed in Chapter 7.

Appendix B presents the methodology used to model the treatment opportunities identified in Chapter 4 and modelling results. This Chapter presents the modelling results in terms of kilograms of TSS, TP, TN and Gross Pollutants reduced and the estimated costs associated with each structural treatment. Costs per kilogram of pollutant removed are also provided and each treatment is ranked accordingly.

Stormwater treatment devices are generally designed to treat stormwater flows resulting from the smaller more frequent storm flow events, which typically account for the majority (approximately 80-90%) of pollutant export from a catchment (on a long term basis). Base flow (i.e. water which enters streams after passing temporarily through a soil store) as distinct from storm flows, makes up a much smaller portion of the total flow and pollutant loads from a catchment.

In the case of the Elster Creek catchment MUSIC model, base flow quantities and pollutant loads are significantly less than storm flow quantities and loads; and both storm flows and base flows and loads are combined prior to entering a treatment device. Consequently, the overall performance of each potential treatment device is assessed in the report as the total load of pollutants (both storm flows and base flows) entering and leaving the device. However as the majority of the flows produced in the model are associated with storm flows, the majority of the pollutant loads presented are also associated with storm flows.
5.1 Efficacy of Proposed Treatment Measures

MUSIC simulation results of each site-specific structural treatment opportunity for the Elster Creek catchment based on the description of structural treatment opportunities described in Chapter 3 are presented in Table B-4 of Appendix B. In addition, GPTs at each site-specific location were modelled as an alternative and these results are presented in Table B-5 of Appendix B. These results in Tables B-4 and B-5 represent the pollutant load reduction achieved by each treatment independently (not as a treatment train). Individual treatments assume that catchment inflow is untreated upstream. In contrast, Table 5-1 presents the MUSIC simulation results for the entire catchment if all treatments were implemented. In such a treatment train situation, treatments located downstream of other treatments would have lower inflow concentrations than if they were modelled individually. Consequently, the pollutant load reduction result for the entire catchment model will be less than the sum of results of each treatment structure modelled individually. Each treatment’s location and drainage has been presented in Figure 3-1 and a photograph of the site provided in Appendix E. Table 5-2 presents the estimated percentage reduction in pollutant loads that could be achieved by using GPTs as an alternative to the structural treatments recommended. Both tables also present the estimated treatment being achieved by existing GPTs in the Elster Creek catchment.

Table 5-1 Summary of export loads for site-specific treatments

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Untreated pollutant loads (kg/yr)</th>
<th>Residual load after treatment (kg/yr)</th>
<th>Percent reduction in pollutant loads from existing GPTs (%)</th>
<th>Percent reduction in pollutant loads from site-specific treatment opportunities (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended solids</td>
<td>1,688,100</td>
<td>1,125,963</td>
<td>0.9</td>
<td>32.4</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>3,500</td>
<td>2,615</td>
<td>0</td>
<td>25.3</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>24,879</td>
<td>20,575</td>
<td>0</td>
<td>17.3</td>
</tr>
<tr>
<td>Gross Pollutants</td>
<td>402,460</td>
<td>158,569</td>
<td>1.4</td>
<td>59.2</td>
</tr>
</tbody>
</table>

Table 5-2 Summary of export loads for site specific gross pollutant traps (GPTs)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Untreated pollutant loads (kg/yr)</th>
<th>Residual load after treatment (kg/yr)</th>
<th>Percent reduction in pollutant loads from existing GPTs (%)</th>
<th>Percent reduction in pollutant loads from site-specific treatment opportunities (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended solids</td>
<td>1,688,100</td>
<td>1,119,210</td>
<td>0.9</td>
<td>32.8</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>3,500</td>
<td>3,500</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>24,879</td>
<td>24,879</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gross Pollutants</td>
<td>402,460</td>
<td>163,801</td>
<td>1.4</td>
<td>57.9</td>
</tr>
</tbody>
</table>

The results suggest that GPTs as an alternative to the site-specific structural treatments recommended treat a smaller range of pollutants. The pollutants that the GPTs do treat for, achieve a slightly lower pollutant reduction for Gross Pollutants and slightly higher pollutant reduction for suspended sediments. The results also demonstrate that if all site-specific treatment opportunities recommended could be implemented, it is likely that a large proportion of pollutants could be removed from the Elster Creek catchment. With the potential future implementation of streetscape bioretention in residential areas and gully pit baskets in commercial area hot spots, these pollutant loads have the potential to be further reduced.
Table 5-3 presents the results of incorporating gully pit baskets, streetscape bioretention and GPTs into 20% of the Elster Creek catchment. While only small incremental reductions in pollutant loads can be achieved street-by-street, the implementation of such treatments needs to be assessed in terms of their gains over the long term. A 20% adoption rate throughout the Elster Creek catchment was therefore chosen to demonstrate the pollutant reduction that could potentially be achieved over the longer term. The results suggest that GPTs have the lowest pollutant reduction potential, however other elements such as engineering feasibility, ongoing maintenance requirements and costs need to be considered prior to dismissing GPTs as an alternative.

Table 5-3 Summary of pollutant export loads if streetscape treatments are implemented across 20% of the catchment

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Percent reduction in pollutant loads from gully pit baskets (200 micron mesh) (%)</th>
<th>Percent reduction in pollutant loads from streetscape bioretention (%)</th>
<th>Percent reduction in pollutant loads from streetscape GPTs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended solids</td>
<td>17</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>0</td>
<td>7.9</td>
<td>0</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>0</td>
<td>5.2</td>
<td>0</td>
</tr>
<tr>
<td>Gross pollutants</td>
<td>19</td>
<td>20</td>
<td>19</td>
</tr>
</tbody>
</table>

While restoration of the lower reaches of the Elster Creek and Elwood Canal have not been assessed for their stormwater treatment benefits, it can be safely assumed that there would be some stormwater treatment capability associated with in-stream rehabilitation. It is important to note that any in-stream habitat improvement in the lower reaches of the Elster creek and Elwood Canal should occur in conjunction with improvements to stormwater treatment in the catchment. Restoration of in-stream habitat, where factors other than habitat simplification are limiting in stream biotic communities (such as urban stormwater pollution and hydrological disturbance), can result in limited or no in-stream community improvement (Walsh and Breen 1999). Consequently, it is recommended that Melbourne Water undertake further investigation to define how the biotic communities in the Elster Creek and Elwood Canal respond to these factors before proceeding with such a strategy. Clearly, the proposed structural treatments in the catchment would reduce pollutant loads entering the Elster Creek and Elwood Canal and improve their water quality and ecosystem health. However, what remains unclear is to what extent. It is recommended that a key component of this investigation would be to define the response of the biotic community to pollutant load reductions in the Elster Creek catchment. Later versions of MUSIC may offer the ability to assess this through a proposed ecological response module.

5.2 Assessing Feasibility

The proposed treatments are highly conceptual. It is through the detailed design phase that a detailed site analysis is undertaken. At this detailed design stage in the structural treatment design process it may be found that some of proposed site-specific treatments are considered unfeasible. An initial feasibility assessment was therefore undertaken to identify those treatments that are most likely to have a successful outcome at the detailed design phase to aid in the prioritisation process of taking such a step. The feasibility assessment was based on the following assessment criteria:

- Whether there are heritage overlays
- Encroaching or competing with current use
- Ease of implementation in terms of engineering aspects

Heritage Overlays – only two parks where spatial opportunity was identified have heritage overlays (Caulfield Park and Greenmeadows Gardens). All other parks do not have heritage constraints.
Engineering – The large-scale site-specific opportunities identified (including sand filters and bioretention) face particularly difficult engineering challenges in getting water to the surface. Many of the opportunities appear to be unfeasible to implement due to the pipe being too deep in relation to levels or grade of the reserve. Gross pollutant traps were also considered to be very challenging to construct and maintain at these sites. This is because gross pollutant traps would need to be installed at a significant depth to be lower than the pipe, which poses challenges in terms of implementation as well as access for maintenance and repairs. Vehicle access for maintenance would be difficult and baskets would need to be removed via a crane, requiring street and park closure. In addition, construction would occur in a confined space work site, making them more expensive to construct.

Three opportunities were identified as being potentially feasible in engineering terms:

- **Princess Park Bioretention Basin** – due to the relatively steep grades in the park, the park is a good candidate for bringing water to the surface for treatment.
- **Bentleigh-Hodgson Reserve Bioretention Basin** – due to the shallower pipe depth and grade of the park, there is potential at the park to bring water to the surface and still have a reasonable area in the reserve for treatment.
- **Mallanbool Reserve and Packer Park Treatment Train** – as the treatment train would be treating localised and surface drainage this opportunity is likely to be feasible.

**Competing Uses** - Of these three parks which were identified as potentially feasible, both Princess Park and Bentleigh-Hodgson Reserve have competing uses where there is a potential for loss of sporting ovals and likelihood of full park re-design to incorporate the treatments appropriately. Bentleigh-Hodgson Reserve in particular was thought to have no space available for bioretention systems. The Mallanbool Reserve and Packer Park treatment train opportunity already has features (such as the wetland, rock scree features and swales) that could be further enhanced to have greater utility in terms of water quality treatment. It was thought that Packer Park was the most likely site for retrofit type works.

Based on this feasibility assessment, it is recommended that of the site specific treatment opportunities identified in this study, only the Mallanbool Reserve-Packer Park Treatment Train and Princess Park Bioretention Basin be further examined. However, the loss of sporting facilities and the requirement of a full park re-design make these options only feasible in the longer term.

The treatment efficacy of those site-specific opportunities considered likely to be feasible in the catchment is presented in Table 5-4. Note that because GPTs were not considered feasible at these sites, none are presented in Table 5-4. However, GPTs at each site-specific location were modelled for interest and these results are presented in Table B-5 of Appendix B. The percentage reduction in pollutant loads achieved in Table 5-4 is much less than those presented in Table 5-1 and Table 5-2. This is because the number of treatments modelled that were considered feasible is much smaller the number of treatment opportunities modelled in Tables 5-1 and 5-2.

**Table 5-4** Summary of export loads for site-specific structural treatments likely to be feasible as opposed to all opportunities modelled in Table 5-1

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Untreated pollutant loads (kg/yr)</th>
<th>Residual load after treatment (kg/yr)</th>
<th>Percent reduction in pollutant loads from existing GPTs (%)</th>
<th>Percent reduction in pollutant loads from site-specific treatments (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended solids</td>
<td>1,688,100</td>
<td>1,578,374</td>
<td>0.9</td>
<td>5.6</td>
</tr>
<tr>
<td>Total phosphorus</td>
<td>3,500</td>
<td>3,388</td>
<td>0</td>
<td>3.2</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>24,879</td>
<td>24,431</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>Gross Pollutants</td>
<td>402,460</td>
<td>341,689</td>
<td>1.4</td>
<td>13.7</td>
</tr>
</tbody>
</table>
5.3 Large scale gross pollutant traps versus a more distributed approach

An optimal catchment size is suggested to be between 10 and 100 hectares for a GPT. Lloyd and Wong (2003) suggest that catchment sizes smaller than 10 hectares may incur a disproportionately high maintenance cost and GPTs on very large catchments are likely to have low trapping efficiencies.

