COLLIER PARK GOLF COURSE

ENVIRONMENTAL MANAGEMENT PLAN

Nicole Siemon and Associates PL

July 2004

EXECUTIVE SUMMARY

The Collier Park Golf Course is one of the most popular public golf courses in the Perth Metropolitan area and has been described as Australia's premier public golf course. The Course offers a high standard of amenities and turf management, with picturesque grounds and an opportunity to see a variety of local wildlife including the occasional Black swan and the declared rare and endangered Carnaby's cockatoo.

The maintenance of the grounds is an intensive operation and has the potential to impact on the environment. Because of the expanse of land, the Course also offers the City a remarkable opportunity to provide for additional biodiversity and protection of water resources. This opportunity was identified in the City's *Green Plan* and has been expanded upon in this report.

The City of South Perth is committed to improving their environmental accountability in all aspects of management of municipal activities. This environmental management plan for the Collier Park Golf Course has been developed to:

- Enable the protection of the quality of surface and groundwater
- Maintain the quality of recharge to groundwater supplies
- Minimise erosion and sediment movement, and
- Preserve, protect and enhance native plants and wildlife habitat.

In general, current management practices are designed to protect the environment. Environmental stewardship ethics are the driving force behind all operations and direct course management decisions. This report makes a number of key recommendations for continuous improvement in operational management, provide for additional planting and habitat provision for native plants and animals and also develop a better understanding of the current state of the course.

There are a number of major initiatives of the plan. These relate to the five key areas of course management.

Surface and groundwater protection
Water quality in the Perth Metropolitan region is generally declining with increased leaching of nutrients and pollutants into the groundwater and Swan and Canning Rivers. This continues to seriously affect the biological productivity, biological diversity, economic and amenity values.

The lakes within the Course reflect management practices and are an environmental indicator. The recommendations are directed towards:

- Obtaining a better understanding of the current quality of soil, surface and groundwater
- Increasing monitoring of water quality
- Upgrading drainage outlets
- Construction of facilities to meet current best management practice, and
- Increasing planning to minimise water, nutrient and pesticide use.

Materials and waste management
Reduce, reuse and recycle is an important catch cry for management of all operations. Minimising waste is another major initiative of this plan.

The recommendations are directed towards:

- Undertaking a waste audit and developing a waste management strategy, and
- Providing patrons with the opportunity to recycle while enjoying their game of golf.

Irrigation management
Water use is under increasing scrutiny in Perth with water restrictions being applied regularly. Ensuring careful application of water is an important operation within course management.

The recommendations are directed towards:

- Undertaking a comprehensive review of water use and the efficacy of the current irrigation system
- Reviewing watering practices and the impact of the trees within the Course, and
- Increasing staff training to improve their ability to manage irrigation in a complex environment.

Conservation, landscaping and rehabilitation
Conservation of the remaining bushland areas and reinforcement of vegetation on the areas of land not used for course operations is an important priority of this report. Increasing the amount of vegetation fringing the lakes within the Course is also important to improve habitat for native animals and to protect nesting Oblong turtles.

The recommendations are directed towards:
- Undertaking revegetation work and reinforcement planting of fringing vegetation to improve fauna habitat, contribute to nutrient removal from waterways and to offer variation in landscape appeal throughout the course
- Controlling and eradicating weeds
- Increasing control of feral animals, and
- Providing more nesting opportunities for wildlife to increase the diversity of wildlife which patrons can see on the course.

Community education and involvement
The successful management of the Course depends on cooperation between the leasee, Course management and patrons with some involvement of state government agencies.

The recommendations are directed towards:
- Increasing community awareness of the City's commitment to improving environmental management within the Course, and
- Offering opportunities for patrons of the Course to learn about key features within the Course.

TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

CHAPTER 1: INTRODUCTION

There is a great deal of public concern, and on occasion, confusion regarding the potential impact of golf course management practices on the environment. Typically the focus of concern is the use of chemicals (herbicides and pesticides), nutrients and water that are required to maintain vigorous and robust turf. Contemporary golf course management practices are highly sophisticated and are designed to avoid the application of chemicals whenever possible. Nonetheless, as with any agronomic situation, limited application of nutrients is required to support turf growth and health. Similarly, when all cultural methods fail, the limited use of pesticides to control certain turf pests is necessary as a last resort to prevent extensive turf damage.

The City of South Perth is committed to improving their environmental accountability in all aspects of the municipal activities. As the custodians of the Collier Park Golf Course, the City has developed this environmental management plan to:

- enable the protection of the quality of surface and groundwater,
- maintain the quality of recharge to groundwater supplies,
- minimise erosion and sediment movement and
- preserve, protect and enhance native plants and wildlife habitat to the greatest extent practicable.

Environmental stewardship ethics are standard operational philosophies that direct golf course management decisions. In general, all management practices are designed to protect the environment. In addition, many courses voluntarily work to enhance environmental conditions as a means of providing a more enjoyable playing experience for the golfer, and using the opportunity to educate golfers on environmental issues.

This plan shall be interpreted and applied to protect environmental quality and to demonstrate environmental commitment to the community at large.

Purpose

The purpose of this environmental management plan is to review the current state of the Collier Park Golf Course, assess the effectiveness of current management approaches and offer best management practice solutions to maximise environmental benefits to the course.

This environmental management plan identifies a wide range of cultural, mechanical, and structural practices to be employed to protect water quality, preserve and protect habitat, and otherwise preserve environmental quality within the Property.

Goals and Objectives

The specific objectives of the environmental management plan are to:

- Identify site, climate, irrigation, soils, geology, water resources, turfgrass, and vegetation conditions at the course.

- Identify turfgrass, soil, and water quality risks.

- Identify specific alternate management practices and current Best Management Practices ("BMPs") for controlling runoff, construction, environmentally sound irrigation, soil and water conservation, fertilisation, pest and disease control, and otherwise protecting water quality. BMPs change from time to time, however and the City reserves the right to impose different, and more stringent BMPs, upon the Golf Course as such practices are revised.

- Develop and implement a water quality monitoring plan to protect water resources.

- Identify action thresholds to meet water, soil and turfgrass quality standards.
- Establish remedial actions to be taken in the event any action thresholds are exceeded.
- Establish documentation requirements to record irrigation practices, fertilisation and pesticide application practices, water quality monitoring results, soil fertility tests, and turfgrass nutrient content tests.
- Offer landscape and habitat restoration principles and designs to enable course management to improve habitat values.

Applicability

These aims and objectives complement the long-term goals of the City as outlined in the City of South Perth Strategic Plan 2002-2005. Relevant goals and strategies from this document are reproduced below:

Goal 3 Environmental Management
To maintain and enhance the City's unique natural and built environment

Strategy 3.2 Continue to implement the Environmental Strategy and associated Management Plans to bring a responsible and coordinated approach to the management of the environment.

Goal 4 Infrastructure
To effectively manage, maintain and enhance the City's infrastructure assets.

Strategy 4.1 Develop appropriate plans, strategies and management systems to ensure Public Infrastructure Assets (roads, drains, footpaths etc) are maintained to a responsible level.

Further, the City of South Perth Green Plan and State of the Environment Report both identified the Collier Park Golf Course as an area of potential habitat enhancement and environmental quality improvement.

Green Plan

The *Green Plan (2002)* was developed in response to the City's *Environmental Strategy 1999-2002.* The purpose of the Green Plan is to offer an environmental management system for protecting, linking and enhancing the public and private green spaces, biological resources and amenities within the City.

One of the key general recommendations of the *Green Plan* is to augment existing landscape features with local native species.

Specific recommendations relating to the Collier Park Golf Course are quoted below:
- Manage the Remnants in the CPCG as native vegetation/native garden.
- These areas abut the water bodies and are in fair condition. Undertake a vegetation survey in spring to determine the species present.
- Encourage expansion of native vegetation around the wetlands in CPGC.
- Vegetation retains a number of native species and are not in the area of play. These areas should be ruled "out of bounds".
- Encourage planting of native species between fairways CPGC.
- Expand native garden planting in Collier Park Golf Course.

This report is consistent with these recommendations and the intent of the *Green Plan (2002).*

State of the Environment

The City prepared it's first State of the Environment report in 2002. It is an important tool for strategic planning purposes and offers a process to enable the community to access reliable base information and systematic responses to their environmental concerns. The basis of this report is the acknowledgement that our way of life depends critically on a range of natural assets – air, water, soil, forests and other biological systems – and that these assets must be safeguarded.

This report reviewed the current state of the environment and resulted in a number of recommended directions for the City of South Perth to reduce the environmental impact of its operations.

Relevant recommendations from this report are reproduced below.

Chapter 4:	Biodiversity
Rec No	Recommendation
4.6	Provision of bushland rehabilitation training for Council's horticultural staff, as a method of in-house skill development.
4.7	Reduce the amount of turf in parkland areas and replace with low maintenance, water sensitive native gardens.

Chapter 5:	Biodiversity
Rec No	Recommendation
5.2	The City of South Perth to progressively redesign Council buildings incorporating climate sensitive design criteria as part of their upgrading and maintenance schedule. Some retrofitting may also be required.
5.3	The objectives of the Cities for Climate Protection program should be incorporated into Council's corporate decision-making processes.
5.4	Solar/wind generation plants established on Council buildings or property to sell energy to Western Power.

Chapter 6:	Water resources
Rec No	Recommendation
6.1	Encourage the principles of water sensitive design to be incorporated into future planning and development or stormwater drainage upgrades. This promotes the recharge of local aquifers and improved water quality.
6.4	Future water conservation initiatives from the South Perth Council should be done in partnership with the Water Corporation.

Chapter 7:	Wetlands and estuarine environments
Rec No	Recommendation
7.1	Improve the biological filtering capacity of wetlands in South Perth through additional foreshore plantings.
7.2	Urban water sensitive design principles (as per State Government guidelines) incorporated into the City of South Perth's stormwater policies and practices. To be implemented with future urban planning and stormwater upgrading.
7.3	City of South Perth to implement nutrient and irrigation management plans (as per State Government guidelines) to match irrigation and fertiliser with turf requirements in parkland management. Fertiliser application in the vicinity of wetlands should be stopped.
7.4	City of South Perth to regularly monitor wetlands for chlorophyll 'a' and the occurrence of blue-green algae blooms.
7.5	Parkland management to demonstrate water efficiency measures (technology and management practices) to the wider community.

Chapter 8:	Reusable resources
Rec No	Recommendation
8.1	In order to achieve our zero waste targets, annual waste reductions targets and associated strategies may prove useful.
8.2	When waste contract conditions allow, the trialing of a pay-by-weight system should be investigated.
8.3	Contractors paid on the percentage of materials recovered for reuse or recycled.

Chapter 9:	Sustainability
Rec No	Recommendation
10.1	To effectively address the areas of consumption, the City of South Perth should adopt a local sustainability program that considers environmental, social and economic issues in an integrated and holistic manner.
10.3	The City of South Perth adopts appropriate indicators from this report and monitors, collects and reports on these data sets.

These strategic recommendations apply to a range of activities within the Course. This environmental management plan goes someway to offering specific state of the environment recommendations and options to proceed along the sustainability path.

Relationship to other Legal Requirements

This plan offers principles and best practice as current but should not be construed to release the golf course management from compliance with any applicable federal, state and local laws, rules or regulations that may otherwise be applicable.

Review period

This plan should be reviewed every five years to ensure it continues to offer best management practice solutions to environmental management. The principles of continuous improvement should apply. All stakeholders should be included in the development of any amendments and written agreement gained prior to the review.

CHAPTER TWO

CURRENT
STATE OF THE ENVIRONMENT

CHAPTER 2: CURRENT STATE OF THE ENVIRONMENT

The Collier Park Golf Course is a 91 hectare course nestled within the City of South Perth (Map 1). Its dominant landscape feature is the presence of many mature pine trees.

The terrain is generally flat with some localised depressions supporting wetlands apart from the northwestern corner of the course, which was formerly a waste disposal site for the City of South Perth.

Physical environment

The majority of Collier Park Golf Course falls within Bassendean Dune System.

This system is comprised of a series of coastal dune deposits formed during the Pleistocene period (approximately 1.6 million years ago). Between the low-lying dunes are seasonally waterlogged wetland areas.

The ancient Bassendean Dunes were originally comprised of calcareous sands. Due to the high permeability and low water holding capacity of the system the sands are highly leached leaving insoluble grey quartz sands at the surface and pale yellow quartz sands at depth. These quartz sands have very low levels of calcium, iron and other minerals and are described as poor. The soils in the low lying waterlogged areas have low permeability and are prone to flooding. These soils feature dark grey to black clayey soils with a high organic content.

Biological environment

Flora

Collier Park Golf Course was constructed in a former pine plantation, remnant *Banksia* woodland and *Melaleuca preissiana* and *Melaleuca rhaphiophylla* dominated wetlands and very few areas of native vegetation have been protected. The remaining vegetation has limited habitat value due to the paucity of native plants, their limited diversity and absence of continuous vegetation cover. There are three wetland areas in the course and four areas retaining some native vegetation cover. There are some persistent understorey plants within these small remnants. The plantings in the rough areas are an eclectic mix of non-indigenous and Australian native plants.

A brief survey of the remnant vegetation present in the roughs and out of play areas of the course was conducted to determine which species have adapted to the change in land use as well as provide baseline data for future species selections in the planting areas. A qualitative species list is provided in Appendix 1.

One important observation made during the vegetation survey was that only one area of native vegetation is reasonably intact and has the ability to self-regenerate. This is located between the 5th and 8th hole of the Pines Nine and the driving range. The major threat to the success of self-management and native vegetation reinforcement is the level of some weed species especially grasses, large woody wattles and the highly competitive pines. A weed management strategy is included in this document in the form of weed control tables and recommendations attached to maps.

There are considerable opportunities to increase the number and diversity of native plants within the course to meet the objectives listed within the City of South Perth Green Plan.

Fauna

The limited vegetation cover and diversity limits the range of fauna that can use the site. Birds such as Carnaby's cockatoo use the site as their preferred habitat *Banksia* woodland no longer occurs within the course. Ravens, Magpie, Corella and Magpie lark are also common visitors and residents of the course.

Black duck, Maned geese, Eurasian coot and Grebe utilise the wetlands in the course. Oblong turtles are still present in the wetlands and lakes.

Some of the regular fauna visitors and residents in the course cause some level of nuisance for course management and patrons for example bird droppings on greens and magpies seeking from patrons around the kiosk.

Wetlands

There is one natural wetland and two modified ornamental lakes within the confines of the Collier Park Golf Course, which are in variable condition. The extent of these natural areas provides excellent opportunities for the Course management to protect and enhance these zones, to add unusual features to the course.

Wetland in the Pine 9 – "no go zone" – bounded by Holes 14 and 17

Parts of this wetland system are in excellent condition with moderately diverse native vegetation and manageable levels of weed invasion. The wetland has been considerably modified with the construction of a moat around an island of vegetation. The dominant weeds present on the island and in the peripheral area of the lake are an eastern states wattle species, pines Victorian coastal teatree, annual and perennial grasses with the introduced bulrush and nut grasses common in and around the water's edge.

This wetland provides a unique opportunity for Collier Park Golf Course as it provides an important refuge for native plants and animals. It is likely this area supports a variety of lizards, frogs and birds occur, although it's isolation and lack of vegetation corridors reduces these values.

Protection of this asset needs to be a priority for the Golf Course management. Minimal effort now to control weeds and exclude golfers and their buggies, will ultimately reduce the maintenance costs of this resource by restoring the wetland and bushland environment's ability to be reasonably self-sustaining. This should be a priority for management.

Detailed management prescriptions are provided in Chapter 13, however general requirements are to:

- Control the introduced grasses prior to them seeding on a regular basis;
- Define a physical barrier between access areas and the native vegetation to exclude golfers and mark the weed control area;
- Begin staged removal of the introduced wattles, Victorian coastal teatree and other weeds;
- Ensure irrigation management limits any overspray reaching the native plant zone; and
- Monitor the areas' level of natural regeneration and assist with plantings and direct seeding if required.

Given the present quality of vegetation, it is strongly recommended that wetland area in the Pine Nine become:

- ***GUR,***
- ***named; and***
- ***be managed as a conservation area.***

Map 1: Collier Park Golf Course

300 0 300 600 900

The Entrance lake

There are a number of factors that are known to influence the growth and survival of algae (e.g. light, temperature, turbidity, nutrients, salinity and pH). Generally blooms occur in nutrient rich calm warm water. Managing water quality in shallow open lakes is very difficult, as it is requires limiting light availability and reducing water temperature. Three stormwater drains feed into this lake, making it prone to algal blooms particularly following summer rainfall events.

This wetland was constructed in 1982 following filling of a natural wetland to the west of the current lake. Any wetland in this environment would have been seasonal.
There are a number of issues that arise as a result of the current management regime. It is likely that the growth of aquatic plants, both microscopic and macroscopic alga, will increase over time as there is readily available light and nutrients, lack of emergent plants and shading trees, and the current water depth ensures high water temperatures.

There are a number of available options to reduce the frequency and intensity of algal blooms as the water recedes.

These are:

- Increase shade by planting dense groves of paperbarks and flooded gum, particularly on the southern and western edge (see map in Chapter 11 of this document), which will impact on aesthetics and playability of the fairway.
- Implement intensive weed control in the lake system and replace weeds with indigenous species.
- Plant tall emergent native vegetation densely on the periphery of the lake and throughout the lake, particularly against the retaining wall on the north side of the lake so that visual intrusion is not too significant.

The Island Nine

This wetland has been modified in a similar manner to the lake in the Pine Nine, with a moat installed, fragmenting the wetland. The vegetation on the island is in moderate to good condition with many mature Modong (*Melaleuca preissiana*).

Water quality management

The lakes within the Golf Course are exhibiting low levels of eutrophication (nutrient loading) and anoxia (loss of oxygen in the water). The Golf Course Superintendent considers that the current management of nutrient and water movement within the Course is being undertaken in a very effective, pre-cautionary way. It is not possible to fully assess the efficiency of current management as there is patchy data on nutrient levels within plant tissue and soils, and very limited water quality data.

In the early stages of the course development, considerable resources were put into soil, leaf and plant tissue analyses to ensure that excess fertiliser applications did not occur. In more recent years sampling has been less comprehensive. Some of the data provided

The lack of comprehensive water quality data makes it difficult to assess whether or not there is an issue with nutrient runoff, however, the species of algae present within the open water bodies within the course are an indication of high nitrogen levels. The source of these nutrients could arise from former landuses (such as the piggery site), leachates from the tipsite, the three stormwater drains including a Water Corporation Main Drain from Technology Park into the Entrance Lake or potentially from a superficial aquifer whose extent is beyond the course boundaries.

There is limited documented evidence of recent efforts to manage water quality within the course.

It is recommended that a comprehensive sampling program be developed and implemented to obtain baseline information about surface and groundwater quality. An assessment of the lake sediments from each of the three lakes would also help review the nutrient use in the course. In addition, regular soil and plant tissue analysis will also improve the long term understanding of nutrient loads within the system. Regular sampling by the Environmental Programs Coordinator is proposed and is discussed in more detail in a later part of the document.

Increasing the density of peripheral plantings and again, shading the lake can also provide considerable benefits. Where tall plants cannot be established, as they will block the line of sight for golfers, rushes within the lakes themselves are appropriate. These plants can contribute to keeping the water cooler, increasing oxygen in the sediments and lower parts of the waterbody (plants release oxygen through their roots) and taking up any available nutrients. These plants are also very attractive, and will add aesthetic appeal to the lakes.

Key actions for lake and water quality management are:

- Increase vegetation using species recommended in Chapter 13, both in and around each waterway;
- Restore natural seasonal conditions in lakes which historically were seasonal;
- Increase native plant buffer around each lake and minimise contact of grasses with the water; and
- Monitoring changes to water quality.

Water conservation

The current reticulation system is nearing the end of its feasible working life, with the mainline providing over 20 years of service.

The reticulation arrangement has a number of inefficiencies as can be seen by viewing the aerial photographs of the course in summer, which show areas of overlap and other areas missed by reticulation completely. Sections of rough appear to be watered unnecessarily. Implementation of a comprehensive upgrade of the reticulation is necessary to enable adoption of water saving devices and efficient sprinkler systems and to meet changing expectations. The reticulation system and its should be reviewed more comprehensively in the *Waterwise strategy* currently being prepared by the City of South Perth.

The course has nine bores. These bores are licensed for:

450 000 ML per annum	Bulk of the course
1670 ML per annum	Roundabout

Bore licenses are coming up for renewal and all bores will be assessed in this process.

The Pines and other landscape features

The course is located in a former pine plantation. The relic pine trees and turf are substantial water users and these plants compete with each other for nutrients and water. Pine trees with substantial shallow root systems have been calculated to use between 15 000 and 30 000 L/day/ha. This equates with an annual water use of 325 to 650 KL per day for the course (not including rainfall events), given that there is close to 21 hectares of pine at plantation spacing. Because of the availability of surface water, it is highly unlikely that the pines draw a significant amount of water from the groundwater.

Many of the landscape plant species are inefficient water users, particularly those from overseas such as Tipuana and Paulownia which are used to drawdown the groundwater table. Removal of these water inefficient species if they are not contributing to aesthetic appeal, and replacement with low water use locally native plants will help to reduce water use and competition with the turf.

While the pines provide a 'sense of place', there is a need to assess some of the trees to ensure they do not pose a substantial risk to patrons. Any removal of pines is likely to be an emotive issue for the City of South Perth, however there are a number of environmental and cost management reasons why selective removal may benefit the course. A comprehensive assessment of the pines will need to be undertaken to determine management options available.

Chemical use and safety

Course management provides a list of currently used chemicals to the City of South Perth Occupational Safety and Health officer who is based at the central office. All staff are trained in chemical use and safety procedures prior to being authorised to use these compounds. Effort is made to minimise the risk to patrons of the course by spraying late in the afternoon or evening. Further, course management have invested in a covered boom spray to minimise the risk to non-target areas, personnel and patrons. While this is a useful approach to protect patrons, it is not necessarily the most effective means of applying the chemicals as plant uptake and watering regimes may minimise the benefit of chemical use.

Vandalism

Vandalism is an area of ongoing concern for course management. Since the establishment of the Course, it has been vandalised on a number of occasions. The activities that are undertaken by vandals include:

- Digging cores out of turf
- Damaging cyclone fencing
- Smashing walls to steal equipment particularly motorbikes
- Graffiti.

The perimeter fencing has had some impact on the frequency of vandalism events, however, it has not overcome the problem entirely.

Environmental planning, training and communication

There is limited documentation of procedures and processes used to minimise environmental harm by activities within the course. There is no statement or expressed vision to ensure management of the course is consistent with enhancing environmental objectives – apart from this document as a first step following broad objectives expressed by the City of South Perth Green Plan and State of the Environment Report.

The City is in the process of developing a Sustainability Management System for the entire of the City's operations. This will provide guidance and a process whereby implementation of actions within this document can be monitored and assessed over time.

Education

There is currently no formal process whereby patrons or staff of the course are advised of the environmental values of the course. There are considerable opportunities to increase awareness of the values and thereby demonstrate appropriate management to all, through a range of simple means including use of 'no-go' areas and signs.

Signage has been used to discourage patrons from feeding the birds in the kiosk area, however, these were installed after the birds had adapted their behaviour to seek food in this location.

Opportunities for increasing environmental education programs and offering interpretive signage near the major conservation areas are available.

CHAPTER THREE

SURFACE
AND
GROUNDWATER PROTECTION

CHAPTER 3: SURFACE AND GROUNDWATER PROTECTION

The water quality of the wetlands and groundwater beneath the course may be influenced by operational practices. This section of the document describes the general principles that will be used to protect surface and groundwater, while later sections of the document offer more comprehensive details about operational approaches.

Management overview

The most intense turfgrass management occurs on putting green surfaces which are under continual moisture, nutritional and mechanical (foot traffic and mowing) stress. Daily vigilance by the Golf Course Superintendent and a finely tuned management system is required to maintain healthy turfgrass on putting greens, fairways and the remaining turfgrass areas of the golf course.

The maintenance of healthy, dense turfgrass is vitally important to minimise turf diseases, weed colonisation and insect infestation.

As with other golf courses, irrigation, fertiliser application, mowing and when necessary, the application of pesticides are the primary aspects of course management. Of these management practices, the applications of fertiliser and pesticides to the golf course are activities most likely to influence water quality.