Gross pollutant traps are not recommended for locations immediately downstream of the commercial area hot spots, as their drainage catchments are less than 10 hectares in size. This is because drainage patterns within these commercial hot spots are herringbone in nature and do not drain to one place. This was confirmed through a closer examination of the drainage pattern at and around each commercial hot spot. Consequently, if GPTs were to treat the commercial hot spots close to source a large number would be required and the catchment area treated would be small with resulting inefficiencies in capital outlay and maintenance costs and inefficient. Such an alternative is also likely to represent a maintenance burden. Implementing a cost effective maintenance regime could be difficult as each gross pollutant trap is likely to have different loading rates and would lead to some being overburdened and others with loads that would not warrant cleaning. However, a monthly inspection regime should allow for varying cleaning regimes to be implemented. As gully pit baskets have not been used to treat stormwater in the Elster Creek catchment before, and the maintenance requirements have the potential to be similarly challenging, it is recommended that each Council seek to install both devices to trial and monitor their success, over a period of two to three years, for pollutant load reductions and maintenance requirements prior to their implementation in all identified hot spot areas.

Locating gross pollutant traps lower down in the catchment (such as at Allnutt Park) has advantages in terms of monitoring the required frequency for cleaning, monitoring the traps performance and cost savings associated with maintaining fewer devices. However, GPTs located further down stream would treat large catchments (greater than 100 hectares) that produce very large volumes of water at a location sometimes far from the pollutant’s source, often with poor trapping efficiency. Allnutt Park for example, has a catchment of greater than 1,000 hectares. Sites that have been examined that have catchments of less than 100 hectares in size include:

- Velodrome at Packer Park;
- EE Gunn Reserve;
- Bentleigh-Hodgson Reserve;
- Greenmeadow Gardens; and
- Victory Reserve.

However, as mentioned before, there are significant engineering challenges at these sites due to pipe depths. These sites represent predominantly residential catchments, with only the site of EE Gunn Reserve having the commercial hot spot area of Glenhuntly Shopping Strip within its catchment. In addition, the pollutant reductions achieved using gross pollutant traps, for the same area of catchment treated, were less than that predicted for streetscape bioretention and gully pit baskets could offer (refer to Table 5-3). Refer to Appendix B Table B-5 for MUSIC modelling results for each of these specific sites. In addition to these park locations, other suitable locations for gross pollutant traps may include roadways, parking lots and verges. Refer to Appendix B Table B-6 for MUSIC modelling results for each of the gross pollutant traps listed below. The proposed locations for gross pollutant traps have not been investigated for feasibility. Potential locations are presented if Figure 5-1 and include:

- (GPT 1) 1,500 mm Melbourne Water drain located along Koorang Rd (corner of Koorang Park) in the Glen Eira City Council. The catchment area is approximately 106 Ha. It is located downstream of Carnegie shopping strip (Melways 68H6).
• (GPT 2) 1,430 mm Melbourne Water drain located between number 31 and 33 Almond St in Glen Eira City Council. The catchment area treated is approximately 115 Ha. It is located downstream of Caulfield south shopping Strip (Melways 68H5).

• (GPT 3) Twin pipes 1,255 & 900 mm Melbourne Water drain runs along Yanakie Crescent, located on the corner of Yanakie St and Garrell St in Glen Eira City Council. The catchment area treated is approximately 58 Ha. It is downstream of Caulfield North shopping strip (Melways 67K1).

• (GPT 4) 1350 mm Melbourne Water drain located opposite 425 Kooyong Road near Aileen Avenue in Glen Eira City Council. The catchment area treated is approximately 74 Ha. It is downstream of Caulfield South shopping strip (Melways 67J6).

• (GPT 5) 600 mm Council drain located on the corner of Beach Avenue and Wave Street (near Elwood Canal) in the City of Port Phillip. The catchment area treated is approximately 11.5 Ha. It is downstream of the Ormond Road shopping strip (Melways 67C4).

• (GPT 6) 1,200 mm Council drain located near the corner of Foam Street and Spray Street (near Elwood Canal) within the City of Port Phillip. The catchment area treated is approximately 11 Ha. It is downstream of the Ormond Road shopping strip (Melways 67D4).

• (GPT 7) 975 mm Council drain located on the corner of Glenhuntly Road and Brighton Road within Glen Eira City Council. The catchment area treated is approximately 33 Ha. It is located downstream of the shopping area of Elsterwick (Melways 67 E3).

Figure 5-1  Potential locations for GPTs other than parks in the Elster Creek catchment

It is commonly believed that a distributed treatment approach has the advantage of a number of smaller treatments installed throughout the catchment and enables pollutant sources to be targeted effectively and only treat water that is expected to contain sufficient pollutants. In this way, lower flow velocities and volumes and high pollutant concentrations at these sites lead to higher operating efficiencies. Consequently streetscape bioretention in residential areas are preferred to gross pollutant traps, as they are located close to the source and target pollutants associated with roadways. However, if these engineering challenges associated with the gross pollutant trap opportunities can be overcome, the installation of GPTs
downstream of commercial areas will produce gains in pollutant reductions in the catchment. To treat pollutants including nutrients and heavy metals works including streetscape bioretention need to be implemented as street upgrades occur.

5.4 Costing of Construction and Maintenance

Specific structural treatment opportunities across the Elster Creek catchment have been identified as potentially suitable via the outcomes of the opportunity assessment discussed in Chapter 3 and feasibility assessment in the previous section. Only those opportunities considered feasible for further examination have been costed (see Figure 6-1). Cost breakdowns for each treatment proposed are presented in Table 6-1 of the following chapter.

The lifetime construction and maintenance cost and an equivalent annual payment were determined for each structural opportunity. This involved estimating the following factors based on information provided by suppliers or estimated from information provided in the Best Practice Environmental Management Guidelines (BPEMG) and the CRCCH report on Structural Stormwater Quality Cost – Size relationship (2002):

- Lifetime of Treatment (years)
- Total Construction Cost ($) – this did not include GST
- Total Maintenance Cost ($) – this did not include GST

The equivalent annual cost was calculated based on a nominal discount rate of 10% per annum and an annual inflation rate of 2.14% and calculated from 2004. Table 5-5 provides a summary of the costs assumed for each structural opportunity type considered.

Table 5-5 Cost Breakdown approach used for estimating structural treatment opportunity costs

<table>
<thead>
<tr>
<th>Structural Measure</th>
<th>Approximate Construction Cost</th>
<th>Approximate Maintenance Cost (per annum)</th>
<th>Information Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioretention basin Bentleigh – Hodson Reserve</td>
<td>$137 m² + 10% for drainage works</td>
<td>7 % of construction cost</td>
<td>(Taylor, 2004)</td>
</tr>
<tr>
<td>Bioretention basin Princess Park</td>
<td>$137 m² + 10% for drainage works</td>
<td>7 % of construction cost</td>
<td>(Taylor, 2004)</td>
</tr>
<tr>
<td>Bioretention systems</td>
<td>$135 per linear metre</td>
<td>7 % of construction cost</td>
<td>(Taylor, 2004)</td>
</tr>
<tr>
<td>Gully pit baskets</td>
<td>$3000 per ha of treated area</td>
<td>$1,500 per ha of treated area</td>
<td>Enviropod technical information</td>
</tr>
<tr>
<td>Wetlands</td>
<td>$730,000 per ha</td>
<td>2 % of construction cost</td>
<td>(Taylor, 2004)</td>
</tr>
<tr>
<td>Stream rehabilitation</td>
<td>$120 per m²</td>
<td>$2.50 per m²</td>
<td>Based on CRCCH report (Taylor, 2004) cost for swales including planting, excavation, soil, cross overs, maintenance and irrigation</td>
</tr>
<tr>
<td>In-ground gross pollutant traps</td>
<td>$13,703 per ha ^ 0.5904</td>
<td>10 % of construction cost</td>
<td>(Taylor, 2004)</td>
</tr>
</tbody>
</table>
6 PRIORITISATION AND IMPLEMENTATION

A key objective when prioritising structural treatment opportunities is to identify those opportunities that offer the best value for money in terms of providing the highest level of environmental management at the lowest cost. To do this, it is necessary to analyse individually each structural treatment opportunity to provide a comparative measure of cost effectiveness. This process involves the assessment of each structural treatment using the MUSIC pollutant load reduction results and determination of a cost ratio.

Based on the suspended solids values derived from the modelling and the ongoing and capital costs estimated for each treatment opportunity, a single score was calculated for each treatment opportunity reflecting its cost-effectiveness. Cost-effectiveness is calculated using the following method:

\[
\text{Cost effectiveness} = \frac{\text{Annual Equivalent Cost ($)}}{\text{(SSkgreduced / yr)}}
\]

The score that is derived for each structural treatment is in $/kg/year of suspended solids multiplied by a factor representing feasibility of implementation with scores of very low to very high. This approach provides a comparative measure of cost effectiveness. For comparison, these scores were derived similarly for TP, TN and Gross Pollutants. Low scores reflect a high level of cost-effectiveness. In its own right, the score has little meaning other than for comparison with scores for other structural treatments being considered in this study, however an annualised cost-effectiveness range has been reported elsewhere of between $1 to $1.70 /kg of SS/year (Lloyd, S et al 2002).

Prioritisation of structural treatments is formulated by selecting the most cost-effective structural treatments, reflecting those that offer the greatest value for money. For those structural treatments offering a similar level of treatment, the more cost-effective is always selected. In addition, structural treatments with poor cost-effectiveness are not recommended. Prioritisation needs to also reflect the pollutant of most concern. For example, in some commercial areas Gross Pollutants may be of most concern and therefore the priority of structural treatments would need to reflect this and would be based on cost effectiveness scores derived from Gross Pollutant reductions achieved.

6.1 Results of Cost Effectiveness Analysis

Table 6-1 presents the results of the cost effectiveness analysis. This table shows the reduction in pollutants, estimated cost and calculated cost-effectiveness for each pollutant. In Table 6-1, structural treatments have also been ranked, in accordance with their cost-effectiveness scores, from highest to lowest. Cost-effectiveness plots for each pollutant (TSS, TP, TN and Gross Pollutants) have also been produced (Figures 6-1, 6-2, 6-3 and 6-4 respectively).

While the two stream reach rehabilitation treatments have not been assessed for their stormwater treatment benefits, it can be safely assumed that there would be some stormwater treatment capability associated with in stream rehabilitation. It is important to note that any in stream habitat improvement in the lower reaches of Elster Creek and Elwood Canal should occur in conjunction with improvements in stormwater treatment in the catchment. Restoration of in stream habitat, where factors other than habitat simplification are limiting in stream biotic communities (such as urban stormwater pollution and hydrological disturbance), can result in poor recovery of biotic communities in these lower reaches (Walsh and Breen 1999). Further investigation would be required to define how the biotic community in Elster Creek and Elwood Canal are responding to these factors before proceeding with such a strategy.