To fully appreciate the relative potential for turfgrass management activities to influence water quality, it is essential to understand the management requirements of various turfgrass locations. As shown in Table 1, the management requirements are most intense for putting green surfaces (greens). It is important to note that while greens have the most intense management requirements, they also represent a small percentage (0.06%) of the total grass area. Similarly, tee surfaces, which represent 0.05% of the total grass area has the next most intensive management requirements. Finally, the fairways which represent 88% of the total grass area, have low management requirements while the rough has very low management requirements. In summary, management practices consisting of irrigation, fertilising and pesticide applications are most intense on a remarkably small proportion of the golf course.

Table 1: Management regimes according to zone

Area	Total area (ha)	% Total grass area	Season	Irrigation requirement	Estimated herbicide applications per year	Estimated pesticide applications per year
Greens	2.3	0.06	Winter Spring Summer Autumn	No application 4 – 6 mm / day 4 – 11 mm / day 4 – 6 mm / day	2 application 2 application	spot treatment as needed
Tee surfaces	2.1	0.05	Winter Spring Summer Autumn	No application 4 – 6 mm / day 4 – 11 mm / day 4 – 6 mm / day	1 application 2 application	no applications
Fairway	46	88	Winter Spring Summer Autumn	No application 4 – 6 mm / day 4 – 11 mm / day 4 – 6 mm / day	1 application 2 application	no applications
Rough	58 ha	10		none	spot treatment as needed	no applications
Native plantings	2			minimal	spot treatment as needed	no applications
Non-indigenous landscaping	60				spot treatment as needed	no applications

The summer water applications are based on 100% evaporation on greens and therefore 100% watering while the fairways is based on 75 – 80% evaporation. The watering program is adjusted daily. From October, the Golf Course Superintendent gets the figures every afternoon from the Meteorology Bureau from which the

irrigation program is set. The adjustments are made to the percentage evaporation, with less emphasis on adjusting the duration of irrigation.

It is important that the operational plans offer a:

- Flexible development, and maintenance, of practices to protect water quality and healthy turfgrass,
- Consistent basis for long-term evaluation and monitoring of the success of this plan, and
- Development and evaluation of practices to mitigate potential adverse water quality effects.

Geology Considerations

An essential element in the protection of groundwater resources is ensuring adequate setbacks from poor quality soils from potential sources of contamination. Potential sources of contamination are identified in Table 2. An emergency contingency procedure shall be included in the surface and groundwater protection plans to address response, containment and remediation of any hazardous materials spilled.

The plan shall identify and protect the general geology and occurrence of groundwater in the area, and shall include an inventory of historical and present potential sources of contamination within 300 metres of each bore.

Abandoned bores not utilised for water quality monitoring purposes located at the golf course must be identified in the plan and meet conditions set by the Office of Water Requirements.

The bore protection plan shall include:

- All bores shall be delineated and location of each bore using GPS, and
- Inventory of potential sources of contamination within the delineated areas.

Table 2 Potential sources of groundwater quality degradation

Potential ground water quality pollution sources that originate on the land surface
Aboveground storage tanks
Accidental spills
Former piggery site, grain storage bins
Dumps
Fertilisers and pesticides
Infiltration of polluted surface water
Land disposal of either liquid or soil wastes
Particulate matter from airborne sources
Stockpiles
Surface runoff
Artificial recharge
Holding ponds and lakes
Leakage from underground storage pipelines
Leakage from underground storage tanks
Sanitary landfills
Septic tanks
Sumps and dry wells
Waste disposal in excavations
Potential ground water quality pollution sources that originate below the water table
Abandoned bores
Bore treatments for iron removal

Policy framework

The course is required to manage its operations in accordance with a number of state government policies and legislation, in addition to meeting the requirements of the City of South Perth. A brief overview of these is below.

Minister for Water Resources

The Minister for Water Resources is responsible for the administration of the Department of Environment (Water and Rivers Commission) and its relevant acts including the *Rights of Irrigation and Water Act 1912*.

Department of Environment (Water and Rivers Commission)

The role of the former Water and Rivers Commission is to manage the State's surface and groundwater resources including rivers and estuaries. Its focus is on the protection of environmental values and allocating water for a wide range of uses to support the State's development in a sustainable manner.

Key relevant DOE (WRC) initiatives and program areas include:

- Public water supply
- Surface water and drainage control
- Water sensitive urban design
- Groundwater quality protection
- Groundwater allocation
- Estuary, river and wetland management and protection

The main Acts under which this portion of the organisation operates are the *Rights of Irrigation and Water Act 1912* and the *Environmental Protection Act (1986)*. A number of points relevant to the course have been selected from these Acts and are listed below.

Under the provisions of this RIW Act, it is illegal to discharge water of a poorer quality than that which has entered a property. Careful baseline monitoring will be necessary to identify sources of pollution, particularly where there is a risk that point sources of contamination may arise from beyond the bounds of the golf course.

Water extraction needs to have appropriate licences from the Office of Water Regulation. The water resources within the City of South Perth are considered to be fully allocated, if not over-allocated. The City is in the process of preparing a *Waterwise strategy*, which will address the licensing issues comprehensively.

The Department of Environment sections of the organisation are focused on:

- Prevention, control and abatement of environmental pollution
- Conservation, preservation, protection, enhancement and management of the environment, and
- Matters incidental to or connected with the foregoing.

This organisation controls air, water and soil pollution and contamination of soil, surface and groundwater from tip sites and other sources.

The Department of Minerals and Energy has responsibility for fuel storage under the volume of one million litres.

Water Corporation

The Water Corporation has some potential involvement in the golf course operations because a main drain enters the course and contributes to drainage in the area.

City of South Perth Policies

The City has a number of policies that relate to a number of golf course operations. Of particular relevance to surface and groundwater protection are:

Environmental Policy E3	Ground water management
Environmental Policy E6	Natural wetlands
Management Practices E1	Control and management of pesticides
Management Practices E2	Use of toxic pesticides
Management Practices H6	Use of dangerous chemicals

Water Pollution Abatement Plan

The strategy to be employed by the City of South Perth will be the implementation of a management system that includes a combination of an integrated pest management plan and a complementary water quality monitoring plan. Details of these proposed documents are outlined in this document.

The system will define proper management practices designed to protect, sustain and enhance the environment of the golf course, and areas surrounding the golf course. A critical feature of the integrated pest management plan is a comprehensive, coordinated management system designed to optimise the retention of chemicals applied to the golf course and to prevent their release from the area of application. The Water Quality Monitoring Plan is designed to provide direct feedback to evaluate the effectiveness of the IPM plan at protecting water quality, and includes a contingency response plan.

Options for managing water quality issues

It is clear from the previous section that the golf course is a diverse environment. It may be appropriate to manage the golf course as a number of management zones with areas of similar environmental risk factors and requiring similar management practices being managed on a per zone basis.

Environmental risk factors include soil type, depth to bedrock (if present), proximity to sensitive features. topography and former landuses.

The processes that have the potential to affect water quality include:

- Subsurface leaching of compounds into the groundwater – particularly in relation to the tip site
- Drift of applied chemicals during initial application and when volatile
- Movement of dissolved chemicals in surface runoff
- Movement of suspended particulates in surface water runoff
- Movement of eroded soils and sediment-bound compounds in runoff
- Movement of stormwater through the course.

In terms of chemical application, this plan presumes that manufacturer's recommendations and commercially available information are adhered to and that the recommendations will aim for ensuring the most effective equipment and approaches.

It may be necessary to obtain baseline data on the level of chemicals within the sediments of the lakes and soils to enable comparison in the future.

Establishing water quality management zones requires the use of several practical considerations including:

- Fairways are treated tree-line to tree-line which inherently protects the margins of the rough that contain wetlands and/or bushland areas. This conservative method of delineation protects three things; water quality, quality of turfgrass and lastly provides for consistent use of management practices.
- Greens and tees may be delineated in different management zones to the remainder of the fairway on the same hole. Greens and tees have their own specific mechanical, nutrient and pest and disease control strategies.
- Structural and vegetative controls may be incorporated into the boundaries of the water quality management zones.

Best management practices

Each of the best management practices within this plan is tailored to the specific conditions and environmental risks present within each zone.

Water quality management zones are highlighted on Map 2. The greatest areas of concern are the:

- stormwater main drains.
- former tip site.

Map 2: Water quality management zones

LEGEND

Toilets and septic tanks

Approximate tipsite boundary

N

Note: All wetlands and the stormwater drains are also considered to require special management.

300 0 300 600 900 1200 Meters

- clubhouse and associated facilities.
- septic tanks and toilet areas.
- maintenance sheds and washdown facility.
- wetlands, and
- general applications of nutrients, chemicals, fertiliser and other compounds.

OPERATIONAL PLANS

The Best Management Practices relevant to the Collier Park Golf Course shall incorporate the following general principles:

- Incorporating soil amendments to improve nutrient and water retention through the addition of small doses of clay and organic material during turf restoration without affecting drainage of surface water.
- Increasing the area of natural vegetation and work to provide vegetated buffer strips around the perimeters of the lakes.
- Directing surface runoff into vegetated bioswales and low detention areas away from the former tip site or other areas likely to have chemical accumulation.
- Vegetating the margins of the lakes to minimise the risk of sediment movement through the outlet in the Lakes 9.
- Using the computer controlled irrigation system that interfaces with a digital weather station (if installed in 2004 or the near future). The computer-based system should be programmed to operate on real-time evapo-transpiration rates from the on-site weather station rather than the current approach which is 24 hours behind. The computer based system should also be programmed to terminate irrigation operations during rainfall events, except where weekly testing of the bores and reticulation system is necessary. All controls should continue to be undertaken manually.
- Promoting the preservation of large native trees, selective removal and replacement of exotic trees and enhancement of understorey vegetation where practicable.
- Amending the stormwater treatment from the carpark, maintenance sheds and storage facilities, clubhouse and pro shop should any upgrade of this area be undertaken. There is currently no treatment of stormwater and direct discharge from the carpark into the lake.
- Ensuring the new washdown area meets current Department of Environment requirements and criteria and drain to an oil/water separator consistent with industry specifications (Appendix 2).
- Ensuring the aboveground storage tanks has a leak detection alarm system.
- Ensuring the below ground storage tanks should be double-walled and meet standards.
- Ensuring the design of any new facilities provides for 150% spill containment volume for above ground storage.
- Buggie paths should be designed and located to control traffic in order to protect sensitive features.
- The Leasee of the clubhouse and associated facilities should ensure that the leach drains and septic tanks are monitored in accordance with Department of Health requirements as part of their leasing agreement.

These general principles are detailed in the relevant sections of the document below.

CHAPTER 4

WATER QUALITY MANAGEMENT ZONES

As outlined above, there are seven key areas of operations and facilities that have the potential to impact on water quality. These are:

- Stormwater drains
- Former tip site
- Clubhouse and associated facilities
- Septic tanks and toilets
- Maintenance shed, chemical storage and washdown facilities, and
- General application of pesticides and herbicides, particularly close to wetlands.

Stormwater drains

There are three stormwater drains that feed into the Entrance Lake. One of these is managed by the Water Corporation, one drains water from the City of South Perth Depot and the last drain collects water from the Clubhouse carpark. The Depot drain has a gross pollutant trap and a grease trap for the mechanical workshop. It is unknown whether or not there is any treatment systems on the other drains. All have the potential to transfer contaminants into the Collier Park lakes.

It is important that the sampling program includes assessment of water quality from these sources to enable identification of the source of contaminants of different types.

As part of the City of South Perth's Integrated Catchment Management Plan it will be possible for an assessment of the pollutant capturing capability of the drainage network to be identified. Gross pollutant traps, and oil and grease traps would be of benefit for all of the drainage lines. Should the drainage lines be upgraded at any time in the future such facilities should be incorporated into the new design, if they are not currently present.

Recommendations

1. Ensure the surface water quality monitoring sampling point selection includes the stormwater drains.
2. Upgrade the drainage to include gross pollutant traps and oil and grease separators should the drainage network be retrofitted.

Former tip site

The City of South Perth landfill site is located within the Collier Park Golf Course. Assorted domestic waste, builders rubble, asbestos sheeting, car batteries and possibly commercial waste was disposed of in this location, and a thin cap of clay placed over the top of the waste. Interviews with numerous staff of the City of South Perth suggest that all manner of waste was buried in the area, and it is possible that the entire fill was not inert. It is generally agreed that some putrescible waste was dumped.

There are many unknowns affecting this part of the course. Groundwater monitoring may help to determine if any leachate is entering the groundwater. This is outlined in detail in the water quality management plan.

It may also be worthwhile to further investigate methane release from the tip site, as it has the potential to affect patrons, plants and animals on the course.

Recommendations

3. Ensure the groundwater quality monitoring sampling point selection includes bores and tests comprehensively for a range of contaminants outlined in Chapter 10 of this document.
4. Determine the need for methane monitoring and develop and implement a strategy if considered to be worthwhile.

Clubhouse and associated facilities

The food service areas and clubrooms are likely to be significant waste generators. The use of disposable cups and plates, beverage containers and fast food packaging would accumulate rapidly. These facilities generate 5.8 cubic metres of waste per week on average, plus 2.6 cubic metres of recycling. Increasing the number and range of initiatives relating to the recycling of materials should be built upon with additional recycling bins provided and clearly marked.

The food and beverage buggie that is used to offer patrons refreshments across the course during play, could also have some capacity to encourage patrons to recycle suitable waste.

The kitchen areas should comply with City of South Perth and Department of Health by-laws relating to oil/grease traps and be of a type that is approved under the relevant laws and regulations. Removal of grease and kitchen waste should be in accordance with the relevant State and local government regulations.

Recommendations

5. Provide recycling bins for patrons around the clubhouse facilities and use appropriate stencils or signs on the bins to encourage patrons to do the right thing.
6. Endeavour to use re-usable boxes and packaging where possible in the kitchen and provision areas to reduce use of plastic bags and cardboard boxes.
7. Investigate the feasibility of recycled paper products for takeaways rather than polystyrene.

On-site sewage/septic facilities

There are five septic systems and other on-site sewage facilities are located in accordance with five toilet sites (Map 2).

These facilities should be inspected at least annually. Based on the results of the inspections, the City's Environmental Health Officers shall have the right to perform leachate analysis and other water quality sampling or monitoring related to the operation of the on-site sewage facilities. The Golf Course Superintendent and Environmental Health Officer shall coordinate with the operator of the course to minimise any disruption to play associated with such inspections, sampling and/or monitoring activities.

Recommendations

8. Assess the septic tanks to determine whether or not they are due for pumping out, in accordance with the regulations of the Department of Health.
9. Investigate the feasibility of linking the toilet facilities with deep sewerage or use of alternative treatment systems such as Biomax ® to reduce the potential for contamination of the groundwater.

Maintenance facilities

On-site maintenance facilities, chemical storage, vehicle and off-road equipment storage areas accumulate used oils, tyres, batteries, cleaning solvents and other waste.

A detailed waste management plan should be developed for this water quality management zone to offer direction in managing these issues. The plan should address as a minimum:

- Vehicle maintenance and repair operations,
- Vehicle and equipment washdown facilities,
- Fuelling operations, and
- Painting operations.

Currently, the maintenance compound generates approximately 1.8 cubic metres of waste per week, with the 1 100 kg bulk waste bin and three 240 litre bins emptied weekly. It comprises a range of materials and the waste left by patrons in the bins located around the course.

Recommendations

10. Develop a detailed waste management strategy for the maintenance shed, upon completion of a waste audit.

General application of chemicals

Chemicals will continue to be applied at broadscale for the foreseeable future. Course management has introduced several initiatives to reduce the risk of off-site contamination however there has not been any monitoring to confirm whether or not these initiatives are sufficient. These are discussed in greater detail in later sections of this document.

All areas of the course are treated using the same general approach, with no extra care being taken to protect the wetlands or small native vegetation fragments. There is a risk of transport of fertiliser and/or pesticides into aquatic areas by application "drift", irrigation, surface water runoff or by infiltration through the sand profile beneath the turf layer. This approach should be adjusted to avoid chemical use close to the wetlands.

Soil analysis for some of the more frequently used chemicals would help to assess whether or not there is residue in the soil and a risk of water contamination.

Recommendations

11. Implement soil and water quality testing as outlined in Chapter 10 to determine whether or not chemical residues are accumulating in the soil.

CHAPTER FIVE

MATERIALS AND WASTE MANAGEMENT

Waste management

Generally the approach is to adopt the waste management hierarchy of:

- Reduce – the production of waste
- Reuse – re-use items
- Recycle – recycle items back into new products
- Disposal – environmental sound disposal options

A comprehensive audit of waste which includes the following activities should be undertaken for the Course:

- the types, amounts and the physical impacts of wastes generated;
- total quantities and cumulative physical impact of each type of waste generated; and
- the feasibility of waste reduction/prevention techniques including waste minimisation.

The audit should give consideration to the following hierarchy of waste management options (which implies an order of increasing environmental impact) by taking into account the potential hazard of contaminants, and the potential impact of the items on the environment in light of a comparative risk assessment:

- Re-use;
- Off-site recycling;
- Destruction of hazardous constituents;
- Treatment to reduce or remove the hazardous constituents; and
- Disposal.

In referring to the above hierarchy, demonstrate that the following considerations have been taken into account:

- planning, including safety, economic and environmental analyses;
- cleaning of the items and their components including removal of all potential pollutants; and
- site clearance.

Strategies for the reduction and reuse of waste would need to come from further examination of the waste stream generated. However, some concepts can be adopted from normal domestic waste practices. For example, using reusable crates for the transport of materials instead of cardboard boxes and plastic bags. This would see a reduction of waste being bought onto the Course. Another strategy, that has already been adopted, is to supply beverages in Aluminium cans in preference to other containers. This allows for better recycling due to the high return for Aluminium cans, hence reducing waste for disposal. Further strategies/policies along these lines need to be investigated and adopted by Course Management.

Recycling

Recycling would provide a significant challenge for Course management, as patrons may not always adhere to the management recommendations. It can be surmised that only the high value products such as aluminium cans would be worth while in recovering. It would be more appropriate to consider more reduction programs, as the labour costs for recycling may negate some options.

Rubbish bins

There are at least 29 bins in which Course patrons can place general combined rubbish. The need for recycling bins applies to the entire Course. Rubbish is disposed of unsorted as a result of this current arrangement. Providing recycling bins alongside general waste bins would reduce the amount of sorting required, and therefore reduces the labour component associated with recycling activity.

Recommendations

12. Provide recycling bins alongside existing rubbish bins and sort waste prior to disposal.

13. Continue emptying rubbish bins at 3 – 4 times per week and work to ensure that ravens and crows cannot gain access to the litter.

Construction and maintenance waste

Construction and maintenance activities generate waste. This can be in a range of forms including greenwaste from turf renovation, pine needles and cones, turf clippings through to used oils, grease, tyres, batteries, cleaning solvents and empty containers.

General waste

- To the extent possible, all vehicle and equipment maintenance shall be performed in the maintenance and storage area, or in the City of South Perth depot facility. This area may require some minor retrofitting to ensure that any spills or releases can be contained.
- Used oils, grease, solvents and batteries shall be stored in a covered container until proper off-site disposal can occur in accordance with applicable regulations.
- Spills or releases shall be cleaned immediately and disposed of in accordance with the relevant regulations.
- All persons involved in maintenance activities shall be trained in pollution prevention practices in accordance with City of South Perth policy.
- The Superintendent should be qualified, competent and certified in accordance with Occupational, safety and health requirements.
- All other waste shall be disposed of in approved, covered, non-leaking containers within the maintenance/storage area and disposed of in a timely manner in accordance with applicable regulations.

Fuel Storage and Use

Storage of fuels in containers outside the fuelling station is not permissible. Any person operating the fuelling station should be trained in pollution prevention practices. Any spill on the site should be cleaned immediately and disposed of in accordance with all applicable regulations. Spills shall be documented (product, quantity, location, date, time etc) and reported to any government entity with jurisdiction as required.

Recommendations

14. Ensure all staff are trained in pollution prevention and spill remediation procedures.
15. Ensure all staff comply with State regulations relating to spill recording.

Greenwaste

Considerable volumes of greenwaste are generated through general maintenance activities and as a result of the dominant landscape plant – the Maritime pines. A number of waste management reduction practices are currently in place including:

- Worm farm.
- Composting turf clippings and dethatching
- Soil recycling, and
- Mulching of branches and other woody debris.

There is a considerable issue in disposing of pine needles and cones from the course. Pines needles are very useful in composting particularly when deciduous tree leaves and turf clippings that are generally high in nitrogen are also available. The ratio that is usually used is about 5 times dry material (pine needles) to 2 parts green 'wet' material.

The current management process for turf clippings is to store them between the third and sixth tees, and allowing them to break down over time. This area could be upgraded by installing a concrete containment cell from which any runoff can be collected. The pine needles could then be added to the turf clippings and

thatching, to improve the quality of the compost. It may also be possible to approach some of the big mulch and soil supply companies to determine whether or not there is a potential market.

Soil is also recycled. Sand is stockpiled following turf renovations and during re-turfing. Once the stockpile is full, a screening machine is brought in. The screened soil is then re-applied in the bunkers and as top dressing.

Recommendations

16. Construct a formal composting capacity to use turf clippings, soil and pine needles on-site and use the resulting compost for soil amendment throughout the course.
17. Investigate opportunities for export of pine needles to large soil and mulch manufacturer's to assess the feasibility of selling the waste product for their use in composting.
18. Purchase a mulcher for the Course to improve disposal of organic material.
19. Construct enclosed soil bays to assist with the soil recycling on the Course.

Materials Management

Pesticides, fertilisers, hydrocarbon-based products and waste from equipment maintenance may contribute to point-source pollution and non-point source contamination if not managed properly. At risk are the soils, surface water and groundwater.

There is an existing materials management plan administered by the City's Occupational, Safety and Health officer.

These materials are stored in a locked compound within the Maintenance Shed and need to be separated according to their hazard rating.

Pesticides

Pesticides shall be stored in a lockable, concrete floored and metal building that allows for fire fighting access. The pesticide storage area should be separated from areas used to store other materials, especially fertilisers. Reinforced metal or plastic shelving should be used and any metal shelving kept painted to avoid corrosion. Timber shelving should not be used as it may absorb spilled pesticide materials.

A whirlybird located directly above a metal shelved cupboard ventilates the pesticide storage area.

The concrete floor should be sealed with a chemical resistant coating, and shall have a continuous sill to retain spilled materials. The floor slopes into the middle of the room and drains to a contained sump with no drainage directed outside the building. It is pumped as required.

An emergency wash area is provided and has a designated sump. This wash area should have a screen constructed around it, to enable staff to use this facility without being exposed to patrons of the course.

An inventory of the pesticides kept in the storage compound and the associated Material Safety Data Sheets for the chemicals used in the operation is maintained on the premises, with a second copy provided to the City's OHS representative. The inventory list and the MSDS shall not be stored inside the pesticide storage area itself, as this would make them unavailable in case of an emergency.

Pesticide containers shall be cleaned immediately upon emptying. Containers should be properly cleaned by pressure-rinsing or triple-rinsing and the rinse water dumped into the containment cells beneath the washdown facilities. This water is contained in a separate

Non-rigid bags should be shaken clean so that all dust and material falls into the application equipment. The clean containers should be stored in a clean area, out of the rain and weather, until they are disposed of in accordance with all applicable regulatory requirements.

Washwater from pesticide application equipment must be managed properly as it contains pesticide residues. The currently required best management practice for this material is to collect it and utilise it as a pesticide in accordance with label instruction for that pesticide. This applies to washwater generated both inside and

outside of the application equipment. Generally this occurs two or three times using a minimum of 50 litres per rinse.

For small spills in the pesticide mixing and loading areas, absorbents such as cat litter (attapulgite) or sand shall be used to clean up the spill and then applied as a top dressing in accordance with the label rates, or properly disposed of as waste. Large spills shall be remediated in accordance with all applicable state and federal regulatory requirements.

The pesticides selected are generally over the counter compounds. Course management reserves the right for a licensed pesticide operator to obtain permits from the Health Department to use chemicals for uses other than which the chemicals have been registered. The Health Department pesticide operators licences have to be renewed annually and the operator tested every five years. It is important that these conditions continue to be met by at least one staff member of the Course.

Fertilisers

Fertilisers shall be stored separately and well away from solvents, fuels and pesticides since many fertilisers are oxidants. Fertilisers shall be stored in a metal building and with a fire resistant floor (concrete slab) and roof (metal). Fertilisers shall always be stored in an area that is protected from rainfall.

Washing down the loading area or using dry collection methods such as sweeping and vacuuming shall be the cleaning techniques used in the fertiliser storage area. Any washwater generated shall be collected and applied to the courses. Discharge of this washwater to stormwater drains is unlawful and prohibited.

Flammable pesticides and fertilisers shall be separated from non-flammable products. Dry bags must be stored on raised pallets to prevent contamination by liquid spills. Labels should be clearly visible.