The Glen Eira City Council has the largest amount of investment associated with the implementation of structural treatment devices to improve water quality to Elster Creek and Elwood Canal. This reflects the large proportion of the
Elster Creek catchment that the Glen Eira City Council covers. Apart from Packer Park, where a bioretention trench and wetland upgrade has been recommended, one bioretention basin has been identified as structural treatment at a park location in the catchment.

The bioretention basin has been identified as being reasonably cost-effective, however its implementation will be dependent on outcomes of community consultation to develop an appropriate design that will have the least impact on current aesthetics and activities in the parks. In addition the costing does not include park redesign and the construction works associated with this and therefore there may be significant additional costs associated with the structure. This may result in the measures being feasible only in the long term. In some cases the size and dimensions of these structures may need to change at the detailed design stage to better reflect the needs of community. It is recommended that the MUSIC modelling and costing be reviewed at this time to assess the revised treatment structure design’s new treatment capabilities.

Plots have been prepared for each Council and Melbourne Water, which present each structural activity they would be responsible for implementing and the cumulative expenditure in order of cost effectiveness (Figures 6-4 to 6-6).
## Table 6-1: Ranking, cost and responsibility for implementation of each structural treatment.

($/kg of pollutant reduced is based on the annual equivalent cost over 50 years)

<table>
<thead>
<tr>
<th>Element Types</th>
<th>Location</th>
<th>Lifetime</th>
<th>Construction Cost</th>
<th>Annual Maintenance Cost</th>
<th>Total Construction and Maintenance Cost Adjusted for Inflation and Discount at 10% per annum</th>
<th>Annual Equivalent Cost Over 50 Years</th>
<th>KG of TSS reduced per annum</th>
<th>KG of TP reduced per annum</th>
<th>KG of TN reduced per annum</th>
<th>KG of gross pollutants reduced</th>
<th>$/kg of SS reduced</th>
<th>$/kg of TP reduced</th>
<th>$/kg of TN reduced</th>
<th>$/kg of gross pollutants reduced</th>
<th>Ranking</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioretention Basin (100m x 20 m)</td>
<td>Princes Park</td>
<td>20</td>
<td>$99,050</td>
<td>$6,003</td>
<td>$176,813</td>
<td>$8,641</td>
<td>56,261</td>
<td>78</td>
<td>320</td>
<td>30,000</td>
<td>0.16</td>
<td>113.35</td>
<td>27.63</td>
<td>0.29</td>
<td>1</td>
<td>Glen Eira</td>
</tr>
<tr>
<td>Bioretention system (150m x 3m), Wetland (500m2), Swales</td>
<td>Packer Park</td>
<td>20</td>
<td>$395,250</td>
<td>$8,918</td>
<td>$495,398</td>
<td>$24,764</td>
<td>18,797</td>
<td>27</td>
<td>123</td>
<td>85,600</td>
<td>1.42</td>
<td>901.08</td>
<td>201.58</td>
<td>14.57</td>
<td>3</td>
<td>Glen Eira</td>
</tr>
<tr>
<td>Streetscape Bioretention System (1m x 8421m)</td>
<td>800 ha catchment</td>
<td>20</td>
<td>$4,168,445</td>
<td>$0</td>
<td>$6,764,779</td>
<td>$0</td>
<td>237,900</td>
<td>348</td>
<td>1,383</td>
<td>85,600</td>
<td>1.42</td>
<td>971.95</td>
<td>244.57</td>
<td>3.95</td>
<td>3</td>
<td>Glen Eira, Bayside, Port Phillip</td>
</tr>
<tr>
<td>SPT 1</td>
<td>Kang Koonong Rd (corner of Koonong Park)</td>
<td>20</td>
<td>$225,658</td>
<td>$22,566</td>
<td>$478,764</td>
<td>$23,938</td>
<td>25,300</td>
<td>0</td>
<td>0</td>
<td>11,685</td>
<td>0.95</td>
<td>NA</td>
<td>NA</td>
<td>2.05</td>
<td>5</td>
<td>Melbourne Water</td>
</tr>
<tr>
<td>SPT 4</td>
<td>Opposite 425 Koorang Road</td>
<td>20</td>
<td>$173,949</td>
<td>$17,394</td>
<td>$369,045</td>
<td>$18,452</td>
<td>16,100</td>
<td>0</td>
<td>0</td>
<td>7,524</td>
<td>1.15</td>
<td>NA</td>
<td>NA</td>
<td>2.45</td>
<td>6</td>
<td>Melbourne Water</td>
</tr>
<tr>
<td>SPT 5</td>
<td>Corner of Yanakie St and Garrell St</td>
<td>20</td>
<td>$150,641</td>
<td>$15,064</td>
<td>$319,605</td>
<td>$15,980</td>
<td>12,600</td>
<td>0</td>
<td>0</td>
<td>5,900</td>
<td>1.27</td>
<td>NA</td>
<td>NA</td>
<td>2.71</td>
<td>7</td>
<td>Melbourne Water</td>
</tr>
<tr>
<td>SPT 7</td>
<td>Corner of Glenhuntly Road and Empire Road</td>
<td>20</td>
<td>$307,261</td>
<td>$30,726</td>
<td>$519,000</td>
<td>$25,900</td>
<td>25,300</td>
<td>0</td>
<td>0</td>
<td>11,685</td>
<td>0.95</td>
<td>NA</td>
<td>NA</td>
<td>2.05</td>
<td>5</td>
<td>Melbourne Water</td>
</tr>
<tr>
<td>GPTs in 20% of catchment</td>
<td>20% of catchment</td>
<td>20</td>
<td>$2,761,849</td>
<td>$276,185</td>
<td>$5,859,613</td>
<td>$292,981</td>
<td>183,000</td>
<td>0</td>
<td>0</td>
<td>81,320</td>
<td>1.60</td>
<td>NA</td>
<td>NA</td>
<td>3.60</td>
<td>9</td>
<td>Melbourne Water</td>
</tr>
<tr>
<td>GPT 3</td>
<td>Corner of Beach Avenue and Wave Street</td>
<td>20</td>
<td>$57,950</td>
<td>$5,795</td>
<td>$122,948</td>
<td>$6,147</td>
<td>1,169</td>
<td>0</td>
<td>0</td>
<td>528</td>
<td>2.63</td>
<td>NA</td>
<td>NA</td>
<td>5.26</td>
<td>12</td>
<td>Port Phillip</td>
</tr>
<tr>
<td>Stream Enhancement (1000m x 6m)</td>
<td>Upstream of Drain Diversion</td>
<td>50</td>
<td>$720,000</td>
<td>$15,000</td>
<td>$889,000</td>
<td>$17,700</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Other benefits</td>
<td>Melbourne Water</td>
<td></td>
</tr>
<tr>
<td>Stream Enhancement (500m x 6m)</td>
<td>Golf Course Catchment</td>
<td>50</td>
<td>$324,000</td>
<td>$6,750</td>
<td>$395,750</td>
<td>$7,304</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Other benefits</td>
<td>Melbourne Water</td>
<td></td>
</tr>
<tr>
<td>Stream Enhancement (500m x 6m)</td>
<td>Upstream of Drain Diversion</td>
<td>50</td>
<td>$720,000</td>
<td>$15,000</td>
<td>$889,000</td>
<td>$17,700</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Other benefits</td>
<td>Melbourne Water</td>
<td></td>
</tr>
</tbody>
</table>

- **Cost Effective**
- **Other Benefits (river health)**
Figure 6-1  Cost-effectiveness plots of structural treatments based on TSS load reductions. Those structural treatments identified with no cost effectiveness do not treat for TSS.

($/kg of SS reduced is based on the annual equivalent cost over 50 years)
Figure 6-2  Cost-effectiveness plots of structural treatments based on TP load reductions. Those structural treatments identified with no cost effectiveness do not treat for TP.

($/kg of TPreduced is based on the annual equivalent cost over 50 years)
Figure 6-3  Cost-effectiveness plots of structural treatments based on TN load reductions. Those structural treatments identified with no
cost effectiveness do not treat for TN.

($/kg of TN reduced is based on the annual equivalent cost over 50 years)
Figure 6-4  Cost-effectiveness plots of structural treatments based on gross pollutant load reductions. Those structural treatments identified with no cost effectiveness do not treat for gross pollutants.

($/kg of gross pollutants reduced is based on the annual equivalent cost over 50 years)
Figure 6-5  Structural treatments recommended for City of Port Phillip
Figure 6-6  Structural treatments recommended for Bayside City Council
Figure 6-7  Stream enhancement for Melbourne Water
Figure 6-8  Structural treatments recommended for Glen Eira City Council

* note that Bioretention is ranked higher than GPTs because it treats a wider range of pollutants
7  

FUTURE RESIDENTIAL DEVELOPMENT SCENARIO ASSESSMENT

The Elster Creek Catchment is continually subject to growth as new housing replaces old and urban developments expand into previously commercial and industrial areas. As environmental awareness grows, pressure is placed on new developments to conform to environmentally sustainable practices. A number of documents, such as the Urban Stormwater Best Practice Environmental Management Guidelines (BPEMG) (VSC 1999) and the more recent White Paper – Securing Our Water Future Together (Victorian Government, 2004), set objectives for urban development stormwater runoff and water reuse. These objectives are gradually becoming requirements for new developments.

In order to assess the potential future impact of developments within the Elster Creek Catchment, additional MUSIC models were created to simulate the urban landscape in 10 years and 25 years. The developments were assumed to meet new planning controls, with assessment based on improvements to water quality within the catchment.

The following sections discuss planning control requirements, scenario development and results of the MUSIC model future scenarios.

7.1 Planning Control Requirements for New Developments

Potential planning control requirements for stormwater in the Elster Creek Catchment are detailed in the document Stormwater Implementation Project: Statutory Frameworks and Standards (ABM, 2001). This provides a model planning scheme for a number of Councils within the Port Phillip Bay catchment.

The stormwater treatment objectives outlined in the document are based on those proposed in the BPEMG (VSC, 1999) and include:

- Total suspended solids - 80% retention of the typical urban annual load;
- Total nitrogen – 45% retention of the typical urban annual load;
- Total phosphorus – 45% retention of the typical urban annual load; and
- Gross Pollutants – 70% reduction of the typical urban annual load.

The Stormwater Implementation Project: Statutory Frameworks and Standards (ABM, 2001) defines the concept of an “Equivalent Percentage Treated Area” (EPTA). The level to which a treatment measure or treatment train can achieve those BPEMG objectives outlined above determines the EPTA. That is, if the treatment measure meets and/or surpasses those objectives outlined above, the EPTA is 100%.

The proposed target for all new developments is an EPTA of 100%. This may be achieved through the use of treatment measures both on and off site. A minimum on-site treatment requirement is set for developments based on size and restrictions. In the case of development within the Elster Creek catchment, the minimum onsite treatment requirement would be 65%. That is, treatment within the catchments should attain 65% of the BPEMG objectives, e.g. 65% of the 80% reduction in TSS. The remaining 35% treatment may be achieved through treatment measures not on the development site.