Both fertiliser and chemical sheds have raised ridge cap for ventilation.

Secondary Containment

Areas where pesticides or fertilisers are stored, mixed and loaded, or where containers or equipment for such materials are rinsed, must have proper secondary containment to collect spills and facilitate product recycling. The volume of the secondary containment must not be less than 150% of the total storage volume.

Secondary containment structures shall be constructed of concrete or other approved materials. The floor should be sloped to a sump where liquid can be pumped into a holding tank for recycling. Due to concrete's porosity and low chemical resistance, concrete coming in contact with pesticides and fertilisers shall be protected with a chemically resistant coating or liner.

Pesticide, fertiliser and other chemical operations shall be isolated from other operations such as material storage and equipment, and golf cart maintenance.

Used oil, Lead-Acid Batteries and Washdown Facilities

Used oil shall be collected in marked containers and offered for recycling.

Lead acid storage batteries, such as used in golf carts and for starting other equipment, must be disposed of by a licensed recycler in accordance with all applicable laws. These are placed at the Transfer Station.

Golf carts are generally replaced every two-three years to avoid battery replacement.

The ProShop has a need for a contained washdown facility for the golf carts. At the moment the carts are washed down on a concrete surface and the runoff drains into a soakwell. It would be appropriate for all wastewater to be contained and disposed of appropriately, to overcome the potential for acid contamination of the soil.

Petroleum products

Petroleum products (fuel, oil and solvents) are currently stored on the floor in the maintenance area, which is physically isolated from the golf course turfgrass. Petroleum products are used only for equipment operation (fuel), maintenance and repair activities (oil, lubricants and solvents). A number of additional safeguards such as a concrete bund to act as a secondary containment cell may be of use. Spill response equipment needs to be installed to ensure the containment of these products and to prevent their release from the maintenance area. The parking area in front of the maintenance shed is not paved and therefore is subject to considerable risk of contaminants leaching into the soil and potentially the groundwater. Containment and cleanup are not feasible with the current surface.

Kerosene, oil and grease are stored adjacent to each other in this area.

Solvents and Degreasers

Solvents and degreasers are generally flammable and toxic and shall be stored in lockable metal cabinets in an area with adequate ventilation, away from ignition sources. They shall not be stored near an area where welding or other similar activities are performed, nor shall they be stored with pesticides or fertilisers. An inventory of the solvents stores and the MSDS for these materials shall be kept on the premises, but not in the solvent storage area. Any emergency response equipment recommended by the manufacturer of the solvent shall remain accessible at all times, but not inside the area itself.

Solvents and degreasers shall be used over a collection basin or pad that is ample to collect all used material. Solvents shall never be allowed to drain onto pavement or soil, or discharge into stormwater drains, sewers or septic systems, even in small amounts. Routine discharge of even small amounts of solvents can result in the accumulation of contaminants in soil or groundwater and is prohibited.

Used solvents and degreasers shall be collected, placed into containers marked with the contents and the date, and then picked up by licensed hazardous waste management firm that will properly recycle or dispose of these materials in accordance with all applicable state and local regulations.

Aboveground Storage Tanks and Underground Storage Tanks

The installation or operation of underground storage tanks for hazardous materials including, but not limited to petroleum products, permanent or temporary, at the golf course is permitted.

Fuel is stored in a fenced compound outside the main maintenance building. There is a 2 500 L above-ground storage tank which was installed about 1986-7. It is a steel tank with galvanised/alloy fittings and surrounded by a brick wall bund. The below ground fuel tank holds 2 500 L of unleaded petrol. It was also installed in 1986-7 by a major fuel supplier and therefore can be assumed to meet State government requirements. It is a steel tank with an outside coating of tar. It has brass fittings and the fill tap. Both of these storage units have been investigated by the Department of Minerals and Energy and are appropriately licensed. The licences are renewed annually and expire in April each year.

Staff must be trained in use of the fire extinguisher and are familiar with the emergency response plan. 100 litres of sand is kept nearby to put on any spills, and once the spills are soaked up the sand is collected and disposed of appropriately.

BMP 1
A spill response kit shall be maintained at the facility.

BMP 2
All personnel who will be fuelling equipment shall be trained concerning proper pollution prevention, proper fuelling procedures and spill response kit use. Records shall be kept concerning all fuel deliveries, consumption and spills.

Specific Management Requirements

The following additional management requirements shall apply to the golf course:

- All liquid accumulated in containment structures shall be pumped from the structure and placed in a container for proper disposal or recycling.
- Gravity underground drains are prohibited in secondary containment structures.
- Buried pits or underground storage of hazardous materials, including, but not limited to petroleum products are prohibited.
- Sumps shall be emptied and cleaned as required.
- Pesticide and chemical mixing, loading and equipment washing shall be performed under a roof and in a structure elevated above stormwater runoff.
- The loading area shall always be clean to prevent tyres of vehicles tracking residues out of the loading area.
- If vehicle tyres come into contact with residues, they shall be cleaned before driving off the loading pad.
- Empty containers shall be promptly rinsed and properly stored prior to disposal or recycling.
- All maintenance personnel shall strictly adhere to all manufacturer instructions for all chemicals.
- All bulk storage facilities for chemicals shall have lockable valves.

CHAPTER SIX

INTEGRATED PEST MANAGEMENT

Background

Integrated pest management offers a coordinated decision-making and action process that uses the most appropriate pest control methods and strategy in an environmentally and economically sound manner to meet agency pest management objectives. The elements of integrated pest management include:

- Preventing pest[1] problems.
- Monitoring for the presence of pests and pest damage.
- Establishing the density of the pest population that can be tolerated, which may be set at zero or correlated with a damage level sufficient to warrant treatment of the problem based on health, public safety, economic or aesthetic thresholds.
- Treating pest problems to reduce populations below those levels established by damage thresholds using strategies that may include biological, cultural, mechanical and chemical control methods and that shall consider human health, ecological impact, feasibility and cost effectiveness.
- Evaluating the effects and efficacy of pest treatments.

The broad objective of any integrated pest management (IPM) plan is to define highly detailed management practices for routine golf course management activities that are designed to minimise, and where possible, eliminate the need for chemical applications to control turfgrass pests. Simply stated, IPM is a management system that utilises systematic, disciplined and documented cultural practices as a first line of defense for pest control. Several examples of cultural methods of pest control include:

- Optimising turf health through turf management practices to enhance natural plant resistance to pest infestation,
- Optimising habitats for beneficial species, and
- Minimising damage resulting from routine golf course operations.

IPM's should clearly define numerical damage thresholds for various turf "pests". A damage threshold is the number of pests (fungal infection, weeds, insects) per unit area (per sq m or per 100 m^2) that must be exceeded before chemical control is justified. As an example, this means that the golf course can "live with" the presence of weeds in the fairway, as long as the density (number per unit area) does not exceed the damage threshold.

On occasion, when cultural practices are not fully effective at controlling pests and defined pest damage thresholds have been exceeded, the use of pesticides to manage pest damage may be necessary. An essential component of the IPM plan is the coordination of the ongoing use of cultural methods with the selective use of these agents as a means of minimising the need for pesticide application. In addition, the practices defined should ensure that the release of chemicals from the immediate area of application to turfgrass will be minimised or prevented.

Recommendation

20. Develop an integrated pest management plan to reduce chemical use across the Course, particularly where chemicals are known to have bioaccumulation impacts on wildlife.

Pesticide Application

Pesticide application will be avoided whenever possible, but in certain instances, when a defined pest damage threshold has been exceeded, the selective use of pesticides on the golf course may be the only viable control option.

The most common, and potentially catastrophic type of turf "pest" is fungal disease. Selection of disease resistant grass types, and the use of standard turfgrass management practices combine to optimise turfgrass health and minimise the potential for the development of fungal disease. However, in spite of best management practices, fungal disease will predictably develop under specific conditions favouring disease development. Fungal disease is most threatening to golf course putting greens owing to increased vulnerability of the turfgrass from a variety of stress factors, including low mowing heights and concentrated foot traffic. Under routine operational circumstances, the majority of pesticide applications at the golf course will be limited to the treatment of putting green surfaces with fungicides. On rare occasions, tee surfaces (0.06% total turf area) will

receive spot treatment (backpack sprayer) with a fungicide. In the early stages of turf development, fairway turf is vulnerable to fungal disease, and may require infrequent treatment with a fungicide until maturity is established. The turfgrass of rough will typically not be vulnerable to fungal disease to the extent that fungicide control is required.

Herbicide treatment of fairways (approximately 88% total turf area) will occur approximately three times per year or less to control broadleaf weeds. Tees (approximately 0.06 % total turf area) will receive occasional herbicide spot treatment along with the rough (approximately 10% total turf area). The putting greens (0.05%) receive a minimum of four herbicide treatments per annum.

Several insects can create significant turf damage, and when damage thresholds are exceeded, require treatment with an insecticide. In general, insecticide treatment is uncommon (once every 2-4 years), and when required, will consist of treating all turf areas (greens, tees, fairways) except the rough (greatest percentage of total turf area).

The environmental concern regarding pesticide entry into water is that of potential toxicity. When a turfgrass damage threshold is exceeded and pesticide use is necessary, every possible precautionary management practice will be followed to prevent release of pesticide from the site of application. All pesticides that will be used are those that are approved for use by the National Registration Authority (NRA) to treat specific indications ("pests"). These products have received a thorough review of physical properties, mobility, half-lives, safety, effectiveness, and environmental compatibility prior to receiving NRA approval for use. All pesticides that have potential for use at Collier Park are those that have a proven history of safety and effectiveness when applied to golf courses.

Insects

Of the numerous insects residing in golf course turf, very few actually injure the turfgrass. The few that do injure the turfgrass are classified as burrowing and root-feeding or shoot-feeding. Several species of Black beetle feed on turfgrass roots. Argentine stem weevil feed on the aerial shoots. Several insects are preferential feeders, which limit the injuring to the turfgrass. Others will injure the turfgrass as they feed on the stems, roots and leaves. Burrowing insects are generally not considered a major turfgrass pest.

Pests present within the course include Argentine stem weevils (*Listronotus bonariensis*) and Black beetle – however the only insects treated for are the stem weevil.

Argentine stem weevils

These animals were first identified in the Course and in Western Australia in 1988. It is most active in hot weather – ranging from spring to early autumn depending on the prevailing weather conditions. The weevil occurs across the Course and the Metropolitan area and only attacks cool season grasses. If the weevils are not dealt with promptly it is possible that these animals can destroy a green in three or four days. Course management had a significant problem with these pests in 2003-2004, and the turf was treated on four occasions.

Assessment of the need to treat for Argentine stem weevils
If any insect is spotted then all greens are treated because the mowers can transport the animals.

Treatment train
The affected area is treated at the first sign of the stem weevils with Chlorpyrifos at a rate of 7 L/hectare immediately following the application of Chlorpyrifos, 9-10 mm of water is used for two nights in a row to water in the chemical.

The rate that is used is greater than the manufacturer's recommended rate of 4 L/hectare. The justification for using the chemical at the higher rate is that experience has shown insufficient success at the lower rate, possible resistance building up and that it avoids the need for a follow-up spray.

In 2002, single treatments were applied every 4 – 6 months.

Another chemical that has been used to enhance the success of stem weevil treatments was 'Choice ™'. It was used for the first time in 2002 at the rate of 75 kg/ha as it appears to have been successful in holding the chemical in the topsoil for an extended period of time.

Future treatment approaches for Argentine stem weevil will be as follows:

- Apply chlorpyrifos at 7 L/hectare (which needs to be assessed in the long term as it greatly exceeds the manufacturer's recommended rates.
- Treat the same area with Choice™.

Black beetle

Course management have not sprayed specifically for black beetle, however, it is likely that the treatment for Argentine stem weevils has been keeping numbers below 25 black beetles / square metre which would trigger control.

Nematodes

Nematodes are microscopic round worms that reproduce eggs and moult four times prior to be becoming an adult. All soils contain nematodes and most are harmless, however a limited number, at some time during their life, parasitise turfgrasses. Plant parasitic nematodes are classified based on their feeding habits and are ectoparasitic or endoparasitic.

The tolerance levels of turfgrasses to parasitic nematodes is dependent on several factors. Areas of turfgrass damage are noted by an irregular shape and will vary in size. Aerial shoots often change from green to light green, to yellow and subsequently to brown. In addition, the turfgrass will appear stunted. Roots will be very short with few, if any root hairs. Brown or red lesions may be visible at the tips and the root may appear swollen. The turfgrass root systems under attack from these nematodes will be severely weakened and unable to take up nutrients from the soil.

Cutworm

Cutworms feed on the leaves at night. They tend to leave a distinctive pattern by chewing the leaf around the top.

Assessment of the need to treat for Cutworm
The turf is assessed insitu.
If 10 feed tunnels are visible per green then the green is sprayed. If the number of tunnels is less than that, then Course management depends on natural predators.

Treatment train
Choice ™ was sufficient in 2002 to control cutworm throughout the golf course.

Weeds

Weed control is a significant part of the overall turfgrass management practice as many weeds are prolific seed producers. Water, wind, maintenance equipment and golfers may transport seeds and therefore, spread weeds throughout the course. Topsoil used to topdress soil surfaces may also contain plant segments capable of growing into mature weeds.

There are two major groups of weed based on the plant form, that are of concern to the aesthetic of the turfgrasses. These two groups are weed grasses and broadleaf weeds. Weed grasses, such as crabgrass etc, are monocots which emerge from a seed with a single seeding leaf. The leaves of monocots display parallel veins. Dicots, which include dandelions and clover, have two seedling leaves as they emerge from the soil. The veins of a dicot plant form a network-like pattern.

The weeds are further subdivided into five groups based on their seasonal growth:

- summer and winter annual weed grasses,
- summer and winter annual broadleaf weeds and
- perennial weeds.

Summer annual weed grasses germinate from seed and compete with turfgrass for available moisture, nutrients, light and space. These aggressive weeds begin to emerge from a seed in spring and grow very fast during the summer months. By the autumn, these weeds have completed their lifecycle and die. Winter annual weeds germinate in autumn and winter. These plants usually complete their lifecycle in the spring.

Summer annual broadleaf weeds emerge from seed in the spring and enter turfgrass in the summer months. Winter annual broadleaf weeds invade cool season turfgrass and complete their lifecycle in the spring. Perennial weed grasses and broadleaf weeds live for more than two years.

Diseases

Diseases can adversely affect turfgrasses and are generally a result of poor nutrition, soil compaction, extreme temperatures, drought and/or excessive rainfall. In addition, turfgrasses are injured physically by divots, shoe spikes, golf cart tyres and hydraulic fluid leaks. Injury from physical means often resemble diseases. Most turfgrass diseases are caused by fungal parasites or pathogens. Diseased turfgrass display bleached leaves, discoloured spots or lesions on the leaves and/or depressed circular areas of blighted turfgrass.

The biological control of turfgrasses consists of utilising other living organisms to prevent or suppress the pathogen growth in plants, thatch or soils. Micro-organisms suppress pathogens by occupying space and preventing contact, reducing the availability of shared energy sources and by producing toxins that reduce pathogen growth rates. Biological controls include certain composts that can suppress some turfgrass diseases.

Fungicides

Course management tends to use ecological controls to manage fungal attacks on the course. Fungi require high levels of moisture and humidity and therefore, by drying the area out periodically, it is possible to minimise the spread of the fungus. This technique is preferred by Course management.

The types of fungi that have been found and treated on the course are:

- Dollar spot – found about once every five years during the early establishment of the course and now occurs about once every three years.
- Winter fusarium
- Anthracnose

Treatment train

Course management assesses fungus on the greens and if the fungi do not respond to mechanical and environmental control methods, then Course management resorts to use of fungicides. Course management selects the least toxic fungicide that is available at the time. The affected areas are then treated in accordance with the manufacturer's specifications.

Pest Control Requirements

An integrated pest management system relies on preventing and controlling pests (e.g. weeds, invertebrates and diseases) in which monitoring is utilised to identify pests, action thresholds are identified, management options are evaluated, and most environmentally-beneficial control is implemented. All references to pesticides within the framework of this report encompasses insecticides, herbicides, nematicides, fungicides and any other chemicals used to control pests, weeds or disease. A detailed pest management plan should be developed that includes the following general pest and disease control components:

- Documentation of action thresholds and turfgrass quality guidelines.
- Maintaining permanent records of practices and their relative success.
- Identification of application rates, time of application and method of application to meet quality goals. These should be specific to each water quality management zone.
- Selecting appropriate pesticides based on label information and chemical and site characteristics to limit mobility.
- Reducing the frequency, extent of application and the amounts of pesticide applied. Reducing the frequency and extent of application is accomplished by using lower rates of application and alternate pest and disease control.

- Defining buffer zones and appropriate setbacks from surface water and environmentally-sensitive features.
- Controlling the timing of pesticide application in relation to precipitation.
- Maintaining healthy, dense turfgrasses.
- Using appropriate pesticide technology for application, clean-up and disposal of containers.
- Provide staff training in general with annual updates.
- All mixing shall occur in a mixing centre with spill containment, and the appropriate amount of pesticide prepared for the area to be treated.
- No application of pesticide will occur during windy conditions.
- Chemicals shall be stored in temperature controlled facilities if recommended by the manufacturer, with access limited to authorised personnel.

Least Toxic Pest Control Strategy

The Integrated Pest Management Plan shall provide for the use of the least toxic control approach to address pest problems. This approach requires that once an action threshold for a specific pest is reached, the least toxic, effective control option available will be used to reduce the pest population to acceptable levels. The control measures set forth in the Integrated Pest Management Plan shall provide for the introduction of natural pest enemies (e.g. predators and parasites), utilising syringing techniques, improving air movement within the soil and mechanical traps prior to chemicals. The Integrated Pest Management Plan shall provide that chemical control strategies shall only be used with other strategies have proven ineffective.

The Integrated Pest Management Plan shall identify the combination of control strategies that will be utilised to suppress pest populations with minimal environmental impact. Control measures include biological, cultural, physical, mechanical and chemical methods. The Integrated Pest Management Plan must include a hierarchy of agronomic, cultural, biological, mechanical and chemical controls.

Selection of Pesticides

A list of all pesticides that are currently used, or have been used in the past is provided below. The more detailed pest management plan should include additional information about the maximum application rate, which shall not exceed manufacturer's recommendations.

Table 3 identifies pesticides currently commercially available and their leaching potential. The selection of pesticides shall be based on leaching potential, soil pH, volatility, microbial decomposition and photo-decomposition. This plan should not be construed as authorising the use of any specific chemical listed in Table 3.

Table 3: Selected pesticides and their poison schedule or HAZCHEM code

Example trade name	Common name	Poison schedule	Application rate
Glyphosate 360	Crop Care Glyphosate 360 Herbicide	S5	
Banner	Nuturf Banner Systemic Turf Fungicide	S6	
Baycor turf	Chipco Baycor fungicide	HAZCHEM code 3XE	
DSMA Clear	DSMA Clear	S7	
Dursban turf 500	Chloropyrifos	S6	
Kerb	Rhorural	HAZCHEM code 2XE	
Mesurol 750	Methiocarb	S6	
MSMA	Chemag MSMA Post Emergence Herbicide	S7	
Spearhead	Chipco Spearhead Selective Herbicide	S	4 – 5 L per ha
Index: Poison Schedule S2 = least toxic and S7 = most toxic, often containing Arsenic. HAZCHEM code Rough guideline: Pesticides with a Schedule 2 or 3 have least residual and toxic impact compared with Schedule 7 pesticides, that have greater residue, bioaccumulation and threats to human and environmental health.			

Specific BMPs for Pesticide Applications

As recommended above, a more detailed *Integrated Pest Management Plan* should be developed for the course, which includes the following principles:

- That a coordinated management approach govern all applications of NRA approved products to ensure the retention of pesticides in the immediately vicinity of treated turfgrass areas.
- That pest tolerance (damage thresholds), proper equipment calibration, pesticide preparation, application procedures and equipment clean up are planned for and managed appropriately.
- That all aspects of pesticide preparation, application and clean up are supervised.
- That appropriately licensed and qualified pest control operators are used if necessary.

It is likely that the greens will receive the most frequent application of pesticides to control fungal diseases and other pests such as Argentine stem weevil, and that the roughs are unlikely to receive any pesticide treatments. Whenever possible, pesticides will be applied in a limited, targeted spot spray fashion with curtained boom sprayer when wind speeds are less than 20 kilometres/hour to prevent 'pesticide' drift into adjacent areas. Otherwise applications occur when wind speeds are less than 10 kilometres/hour. Pesticides will not be applied if heavy rain is forecast following the potential application event to prevent pesticide transport by surface water runoff and infiltration.

Risk assessment

Assessment of potential offsite transport of chemicals by runoff or leaching loss prior to application provides essential information on selection of pesticides appropriate for a specific site. The Integrated Pest Management Plan shall identify the pesticides proposed for application to the course and areas on which application is proposed. The Integrated Pest Management Plan shall prohibit the application of pesticides in buffer zones for sensitive features and other areas that have a greater potential for impacting water quality. Any areas requiring additional protection can have prohibition of pesticides.

BMP 1 Management options
Management options for the control of pests and diseases shall include a well-balanced program of cultural, mechanical, structural, biological and chemical control practices. Using a combination of practices it is possible to achieve a reduction in:

- the reliance on pesticides to control pests and diseases
- local resistance of pests and diseases to specific compounds, and
- site loading of chemical compounds.

BMP 2 Action thresholds
Action levels for pests shall be included in the Integrated Pest Management Plan. Establishing action thresholds permits control of pests and reduces the total quantity of pesticides applied in a given area. Another factor includes the use of turfgrass species and cultivars resistant to known pests and diseases. Early detection of pest problems allows for proactive use of alternative control options. Applying pesticides only when and where necessary significantly decreases chemical loading and adverse effects on water quality and the environment.

BMP 3 Follow labels
The Integrated Pest Management Plan should disallow pesticide and fertiliser applications in buffer zones. In addition to the general buffer zone criteria, the Integrated Pest Management Plan shall prohibit the application of persistent and mobile pesticides in areas near surface water, sensitive features, drainage lines, impervious surfaces and areas with thin soils.

BMP 4 Frequency, amount and location of applications
The Integrated Pest Management Plan shall minimise the frequency and extent of pesticide applications. Reducing the frequency and extent of pesticide applications to turfgrass are two of the most effective practices used to reduce potential adverse environmental effects and impacts on water quality. Combining cultural and mechanical practices with chemical control reduces the necessity of chemical applications. Reducing the number of pre-emergent applications of herbicides and making applications only to areas with known problems reduces the total environmental load for each pesticide.

Proper application rates, equipment selection and calibration, careful application to the target site ensures effective use of the applied pesticide. Spot applications shall be used to reduce the amount of chemical applied to turfgrass and to limit total environmental loading. Application of pre-emergent herbicides shall be applied only to areas with known infestations of weeds to further reduce the extent of herbicide application. This is important for the turf nursery area. The Integrated pest Management Plan shall also provide for the placement of pesticides below the soil/thatch surface and 'watering-in' to reduce exposure to runoff process and enhance soil adsorption.

Controlling the timing and amount of a pesticide application in relation to local environmental conditions, especially rainfall, determines the potential for offsite movement and onsite decomposition. The Integrated Pest Management Plan shall restrict pesticide applications prior to anticipated storm events in order to reduce surface and subsurface losses of pesticides in accordance with the criteria set forth below. The following precipitation criteria shall be used in the Integrated Pest Management Plan to schedule pesticide applications:

- Pesticides shall not be applied if, at the time of application, the probability of rain or heavy dew occurring on the day of application is greater than 30%.
- Pesticides shall not be applied if, at the time of application, there is a greater than 35% probability of rain or heavy dew occurring on the day following the scheduled application.
- Pesticides shall not be applied if, at the time of application, there is greater than a 45% probability of rain or heavy dew occurring two days following the scheduled application.
- Pesticides shall not be applied when patrons are utilising the course.

Drift losses of pesticides can be deposited offsite and potentially affect water quality. Drift losses of applied pesticides shall be minimised by:

- Determining wind speed and direction
- Assessing air turbulence or stability
- Optimising droplet density and size distribution
- Evaluating evaporation rate
- Controlling the height and swath pattern of spray delivery
- Controlling volume and amount of pesticide carrier solution, and
- Controlling the proximity of application to sensitive areas with non-target organisms.

Loss of wildlife or aquatic species shall be avoided by restricting application of chemicals with high toxicity during critical lifestage periods.