It should also be noted that, with the release of the Victorian Government White Paper (2004), additional targets have been set for Melbourne as a whole. These targets are:

- Reducing Melbourne’s drinking water demand by 15% per capita by 2010; and
- Recycling 20% of Melbourne’s “waste” water by 2010.
7.2 Scenario Descriptions

With the introduction of the White Paper, new developments throughout Victoria will soon be subject to a range of planning control requirements aimed at reducing water usage and increasing water reuse.

To assess the long-term impacts of the proposed planning controls, a number of scenarios were investigated in the Elster Creek Catchment. Scenarios were assessed on a 10 (2004-2014) and 25 (2004-2029) year timeframe. Expected growth rates and approximate housing densities were obtained from the Port Phillip Council, Bayside City Council and Glen Eira City Council (see Appendix C). Housing growth rates are discussed below, with a subcatchment breakdown presented in Appendix C. On average, housing growth or replacement within the Elster Creek Catchment is expected be 8.3% in 10 years and 21.5% in 25 years.

7.2.1 Growth Rates

Glen Eira City Council currently has approximately 53,000 dwellings of which approximately 42,000 are located within the Elster Creek catchment. It has been projected that over the next 10 years an additional 3,344 dwellings will be developed with an additional 8,357 dwellings developed over the next 25 years. Total dwellings within the Glen Eira portion of the Elster Creek catchment have therefore been estimated to grow over the next 10 years to 45,344 and 50,357 in the next 25 years. Based on these numbers, growth rates of new and replacement housing were determined to be 8% over the next 10 years and 20% over the next 25 years. These growth rates were applied to all subcatchments located within Glen Eira City Council.

Bayside City Council calculated an annual development rate for new dwellings of 1.141% could be applied to all Bayside areas in the Elster Creek catchment up to 2025. With compounded growth, it was estimated that an additional dwelling growth rate of 12.01% would occur over the next 10 years and 32.79% over the next 25 years.

The City of Port Phillip provided growth rates for the subcatchments of Elwood Canal 1 and Elwood Canal 2, which represented the majority of the municipality’s coverage within the Elster Creek catchment. It was predicted that development rates would progressively decline over the next 25 years. Based on the annual growth rates provided for each subcatchment and taking into account compounded growth, it was estimated that dwelling growth rates within the Elwood Canal 1 subcatchment would be 3.32% over the next 10 years and 7.41% over the next 25 years. It was estimated that dwelling growth rates within the Elwood Canal 2 subcatchment would be 8.4% over the next 10 years and 19.22% over the next 25 years.

Where subcatchments were located in more than one municipality, development rates were applied based on the area of each municipality represented within the subcatchment.

7.2.2 Objectives

In line with the requirements of the Stormwater Implementation Project: Statutory Frameworks and Standards (ABM, 2001) and BPEMG (VSC, 1999), both the 10-year and 25-year assessments were undertaken for two scenarios: assuming new developments meet 65% of best practice and 100% of best practice (see Section 7.1).

The selection of appropriate treatment trains and other best practice tools in new developments is largely site specific. The future scenarios investigated here therefore look at the impacts of achieving 65% and 100% BMP objectives, but do not consider the tools required to accomplish these goals. General information on various treatment tools is provided in Appendix D.
7.3 Model Methodology

The model of the Elster Creek catchment was simplified into areas of parks, unaltered urban and new developments. A GPT was included in the model to represent the GPTs already in place within the catchment. It was assumed that the subcatchments of the GPTs contained the same proportion of new urban to unaltered urban as other areas. Figure 7-1 presents an example of the MUSIC layout for the future scenarios.

Figure 7-1 Future scenario model layout example

A generic treatment node was used to represent the treatment of new development to best practice. The generic node allows for control over the levels of pollutants exiting a catchment. Pollutant reductions were therefore adjusted to obtain outflows from the new developments equal to 65% and 100% of the best practice objectives for the respective scenarios. The treatment levels used in each scenario are presented in Table 7-1.

Table 7-1 Scenario Treatment Levels

<table>
<thead>
<tr>
<th></th>
<th>BMP Objectives Pollutant Reductions</th>
<th>65% BMP Pollutant Reductions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Suspended Solids</td>
<td>80%</td>
<td>52%</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>45%</td>
<td>29%</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>45%</td>
<td>29%</td>
</tr>
<tr>
<td>Gross Pollutants</td>
<td>70%</td>
<td>46%</td>
</tr>
</tbody>
</table>
7.4 MUSIC model results

The impacts of implementing best practice, and achieving the objectives of 65% and 100% BMP in new developments, were assessed at the downstream end of the Elster Creek Catchment. Table 7-2 presents the percentage reductions achieved within the catchment for each of the four future scenarios. The “Current Treatment” column represents the impacts of the GPTs already in place in the catchment.

**Table 7-2 Future scenario overall pollutant reductions**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Current Treatment</th>
<th>65% BMP 10yr</th>
<th>65% BMP 25yr</th>
<th>100% BMP 10yr</th>
<th>100% BMP 25yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Suspended Solids</td>
<td>0.9%</td>
<td>4.2%</td>
<td>10.3%</td>
<td>7.2%</td>
<td>14.3%</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>0%</td>
<td>2.1%</td>
<td>5.2%</td>
<td>3.4%</td>
<td>7.9%</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>0%</td>
<td>2.3%</td>
<td>5.1%</td>
<td>3.5%</td>
<td>7.6%</td>
</tr>
<tr>
<td>Gross Pollutants</td>
<td>1.4%</td>
<td>4.7%</td>
<td>9.3%</td>
<td>6.6%</td>
<td>13.4%</td>
</tr>
</tbody>
</table>

It can be seen that BMP implementation in new developments has a similar impact to the proposed structural measures on the overall catchment loads. It is recommended that treatment and reuse options on a municipal scale also be investigated in order to work toward the targets set out in the Victorian Government’s White Paper: *Our Water Our Future* (2004). The paper promotes the delivery of water savings through the adoption of WSUD principles and utilising this recycled urban stormwater for non-drinking uses such as park irrigation (Victorian Government, 2004).

The long term move to WSUD is likely to cost-shift the potential drainage and water management cost from State (Melbourne Water) to councils through moving treatment up into smaller catchments away from the trunk (Melbourne Water) drainage system. The recently developed DRAFT WSUD Engineering Procedures: Stormwater (Melbourne Water, 2004) should assist councils in achieving their targets and further developing existing works.

As part of the White Paper’s action plan the State Government has made $10 million in funding available to conserve our water supplies and develop new water sources, particularly by taking advantage of stormwater. The three-year Stormwater and Urban Water Conservation Fund will be used to develop infrastructure, demonstration projects and education projects in cities and towns across the State. The Fund will support local scale innovative water sensitive urban development initiatives, stormwater conservation and water recycling initiatives across Victoria.
8 RECOMMENDATIONS

- It is recommended that the Working Group continue to meet to discuss the implementation of the structural treatments on a regular basis to ensure continued involvement of each organisation and their ongoing commitment to the implementation of recommended structural treatments.

- It is recommended that the first activity for the Working Group should be to utilise the structural ranking table (Table 6-1) and Figures 6-1 to 6-7 provided in this report to guide prioritisation of implementation planning. Implementation of priority structural treatments should be a medium to long-term goal and implementation should occur through a scheduled program, with flexibility to accommodate opportunistic projects (as an example road upgrades or new developments).

- Site-specific structural opportunities at the park level offer many challenges in terms of their feasibility. It is therefore recommended that WSUD principles be integrated into each Council’s operations (such as street upgrades) and management framework.

- The most viable form of structural treatment for reducing nutrients and heavy metals is streetscape bioretention. The implementation of streetscape bioretention has the potential to significantly reduce pollutant loads, however with only a small number of street upgrades occurring per year, implementation through these means would be considered long term. To achieve significant reductions sooner, it is recommended that designs of the site-specific structural treatments be advanced in order of priority over the near to medium term, to identify those to construct. The detailed design phase may require revision of designs and forecast expenditure depending on how well these recommended treatments could be integrated within each specific site.

- It is recommended that costs and pollutant removal efficiencies be monitored as a part of the implementation of structural measures. This will enable implementation to be evaluated and refined using the principle of ‘adaptive environmental management’, reflecting the outcomes of monitoring and in accordance with each organisations’ budget planning activities.

- It is recommended that a proactive approach to stormwater management be adopted to minimise the impacts of new and in-fill developments. Long-term stormwater quality improvements can be assured through changes to the planning and design requirements to implement new and improved stormwater management methods. It is recommended that WSUD be included as part of Councils’ planning documentation frameworks to encourage developers to address stormwater quality management issues as part of the development design process. It is recommended that Councils engage in implementing WSUD through their planning schemes and that the planning controls examined in this report should be adopted for new developments located throughout the Elster Creek catchment.

- The catchment is predominantly residential. It is recommended that a multi-faceted approach be adopted to effectively manage stormwater in the Elster Creek catchment by utilising non-structural stormwater management tools such as education, planning, regulation and enforcement in addition to the stormwater treatments recommended. For example, it is recommended that Councils consider planning and enforcement options to control sediment from building sites in addition to treatment measures. In addition, education and enforcement may be a better alternative to manage some pollutants such as E.coli and pathogens, which are commonly derived from illegal connections, animal droppings or sewer leakages. These stormwater management tools also have the potential to offer an improved benefit to cost ratio.

- Instream habitat improvement in the lower reaches of the Elster Creek and Elwood Canal should occur in conjunction with improvements in stormwater treatment in the catchment. It is recommended that further investigation be undertaken by Melbourne Water to demonstrate if stream restoration is warranted based on whether it improves instream biotic communities and stream health.
CONCLUSIONS

9 CONCLUSIONS

The Elster Creek Catchment Study provides a basis to manage stormwater using structural treatments and reports the current water quality status for the study area. In addition, the study provides a sound basis to support each prioritised allocation of funding for structural treatment measures in the future.

The Elster Creek Catchment Study has been developed with the involvement of a Working Group. In this regard, the study reflects the specific requirements of each Council and the practical implications of applying various treatment trains and recommendations. Each Council’s continued commitment to the implementation of the study recommendations will be critical to its success and final effectiveness.

The implementation of site-specific structural treatments offers good pollutant reduction potential. A reduction in TSS of 5.6 %, TP of 3.2 %, TN of 1.8 % and Gross Pollutants of 13.7 % could be achieved with just three bioretention systems being placed in the catchment. A reduction in metals, many of which can be associated with TSS, would also be achieved. This is impressive when compared to a larger catchment within Victoria, where it would currently cost approximately $600 million to achieve a 20% reduction in TSS and a 16% reduction in TP through the adoption of current best management practices (including WSUD). However, implementing site-specific treatments poses a significant challenge due to constraints associated with available open space, recreational use and other services. Further reductions may be achieved as streets within each municipality are upgraded based on water sensitive urban design principles. Gross pollutants can be effectively targeted in commercial zones through the implementation of gross pollutant traps or gully pit baskets.