BMP 5 Equipment maintenance and calibration

Proper equipment maintenance and calibration is essential for even applications at the intended volumes. All label instructions, storage requirements and regulations shall be followed to insure safe handling of pesticides. Proper mixing, handling and loading prior to application will reduce fill-site contamination. Closed systems for loading and mixing pesticides shall be used to prevent contamination of the site. Good housekeeping practices shall be used in loading areas to ensure that any spilled pesticides are not exposed to surface runoff or leaching.

BMP 6 Proper disposal

Proper disposal of unused chemicals and containers will ensure safety of the user, water resources and non-target organisms. Pesticide operators shall avoid chemical exposure by safe handling practices including use of protective clothing, respirators, gloves and shoes.

BMP 7 Chemicals through irrigation system

- ❖ Options for anti-back-siphoning devices to reduce the potential for pesticide contamination of groundwater and other water supplies during irrigation.
- ❖ Flushing of injection equipment to prevent pesticide accumulation.
- ❖ Flushing the irrigation system after pesticide injection.
- ❖ Using properly calibrated equipment.
- ❖ Preventing runoff of the mixture of irrigation water and pesticide.
- ❖ Avoiding application to permanent surface water, semi-permanent standing water or near sensitive areas.
- ❖ Periodic monitoring of equipment to ensure proper application to the intended target.

BMP 8 Periodic review
Periodic review of the success of pest and disease management strategies and program is essential. The Integrated Pest Management Plan shall provide for periodic review of the:

- Management objectives
- Success of the control practices
- New problems, and
- Results of water and soil monitoring programs.

All reviews and results shall be made available to the City of South Perth Community Environmental Advisory Group.

BMP 9 Record keeping
Detailed records shall be kept for not less than three years identifying all amounts and locations of pesticides applied to the golf course.

CHAPTER SEVEN

NUTRIENT PRACTICES

Fertiliser application

The "major" nutrients of fertiliser applied to turfgrass are nitrogen, phosphorus, and potassium (NPK) which are common to virtually all fertilisers. Fertilisers applied to golf courses consist primarily of NPK, and rates of application are typically expressed as kilograms of nitrogen per 1000 square metre. "Minor" nutrients required for robust turfgrass health include calcium, sulphur, iron, boron, copper, manganese, magnesium, and zinc. In general, compared to the application of NPK, "minor" nutrients are applied rarely, if at all, because of the low requirements by turfgrass, and the presence of naturally occurring "micro" levels of this nutrients in soil.

The primary environmental concern regarding the influence of fertiliser application on water quality is eutrophication (nutrient loading). Nutrient loading can stimulate undesirable aquatic plant growth, which in turn can lead to a variety of negative, secondary impacts on aquatic environments. The two nutrients present in fertiliser known to cause eutrophication are phosphorus and nitrogen. Phosphorus, which can stimulate plant growth at relatively low levels, is highly mobile in sandy Western Australia soils. Nitrate (a byproduct of applied nitrogen) is comparatively mobile in soil, and as such is a good indicator of nitrogen movement.

Phosphorus loss is often associated with sediment transport, while nitrogen can be transported by surface runoff, especially if applied prior to a rain event or if there is excess irrigation. As the time between application of the product and runoff increases, the amount of nitrogen subject to transport decreases.

The leaching potential of nitrate is reduced if turfgrass is properly maintained. The potential for leaching increases when nitrogen is applied in excess of individual plant requirements or subsequent to a significant rain event. In addition, drought may increase nitrate leaching. To reduce the possibility of nitrate losses, slow release nitrogen sources shall be used. Timing of the application of the nitrates, coupled with limiting irrigation to the amount needed by the turfgrass is the most effective method to mininise leaching capabilities.

Healthy turfgrass roots are ideally suited to uptake these nutrients from the soils. Healthy turfgrasses have root systems that are extensive, fibrous and contain a large surface area. All nutrients are mobile inside plants, but the mobility in the soil varies. Soils rarely supply the needed nitrogen to support high quality, wear resistant turf. The amount of nitrogen required varies by the type of turfgrass. Excess nitrogen fertilisation will result in poor turfgrass rooting which allows for a greater susceptibility for disease to attack the plants.

Turfgrasses deficient in nitrogen often appear stunted, with short leaves and lack of colour. Older leaves may first turn pale green in colour, followed by a yellow colour as the deficiency symptoms progress toward the base of the blades.

Phosphorus is very important in the transfer and storage of energy within the turfgrass. In addition, phosphorus-containing compounds have an effect on the genetic information. Phosphorus is highly mobile in sandy soils.

Potassium is associated with several turfgrass internal processes. It activates enzymes, is involved with photosynthesis and helps regulate the stomates on the exterior of the turfgrass, which is responsible for releasing water from the plant into the atmosphere. Turfgrasses with low potassium are not very tolerant to the stress of either high or low temperatures or even drought.

Required Nutrient Practices

The objective of the fertiliser program is to provide optimal nutrition for the turf grasses while simultaneously avoiding the application of excess nutrients to avoid weed infestation, disease development and offsite nutrient contamination. Every effort needs to be made to prevent the escape of nutrients from application areas through careful practices.

Fertiliser requirements vary considerably depending on the type of turf, location and area. Areas of rough that are currently turf receive the least frequent application of fertiliser and the smallest areas of turf such as the tees

and the greens receive the most frequent applications. In all instances, fertiliser is applied at a rate to maximise the efficiency of plant uptake, which occurs at a depth of 50 mm to 100 mm below the turf surface. To minimise nutrient transport by surface water runoff and/or infiltration into the soil, slow release sources and/or light applications of soluble, foliar adsorbed nutrients may be used. All applications are to be made using calibrated equipment to ensure the proper rate of application.

The potential for nutrient transport by surface water runoff and infiltration is reduced by the application of fertiliser in times when heavy and sustained rainfall is unlikely. Fertiliser applications tend to occur when turfgrass becomes active in the spring and is continued over summer on an as-needed basis until turfgrass enters dormancy in autumn. Regardless, fertiliser is not applied if heavy rain is forecast following the proposed application event.

A nutrient management plan should be developed for the course that includes the following best management practices.

BMP 1 Application frequency, rate and timing
Identification of application rates, time of application and method of application to meet quality goals and specific to each water quality management zone.

BMP 2 Soil and tissue tests
Use soil and tissue tests to establish proper application rates, and use the nutrient application history or credits for all sources of nitrogen. Sampling to analyse soils to determine chemical content and to set fertiliser application rates so as to correspond to nutrient uptake.

BMP 3 Thatch management
- ❖ Monitor and maintain thatch level.
- ❖ Conduct top dressing to enhance the thatch layer.
- ❖ Implement periodic soil aerification – with penetration into the soil profile shall not exceed 50% of the soil profile.

BMP 4 Nutrient budgets
- ❖ Establish nutrient budgets for all sources of nitrogen and phosphorus, including the uptake by the mature pines and non-indigenous landscape plants.
- ❖ Minimise the total input of fertilisers.
- ❖ Utilise buffer zones and setbacks from surface water and environmentally sensitive features.
- ❖ Control the timing of fertiliser applications in relation to precipitation events.

BMP 5 Equipment management
Use of appropriate application technology including multiple low rate applications, granular formulations, proper equipment calibration and maintenance, proper disposal of unused fertiliser and no application to bare soil or impervious surfaces.

BMP 6 Maintenance
Maintaining healthy turfgrass using appropriate irrigation, pest and compaction control strategies.

Recommendation

21. Develop a nutrient management plan to reduce chemical use across the Course, particularly where chemicals are known to have bioaccumulation impacts on wildlife.

ESTABLISHING NUTRIENT BUDGETS

The detailed nutrient management plan shall include complete nutrient budgets for each water quality management zone, fairway, green and tee. The budgets shall include the following:

- Quantifying the total input of fertiliser and nutrients: inorganic, organic and irrigation water.
- Use of soil tests, tissue tests and application history or nutrient credits to establish proper application rates. Clipping management is part of nutrient credits.

The timing of fertiliser application will depend on weather conditions and stage of turfgrass development. Fertilisers are to be applied in line with turfgrass needs. Nitrogen or phosphorus applied in excess of turfgrass uptake ability can be lost in runoff, interflow, drainage or leachate and is prohibited.

Interviews with other golf course superintendents throughout Perth show their fertiliser applications tend to be at the minimising end of the scale with 20 – 25 kg N, 20 kg P and 40 kg K per ha per annum at the break of the season. This is followed by a mid-winter foliar feed of urea (10 kg/ha) with trace elements iron and manganese. Such a regime minimises de-thatching and mowing.

It is important that Course management documents their fertiliser use.

Reduction of Fertiliser Input

Fertiliser applications shall be based on need, not calendar dates. Using appropriate (and not excessive) rates or nitrogen and phosphorus to maintain nutrient levels to sustain turfgrass quality is one of the primary best management practices to protect water resources. The following are additional general requirements that shall be followed concerning the timing of fertiliser applications that shall be incorporated into the Nutrient Management Plan:

- The optimum time of application depends on turfgrass species and weather, soil conditions and chemical formulation of the fertiliser. Application of nitrogen after turfgrass uptake of nitrogen has ceased is prohibited.
- Dates of fertilising.
- Light irrigation or watering-in after application shall be employed to reduce runoff and leaching losses of fertilisers.
- Over-application of any form of nitrogen is prohibited.
- Drift losses of nutrients can be deposited offsite and potentially affect water quality. Drift losses of applied nitrogen shall be minimised by
    - ❖ Determining wind speed direction
    - ❖ Assessing air turbulence or stability
    - ❖ Optimising droplet density and size distribution
    - ❖ Evaluating evaporation rate
    - ❖ Controlling the height and swath pattern of spray delivery, and
    - ❖ Controlling the volume and amount of applied nutrient carrier solution.

Turf/Leaf Tissue Analysis

The Nutrient Management Plan shall require indicative samples for turf grass/leaf tissue analysis at least once a year. Analytical results should be entered into a database to ensure this information is available in the long-term. The data should also be graphed and the proposed fertiliser regime reviewed in light of the results of the sampling.

Plant tissue analysis shall identify the amount of nitrogen and phosphorus in plants. This data combined with an evaluation of the aesthetics of the turf, will determine the next set of fertiliser application rates which will be based upon nutrient deficiencies.

Fairway plant tissue parameters to be analysed shall include, at a minimum, phosphorus and nitrogen. Sampling results shall be incorporated into the nutrient budgets.

Soil Analysis

Applications of fertilisers at rates higher than those recommended by soil tests, plant tissue analysis or those estimates based on realistic growth requirements, increases the risk of offsite nutrient movement by surface runoff or leaching, and is prohibited. Soil test shall be taken regularly to determine specific nutrient requirements.

Fertiliser applications shall be based on plant tissue analysis, soil tests, soil temperatures, turfgrass conditions and weather conditions. Soil test results will aid in the development and modification of the nutrient budget.

Use of slow release formulations of nitrogen

The golf course shall utilise slow release fertilisers, which reduce environmental impacts resulting from losses of nitrates. However, the release of available nitrogen form the slow release fertilisers must match the time of active turfgrass uptake. Nitrogen released from slow release formulations during turfgrass dormancy is subject to long-term losses in leachate and runoff. Over-application of slow release and organic forms of nitrogen is prohibited in order to reduce the long-term potential for both surface water and groundwater contamination.

Liquid fertiliser use is currently being evaluated and may be used in the course in the near future. The proposal is to use Super Energy along with potassium sulphate and calcium nitrate and to avoid watering it in at night. Blanket spraying the Course takes 8 – 10 hours so it can only occur when there are no patrons – which means this work must be undertaken at night. This is not the ideal time for application as the plants are not active, however, keeping patrons on the course and the difficulties with human resource management associated with getting staff to work before 5 am makes this approach necessary.

Monthly application of one of three treatments to each series of nine holes – to assess their effectiveness.

Osmocote or Scotts should be trialled with the intention of keeping the nutrients available for longer. While the most frequently used fertiliser 'Horticulture Special' (CRISCO or CSBP) is easy to spread and quick to put out, there is a four day delay in the uptake by plants – which in the event of a rainfall event increases the risk of the nutrient leaching through the soil.

It may also be worth trialling seaweed emulsifier, increasing use of water holding granules and testing a range of organic and slow release fertilisers to assess the feasibility of using less inorganic forms of fertiliser.

BUFFER ZONES AND SET BACKS

The wetland or natural areas within the course should be treated as sensitive areas and have defined buffer zones around them. These areas should receive no application of fertiliser, fungicides, insecticides or broadleaf herbicides. The width of the buffer areas will be defined in discussion.

a) Wetlands
Buffer zones of 5 metres surrounding all wetland areas will be established and maintained. No application of fertiliser, fungicides, insecticides or broadleaf herbicides will occur in buffer zones. Entry by golfers into buffer zones should be prohibited by the signage designating these areas as environmentally sensitive.

b) Natural areas - bushland
Buffer zones of 5 metres surrounding all bushland areas will be established and maintained. No application of fertiliser, fungicides, insecticides or broadleaf herbicides will occur in buffer zones. Entry by golfers into buffer zones should be prohibited by the signage designating these areas as environmentally sensitive.

To reduce the transport of nutrients and/or pesticides from the area of application to the aquatic areas, it may be possible to use strategically placed contoured areas of turfgrass to direct surface water runoff away from sensitive areas. This can then evenly distribute runoff over turfgrass areas to utilise the bio-filtration properties and capture and retain the bulk of nutrients and pesticides within turfgrass areas.

The sandy soils within the course have very limited capacity to bind and hold nutrients or other chemical compounds.

Control the timing of fertiliser applications in relation to precipitation and heavy dew events

Research on turfgrass and water quality demonstrates that major runoff and leaching losses of nitrogen, phosphorus and pesticides will occur if rain events or heavy dew occurs on the day of application or the day after application. The following criteria shall be incorporated into the Nutrient Management Plan and shall be utilised to schedule fertiliser applications:

- ❖ Fertiliser shall not be applied if, at the time of application, there is greater than 30% probability of rain or heavy dew occurring on the day of the scheduled application.
- ❖ Fertiliser shall not be applied if, at the time of application, there is greater than 35% probability of rain or heavy dew occurring on the day following the scheduled application.
- ❖ Fertiliser shall not be applied if, at the time of application, there is greater than 45% probability of rain or heavy dew occurring two days following the scheduled application.

Light irrigation or 'watering in' after application shall be utilised to reduce the risk of runoff and leaching losses of fertiliser.

Use of Appropriate Application Technology

Application techniques that reduce surface and leaching losses must be included in the Nutrient Management Plan. These techniques include:

- Incorporation, placement below the soil/thatch surface and watering in of fertiliser reduces fertiliser losses in runoff and enhances soil adsorption.
- Frequent application at reduced rates. This practice reduces the total load of nitrogen available for surface and subsurface losses and increases the efficacy of turfgrass uptake.
- Granular formulations shall be used whenever possible as opposed to surface applied liquid formulations of nitrogen.
- Application of fertilisers shall never occur on bare soil surfaces or impervious surfaces such as maintenance roads.
- Maintenance and calibration of all application equipment is essential to provide for proper placement and nutrient delivery. Improper calibration and equipment maintenance will result in over- or under-application and uneven distribution of nutrients.
- Maintenance of clean loading pads and clean up of any fertiliser spills in the maintenance areas is required.
- Disposal of granular fertiliser sacks, liquid fertiliser containers and unused fertiliser shall be in accordance with all applicable regulatory requirements. Plastic containers shall be triple rinsed prior to disposal.

Record Keeping

Detailed records shall be kept identifying all forms and sources of nutrients applied to all turfgrass in order to determine loading rates of fertiliser application. Records of nutrient applications shall include:

- Types and amounts of commercial fertilisers
- Whether clippings are returned to fairways and roughs from tees and greens.
- Available nutrients in irrigation water. The amount of irrigation water for a given area and concentration of the nutrient in the water is needed to determine the total mass of nutrient applied.

CHAPTER EIGHT

TURF GRASS MANAGEMENT

Turf grass management

The goal of irrigation is to provide the minimum amount of water required to produce the desired playing characteristics. Among the factors that are important to water need are grass selection and installation, plants in non-turf areas, irrigation zoning, determining when to water and maintenance. Some of these issues have already been addressed in previous chapters, and therefore will not be repeated in this section of the document.

Turf Selection and Installation

Collier Park Golf Course principally uses a variety of Couch known as Santa Anna on all of the fairways and greens surrounds. There is currently 46 hectares of Santa Anna within the Collier Park course.

Several different varieties of Bentgrass are used on the greens. The breakdown of varieties is provided in Table 4.

Table 4: Bentgrass varieties current and proposed for greens

Hole	Bentgrass variety current
1	Penn Eagle
2	Penn Eagle
3	Penn Eagle
4	Penn Eagle
5	Putter
6	Penn G2
7	Penn Eagle and Cato
8	Penn Eagle
9	Cato
10	Penn Eagle
11	Penn Eagle
12	Penn Eagle
13	Penn Eagle
14	Penn Eagle
15	Penn Eagle
16	Penn Eagle
17	Cato
18	Penn Eagle
19	Cato
20	Cato
21	Cato
22	Cato
23	Cato
24	Cato
25	Cato
26	Cato
27	Penn Eagle
Chipping and putting greens	Penn Eagle

Two metre surrounds on greens of rye grass (3 –4 varieties) are currently being considered for use as it is an effective means of preventing couch invasion into the bentgrass turf.

Turfgrass is most efficient when it grows on soil sufficiently enriched with organic material. As turf replacement and restoration occurs, the substrate should be enhanced with organic material to a depth of at least 200 mm.

Sodding is more desirable than plugging for turf establishment as is reduces the water required to establish the grass and it reduces the threat of wind erosion during the establishment of grass coverage.

The seed of Penn Eagle is becoming very difficult to source so Course management is investigating alternatives. Cato was trialled and used extensively in the course for a five year period and has been shown to not recover from damage quickly enough.

A new variety of grass Penn G2 or PennX is proposed for introduction to the course. A detailed management regime for turf needs to be prepared to provide an overview of the frequency of renovations, de-thatching, mowing and other treatments.

Recommendation

22. Develop a detailed turf management plan justifying the turf selection and management regimes, including scheduling renovations.

Grass establishment protocols

Replacing greens

- Strip back to soil level.
- Rotary hoe, rip, aerate and loosen soil without damaging the reticulation.
- Assess soil condition and if poor quality, import new soil from course or off-site if necessary to build up levels (contours) – selecting well draining soil with some organic matter to improve nutrient retention.
- Water.
- Shape the green and level it to required contours.
- Water well and then compact the surface until firm.
- Fertilise with 'Horticulture Special' (27% NPK plus trace elements) at 20 kg per green – which lasts 14 days.
- Seed at 4 - 5 gm / square metre.
- Water 5 minutes every hour when establishing in summer. Each green usually has 4 – 6 heads at a rate of 156 L/min/head on the old course while the new nine has more efficient sprinkler heads which use 94 L/min/head.
- Fertilise with 50% on the 14th day.
- Fertilise with 25% on the 24th day.
- Fertilise with 25% on the 34th day.
- Fertilise with 25% on the 44th day.
- Add extra K and N if necessary.

Using this approach turf establishment tends to take 12 – 16 weeks. More frequent fertiliser applications can reduce the establishment time to 12 weeks. It is possible for the green to played by up to 150 patrons per day after six weeks, however, as Collier tends to have more than 450 patrons per day it is critical that the turf is more mature before play resumes.

Issues include continuous patronage of the course and difficulty excluding patrons from the establishing turf areas and relatively high watering requirements when turf is established in summer.

To improve water efficiency and minimise disruption to patrons and potential conflict between course management and patrons, the following BMPs are recommended.

BMP 1
Establish new greens in winter. Although turf establishment will take longer, watering in will be minimised as well as watering required during site preparation. Further, fewer patrons utilise the course in these months which reduces disruption to players.

BMP2
Should additional sand be required, order by particle size to improve consistency. Some effort should be placed into increasing the organic material loading of the soil where possible, to improve it's nutrient and water holding capacity.

BMP 3
Where possible, grow turf in the turf nursery and re-turf instead of growing on from seed. This will reduce the establishment time to 3 – 4 weeks and reduce fertiliser and water applications.

Non-Play Areas

Non play areas that surround the fairway and roughs should be restored to native *Banksia* woodland, with the addition of native plants to enhance the aesthetic and habitat value of the course. These areas should not be irrigated, but plants installed in May-June to maximise their establishment through the use of rainfall.

Measures for management of these areas should include:
- Protection from soil compaction,
- Replacement of non-local species with appropriate natives should continue.
- Out of bounds signs or GUR should be placed strategically around these areas.

CHAPTER NINE

IRRIGATION MANAGEMENT

Bores

During the time of the initial establishment of the course, a number of bores were established to irrigate the new course. These are known as bore numbers 1, 2 and 3 (Map 3). Bore number 2 has been re-drilled but still working the original location – technically there are two bores known as 2, of which one is considered to not exist. Bore No 4 was installed approximately 1992. Bore numbers 5, 6, 7 and 8 were installed 1994-95.

Of these eight bores only five extraction points are licensed by the Office of Water Regulation. The total allocation is just over 450 000 GL.

The computer controlled irrigation system enables close monitoring of the volume of water used for irrigation purposes. The pipe network however is in poor condition and, by assessing the grass quality in aerial photographs, does not appear an effective arrangement to achieve efficient water use.

Recommendation

23. Develop a bore management plan and review licence arrangements through the *Waterwise Strategy* that is currently being prepared by the City of South Perth.

Irrigation Plan

The maintenance of proper soil moisture content is critical to prevent turfgrass damage from dehydration. Equally important is the prevention of over-watering, which can create saturated soil conditions that result in turfgrass damage. The areas that require the most frequent irrigation are tees, fairways and greens while the rough has limited watering to conserve water.

There is a need to conserve water. By reducing the use of turf in rough areas, and watering native plantings and establishing trees sparingly it is possible to reduce water consumption. It is difficult to reduce the watering of turf over summer months as this is the time of the greatest traffic.

The root systems of the golf course grass types, in this case bentgrass and fescue, have the potential to reach a maximum depth of about 10 centimetres. If the proper moisture content required is actually applied, then healthy turf grass will tend to have much shallower root systems.

In Collier Park Golf Course there is the additional complication of water extraction by the Pine trees and exotic landscaping species such as Tipuana that tend to have shallow root systems. These trees compete with the turf for water and nutrients, so while they provide landscape value and some habitat benefit they cause additional consumption of water and fertiliser. As mentioned in Chapter 2 the Pine trees remove significant volumes of water from the Course.

The City of South Perth has invested considerable resources into the development of irrigation management system that maintains a proper soil moisture content at the appropriate depth by the use of a computer controlled irrigation system. This system is designed to deliver water to turfgrass on an as-needed basis, and in a highly targeted manner. It is managed so that a smaller volume of water is applied twice a night, to try to achieve sufficient coverage while there are strong easterly winds.

One of the most significant issues with the Collier Park Golf Course is the alignment of the main irrigation line within the rough and beneath a number of trees. These trees pose a threat to the mainline.

As mentioned above, aerial photograph interpretation also shows that the current reticulation design has a number of inefficiencies with dry areas between the spray diameter of each knocker and other areas being watered unnecessarily. Combined with the location of the mainline and the age of the mainline, it is clear that there is an urgent need to review the irrigation system and associated infrastructure. The existing infrastructure appears to be reaching the end of its working life, therefore forward planning to ensure replacement of the system is necessary.

Map 3: Bores and piped drainage

Note: it is likely that only bore extraction points 5, 6, 7 and 8 are licenced.

300 0 300 600 900 Meters

N

LEGEND

- % Outfall
- Ú Bore
- (Inlet
- # Outlet from lake
- § Inspection pits
- Piped drainage

The primary means of determining turfgrass irrigation requirements will be the daily monitoring of the turfgrass conditions by the Superintendent and staff. Data obtained from weather forecasts and it is proposed that a weather station be installed at the City of South Perth Depot to assist in this decision making process. Currently however, the data tends to be at least one day behind – which can be a critical problem in the heat of summer in Western Australia.

Evapotranspiration data, from this equipment could be entered into the computer controlled irrigation system to establish location specific irrigation duration and frequencies.

By ensuring irrigation practices limit soil moisture content to a depth of less than 10 centimetres to support healthy turfgrass, water conservation can be optimised. In addition, highly controlled irrigation systems will help to eliminate the possibility of nutrient and pesticide transportation or infiltration by water arising from the irrigation system.

Recommendation

24. Develop a detailed irrigation management plan including a review of the current reticulation system, the relative extraction of water by pines versus the turf and identifying new technologies that could improve watering throughout the Course.