It is also important to note that the implementation of structural treatments is only one component of stormwater management, and it is recommended that stormwater management be included in planning controls, education, regulation and enforcement and capacity building within each Council.

While the study provides many structural treatment recommendations to address current stormwater threats, it also identifies how the implementation of new planning control requirements for future development will improve stormwater in the study area for 10 and 25 years. The implementation of new planning controls on all new developments may achieve significant reductions in catchment loads. It is envisaged that as catchment redevelopment proceeds over the next 25 years, even greater gains may be achieved.

Adoption of these recommendations and the implementation of the new planning controls, accompanied by ongoing maintenance and support, will help secure the protection of values associated with Elster Creek for years to come. Ultimately, improvement to the water quality reaching Elster Creek and the Elwood Canal relies on each Council’s ability to embrace and implement the recommendations in this study and the new planning controls so that stormwater management becomes an integrated and seamless part of each Council’s long term management strategy.
REFERENCES

10 REFERENCES


Coleman, R., Faecal Surveys 2000-2001: Elster Creek, Murrumbeena Main Drain & Heatherton Road Drain, Catchments & Waterways Melbourne Water, June 2001


Glen Eira City Council (2004) Sections from the Preliminary Draft Stormwater Management Plan (Unpublished)


WATER ECOscience (1999) Stormwater Management Plan, for City of Port Phillip, March 1999
APPENDIX A: SUMMARY OF AVAILABLE DATA AND INFORMATION

This Appendix provides a summary of key data and information used in the study. Data and information have been used to:

- Describe existing characteristics of the stormwater drainage system;
- Gain an understanding of current and proposed land uses; and
- Provide background information to assist in identifying treatment opportunities.

A-1 Background Material

Background material used in the study was obtained from a variety of sources including Melbourne Water, Bayside, Glen Eira and Port Phillip Councils. Table A-1 summaries the following information:

- The author/origin of the document;
- Document title; and
- Date of publication.

A-2 GIS Data

To undertake the study, GIS data were obtained from the Melbourne Water, City of Port Phillip, Glen Eira City Council, and Bayside City Council and incorporated into a MapInfo GIS database. The following list outlines the data obtained:

- Land use zones and planning overlays
- Road layouts
- Municipal boundary
- Drainage system information
- Contours
- Waterways and structural treatment management devices
- Aerial photography

In addition to digital data, Councils also provided information identifying the location and details of existing structural treatment devices.
### Table A-1  Local information summary

<table>
<thead>
<tr>
<th>Author/origin</th>
<th>Document Title</th>
<th>Publication Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhys Coleman, Catchments &amp; Waterways</td>
<td>Faecal Surveys 2000-2001: Elster Creek, Murrumbeena Main Drain &amp; Heatherton Road Drain</td>
<td>June 2001</td>
</tr>
<tr>
<td>Melbourne Water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glen Eira City Council</td>
<td>Sections from the Preliminary Draft Stormwater Management Plan</td>
<td>Unpublished</td>
</tr>
<tr>
<td>Association of Bayside Municipalities</td>
<td>Port Phillip Coastal Marine Planning Program: Statutory Framework and Standards</td>
<td>September 2001</td>
</tr>
<tr>
<td>WATER ECOscience</td>
<td>Port Phillip Stormwater Management Plan</td>
<td>March 1999</td>
</tr>
</tbody>
</table>
APPENDIX B: MUSIC MODELLING

B-1 Pollutant Export Concentrations

MUSIC pollutant export concentrations were defined based on the concentration of a given pollutant within runoff under stormwater and base flow conditions. The pollutant loading rates adopted for the purposes of this study were based on a review of international and Australian data. The CRCCH publication Urban Stormwater Quality: A Statistical Overview (Duncan 1999) provides a summary of available data that were used as a basis for identifying runoff concentrations for various land uses and pollutant types based on event mean concentration data. The adopted pollutant concentrations are summarised in Table B-1 for the two generic land use types used in the modelling: “Urban” and “Parks and Recreation”.

With respect to the pollutant concentrations, the following comments may be made:

- The pollutant loading rates are averages of data from a number of national and international sources. Their direct applicability to the Elster Creek catchment has not been established as insufficient local water quality data are available. However, the data provides a means of predicting the relative loads for each land use considered in this study.
- Base flow pollutant load parameters for all catchment types were the same and based on MUSIC default urban node values. This reflects that Parks and Recreation also occur in an ‘urban’ environment.
- Event flow load parameters were left as default for Urban nodes and adjusted to represent low urban forest as defined in Duncan (1999) for Parks and Recreation nodes, with default standard deviations maintained.

Table B-1 MUSIC modelling parameters for land use types

<table>
<thead>
<tr>
<th>Land Use Type</th>
<th>Base flow concentration parameters</th>
<th>Storm flow concentration parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Suspended Solids (log mg/L) Mean</td>
<td>Total Phosphorus (log mg/L) Mean</td>
</tr>
<tr>
<td></td>
<td>Std Dev</td>
<td>Std Dev</td>
</tr>
<tr>
<td>Urban</td>
<td>1.100 0.17</td>
<td>-0.820 0.19</td>
</tr>
<tr>
<td>Parks and Recreation</td>
<td>1.100 0.17</td>
<td>-0.820 0.19</td>
</tr>
<tr>
<td></td>
<td>2.200 0.32</td>
<td>1.905 0.32</td>
</tr>
</tbody>
</table>

B-2 Hydrological Parameters

Hydrological processes, i.e. rainfall and runoff, are modelled in MUSIC using an algorithm that considers the behaviour of soil moisture store and impervious area. Runoff is generated when the capacity of the soil moisture storage is exceeded and in proportion with the area of imperviousness of the catchment. Principal parameters used in these analyses were:

- Catchment area of each land use; and
- Variation of the proportion of catchment that is impervious to achieve an appropriate long-term proportion of rainfall being converted to runoff.

Areas of the two-land use types (Urban and Parks and Recreation) were defined based on information derived from the planning scheme to allow for a spatial assessment approach of treatment opportunities.

Ranges of fraction imperviousness were adopted to reflect different land uses within the study area. Total fraction imperviousness as outlined in the Melbourne Water MUSIC Input Parameter Guidelines (2004) was used as a guide to define the effective fraction impervious of different land uses. 80% of the typical value for total imperviousness provided in these guidelines was adopted as the effective fraction impervious for the purposes of this study (Table B-2). In addition to percent impervious, a number of pollutant export and other hydrologic parameters may be entered into MUSIC, however default values were used apart from storm flow the pollutant generation rates mentioned before, reflecting the
likely similarity of fraction imperviousness across urban areas of the Elster Creek catchment and limitations in knowledge about the catchment.

### Table B-2 Adopted fraction imperviousness for study area land uses zones

<table>
<thead>
<tr>
<th>Zone</th>
<th>Zone Codes</th>
<th>Brief Description / Examples</th>
<th>Normal Range</th>
<th>Typical Value</th>
<th>Adopted Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential 1 &amp; 2 Zone</td>
<td>RDZ1</td>
<td>Normal Density Range</td>
<td>0.40 - 0.50</td>
<td>0.45</td>
<td>0.4</td>
</tr>
<tr>
<td>Mixed Use Zone</td>
<td>MUZ</td>
<td>Mix of residential, commercial, industrial &amp; hospitals.</td>
<td>0.40 - 0.60</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Public Park and Recreation Zone</td>
<td>PPRZ</td>
<td>Main zone for public open space, inc golf courses.</td>
<td>0.00 - 0.20</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

### B-3 Rainfall and Evapotranspiration

Rainfall and evapotranspiration data from the Bureau of Meteorology (BOM) are available for various stations around Australia, and a number of stations with varying rainfall distributions have been identified throughout Victoria for the use in MUSIC. A relatively frequent time step is required to reflect most accurately the time of concentration that is likely to occur in the smallest of the study subcatchments and subsequently all models were run stochastically using a 30-minute time step.

The reference year of 1959 of Melbourne Rainfall data, as recommended in the Melbourne Water MUSIC guidelines (2004), was used in MUSIC simulations. To ensure that the rainfall data used was applicable to the Elster Creek Catchment, comparisons were made between the mean monthly rainfall data for Melbourne Regional Office (1908 to 2003) and Brighton (1924 to 2003). Figure B-1 presents the mean monthly rainfall data from both stations. It can be seen that the rainfall patterns and averages are similar at the two stations, and the use of the Melbourne data is therefore considered appropriate.

![Figure B-1 Mean monthly rainfall data](image)

Evapotranspiration data for Melbourne available in the MUSIC model was used in the simulations. The mean daily values are presented in Table B-3.
Table B-3  Mean daily evapotranspiration data

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evap (mm)</td>
<td>4.84</td>
<td>4.29</td>
<td>3.23</td>
<td>2.33</td>
<td>1.29</td>
<td>1.33</td>
<td>1.29</td>
<td>1.45</td>
<td>2.33</td>
<td>3.39</td>
<td>4.5</td>
<td>4.35</td>
</tr>
</tbody>
</table>

B-4 Model Design

The Elster Creek catchment was separated into a series of subcatchments, which enabled an assessment of each structural treatment opportunity. The established MUSIC model, which was built to reflect these subcatchments, is provided in Figure B-2.

![Figure B-2](image_url)
**B-5 Treatment Opportunity Pollutant Export Modelling**

MUSIC was used to assess stormwater treatment opportunities with the Elster Creek catchment by simulating their level of performance. MUSIC estimates the level of stormwater treatment these opportunities would achieve in a given catchment. The following section provides an overview of the set up and inputs used for the simulation of treatment measure design parameters. Information on each of the proposed treatment measures is presented in more detail in Appendix D.

**Gross Pollutant Traps**

MUSIC allows the effectiveness of gross pollutant traps to be simulated by varying the parameters for the removal efficiency of total suspended solids (TSS), total phosphorus (TP), total nitrogen (TN), and gross pollutants. For the simulation of the gross pollutant trap in this study, adjustments were made to the TSS and Gross Pollutant MUSIC defaults, while the TN default was maintained.

The default curves provided in the model do not allow for any removal of incoming pollutants by GPTs and have to be modified by the user. Investigations into the removal of TSS by a GPT suggest that TSS removal is relatively effective for incoming concentrations above 75 mg/L, but less so for concentrations below this level (Walker, Allison, Wong and Wootton, 1999). In accordance with this, the efficiency removal curve for TSS was adjusted to provide no removal for incoming concentrations below 75 mg/L. The removal efficiency was set at 70% for TSS concentrations above 75 mg/L. Gross pollutants were adjusted to have 95% removal efficiency, while TP and TN were left as having no treatment.

**Wetland Parameters**

As has previously been identified, there is the potential opportunity for the development of a wetland as part of a treatment train within the Elster Creek Catchment. The wetland node within MUSIC requires the input of a range of inlet, outlet, and storage properties.