Irrigation Schedules

The Irrigation Plan utilises programmable irrigation control systems to meet the needs of the plants without overwatering. Modern irrigation technologies have been introduced to provide for highly efficient water use. The use of data from the proposed weather station should help to determine evapotranspiration loss from the turf grass daily. Irrigation head placement shall be designed to provide complete coverage of the necessary golf course turf area, when the irrigation is overhauled in the future. As mentioned above, the current irrigation system is ineffective with areas of overlap and areas lacking coverage. A complete overhaul of the irrigation infrastructure is necessary to achieve improved water efficiencies. In particular, the existing mainline is also reaching the end of its life and should be upgraded to a more appropriate location.

Replacement irrigation will be based on evapotranspiration as determined by the onsite weather station and shall utilise best management practices to conserve water. Actual irrigation rates must be recorded and a report summarising irrigation practices is to be made available to the Manager of Parks and Environment annually upon request.

The irrigation plan shall establish irrigation schedules and volume based on need. Irrigation schedules shall minimise evaporation and reduce the potential for disease. Irrigation scheduling and control of irrigation volume effectively conserves water resources and protects water quality. Use of calendar irrigation methods should be avoided. Manipulation of irrigation volume, timing and rate of application are the principal components of irrigation scheduling. Runoff and leaching caused by overwatering should be avoided.

Irrigation Zoning

The golf course irrigation system is designed to allow individual sprinkler zones to operate independently. The irrigation system has been designed to be compatible with the following criteria:

- Future use of an onsite weather station to measure evapotranspiration
- Interfacing between the weather station and the irrigation system to operate the zones based on water need determined by the evapotranspiration rate.
- Using best management practices shall be employed to conserve water and prevent over-watering in connection with all irrigation operations.

Course management has used two cycles per night across all irrigation zones to try to ensure adequate coverage with westerly and easterly winds over night. This helps to overcome poor sprinkler coverage.

Water Conservation

A detailed irrigation plan should be developed that provides for the efficient management and conservation of water supplies to prevent depletion of local water resources.

Water conservation shall be achieved by using specific irrigation schedules based on replacing evapotranspiration loss, minimising the area to be irrigated for golf course purposes and through the development of a general 'waterwise' strategy, as proposed by the City of South Perth.

The overall water conservation strategy should target the conservation of water on a continuous basis using the following general principles:

- Establish a lower boundary for deficit irrigation strategy for example reduce the percentage of evapotranspiration replacement. This may need to be based on field trials conducted by water quality management zone and by soil mapping units to establish the potential lower limits of deficit irrigation.
- Establish priority turfgrass areas requiring irrigation. Greens and tees have the highest priority followed by fairways, ornamental plantings, roughs and unmanaged/natural areas. Irrigation priorities should be established prior to emergency conditions.
- Reduce the total area irrigated and the total volume applied to irrigated areas during water shortage conditions.

The Parks and Environment group within the Council will have prepared a *Waterwise strategy* for the City by early 2004. This document will provide a valuable resource for re-applications for bore licensing and may result in a requirement for the course to reduce their water use.

Maintenance

Maintenance is a critical component of efficiently and effectively utilising irrigation water. Currently sprinklers are checked weekly and pumps are flow tested annually.

The irrigation plan shall provide for regular inspection of irrigation systems to identify leaks and to monitor water usage. The irrigation plan shall specify the frequency of regular mechanical performance evaluations to detect problems such as worn nozzles, leaking valves/heads, valve operation, satellite controller security and pump operation. Relief valves and pump mates need to be checked quarterly.

Golf Course staff will be trained to identify leaks and malfunctioning irrigation heads. A formal system shall be established to report conditions and initiate repair work immediately. All irrigation heads shall be inspected not less than weekly. This inspection will be documented by the Course Superintendent in a report completed and retained on site and made available for review by the Manager Parks and Environment upon request.

A licenced irrigator shall conduct an annual audit of the irrigation system. The audit will include an efficiency determination and identify new technologies and solutions (if they exist) to maintain the golf course irrigation system(s) at a minimum of 85% efficiency.

Iron management

The use of bore water in the course means that there is frequently an accumulation of iron minerals in the pipe work. This further reduces the efficiency of the irrigation system and can impact on the pumps. Flushing is undertaken periodically – to improve water flow. There are a range of products available to help breakdown iron accumulation in the pipe work. The Golf Course Superintendent should closely monitor the accumulation in the pipe work and treat as necessary.

New technologies should be investigated that use less toxic compounds than some of those currently used. This review of options should be prepared by Course management and provided to the Environmental Programs Coordinator for assessment.

CHAPTER TEN

WATER QUALITY MONITORING PLAN

CHAPTER 10: WATER QUALITY MONITORING PLAN

Water quality monitoring plans offer a mechanism to evaluate the effectiveness of management practices at preventing the introduction of nutrients and/or pesticides applied to the golf course into water. There are three areas of surface water and the unconfined groundwater that are potentially influenced by course management practices. Other potential influences on water quality include a Water Corporation drainage inlet in the entrance lake – which arises from beyond the course boundaries, a City of South Perth drainage inlet, a carpark stormwater inlet and historical landuses within the course grounds.

There is some limited water quality data that was collected in the early years of the course development. It is recommended that a comprehensive water quality study be undertaken to establish a baseline data set. This data set will allow comparisons to be drawn about the success in implementing this environmental management plan.

It is important that the data collected meets the rigorous scientific standards required by the Waste Management directorate within the Department of Environment. Therefore the sampling procedure and findings need to be consistent with this department's requirements. The results will then need to be reviewed against *Australian Water Quality Guidelines for Fresh and Marine Waters* (ANZECC 2002). In the event that a nutrient level exceeds the respective baseline value, or if a pesticide is detected, a specific set of corrective action procedures defined in this *Water Quality Monitoring Plan* will need to be implemented.

The stormwater, surface water, groundwater sampling components, and possibly leachates, shall be included in water quality monitoring plan. Comprehensive sampling will occur at agreed locations for surface water, bores, lakes, sediments within the lakes and any other onsite testing deemed necessary to monitor the quality of water within the course. All sampling points will be marked with a Geographic Positioning System to enable consistency in sampling in future years. Course management and the City's Environmental Coordinator shall agree on the sampling locations. The locations should be based in part on proximity to sensitive features and an assessment of water quality risk factors.

Recommendation

25. Undertake a comprehensive water quality monitoring program to obtain baseline data to determine if the chemicals used across the Course are leaching into the groundwater or being transported in the surface water.

Groundwater

The course has eight bores which provide an opportunity to monitor groundwater quality and measure the influence of golf course management practice on water quality.

As mentioned above, it is important to obtain a comprehensive baseline data set against which management can assess their operational practices. Once this baseline data set has been developed, monitoring should occur at quarterly intervals. Samples will be tested for nitrogen and phosphorus, all pesticides that have been used in the past five years and possibly heavy metals for areas close to stormwater entry points and the maintenance compound. The minimum sampling parameters are outlined in more detail below, and identified in Table 7.

With respect to fertilisers and pesticides, it is important the parameters be adjusted to reflect the specific compounds utilised in the course. Considerable effort has been put into identifying these compounds. The Course Superintendent provides the manufacturer's Material Safety Data Sheets for the pesticides, herbicides, fungicides, algaecides and other materials applied to the course to the City's OSH representative. These MSDS's should be used to develop a list of proposed analytes. This method will provide for the sampling of indicator metals and other materials that may be present in the pesticides, herbicides, fungicides and other materials applied.

A copy of all such data sheets shall also be retained with the City of South Perth Environmental Programs Coordinator. The list of analytes shall be approved by the Environmental Programs Coordinator, and the option to change the analytes from time to time, based on the leachate potential and other water quality risk factors presented by the compounds applied to the course.

The plan outlined below sets forth specific trigger levels for corrective action. Trigger levels are based on specific percentages of the following regulatory standard:

Surface water and leachate	100% of ANZECC standards
Lake water adjacent to outfall	100% of ANZECC standards
Groundwater	100% of ANZECC standards

Golf Course Surface Water Sampling

There are areas within the course where surface water flows as a result of water repellancy and areas of clay capping around the former waste disposal site. This water has been directed through subsurface pipes to bioswales to allow for infiltration. These bioswales have been located in areas believed to be devoid of rubbish and tipwaste – minimising the risk of inadvertent contamination of groundwater by the percolating surface water. These areas could be sampled periodically to ensure that the water quality meets environmental guidelines.

Non-Golf Course Surface Water Monitoring

A significant stormwater drain feeds into the Entrance Lake and collects road and development runoff from Technology Park, Kent Street and Hayman Road. This drain has the potential to contribute a range of pollutants including heavy metals, hydrocarbons, nutrients and organic matter. It is important to sample water entering the course from this source to allow for adequate breakdowns of pollutant sources to be identified, and the relative contributions to be assessed.

Golf Course Leachate Sampling

The surface water sampling component of the plan shall provide for the sampling of surface runoff on not less than two holes on the course and in all lakes and stormwater drains beyond the bounds of the course.

As a best management practice, the fairways must be designed to retain stormwater longer and allow infiltration and uptake by the turf rather than allowing stormwater to run quickly offsite. Where the fairways have been constructed over the former rubbish tip site, stormwater runoff must be directed to an infiltration point that does not occur over the former tip site. These infiltration points may allow representative sampling of water quality.

The second surface water sampling point shall be from the green area. The sampling location is to be approved by the Golf Course Superintendent in discussion with the Environmental Programs Coordinator, and shall allow for comprehensive sampling of the quality of any stormwater runoff from the green area.

Sampling will be performed on two randomly selected holes and each bore and lake not less than four times per year, on a quarterly basis. A grab sample will be taken from the first flush during the first thirty minutes of the runoff event from the stormwater drains, lakes and the recommended sampling points.

The City may wish to invest in a sampling station at the entrance lake and discharge lake to allow composite samples to be taken 20 minutes apart during an entire storm event or for the first three hours, whichever is shorter.

Sampling must also be performed during the first rain event that generates runoff after each blanket application of pesticides or fertilisers. Such sampling may qualify as one of the required quarterly sampling events, provided it meets all applicable requirements of the agreed *Water Quality Monitoring Plan.*

In addition to the surface water monitoring, each of the three lakes on the golf course shall be sampled quarterly.

Soil analysis

Analysis of soil chemistry has been undertaken periodically to assist the Golf Course Superintendent to determine the cause of poorly performing turf. The bulk of the sampling was focused in the early establishment of the turf and does not appear to have been used regularly to assess changes in soil condition. The low readings that have generally occurred are consistent with the use of well screened, sandy soils with little or no organic matter, and therefore no capacity to bind nutrients. The results of the soil analysis should be reviewed against plant tissue analysis taken at the same time to determine whether or not there are adequate levels of nutrient to meet plant growth needs without providing excess. Most of the more recent samples have been limited to greens with some in the early phases including fairways (Table 6).

The analysis included the following parameters:

Texture
Gravel %
Colour
Phosphorous mg/kg
Nitrogen
Nitrate mg/kg
Ammonium mg/kg
Potassium mg/kg
Sulphur mg/kg
Reactive Iron mg/kg
Salt (E.C. dS/m)
pH
Organic Carbon %

Table 5: History of soil analyses

Year	Total Number sampled	Numbers of each green (based on 2004 numbering system)
1983	2 Greens 4 Fairways	10 Green, 13 Fairway, 15 Fairway, 6 Fairway, 3 Tee and 2 Green
1985	Clubhouse Practice green 2 Tees 3 Fairways 5 Greens	Clubhouse, Practice putting green, 10 Tee, 11 Green, 14 Green, 17 Fairway, 6 Green, old 12 Tee, 3 Green, 7 Fairway, 27 Fairway and 27 Green
1987	2 Tees 2 Fairways 2 Greens	13 Fairway, 14 Green, 18 Tee, 7 Fairway, 2 Tee and 27 Green
1990	2 Tees 7 Fairways 8 Greens 3 Roughs	6, 2 and 12 Rough, 6 Fairway, 6 Green, 3 Green, 4 Fairway, 4 Green, 1 Green, 2 Fairway, 27 Tee, 27 Green, 10 Fairway, 12 Fairway, 12 Green, 13 Fairway, 13 Green, 14 Tee, 16 Fairway and 18 Green
1991	2 Fairways 4 Greens	6 Fairway, 4 Green, 27 Green, 11 Fairway, 14 Green and 18 Green
1992	2 Fairways 4 Greens	8 Fairway, old 12 Green, 4 Green, 2 Fairway, 13 Green, 15 Green
1993	1 Fairway	2 Fairway (Sports Turf Technology limited sampling)
1994	Chipping 5 Greens	Chipping, 1 Green (in 2004 no longer used), old 12 Green, 27 Green, 14 Green and 18 Green
1995	Backhoe excavations 1 Fairway	26 Fairway
1997	4 Fairways 5 Greens	7 Fairway, 2 Green, 9 Fairway, 10 Green, 11 Green, 15 Fairway, 20 Green, 25 Fairway and 26 Green
1999	6 Greens	7 Green, 2 Green, 12 Green, 17 Green, 20 Green and 27 Green
Year	Total Number sampled	Numbers of each green (based on 2004 numbering system)
2000	3 Greens	7 Green, 20 Green and 26 Green
2002	8 Greens	5 Green, 6 Green, 10 Green, 12 Green, 14 Green, 17 Green, 20 Green and 26 Green

Regular soil analysis combined with plant tissue analysis may also assist in confirming the suitability of the proposed amendments to the nutrient and irrigation management plan that is to be trialled in 2004.

RESPONSIBILITY FOR MONITORING

The Golf Course Superintendent with the support of the Environmental Programs Coordinator will be responsible for arranging for suitably qualified consultants to undertake the sampling.

ANNUAL BUDGET FOR WATER QUALITY MONITORING

The cost of the proposed analyses will be greater in the first year as it is important to obtain solid baseline data of the environmental health of the course. Following analyses can be more limited, with sampling for nutrients undertaken four times a year, while heavy metals investigations may only be required every two years.

Table 6: Indicative costs for analysis of different analytes is as follows:

Physical parameters	PH		$ 30 per sample plus GST
	Total dissolved solids (TDS)		
	Dissolved oxygen (DO)		
Nutrients	Total Nitrogen		$ 30 per sample plus GST
	Nitrate-N		
	Ammonia - N		
	Total phosphate		
	Soluble phosphate (sulfate)		
Metals	Iron	Arsenic	$ 30 per sample plus GST
	Aluminium	Cadmium	
	Lead	Chromium	
	Zinc	Copper	
	Manganese		
Inorganics	Sulphide		
	Potassium		
Pesticides	2-4-4		Price is highly variable and quotations should be sought prior to proceeding.
	Dieldrin		
	Heptachlor		
	Glyphosate		
	Chlorpyrifos		

Following the initial comprehensive sampling program for which several quotes should be sought, it is suggested that a minimum budget of $3 500 be set aside annually with each second year requiring a budget of $4 500.

SAMPLING PROTOCOL

Sample collection methods, documentation, handling and analysis will be conducted in accordance with standard scientific methods recognised by the Department of Environment or in accordance with Australian Standard 5667.1-1998. The water quality monitoring programme is likely to depend on hand collected samples, and should be multi point sampling (5 points per water body).

Specific sample preservation techniques will be used in accordance with Australian Standard 5667.1 and Australian Standard 5667.11. These offer guidance on the design and sampling techniques as well as the preservation and handling of samples, and, guidance on sampling of groundwaters respectively. All samples shall be packed, stored and dispatched for laboratory analysis in accordance with chain of custody protocols.

Samples collected for heavy metal analysis should be field filtered to less than 0.45µm. Once filled, all sample containers will be capped tightly and stored at or below 4°C (as required) until dispatched.

The preferred depth for sampling of surface water from lakes is between 0.2 and 0.4 m below the water surface. Representative composite samples should be obtained in areas free from vegetation. All volumes of water forming the composite should be measured using a measuring cylinder to ensure equal contributions.

Field chemical parameters

The following parameters can be tested in the field during the surface water sampling and purging of the bores: pH, temperature and electrical conductivity. The pumps will need to be started and run until at least three volumes of the bore casing (diameter and depth to be used to calculate the volume) before sampling proceeds. Water is to be discharged in a manner deemed appropriate by the Golf Course Superintendent. Should fine particulate clays and silts be present in the samples, then sampling should occur 24 hours after pumping has ceased.

Laboratory analysis

All samples shall be analysed by appropriately licensed laboratories that utilise detection limits that are lower than the applicable ANZECC standard for each analyte. The laboratory should have a current registration for all of the analyses specified through the National Association of Testing Authorities. All parameters will be analysed in accordance with the current *'Standard methods for examination of water and wastewater (APHA, AWWA and WEF)*, unless an alternative method is approved by the Department of Environment.

Quality assurance or control samples shall be submitted to the laboratory with each batch of samples. The testing laboratories' quality assurance and control data, together with the analytical reports, shall be provided to the Environmental Programs Coordinator upon request.

Reporting

It is critical that the data collected be analysed and put into a database to enable interpretation of results. The City should request that any contractor undertaking the sampling work provide data in a format that is compatible with the State Water Resources Information System and the WMD. Further, the results should highlight any analyte that exceeds or close to the ANZECC guidelines in a short report, to enable rapid assessment by the Environmental Programs Coordinator.

It is important that the results are reviewed annually and trends graphed or mapped to show changes in environmental quality.

The contractors should also be required to report any actions that may be required by the City of South Perth to enable consistency of sampling, such as blocked bores, significant density plant growth in the sampling locations or any similar issue.

Minimum sampling requirements

The following tables summarise the minimum requirements to be included in the water quality monitoring plan for parameters to be sampled, sampling frequency and corrective action trigger levels for the course surface water runoff and lake sampling.

Table 7: Sampling parameters

SURFACE RUNOFF, BORE AND LAKE SAMPLING (GOLF COURSE SAMPLING POINTS)		
	Units	Sample frequency
General quality parameters		
Temperature	°C	Four times per year
PH		Four times per year
Conductivity	µs/cm	Four times per year
Total suspended solids	mg/L	Four times per year
Nutrients		
Nitrate-N	mg/L	Four times per year
Nitrite-N	mg/L	Four times per year
Nitrate-nitrite-N	mg/L	Four times per year
Ammonia-N	mg/L	Four times per year
Sulfate	mg/L	Four times per year
Total phosphorus	mg/L	Four times per year
PO4		Four times per year
Heavy metals		
As	mg/L	Baseline sampling then after blanket application or at least once every two years.
Pb	mg/L	Baseline sampling then after blanket application or at least once every two years.
Cd	mg/L	Baseline sampling then after blanket application or at least once every two years.
Zn	mg/L	Baseline sampling then after blanket application or at least once every two years.
Fe	mg/L	Four times per year
Pesticides/herbicides/fungicides/algaecides		
Pesticides – Atrazine, Chlorpyrifos, Heptachlor, Dieldrin, Organophosphates, Organochlorines Isopropylamine	mg/L	Baseline sampling then after blanket application or at least once every two years.
Herbicides – 2,4-D (previous landholder)	mg/L	Baseline sampling then after blanket application or at least once every two years.
Fungicides	mg/L	Baseline sampling then after blanket application or at least once every two years.
Algaecides	mg/L	Baseline sampling then after blanket application or at least once every two years.
Trigger levels – 100% ANZECC criteria Blanket applications refers to chemical applications made over a large proportion of the course, rather than spot allocations.		

Should the City choose to contract out the water quality sampling programme, it is recommended that the City requires the contractors to use a GPS to record the sampling locations and to ensure that their reporting highlights any analytes that exceed ANZECC guidelines.

The Contractor shall contact the Golf Course Superintendent to arrange for access so as to minimise any disruption to course play.

CORRECTIVE ACTION

This plan is intended to ensure that there is no degradation of surface or groundwater quality as a result of the operation of the course. To achieve this result, substance specific numerical standards for contaminants shall serve as 'action-thresholds' for purposes of triggering the need for corrective action.

The action thresholds shall be based on a specific percentage of the relevant ANZECC water quality guidelines.

Thresholds

The level of pollutants in surface water and leachate sampled within the course shall not exceed 100% of regulatory standards.

Corrective action plan

In the event that water quality monitoring indicates the presence of any contaminant above trigger levels likely to have originated within the golf course grounds, then immediate corrective action shall be taken and continued until the contaminant is stabilised or improved to appropriate cleanup levels.

A corrective action plan shall be developed that includes at least the following components:

- Identification of the potential source.
- Continued monitoring of the contaminant of concern.
- Modification of fertiliser application, nutrient application, irrigation rates and other management practices to address the contaminant of concern.
- Remediation as necessary.
- Proposed implementation schedule including an indication of the completion of the corrective action, and
- Proposed final cleanup level.

Responsibility for corrective action

The Golf Course Superintendent with the support of the Environmental Programs Coordinator will be responsible for all corrective action. This will apply only to contaminants that arise within the bounds of the golf course. The organisation will have no responsibility to perform corrective action for contamination unrelated to golf course operations.

CHAPTER ELEVEN

MANAGEMENT OF THE NATURAL ENVIRONMENT

Introduction

Traditionally golf courses have put little emphasis and effort into protection and maintenance of the "rough". These areas may comprise up to 50% of the total golf course area but often less than 5% of the budget is allocated to their maintenance.

The creation of attractive, natural roughs between fairways increases the level of enjoyment for golfers and ultimately increases the overall value of the course. This has to be balanced with maintaining the flow of patrons through the course, particularly in a course such as Collier Park when many patrons are novice or inexperienced golfers. It is also essential to understand the requirements within the Course in terms of playability. Within the roughs and feature areas there will be specific plant height and density requirements. The natural life form of the plants will be considered when recommending species to be planted.

This portion of the document identifies opportunities for the establishment of feature plantings within existing roughs and the creation of new features at tee-off zones within the Golf Course. The implementation of this program will also improve the level of environmentally responsible activity within the Course. Native species that are naturally adapted to the area will require minimal maintenance once established.

Strategies

- To continue the development of a theme for each series of nine holes on the golf course.
- To preserve and re-establish dense areas of native bush for the protection of indigenous flora and fauna.
- To reduce the number of non- indigenous plants and replace them with local flora.
- To ensure the ongoing development and preservation of the native flora over time and to protect water quality and the environment.
- To identify nuisance areas within the Golf Course and improve the playability and strategy of the Golf Course.
- To enhance the pleasure derived from playing golf amongst beautifully landscaped surroundings.
- To assist in improving safety for passers-by and minimise litigation hazards.

Outcomes

- Provision of a detailed species list for the course including native species and dominant weed species.
- Development of a series of maps of existing and proposed vegetation communities, with detailed recommendations for implementation.
- Provision of outlines of the most effective weed control methods for each of the major species present in the Golf Course.
- Provision of guidelines for planting.

Design criteria and objectives

A series of themes should be developed for the Course to set it apart from other courses in the metropolitan area.

- Linkage with natural bushland.
- Screening from adjacent holes.
- Creation of "no go" zones within roughs to minimise vegetation damage and increase difficulty of some sections of the course.
- To redevelop existing bushland and wetland areas.
- To incorporate plantings of suitable endemic species that are aesthetically pleasing in a landscape sense.

Vegetation

As outlined in Section 2 of this report, the Course has limited areas of native vegetation remaining. A key priority of the City's environmental programs is to increase the coverage of native vegetation, develop vegetation corridors to maximise habitat benefit for local fauna and push towards more sustainable management of turf areas by reducing irrigation and nutrient use throughout the Municipal area.

The Course is one of the largest areas of land within the control of the City of South Perth. It therefore provides the most substantial opportunity within the central portion of the Municipal area to establish large tracts of native vegetation.

Revegetation

Revegetation is recommended in no-play areas and particularly along the boundaries of the Course (Map 4). The focus needs to be on restoring understorey in dense groups where possible using a combination of planting, direct seeding and selective weed control around existing remnants.

A description of treatments for these areas is provided in the site specific recommendations in Section 13 of this report including some sample landscape designs for selected sites.

Techniques that are recommended include:
- Tubestock planting
- Direct seeding
- Supporting natural regeneration by targeting weeds around persistent native seedlings and plants.

Principles to follow are:
- Plant mostly understorey plants around tees and in no-play areas ,
- Plant trees in areas devoid of tree cover or in areas where balls are likely to impact beyond the boundary fences.
- Plant rushes and sedges around the margins of the lakes.
- Plant low fire resistant groundcovers beneath pines and close to the fencelines, to allow for fire management.

Selection

Native vegetation shall be incorporated into the areas not designated as play areas. The native vegetation will be planted to emulate *Banksia* woodland in selected rough areas, with some semi-formal native gardens. Emergent rushes and sedges with *Melaleuca* will be used around the wetlands and lakes. A breakdown of species selections, planting densities and their arrangement is provided in Appendix 1.

In the play areas, the turf and grass selections are varieties of couch, although it is not necessarily the best combination of grasses in terms of their level of adaptation to the local environmental conditions. It may be possible to trial the use of the native Saltwater couch (*Sporobolus virginicus*).

A comprehensive review of available turf grasses should be undertaken to determine if there are some alternative species that require less maintenance effort.

Landscaping

A comprehensive landscape assessment of the Course should be prepared, from which a complete landscape plan can be developed. This project should be included in the forward planning for the Course. Alternatively the City's Horticultural Officer could be scheduled to undertake the project.

Map 4: Proposed revegetation areas

Recommendations

26. Implement a whole of course approach to landscaping and prepare a comprehensive landscape plan and details for the entire course.
27. Selectively replace non-indigenous plants with locally indigenous plant species for use within the course and plant in late autumn to minimise the need for supplementary watering.
28. Remove any unhealthy or damaged trees and replace promptly with appropriate native species selected from the list provided in Appendix 1.
29. Remove tree stakes once no longer required to maximise the survival of any planted stock.
30. Ensure any purchased nursery stock is hardened off, has sufficient rootball and is disease and pathogen free prior to planting within the course.
31. Inject or foliar spray Phostoxin into plants susceptible to dieback to maximise their survival, and repeat bi-annually.

Pine tree and exotic tree assessment

While the pine trees provide considerable landscape character for the Course and are an integral part of the amenity of the Course. The trees however are not indigenous, provide limited habitat value and compete for water and nutrients. The shallow root systems on these trees causes damage to machinery. Other exotic trees present in the course including Chinese tallow, Tipuana, Umbrella tree and Norfolk Island hibiscus.

A range of measures should be trialled to reduce the impacts of these plants on management activities. These include use of tree guards, digging out and removal of superficial roots, deep ripping between the trees and turf and use of extensive sections of root barrier.

A number of trees have been identified for comprehensive assessment by an arboriculturalist (Map 5). The total number of plants proposed for assessment is:

Type of tree	Number proposed for assessment
Unhealthy pines	7
Removal of unhealthy landscape plants and tree weeds	16
Removal of unhealthy native plants	28

The benefits and drawbacks of removal of the mature but unhealthy pines are outlined below. Most of the unhealthy trees earmarked for removal are relatively small trees.

Pine Issues	Pine Benefits
Landscape values will be modified over time.	Reduce water loss from the superficial aquifers and reduce amount of turf watering required to compensate.
Removal of large trees of any sort is likely to cause some disquiet within the community.	Reduce fertiliser applications necessary to keep turf growing above the root systems.
Provide periodic habitat for fauna such as Carnaby's cockatoos.	Potentially saleable logs – from which the money can be put towards revegetation and rehabilitation of the wetland remnants within the Course.
	Replacement of pines with indigenous trees will offer greater habitat opportunities and support a more diverse range of native fauna.
	Reduction in green waste (pine needles and cones) that is currently difficult to dispose of.
	A relatively small proportion of the total number of pine trees will be removed therefore the impact on habitat will be minimal.
	Superficial roots lifting paving around toilet blocks.

The removal of any trees will need to be negotiated between the Director of Corporate and Community Services and the Manager of Parks and Environment. A project team comprising the Horticultural Officer,

Environmental Programs Coordinator, Golf Course Superintendent, Director of Corporate and Community Services and Manager of Parks and Environment should jointly assess the trees earmarked for removal. A map showing prioritised trees for assessment should be developed as the next step. Thirteen trees may need to be removed close to the maintenance compound to enable the construction of the washdown bays. Again, all alternative sites need to be investigated to minimise the need for tree removal.

The trees selected for assessment should be tagged to ensure that there is no confusion.

Recommendations

32. Prepare a map showing prioritised trees for assessment by an arboriculturalist and for use of alternative management techniques to overcome root mass issues, and undertake the assessment.
33. Liaise with Perth based logging companies to determine the minimum number of trees that need to be removed to make any harvesting cost effective.
34. Develop a communication strategy to allow for community liaison to minimise the conflict associated with removal of unhealthy and unstable trees.
35. Implement a progressive removal of the selected unhealthy trees.

Map 5: Unhealthy trees for assessment

Weed control

There are a number of serious environmental weeds present (Appendix 1). Environmental weeds pose a threat to the integrity of remnant vegetation, increase the fire risk and reduce the ability of the naturally occurring plant communities to survive. This lowered resilience impacts on native animals by removing habitat, reducing the viability of the bushland and can result in the loss of animals from the system.

Sourcing sufficient resources to effectively control weeds is not easy in the current economic climate, where funds tend to be spent on issues that draw the attention of the community. However, managing weeds before they become a significant problem is critical even where resources are stretched to the limit. The cost of controlling weeds when present in small numbers is significantly less than if control is attempted in later years when the plant populations are much larger.

Weed control should be undertaken using specific herbicides where feasible. Care should be taken to follow manufacturers instructions and if necessary use qualified weed sprayers. The use of specific chemicals as opposed to broad-spectrum herbicides will reduce the potential for accidental or inadvertent damage to native flora. Regular monitoring is necessary to enable weed infestations to be controlled before the populations become extensive.

Grass specific chemicals are suitable for use against introduced perennial grasses such as Kikuyu (*Pennisetum clandestinum*) and Perennial Veld grass (*Ehrharta calycina*). Both species are present in reasonably small numbers. These species pose a significant threat to natural regeneration. The migration of Couch (*Cynodon dactylon*) from fairways into the rough, also impacts on native plant survival. Selective control may be necessary in areas set aside for conservation or landscaping.

There are a number of other grasses that occur within the turf portion of the Course such as Crab grass, Annual veld grass, African love grass, Guildford and Parramatta grass. These are more difficult to manage as grass specific herbicides are likely to damage the desired turf.

Depending on the staging of environmental management projects, weed control activities can fall into three categories:
1. Control aiming for eradication,
2. Control to restrict spread without affecting total areas, or
3. No management effort.

The first category is the priority in areas where revegetation works are to occur. It is difficult to establish native plants in the absence of effective grass control. If there are insufficient resources to implement the entire program, focus on creating weed free zones up to 1 m diameter around persistent native plants. This will help the native plants spread naturally. In areas that have been subject to extensive grass control, it is important to plant once grass has been removed.
The second category can be applied to areas that are proposed for revegetation in the following years. The first year can just be maintenance with an aim to prevent the plants from spreading or seeding. Slashing prior to the weed seed ripening is effective. A second treatment will be required for late seeding plants. Monitoring of the weed seed will help determine the most appropriate time for works.

The third category should only occur in areas where no action is proposed, although the threat to habitat, loss of amenity and native vegetation and the increased fire risk should discourage a "no-action" approach.

New weeds

It is essential that weeds, which are new to the area, are managed before they spread and become difficult to control or eradicate. Keeping an eye out for new weeds appearing in this area, is an important part of minimising weeding work in the future. Weeding while there is only a few plants is an important first step.

A number of weeds occur beyond the bounds of Collier Park Golf Course but have not yet been identified within the Course. Vigilance is required to prevent these plants from extending their range into Collier Park.

Focusing on weeds that are familiar is an important way to start. If there are any doubts about whether or not the target plant is a weed or native plant, it is recommended that the focus be on preventing seed production until identification has been achieved.

Priority weeds

Specific advice on control is provided in Appendix 1. This information is intended to reflect growing conditions, however, timing can only be indicative as it depends on seasonal variations. Records should be kept and updates made to the table to gain the most benefit.

Overall priorities for hand weeding, wick wiping and follow-up treatment:

- Fleabane
- Black berry nightshade
- Fig
- Fishbone fern

Priorities for mechanical/herbicide removal

- Brazilian pepper
- Gladiolus
- Gazania – can be offered to patrons or staff for their gardens
- Victorian coastal teatree
- Watsonia
- Bindii
- Perennial and annual grasses

Recommendations

36. Undertake selective removal of weedy shrubs and trees, particularly from the wetland and bushland areas.
37. Remove weeds with a limited distribution and monitor for any new germinants and remove promptly.
38. Begin a process of defining revegetation areas from mown and turf areas by creating identifiable boundaries.

Habitat enhancement

At the moment, the bulk of the rough through the Collier Park Golf Course is dominated by non-local species, although there are some persisting areas of remnant bushland.

Habitat enhancement can occur in a range of ways. The most straightforward method is to protect and enhance the health and extent of the native vegetation, and controlling feral animals. Restricting access through native vegetation pockets and establishing continuous corridors of vegetation will also help fauna to persist within the Course grounds.

Opportunities for habitat enhancement include:

- Weed control and removal of selected non-local landscaping species and replacement with suitable native species;
- Installation of nesting boxes and bird count inventories
- Increasing use of corridors and vegetation
- Encouraging birds of prey by installing nesting platforms
- Working in conjunction with community groups and wildlife groups.

It is possible to arrange for translocation of injured birds such as swans from native animal havens if the Course can guarantee protecting the animals and providing suitable food and habitat. Further discussions with native fauna rescue groups will need to be held if Course management is keen to encourage birds such as Black swan to become resident animals. Department of Conservation and Land management and a number of wildlife rescue groups could be approached.

Another issue relating to encouraging wildlife to the Course is the use of pesticides like Chlorpyrifos. Such chemicals could cause inadvertent poisoning of small birds such as Willie wagtail that feed on the targeted invertebrates. Further there are potential bioaccumulation issues for a number of chemicals throughout the Course. The development of the Integrated Pest Management Plan and implementation of the soil and plant tissue analysis program proposed will help to determine if there is an issue with residual pesticides.

Recommendations

39. Implement progressive removal of exotic species and replacement with locally indigenous plants.
40. Investigate the feasibility of installing a nesting platform for birds of prey and nesting boxes for other fauna in selected trees around the Course.
41. Liaise with CALM and wildlife rescue groups to determine the feasibility of housing injured wildlife that cannot be released back into the wild e.g. Black swan.
42. Undertake the soil and plant tissue analysis to determine if there are chemical accumulation issues as recommended in earlier sections of this document.

Native animals behaving as pests

There are a number of native animals that can interfere with Course management. A number of these issues are outlined below with potential management options.

Animal	**Issues associated with their presence**	**Management options**
Corellas	Eat black beetle and turf rhizomes particularly in late summer when other food sources are limited.	❖ Continue to liaise with CALM about their current programs to remove corellas including the involvement of the Environmental Programs Coordinator.
Magpies	Seeking food from patrons at pro shop because they have been fed in the past.	❖ Ensure signage is maintained to discourage patrons from continuing to feed the birds. ❖ Trial use of mobile kites to discourage the birds from visiting the kiosk area.
Carnaby's cockatoos	Can cause a nuisance by dropping pine cones and clipping flowers off native trees.	❖ Install a platform to try to encourage a bird of prey to take up residence in the course. ❖ Increase the native vegetation coverage both within and beyond the Course boundaries to provide more potential feeding and roosting areas.
Eurasian coot	Produce considerable volumes of droppings on greens and tees which is health issue for mowing staff and patrons.	❖ Continue frequent mowing to clear the droppings. ❖ Reduce habitat available by increasing the density of rushes and sedges on the margins of the lakes. ❖ Install a platform to try to encourage a bird of prey to take up residence in the course. ❖ Liaise with CALM and wildlife rescue groups to investigate the feasibility of moving the animals to another wetland.
Maned geese	Produce considerable volumes of droppings on greens and tees which is health issue for mowing staff and patrons.	As above.

Feral animals

Introduced species of animals such as domesticated cats and dogs, foxes and rabbits degrade the local environment through predation, competition for food resources and habitat destruction. Most feral and domesticated animals are excluded by the perimeter fencing provided it is maintained in good repair. Cats, along with foxes, represent the greatest threat to native fauna, apart from habitat loss.

Ensuring domestic pets cannot gain access to the Course is the most effective means of minimising their potential impact on the native fauna.

Fox control is difficult in areas adjoining residential land because of the threat posed to pets. The perimeter fence however may offer the Council the opportunity to arrange for a permit to shoot, poison or trap foxes. This may be feasible provided the threat posed to uncontrolled domestic pets is addressed by making sure that all residents of the area are aware of the activity.

Rabbit control activities have occurred in the past and are repeated on an as needed basis. Care needs to be taken that the poisoned oats are not used when the temperature is above 24°C and reptiles are likely to be active. Possums and grain eating birds are also at risk from this poison. A strategy needs to be developed in conjunction with the Environmental Programs Coordinator to protect non-target animals.

Recommendations

43. Develop a pest fauna management program in accordance with need if such animals are found to be active in the Course.
44. Ensure any damage to the fence is repaired promptly to minimise the potential for domestic or feral animals gaining access to the Course grounds.

Sustainable Maintenance

Integrated plant management includes pest management with an emphasis on plant nutrition and maintaining a good level of overall plant health which minimises the requirement for intervention by Course management. Similar principles apply to managing the native plants and animals of the Course.

Maintenance is a critical aspect of environmental management. Defining access to revegetation areas is important to allow for maintenance activities. Review of the need for maintenance can occur in two key ways:

- regular visits by the Course superintendent or advice from staff members, and
- depending on advice from patrons using the facilities.

A monitoring strategy that considers weed management should be implemented. A monthly inspection service to assess the weed growth, plant establishment and other parameters is beneficial particularly in the conservation areas. Successful revegetation programs are dependent upon effective site preparation, selection of appropriate plant species and then, most importantly, ongoing management effort. Many projects have considerable potential when initiated, but often the lack of sufficient resources for maintenance reduces the success.

Efficient use of resources is critical to the success of this environmental management plan.

Monitoring

The success of works undertaken by Course management and supporting officers from the City of South Perth will be monitored in a number of ways. The recording of this information will help the City to reflect on it's achievements and also help to justify budget expenditure.

Monitoring activities are:

- Water quality, macroalgae and phytoplankton monitoring
- Macro-invertebrate sampling
- FrogWatch: determining species present and populations.
- BirdWatch: diversity of birds, breeding habits and their seasonality, and
- Flora surveys - transects and photo points in areas without active management, direct seeded zones, selective weed control and revegetation areas.

The framework for water quality data collection has been provided in previous sections of this document and FrogWatch and Bird Watch offer protocols for monitoring over time. The flora monitoring can be undertaken using a standard developed by BushCare.

CHAPTER TWELVE

MANAGEMENT OF THE SOCIAL ENVIRONMENT

Vandalism

Vandalism is an area of ongoing concern for course management. Since the establishment of the Course, it has been vandalised on a number of occasions. The activities that are undertaken by vandals include:

- Digging holes in greens
- Damaging cyclone fencing and driving vehicles over turf
- Steal flags, flag sticks and tee markers
- Burning rubbish bins
- Depositing faeces in flag cups
- Smashing walls to steal equipment particularly motorbikes
- Graffiti.

Graffiti and wilful damage tends to occur primarily at main access points with resulting damage to fences and signs. Ensuring infrastructure is not visible from the road network may reduce the frequency of vandalism. Making the susceptible areas less attractive for vandals can also alleviate the problem to some extent.

Increasing lighting along the fencelines may be an effective way of reducing the incidence of undesirable behaviour.

Graffiti and other vandalism should be repaired as soon as possible after its occurrence, as its continued presence tends to invite further acts of vandalism. Graffiti resistant compounds should also be applied to any property that is targeted constantly. The community should also be encouraged to report any acts of vandalism or antisocial behaviour to the police and Council. Successful arrests should then be followed up with a note of thanks to the person who reported the incident.

Recommendations

45. Ensure any damage resulting from vandalism is repaired as quickly as possible to discourage further acts.

Education

Patrons

When people are new to a Course they seek information and directions, and need some guidance to explore their new surroundings. The information currently provided to patrons is focussed on the activity of golfing. This could be expanded to aid interpretation of the natural features and influence the behaviour of people particularly relating to rubbish disposal. Identifying features of interest in the Course may enhance the experience of patrons, encourage a greater understanding of the environment and develop an increased sympathy for the conservation values of the Course. Plant identification plaques could be installed to highlight the value of different species. Simple code of conduct signs could also be used to discourage access to the wetland and native vegetation nodes.

It may also be worthwhile to put informative posters up around the kiosk and toilet facilities outlining the Course's environmental programs and explaining any disruption to play associated with some of the management activities.

Staff

Staff could be involved in a range of environmental improvement activities including planting, weed control and habitat creation in the Course. Ensuring all staff are trained in environmental best management practice and think about the impact of their day to day activities may also assist in increasing the environmental ethos

Ensuring staff are adequately trained in appropriate disposal of chemicals and meeting occupational, safety and health requirements is also a priority. This is discussed in previous sections of this document.

The sustainability programs being run by the Environmental Programs Coordinator should also be provided to Course management. There appears to be some difficulty in keeping staff informed because of a lack of email contact and problems with information transmission between Head Office, the Depot and the golf course. A protocol should be developed for information transfer and inclusion of course staff in environmental programs. This should be extended for other aspects of course management.

Recommendations

46. Provide interpretive signage including the key elements listed above.
47. Develop and install plant identification plaques for key species in the Course.
48. Prepare informative posters outlining the environmental management projects.
49. Develop a protocol for involving staff in environmental activities and providing training.

Involving the community in management

The feasibility of involving school groups and other community members is limited because of the potential threat of injury. Public liability insurance for people working on golf courses, but not playing, is substantial and would be difficult to justify.

The only mechanism to avoid the liability issues would be only having assistance on the Course when it is not open to patrons. This would require negotiation with the Leasee and Course Superintendent.

The types of activities that community members could undertake include:

- Bird watching and recording
- Frog watching and recording
- Weeding, and
- Planting.

It may be possible to have a sponsored event at the Course where participants in environmental works are allowed to have a round of golf in return. University or high school groups could be approached for such as option.

A detailed strategy assessing the viability of involving the wider community in environmental improvement activities should be developed.

Recommendations

50. Develop a detailed strategy assessing the viability of involving the community in environmental improvement activities.

CHAPTER THIRTEEN

SPECIFIC MANAGEMENT RECOMMENDATIONS

General recommendations

G1 Consider removing conifers used as distance markers and replace with plastic signs or stone pillars to remove this potential source of pathogens.

G2 Liaise with Western Power to encourage them to replace the high-voltage powerlines on the southern boundary of the Course with underground power.

G3 Rip four metres from the pine tree lines along the margins of the fairway to stop root interference with turf.

G4 Develop a complaints management procedure for comments made about the status of the Course to ensure complainants are responded to in a professional manner.

G5 Keep a log of balls that pass out of the Course and over Jackson Road.

G6 Ensure the Course Superintendent tracks all power, water and telephone bills.

G7 All revegetation works to be set back at least 3 metres from the fencelines so that plantings do not interfere with access.

G8 Consider closing nine holes of the Course once a week to allow for management activities.

G9 Investigate use of Work for the Dole programs for general golf course works.

Specific suggestions per hole

Hole 1

Issue	Details	Timing	Budget allocation
Weeds	*Gladiolus*, *Gazania*, Golden wattle, broadleaf weeds, Kikuyu, Parramatta, Winter grass and Summer couch. Budget allocation for bushland area only.	All year (Ongoing)	$ 1 000.00
Pine trees	❖ Two mature trees proposed for assessment. ❖ 750 metres of deep ripping is required and clean up (level, compact and repair turf).	Winter (2007-2008)	$ 1 125.00
Irrigation	It is feasible to reticulate any establishing planting if required. 375 metres of mainline required when upgraded - materials - trenching - installation		 $ 2 800.00 $ 375.00 $ 2 250.00
Revegetation (9 320 m² in three nodes)	Pocket of mixed bushland needs weed control. Currently 50% vegetated so infill only required - plant supply (2000 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter (2005-2006)	 $ 2 000.00 $ 3 500.00 $ 2 000.00 $ 200.00 $ 400.00
Fauna protection	❖ Consider protecting areas of open sand to encourage oblong turtle breeding.	Ongoing	
		Subtotal	$ 15 650.00
		GST	$ 1 565.00
		TOTAL	$ 17 215.00

Hole 2

Issue	Details	Timing	Budget allocation
Weeds	❖ Kikuyu, Parramatta, Winter grass, Summer couch and broadleaf weeds.	All year (Ongoing)	
Pine trees	❖ Four mature trees proposed for assessment and root management. ❖ 200 metres of deep ripping is required and clean up (level, compact and repair turf).	Winter (2007-2008)	$ 300.00
Irrigation	100 metres of mainline required when upgraded - materials - trenching - installation		 $ 750.00 $ 100.00 $ 600.00
Revegetation (800 m² in one node)	❖ Wattles too close to fenceline and causing damage. ❖ Remove wattle and replace with more suitable species. Reinforce vegetation - plant supply (400 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter (2004-2005)	$ 100.00 $ 400.00 $ 600.00 $ 400.00 $ 200.00 $ 80.00
		Subtotal	$ 3 450.00
		GST	$ 345.00
		TOTAL	$ 3 795.00

Hole 3

Issue	Details	Timing	Budget allocation
Weeds	❖ Typha control in the lake – cutting leaves as close to ground level as possible. Paint leaves with Glyphosate to eradicate. ❖ Remove *Acacia longifolia* and Sugar gums from island. ❖ Kikuyu, Parramatta, Flat weed, Winter grass, Summer couch, Crab grass and Broadleaf weeds	Late autumn (2004–2005)	
Pine trees	❖ Remove establishing pines from the island and on the northern margin of the lake. ❖ Two mature trees proposed for assessment and root management. ❖ 400 metres of deep ripping is required and clean up (level, compact and repair turf).	Late autumn (2004–2005) Winter (2008-2009)	 $ 600.00
Irrigation	300 metres of mainline required when upgraded - materials - trenching - installation		 $ 2 250.00 $ 300.00 $ 1 800.00
Revegetation (3 440m² in two nodes)	❖ Selective removal of mature shrubs and reinforcement with dense large shrubs to screen stockpile and improve aesthetics (400 plants) and rushes and sedges on lake margins (400 plants). Reinforce vegetation - plant supply (800 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm) - U-shaped steel pegs	Winter (2004-2005) Spring (Ongoing)	$ 300.00 $ 800.00 $ 1 200.00 $ 800.00 $ 200.00 $ 400.00 $ 200.00
Fauna protection	❖ Check drainage grates for turtles daily and remove if trapped within the drainage pipes. ❖ Consider creating areas of open sand to encourage Oblong turtle breeding on the southern margin of the lake. This should only occur if the grass is removed and replaced with dense stands of rushes and sedges. ❖ Consider installing a floating platform to enable swans to breed on the lake and try to encourage a pair of swans to become resident.	Ongoing Ongoing Autumn 2005	
		Subtotal	$ 8850.00
		GST	$ 885.00
		TOTAL	$ 9735.00

Hole 4

Issue	Details	Timing	Budget allocation
Weeds	❖ Continue program to control *Typha* in lake. ❖ Remove Gazanias and replace with suitable flowering native plants. ❖ Kikuyu, Parramatta, Flat weed, Winter grass, Summer couch, Crab grass and Broadleaf weeds	Ongoing Winter (2004-2005)	
Pine trees	❖ Remove pines and exotic eucalypts from the island.	Anytime	
Irrigation	160 metres of mainline required when upgraded - materials - trenching - installation		 $ 1 200.00 $ 160.00 $ 960.00
Revegetation (620 m² in one node)	❖ Establish rushes and sedges and Swan River myrtle on lake margins. Reinforce vegetation - plant supply (300 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm) - U-shaped steel pegs	Winter – Spring (2005-2006)	 $ 300.00 $ 450.00 $ 300.00 $ 200.00 $ 60.00 $ 150.00
Water quality	❖ Monitor water quality. ❖ Continue to manage discharge from the lakes by adjusting the boards on the outlet. ❖ Remove any litter from the drainage grates.		
		Subtotal	$ 3 780.00
		GST	$ 378.00
		TOTAL	$ 4 158.00

Hole 5

Issue	Details	Timing	Budget allocation
Weeds	❖ *Nasturtium* and weed control on the mulch pile against the fence to the west of this point and the usual assortment of Kikuyu, Parramatta, Flat weed, Winter grass, Summer couch, Crab grass and Broadleaf weeds	Ongoing	
Pine trees	❖ Three mature trees proposed for assessment and root management. ❖ 950 metres of deep ripping is required and clean up (level, compact and repair turf).	Winter (2008-2009)	$ 1 425.00
Irrigation	❖ Rough watered periodically to support tree growth. 950 metres of mainline required when upgraded - materials - trenching - installation		 $ 7 125.00 $ 950.00 $ 5 700.00
Revegetation (7 390 m² in four nodes)	❖ Increase the number of trees to meet the requirements of the insurance company using 30 mature stock. ❖ Reticulate over the first two summers to maximise the plant growth rate.	Winter (2004-2005)	$ 3 000.00
		Subtotal	$ 18 200.00
		GST	$ 1 820.00
		TOTAL	$ 20 020.00