For each of the simulations, the size of the wetland was based on available space. Additional model parameters adopted for the wetlands were:

- Inlet volume – 10% of the total volume of the wetland;
- Permanent pool volume – 15% of the total volume of the wetland;
- Extended detention depth – 0.5m;
- Outlet pipe diameter – varied to provide a flow rate equivalent to a detention time of 72 hours when the wetland was full;
- Default parameters were adopted for the remaining model parameters.

**Bio-retention System**

A bio-retention system is an ephemeral storage underlain by porous media. The MUSIC parameters for a bio-retention system include filter properties in addition to inlet, storage, and outlet properties. The size of each bioretention system was based on an estimate of available space performed during the opportunity assessment. The filter area for each bio-retention system was estimated to be 50% of the available space, which roughly takes into account the area required for ephemeral storage zones and side slopes. The MUSIC defaults were used for all other parameters for each infiltration trench assessed:

- seepage loss (0 mm/hr);
- extended detention depth (0.2 m);
- filter particle effective diameter (0.45mm);
• saturated hydraulic conductivity (100mm/hr);
• equivalent weir width (2m);
• low flow bypass (0 m3/s); and
• high flow bypass (100 m3/s).

Infiltration Trench

An infiltration trench is a shallow, excavated trench filled with gravel, rock or porous material, in which run-off collects. Stormwater filtrates from the trench into the surrounding soil. The trench discharges the treated stormwater into a conventional pipe system. Figure D-2 presents an end view of a typical infiltration trench.

The MUSIC parameters for a channel infiltration system include filter properties in addition to inlet, storage, and outlet properties. The Bioretention Treatment node in the MUSIC model was therefore adjusted to reflect an infiltration trench system.

The surface area of the infiltration trench would be the trench width by the length of the trench. Filter areas and MUSIC parameters were modelled similarly to the Bioretention Treatment node described above.

Sand Filters

A sand filter operates in a similar manner to bioretention systems apart from having no vegetation growing on the surface. This is because sand filters are either installed underground or the filter medium does not retain sufficient moisture.

The MUSIC parameters for a sand filter system include filter properties in addition to inlet, storage, and outlet properties. The Bioretention Treatment node in the MUSIC model was therefore adjusted to reflect a sand filter system.

Filter areas and MUSIC parameters were modelled similarly to the Bioretention Treatment node described above.

Gully Pit Baskets

Gully pit baskets are considered to be an at-source control (located as close to the source of pollution as possible). Gully pit baskets are installed as an integral component of a gully pit (not within the pipeline) and screen the pollutants out of the runoff as it enters the pit. They are generally located directly beneath the grate. Fine filtration media can be used as an effective treatment for fine particulates as particles greater than the mesh size are retained. Figure B-3 presents a cross section of an ENVIROPOD gully pit basket.

Similar to gross pollutant traps, gully pit baskets perform as filters. The gross pollutant trap node in the MUSIC model was therefore adjusted to reflect a gully pit basket system. Research assessing the performance of ENVIROPOD gully pit baskets with a 200 micron mesh indicates that 78% TSS removal efficiency is appropriate to be adopted for the GPT node in MUSIC (Enviropod Holdings Ltd, 2001; Diffuse Sources Ltd, 2001).

Gross pollutants and nutrient removal efficiencies for GPTs were adopted for the gully pits as there were not reported results for these pollutants. Gross pollutants therefore had 95% removal efficiency, while TP and TN had no treatment.
The established MUSIC model built to reflect treatment opportunities is provided in Figure B-4.
A streetscape bioretention and gully pit basket model was developed to assess their implementation across 20% of the Elster Creek catchment. A MUSIC model was built to assess the implementation of streetscape bioretention and gully pit baskets and is provided in Figure B-6. The sizing of the bioretention treatment area was based on typical street, which was assumed to be 40 m long and 15 m wide with house blocks of 10 m wide and 40 m deep. Bioretention was assumed to be 1 m wide and span the length of the street. Street catchment area size was therefore 3800 m² and the area of bioretention was 40 m². The ratio of bioretention to catchment size area was applied to 20% of the catchment (approximately 800 ha) to determine a bioretention area of 8400 m².
Figure B-6 Streetscape bioretention and gully pit basket MUSIC models
Table B-4 MUSIC results for each subcatchment and streetscape treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Subcatchment</th>
<th>Pollutant</th>
<th>Sources</th>
<th>Residual Load</th>
<th>% reduction</th>
<th>Reduction in Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioretention Basin</td>
<td>Caulfield Park</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>45300</td>
<td>8290</td>
<td>82</td>
<td>37010</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>92</td>
<td>35</td>
<td>62</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>660</td>
<td>418</td>
<td>37</td>
<td>242</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>11200</td>
<td>0</td>
<td>100</td>
<td>11200</td>
</tr>
<tr>
<td>Bioretention Basin</td>
<td>Green Meadows Garden</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>51900</td>
<td>11989</td>
<td>77</td>
<td>39911</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>102</td>
<td>43</td>
<td>58</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>752</td>
<td>493</td>
<td>34</td>
<td>259</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>12600</td>
<td>0</td>
<td>100</td>
<td>12600</td>
</tr>
<tr>
<td>Bioretention Basin</td>
<td>Princess Park</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>127000</td>
<td>70739</td>
<td>44</td>
<td>56261</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>252</td>
<td>174</td>
<td>31</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>1770</td>
<td>1450</td>
<td>18</td>
<td>320</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>30000</td>
<td>0</td>
<td>100</td>
<td>30000</td>
</tr>
<tr>
<td>Bioretention Basin</td>
<td>Victory Reserve</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>256000</td>
<td>216720</td>
<td>16</td>
<td>41280</td>
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<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>517</td>
<td>454</td>
<td>12</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>3830</td>
<td>3508</td>
<td>8</td>
<td>322</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>62300</td>
<td>0</td>
<td>100</td>
<td>62300</td>
</tr>
<tr>
<td>Bioretention Basin</td>
<td>Halley Park</td>
<td>Total Suspended Solids (kg/yr)</td>
<td>242000</td>
<td>192148</td>
<td>21</td>
<td>498852</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>515</td>
<td>436</td>
<td>15</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>3550</td>
<td>3280</td>
<td>8</td>
<td>270</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>56600</td>
<td>0</td>
<td>100</td>
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## Table B-5  MUSIC results for each subcatchment and streetscape treatments as GPTs

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### Table B-6  MUSIC results for each additional GPT identified in the Elster Creek catchment

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<td>49</td>
<td>12600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>53</td>
<td>53</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>382</td>
<td>382</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>6210</td>
<td>310</td>
<td>95</td>
<td>5900</td>
</tr>
<tr>
<td><strong>GPT 4</strong></td>
<td></td>
<td>Total Suspended Solids (kg/yr)</td>
<td>33100</td>
<td>17000</td>
<td>49</td>
<td>16100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>68</td>
<td>68</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>478</td>
<td>478</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>7920</td>
<td>396</td>
<td>95</td>
<td>7524</td>
</tr>
<tr>
<td><strong>GPT 5</strong></td>
<td></td>
<td>Total Suspended Solids (kg/yr)</td>
<td>4920</td>
<td>2580</td>
<td>48</td>
<td>2340</td>
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<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>11</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>77</td>
<td>77</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>1230</td>
<td>62</td>
<td>95</td>
<td>1169</td>
</tr>
<tr>
<td><strong>GPT 6</strong></td>
<td></td>
<td>Total Suspended Solids (kg/yr)</td>
<td>4840</td>
<td>2490</td>
<td>49</td>
<td>2350</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>73</td>
<td>73</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>1180</td>
<td>59</td>
<td>95</td>
<td>1121</td>
</tr>
<tr>
<td><strong>GPT 7</strong></td>
<td></td>
<td>Total Suspended Solids (kg/yr)</td>
<td>15300</td>
<td>7700</td>
<td>50</td>
<td>7600</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Phosphorus (kg/yr)</td>
<td>32</td>
<td>32</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total Nitrogen (kg/yr)</td>
<td>220</td>
<td>220</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gross Pollutants (kg/yr)</td>
<td>3530</td>
<td>177</td>
<td>95</td>
<td>3353</td>
</tr>
</tbody>
</table>
APPENDIX C: FUTURE SCENARIO ASSESSMENTS
Table C-1  Future scenario subcatchment areas