Hole 6

Issue	Details	Timing	Budget allocation
Weeds	❖ Kikuyu, Parramatta, Flat weed, Winter grass, Summer couch, Crab grass and Broadleaf weeds	Ongoing	
Pine trees	❖ Three mature trees proposed for assessment and root management. ❖ 400 metres of deep ripping is required and clean up (level, compact and repair turf).	Winter (2008-2009)	$ 600.00
Assessment of landscape plants	❖ Two trees proposed for assessment and root management.		
Irrigation	400 metres of mainline required when upgraded - materials - trenching - installation		$ 3 000.00 $ 400.00 $ 2 400.00
Revegetation (440 m² in one node)	Reinforce vegetation - plant supply (1 000 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter – Spring (2005-2006)	$ 1 000.00 $ 1 500.00 $ 1 000.00 $ 200.00 $ 200.00
		Subtotal	$ 10 300.00
		GST	$ 1 030.00
		TOTAL	$ 11 330.00

Hole 7

Issue	Details	Timing	Budget allocation
Weeds	❖ Parramatta, Kikuyu, Winter grass, Crab grass and Broadleaf weeds	Ongoing	
Pine trees	❖ Six mature trees proposed for assessment and root management. ❖ 520 metres deep ripping is required and clean up (level, compact and repair turf).	Winter (2008-2009)	$ 780.00
Assessment of landscape plants	❖ Two trees proposed for assessment and root management.		
Irrigation	380 metres of mainline required when upgraded - materials - trenching - installation		$ 2 850.00 $ 380.00 $ 2 280.00
Turf management	❖ 7th tee requires rebuilding.		
		Subtotal	$ 6 290.00
		GST	$ 629.00
		TOTAL	$ 6 919.00

Hole 8

Issue	Details	Timing	Budget allocation
Weeds	❖ Parramatta, Kikuyu, Winter grass, Crab grass and Broadleaf weeds	Ongoing	
Pine trees	❖ One mature tree proposed for assessment and root management. ❖ 900 metres deep ripping is required and clean up (level, compact and repair turf).	Winter (2004-2005)	$ 1 350.00
Irrigation	460 metres of mainline required when upgraded - materials - trenching - installation		$ 3 450.00 $ 460.00 $ 2 760.00
Revegetation (510 m² in one node)	Reinforce vegetation - plant supply (20 mature plants) - labour	Winter – Spring (2005-2006)	$ 600.00 $ 450.00
Turf management	❖ Establish Bent grass nursery between 17 Green and Jackson Road as a matter of priority to reduce harvesting from within the Course.	June (2004)	
		Subtotal	$ 9 070.00
		GST	$ 907.00
		TOTAL	$ 9 977.00

Hole 9

Issue	Details	Timing	Budget allocation
Weeds	❖ Parramatta, Kikuyu, Winter grass, Crab grass, African love grass and Broadleaf weeds	Ongoing	
Pine trees	❖ 700 metres deep ripping is required and clean up (level, compact and repair turf).	Winter (2008-2009)	$ 1 050.00
Assessment of landscape plants	❖ Two trees proposed for assessment and possible replacement with mature native plant stock.		
		Subtotal	$ 1 050.00
		GST	$ 105.00
		TOTAL	$ 1 155.00

Hole 10

Issue	Details	Timing	Budget allocation
Weeds	❖ Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weeds	Ongoing	
Pine trees	❖ Six mature trees proposed for assessment and root management. ❖ 830 metres deep ripping is required and clean up (level, compact and repair turf).	Winter (2004-2005)	$ 1 245.00
Irrigation	400 metres of mainline required when upgraded - materials - trenching - installation		 $ 3 000.00 $ 400.00 $ 2 400.00
Revegetation (8 740 m² in three nodes)	Reinforce vegetation - plant supply (1 500 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter – Spring (2005-2006)	 $ 1 500.00 $ 2 250.00 $ 1 500.00 $ 200.00 $ 300.00
		Subtotal	$ 12 415.00
		GST	$ 1 241.50
		TOTAL	$ 13 656.50

Hole 11

Issue	Details	Timing	Budget allocation
Weeds	❖ Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weeds.	Ongoing	
Pine trees	❖ Fifteen mature trees proposed for assessment and root management. ❖ 760 metres deep ripping is required and clean up (level, compact and repair turf).	Winter (2004-2005)	$ 1 140.00
Assessment of landscape plants	❖ Pruning and general maintenance of existing mature shrubs north of the 11th Tee.	Winter (2004-2005)	
Irrigation	380 metres of mainline required when upgraded - materials - trenching - installation		 $ 2 850.00 $ 380.00 $ 2 280.00
Revegetation (4 160 m² in one node)	❖ All revegetation to set back 3 metres from the fenceline to allow for access and 15 metres from the fairway. ❖ Selective replacement and reinforcement of shrub zone north of the 11th Tee. Reinforce vegetation - plant supply (1 500 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)		 $ 1 500.00 $ 2 250.00 $ 1 500.00 $ 200.00 $ 300.00
		Subtotal	$ 12 400.00
		GST	$ 1 240.00
		TOTAL	$ 13 640.00

Hole 12

Issue	Details	Timing	Budget allocation
Weeds	❖ Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weeds	Ongoing	
Pine trees	❖ Eight mature trees proposed for assessment and root management. ❖ 400 metres deep ripping is required and clean up (level, compact and repair turf).	Winter (2007-2008)	$ 600.00
Irrigation	190 metres of mainline required when upgraded - materials - trenching - installation		 $ 1 425.00 $ 190.00 $ 1 140.00
		Subtotal	$ 3 355.00
		GST	$ 335.50
		TOTAL	$ 3 690.50

Hole 13

Issue	Details	Timing	Budget allocation
Weeds	❖ Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weeds	Ongoing	
Pine trees	❖ Seven mature trees proposed for assessment and root management. ❖ 700 metres deep ripping is required and clean up (level, compact and repair turf).	Winter (2004-2005)	$ 1 050.00
Irrigation	380 metres of mainline required when upgraded - materials - trenching - installation		 $ 2 850.00 $ 380.00 $ 2 280.00
Revegetation (4 280 m² in three nodes)	Reinforce vegetation - plant supply (1 000 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter (2006 – 2007)	 $ 1 000.00 $ 1 500.00 $ 1 000.00 $ 200.00 $ 200.00
		Subtotal	$ 10 460.00
		GST	$ 1 046.00
		TOTAL	$ 11 506.00

Hole 14

Issue	Details	Timing	Budget allocation
Weeds	❖ Remove *Gazania*, feral Acacia, Veld grass, Cape weed, introduced eucalypts and Victorian coastal teatree from conservation areas. It may be possible to obtain access to the Work for the Dole crew that is available. ❖ Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weeds	Winter (2004 – 2005) Continue as required. Ongoing	$ 2 500.00
Pine trees	❖ Remove pine trees from island. ❖ Eight mature trees proposed for assessment and root management. ❖ 1 000 metres deep ripping is required and clean up (level, compact and repair turf).	Winter (2004-2005)	$ 1 500.00
Assessment of landscape plants	❖ Six trees proposed for assessment.		
Irrigation	500 metres of mainline required when upgraded - materials - trenching - installation		$ 3 750.00 $ 500.00 $ 3 000.00
Revegetation (3 460 m² in four nodes)	Reinforce vegetation where necessary following weed control - plant supply (500 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter (2006 – 2007)	$ 500.00 $ 750.00 $ 500.00 $ 200.00 $ 125.00
Fauna protection	❖ Consider protecting areas of open sand to encourage oblong turtle breeding.	Ongoing	
		Subtotal	$ 13 325.00
		GST	$ 1 332.50
		TOTAL	$ 14 657.50

Hole 15

Issue	Details	Timing	Budget allocation
Weeds	❖ Remove *Gladiolus*, Veld grass, African lovegrass, Flat weed, Wild oats, *Gazania* and Cape weed. ❖ Continue Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weed control program.		
Pine trees	❖ Fourteen mature trees proposed for assessment and root management. ❖ 500 metres deep ripping is required and clean up (level, compact and repair turf).	Winter (2004-2005)	$ 750.00
Assessment of landscape plants	❖ Seventeen trees proposed for assessment and replacement program.		
Revegetation (21 920 m² in nine nodes)	Reinforce vegetation where necessary following weed control - plant supply (23 000 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Progressive implementation of 5000 plants per annum starting winter (2005 – 2006)	($19 000 pa) detail $ 23 000.00 $ 34 500.00 $ 23 000.00 $ 600.00 $ 4 600.00
Irrigation	360 metres of mainline required when upgraded - materials - trenching - installation		 $ 2 700.00 $ 360.00 $ 2 160.00
		Subtotal	$ 91 670.00
		GST	$ 9 167.00
		TOTAL	$100 837.00

Hole 16

Issue	Details	Timing	Budget allocation
Weeds	❖ Continue Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weeds, Black berry nightshade, Paspalum control program.	Ongoing	$ 1 000.00
Pine trees	❖ Nine mature trees proposed for assessment and root management. ❖ 300 metres deep ripping is required and clean up (level, compact and repair turf).	Winter (2008-2009)	$ 450.00
Assessment of landscape plants	❖ Four trees proposed for assessment.		
Irrigation	230 metres of mainline required when upgraded - materials - trenching - installation		 $ 1 725.00 $ 230.00 $ 1 380.00
		Subtotal	$ 4 785.00
		GST	$ 478.50
		TOTAL	$ 5 263.50

Hole 17

Issue	Details	Timing	Budget allocation
Weeds	❖ Continue Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weeds control program.	Ongoing	
Pine trees	❖ One mature tree proposed for assessment and root management. ❖ 900 metres deep ripping is required and clean up (level, compact and repair turf).	Winter (2006-2007)	$ 1 350.00
Assessment of landscape plants	❖ Eight trees proposed for assessment.		
Irrigation	500 metres of mainline required when upgraded - materials - trenching - installation		 $ 3 750.00 $ 500.00 $ 3 000.00
Revegetation (8 910 m² in five nodes)	Reinforce vegetation where necessary following weed control - plant supply (4 000 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter (2006 – 2007)	 $ 4 000.00 $ 6 000.00 $ 4 000.00 $ 200.00 $ 800.00
Turf management	❖ Establish Couch nursery between 17 Green and Jackson Road as a matter of priority to reduce harvesting from within the Course.		
		Subtotal	$ 23 600.00
		GST	$ 2 360.00
		TOTAL	$ 25 960.00

Hole 18

Issue	Details	Timing	Budget allocation
Weeds	❖ Continue Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weed control programs.	Ongoing	
Pine trees	❖ Seven mature trees proposed for assessment and root management. ❖ 650 metres deep ripping is required and clean up (level, compact and repair turf).	Winter (2006-2007)	$ 975.00
Irrigation	360 metres of mainline required when upgraded - materials - trenching - installation		 $ 2 700.00 $ 360.00 $ 2 160.00
Revegetation (2 500 m² in one node)	Reinforce vegetation where necessary following weed control - plant supply (400 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)		 $ 400.00 $ 600.00 $ 400.00 $ 100.00 $ 80.00
		Subtotal	$ 7 775.00
		GST	$ 777.50
		TOTAL	$ 8 552.50

Hole 19

Issue	Details	Timing	Budget allocation
Weeds	❖ Continue Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed, African love grass and Broadleaf weed control programs.	Ongoing	
Irrigation	❖ Cleaning of 500 metres mainline required. ❖ Sprinkler heads need to be upgraded to double rear jets.	2007-2008	
	❖		
Revegetation (6 990 m² in three nodes)	❖ Monitor *Melaleuca rhaphiophylla* where they are located in dry sandy locations above groundwater, and remove if unhealthy. ❖ Reinforce vegetation on southern side of fairway as necessary. Revegetation - plant supply (4 500 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter (2007-2008)	$ 4 500.00 $ 6 750.00 $ 4 500.00 $ 200.00 $ 900.00
Water management	❖ Additional drainage may be required and will be constructed to direct the water away from the rubbish tip.		
Rubble in bunkers	❖ Sand sieving of sand in bunkers.		
		Subtotal	$ 16 850.00
		GST	$ 1 685.00
		TOTAL	$ 18 435.00

Hole 20

Issue	Details	Timing	Budget allocation
Weeds	❖ Continue Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed, African love grass and Broadleaf weed control programs.	Ongoing	
Irrigation	❖ Cleaning of 370 metres mainline required. ❖ Sprinkler heads need to be upgraded to double rear jets.	2007-2008	
Revegetation (9 360 sq m)	❖ Rubbish tip impacts on plant establishment so monitoring of the success of revegetation works is necessary, with ongoing infill as required. ❖ Reinforce vegetation on northern side of fairway as necessary. Revegetation - plant supply (2 500 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter (2006 –2007)	$ 3 500.00 $ 3 750.00 $ 2 500.00 $ 200.00 $ 500.00
Water management	❖ Additional drainage may be required and will be constructed to direct the water away from the rubbish tip.		
Rubble in bunkers	❖ Sand sieving of sand in bunkers.		
		Subtotal	$ 10 450.00
		GST	$ 1 045.00
		TOTAL	$ 11 495.00

Hole 21

Issue	Details	Timing	Budget allocation
Weeds	❖ Remove Cape lilacs that are interfering with the fenceline. ❖ Continue programs to control Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed, African love grass and Broadleaf weeds.	Winter (2004-2005) Ongoing	
Irrigation	❖ Cleaning of 170 metres mainline required. ❖ Sprinkler heads need to be upgraded to double rear jets.	2007-2008	
Revegetation (2 880 m² in four nodes)	❖ Rubbish tip impacts on plant establishment so monitoring of the success of revegetation works is necessary, with ongoing infill as required. ❖ Reinforce vegetation on southern side of fairway as necessary. Revegetation - plant supply (500 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter (2008-2009)	 $ 500.00 $ 750.00 $ 500.00 $ 120.00 $ 100.00
Water management	❖ Additional drainage may be required and will be constructed to direct the water away from the rubbish tip.		
Rubble in bunkers	❖ Sand sieving of sand in bunkers.		
		Subtotal	$ 1 970.00
		GST	$ 197.00
		TOTAL	$ 2 167.00

Hole 22

Issue	Details	Timing	Budget allocation
Weeds	❖ Continue programs to control Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weeds.	Ongoing	
Assessment of landscape plants	❖ Four shrubs/trees proposed for assessment and ultimately replacement.		
Irrigation	❖ Cleaning of 390 metres mainline required. ❖ Sprinkler heads need to be upgraded to double rear jets.	2007-2008	
Revegetation (2 730 m² in three nodes)	❖ Reinforce vegetation on southern side of fairway as necessary. Revegetation - plant supply (1 500 plants including some large stock) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter (2005-2006)	 $ 2 500.00 $ 2 250.00 $ 1 500.00 $ 200.00 $ 300.00
		Subtotal	$ 6 750.00
		GST	$ 675.00
		TOTAL	$ 7 425.00

Hole 23

Issue	Details	Timing	Budget allocation
Weeds	❖ Manually remove Becopa from the lake margins to reduce competition with the rushes proposed for establishment. ❖ Control *Cyperus* and other weeds on the margins of the lake. ❖ Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weeds	Ongoing	
Pine trees	❖ One mature tree proposed for assessment and root management because it is unhealthy. ❖ Tree guards for six pines close to tee.		$ 3 000.00
Assessment of landscape plants	❖ One tree proposed for assessment.		
Irrigation	❖ Use drip irrigation for garden beds in the area. ❖ Rationalise reticulation if turf removed. ❖ Cleaning of 150 metres mainline required. ❖ Sprinkler heads need to be upgraded to double rear jets.	2007-2008	
Water quality	❖ Monitor water quality from the Water Corporation Main Drain and the two City of South Perth drains. ❖ Report any algae blooms to the Environmental Programs Coordinator.		
Entrance lake (1 040 sq m) (2 000 sq m)	❖ Install two dense stands of *Baumea preissii* (Broad twig sedge) and *Schoenoplectus validus* (Lake club sedge) as shown on the revegetation map (Map 4) to improve water quality and habitat options. ❖ Remove turf between the road and water's edge and plant with dense shrubs and rushes/sedges under 1.5 m grading to less than 0.5 m close the roadway to reduce turf area, water use and improve habitat.	Spring (2004-2005)	$ 1 500.00 $ 5 500.00
Fauna protection	❖ Consider creating areas of open sand to encourage oblong turtle breeding on the southern margin of the lake. This should only occur if the grass is removed and replaced with dense stands of rushes and sedges. ❖ Consider installing a floating platform to enable swans to breed on the lake and try to encourage a pair of swans to become resident.		
Revegetation (2 730 m² in three nodes)	❖ Reinforce planting alongside the Depot boundary to reduce the visual impact of the mulch and other stockpiles. Revegetation - plant supply (1 500 plants including some large stock) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm) ❖ Consider replacing the landscaped garden beds to the east of the Tee with flowering native plants. ❖ Consider removing the narrow strip of grass between the retaining wall and fence to reduce mowing effort.		$ 1 500.00 $ 2 250.00 $ 1 500.00 $ 200.00 $ 300.00
		Subtotal	$ 15 750.00
		GST	$ 1 575.00
		TOTAL	$ 16 325.00

Hole 24

Issue	Details	Timing	Budget allocation
Weeds	❖ Continue Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weed control programs.	Ongoing	
Assessment of landscape plants	❖ Four trees proposed for assessment.		
Irrigation	❖ Cleaning of 330 metres mainline required. ❖ Sprinkler heads need to be upgraded to double rear jets.	2007-2008	
Revegetation (2 630 m² in two nodes)	❖ Rubbish tip impacts on plant establishment. ❖ Continue reinforcement of vegetation. Revegetation - plant supply (1 000 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter (2005-2006)	 $ 1 000.00 $ 1 500.00 $ 1 000.00 $ 60.00 $ 200.00
Water management	❖ Additional drainage may be required and will be constructed to direct the water away from the rubbish tip.		
Rubble in bunkers	❖ Sand sieving of sand in bunkers.		
		Subtotal	$ 1 100.00
		GST	$ 110.00
		TOTAL	$ 1 210.00

Hole 25

Issue	Details	Timing	Budget allocation
Weeds	❖ Continue programs to control Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weeds.	Ongoing	
Irrigation	❖ Cleaning of 350 metres mainline required. ❖ Sprinkler heads need to be upgraded to double rear jets.	2007-2008	
Revegetation (10 450 m² in five nodes)	❖ Rubbish tip impacts on plant establishment. ❖ Continue reinforcement of vegetation. Revegetation - plant supply (4 500 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter (2005-2006)	 $ 4 500.00 $ 6 750.00 $ 4 500.00 $ 200.00 $ 900.00
Water management	❖ Additional drainage may be required and will be constructed to direct the water away from the rubbish tip.		
Rubble in bunkers	❖ Sand sieving of sand in bunkers.		
		Subtotal	$ 16 850.00
		GST	$ 1 685.00
		TOTAL	$ 18 535.00

Hole 26

Issue	Details	Timing	Budget allocation
Weeds	❖ Continue Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weed control programs.	Ongoing	
Water management	❖ Additional drainage may be required and will be constructed to direct the water away from the rubbish tip.		
Irrigation	❖ Cleaning of 150 metres mainline required. ❖ Sprinkler heads need to be upgraded to double rear jets.	2007-2008	
Revegetation (6 430 m² in three nodes)	❖ Rubbish tip impacts on plant establishment. ❖ Continue reinforcement of vegetation. Revegetation - plant supply (4000 plants) - labour - tree guards and three stakes - GUR signs - Slow release fertiliser tablets (20 gm)	Winter (2007-2008)	 $ 4000.00 $ 6000.00 $ 2000.00 $ 200.00 $ 800.00
Rubble in bunkers	❖ Sand sieving of sand in bunkers.		
		Subtotal	$ 13 000.00
		GST	$ 1 300.00
		TOTAL	$ 14 300.00

Hole 27

Issue	Details	Timing	Budget allocation
Weeds	❖ Continue programs to control Parramatta, Kikuyu, Winter grass, Crab grass, Flat weed and Broadleaf weeds.		
Revegetation (400 m² in one node)	❖ Continue reinforcement of vegetation. Revegetation - plant supply (30 large tree stock) - labour - tree stakes	Winter (2004-2005)	 $ 600.00 $ 600.00 $ 120.00
Irrigation	❖ Cleaning of 500 metres mainline required. ❖ Sprinkler heads need to be upgraded to double rear jets.	2007-2008	
		Subtotal	$ 1 320.00
		GST	$ 132.00
		TOTAL	$ 1 452.00

BUDGET ASSUMPTIONS

Preliminary quotes were obtained from a number of suppliers in March 2004 and the budget estimates have been based on these prices excluding GST.

ACTIVITY	COST PER UNIT
TREE ROOT INTERFERENCE OPTIONS	
Deep ripping, clean up and turf repair	$ 1.50 per metre
Tree guards	
Root guard	$ 80.00 each installed
MAINLINE REPLACEMENT	
Materials	$ 7.50 per metre
Trenching	$ 1.00 per metre
Installation	$ 6.00 per metre
REVEGETATION	
Plant supply	Some stock can be grown at the Council nursery to reduce the cost of plant supply. The budget has allowed for tubestock only with occasional items of large stock.
Tree guards and stakes	$ 1.00 per plant
20 gm slow release fertiliser tablets	$ 0.20 each
Mulch installation	Council has access to considerable mulch and machinery to enable this work to be undertaken in house
Soil amendment	
Excavator – 4 tonne	
Machine mounted cutter	
WEED CONTROL	
Grass weed control (herbicide)	$ 400 / ha
Broadleaf weed control	$ 80 / ha
SAND SIEVING	$ 1 000 per bunker
FLOW METERS	
Four flow meters	$ 2 000.00 installed

CHAPTER FOURTEEN

IMPLEMENTATION AND BUDGETING

Facilities requiring maintenance

The ongoing maintenance requirements of existing infrastructure and works outlined in this document will be:

Access tracks through revegetation areas and along perimeter boundary	Slashing of grasses and top-dressing of mulch trails quarterly. Annual pruning of vegetation to maintain access.
Maintenance shed and washdown facilities	Emptying of sumps and cleaning up storage areas as required.
Revegetation	Reinforcement if required.
Signs and trail markers	Check bi-monthly when undertaking general monitoring, and repair as necessary.
Weed control	Quarterly grass and broadleaf weed control particularly in wetland areas.
Rubbish collection	Weekly collection and more frequently during peak periods.
Toilets and septic tanks	Assessment of need for emptying in 2004 and then in accordance with environmental health regulations.

Process

This finalised report will be provided to the City of South Perth for endorsement, and implementation will follow. Progress should be monitored on a regular basis and any opportunities for sourcing external funding acted upon.

Implementation

The implementation of this environmental management plan will need to be undertaken jointly and cooperatively between the Course management and their supporting staff in other divisions of the City of South Perth. Sourcing ongoing funds will be an important part of ensuring implementation in the long term. Grants may be available from external sources.

To make this program work in both the short and long term, it may be possible to obtain outside funding and labour sources – particularly in relation to school groups and wildlife protection initiatives. It is suggested that different staff of the City of South Perth become responsible for overseeing single aspects of the overall project. For example, the Environmental Programs Coordinator could take responsibility for water quality monitoring and any staff member of the Course with an interest in native plants may work towards revegetation goals. Any meetings held can then be used to enable different staff members to report back on progress towards achieving a specific recommendation or item. This will ensure that everyone participates.

Discussions will need to be held between all parties to enable delegation of specific tasks to different individuals. An implementation sheet is provided below in which possible coordinators can be identified for selected recommendations. This worksheet needs to be filled in by the Course Superintendent with the support of the Manager of Parks and Environment, and the other stakeholders to enable works programming.

Funding

Funding is required to undertake any development or management operation. Future monies will have to be found by the Council although it is possible that some activities may be eligible for external grants.

Staging

The following list is the suggested sequence for the implementation of key recommendations contained within this environmental management plan. These priorities have been identified by the Contractor and have not been discussed or negotiated with the key stakeholders. The priorities can be adjusted in accordance with Council needs.

Budgeting

A detailed budget has been developed for items beyond standard Course management operations. These are targeted towards improving the environmental accountability of the course. The budgets are divided into the cost of implementing the general recommendations and then a hole by hole breakdown of selected works.

Rec No	Recommendation	**Budget estimate (based on preliminary quotes)**
1	Ensure the surface water quality monitoring sampling point selection includes the stormwater drains.	Within existing Council resources
2	Upgrade the drainage to include gross pollutant traps and oil and grease separators should the drainage network be retrofitted.	$ 25 000
3	Ensure the groundwater quality monitoring sampling point selection includes bores and tests comprehensively for a range of contaminants outlined in Chapter 10 of this document.	Within existing Council resources
4	Determine the need for methane monitoring and develop and implement a strategy if considered to be worthwhile.	Within existing Council resources
5	Provide recycling bins for patrons around the clubhouse facilities and use appropriate stencils or signs on the bins to encourage patrons to do the right thing.	
6	Endeavour to use re-usable boxes and packaging where possible in the kitchen and provision areas to reduce use of plastic bags and cardboard boxes.	Discussion with Leasee
7	Investigate the feasibility of recycled paper products for takeaways rather than polystyrene.	Discussion with Leasee
8	Assess the septic tanks to determine whether or not they are due for pumping out, in accordance with the regulations of the Department of Health.	Within existing Council resources
9	Investigate the feasibility of linking the toilet facilities with deep sewerage or use of alternative treatment systems such as Biomax ® to reduce the potential for contamination of the groundwater.	Within existing Council resources
10	Develop a detailed waste management strategy for the maintenance shed, upon completion of a waste audit.	$ 5 000.00
11	Implement soil and water quality testing as outlined in Chapter 10 to determine whether or not chemical residues are accumulating in the soil.	Soil testing component $ 5 000 per annum
12	Provide recycling bins alongside existing rubbish bins and sort waste prior to disposal.	$ 2 500.00

Rec No	Recommendation	Budget estimate (based on preliminary quotes)
13	Continue emptying rubbish bins at 3 – 4 times per week and work to ensure that ravens and crows cannot gain access to the litter.	Within existing Council resources
14	Ensure all staff are trained in pollution prevention and spill remediation procedures.	Within existing Council resources
15	Ensure all staff comply with State regulations relating to spill recording.	Within existing Council resources
16	Construct a formal composting capacity to use turf clippings, soil and pine needles on-site and use the resulting compost for soil amendment throughout the course.	$ 10 000.00
17	Investigate opportunities for export of pine needles to large soil and mulch manufacturer's to assess the feasibility of selling the waste product for their use in composting.	Within existing Council resources
18	Purchase a mulcher for the Course to improve disposal of organic material.	$ 3 500.00
19	Construct enclosed soil bays to assist with the soil recycling on the Course.	$ 2 500.00
20	Develop an integrated pest management plan to reduce chemical use across the Course, particularly where chemicals are known to have bioaccumulation impacts on wildlife.	$ 8 000.00
21	Develop a nutrient management plan to reduce chemical use across the Course, particularly where chemicals are known to have bioaccumulation impacts on wildlife.	$ 10 000.00
22	Develop a detailed turf management plan justifying the turf selection and management regimes, including scheduling renovations.	$ 5 000.00 with substantial inhouse support
23	Develop a bore management plan and review licence arrangements through the *Waterwise Strategy* that is currently being prepared by the City of South Perth.	$ 3 500.00
24	Develop a detailed irrigation management plan including a review of the current reticulation system, the relative extraction of water by pines versus the turf and identifying new technologies that could improve watering throughout the Course.	$ 15 000.00
25	Undertake a comprehensive water quality monitoring program to obtain baseline data to determine if the chemicals used across the Course are leaching into the groundwater or being transported in the surface water.	$ 35 000 initially $ 3 500.00 and $ 4 500.00 alternate future years
26	Implement a whole of course approach to landscaping and prepare a comprehensive landscape plan and details for the entire course.	$ 20 000.00
27	Selectively replace non-indigenous plants with locally indigenous plant species for use within the course and plant in late autumn to minimise the need for supplementary watering.	Refer to specific recommendations on a per hole basis
28	Remove any unhealthy or damaged trees and replace promptly with appropriate native species selected from the list provided in Appendix 1.	Within current budgeting arrangements
29	Remove tree stakes once no longer required to maximise the survival of any planted stock.	Within current budgeting arrangements
30	Ensure any purchased nursery stock is hardened off, has sufficient rootball and is disease and pathogen free prior to planting within the course.	General administration issue

Rec No	Recommendation	Budget estimate (based on preliminary quotes)
31	Inject or foliar spray Phostoxin into plants susceptible to dieback to maximise their survival, and repeat bi-annually.	Within current budgeting arrangements
32	Prepare a map showing prioritised trees for assessment by an arboriculturalist and for use of alternative management techniques to overcome root mass issues, and undertake the assessment.	$ 2 000 quoted by FPC for assessment and documentation (2 day estimate)
33	Liaise with Perth based logging companies to determine the minimum number of trees that need to be removed to make the harvesting cost effective.	General administration issue
34	Develop a communication strategy to allow for community liaison to minimise the conflict associated with removal of unhealthy and unstable trees.	Within current budgeting arrangements
35	Implement a progressive removal of the selected unhealthy trees	Within current budgeting arrangements
36	Undertake selective removal of weedy shrubs and trees, particularly from the wetland and bushland areas.	As per budget schedule outlined in Chapter 13.
37	Remove weeds with a limited distribution and monitor for any new germinants and remove promptly.	Combination within existing schedules and as per budget schedule outlined in Chapter 13.
38	Begin a process of defining revegetation areas from mown and turf areas by creating identifiable boundaries.	General management issue
39	Implement progressive removal of exotic species and replacement with locally indigenous plants.	Combination within existing schedules and as per budget schedule outlined in Chapter 13.
40	Investigate the feasibility of installing a nesting platform for birds of prey and nesting boxes for other fauna in selected trees around the Course.	General management issue
41	Liaise with CALM and wildlife rescue groups to determine the feasibility of housing injured wildlife that cannot be released back into the wild.	General management issue
42	Undertake the soil and plant tissue analysis to determine if there are chemical accumulation issues as recommended in earlier sections of this document.	As per budget outlays provided above.
43	Develop a pest fauna management program in accordance with need if such animals are found to be active in the Course.	$ 2 500.00
44	Ensure any damage to the fence is repaired promptly to minimise the potential for domestic or feral animals gaining access to the Course grounds.	General management issue
45	Ensure any damage resulting from vandalism is repaired as quickly as possible to discourage further acts.	General management issue
46	Provide interpretive signage including the key elements listed above (refer to text).	$ 2 000.00
47	Develop and install plant identification plaques for key species in the Course.	$ 2 000.00
48	Prepare informative posters outlining the environmental management projects.	$ 2 000.00
49	Develop a protocol for involving staff in environmental activities and providing training.	General management issue
50	Develop a detailed strategy assessing the viability of involving the community in environmental improvement activities.	General management issue

CHAPTER FIFTEEN

DEFINITIONS

CHAPTER 15: DEFINITIONS

In addition to the terms described in the text, the following definitions shall apply to defined terms, except when the context provides otherwise.

Above ground storage tank
Defined as a non-vehicular device including any associated piping, that is made of non-earthen materials located on or above the ground surface and containing an accumulation of static hydrocarbons or hazardous substances.

Best management practice (BMP)
An effective integration of environmental management practices that incorporates the stormwater management systems with appropriate combinations of landscape conservation, enhancement, structural control and water conservation approaches. These provide an optimum way to convey, store and release runoff so as to reduce peak discharge, remove pollutants and enhance the environment. The BMPs also ensure the effectiveness of structural controls, schedules of activities, prohibitions of practices, maintenance procedures and other management practices that contribute towards environmental enhancement.

Biological oxygen demand (BOD)
A measure of the amount of oxygen consumed in the biological processes that breakdown organic matter in water. The greater the BOD, the greater the degree of pollution.

Buffer zone
A strip of vegetation used for removing sediment, organic matter and/or other pollutants from runoff and wastewater.

Chemical oxygen demand (COD)
A measure of the amount of oxygen required to oxidise all compounds, both organic and inorganic, in water.

Composite sample
A series of water samples taken over a given time and weighted by flow rate or time.

Detection limit
The lowest concentration of an analyte that can be determined with reasonable confidence.

Detention
The temporary storage of stormwater runoff, which is used to control the peak discharge rate and which provides gravity settling of pollutants.

Evapotranspiration
The loss of moisture through the processes of evaporation from land and water surfaces, and through transpiration by plants.

Fertiliser
Any of a large number of natural or synthetic compounds, including manure and nitrogen, phosphorus and potassium compounds, spread on or worked into the soil to increase its capacity to support plant growth.

First flush
At least the first 10 mm of runoff generated in a single storm event that flushes off and contains a disproportionately large loading of the accumulated pollutants from impervious and non-impervious surfaces.

Biological oxygen demand (BOD)
A measure of the amount of oxygen consumed in the biological processes that breakdown organic matter in water. The greater the BOD, the greater the degree of pollution.

Impervious cover
Roads, parking areas, buildings, sheds and other impermeable construction covering the natural land surface. Percent impervious cover is calculated against the total boundary of the golf course.

Grab sample
A sample taken at the discretion of the sampler, as to the condition or event that it would represent.

Herbicide
A chemical substance used to destroy or inhibit the growth of plants, especially weeds.

Material safety data sheet (MSDS)
Occupational, safety and health established guidelines for the use of particular compounds that includes precise descriptive data on a data sheet to serve as the basis for written hazard communication.

Milligrams per litre (mg/L)
A unit of concentration equal to one thousandth of a gram per one litre of water.

Miticide
A range of chemical compounds that kills mites.

Monitoring
Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants and animals.

Nematodes
Any of several worms of the phylum Nematoda, having unsegmented cylindrical bodies, often narrowing at each end and including parasitic forms such as the hookworm and pinworm.

Nitrate
Plant nutrient and inorganic fertiliser that enters water supplies from septic systems, fertilisers, manure, industrial wastewater, sanitary and general landfill.

Non-point source
Diffuse pollution sources are without a single point of origin or not introduced into a receiving water from a specific outlet. The pollutants are generally carried off the land by stormwater.

Pesticide
A range of chemical compounds that kills pests, especially insects.

Potential evapotranspiration
The process that estimates actual water use by turf through measuring weather conditions by means of a weather station.

pH
An expression of the intensity of the basic or acidic condition of a solution.

Stomate
An opening on a lead through which water evaporates.

Structural controls
A range of pollution prevention best management practices ranging from vegetated buffers to on-site stormwater detention lakes.

Total suspended solids (TSS)
TSS represents the total amount of solid matter in a representative water sample that is retained by a membrane filter. It includes all sediment and other constituents that are fluid suspended.

Underground storage tank
Any one or combination of underground storage tanks and any connecting underground pipes used to contain an accumulation of regulated substances, the volume of which, including the pipes, is 10% or more below grade.

APPENDIX 1

Species lists for Course including revegetation and weed lists

APPENDIX 1: SPECIES LISTS FOR COLLIER PARK GOLF COURSE

Species	Common name	Planting density	Arrangement	Nursery availability
LARGE TREES (> 20 Metres)				
Corymbia calophylla	Marri	1 per 50 sq m	Random	easy
Eucalyptus marginata	Jarrah	1 per 50 sq m	Random	easy
SMALL TO MEDIUM TREES (~10 Metres)				
Allocasuarina fraseriana	Common Sheoak	1 per 30 sq m	Random	easy
Banksia attenuata	Candle banksia	1 per 15 sq m	Groups of 15	easy
Banksia grandis	Bull banksia	1 per 15 sq m	Groups of 15	easy
Banksia ilicifolia	Holly-leaf banksia	1 per 15 sq m	Random	easy
Banksia menziesii	Firewood banksia	1 per 15 sq m	Groups of 15	easy
Corymbia ficifolia	Red flowering gum	1 per 15 sq m	Random	easy
Eucalyptus todtiana	Pricklybark	1 per 20 sq m	Groups of 5	easy
Nuytsia floribunda	Christmas tree			very difficult
Xylomelum occidentale	Woody pear	1 per 20 sq m		easy
TALL SHRUBS (~5 Metres)				
Acacia saligna	Golden-wreath wattle	1 per 10 sq m	Random	easy
Adenanthos cygnorum	Woollybush	1 per 10 sq m	Groups of 4	difficult
Conospermum triplinervium	Tree smokebush	1 per 5 sq m	Groups of 5	variable
Dodonaea hackettiana	Perth hop-bush	1 per 15 sq m	Random	variable
Jacksonia furcellata	Grey stinkwood	1 per 5 sq m	Random	easy
Jacksonia sternbergiana	Green stinkwood	1 per 3 sq m	Random	easy
Kingia australis	Drumsticks	1 per 2 sq m	Random	difficult

MEDIUM TO LARGE SHRUBS (~ 3 METRES)	Common name	Planting density	Arrangement	Nursery availability
Acacia pulchella	Prickly moses	1 per 2 sq m	Groups	easy
Allocasuarina humilis	Dwarf sheoak	1 per 2 sq m	Random	easy
Calothamnus lateralis		1 per 3 sq m	Groups	difficult
Conospermum stoechadis	Common smokebush	1 per 4 sq m	Groups of 10	variable
Dryandra armata	Prickly dryandra	1 per 4 sq m	Groups of 20	difficult
Hakea ruscifolia	Candle hakea	1 per 5 sq m	Random	variable
Jacksonia densiflora		1 per 4 sq m	Random	difficult
Jacksonia floribunda	Holly pea	1 per 4 sq m	Random	difficult
Lambertia multiflora	Many-flowered honeysuckle	1 per 3 sq m	Groups of 5	variable
Leucopogon parviflorus	Coast beard-heath	1 per 1 sq m	Random	variable
Macrozamia riedlei	Zamia	1 per 5 sq m	Random	variable
Melaleuca thymoides		1 per 4 sq m	Groups of 30	easy
Pimelea leucantha		1 per 2 sq m	Random	variable
Pultenaea reticulata		1 per 5 sq m	Groups of 10	variable
Regelia inops		1 per 4 sq m	Groups of 20	easy
Verticordia nitens	Morrison featherflower	1 per 3 sq m	Groups of 20	variable
Xanthorrhoea brunonis		1 per 5 sq m	Random	variable
Xanthorrhoea drummondii		1 per 5 sq m	Random	variable
Xanthorrhoea preissii	Blackboy	1 per 5 sq m	Groups of 3	easy
LOW SHRUBS (< 1 METRE)				
Acacia huegelli		1 per 2 sq m	Random	variable
Acacia sessilis			Random	variable
Acacia sphacelata		1 per 4 sq m	Random	variable
Acacia stenoptera	Narrow-winged wattle	1 per 2 sq m	Random	easy
Acacia willdenowiana	Grass wattle	1 per 2 sq m	Random	easy

LOW SHRUBS CONTINUED (< 1 METRE)	Common name	Planting density	Arrangement	Nursery availability
Amperea ericoides		1 per 4 sq m	Random	very difficult
Andersonia lehmanniana		1 per 1 sq m	Random	very difficult
Astroloma glaucescens		1 per 2 sq m	Random	very difficult
Astroloma macrocalyx	Swan berry	_____	Groups of 10	very difficult
Astroloma pallidum	Kick bush	_____	Random	very difficult
Astroloma xerophyllum		_____	Random	very difficult
Baeckea camphorosmae	Camphor myrtle	1 per 2 sq m	Groups of 15	easy
Banksia incana		1 per 2 sq m	Groups of 5	variable
Beaufortia elegans		1 per 2 sq m	Groups of 10	easy
Boronia purdieana	Winter boronia	1 per 2 sq m	Groups of 15	difficult
Bossiaea eriocarpa	Common brown pea	1 per 1 sq m	Random	easy
Brachyloma preissii	Globe heath	1 per 1 sq m	Groups of 4	very difficult
Calytrix angulata	Yellow starflower	_____	Groups of 15	variable
Calytrix flavescens	Summer starflower	_____	Groups of 15	variable
Calytrix fraseri	Purple starflower	_____	Groups of 15	variable
Calytrix leschenaultii		_____	Random	very difficult
Calytrix sapphirina		_____	Random	very difficult
Conospermum acerosum	Needle-leaved smokebush	1 per 2 sq m	Groups of 3	very difficult
Conospermum crassinervium	Summer smokebush	_____	Random	variable
Conospermum incurvum	Plume smokebush	_____	Random	very difficult
Conostephium minus	Pink-tipped pearl flower	1 per 1 sq m	Groups of 20	very difficult
Conostephium pendulum	Pearl flower	1 per 2 sq m	Groups of 10	very difficult
Conostephium preissii		1 per 3 sq m	Random	difficult
Conothamnus trinervis		_____	Groups of 5	difficult
Corynotheca micrantha	Sand lily	1 per 1 sq m	Groups of 20	very difficult
Croninia kingiana		1 per 2 sq m	Random	very difficult

LOW SHRUBS CONTINUED (< 1 METRE)	Common name	Planting density	Arrangement	Nursery availability
Cryptandra pungens		1 per 1 sq m	Random	very difficult
Dampiera linearis	Common dampiera	_____	Variable groups	easy
Daviesia angulata		1 per 2 sq m	Random	very difficult
Daviesia decurrens	Winged bitter-pea	1 per 1 sq m	Groups of 3	variable
Daviesia divaricata	Marno	1 per 2 sq m	Groups of 10	variable
Daviesia gracilis		1 per 1 sq m	Random	very difficult
Daviesia nudiflora		1 per 2 sq m	Random	variable
Daviesia quadrilatera		1 per 2 sq m	Groups of 4	very difficult
Daviesia triflora		1 per 1 sq m	Groups of 4	variable
Dryandra mimica	Summer honeypot	1 per 1 sq m	Groups of 3	very difficult
Dryandra nivea	Couch honeypot	1 per 1 sq m	Groups of 3	easy
Eremaea asterocarpa	Star-fruited eremaea	1 per 1 sq m	Groups of 10	very difficult
Eremaea fimbriata	Pink-flowered eremaea	1 per 1 sq m	Groups of 15	very difficult
Eremaea pauciflora	Orange-flowered eremaea	1 per 1.5 sq m	Groups of 15	variable
Eriostemon spicatus	Pepper-and-salt	1 per 1 sq m	Groups of 3	variable
Gompholobium confertum		1 per 1 sq m	Random	very difficult
Gompholobium knightianum		1 per 1 sq m	Random	very difficult
Gompholobium scabrum	Painted lady	1 per 1 sq m	Random	very difficult
Gompholobium tomentosum	Hairy yellow pea	1 per 1 sq m	Groups of 10	easy
Gyrostemon subnudus		1 per 5 sq m	Random	very difficult
Hakea prostrata	Harsh hakea	1 per 8 sq m	Groups of 4	easy
Hemiandra pungens	Snakebush	1 per 2 sq m	Random	easy
Hibbertia acerosa	Needle leaved guinea flower	1 per 1 sq m	Random	very difficult
Hibbertia huegelii		_____	Random	very difficult
Hibbertia hypericoides	Common buttercups	1 per 1 sq m	Random	variable
Hibbertia racemosa	Stalked guinea-flower	1 per 2 sq m	Random	variable

LOW SHRUBS CONTINUED (< 1 METRE)	Common name	Planting density	Arrangement	Nursery availability
Hibbertia subvaginata		1 per 2 sq m	Random	very difficult
Hibbertia vaginata		1 per 2 sq m	Random	very difficult
Hovea pungens	Devil's pins	1 per 1 sq m	Groups of 5	easy
Hovea trisperma	Common hovea	1 per 2 sq m	Variable groups	easy
Hybanthus calycinus	Native violet	1 per 1 sq m	Random	variable
Hypocalymma robustum	Swan River myrtle	1 per 1.5 sq m	Groups of 25	easy
Isopogon drummondii		1 per 1 sq m	Random	variable
Isotropis cuneifolia	Granny's bonnets	1 per 1 sq m	Random	variable
Jacksonia sericea	Waldjumi	1 per 1 sq m	Random	very difficult
Labichea punctata	Lance-leaved cassia	1 per 1 sq m	Groups of 5	variable
Lachnostachys albicans		1 per 1 sq m	Random	very difficult
Lasiopetalum lineare		1 per 0.5 sq m	Groups of 10	very difficult
Lechenaultia floribunda	Free-flowering lechenaultia	1 per 0.8 sq m	Groups of 30	variable
Leptospermum spinescens		1 per 3 sq m	Groups of 10	very difficult
Leucopogon conostephioides		1 per 1 sq m	Random	very difficult
Leucopogon nutans	Nodding beard-heath		Random	very difficult
Leucopogon oldfieldii			Random	very difficult
Leucopogon oxycedrus			Random	very difficult
Leucopogon polymorphus			Random	very difficult
Leucopogon propinquus			Random	variable
Lysinema ciliatum	Curry flower		Random	variable
Macarthuria australis			Random	variable
Melaleuca seriata			Groups of 3	easy
Melaleuca scabra	Rough honeymyrtle		Groups of 5	easy
Melaleuca conothamnoides			Random	very difficult
Melaleuca trichophylla		1 per 2 sq m	Groups of 10	variable

LOW SHRUBS CONTINUED (< 1 METRE)	Common name	Planting density	Arrangement	Nursery availability
Mirbelia spinosa		1 per 1 sq m	Random	variable
Nemcia capitata	Bacon and eggs	1 per 1 sq m	Groups of 8	easy
Persoonia saccata	Thread-leaf snottygobble	1 per 2 sq m	Random	variable
Petrophile linearis	Pixie mops	1 per 1 sq m	Groups of 3	variable
Petrophile macrostachya		1 per 1 sq m	Random	variable
Pimelea rosea	Pimelea rosea	1 per 2 sq m	Random	variable
Pimelea suaveolens	Scented banjine	1 per 1 sq m	Random	variable
Pimelea sulphurea	Yellow banjine	_____	Random	variable
Ptilotus drummondii	Narrowleaf mulla mulla	_____	Random	variable
Scaevola canescens	Grey fanflower	_____	Random	variable
Scaevola repens		_____	Random	very difficult
Scholtzia involucrata	Spiked scholtzia	1 per 2 sq m	Groups of 15	variable
Synaphea spinulosa		1 per 1 sq m	Random	very difficult
Thomasia purpurea		1 per 1 sq m	Random	very difficult
Verticordia densiflora	Bushy featherflower	1 per 1 sq m	Groups of 5	variable
Verticordia drummondii	Drummond's featherflower	1 per 1 sq m	Groups of 15	variable
CLIMBERS				
Hardenbergia comptoniana	Native wisteria	1 per 3 sq m	Random	easy
Kennedia prostrata	Running postman	1 per 1 sq m	Random	easy
Pronaya fraseri	Pronaya	1 per 1 sq m	Random	variable
PERENNIAL HERBS				
Anigozanthos humilis	Catspaw	1 per 0.8 sq m	Groups of 25	easy
Anigozanthos manglesii	Mangles kangaroo paw	1 per 1 sq m	Groups of 5	easy
Arnocrinum preissii		1 per 1 sq m	Random	very difficult

PERENNIAL HERBS CONTINUED (< 1 METRE)	Common name	Planting density	Arrangement	Nursery availability
Conostylis aculeata	Prickly cottonhead	1 per 0.8 sq m	Variable groups	easy
Conostylis candicans	Grey cottonhead	1 per 0.5 sq m	Variable groups	easy
Conostylis setigera	Bristly conostylis	1 per 0.5 sq m	Variable groups	easy
Danthonia caespitosa	Common wallaby grass	1 per 0.8 sq m	Variable groups	variable
Danthonia occidentalis		1 per 0.8 sq m	Variable groups	variable
Dasypogon bromeliifolius	Pineapple bush	1 per 1.5 sq m	Groups of 10	very difficult
Dianella revoluta	Blueberry lily	1 per 3 sq m	Groups of 3	easy
Lomandra caespitosa	Tufted mat rush	1 per 1 sq m	Groups of 5	very difficult
Lyginia barbata		1 per 1 sq m	Random	very difficult
Microlaena stipoides		1 per 0.8 sq m	Groups of 15	variable
Orthrosanthos laxus		1 per 1 sq m	Groups of 5	easy
Patersonia occidentalis	Purple flag	1 per 1 sq m	Groups of 15	easy
Phlebocarya ciliata		1 per 1 sq m	Random	very difficult
Thysanotus manglesianus	Fringed lily	1 per 1 sq m	Random	very difficult
Thysanotus multiflorus		1 per 1 sq m	Random	very difficult

WETLAND PLANTINGS

Agonis linearifolia	Swamp peppermint
Anigozanthos viridus	Green kangaroo paw
Astartea fascicularis	Common astartea
Baumea articulata	Joint leaf sedge
Baumea juncea	Bare twig sedge
Baumea preissii	Broad leaf sedge
Baumea rubiginosa	River sedge
Hypocalymma angustifolium	White myrtle
Juncus kraussii	Shore rush
Juncus pallidus	Pale rush
Juncus pauciflorus	Loose-flowered rush
Melaleuca preissiana	Stout paperbark

Aotus gracillima	
Aotus procumbens	
Boronia crenulata	Aniseed boronia
Lechenaultia expansa	
Pericalymma ellipticum	
Melaleuca rhaphiophylla	Freshwater paperbark