<table>
<thead>
<tr>
<th>Subcatchment</th>
<th>Municipality</th>
<th>Parks (ha)</th>
<th>Expected growth (%)</th>
<th>Unaltered urban (ha)</th>
<th>New development (ha)</th>
<th>Additional houses</th>
<th>Houses with tanks</th>
<th>Reduction in volume (ML)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>10y</td>
<td>25y</td>
<td>10y</td>
<td>25y</td>
<td>10y</td>
<td>25y</td>
<td></td>
</tr>
<tr>
<td>Elwood Canal 1</td>
<td>Port Phillip/ Bayside/Glen Eira</td>
<td>11.66</td>
<td>6.75</td>
<td>16.67</td>
<td>470.36</td>
<td>430.37</td>
<td>31.75</td>
<td>71.74</td>
</tr>
<tr>
<td>Elwood Canal 2</td>
<td>Port Phillip/Bayside</td>
<td>10.22</td>
<td>8.87</td>
<td>21.00</td>
<td>59.98</td>
<td>53.97</td>
<td>5.32</td>
<td>11.33</td>
</tr>
<tr>
<td>Golf Course 1</td>
<td>Glen Eira</td>
<td>7.08</td>
<td>8.00</td>
<td>20.00</td>
<td>52.58</td>
<td>47.33</td>
<td>4.21</td>
<td>9.47</td>
</tr>
<tr>
<td>Golf Course 2</td>
<td>Bayside</td>
<td>4.43</td>
<td>12.01</td>
<td>32.79</td>
<td>28.83</td>
<td>24.32</td>
<td>3.46</td>
<td>7.97</td>
</tr>
<tr>
<td>Upstream Diversion 1</td>
<td>Bayside/Glen Eira</td>
<td>6.47</td>
<td>8.69</td>
<td>22.20</td>
<td>481.72</td>
<td>428.46</td>
<td>41.86</td>
<td>95.12</td>
</tr>
<tr>
<td>Upstream Diversion 2</td>
<td>Bayside</td>
<td>6.16</td>
<td>12.01</td>
<td>32.79</td>
<td>270.06</td>
<td>227.80</td>
<td>32.43</td>
<td>74.69</td>
</tr>
<tr>
<td>Landcox Park</td>
<td>Bayside</td>
<td>9.97</td>
<td>12.01</td>
<td>32.79</td>
<td>43.52</td>
<td>36.71</td>
<td>5.23</td>
<td>12.04</td>
</tr>
<tr>
<td>Victory Reserve</td>
<td>Glen Eira</td>
<td>1.57</td>
<td>8.00</td>
<td>20.00</td>
<td>49.23</td>
<td>44.31</td>
<td>3.94</td>
<td>8.86</td>
</tr>
<tr>
<td>Halley Park</td>
<td>Glen Eira</td>
<td>32.33</td>
<td>8.00</td>
<td>20.00</td>
<td>482.25</td>
<td>434.03</td>
<td>38.58</td>
<td>86.81</td>
</tr>
<tr>
<td>Greenmeadow Gardens</td>
<td>Glen Eira</td>
<td>0</td>
<td>8.00</td>
<td>20.00</td>
<td>12.49</td>
<td>11.24</td>
<td>1.00</td>
<td>2.25</td>
</tr>
<tr>
<td>Caulfield Park</td>
<td>Glen Eira</td>
<td>45.89</td>
<td>8.00</td>
<td>20.00</td>
<td>86.22</td>
<td>77.60</td>
<td>6.90</td>
<td>15.52</td>
</tr>
<tr>
<td>Princes Park</td>
<td>Glen Eira</td>
<td>15.87</td>
<td>8.00</td>
<td>20.00</td>
<td>256.33</td>
<td>230.70</td>
<td>20.51</td>
<td>46.14</td>
</tr>
<tr>
<td>Lord Reserve</td>
<td>Glen Eira</td>
<td>30.32</td>
<td>8.00</td>
<td>20.00</td>
<td>131.10</td>
<td>117.99</td>
<td>10.49</td>
<td>23.60</td>
</tr>
<tr>
<td>EE Gunn Reserve</td>
<td>Glen Eira</td>
<td>12.06</td>
<td>8.00</td>
<td>20.00</td>
<td>73.17</td>
<td>65.85</td>
<td>5.85</td>
<td>13.17</td>
</tr>
<tr>
<td>Allnutt Park</td>
<td>Glen Eira</td>
<td>25.86</td>
<td>8.00</td>
<td>20.00</td>
<td>545.69</td>
<td>491.13</td>
<td>43.66</td>
<td>98.23</td>
</tr>
<tr>
<td>Velodrome</td>
<td>Glen Eira</td>
<td>4.56</td>
<td>8.00</td>
<td>20.00</td>
<td>25.11</td>
<td>22.60</td>
<td>2.01</td>
<td>4.52</td>
</tr>
<tr>
<td>Packer Park</td>
<td>Glen Eira</td>
<td>15.15</td>
<td>8.00</td>
<td>20.00</td>
<td>14.06</td>
<td>12.66</td>
<td>1.13</td>
<td>2.53</td>
</tr>
<tr>
<td>Joyce Park</td>
<td>Glen Eira</td>
<td>11.16</td>
<td>8.00</td>
<td>20.00</td>
<td>157.95</td>
<td>142.16</td>
<td>12.64</td>
<td>28.43</td>
</tr>
<tr>
<td>Duncan McKinnon Reserve</td>
<td>Glen Eira</td>
<td>9.64</td>
<td>8.00</td>
<td>20.00</td>
<td>127.35</td>
<td>114.62</td>
<td>10.19</td>
<td>22.92</td>
</tr>
<tr>
<td>Bentleigh -Hodgson Reserve</td>
<td>Glen Eira</td>
<td>1.1</td>
<td>8.00</td>
<td>20.00</td>
<td>80.48</td>
<td>72.43</td>
<td>6.44</td>
<td>14.49</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>261.5</strong></td>
<td></td>
<td><strong>3448.4</strong></td>
<td><strong>3074.4</strong></td>
<td><strong>287.6</strong></td>
<td><strong>661.7</strong></td>
<td><strong>4481</strong></td>
</tr>
</tbody>
</table>
Development Rates Provided by Council

Bayside

Bayside has areas in seven subcatchments as indicated on the map boundaries supplied by WBM. The majority of the areas are covered by Brighton East. Bayside does not possess data on expected development rates. Existing data on development in Bayside is available on a postcode area basis. For the purposes of modelling based on the available data it was considered adequate to use the average development rate in East Brighton post code area 3187 over the preceding six years (1998-2003) as the basis for expected development rates in these seven catchments over the next 20 years.

The development rate was based on an approximate number of households of 6000 in postcode 3187. This was based on the number of rateable domestic dwellings and cross checked with 2001 Census data for validation. The number of new residences constructed each year was determined from Councils building database and includes houses, flats and townhouses.

The calculated average development rate for the period 1998 to 2003 is 1.141%.

This annual development rate is considered appropriate to apply for all Bayside areas in the Elster Creek subcatchments up to 2025.

The predicted development rate of 1.14% will apply to the areas of Bayside in the following catchments: Elwood Canal 1, Elwood Canal 2, Golf Course 1 and Golf Course 2, Upstream Diversion 1, Upstream Diversion 2, Landcox Park.

Port Phillip

The City of Port Phillip has areas in four subcatchments as indicated on the map boundaries supplied by WBM. The majority of the coverage is in Elwood Canal 1 and Elwood Canal 2 subcatchments. Very small areas of Port Phillip are in the Golf Course 1 subcatchment.

Data on the total number of properties and number of developments for houses and units over the period 1998 to 2003 have been extracted for the areas of Port Phillip in Elwood Canal 1 and Elwood Canal 2 subcatchments.

Over the period 1998 to 2000 the average number of houses and units developed in Elwood Canal 1 per annum was 29.33 and the area has 7370 properties. In Elwood Canal 2 an average of 32.5 properties were built each year. The total number of properties in Elwood Canal 2 is 3284.

There was not enough data to make estimates of the development rate in either the Golf Course 1 or Morres St Reserve subcatchments. As the majority of these catchments are located in the Glen Eira City Council it would be appropriate to use the rates supplied by Glen Eira.

Strategic planners at Port Phillip have developed predictions of future development rates for the City of Port Phillip. These assumptions are based on:

Predicted slowdown in residential property market to 2010

Progressive reduction in number of sites available for large infill after 2010

A progressive reduction in the total number of infill dwellings in established residential areas due to the majority of medium density infill in strategically preferred locations associated with Melbourne 2030 policy directives.
For developments of 1-5 dwellings it is predicted that there will be a reduction from current rates of 20% from 2006 to 2015 and 30% from 2016 to 2020 and 40% from 2021 to 2030. It is appropriate to use these reductions for modelling future development in the areas of Elwood, Elsternwick and Balaclava that are in the Elster Creek Catchment.

The predicted development rates based on these reductions are as follows:

Table C-2 Elwood Canal 1 subcatchment

<table>
<thead>
<tr>
<th>Expected Development Rate</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4%</td>
<td>2004-2005</td>
</tr>
<tr>
<td>0.32%</td>
<td>2006-2015</td>
</tr>
<tr>
<td>0.28%</td>
<td>2016-2020</td>
</tr>
<tr>
<td>0.24%</td>
<td>2021-2030</td>
</tr>
</tbody>
</table>

Table C-3 Elwood Canal 2 subcatchment

<table>
<thead>
<tr>
<th>Expected Development Rate</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.99%</td>
<td>2004-2005</td>
</tr>
<tr>
<td>0.79%</td>
<td>2006-2015</td>
</tr>
<tr>
<td>0.69%</td>
<td>2016-2020</td>
</tr>
<tr>
<td>0.59%</td>
<td>2021-2030</td>
</tr>
</tbody>
</table>
Table C-4 Project additional dwellings for Glen Eira

<table>
<thead>
<tr>
<th>Sub-catchment area</th>
<th>Area (km²)</th>
<th>Percentage % of total area of Glen Eira</th>
<th>Projected additional dwellings in sub-catchment areas*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(Total area = 38.67 km²)</td>
<td>2004 – 2014 (10 years)</td>
</tr>
<tr>
<td>Elwood Canal 1</td>
<td>3.5652</td>
<td>9.219</td>
<td>391</td>
</tr>
<tr>
<td>Elwood Canal 2</td>
<td></td>
<td>Not in Glen Eira Municipal Area</td>
<td></td>
</tr>
<tr>
<td>Golf Course 1</td>
<td>0.3975</td>
<td>1.028</td>
<td>44</td>
</tr>
<tr>
<td>Golf Course 2</td>
<td></td>
<td>Not in Glen Eira Municipal Area</td>
<td></td>
</tr>
<tr>
<td>Upstream Diversion 1</td>
<td>4.3200</td>
<td>11.171</td>
<td>473</td>
</tr>
<tr>
<td>Upstream Diversion 2</td>
<td>1.4330</td>
<td>3.706</td>
<td>157</td>
</tr>
<tr>
<td>Landcox Park</td>
<td></td>
<td>Not in Glen Eira Municipal Area</td>
<td></td>
</tr>
<tr>
<td>Victory Reserve</td>
<td>0.5294</td>
<td>1.369</td>
<td>58</td>
</tr>
<tr>
<td>Halley Park</td>
<td>2.1300</td>
<td>5.508</td>
<td>233</td>
</tr>
<tr>
<td>Greenmeadow Gardens</td>
<td>0.1416</td>
<td>0.366</td>
<td>16</td>
</tr>
<tr>
<td>Caulfield Park</td>
<td>1.3980</td>
<td>3.615</td>
<td>153</td>
</tr>
<tr>
<td>Princes Park</td>
<td>3.0140</td>
<td>7.794</td>
<td>330</td>
</tr>
<tr>
<td>Lord Reserve</td>
<td>1.7190</td>
<td>4.445</td>
<td>188</td>
</tr>
<tr>
<td>EE Gunn Reserve</td>
<td>0.9108</td>
<td>2.355</td>
<td>100</td>
</tr>
<tr>
<td>Allnutt Park</td>
<td>6.2640</td>
<td>16.199</td>
<td>686</td>
</tr>
<tr>
<td>Velodrome</td>
<td>0.3168</td>
<td>0.819</td>
<td>35</td>
</tr>
<tr>
<td>Packer Park</td>
<td>0.2167</td>
<td>0.560</td>
<td>24</td>
</tr>
<tr>
<td>Joyce Park</td>
<td>1.8170</td>
<td>4.699</td>
<td>199</td>
</tr>
<tr>
<td>Duncan Reserve</td>
<td>1.4720</td>
<td>3.807</td>
<td>161</td>
</tr>
<tr>
<td>McKinnon Reserve</td>
<td></td>
<td>Not in Glen Eira Municipal Area</td>
<td></td>
</tr>
<tr>
<td>Bentleigh-Hodgson Reserve</td>
<td>0.8752</td>
<td>2.263</td>
<td>96</td>
</tr>
<tr>
<td>**Total</td>
<td>30.5202</td>
<td>78.923%</td>
<td>3,344 dwellings</td>
</tr>
</tbody>
</table>

Source: Household Projections from “Victoria In Future 2004” (unpublished figures)

* 2004 – 2014 = 4,236 projected additional dwellings over 10 years

** 2004 – 2029 = 10,590 projected additional dwellings over 25 years

Note: In the columns for projected additional dwellings, figures have been rounded up and down to whole numbers.
Methodology

Projected additional household figures were available for 5 year periods from 2001 to 2031. In order to relate these to the 10 and 25 year periods requested the following methodology was used:

<table>
<thead>
<tr>
<th>Period</th>
<th>Source</th>
<th>Additional Households</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001 – 2031</td>
<td>VIF 2004</td>
<td>13,240</td>
</tr>
<tr>
<td>2001 – 2004</td>
<td>Glen Eira Statistics</td>
<td>1,803</td>
</tr>
<tr>
<td>2004 – 2031</td>
<td>1. subtract 2.</td>
<td>11,437 over 27 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>= 423.6 per annum</td>
</tr>
<tr>
<td>2004 – 2014</td>
<td>10 years @ 423.6 pa</td>
<td>4,236</td>
</tr>
<tr>
<td>2004 – 2029</td>
<td>25 years @ 423.6 pa</td>
<td>10,590</td>
</tr>
</tbody>
</table>

Disclaimer

The figures shown in the main table are raw figures based on overall household projections for Glen Eira. The effect of Council Policy on projected additional households has not been taken into account. Glen Eira has policies that encourage multi-dwelling housing to locate in and around activity centres, with lower levels of development in the remaining minimal change areas. The impact of these policies in terms of the location of future additional households has not been included.

Similarly, no adjustments have been made for the restrictions imposed in areas affected by restrictive covenants, heritage overlay controls and special building overlay controls.
APPENDIX D: WATER SENSITIVE URBAN DESIGN ELEMENTS

This Appendix presents preliminary design details of each of the treatment measures. This is to provide guidance on the construction of the treatment measures.

Treatment measures discussed here include:

- Wetlands
- Infiltration Trenches
- Bioretention Systems
- Gully Pit Baskets (with Fine Mesh)
- Gross Pollutant Traps
- Sand Filter Systems

Further information on the design and treatment capacity of each of these measures can be found in the BPEMG (VSC, 1999) and the Draft Water Sensitive Urban Design Engineering Procedures – Stormwater (Melbourne Water, 2004).

D-1 Wetlands

Artificial wetlands provide an opportunity to improve existing stormwater systems especially in areas of limited space. Benefits of using these structures include reducing peak stormwater discharges from paved areas; increasing groundwater recharge, improving stormwater quality; and reducing the area of land dedicated solely to stormwater management.

Wetlands are designed to capture and store runoff, with a controlled release of flows over a period of a few days. Key features of wetlands are summarised in Figure D and include:

- Inlet Zone – The inlet zone is used to settle large sediment particles and divert extreme flows away from the inlet zone. The inlet zone is mostly open water with vegetation at the fringes.
- Macrophyte zone – The macrophyte zone is responsible for much of the pollutant removal. Most of this area is vegetated with a variety of wetland plants. The storage within this area is ephemeral, with water levels varying up to 0.6 metres above the permanent water level. Outflow from the macrophyte zone is controlled by an outlet that allows the wetland storage to fill and slowly draw down, thus promoting pollutant removal processes.

A number of wetland design criteria are currently available. Within Victoria, Melbourne Water has developed a detailed set of design requirements for their purposes, and it is recommended that these guidelines be referred to in the first instance. Engineers Australia is also in the process of developing a set of guidelines for stormwater quality management, namely Australian Runoff Quality (2003), with a draft version currently available.
In general, wetlands should have the following characteristics:

- A minimum detention time of 72 hours for storage of the design storm event. Length to width ratio in the order of 6 to 1 to minimise short-circuiting of the system, and promote longer residence time. The path of flow of the water, from inlet to outlet, should be maximised, with potential use of berms;
- Energy dissipaters should be installed at the inlet to the structure to reduce velocities and therefore promote sedimentation;
- Cross sectional profile should provide a uniform depth;
- Long section should vary to provide a series of benches at varying depths to allow a variety of plant zones to be established;
- Side slopes should be designed to meet safety and maintenance requirements;
- An energy dissipater should be used at the downstream end of the outlet to minimise erosion of downstream waterways;
- The wetland should be planted with a range of emergent macrophyte species; and
- Where possible, the wetland should be arranged such that the permanent pool level is at or below the outlet of the upstream culvert and above any downstream water bodies.
D-2 Infiltration Trenches

An infiltration trench is a rock or gravel filled trench designed to detain stormwater and transfer it to surrounding soils through infiltration. The local soil profile determines the rate of infiltration and the potential level of treatment of the stormwater (primarily in terms of removal of sediment). The trench should be lined in a geotextile fabric, with a shallow layer of topsoil. Infiltration trenches act to reduce stormwater flow velocities, provide some treatment and recharge groundwater. Figure D-2 presents a schematic of an infiltration trench cross-section.

![Infiltration trench diagram](image)

Figure D-2 Infiltration trench (VSC, 1999)

D-3 Bioretention Systems

Bioretention systems combine various WSUD treatment types to retard flows and to provide primary and/or secondary treatment to stormwater (Melbourne Water, 2004). Bioretention systems currently include the use of swales and infiltration trenches to retard and treat flow.

Generally, bioretention trenches consist of a shallow, excavated trench filled with a relatively fine filter medium (such as sand), covered by a layer of topsoil and vegetation. Vegetation types used in bioretention systems can vary greatly and are selected so that integrate well with their surrounding environment. Stormwater drains through the vegetation and filter medium, reducing velocities and receiving treatment through the capture of fine particulates and the processes of biological uptake. Depending upon the infiltration capacity of soils in the catchment area, stormwater in a bioretention trench may infiltrate into the ground, or may be collected in a slotted drainpipe and discharged downstream. Figure D-4 presents an example of a bioretention trench cross-section. An example of a bioretention basin being retrofitted is at Hoyland Street, Bracken Ridge Brisbane (Figure D-3).

![Bioretention basin image](image)

Figure D-3 Bioretention basin at Hoyland Street Bracken Ridge, Brisbane
D-4 Streetscape Bioretention

Bioretention systems may be incorporated into streetscapes in place of traditional kerb and channel systems. Figure D-5 and D-6 present examples of a streetscape with a bioretention system having been retro-fitted into the streetscape. Stormwater is collected from housing lots within the estate and directed through a bioretention system. The filtered stormwater is collected in a pipe at the bottom of the trench and released into a downstream wetland.

*Photos provided by Matt Francey (Melbourne Water)
D-5  Gully Pit Baskets (with 200 micron Mesh)

Gully pit baskets such as the Enviropod™ filter are stormwater filtration systems that filter stormwater runoff that enters the gully pit. They comprise a supporting framework and a replaceable filter cartridge (or filter bag). They are designed to remove suspended sediment via a mesh bag and are often used in existing gully pits. The gully pits need to be serviced regularly with the use of gully sucker trucks to avoid catchpit and line blockages that can cause flooding and damage to local business and residential areas. Gully pit basket filter systems therefore filter stormwater runoff before it enters the reticulation system.

Figure D-7 Hand maintenance of Gully Pit Baskets
(image obtained from http://www.ingalenviro.com/enviropod.asp)

Figure D-8 Pump maintenance of Gully Pit Baskets
(image obtained from http://www.ingalenviro.com/enviropod.asp)
D-6  Gross Pollutant Traps

GPTs are designed to capture litter, debris (litter and debris greater than five millimetres) and coarse sediment from stormwater and prevent it from entering downstream receiving waters or treatment measures. There are a range of GPT designs available from a large-scale trash rack that may be used in a river, to smaller scale self-cleaning devices for stormwater pipes. GPTs actively capture larger litter, with coarse sediments settling out through the reduction of flow velocities, promoted within the GPT.

The removal of litter and debris from stormwater may be achieved through the use of screening devices, reductions in flow velocities (enhancing sedimentation), flow separation and floatation devices.

A poorly performing GPT can result in litter, debris and coarse sediments being transported downstream. A poorly maintained GPT can also contain gross pollutants for some time. During this period, some types of GPTs can transform collected contaminants in more bio-available forms. Small flows through the collected pollutants can then leach transformed pollutants downstream where they can be detrimental, in some cases causing more problems than if a GPT was not installed at all. GPTs therefore need to be well maintained, with wastes removed regularly, to ensure that collected wastes do not generate pollutants themselves.

D-7  Sand Filters

Sand filters operate in a similar manner to bioretention systems apart from having no vegetation growing on their surface. This is because they are either installed underground or the filter medium does not retain sufficient moisture. Sand filters are used in areas where space is limited and treatment is best achieved underground.

Prior to entering the sand filter, untreated stormwater flows into a pre-treatment, which is usually a sedimentation chamber to remove litter, debris and coarse sediments. Spreading it over the sand filter media then further treats this water by percolating it through the sand to perforated pipes below. This treated water is then conveyed downstream. High flows are diverted around the sand filter to protect it from scour.

Sand filters require regular maintenance to ensure the surface of the sand filter media remains porous and does not become clogged with accumulated fine sediments.
APPENDIX E: LOCATION OF SPECIFIC OPPORTUNITIES

Figure E-1 Allnutt Park (4.03 ha)

Figure E-2 Duncan McKinnon Reserve (8.95 ha)

Figure E-3 EE Gunn Reserve (6.44 ha)

Figure E-4 Princess Park (12.08 ha)

Figure E-5 Joyce Park (3.33 ha)

Figure E-6 Halley Park (1.73 ha)

Figure E-7 Bentleigh-Hodgson Reserve (3.32 ha)

Figure E-8 Lord Reserve, Koonang Park (10.74 ha)
Figure E-9 Caulfield Park (24.09ha)

Figure E-10 Greenmeadows Gardens (1.36ha)

Figure E-11 Velodrome, Packer Park and Mallanbool Reserve (8.15 ha)

Figure E-12 Victory Park (4.29 ha)
APPENDIX F: COMMERCIAL HOT SPOTS STRUCTURAL TREATMENT OPPORTUNITIES
Figure F-1  Side entry pits identified for gully pit baskets in commercial hot spots throughout the Elster Creek catchment
Figure F-2 Side entry pits identified for gully pit baskets in commercial hot spots in the Bentleigh Shopping Strip

Figure F-3 Side entry pits identified for gully pit baskets in commercial hot spots in the Carnegie Shopping Strip
Figure F-4 Side entry pits identified for gully pit baskets in commercial hot spots in the Caulfield North Shopping Strip

Figure F-5 Side entry pits identified for gully pit baskets in commercial hot spots in the Caulfield South Shopping Strip
Figure F-6 Side entry pits identified for gully pit baskets in commercial hot spots in the Centre Road Shopping Strip

Figure F-7 Side entry pits identified for gully pit baskets in commercial hot spots in the Elsternwick Shopping Strip
Figure F-8 Side entry pits identified for gully pit baskets in commercial hot spots in the Glen Eira Shopping Strip

Figure F-9 Side entry pits identified for gully pit baskets in commercial hot spots in the Glenhuntly Shopping Strip
Figure F-10 Side entry pits identified for gully pit baskets in commercial hot spots in the McKinnon Shopping Strip

Figure F-11 Side entry pits identified for gully pit baskets in commercial hot spots in the Moorabbin Shopping Centre
Figure F-12 Side entry pits identified for gully pit baskets in commercial hot spots along Ormond Road

Figure F-13 Side entry pits identified for gully pit baskets in commercial hot spots in the Ormond Shopping Strip